COLLEGE OF ENGINEERING

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DEPARTMENT OF BIOLOGICAL AND ECOLOGICAL ENGINEERING

Design of a Model Predictive Controller for Optimal Algal Growth

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Resurgence of interest in algal biofuels, can be attributed to the possibility of year round production at higher productivities compared to terrestrial crops, non-competition with food crops, reduced need for arable land and water treatment benefits with nutrient cycling. The progress in commercial scale biofuels production from microalgae has been slow due to multiple challenges such as high cost of production and processing. The proposed algal biorefinery concepts envision use of large scale algal ponds/photobioreactors which require efficient tools for management of these facilities. An efficient management system for algal growth which can ensure optimal algal production with minimum economic and environmental impact does not currently exist. This study aims to design an optimum controller to encompass optimization of process, economic and environmental aspects of algal production process. A model predictive control will be developed using a previously developed kinetic model. The set point profiles for the controller will be generated by an optimization function minimizing the process, economic and environmental cost. The controller will be demonstrated at a 20-L lab scale pond. Temperature, light, nitrates and carbon will be measured, and biomass growth will be estimated using a previously developed genome scale metabolic reconstruction model. System performance will be compared with and without controller under measured external disturbances in the light intensity and temperature.

Testing the Ideas of Walter White: An Estimation of Riparian Evapotranspiration Using Groundwater Upwelling

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In arid and semi-arid systems the riparian zone boarding a stream has high evapotranspiration rates compared to uplands. Evapotranspiration (ET) is difficult to estimate, but accounts for much of the water loss from landscapes. Walter White (1932) introduced a method using the diurnal fluctuation of groundwater depth to estimate ET. With the advent of accurate data logging pressure sensors, the White method has recently reemerged as an important strategy. A persistent challenge of the White method is knowledge of how much water is released per unit fall in the water table (the "specific yield"). Specific yield is highly variable, and there exists no validated method for its measurement. Our experiment will directly measure this term using soil moisture probes, spaced 2cm apart along the vertical axis of a soil column to measure the volumetric change in water content accompanying changes in water table. We will compare estimations of evapotranspiration derived from groundwater table depth and soil texture data that have been calibrated using a series of soil moisture probes against values from micrometeorological stations equipped with a 3D ultrasonic anemometer and high-speed humidity sensor based on the "eddy covariance" method. The deliverable by the end of this project will be a simple method to install and calibrate a groundwater table depth observation well to produce an accurate estimation of evapotranspiration and groundwater upwelling in areas with shallow water tables such as riparian areas.

SCHOOL OF CHEMICAL, BIOLOGICAL, AND ENVIRONMENTAL ENGINEERING

Development of Fischer-Tropsch Synthesis CFD modeling

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Fisher-Tropsch Synthesis (FTS) is the process that converts synthesis gas (syngas, a mixture of carbon monoxide and hydrogen) into a wide range of long chain hydrocarbons and oxygenates in the presence of catalysts such as iron or cobalt. The products of the reaction include jet fuel, naphtha and diesel. The goal of this study is to create a computational model using COMSOL Multiphysics of a system where FTS occurs in a microchannel. The mathematical model includes the fundamental physics of momentum, mass and heat transport as well as chemical reaction. The present model is based on isothermal two phase flow system with diffusion to a catalyst layer on the walls, with the two phases being a gas bubble (syngas and products) surrounded by a moving paraffin like liquid. This model can be used to investigate computationally the effect of reaction conditions, such as temperature and pressure, on the performance of the reactor. In this contribution we will present important features of the model as well as summarize some recent insights derived from its use.

Synthesis of CPO-27-Ni Metal Organic Framework Materials Using a Microwave-assisted Continuous Flow Reactor

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Metal-organic framework materials (MOFs) are of considerable scientific and technological interest due to the extreme flexibility of modifying their physical and chemical properties by changing metal coordinating species and organic linkers. MOFs can have three dimensional long-range order, high surface area, large internal free volume space, and tunable adsorption properties. MOFs have wide-ranging applications in the areas of gas storage, separations and purification, catalysis, and more recently biological and medical applications. The focus of this study was to develop methods to improve the synthesis of MOF CPO-27-Ni by using a continuous-flow microwave assisted reactor. We have optimized the chemistries so that the synthesis can be performed under relatively mild conditions with high yields for short reaction times (i.e., minutes as opposed to days for typical reaction conditions). In addition, we have found that the continuous-flow microwave assisted reactor provides excellent control over materials properties due to more uniform nucleation compared to traditional heating methods. Optimization of CPO-27-Ni reaction conditions for the continuous-flow microwave assisted reactor has led to improvements in the MOFs crystallinity, conversion efficiencies, and production rates. Modulating microwave power allowed significant enhancement of nucleation events, resulting in the relative improvement of crystallinity for the final product. Differences in MOF adsorption capacities were observed when using different synthetic conditions, and a detailed understanding of these changes were correlated to the structure of the MOFs as determined by X-ray diffraction, scanning electron microscopy, transmission electron microscopy, BET isotherms, and ultraviolet-visible spectroscopy.

Solar Thermochemical Storage Using Strontium Carbonate

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Global energy demands are continuously increasing while the forecast for fossil fuels is filled with uncertainty. In addition to increasing energy consumption, there are also inevitable problems associated with using fossil fuel as a main energy resource, such as climate change and atmospheric pollution. Concentrated solar power (CSP) is one promising method of converting clean solar thermal energy into electricity which avoids such environmental problems. Thermal energy storage (TES) in conjunction with CSP, can avoid these environmental problems and increase the utilization of solar energy by enabling plant operators to generate electricity beyond normal on-sun hours. Thermochemical energy storage is an emerging type of TES system based on a reversible reaction. Thermochemical energy storage of on-sun thermal energy is achieved when a reactive system absorbs thermal energy and proceeds with a reversible chemical reaction. In a time of off-sun power demand, the reverse reaction is then initiated and energy is released, thus recovering thermal energy for use in a power cycle. One such reactive system is the reversible carbonation/decomposition of $SrO/SrCO_3$, which occurs ca. 1200˚C. Such high quality heat is suitable for high efficiency, combined cycle power generation, which has the potential to translate into more competitive solar electricity prices. In order to accurately predict the rate of heat generation from a TCES system, the carbonation kinetics of SrO and decomposition kinetics of $SrCO_3$ under CO_2 atmosphere must be determined. Several experiments include performing isothermal reactions using TGA at several temperatures and partial pressures of CO_2 to determine the temperature and pressure dependence of the carbonation and decomposition reactions will be done. A kinetic model with associate Arrhenius parameters will be derived.

Degradation Study of Conductive Coatings Used in Marine Electrochemical Antifouling Applications

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In marine environments fouling organisms rapidly colonize surfaces, with heavy coverage observed in as little as one month. In shipping, fouling causes increased drag which results in fuel consumption increases of as much as 40%. This cost has been the primary driver in the development of marine antifouling technologies, such as self-polishing biocide release paints and biocide release slick paints. These coatings have maximum service lives on the order of 5 and 8 years, respectively. The developing marine hydrokinetic energy (MHK) field is also concerned with performance losses and hull damage due to fouling organisms. The most promising locations for MHK installations are by definition in areas of consistent high seas, making maintenance access with heavy lift equipment, which is already costly, hazardous as well. As a result longer service life antifouling technologies are required. Electrochemical antifouling technology is a possible solution to this need. The main advantage of this technology is that paint degradation is not necessitated for antifouling performance, in stark contrast with conventional methods. Several proofs of concept have been demonstrated, however little engineering data is available in the literature. The present research investigates the degradation rate and mechanism of conductive graphite filled polyurethane coatings used in marine environments for antifouling service. Performance parameters are determined as a function of cumulative electrical charge passed, enabling accelerated aging data to predict values through an expected life on the order of 20 years.

Continuous Methanol Production by Methylosinus trichosporium OB3b Inhibition

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Inhibition of the methanol dehydrogenase enzyme in Methylosinus trichosporium OB3b has been shown to be an effective way of converting methane gas into methanol. Sustained production of methanol by a bacterial culture is limited by the loss in cell energy due to inhibition of the methanol oxidation step in the metabolic pathway. Long-term biological production of methanol may be possible by providing an exogenous source of energy or by only partially inhibiting the metabolic pathway. Steady state growth of M. trichosporium was obtained in a chemostat with constant flow of methane, air, and growth media. Cyclopropanol was used as the inhibitior with formate added as an exogenous form of energy. M. trichosporium in the presence of cyclopropanol at or below a concentration of 6 µg/g dry cell weight recovered rapidly from inhibition. At higher cyclopropanol concentrations methanol production ceased after six to twelve hours, while methanol oxidation did not resume until much later. When formate was added prior to methanol dehydrogenase recovery, methanol production resumed. In all cases, a loss in methane and methanol oxidation capability of the culture was observed following the addition of cyclopropanol, while the downstream metabolic step of formate oxidation remained active. Cyclopropanol restricts energy return through the metabolic pathway of M. trichosporium at low, near non-inhibitory concentrations resulting in the need for an exogenous form of energy for sustained methanol production.

Diatom Frustule Thin Films for Enhanced Photovoltaic Performance

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Solar energy holds promise as a clean and abundant power source that is capable of meeting the demands of the growing world population, but adoption of solar cell (photovoltaic) technologies has been delayed by the high cost of established silicon-based systems and the low efficiency of next-generation technologies. Diatoms, a diverse class of single-celled marine algae, biologically fabricate nanostructured glass cell walls (frustules) that are believed to enhance the cells' ability to capture light for photosynthesis. This suggests that integration of diatom frustules into photovoltaic devices may improve their performance via improved light capture. To investigate the potential of frustules in photovoltaics, diatom frustules were assembled into planar thin films using colloidal assembly of living cells as well as vertical deposition of purified diatom frustules. The optical properties (spectral reflectance, transmittance) of the assembled frustule films were then characterized spectroscopically and frustule integrated dye-sensitized solar cells were tested for enhanced current generation and overall device efficiency.

Control of Growth and Product Stimulation of the Photosynthetic Diatom Cyclotella by Co-Limitations of Nutrients

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Understanding the metabolic pathways that microalgae undergo in photobioreactors to produce metabolites and biofuels is achieved by specific feeding regimes. Diatoms need silicic acid to create their silica cell wall, which is made during cell division. Nitrate is used by diatoms to produce cellular material and nitrogen bearing metabolites, such as chitin. Cell biomass, lipid and chitin productivity by the marine diatom Cyclotella sp was studied in batch and perfusion feeding under sequential co-limitation of two macronutrients, silicon and nitrogen in a bubble column photobioreactor. During the cultivation in the photobioreactors, the cell suspension was assayed for cell number density, dissolved silicon and nitrate concentrations in the media. In specific points of the experiment, biomass samples were analysed for lipid and chitin content. In the batch experiments, the co-limitation was carried out by increasing the initial nitrate concentration from 0.5 to 5.0 mM. In the perfusion feeding experiments, the initial silicon to nitrate concentration ratio (Si/N) is 0.7, and it is maintained throughout the perfusion, in silicon and nitrate starved environments. The perfusion is carried out through sequential periods of time ranging from 2 to 21 days. In batch cultures, chitin is produced at Si depletion within the first 48 hours of stationary phase. The range of chitin production is 2 to 10 mg/ 100 mL of culture. Lipids production is induced at silicon depletion, and ranged from 10-15 wt% lipid in dry biomass. These results show that nitrate delivery at silicon limitation is the primary variable for the metabolic flux of chitin and silicon-nitrogen delivery in a silicon-nitrogen starved regimes through extended periods of time inhibits the metabolic production of lipids.

Growth Kinetics of Zn(O,S) Thin Films in a Chemical Bath Deposition

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ZnS thin film can be part of the precursor of CZTS ($Cu_2ZnSnSe_4$) solar cell. The growth kinetics was studied to search for high-rate and high quality thin film growth condition. Chemical bath deposition of ZnS thin film using Zinc Sulfate Heptahydrate, thioacetaamine (TAA) and Nitrilotriacetic acid trisodium salt (Na_3NTA) has been studied. To study the growth kinetics, processing parameters such as reagent concentration and temperature were varied. The ZnS thin film grown in this study is of good quality and free of white particles. UV-Vis spectroscopic was used to calculate bandgap to be 3.6 eV. The activation energy of the deposition measured from Arrhenius plot is 35 KJ/mole. The measured deposition rate with fractional values of reaction order is calculated. Currently, a CZTS solar cell with SnO/ZnS/CuS precursor was under study.

High-Performance, Low-Temperature Solution Processed Indium Oxide Thin-Film Transistors Using a Volatile Nitrate Precursor

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Metal oxide semiconductors have been intensively researched over several decades due to their unique electrical and optical characteristics. In conjunction with high optical transparency, high electronic properties and excellent thermal/environmental durability make them promising alternative materials to replace hydrogenated amorphous silicon and organic semiconductors as active channels for thin-film transistors. In this study, Amorphous In_2O_3 thin film transistors (TFTs) were fabricated on a display glass substrate using a volatile indium nitrate precursor solution. Taking advantage of a volatile nitrate precursor, the device performances with an average mobility of 7.5 $cm^2 V^{-1} s^{-1}$, on-off ratio of 10^7, and V_{on} = -5 V were fabricated at 300 ˚C annealing process. The devices prepared at 200 ˚C still exhibited transistor characteristics with an average mobility of 0.04 $cm^2 V^{-1} s^{-1}$, on-off ratio of 10^5, and V_{on} = 0 V. This study demonstrates that using volatile nitrate precursors can be a promising approach to manufacture high performance amorphous indium oxide TFTs at low temperature process.

An Investigation of Fluid Flow in Complex Microchannel Geometries for Hemodialysis using Residence Time Distribution Analysis

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OSU's Microproducts Breakthrough Institute is currently engaged in design, manufacturing and testing of a microscale-based device, which is a unique platform for variety of In-Vivo blood processing developments; with an immediate focus on hemodialysis. The application of high throughput microchannel devices in hemodialysis may open opportunities for at-home, nocturnal treatment and greatly improve the survival rate and quality of life for ESRD patients. Device defects, air bubble stagnation and lamina design can contribute to flow maldistribution, resulting in decreased filtration performance of the device. Multi-lamina microchannel devices require a non-visual, diagnostic and characterization tool to better understand their complex flow paths and determine if our ideal scenarios and models are truly reflected in physical devices. Residence time distribution analysis was proposed as a method of: 1) detection of fabrication and operational defects, and 2) characterization of flow distribution for various microchannel lamina designs. A test loop was developed to measure the pulse response of injected coomassie blue dye at the device inlet and outlet and mean residence times were calculated at varying levels of blocked channels. As a diagnostic tool, the current test loop was able to detect defects down to 4 out of 60 blocked channels or a reduced volume fraction of 4%. Inlet and Outlet concentration profiles were further deconvoluted to arrive at residence time distribution profiles for various lamina designs and conditions. Experimental results were used to develop and validate a CFD simulation that in conjunction with experiments provide a more complete understanding of the dialysis system.

Pseudomonas Aeruginosa Biofilm Rheology

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Bacterial biofilms are one of the most intractable problems facing industries ranging from petroleum to the healthcare industry. This matrix of EPS provides diffusion barrier against antimicrobial agents and provides protective microenvironment where bacterial cultures can thrive. Pseudomonas aeruginosa is an environmental bacteria that is known for its ability to produce alginate incased biofilm. It can cause major problems in the medical field as an opportunistic pathogen causing recurrent infections in cystic fibrosis patients and acute infections in burn victims. Rheology is the study of material behavior in response to applied stress and strain. The rheology of a P. aeruginosa biofilm can reveal the mechanical properties that give this biofilm its characteristic resistance to environmental stresses such as antibiotics. From preliminary studies, P. aeruginosa (PAO1) biofilm is viscoelastic and shows predominantly elastic property. The elastic modulus describes the resistance to deformation or the solid-like behavior of the P. aeruginosa biofilm, so this property is likely responsible for P. aeruginosa biofilm robustness in the face of outside stresses such as pH, temperature, DO, and antibiotics.

Development of Traceable Metal Oxide Nanoparticles for Examining Environmental Fate and Transport

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The range of commercial and industrial applications for titanium dioxide nanoparticles (TiO_2 NPs) has resulted in a production rate on the order of millions of tons per year. A growing body of research indicates that TiO_2 NPs have the potential to negatively impact both aquatic ecosystems and water treatment processes, while the nature of TiO_2 NP-containing products like sunscreen ensures that these materials will find their way into natural waters and wastewater streams. It is imperative that the behavior and quantity of these engineered materials in natural and engineered systems is well understood. In order to accurately differentiate between engineered TiO_2 NPs and naturally occurring titanium in the environment, a traceable TiO_2 particle was synthesized utilizing a rare-earth element as a label. Methods were adapted from the Goebl group for the synthesis of titanium dioxide-coated gold nanoparticles (Au@ TiO_2 NPs) to be used in fate and transport experiments. The Au@ TiO_2 NPs were then characterized via dynamic light scattering, zeta potential, and inductively coupled plasma optical emission spectrometry to determine the size, surface charge, and Au:Ti mass ratio. Unlabeled TiO_2 NPs were then synthesized and characterized for comparison; the size and surface charge of the labeled and unlabeled particles were very similar. Efforts are currently underway to compare the behavior of the labeled and unlabeled particles in simulated drinking water treatment, and preliminary results will be presented.

Electron Stimulated Desorption and Raman Investigations of HafSOx Inorganic Resists

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Hafnium oxide hydroxide sulfate (HafSOx) materials are under investigation as inorganic photoresists due to their high patterning fidelity, which is important for next-generation nano-lithography. In order to develop materials with better patterning sensitivity and higher resolution it is critical to understand the underlying mechanisms that result in the soluble/insoluble transition after exposure to radiation. Prior studies have shown that hydrogen peroxide can be integrated in HafSOx to improve the radiation sensitivity. We have also shown that electron stimulated desorption (ESD) is very sensitive to radiation induced processes in these materials, where HafSOx films containing hydrogen peroxide have a strong O_2 desorption spectrum during ESD, while HafSOx films not containing hydrogen peroxide did not. These studies suggest that O_2 is the primary desorption species, and can be correlated with the radiation sensitive hydrogen peroxide that is incorporated in the films. We have also further characterized the peroxide-containing HafSOx where we have combined ESD and Raman spectroscopy to better understand these radiation-induced processes. Estimates using the Menzel-Gomer-Redhead desorption model gave O_2 ESD cross-sections of ~$1x10^{-14}$ cm^2 for 500 eV electron beam energies. To confirm that the peroxide species is active throughout the thickness of HafSOx, further characterization was performed using Raman spectroscopy for the ESD exposed films. Very similar trends were observed in terms of reaction kinetics using both ESD and Raman. To better understand the radiation-induced mechanisms more recent results will be presented where lower electron energies and current densities have been used.

Printed Hydrophobic/Hydrophilic Bi-Functional Heterogeneous Surface for Enhanced Boiling Performances

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The combination of hydrophobic and hydrophilic surface (bi-functional heterogeneous surface) has been considered a promising strategy to enhance the nucleate boiling performance. Many fabrication techniques have been employed to engineer the bi-functional heterogeneous surface. In this study, we developed a printed bi-functional heterogeneous surface for the enhanced boiling performances. We first deposited fluorine polymer pattern by using inkjet printing, and then deposited hydrophilic metal oxide nanostructures on the patterned surface via solution-based processes. The printed fluorine polymer showed the static contact angle of 120˚ while metal oxide nanostructures possessed super-hydrophilic property of 0~20˚ contact angle. It was found from SEM analysis that the surface consists of well-aligned fluorine polymer dot arrays and metal oxide nanostructures surrounding the fluorine polymer dot arrays. This study demonstrates the ability of our technique in manufacturing the bi-functional heterogeneous surface more efficiently and conveniently for enhanced boiling performances. The boiling test apparatus is currently constructed, and our bi-functional heterogeneous surface will be evaluated in pool boiling experiment.

Probing the Orientation and Biophysical Interactions of Anti-Microbial Peptide WLBU2 Using a Model Membrane System

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WLBU2 is an engineered cationic amphiphilic peptide that targets Gram-positive and Gram-negative bacteria, envelopes endotoxin, while avoiding other cell types. The exact mechanism of how WLBU2 targets, binds, and disrupts bacterial cell membranes is still not completely understood. Thus, the overall goal of this investigation is to determine the structural basis for recognition and specific interactions between the engineered antimicrobial peptide WLBU2 and cell membranes (both bacterial and mammalian). Biophysical studies of the interactions of peptides with model membranes provide a simple and effective approach in understanding how peptides target and subsequently disrupt bacterial cell membranes. In this investigation we applied the use of self-assembled monolayers fabricated from the full membrane-spanning thiols (FMST) 3-((14-((4'-((5- methyl-1-phenyl-35-(phytanyl) oxy-6,9,12,15,18,21,24,27,30,33,37-undeca oxa-2,3-dithiahenpentacontan-51-yl)oxy)-[1,1'-biphenyl]-4-yl)oxy)tetradecyl)oxy)-2-(phytanyl)oxy)glycerol for ultra-high vacuum (UHV) based experiments. FMST head groups in the study include both the hydroxyl FMST and zwitterionic version FMST. UHV-based methods such as electron spectroscopy and mass spectrometry can provide important information about how peptides bind and interact with membranes, especially in regards to the hydrophobic core of a lipid bilayer. Near-edge X-ray absorption fine structure spectra (NEXAFS) and X-ray photoelectron spectroscopy (XPS) data shows that FMST forms UHV- stable and ordered films on gold. The WLBU2 binds to the FMST with a XPS measured N to Au atomic percent ratio of 0.4 ±0.1 for a hydroxyl head group and 0.40 ±0.02 for a phosphocholine head group, corresponding to a monolayer to bilayer surface coverage. NEXAFS results show that WLBU2 is ordered at both the FMST and the zwitterionic version FMST.

Kinetic Prefactors of Adsorbed Alkanes on Pt(111): A Density Functional Theory Study

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Catalytic chemical reactions play a major role in many technologies and chemical processes such as the electrocatalysis of fuel cells and batteries and the synthesis of polymers and renewable fuels. In order to fully understand the kinetics and mechanisms of these catalytic reactions, the properties of surface adsorbates and rate constants for different elementary reaction steps must be determined. As a sample system, the diffusion and rotation of alkanes on a surface were studied using density functional theory. Theoretical calculations of the rates of diffusion and rotation require knowing the activation energy barrier and the kinetic prefactor. Kinetic prefactors of surface reactions are often estimated using harmonic transition state theory, which requires the configuration of the initial state and transition state to be determined and then a vibrational frequency analysis to be performed on the two states. The lower vibrational frequencies which contribute the most to the kinetic prefactor are difficult to determine accurately and so is finding the required transition state. Therefore, a new method for determining the kinetic prefactors which does not require a vibrational frequency analysis has been proposed. This method utilizes the hindered rotor and hindered translator approximations to estimate the partition functions of the system and requires knowing only the activation energy barrier and lattice constant of the surface. Kinetic prefactors and surface entropies of methane, ethane, and propane on Pt(111) determined with vibrational frequency analyses and those determined by the new hindered rotor/translator method are discussed and compared with earlier calculations and experimental data.

Anti-Reflective Coating of Hollow Silica Nanoparticles by Inkjet Printer

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Hollow silica nanoparticles (HSNPs) are a promising material for anti-reflective coating (ARC) due to their tunable void space and unique cage-structured shells. Optimal ARC on different substrates can obtain by control the particle size and its shell thickness. In this study, unique micromixer-assisted system was used to control the particle size of HSNPs and were able to produce a HSNPs with an average diameter of <30 nm and with narrow size distribution. Different coating technologies such as spin coating and dip coating have been normally used to deposit the HDNPs. We herein investigated the novel inkjet printing method to form the HDNPs-based antireflective film. An accurate control of film thickness and patterns like a phone screen could be achieved by changing the various parameters such as inkjet nozzle's number, alignment, and ink volume. Combined with a binder, tetraethylorthosilicate-acid solution, the films possesses not only high antireflection but also good mechanical resistance. Further investigations of the films providing enhanced light transmittance and mechanical resistance are subject to withstand harsh environment. In addition, an anti-dust ability will also be investigated by modify the particle surface.

Genome-Scale Metabolic Reconstruction and Analysis of a Pure-Culture Anaerobic Digester through the Application of OptCom

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Anaerobic digestion is a biological process in which organic matter is decomposed by a community of microorganisms in the absence of oxygen. The end product of anaerobic digestion is biogas, composed of methane and carbon dioxide. Biogas can be recovered and used to generate energy, replacing traditional fossil fuels. Often, biogas is not produced in sufficient quantities suitable for economic recovery, resulting in the flaring of biogas to the atmosphere. To support digester performance, in silico models have been created to assist in the optimization of the anaerobic digestion process. While current models have examined the critical components of anaerobic digestion, they approach the system at a macroscopic level, focusing primarily on major metabolites. To address the limits of current macroscopic in silico models, a genome-scale model of a pure culture anaerobic digester will be constructed that evaluates both the individual organism's metabolic activity and the community level fitness. An in silico pure-culture anaerobic digester was defined to include the acidogenic bacteria Clostridium acetobutylicum, the syntrophic short chain fatty acid oxidizer Synrophomonas wolfei, and the methanogenic archaea Methanosarcina barkeri. While genome-scale models for both C. acetobutylicum and M. barkeri have been previously published, a novel genome scale model for S. wolfei was constructed. Flux balance analysis will be performed on the S. wolfei genome-scale model to determine reaction fluxes through the system for various experimental conditions. The pure culture anaerobic digester will be analyzed through the application of OptCom, which utilizes multi-level and multi-objective optimization techniques.

Activation of Chemical Reactions Through Corona Discharge

Peter Kreider, Justin Pommerenck, Yu Miao, Yousef Alanazi, Jacob Lum, Kevin Caple, Xiangru Fan, Goran Jovanovic, and Alex Yokochi

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Activation of otherwise non-spontaneous chemical reactions usually requires the addition of external activating energy through heat, ultrasound, or light in addition to catalytic materials. Recently, our lab has started investigation into the activation of chemical reactions employing low voltage electrical corona discharge. The inception of corona discharge requires strong electric field gradients and we can achieve corona discharge onset at low voltages via the application of high aspect ratio materials (e.g. carbon nanotubes) in microreactor channels. Approaches similar to this, both in literature and in our lab, have demonstrated efficient and inexpensive advanced oxidation of chemical compounds including the oxidation of volatile organic compounds (VOCs) in wastewater. In our recent work, these corona discharge microchannel devices were fabricated in order to assess the feasibility of using corona discharge to facilitate two model reactions, 1) activation of methane to yield larger molecules and 2) the oxidation of refractory sulfur compounds in fuel-like media. Preliminary work has demonstrated that both model reactions take place in the corona discharge reactor. In this contribution, recent results from our work on both processes will be presented.

Accelerating Post-Thaw Processing of Cryopreserved Blood Using Mathematical Modeling and Microfluidics

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In current practice, blood is prepared for freezing in a solution of 40% glycerol, a well-defined procedure that has been carried out for over fifty years with great success. While glycerol is not inherently toxic to humans, it must be removed from the blood prior to transfusion or the osmotic gradients across the cell membrane will result in hemolysis. The industry standard, state of the art deglycerolization procedure is a batch process resulting in a deglycerolization time of approximately one hour per unit of blood. This prevents cryopreserved blood from being used in an emergency situation, and relegates the use of frozen blood primarily to long term storage of rare blood types. We have previously demonstrated that a multistep procedure with precisely controlled timing can reduce deglycerolization times to as low as 3 minutes with 20% hemolysis. Our most recent work aims to lower the deglycerolization time and RBC hemolysis even further by utilizing higher temperatures to speed up glycerol transport and micro-scale mixing to minimize cell damage due to local concentration effects. A concentration dependent glycerol transport model is in development to further improve the procedure. Preliminary results show that we can achieve an even faster deglycerolization time at temperatures of 45°C. We have also demonstrated a continuous flow microfluidic dilution device for rapid glycerol removal. These results may enable continuous, rapid glycerol removal, which will facilitate the use of frozen blood in emergency situations.

Photoluminescence Detection of TNT by Genetically Modified Diatom Biosilica

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Diatoms are single-celled algae that make microscale silica shells called frustules which possess intricate nanoscale features imbedded within periodic two-dimensional pore arrays. Their nanoscale and hierarchical structure represent a path to the scalable and controlled fabrication of advanced functional materials through biosynthesis of composite inorganic-organic structures. These materials have uses in sensing, energy storage, and as platforms for chemical reactions. Recent advances in the Roesijadi laboratory at Pacific Northwest National Laboratory (PNNL) have led to the genetic modification of the photosynthetic diatom, Thalassiosira psuedonana, to express an anti-TNT single chain variable fragment (scFv) in the biosilica shell to serve as a microscale biosensor platform for the selective and label-free photoluminescence (PL)-based detection of the explosive trinitrotoluene (TNT). It is well known that diatom biosilica emits an intrinsic blue PL around 450 nm upon ultraviolet (UV) excitation. In this study, the transformed living diatom cells and biosilica shells are tested for TNT detection by quenched PL of the biosilica. The results of this study will further the development of a label-free, in situ TNT detection platform with high specificity and high sensitivity that will help identify TNT in marine waters, mitigating environmental hazards.

Reduction of Carbon Dioxide into Useful Products Through Corona Discharge in Micro-Nano Scale-Based Chemical Reactors

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Carbon Dioxide (CO_2) is considered one of the major causes of climate change, because of its greenhouse properties and continuous accumulation in the atmosphere. To curb future emissions of CO_2 and reduce its accumulation, and take advantage of sequestered CO_2 in the future, utilization options for CO_2 conversion into useful products need to be developed. The line of products that could be obtained from the conversion of CO_2 contain: methane, methanol, formic acid, formaldehyde, ethylene, acetylene, syngas, etc. CO_2 molecule has very low energy content, thus a large amount of energy is required to overcome the energy barrier for the reduction of this greenhouse gas. Among various CO_2 conversion methods (including corona discharge) the non-thermal plasma chemical conversion approaches has demonstrated potentials for the effective and efficient activation of CO_2. The energy input into this process (electric power) necessarily needs to be renewable, as it is from photovoltaic, wind and wave energy sources. In addition, the implementation of Micro-Nano-Atto engineering technical approach in designing this chemical process provides unprecedented process intensification, which is highly beneficial in achieving very high conversion of CO_2 in extremely small reaction volumes. Micro & Nano scale-based features of the corona microscale-based chemical reactor are highly favorable for this process, since strong electric field gradients are needed for the onset of corona discharge, and for the intensification of chemical reaction process. In our recent work, corona discharge microscale-based devices were fabricated for CO_2 reduction process to assess the feasibility of creation of an industrial application. Preliminary experimental work has demonstrated that CO_2 can be reduced and converted into useful fuel chemicals such as methane (CH_4), carbon monoxide (CO) and several additional chemical compounds.

Microbial Conversion of Natural Gas to Biofuel Using a Naturally Occurring Methanotroph.

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Methane, the second most prominent greenhouse gas, comes from multiple sources including refining of petroleum, domestic livestock, and landfills, and accounts for approximately 9% of greenhouse gas emissions in the United States according to the EPA. This research focuses on the conversion of methane to methanol to be used as a biofuel. The bacterium Methylosinus tricosporium OB3b, a naturally occurring methanotroph, is being evaluated to promote this conversion. The M. tricosporium OB3b cultures were immobilized in alginate beads and placed into a packed column with liquid up-flow capabilities. Immobilizing the culture in alginate allows the culture to be easily used in a packed bed while maintaining mass transfer properties. A methane and oxygen saturated solution was passed through the packed column where methane was oxidized to methanol. To stop the further metabolism of methanol, cyclopropanol was used to inhibit the methanol dehydrogenase (MDH) enzyme, resulting in methanol accumulation. Long and short inhibition cycles have been tested with the overall goal of achieving long term methanol production. Methanol concentrations of 0.1 mmol/L have currently been obtained. The culture has survived in the packed column for up to two weeks, through cycles of inhibition and methanol accumulation, which supports long term methanol production process capabilities.

Printing Functional Inks for a Flexible Amperometric Glucose Sensor

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Type 1 diabetes is a pancreatic disease where individuals are not able to produce insulin to effectively control blood glucose levels. A promising approach to control blood sugar for individuals with type 1 diabetes is an artificial endocrine pancreas, which continuously reads blood glucose concentrations and automatically controls the insulin/glucagon injections. In this presentation, we will discuss the printing of functional inks for the fabrication of a novel flexible amperometric glucose sensor that is a critical component for an artificial endocrine pancreas. Additive manufacturing approaches, including electrohydrodynamic (e-jet) printing and electroplating, are being evaluated for rapid fabrication of the sensor, provides improved uniformity, and ultimately reductions in manufacturing costs. The amperometric sensor incorporates a plated Ag/AgCl reference electrode and plated platinum indicating electrodes.

E-jet printing is used for the deposition and patterning of the glucose oxidase (GOx) enzyme layer on the indicating electrodes, and provides a precise method to control both the thickness and shape of these layers. Details on optimization of the GOx enzyme inks and e-jet printed patterns will be discussed, along with electrochemical characterization of the sensors.

Comparison of Student Model Development in Physical and Virtual Laboratories

Erick Nefcy and Milo Koretsky

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This research characterizes student teams' use of models as they proceed through three laboratory projects in the first quarter of the capstone laboratory sequence in the School of Chemical, Biological, and Environmental Engineering at Oregon State University. Two of the laboratories are physical laboratories, based on the unit processes of heat exchange and ion exchange. Between these two laboratories, students undertake a virtual laboratory project. The virtual laboratory is used to simulate complex or expensive tools that are not readily available for use by undergraduate students, but are more representative of industrial systems. In this class, a virtual chemical vapor deposition laboratory is used. We present a method to characterize the modeling actions of student teams, termed Model Maps, which provide a graphical representation of student teams' model development as they proceed through the task. Analysis of the Model Maps provides among other things, descriptive information on entities the students chose to model, for instance, chemical, physical, or statistical principles, or the physical structure of the experimental apparatus; and the types of representations, for instance, linguistic, diagrammatic, or symbolic. The work products produced by the 2012 cohort (notebooks, memoranda, final reports, and oral presentations) are examined as they complete the physical and virtual laboratory projects. For consenting teams, audio was recorded, transcribed, and assessed in depth to gain an understanding of the iterative model development process undertaken. Analysis of the Model Maps shows the virtual laboratory affords students a richer opportunity for model development, modification, and use of evidence-based reasoning.

Dynamics of CO_2 Consumption, and Biomass and Lipid Production of the Diatom Cyclotella under High and Low Light Intensity

Altan Ozkan and Gregory Rorrer

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Light intensity is a critical parameter for maximized productivity of algal photobioreactors (PBRs) as the rate of photosynthesis can get significantly reduced under light limited and light inhibited conditions. Moreover, the quantity of metabolites in the algal biomass is also light dependent as the cells regulate their carbon metabolism based on the light intensity they receive. To study the influence of light intensity on carbon dioxide (CO_2) consumption and the correlation of this consumption to the production of biomass and lipids during cultivation of the diatom Cyclotella under high and low light intensity, two photobioreactors were instrumented to (i) deliver any light intensity to the algal cultures, (ii) provide controlled CO_2 concentration in the inlet aeration gas, and (iii) real time measurement of CO_2 concentration in the outlet gas. During cultivation, biomass samples and lipids extracted were analyzed for carbon and nitrogen contents. PBRs only differed in terms of the light intensity they received. Real time measurement of CO_2 consumption successfully predicted biomass productivity. The cultures under both scenarios consumed similar amounts of carbon for biomass production during log phase and diverted about 20% of that algal carbon for lipid production. Moreover, during eight day long stationary phase, under constant cell number density, the carbon consumed for biomass production was 10.8 mM and 27.0 mM and that consumed for lipid production was 2.7 mM and 11.8 mM under low and high light intensity modes, respectively. Thus, under low light intensity during stationary phase not only carbon consumed for biomass production decreased to 45% of that consumed at high light intensity mode but also the algal carbon diverted to lipid production decreased from 44 to 25%. The PBR system and results presented here demonstrate the unique capability of real-time CO_2 consumption measurement for metabolic assessment of biomass and lipid productivity in photosynthetic diatom cultures.

MoS_2 Thin Film Deposition Using a Packed Bed Microreactor

Changqing Pan, Zhongwei Gao, and Chih-hung Chang

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Molybdenum disulfide (MoS_2) has recently attracted a lot of attention due to its graphene-liked two dimensional layer structure. However the fabrication of large area mono- or few-layer MoS_2 is still a challenge which limits the potential application of MoS_2 in microelectronics and optoelectronics. Hydrazine (N_2H_4) based dimensional reduction could achieve a large area, uniform thin film deposition. Unfortunately there are lots of safety concern in using N_2H_4 which is a toxic rocket fuel. By using a packed bed microreactor, we minimize the exposure of N_2H_4 and successfully deposit MoS_2 thin-film from bulk powder MoS_2.

Instructor Concerns and Use of Resources in the Development of Course Materials

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Limited research in engineering education has been aimed at addressing the implementation gap of research-based course materials. It has been suggested that involving instructors in the development process could help in reducing this gap. To further examine this, a materials-development workshop was held where 17 instructors from 14 institutions worked in small groups to develop research-based course materials. Previous research on students' conceptual understanding of mechanics of materials was utilized in the development process. Audio recordings were analyzed using constant comparative coding for concerns and resources. Concerns-Based Adoption Model (CBAM) was utilized to define what a concern is in the coding process. In CBAM, a "concern" is any thought or feeling that affects evaluation and planning of curricular activities. For our research, a "resource" is defined as any personal, structural, or material asset whose absence or insufficiency obstructs pursuit of instructors' goals. A common concern cited by nearly all of the instructors was time while some also referred to time as a resource. Many of the resources cited by our participants were out of their control such as classroom layout (e.g. lecture-hall seating discouraged group work), or the credit hours assigned to their courses. Our findings therefore suggest which features of engineering departments that may hinder the adoption of research-based course materials.

DFT Study of the Rate-Determining Steps on Carbon Chain Growth on Co Catalyst

Dennis Petersen, Andrew Traverso, Yousef Alanazi, Christopher Loeb, Alex Yokochi, Goran Jovanovic, and Liney Arnadottir

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The purpose of this study is to investigate the reaction mechanism of Fischer-Tropsch (FT) hydrocarbon chain propagation on an hcp(0001) cobalt catalyst in order to increase reaction selectivity for desired products (C_{8-12}). Density Functional Theory is used to calculate the energy landscape, reaction and activation energies, of selected reaction steps and the effect of co-adsorbates and surface coverage of CO and H. A microkinetic model of the carbide chain growing mechanism up to C_2 hydrocarbon chains, formulated from an extensive literature review, is used for finding optimal operating conditions for chain propagation by multi dimensional parameter sweeps for an FT-synthesis micro-reactor. Parameters under investigation for process optimization include pressure, temperature, feed ratio (CO and H_2), Gas Hourly Space Velocity (GHSV), and surface site density. Current model analysis has shown optimal chain propagation temperature between 220 and 250 ˚C in good agreement with experimental results. A Degree of Rate Control analysis is also performed on the model in order to determine the rate limiting steps in the production of hydrocarbon chains, utilization of feed CO, and the minimization of byproducts such as CH_4 and CO_2. Rate limiting step identification can be followed up with specific DFT analysis to optimize the catalyst for higher C_{8-12} hydrocarbon selectivity and lower byproduct formation. This study is being conducted as part of a larger initiative to design and optimize a FT-synthesis micro-reactor for commercial use.

Polymer Tethered Peptides for Capture of Circulating Bacteria in Sepsis

Ramya Raman and Karl Schilke

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Severe sepsis is a blood infection that affects over 750,000 people each year in the US alone, killing 28-50% (more than prostate cancer, breast cancer and AIDS combined). Symptoms result from a highly dysregulated immune response, which, if untreated, can lead to multiple organ failure and death. Currently, treatment uses wide-spectrum antibiotics, but this is hindered by the rise of antibiotic-resistant "superbugs." One potential novel treatment is a high-throughput microfluidic hemoperfusion device, which specifically removes circulating bacteria and cell wall fragments ("endotoxin") from blood. Microfluidics offer enhanced mass transfer and control of particle trajectory, as well as very high surface-to-volume ratios. A microfluidic device with a biocompatible and bioactive surface coating could selectively bind circulating bacteria and endotoxins from blood, enabling rapid, safe treatment of bacterial sepsis. WLBU2 is an α-helical, cationic amphiphilic peptide (CAP) with 13 positively-charged arginine and 11 hydrophobic tryptophan/valine residues oriented on opposite faces of the helix. WLBU2 has high anti-microbial against a variety of pathogens, and integrates into bacterial cell membranes (Deslouches, et al. J. Antimicrob. Chemother. 2007; 60: 669-672). WLBU2 retains its helical structure when bound to a surface, and immobilized WLBU2 binds bacteria and endotoxin. Biocompatible, non-fouling surfaces can be made by covalently tethering a dense brush of polyethylene oxide (PEO) polymer chains at the surface. Longer PEO tethers terminated with WLBU2 should enable increased mobility and solvent accessibility to tethered WLBU2, allowing it to bind bacterial cells/endotoxin, without compromising the biocompatibility of the coated surface.

Characterization of Carboxylic Acid Ligands on HfO_2 Surfaces

Peter Ray and Gregory Herman

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Hafnium oxide (HfO_2) thin films are of interest as gate dielectrics for metal-oxide-semiconductor field-effect transistors, and more recently as next generation HfO_2 nanoparticle-based photoresists. The International Technology Roadmap for Semiconductors has identified extreme ultra-violet (EUV) lithography as the primary patterning technology for generation of sub-20 nm features, where considerable development is necessary for next generation photoresists that are compatible with EUV radiation. Current polymer based photoresists have significant limitations at these resolutions due to high edge roughness, low sensitivity, and poor etch resistance leading to high aspect ratios. Inorganic resists have gained attention due to the combination of high resolution, high etch resistance and low line edge roughness, but have generally suffered due to low sensitivity to EUV photons. Furthermore, the low intensity of current EUV sources necessitates significantly higher sensitivity than what has been demonstrated for purely inorganic high-resolution photoresists. Recently, a hybrid organic/inorganic approach has shown significant promise for next generation photoresists where radiation sensitive organic ligands are attached to HfO_2 nanoparticles, resulting in a negative tone photoresist. To better understand the thermal and radiation chemistries of this hybrid photoresist we have developed a model system, where a variety of carboxylic acid based ligands can be attached to HfO_2 thin films. The HfO_2 thin films were formed by spin-coating aqueous-based precursors, which were then annealed to various temperatures to control both film dehydration and surface chemistries. For these studies three different photosensitive carboxylic acid ligands (i.e., methacrylic acid, benzoic acid and 4-vinyl-benzoic acid) were used. The adsorption of these ligands were monitored using attenuated total reflectance Fourier transformed infrared spectroscopy, while the thermal and radiation induced desorption were characterized using temperature programmed desorption and electron stimulated desorption, respectively. These studies allow us to understand the fundamental exposure mechanisms for these hybrid photoresists and will help guide future improvements.

Paper Microfluidic Device for the Home Monitoring of Phenylalanine Concentration from Blood

Robert Robinson, Liam Wong, and Elain Fu

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Paper microfluidics uses porous materials to create simple, low-cost devices that operate by capillary flow to transport fluids within the devices. These devices offer a useful alternative to high-resource laboratory-based testing in cases in which the laboratory-based testing is not appropriate because it is too slow or too expensive, or is not accessible. For example, phenylketonuria (PKU) is a genetic disease, characterized by high phenylalanine levels in the blood, which has severe medical consequences including seizures and permanent cognitive impairment. People with PKU are required to undergo laboratory-based testing to assess the concentration of phenylalanine in their blood for therapy monitoring. This current test scenario is non-ideal due to a long, i.e., several days, time to result. The focus of this presentation is the development of a reliable paper-based test for use in the home that allows an untrained individual to semi-quantitatively measure clinically-relevant levels of phenylalanine with a finger-prick volume of whole blood in under 20 minutes. The test design, based on a two-step chemical reaction for phenylalanine detection includes all reagents dried on the card, and has a simple intensity-based colorimetric readout. The test response has been characterized in human plasma with a limit of detection near 1 mg/dL. In addition, a second version of the test has been developed that separates plasma from a whole blood sample on the device. These results will be presented as well as a discussion of next steps.

Microcosm Studies to Evaluate Biodegradation of Chlorinated Solvents and 1,4-Dioxane prior to Push-Pull Tests at Fort Carson, CO

Hannah Rolston, Mohammad Azizian, and Lewis Semprini

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Due to its use as a stabilizer for chlorinated solvents, 1,4-Dioxane (1,4D), a probable human carcinogen, is a common co-contaminant in solvent spills at industrial and military sites and landfills. Its persistence in large groundwater plumes at relatively low concentrations makes it a good candidate for in-situ biological treatment via cometabolism. Microcosm studies were performed to evaluate the capability of isobutane-utilizing microorganisms to degrade 1,4D and chlorinated solvent mixtures prior to push-pull tests at Fort Carson, Colorado, a contaminated site. Microcosms were constructed using aquifer solids from Fort Carson to assess the isobutane-utilization and solvent degradation capacity of the microorganisms native to the site. Additional microcosms were augmented with Rhodococcus rhodochrous, a bacterium shown to degrade chlorinated solvents and 1,4D, for comparison. Contaminant degradation in the microcosms was measured through headspace analysis by gas chromatography. Initial microcosm test results indicate that microorganisms are present that grow on isobutane. Studies are currently being conducted to determine if a mixture of the chlorinated solvent 1,2-cis-dichloroethene and 1,4-D can be cometabolized in the biostimulated microcosms and whether the microcosms augmented with Rhodococcus rhodochrous are more effective.

Results from the microcosm tests will be used to design field tests to be performed at Fort Carson this summer.

Epistemological Framing and Practice of Graduate Teaching Assistants in Studio-Based Engineering Courses

Christina Smith, Debra Gilbuena, Devlin Montfort, and Milo Koretsky

School of Chemical, Biological, and Environmental Engineering

Many Science, Technology, Engineering and Mathematics (STEM) courses have seen an increase in enrollment. To help cope with this increase, some engineering disciplines have restructured courses to include a studio component to complement the traditional lecture. These studios are designed to be learning environments in which students may actively engage in content presented in lecture through activities (e.g., students solving worksheet problems in groups). The enrollment in a single studio is typically limited to about 25 students to achieve an instructional model of facilitating learning and rapid feedback. Graduate teaching assistants (GTAs) typically lead and facilitate these sections and work with instructors to deliver the material, but often do not receive frequent pedagogical training on how to facilitate these environments. This study aimed to better understand the connection between a GTA's epistemology, or what they believe knowledge and learning is, and the pedagogical choices that they make while facilitating studio in order to provide future professional development to improve this facilitation. We use the framework put forth by Hammer and Elby, that personal epistemology is a manifold construct that is made up of belief-like structures called frames, which are highly context dependent. Using this framework, we used emergent coding and thematic analysis to determine possible epistemological frames of GTAs in a chemical engineering department. Observations were also conducted to understand how studios were being implemented. We found that some GTAs have inconsistent epistemological frames across contexts which were reflected in different teaching practices of the GTAs.

Alignment of Magnetic Micro-Disks in Magnetic Field

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To develop next generation wireless communication devices, we need the inductors and antennae to be able to work at a high frequency. Composite materials, consisting of soft magnetic particles embedded in a non-magnetic insulating matrix, have great potential for such high frequency applications. Magnetic particles with high aspect ratio (i.e., rod-shaped or disk-shaped) are gaining increased attention as they exhibit high frequency permeability in comparison to spherical particles. The dynamics of micro-disk (5 micron in diameter and 150 nm in thickness) alignment dispersed in Newtonian fluid (silicon fluid) is studied by real time microscopy and explained by theoretical model we developed. We study the dependence of alignment time on fluid viscosity and magnetic field strength and rotating

frequency by using silicon fluid of two viscosity (117cp and 550cp) and by varying magnetic field strength(1mT to 7mT) and rotating frequency (10Hz to 500Hz). We also developed a theoretical model based on Stokes flow of single oblate ellipsoidal particle in a rotating magnetic field. By the model, we predict that if the field rotates so fast that the micro-disk cannot respond to it, the alignment time is linearly proportional to viscosity, inversely proportional to square of external field strength and independent of rotating frequency. This is in good agreement with measured results.

Deposition of a Cobalt Catalyst onto an Anodized Aluminum Support for Fischer-Tropsch Synthesis within a Microreactor

Andrew Traverso, Dennis Peterson, Yousef Alanazi, Christopher Loeb, Liney Arnadottir, Goran Jovanovic, and Alexandre Yokochi

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The Fischer-Tropsch synthesis (FTS) is a well-known collection of reactions that arise from the catalytic hydrogenation of carbon monoxide. This reaction produces a myriad of products such as alkanes, alkenes, aldehydes, alcohols, and aromatic hydrocarbons, but its use in industry has traditionally been limited by poor selectivity for desired products. It is hypothesized that enormous gains in selectivity can be achieved using micro-scale architecture due to decreased diffusion lengths and increased heat dissipation. To construct a catalytic microreactor to implement FTS, alumina supports were prepared by anodizing pure aluminum in a sulfuric acid bath to produce a nanoporous structure capable of high catalyst loading, which was then functionalized with a cobalt catalyst deposited using the incipient wet impregnation technique. In this contribution, results of the use of the reactor constructed using this methodology will be presented.

Bio-Lamina-Plate Bioreactor for the Conversion of Methane to Methanol

Yorick Wahaus, Tanner Bushnell, Brian Fuchs, Chris Loeb, Fred Atadana, Goran Jovanovic, Lewis Semprini, Karl Schilke, and Mark Dolan

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As part of the ARPAe-REMOTE program our OSU project team is using the bacteria Methylosinus trichosporium OB3b (OB3b), immobilized in a bio-lamina-plate (BLP) micro-reactor, to oxidize methane to methanol. The BLP reactor is designed to provide for high mass and energy transfer in order to achieve enhanced rates of biochemical conversion. It consists of 2 parallel plates that are ~30 cm by ~15 cm with ~300 mm etched out of each plate. In the bottom plate, OB3b is immobilized in a ~300 mm thick alginate film. A ~300 mm deep space in the top plate is etched with 2mm diameter posts to control two phase flow of liquid and gas over the OB3b/alginate gel. An aqueous growth media for OB3b and a gas mixture of methane and oxygen/air are applied. The methane and oxygen diffuse into the alginate and are converted to methanol and methanol diffuses out of the gel into the liquid stream. The system is designed to operate with liquid flows up to 500 mL/hr and gas flows up to 5,000 mL/hr total at 1 bar and up to 20 bars. Initial reactor tests provide a prove-of-concept that methanol can be produced in the BLP micro-reactor.

Differential Responses of Single Species and Mixed Community Exposures to Environmentally Relevant Concentrations of Zinc Oxide

Fan Wu, Bryan Harper, and Stacey Harper

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Despite zinc oxide nanoparticles (ZnO NPs) currently being one of the highest production volume nanomaterials, very little is known about their impacts on aquatic ecosystems. Research has shown that ZnO NPs can be highly toxic to aquatic organisms, but their fate and toxicity in a complex community comprised of multiple organisms is largely unknown. The lack of environmental realism in single species laboratory exposures precludes the thorough understanding of ZnO NP risk to aquatic environments. Potential differences in species susceptibility to contaminants make the use of mixed community toxicity testing strategies beneficial in understanding the ecological risk of NPs. Thus, to better understand the ecological risk of engineered ZnO NPs, we conducted a microcosm study to compare the responses of individual species to the same species in a mixed community exposure under environmentally relevant concentrations (0.01 and 1 mg/L) of two commercially available ZnO NPs. Our results showed that engineered ZnO NPs can elicit significant toxicity to some organisms at environmentally relevant concentrations, with lower level organisms including algae and bacteria having greater and more varied impacts than the higher level organisms (crustaceans and fish). In addition, ZnO NPs caused more adverse outcomes to test organisms when exposed as a single species rather than within a community. Overall, our findings suggest that exposure to environmentally relevant concentrations of engineered ZnO NPs has the potential to disrupt community balance, primarily through differential toxicity to lower-level organisms such as algae and bacteria, which may have long-term impacts on aquatic ecosystems.

Techno-Economic Analysis of Glucosamine and Lipid Fuels Production from Autotrophic Diatom Algae

Xuwen Xiang, Bryan Kirby, and Christine Kelly

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Currently the production of biofuel from algae is not economically competitive with petroleum fuel. However, co-production of a high-value product may be able to justify the cost of large-scale algae cultivation. A techno-economic analysis (TEA) of the production of co-production of a high value nutraceutical, glucosamine, and lipid fuel from Cyclotella for both raceway open pond and photobioreactor (PBR) pathways is presented. A comprehensive analysis has been performed for a 20 year project with an annual production rate of 500 metric ton of glucosamine. The model analyzes the technologies required for each step of the process, from Cyclotella cultivation to lipid extraction and glucosamine upgrading. The TEA uses input parameters from the published literature and Cyclotella cultivation and chitin separation experimental research performed at OSU. Based on the assumptions that lipid production was triglyceride (TAG) which is sold for $3/gal as biofuel, the cost of diatom derived glucosamine was determined to be $23.0/kg for open pond and $199/kg for PBR systems. These costs have potential to be significantly improved through increases in diatom growth rate. For

PBR systems, the main contributor of capital cost is tubular PBRs. By performing economic sensitivity analysis of influential cost drivers, diatom productivity, chitin content and cost of tubular PBRs were identified as the parameters that most influenced the glucosamine cost.

Highly Oriented Growth of Cu-BTC Metal-Organic Framework Thin Films on Metal Oxide Substrates

Yujing Zhang, Ki-Joong Kim, and Chih-Hung Chang

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Metal-organic frameworks (MOFs) are crystalline nanoporous materials connected with metal ions and organic linkers. MOFs are of part of advanced and promising materials with extremely high surface area, uniform and permanent porosity and relatively high thermal stability. These properties utilize as gas purifications, separations and storages, catalysis, optical sensors, etc. In these applications, one of the major challenges is to control the growth direction with well-defined pores, allowing for the additional advantages of the fine-tuned thickness control and the ability to create multilayer or heteroepitaxy MOF thin films. These approaches normally require the surface functionalization of the substrate with a self-assembled monolayer (SAM) to nucleate formation. Gold substrates functionalized by thiol-based SAM are primarily used for oriented MOF thin film growth. We investigated the growth of MOF thin films on a metal oxide surface without SAM using stepwise layer-by-layer (LBL) method. Homogeneous and highly oriented Cu-BTC MOF thin films with growth only in the (111) direction are obtained on the surface. The thicknesses of the films can be readily controlled by the number of LBL growth cycles. No thiol-based organic SAM layers are required and therefore, we believe this result makes them intriguing candidates for applications such as optical sensors. For further research, we intend to conduct with different metal oxide substrates, for example, SiO_2, Al_2O_3 and Si_2N_2O, to investigate the growth mechanism through a number of experimental studies.

SCHOOL OF CIVIL AND CONSTRUCTION ENGINEERING

Modified Shields Parameter

Abbas Abdollahi and H. Benjamin Mason

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Soil instability is a major cause of building and infrastructure damage. Soil instability is caused by many phenomena; in this work, we are investigating soil instability due to tsunami-induced soil liquefaction. The Shields (1936) approach is often used to predict the extent of soil instability due to bed loading; however, the Shields approach cannot predict the effects of soil liquefaction on soil instability. Recently, Yeh and Mason (2014) introduced a modified Shields approach to predict soil instability due to tsunami-induced liquefaction. In this work, we extend the work of Yeh and Mason (2014) to include the importance of particle shape. The results show that particle shape greatly affects the extent of soil instability that is expected during tsunamis, and this is important, because different beaches have differing sands. The results imply that different mitigation schemes to protect coastal structures may be specified given the local beach sand conditions.

Effects of Infill Strut Model Class Uncertainty on Seismic Response of Reinforced Concrete Masonry Infilled Frames

Mohammad Alam and Andre Barbosa

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Multi-storied reinforced concrete (RC) frame buildings with masonry infill walls are prevalent form of construction throughout the world. However, in current practice, the influence of infills to lateral load carrying capacity is typically neglected. This study is divided into two phases. In the first phase, the performance of a code compliant RC frame building with infill walls constructed in 2010 is evaluated through nonlinear static pushover analysis and nonlinear response history analysis. To capture the infill-frame interaction, the modeling scheme developed combines: (i) finite length plastic hinge elements, which account for strength and stiffness deterioration of RC members in flexure, (ii) an experimentally validated limit state material model capable of capturing shear failure of columns based on floor inter-story drift, and (iii) experimentally calibrated phenomenological strut models that account for the contribution of the infill to the story lateral stiffness and lateral strength capacity. Preliminary model calibration and validation is achieved by comparison of numerical results to recent testing done under the Network for Earthquake Engineering Simulation consortium. The results of the analyses indicate that accounting for infills introduces a significant increase in stiffness and over strength. A systematic component level and system level investigation further indicates that incorporating the infill-frame interaction and shear degradation of columns impacts the system failure mechanisms, justifying the need for including these in the design of new buildings and the performance based seismic assessments of existing structures. In the second phase of the study, the effect of infill strut model class uncertainty on the seismic response of the infill RC frame is studied by adopting three state-of-the-art phenomenological strut models. It is observed that the response varies greatly and that further developments are needed for incorporating model class uncertainty in probabilistic performance-based design and assessments.

Degrees of Connectivity Impact on Construction Worker Safety

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Construction worker safety performance has improved with time; great efforts by industry and researchers have made this happen. Although jobsite safety is improving, more research is needed to make jobsites even safer. Traditional studies typically focus on a single worker only and accident causation theories explain how accidents happen from this viewpoint. There is less clear focus on groups of workers, especially the impact of workers themselves on each other and/or the impact of the design element on the workers. Starting from this standpoint, the authors are working on an ongoing project that relates to this concept, which they call "Degrees of Connectivity" (DoC). To conduct the research, the researchers have applied more than one approach in order to improve confidence. The research methods include surveys, an OSHA records search, and practical observation on construction sites. In this study, survey

questionnaire was distributed to project engineers. Questions were divided into three groups: demographic, safety-related, and degrees of connectivity concept. The collected results at this stage of the research show that there is an impact of one worker on other workers in terms of safety achievement. Moreover, the results reveal connectivities between a worker(s) and the design elements within the project being constructed.

Modeling Multi-Decadal Shoreline Evolution in the Pacific Northwest

Dylan Anderson and Peter Ruggiero

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A recent study of shoreline change between 1967 aerial photos and a 2002 lidar survey revealed a consistent pattern of counter-clockwise shoreline rotation on decadal timescales within headland-bounded littoral cells along the Pacific Northwest coast (Ruggiero et al., 2013). In this study, the relationship between climate indices, shoreline rotation trends, and the rates of shoreline change are investigated on inter-annual and multi-decadal timescales using a one-line shoreline evolution model. The shoreline is updated by calculating longshore sediment transport forced by gradients in the alongshore component of wave energy. Relating historical wave conditions (height, period, direction) to climate indices reveals trends in the direction wave energy dependent on the state of the El Niño Southern Oscillation during the winter months. El Niño conditions consist of larger than average waves approaching from more southerly oblique angles, causing a counter-clockwise rotation of the shoreline orientation (erosion in the south and accretion in the north). Conversely, La Niña conditions produce waves approaching from northerly oblique angles and cause a clockwise rotation. Model results suggest that the counter-clockwise rotation observed in the end-point rate shoreline change study did not begin until approximately 1980, with decades previous to that exhibiting clockwise rotation. The inter-annual rate of rotation varies significantly within these multi-decadal trends, with higher rates in the 1980s and 2000s, and little change in 1990s. By associating climate indices with shoreline evolution in this methodology, the effect of ENSO variability on future shoreline changes and coastal hazards can be assessed under various climate projections.

Platform Edge Detection and Protection Effects on Platform-Train Interface Safety

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The purpose of this study is to provide background information and examples of best practices relating to platform-train-interface (PTI) safety. This manuscript was adapted from a literature review that was undertaken as part of the Transit Cooperative Research Program (TCRP) project A– 40 that aims to improve platform safety for rail modes of public transportation. The findings come from an extensive literature review, transit operator safety data, input from two workshops, and interviews with various stakeholders. Specifically, information was gathered from transit operators, station designers, station builders, car builders, and accessibility equipment manufacturers. The background research has shown that platform safety is primarily affected by technical factors, operational aspects, and passenger characteristics. This paper identifies possible issues and best practices for the technical design aspects of platform edge safety. It was determined that certain factors are universal between modes and can be grouped together. However, the research suggests that each mode has many factors that should be considered separately when determining potential mitigation strategies. The second part of this paper considers each mode separately.

Tsunami Wave Loading and Inundation on Oregon Coastal Cities

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This project presents laboratory experiments and modelling data to depict how a tsunami wave force would be effected and distributed into a present Oregon coastal city. The laboratory experiments are conducted at Oregon State University's Tsunami Wave Basin due to the design of the wave maker to produce long waves (shallow waves) such as a tsunami coupled with having a long shallow shoreline to depict the Oregon coast. With the use of fluid-structure interaction software, we can compare the findings in the lab and the model to identify specific improvements that can be made. The findings indicate that the present design of infrastructure on the Oregon coast will not withstand a potential tsunami from the Cascadia fault and measures should be taken to retrofit key structures to avoid failure.

Investigation of Finite Modelling for Determining True Soil Behavior

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The primary focus of geotechnical engineering has historically been on the macroscale behavior of soil. That is, soil behavior has been understood by bulk stress and strain parameters. Recently, the focus of literature has been shifted to the microscale behavior between individual soil particles (or several soil particles). The use of computer software for extensive computations allows for complex models instead of treating soil as a singular object. This modelling also relies on more fundamental physics parameters as opposed to empirical data. A model can be compared to actual data to assess the validity of the model and the modelling parameters. Typically soil interactions are modeled using a spring analogy to model grain interaction. The objective of this research is to investigate computer aided modeling for microscale behavior of soil particles and how it compares to true soil behavior. This research incorporates parameters such as porosity, particle density, grain size distribution, stiffness and grain shape to predict soil performance and behavior. As computer modeling progresses, finite modeling can be incorporated into many design applications (foundation, walls, etc.).

Reliability-based Robustness Assessment of Structures – Application to Mainshock – Aftershock Hazards

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The main objective of this work is to propose a reliability-based framework for quantifying structural robustness considering the occurrence of a mainshock and subsequent cascading hazard events, such as aftershocks that are triggered by the mainshock. Aftershocks can significantly increase the probability of failure of buildings, especially those that are damaged during the mainshock. Herein, the framework is applied to three 2D steel moment resisting frame buildings: 3, 9 and 20-storey buildings which models were validated through nonlinear static (pushover) and nonlinear dynamic time-history analyses compared with results of past studies; and a 3D plan-asymmetric building which was tested under pseudo-dynamic conditions and subjected to bi-directional seismic loading. Nonlinear finite element models are developed in the Open System for Earthquake Engineering Simulation (OpenSees) software. Strength and stiffness deterioration of beams and columns are accounted for in the modeling. Damage evaluation due to mainshock-aftershock sequences is performed by using mainshock-aftershock interaction diagrams which show the aftershock spectral accelerations at a fundamental period of the structure that lead to structural failure after the structure has been subjected to a mainshock, which did not lead to failure. Comparison of the structural reliability associated with different sequences of events and the one associated with the mainshock alone allow for the definition of a robustness measure for the structures. For the buildings analysed herein, it is shown that the structural reliability under a single seismic event can be significantly different from that under a sequence of events, as captured by the reliability-based robustness indicator.

Student Conceptual Understanding of Mechanics and Materials for Columns and Beams

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Concept inventories have been used in various academic disciplines such as statics, thermodynamics, and mechanics of materials to assess students' understanding of fundamental concepts within those subjects. Although concept inventories provide evidence on whether students understand concepts, they do not offer insight into misconceptions that lead to correct or incorrect understanding. For this research, Piaget's clinical interview methods were used in an effort to reveal misconceptions students may have related to mechanics of materials. Students were asked semi-structured questions, and the interviewer asked follow-up questions or clarifications to further probe understanding.

Students interviewed had completed a sophomore-level course in mechanics of materials. This research specifically focused on students' understand of normal stress, shear stress, normal strain, and shear strain in pure axially loaded members (columns) and pure bending members (beams). The results show that students oversimplify stress and strain distribution in columns and beams by solely relating maximums and minimums to the direction or location of applied loads. These misconceptions may relate to conceptual understanding that develops through interactions with the real world. The framework theory of conceptual change suggests that to fully understand a new concept, a person must first address previously derived concepts that developed through everyday experiences. New concepts must integrate with previous concepts, which is especially challenging when new and previous concepts conflict. Specific instructional techniques such as analogy and cross-domain mappings may be used to help students address conflicting concepts and to correct misunderstandings of mechanics of materials.

Understanding the Role of Transportation Engineering Concepts in Work Practices, Interactions, and Activities

Floraliza Bornasal and Shane Brown

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Contemporary perspectives from the learning sciences identify engineering concepts (e.g. force, stress, strain, sight distance, etc.) as one of "the important things" on which students' engineering knowledge must be constructed as they transition into the community of engineering practitioners. However, there exists a gap within research identifying how such concepts are actually utilized, represented, and interpreted by practicing engineers in their everyday tasks, interactions, and activities. If the goal is to prepare students to become experts within the engineering profession, understanding how concepts actually function in experts' work is an important area of inquiry. Informed by situated and distributed cognition theories, this study examines the ways engineers learn and practice in the ubiquitous and every day. Using case study methodology informed by ethnographic research methods, insight into how a group of engineers utilized, talked about, and represented a series of transportation engineering concepts as they produced project deliverables for a roundabout design is provided. Five months of in-depth participant-observation provided a triangulation of data via analysis of project documents, interviews, and observational field notes. Findings indicate that concepts function dynamically in engineers' interactions and production of artifacts: This challenges the idea that concepts are wholly static ideals unchangeable by negotiation, perception, or persuasion. Additionally, results point to the socially mediating role of concepts further challenging assumptions regarding concepts' limited capacity in application within individual mental schemas. The results of this study indicate that conceptual understanding requires active negotiation between individuals, and this approach should be incorporated into engineering education curriculum.

Assessing Lateral Spread in Areas Prone to Great and Long-Duration Earthquakes

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Over the last three decades, researchers have developed several empirical models for predicting ground deformations caused by lateral spreading during earthquakes. Of the models, that of Youd et al. (2002) has become a prominent method used by practicing engineers to evaluate the lateral spread hazard of a particular site. Unfortunately, neither the Youd et al., nor any other empirical model incorporated data from great (magnitude 8 or greater) earthquakes, with the exception of the 1964 Alaska earthquake. This lack of data means that extrapolation of existing models would be required to assess hazard in regions susceptible to strong subduction zone earthquakes, such as Chile, Japan, or the Pacific Northwest. Recently, the occurrence of several great earthquakes, including Tohoku, Japan in 2011 and Maule, Chile in 2010, has shown the destructive nature of these events, but also has added further case studies with which the performance of existing models may now be studied. The objectives of this research are to use this new information and perform the following tasks: (1) compile data from the case studies of great earthquakes in a GIS spatial database; (2) evaluate the occurrence or non-occurrence of lateral spread from the new case history database; (3) test predicted displacements from existing empirical methods versus measured displacements from the new case studies; and, (4) develop new or revise existing empirical equations based on the results. Preliminary results suggest that extrapolation of the existing equations tends to under-predict the lateral spread hazard of subduction zone earthquakes.

Multi-objective Loss Assessment of Oregon Bridges Due to Cascading Seismic and Tsunami Hazards

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Based on the 2013 National Bridge Inventory (NBI) data, there are a total of 7,656 bridges in Oregon. Of these, more than half were built prior to 1975 and were designed to resist seismic demands far lower than current seismic standards. Additionally, geologic evidence supports a 37% probability of a subduction zone earthquake with magnitude greater than 8.0 occurring along the southern Oregon coast in the next 50 years. Earthquakes of this magnitude would not only cause significant damage to bridges, but also bring forth devastating tsunamis that can further amplify damage and disrupt the transportation network. This study aims to examine vulnerabilities of Oregon bridges using HAZUS-MH, a loss estimation software, and fragility curves developed recently outside of HAZUS-MH to estimate the probability of damage, estimate structural losses, and the associated impacts to the Oregon transportation network. This study analyzes scenario earthquakes produced by ShakeMaps, including the Portland Hills Fault and the Cascadia Subduction Zone earthquake scenario recently developed as part of the Oregon Resilience Plan. The results will consider the combined effect of earthquake and tsunami impacts, when applicable. Such an analysis helps identify, for each scenario, which assumptions on costs and fragilities have significant impacts when evaluating the transportation network. The results from this study can help identify which parameters, including traffic delay, cost of repair, and economic implications, have the greatest influence in identifying fragilities when evaluating bridge inventories across an entire state.

PWRI Bridge Experiments Modeled in OpenSees 2DPFEM

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The past decade has shown that tsunamis are a significant threat to coastal communities and industry. The Indian Ocean tsunami in 2004 is one of the worst natural disasters in history in terms of life lost, while the Tohoku tsunami in 2011 showed the far reaching effects and rebuilding costs in even the most developed countries. Therefore, it is critical to properly assess the loads and damage on coastal structures incurred by tsunami in order to maximize safety and provide quick relief responses. Numerical methods are an efficient means of understanding the tsunami-structure interaction as they can analyze the wide range of input variables possible, including: bridge deck geometry and material, flow directions and currents, and wave type such as bores or breaking waves, etc. The Particle Finite Element Method (PFEM) in OpenSees is a Lagrangian formulation that utilizes the fractional step method (FSM) to directly solve the monolithic fluid structure model. In order to validate PFEM, OpenSees numerical simulations are compared to experiment results for a series of 1/20 scale flume tests performed by PWRI in Japan. The force, water surface, and velocity comparisons between the lab experiments and numerical simulations show good agreement for the 4 flume cases explored.

Performance Based Selection of RAP/RAS in Asphalt Mixtures

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The ability to reuse old asphalt for future mixes can reduce both the cost of virgin material and stress on the environment. Currently, Oregon uses 30% recycled asphalt (RAP) in the majority of roadway designs within the state. The Oregon Department of Transportation is unable to use more RAP due to its variability of binder content, stiffness, and gradation. By applying extensive quality control measurements to mix designs containing 20%, 30%, and 40% RAP with different binder gradations (64-22, 58-28, and 58-34) and conducting a Dynamic Modulus Test on the samples, it will be possible to determine the rate of plastic deformation on asphalt with different levels of RAP with respect to the stiffness of the virgin binder. The results of the dynamic modulus test show that as the RAP content is increased, so is the asphalts resistance to rutting; however the aged cracking is more severe. Further comparisons show that by softening the virgin binder used, the material becomes more susceptible to rutting but more resistant to aged cracking.

Optimally Minimizing Linear Distortion of Conformal Projected Coordinate Systems

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All map projections are distorted. Conformal map projections are the type most commonly used for engineering and surveying, because their linear distortion is the same in all directions. Although formally defined at a point, linear distortion can be conceptualized as the difference in distance between a pair of projected coordinates and the true horizontal "ground" distance on the Earth's surface. This difference can be significant for existing published coordinate systems, such as State Plane (e.g., up to 20 cm per km in Bend, Oregon), and it can lead to confusion about which distances are "correct." Such distortion cannot be eliminated, but it can be reduced, and often it is desirable to minimize distortion over the largest area possible. However, these goals are at odds with one another, and so design of low-distortion coordinate systems is an optimization problem, and the design process can be quite complex. This research shows methods for optimally minimizing such distortion, with particular emphasis on areas of high and varying topographic relief, as well as elongate areas (such as transportation projects). An important aspect of the design process is using rigorously defined coordinate systems that are compatible with a wide variety of existing engineering, surveying, and GIS software packages. Doing so allows immediate use of the designs, which facilitates rapid implementation and data sharing between organizations. This design process is compared to existing methods that typically do not optimally minimize distortion and often are not readily transferrable due to incompatibility between the methods and software used.

An Agent-based Modeling Framework to Evaluate Dynamic Lifeline Interdependency: Stochastic Damage and Life Safety

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The society relies on a bewildering collection of complex, interwoven and critical lifeline systems, includes transportation, water, electricity, fuel and communication networks. Isolated network has been extensively investigated, however, these critical infrastructure are interacting with each other and less research were conducted on the network interdependency. A failure in one system would impact the normal function of the other system. For example, an electrical power loss will result in failure of a cellular phone tower; a power shortage would deactivate the traffic light; a tree fall that brings down electrical distribution, television and telephone cables. These damages are also full of uncertainty. In order to address the complex network behavior, this research focuses on developing an agent-based modeling framework to evaluate the dynamic nature of the lifeline interdependency, with considering the stochastic damage and life safety. A combination of empirical analysis and simulation tools will be used to evaluate the recovery time for different level of damages. The proposed framework can also serve as a decision-making tool to improve the resilience of lifeline corridors.

An Exploratory Analysis of Injury Severity Due to Large Truck-Involved Crashes in the Northwest: An Econometric Modeling Compari

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Current studies related to large truck-involved crashes have typically relied on single state specific data or the use of the Fatality Analysis Reporting System (FARS) national data (sample of crashes from the 50 States). Although the FARS data is a representative sample, it is difficult to draw meaningful conclusions especially when trying to develop a single model that is transferable and applicable to all States (also requires that estimates be adjusted with adjustment factors due to sampling technique). A more meaningful approach may be to identify regions by similar characteristics and group the data of these States for injury severity analyses. Hence, the purpose of this study is to develop an injury severity model for the Northwest region. Since this is an exploratory analysis, Oregon, Washington, and Idaho State specific datasets will be merged for large truck-involved crashes. Two econometric modeling techniques will be used to estimate the Northwest injury severity model on US interstates. These techniques are the random parameters logit (or mixed logit) model and the latent class logit model. A series of log likelihood ratio tests will be used to compare the two models. The results of the log likelihood ratio tests will indicate whether the random parameters model or the latent class model is more appropriate. It is envisioned that estimation results will indicate that the level of injury severity outcomes will be highly influenced by several complex interactions between factors and that the effects of some factors could vary across observations. The contributing factors may include driver demographics, traffic flow, roadway geometric features, land use, time characteristics, weather, and lighting conditions.

Effect of Local Tsunamis on Coastal Soil-Structure Systems

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This object of this research is to determine the effects of tsunamis on coastal soils and the subsequent impacts to critical coastal infrastructure. Local tsunamis can be created by an offshore fault rupture, submarine landslide, or a combination of both. Coastal soil instability is caused by two forms of soil liquefaction: earthquake-induced residual liquefaction and tsunami-induced momentary liquefaction. The devastating effects of coastal soil instability can be evidenced by the 2011 Great East Japan Tsunami. In this research, we will employ numerical and physical modeling to examine the effects of earthquake-induced and tsunami-induced liquefaction on coastal soil-structure systems. Findings from this research will inform the design of critical coastal infrastructure, including armoring systems.

Hurricane Swell with Debris Water Damming Acting Upon Bridge Decks

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The purpose of this study is to quantify the forces induced on bridges due to oncoming hurricane swells with debris that is typical of these large storm events. Floating objects and debris of storm events can cause significant damage to coastal structures in the way of impact loading and water damming. This study examines the current research in the coastal engineering field specifically that on the influences of water damming. A qualitative correlation between various hurricane debris and the loadings induced will be illustrated. The main findings of this study would demonstrate what improvements would have the most benefit to the performance of bridges in this particular loading scenario. The main features that will be considered will be the potential for shear failure of the bridge deck as well as increases to hydrodynamic uplift. The study would support the idea of increasing the durability of bridges to regular hurricane events.

Tsunami-Induced Soil Instability: Numerical Modeling and Risk Assessment of Seaside, Oregon

Rachael Fischer and Ben Mason

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Seismologists and geophysicists have long predicted the occurrence of a large earthquake along the Cascadia Subduction Zone (CSZ) that could ultimately create a sizable tsunami event along the Pacific Coast. Previous research on the aftermath of tsunami waves in coastal environments has looked into the formation of scour, erosion, sediment transport, and deposits for multiple tsunami events around the world, yet the local prediction of tsunami-induced soil hazards in the Pacific Northwest is notably absent. To bridge this gap, we set to produce a comprehensive picture of potential hazards faced in the coastal city of Seaside, Oregon. We piece together the existing knowledge of tsunami behavior and loading during runup and drawdown with new methods of analyzing the sediment motion and pore-pressure gradients caused by the rapid reduction in water pressure on the soil bed. By first applying a hypothetical tsunami and considering the behavior of the soil at different locations into the shoreline, we then employ numerical methods for computing the pore pressure field and predicting scour depth. The effects of these pore-pressure gradients are then quantitatively evaluated with a modified Shields parameter as presented in an earlier study. Ultimately, we are able to formulate a better picture of soil instability and momentary liquefaction risk during an earthquake-generated tsunami in Seaside.

Eco-Hydrological Optimization for the Size and Placement of Best Management Practices in an Agricultural Landscape

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Wetlands and riparian areas provide multiple ecosystem services. However, development for agricultural production has resulted in the loss and degradation of these ecosystems and reduced their ability to support water storage, biodiversity, and maintenance of water quality. This contributes toward nutrient pollution and the Gulf Hypoxic Zone, as well as declines in wildlife species. Climate change is expected to place additional stress on ecosystems, particularly wetlands and riparian areas, and in agricultural areas. Furthermore, fragmented landscapes, such as the American Midwest, possess a reduced capacity to facilitate adaptation to climate change, such as range shifts by species and the storage and treatment of water. This study establishes a method to determine optimal size and location of wetlands and riparian areas for restoring habitat, and water storage and treatment functions. Data sets used to predict species distributions from the USGS Gap Analysis Program will be combined with potential wetland and riparian buffer locations to identify specific sites where habitats would meet ecological and hydrological goals. Then, a geospatially-referenced hydrologic simulation model will be employed in a multi-objective optimization with objectives set as: peak flow reduction and minimum spanning tree among existing and the created habitats. Restrictions on the optimization will be to minimize the total footprint of the new habitats, and a requirement that riparian buffers serve as corridors of connectivity among the existing and created habitats. This methodology will be incorporated into a decision support system and serve as a tool for land management decisions at multiple spatial scales.

Traffic Signal Concept Inventory Demonstration in a Designed Curriculum

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Based on the results of a previous research on identifying misconceptions in novice and expert students and practicing engineers about Traffic Signalization a curriculum has been designed to bridge the gap between academia and the workplace. This study is intended to explicitly evaluate the effectiveness of curriculum development which attempts to find an authenticated curriculum in traffic signalization studies. In order to achieve this goal, we disseminated some provided materials at institutions across the country. Specifically we asked individuals who teach classes at the graduate or undergraduate level that cover topics on traffic signal systems to try the newly developed questions with their students. For the next step, we interview all the participants to evaluate the material. In the interview we are eager to know about the way in which all the materials were implemented, students' feedback, any changes in method of teaching based on the provided material and if the instructors are going to utilize such materials in future.

Field Investigation of Driven Timber Pile Ground Improvement

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Seismically-induced liquefaction causes damage to civil infrastructure that is associated with billions of dollars of damage following major earthquakes. The three most common ground improvement methodologies used by engineers to mitigate the potential damage from liquefaction include densification, drainage, and reinforcement. Conventional driven timber pile ground improvement can provide a cost-effective mitigation methodology, as it provides densification and reinforcement to the subgrade. Drained timber piles may improve densification and potentially reduce pore pressures and could provide all three improvement methodologies in one improvement method. However, the densification possible with timber pile ground improvement is rarely incorporated into stability analyses owing to the lack of understanding of the effect of pile spacing on densification. This study focuses on a field trial of driven conventional and drained timber piles to investigate the effect of pile spacing, time, and drainage on the amount of densification. The test site consisted of clean to silty sands with relative densities ranging from 40 to 50 percent prior to installation. Following installation of timber piles spaced at two, three, four, and five pile diameters, cone penetration tests were conducted to evaluate the degree of densification. These tests were performed at approximately one week, one month, three months, and six months following installation to evaluate the effect of time and to understand the role of fines content on the degree of densification. In general, the relative density of the soils improved to approximately 60 to 80 percent depending on the pile spacing and the presence of drainage elements.

Dam Control under Unsteady Flow Conditions Using Precomputed Solutions

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Dams with a combination of tainter and roller gates are often found in regulated river networks. Complex arrays of these gates are often operated using predefined rules that specify the number of gates to open and percentage of openings while addressing issues such as scour, safety, and outdraft. The hydraulic analysis of complex gate arrays under unsteady flow conditions may be challenging for engineers. The present study presents a novel approach for determination of flows through structures with complex arrays of non-moving and moving gates under unsteady flow conditions. This approach uses precomputed assembles of solutions of the dynamic relation between the flow through, and the stages upstream and downstream of an in-line structure. Application of the precomputed assembles to simulate the flow through complex arrays of non-moving and moving gates under unsteady flow conditions shows promising results in terms of accuracy, robustness and computational efficiency.

Spatiotemporal Shadow Analysis via LiDAR for Understanding Photovoltaic System Performance

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Photovoltaic technology is rapidly advancing as a viable, clean, and profitable means of enhancing the energy security of the United States. With the photovoltaic cost per watt at an all-time low, many large commercial companies have started substantial investments in photovoltaic systems on their large unobstructed rooftops. Photovoltaic investments by owners of small commercial or residential buildings are still restrained by a number of barriers. A 2006 study by Margolis and Zuboy found nontechnical photovoltaic barriers (shading, climate, panel positioning) can increases uncertainty causing users installation concerns. Unlike large commercial buildings with unobstructed rooftops, photovoltaic investments on small buildings must account for the uncertainties stemming from micro spatiotemporal factors like: local landscape shading, installation space, local climate, and inferior panel positioning. When combined these factors can compound into a significant level of uncertainty in system performance and resulting financial benefit. As a result, these factors will act as a barrier preventing individuals from system installation commitment. The industry currently lacks any simulation techniques for understanding how a system could meet expectations prior to investment, why a system did not meet expectations, or how crucial the spatial and temporal variables are regarding photovoltaic performance. Therefore, an effort must be made to develop a robust model to assess spatiotemporal properties of a photovoltaic installation, to reduce unique spatiotemporal uncertainties, and eventually to increase property owners' confidence in their investments. Here the first phase of this work is being presented; spatially explicit shadow analysis derived from airborne Light Detection and Ranging (LiDAR) data.

Mid-Block Crossing Project

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One of the main streets that connects the OSU Campus and downtown is SW Western Blvd that crossed through the southside of OSU campus. The project is focused on safety issues for pedestrians crossing the street and for other road users, especially for students and staff studying, living and working in ILLC and the University Plaza, within the section from the intersection of 15th street and SW Western Blvd to the intersection of 26th street and SW Western Blvd. Currently the nearest marked crosswalks are located at two ends of the 1600 feet long section. Most of the pedestrians prefer to jay walk rather than walk to the marked crosswalks. From site observations, it was observed that vehicles merely yield to crossing pedestrians, and pedestrians take huge risks when they are crossing. On the other hand, since fall in 2014, OSU implemented a new parking policy, and the parking lot outside the University Plaza is one of the lower cost parking areas in campus. People who park at the parking lot choose a path to jaywalk across the street and enter the campus. According to the data collected from the site, the most often used crossing path and also the shortest crossing path is located at the bus top on SW Western Blvd. The project is to study the site's traffic flows and pedestrian crossing behaviors, and then design a pedestrian crosswalk near the most often used crossing path for pedestrians to reduce the safety risks.

Quick Access to Construction Documents in Highway Construction Using Quick Response Codes.

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The research aims to determine the feasibility of using quick response (QR) codes in the document control process of highway construction projects. Accordingly, this research involves investigating the need for incorporating mobile information technology in the construction industry and also quantifying the benefits of using QR codes for various purposes in the industry. The research is based on online survey and time study. First, an online survey was performed to identify the issues—faced by highway construction engineers—related to the current document management and control practices. The survey led to the assessment of the need for a quick access to construction documents on the job site using mobile technology. Second, a time study using a real-world infrastructure project was conducted in two phases to assess the feasibility of using the QR codes. The study was mainly based on three scenarios: (a) detail look-up, (b) specification check, and (c) version checking. The results of the time study are used for a cost-benefit analysis for implementing the technology in the industry. Lastly, the study targets to develop an implementation guideline that will support state transportation agencies to establish the standardized process to implement QR code technology in their document control process.

Assessing Highly Workable Concrete Mixtures for CIDH Pile Applications

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Cast-in-drilled-hole (CIDH) concrete piles placed using the slurry displacement method require inspection pipes to be placed parallel to the longitudinal reinforcement. These pipes are used to detect voids. However, the inspection pipes may cause voids due to the limited spacing between the longitudinal reinforcing bars and the inspection pipe. The minimum specified spacing per Caltrans is 3 inches (76 mm). If contractors are to maintain this clear spacing they must construct the reinforcing bars in a manner that violates the bridge design specifications on maximum 8-inch (203 mm) reinforcement spacing. This research will assess the influence of coarse aggregate (CA) type and mixture proportions on workability (i.e. flowability, stability, and passability) of concrete to minimize voids for CIDH pile applications. Concrete containing round CA can achieve higher slump flow values than concrete containing crushed CA at the same paste volume. Based on the testing, results indicate that increasing the paste and decreasing the aggregate voids can significantly increase slump flow. Increasing paste can also decrease stability. Stability can be increased by increasing the FA/CA. Results for assessing passability using the standard J-ring and C-bar tests were unclear and further research is

needed. However, the C-bar and J-ring test both seem to be reasonable approaches for assessing passability. Based on the findings of this research, a methodology for proportioning mixtures for CIDH applications is provided. The objective is to generate mixture proportions that result in adequate flowability, stability, and passing ability to minimize or eliminate voids in CIDH piles.

Remote Sensing Derived Depth Estimates: From Open Beaches to Estuary Mouths

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Underwater topography (bathymetry) plays a vital role in maritime safety and in coastal hydrodynamics, yet often remains unknown or poorly constrained. New techniques for estimating bathymetry via remote sensing show promise to fill this data gap. Both optical and radar sensors collect image time series of the ocean surface, and by employing the known relationship between water depth and ocean wave speed, we can estimate nearshore bathymetry over large spatial scales and monitor changing bathymetry through the seasonal cycles. Here we expand the application of these new techniques from open beaches to complex river mouths and from optical video to X-band marine radar imagery. Radar imagery can complement the high near-field resolution of optical video with its larger spatial domain coverage and with image acquisition during dark (i.e. nighttime) or foggy periods. First, linear wave theory derived depth estimates from both sensors are shown to be of comparable accuracy at an open beach (Duck, NC). We then present radar-obtained depth estimates that span a microtidal inlet (New River Inlet, NC) and an energetic, mesotidal estuary mouth (Columbia River Mouth, OR/WA). Although a complex ebb-shoal structure is reproduced at the inlet during slack tide, current-induced Doppler shifts to the wave field are shown to significantly affect the estimated depths. This effect is even more pronounced at the Columbia River Mouth, where the depth estimate error reaches 2 m at peak flood. Mitigation (tidal averaging) and solution (inversion of both currents and depth) efforts highlight their relative advantages and disadvantages.

Multi-Objective Optimization of Reservoir Operation Considering Flexibility in Decision Variables

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Deterministic optimization of reservoir operation has been studied in the literature for several decades. Robust optimization of reservoir operation, which considers different sources of uncertainty, is a recent improvement. However, as some of the uncertain variables are not quantifiable ahead of time, it is important to give the decision maker a range of options to choose from. The method proposed in this paper finds a range of optimal solutions for the decision variables rather than a single optimal value. This range is represented as the mean and variance of the decision variables. In finding this range of options, there is a trade-off between the amount of flexibility that can be allowed and the value of the original objectives. It is clear that in order to have the greatest flexibility, the original objectives will be sacrificed to some extent. The original objectives are thus combined with the objective of maximizing the variance of the range of solutions to form the new robust and flexible multi-objective optimization problem. An evolutionary optimization algorithm (multi-objective Genetic Algorithm) is used to find solutions to this new problem. To estimate the variance of the decision variable, Polynomial Chaos Expansion is implemented within the process of optimization. Instead of using traditional random sampling methods such as Monte-Carlo for the evaluation of expectations, the Stochastic Collocation method is used, which deterministically samples the random variable at strategically chosen points known as collocation nodes and uses corresponding weights to perform the quadrature. The use of the Stochastic Collocation method decreases the number of function evaluations compared to the Monte-Carlo approach and therefore increases the convergence rate. Simple mathematical test problems are used to provide evidence of the practicality of the proposed framework. The idea is then extended to the robust and flexible multi-objective optimization of a reservoir system. The results show the functionality of finding a range of nearly optimal scenarios for the decision variable.

Remote Sensing Data Assimilation in Water Quality Numerical Model of Eagle Creek Reservoir Using Ensemble Kalman Filter Method

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Numerical models are used as effective tools for simulating complex processes in aquatic systems, such as hydrodynamic and water quality processes. The accuracy of the model is reliant on the multiple model parameters and variables which need to be calibrated and regularly updated to reproduce changing conditions accurately. Different sources of observations such as remote sensing data or in-situ monitoring technologies can improve the model accuracy by providing benefits of individual monitoring technology within the model updating process. Remote sensing technology can provide the spatially dense surface temperature of water body, while in-situ technology is able to prepare more frequent time interval data along the depth. Although several studies have used remote sensing and in-situ observations to assimilate water temperature, it is unclear of whether updating temperature based on remote sensing observations would improve the model's prediction of temperature with respect to in-situ observation. This study explores a sequential data assimilation method to overcome the challenge of using data from heterogeneous sources for improving the model performance. The main goal of this study is to adjust the water column temperature using surface temperature and present an ensemble Kalman filter data assimilation framework that combines three-dimensional finite difference numerical model with multiple sources of observations to simulate water column temperature in Eagle Creek Reservoir (ECR) in central Indiana.

Addressing Safety of Construction Workers into the Design

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The construction industry is one of the most dangerous industries in the world. Many studies have shown that the high incident rate in the construction industry is attributed the lack of safety input during the planning and design stages (Tymvios et al., 2012). Therefore, this research aims to investigate the impact of the design process on the safety of construction workers. The study tries to find out if specific design alternatives and procedures might improve the safety of the whole process, especially during the construction stage. The methodology of this research is to search for individual innovative designs, analyze them, and formalize them in a proper way to be valid to use since the beginning of the project lifecycle. In addition to that, the probability of getting the designer more involved in the process of assuring safety as well as the advantages of legalizing this process, which is making the designer liable for safety of construction workers. The expected outcome would be new ways and procedures of addressing safety of construction workers in the design to eliminate hazards completely instead of other traditional controls prior or during the construction process. The new proposed way would be better it terms of: cost, productivity, quality, time and safety. At the end, construction workers would not only be safer, but also more productive, alert and incentive.

Ground Surface Settlement in Blast Induced Liquefaction

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Volume change of cohesiveless and low plastic granular materials due to blast induced liquefaction is caused in a fundamentally different manner as compared to earthquake induced liquefaction. Although the residual pore water pressure generation causes decrease of soil shear resistance in both blast and earthquake induced liquefaction, the magnitude, the area, and the shape of the ground surface settlement are not same. The reason is that the intensity of explosive energy (i.e., frequency, duration, acceleration) to the liquefied soils varies with blasting test properties, which makes it difficult to predict the ground surface settlement. In this work, the effect of the blasting test properties and the contributions of explosive energy on the ground settlement are discussed using observed data from recently conducted blast induced liquefaction testing by describing the explosive energy - volumetric strain relationships and the blasted area - ground settlement diagrams. The results show that blasting test layout controls the area and the shape of the ground settlement nonetheless soil density and characteristics are different. Moreover, the initial soil density, Hopkinson's number and powder factor are critical factors to evaluate the maximum ground settlement. The important implication of this study is that pore volume change and ground surface settlement under blast induced liquefaction testing strongly relates to the total explosive energy and charge density.

Pedestrian Distraction: Pedestrian Behaviors at Midblock Crossings Considering Geometric and Environmental Conditions

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Pedestrian distraction at roadway crossings has been correlated with a higher risk of pedestrian-vehicle collisions due to the pedestrian's cognitive, visual, and motor attention being drawn to a wide variety of secondary tasks. Previous research in pedestrian distraction has focused on pedestrian behavior at intersections and midblock crossings with three general types of data collection methods: dataset data and questionnaires, laboratory testing, and direct observations. While previous studies differed in data acquisition and analysis techniques, the studies, in general, agreed on several key results: that distraction affects a pedestrian's walking speed; that the adjacent built environment may affect the pedestrian; that different types of distractions affect the pedestrian in different ways; and that the compliance rates of pedestrians are affected by age and gender. This study focused on pedestrian distraction at midblock crossings located in Corvallis, Albany, and Eugene, Oregon. A combination of digital video and researcher field notes were used to obtain the data at each site. The independent variables, type of distraction, cross walk configuration, zoning type, and pedestrian gender, were used to predict the dependent variables, pedestrian walking speed and compliance. The goal of this research is to contribute to the current knowledge of pedestrian distraction while crossing roadways.

Seismic Behavior of Ultra-High Performance Fiber-Reinforced Cementitious Composite Columns

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To enhance the displacement ductility of reinforced concrete columns to seismic loading, an ultra-high performance fiber-reinforced cementitious composite material (UHP-FRCC) will be proposed. The composite will consist of the UHP-FRCC matrix and steel fibers of different surface deformation, different aspect ratios, and different volume fraction. The matrix will be designed to achieve adequate bond between the fibers and the surrounding matrix and a UHP-FRCC with a compressive strength at least 22ksi (150 MPa). Based on a series of compression, tension, and cyclic tests, a new hysteretic constitutive model will be developed for UHP-FRCC. It is anticipated (pending funding) that a half-scale bridge column will be constructed with UHP-FRCC and subjected to cyclic lateral loading. The test results will be compared to a reference column tested at Oregon State University in 2013. An advanced nonlinear finite element model will be developed in Ansys and OpenSees and validated against the test results. A sensitivity study of the model parameters will be used to test the robustness of the numerical results.

Discrete Element Method Simulations of Triaxial Tests on Bio-Cemented Sand Using a New Cementation Model

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Bio-cementation is a promising method for the natural improvement of potentially liquefiable soil deposits (e.g., loose saturated sands). In the improvement process a bacterium that can be found naturally in soil deposits is fed urea. The bacterium consumes and breaks down the urea to form ammonium and carbonate. In the presence of calcium, calcium carbonate will precipitate at particle contacts and act as a cementitious agent to solidify the deposit. Moreover, experimental tests show that bio-cemented sand exhibits more ductile behavior than chemically cemented sand. This is a desirable response from an engineering point of view, since brittle failure is often catastrophic and occurs without warning. The scope of this study is to investigate the response of bio-cemented sand using the discrete element method (DEM). This numerical method is capable of simulating behavior of granular materials realistically. A new cementation model is proposed that replicates the presence of cement between soil particles. This bond is able to capture the progressive contact dissolution between two soil particles. Triaxial samples were built and the aforementioned contact bond was applied to all contact points within the assembly. Samples with and without cementation were sheared and the stress-strain responses were compared in terms of soil strength and stiffness.

Engineering Design Considerations for Ecoroofs

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Ecoroofs, also referred to as green roofs or living roofs, are becoming a sustainable roofing alternative. These roofs provide a myriad of benefits including habitats for urban flora and fauna, aesthetically pleasing leisure space, urban heat island effect reduction, stormwater runoff reduction, and reduced energy use for heating and cooling. Notwithstanding these benefits, there is currently a paucity of engineering guidance regarding the design, construction, and maintenance of ecoroofs. Potential engineering concerns include: (1) roof collapse due to excessive ponding and loading, (2) sliding stability issues (especially for sloped roofs), and (3) inertial loading of parapet walls during earthquake motions. To better understand and manage these risks, the research team has taken ecoroof soil samples from 18 extensive and intensive ecoroofs in Portland, Oregon. Soil characterization tests were performed on the sampled in situ ecoroof soil, which showed that ecoroof soil properties were widely variable. Soil strength and liquefaction tests were also performed using a simple shear device for static and cyclic testing. Moving forward, direct shear testing will be performed to determine which interface of the ecoroof system is most susceptible to sliding. Further, 1 m by 1 m model ecoroofs will be subjected to earthquake motions via shake table testing to better understand the seismic response.

Rip Current Observations Using Marine Radar

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Rip currents can create dangerous conditions for recreational activity in coastal waters, putting swimmers at risk of being swept off-shore. Rip current observations can help determine when and where rip currents are likely to form, keeping swimmers safe. One way to monitor rip currents is with marine radar. The marine radar microwave backscatter is stronger over rip currents due to the scattering of the microwaves off of surface roughness. Surface roughness over rip currents is created from the interaction of the rip current with the intermediate to short waves, causing the waves to break. Marine radar cannot be used to observe rip currents for all conditions under which rip currents exist. To better understand when marine radar can be used to observe rip currents, the effects that wave-current interactions have on marine radar backscatter was quantified. Lyzenga (1998) developed a method for determining the effects that intermediate waves have on radar signatures of ocean fronts and internal waves. The effects on radar signature were looked at by quantifying the changes in spectral density of the microwave backscatter from the wave-current interaction. This method was used to determine the rip current velocities required to change the microwave spectral density enough to be observable by marine radar.

On the Upstream Propagation of Tsunamis in Rivers

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In the event of a tsunami, energy can propagate upstream, against the current of a river, forming a weak bore. A weak bore, also referred to as an undular bore will manifest itself when the upstream Froude number is approximately between 1 and 1.2, and occurs with a sudden change in water surface elevation, followed by a growing train of harmonic waves. The importance of this topic of research stems from its implications to forces felt by coastal and riverine structures. For example, the undulations which occur, can generate vertical forces on a bridge. Thus, possibly leading to the uplift of the bridge structure, rupture of bolts, and ultimately, failure of the bridge. Therefore, upstream tsunami propagation plays a societal role not only in the sense of bridge design, but also transportation. To study the physical processes which take place during such an event, numerical, experimental, and analytical research is being done, as to facilitate a comprehensive understanding of the phenomenon. A pseudo-spectral method is implemented to solve Euler's equations of motion with a four stage Runge-Kutta scheme for time stepping. The subject is being studied under the assumptions that the fluid is inviscid, irrotational, and that the undular bore initially forms from a water surface profile which follows a hyperbolic tangent.

Shear and Flexural Strengthening of Deficient Concrete Bridge Girders Using Titanium Reinforcement

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Many of the concrete bridge girders constructed in the 1950's are structurally deficient, and there is insufficient funding for replacing these under-designed bridges. Titanium reinforcement has been proposed as an innovative, cost-effective option for extending the service life of these bridges, due to its strength and non-corrosive properties. The goal of the current research is to study the feasibility of near-surface mounted titanium to increase shear capacity, and externally mounted titanium to increase flexural capacity. This will be done by casting eight full-scale, under-reinforced concrete girders that mimic 1950's construction, and testing them to failure. Four of the girders will be retrofitted with near-surface mounted titanium and tested for shear strength, while the other four girders will be retrofitted with externally mounted titanium and tested for flexural strength. It is intended that this research will establish titanium reinforcement as a competitive retrofit technique for extending the service life of existing bridges.

Tsunami Induced Buoyancy Force Effects on Structural Stability

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The 2011 Great East Japan Tsunami has altered our traditional concepts for estimating loadings on structures. Prior to this event, we generally understood that reinforced concrete structures – those often used for critical coastal facilities – could withstand tsunami actions. This is no longer the case. Many concrete buildings and coastal protective structures (seawalls, coastal dykes and the like) failed due to the 2011 Tsunami. In many of these cases, these concrete buildings failed due to stability failure that resulted from buoyancy forces. Buoyancy reduces the net structural body force; thereby reducing the restoring forces to resist sliding and overturning failures. Buoyancy force is an upward pressure force under the building, which is caused by an increase of pore-water pressure in the soil by excess water weight on the ground surface; therefore it takes a finite time to build up. Using a finite difference model, we numerically simulated the effect of buoyancy force on a structure. The finite difference model was based on the two-dimensional diffusion equation written in cylindrical coordinates. Simulation cases were run with constant inundation depth and with inundation data taken from the 2011 Great East Japan Tsunami in Onagawa. We demonstrated that the effect of buoyancy force depends on 1) duration and depth of tsunami inundation, and 2) burial depth of the building.

Seismic Resiliency of New and Existing Wastewater Pipeline Systems

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Vital infrastructure lifelines, such as underground pipeline systems, are affected by strong earthquake motions. In particular, liquefaction of loose, saturated sediments can cause pipeline and manhole uplift, which fractures critical connections. Uncontained raw sewage creates life threatening public health issues and impedes earthquake recovery efforts. Post-earthquake reconnaissance and research has shown that buried pipelines can be seismically fragile. The seismic performance of wastewater pipeline systems in liquefiable ground is a young research area in the U.S. This doctoral research, will devise novel design techniques for increasing the seismic resiliency of wastewater pipeline systems in liquefiable soil. To accomplish this goal, there is a need to develop the science of soil liquefaction at a micro-scale level and determine a soil-fluid-structure interaction of relatively rigid and buried pipelines, which is an emergent field in earthquake engineering. The research plan proposes discrete element modeling to investigate particle-to-particle interaction during earthquake loading and compare it with a micro-scale physical model, where soil particle motion can be tracked via high-speed cameras, and pore pressures be measured via transducers. Structural elements, such as pipelines, will be modeled within the discrete element framework. After the micro-scale level work is complete, the problem will be scaled to the macro-scale with finite-element modeling techniques, which are used more frequently by practicing engineers. This work has a strong social component, because wastewater systems in the U.S. are deteriorating, and important work has to be done to decrease public health risks and improve recovery efforts after earthquake events.

Torsional Capacity of Drilled Shaft Foundations

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Drilled shafts are commonly used to support cantilevered traffic signs and signals. The loading includes axial loads and moments, but in general, the maximum anticipated loading develops due to wind gusts, and this transfers a torsional load to the foundation. Despite their prevalence in practice, the understanding of the actual resistance provided by drilled shafts under torsional loading is not well established. Two instrumented drilled shafts, 0.9 m in diameter and embedded 4 m below the ground surface, were constructed at the Geotechnical Engineering Field Research Site (GEFRS) at Oregon State University to study the capacity and load transfer of drilled shafts loaded in torsion. First, a comprehensive geotechnical investigation program carried out at the test site, including cone penetration tests (CPT), standard penetration test (SPT), laboratory triaxial CU tests, and field vane shear test (VST), to establish the relevant soil properties is described. Then, the instrumentation program and loading protocol for the shafts is presented. Experimental data, such as the torsional load-rotation relationship, torsional strain distribution, and longitudinal strain distribution observed during testing is presented, and the results compared to existing design approaches is described. Recommendations for design based on these and other test data are provided.

CLT. Sustainable Hybrid Cross-Laminated Timber Solutions for Mid-Rise Buildings

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Cross-laminated timber (CLT) is a prefabricated solid engineered wood product made of at least three orthogonally bonded layers of solid-sawn lumber or structural composite lumber (SCL) that are laminated by gluing of longitudinal and transverse layers with structural adhesives to form a solid rectangular-shaped, straight, and plane timber intended for roof, floor, or wall applications. Our hypothesis is that CLT panels with hybrid layups, where layers are arranged from high- and low-grade lamellas, can meet the current standard requirements for critical engineering parameters as specified in ANSI PRG 320 2012 performance standard, and that adhesive systems alternative to polyurethane PUR can be successfully utilized in hybrid CLT products. The overarching goal of this project is to verify this hypothesis. This project is developed in five tasks ranging from adhesive to structural system characterization. In this poster, tasks four and five are highlighted, which focuses on static and dynamic performance of connectors. Task four is developed in two main sub-steps: (i) Connection testing using 2'x2' hybrid CLT panels and (ii) a set of full-scale wall tests. In task five we develop a numerical model to predict the performance of the hybrid CLT systems under static and dynamic loads. Preliminary results are shown for these two tasks.

Detecting Moving Objects within High Dynamic Range Images

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This paper addresses the problem of detecting a moving object (ghost) in a set of optical images that are combined to create a high dynamic range image (HDR). Each image in the set shows the same scene from the same viewpoint but is captured with a different exposure time. A new, low-level approach is presented, which advances existing methods because it does not require: 1) robust estimation of a camera response function, 2) supervision of objects in the scene such as explicit object detection and tracking, and 3) selection of a reference image without a moving object. In our approach, every image in the set is first partitioned into patches of equal sizes. Next, the properties of values within the window of the same patch are compared between the images to identify differences. To this end, we describe image patches using two alternative descriptors: histograms of pixel intensity and histograms of oriented gradients. For the classification, we developed a statistical classifier to recognize significant differences between patch descriptors to identify patches containing moving objects. Finally, a k-nearest neighbor algorithm is applied for each patch to minimize false detections by ensuring that its neighborhood contains suspected moving object patches before giving a final designation. Additionally, a sensitivity analysis indicated that the best performance occurs with four to six images used to create the HDR image. However, the optimal patch size is dependent on the size

of the moving object to be detected. When patch sizes and exposure ranges are not optimized, the approach results in Matthew's correlation coeficient (MCC) values around 0.51 on images from both indoor and outdoor scenes. However, when selecting the proper patch sizes, the proposed approach yields significantly improved results with MCC values near 0.82.

Field Investigation on Seasonal Effects on the Capacity of Aggregate Piers

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Aggregate piers are a ground improvement methodology used to improve the bearing resistance of native or fill (matrix) soils, and consists of columnar lifts of compacted aggregate installed below the footprint of structural foundations. Soil surrounding the aggregate piers provides confinement, providing an important contribution to load bearing capacity. Thus evaluation of two matrix soil properties, the effect of soil moisture on shear strength and the subsequent role on pier capacity, was evaluated using full-scale loading tests. Particular attention was given to the wetting and drying cycles that influence soil suction, which has been shown in laboratory studies to influence bearing capacity by four to ten times. Plate load tests (0.76 meter diameter) and full-scale footing (2.44 meter square) tests were performed to produce representative load-displacement curves and indications of capacity. Aggregate pier lengths of two to five diameters were tested using the plate load tests, while the large footings were used to evaluate groups of four piers four pier diameters in length. Duplicate plate load tests were conducted under saturated soil conditions (Spring) and unsaturated, dryer conditions (late Summer). The results of the tests show correlation between the undrained shear strength of the soil at the time of testing and bearing capacity of the aggregate piers using a recently developed model.

Evaluation of "Jerk" as a Measure of Passenger Safety and Comfort on Public Transit Vehicles

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The purpose of the research is to define an acceptable change in acceleration over a given time, in reference to the passenger comfort and safety on public transit vehicles. The rate of change of acceleration is commonly defined as "jerk." Research in passenger comfort definitions and standards will be utilized to set parameters and context for the data analysis. Data for this study was collected on two different types of public transit vehicles. A large bus used in bus rapid transit service bus by Lane Transit District (LTD) and a steel tired street car from United Street Car. This data was utilized for the analysis to find the change in acceleration over a given time. Different braking and acceleration regiments were followed in the testing to illustrate different regular and severe driving maneuvers commonly performed by public transit vehicles. The study also includes observations of side and foreword facing seated passengers that were restrained and unrestrained. This analysis will determine what the measurable characteristics of acceleration, deceleration, and the change in acceleration over

a defined time. The analysis will also yield measurable characteristics of braking conditions. The report will recommend acceptable levels of a change in acceleration over a defined time for transit vehicles for several passenger conditions, acceleration conditions, and vehicle types in reference to passenger comfort.

Synergistic Effect of Corrosion and Alkali Silica Reaction (ASR)

Vandad Mazarei and David Trejo

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Corrosion of rebar in reinforced concrete and alkali silica reaction (ASR) are two of the main deteriorations of the concrete. This research describes how ASR affects the progress of corrosion in reinforced concrete. Concrete specimens with different fly ash content (0%, 20% and 40%) and aggregate reactivity were cast with embedded continuous rebar (CR) and jointed rebar (JR). Specimens were subjected to 38 °C and 95% relative humidity. They were ponded with 3% sodium chloride (NaCl) solution for two weeks then dried for two weeks. In this period, the specimens were inverted and ponded with distilled water on the other side to prevent warping of the specimens. Expansion of the specimens, corrosion potential and voltage drop across the 100-ohm resistor between the top and bottom reinforcement measured for each specimen. The results obtained in this study show that the addition of fly ash strongly affects the effects of ASR and corrosion. In addition, the total corrosion of the control specimens with non-reactive aggregate exceeds the specimens with reactive aggregate after 85 days of ponding. This shows that the ASR gel limits the ingress of chloride into the concrete which results in lower corrosion.

Experimental Investigation of the Influence of Concrete Cracks and Corrosion on Electrical Resistivity Measurements

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It is widely reported that electrical resistivity of concrete plays a major role in controlling the corrosion rate of embedded reinforcement in concrete. In addition, many recent studies have shown that resistivity and micro-structural changes in concrete are highly correlated. In the past, a number of studies have identified the factors affecting the resistivity measurements using four-point Wenner probes and provided guidelines for minimizing their confounding effects on the accuracy of resistivity readings. However, the effects of existing surface cracks in concrete and corrosion of reinforcing steel on the measurements have not been studied systematically. In this study, laboratory testing on a custom-designed reinforced concrete slab is used to investigate the issue. Investigation parameters include (1) crack dimensions, (2) crack locations and orientations with respect to the probe position, (3) density and location of embedded reinforcement, (4) orientation of the probe with respect to reinforcement, (5) orientation of the probe with respect to corroded reinforcement and (6) moisture content of concrete. It is demonstrated that concrete resistivity measurements can contain considerable errors depending on the location and geometrical properties of the crack as well as its angle

with respect to the Wenner probe. The presence of rebar mesh, corrosion, and the probe's misalignment with respect to the crack and the measurement direction will exacerbate the errors – in some cases by over 100%. Suggestions will be provided to help minimize the effects of the cracks and corrosion on electrical resistivity measurements.

How Successful a Near-Field Tsunami Evacuation is Multimodal: An Agent-Based Modeling and Simulation of Seaside, Oregon

Alireza Mostafizi, Haizhong Wang, Dan Cox, and Lori Cramer

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The Cascadia Subduction Zone (CSZ) is a major threat to the coastal community's life safety in the Pacific Northwest region since it can initiate mega-earthquakes and tsunamis accordingly. A near-field tsunami is likely to come onshore within 20 to 40 minutes after the initial earthquake. This research presents a multimodal evacuation simulation for a near-field tsunami through an agent-based modeling framework. The goals of this research is to investigate how the choice of different modes of transportation (i.e., walking, automobile, and public transit) impacts the estimation of casualties. The city of Seaside, Oregon, was selected as a case study site for this research because the city is prone to a near-filed tsunami due to the presence of Cascadia Subduction Zone. The current tsunami evacuation plan for the area calls for horizontal evacuation on foot. However, other modes of transportation (i.e., automobile uses, public transit) need to be considered as well to ensure an efficient evacuation. This is an ongoing study to understand how different modes of transportation impact life safety in the context of the near-field tsunami hazard. For this project, we use an agent-based evacuation model, which considers the milling time, and variation in travels speeds to estimate the loss of life due to the tsunami hazard. We compare the general case of tsunami evacuation with the varying adoption rate of different modes of transportation. As a result, a comprehensive multimodal tsunami evacuation plan is evaluated through this model.

Infiltration Rate of Aviary Park Rain Garden

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Rain garden is one of many methods used to control or at least minimize flooding, it's also serves as a filter of water which goes through the Rain garden. Rain garden mainly works as a detention basin which holds water in the soil, slows it down, filters it and then releases water to the main sewer system, hence the rate at which water enters the main sewer system is reduced, therefore flooding risk is decreased and also water quality is increased due to filtering. Infiltration rate test is done to investigate the rate at which water can enter the soil and based on that rate, we will be able to know if the rain garden is able to take all the water coming in the garden, control it and then drain it to the main sewer system. We are doing the Infiltration rate test in two different time periods, winter and spring, to spot the differences between the two periods.

High Strength Reinforcing Steel Bars: Low Cycle Fatigue and Horizontal Shear Interface Behavior

Drew Nielson, Andre Barbosa, and David Trejo

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High-strength steel (HSS) reinforcement, specifically ASTM A706 Grade 80, is now permitted by the AASHTO LRFD Bridge Design Specifications for use in reinforced concrete bridge components in non-seismic regions. Using Grade 80 steel reinforcement instead of Grade 60 steel reduces material and construction costs. However, state highway agencies (SHAs) only allow Grade 80 reinforcing steel in bridge structural elements that are not expected to undergo large strain reversals (low cycle fatigue) during an earthquake. AASHTO and SHAs have concerns with using Grade 80 reinforcement in elements designed for low cycle fatigue due to the lack of experimental data. The poster presented summarizes research done to date on characterizing tensile and low cycle fatigue behavior for Grade 80 reinforcing steel, which is crucial to provide designers data on cyclic/seismic performance of bridge columns and on performance of Grade 80 steel in resisting interface shearing action, which is critical for precast girders and for shear-keys. For the low cycle fatigue testing, universal testing machine uniaxial material testing are being performed to compare toughness and buckling behavior of the four types of reinforcement bar. For the interface shear, push-off experimental designs using ASTM A706 Grade 60 and Grade 80 reinforcing steel have been tested to discern if the design can account for the higher strength-steel. The poster presents initial results for this second part. From the experimental data, further knowledge of low cycle fatigue behavior for use of ASTM A706 Grade 80 in plastic hinge regions will be obtained.

Immersive Virtual Reality (VR) Visualization System for Use in Civil Engineering and Geomatics

Matthew O'Banion and Michael Olsen

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The Civil and Construction Engineering Geomatics Research Lab at Oregon State University (OSU) has constructed an Immersive VR visualization system for the purpose of visualizing digital 3D data, more specifically, LiDAR point clouds, and digital elevation models. The VR system was constructed based on a hardware configuration developed by UC Davis Research Scientist, Oliver Kreylos. The VR system consists of a 65 inch active 3D LED television coupled with an Optitrack infrared tracking array and VR software (Vrui). The array of three Optitrack cameras track custom made tracking antlers mounted on the user's 3D glasses and a Nintendo Wii remote used for data interaction. Tracking of the user's head position allows the VR software to adjust the displayed stereo 3D scene for the user's point of view allowing for realistic perspective and a more immersive experience. The VR system has proved very useful for navigating, analyzing and processing dense terrestrial LiDAR point clouds. Current work using the VR visualization system has included quality control of registered point clouds comprised of numerous laser scanner positions, review of seismically induced damage inflicted upon residential structures and refinement of visualization performance for individual users of the system. Future goals include using this new visualization tool to enhance LiDAR point cloud analysis and processing and development of custom Vrui software modules for further applications.

Spatial Transferability of Large-Truck Crash Models between Oregon and Texas

Jasmine Pahukula and Salvador Hernandez

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The spatial transferability of large-truck crash models between Texas and Oregon is evaluated. Large-truck drivers complete extensive training in order to obtain a commercial driver's license (CDL) which is required for operation of a large truck. This training has been standardized at a national level, thus this study will compare the driving behavior of large-truck operators between states. A random parameters (mixed) logit model for large-truck involved crashes in urban areas in Texas and Oregon were developed separately. A series of log likelihood ratio tests will be used to compare the two models from each state. The results of the log likelihood ratio tests will indicate whether separate models for each state are necessary or if one model can explain the crash and driver behavior for both states. The vehicle type (i.e. large trucks), land use (i.e. urban areas), time period (i.e. 5-year crash history), and variables will be held constant.

Tsunami Inundation Modeling: Sensitivity of Velocity and Momentum Flux to Bottom Friction with Application to Building Damage at Seaside, Oregon

Hyoungsu Park and Daniel Cox

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We examine the sensitivity of three different tsunami inundation numerical models using various friction terms. We use the model output to examine the probabilistic damage levels using fragility curves applied over a community scale and resolved at the scale of individual tax lots for Seaside, OR. With this work, we estimate the inundation hazard using the "500 year" tsunami originating from a Cascadia Subduction Zone earthquake and then compare the maximum surface elevation, velocity, and momentum flux results across the three models. We find a larger variation in the velocities and momentum fluxes when varying model types and friction coefficients; surface elevation variations are not as large. We also find that absolute velocity and momentum flux are more sensitive to friction factors rather than model type, while surface elevation varies with model type. For the fragility curve analysis, we consider flow depth, velocity, and momentum flux as the intensity measure to estimate the probability of a certain damage level based on the known structure type and characteristic tsunami intensity. We examine the sensitivity of damage levels to various fragility curves, using different intensity measures, and we find that velocity and momentum flux curves provide a more realistic estimate of damage.

The Impacts of Climate-Change on Estuarine Flooding: a Pacific Northwest Case Study

Kai Parker, Tiffany Cheng, David Hill, Jordan Beamer, and Gabriel Medina

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While understanding of climate change's impact on coastal systems has recently seen great improvements, there still remains much to be understood, especially for systems as hydraulically complex as estuaries. On the decadal to century scale, climate change modulated variability in the multiple forcings to estuarine systems will drastically effect the overall state, resulting in changes to experienced extreme water level events. A study of climate change impacts on two Pacific Northwest estuaries is presently underway. A hydrodynamic model (ADCIRC-SWAN) is being used to conduct multi-decadal simulations of water levels across the study estuaries. A global climate model is used to resolve future changes to the climate and is run through a set of companion models in order to develop future forcing. At the open ocean boundary, the model is forced with wave output from the WaveWatch III model. The free surface of the model is forced with downscaled surface winds and pressure and the stream flow boundaries are forced with hydrographs obtained from the suite of hydrologic runoff routing models. The ADCIRC-SWAN output provides time series data on total water levels (TWLs) throughout the model domain. These time series can be used to derive return periods for extreme water level events as well as inundation maps. Of particular interest to this study is how these products change from the historical to future runs and which processes (changing offshore waves, changing stream flow) are primarily responsible for the observed changes in flooding characteristics.

Agreement and Disagreement in Watershed Plans Generated by Human-Centered Optimization

Adriana Piemonti and Meghna Babbar-Sebens

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Generation of optimal designs to accomplish integrated water resources management in an agricultural watershed is a challenging task. In most of the cases, decision makers and planners have the need of decision support systems to project the results of critical goals on natural and socio-economical structures. The design of such decision support systems is, per se, a very intricate problem. Complexity and uncertainty of biophysical modelling, variability of preferences, constrains of stakeholders and decision makers, as well as selection of appropriated techniques of multi-objective optimization are some of the subjects to consider during the planning and development processes of those decision support systems. The present work explored interactive genetic algorithms used in the optimization of conservation practices in an agricultural watershed. This optimization process is based on the iterative feedback of alternatives that satisfy the individual's preferences. The results showed presence of patterns in desirable watershed management plans. The patterns support the measurement of agreements and disagreements within community's members. Due to this variability a characterization and identification of robustness indicators is necessary. The robustness will support classification of

preferences and identification of solutions that better suite global (watershed scale) and local (subbasin scale) goals across individuals. In this work we present the results for such patterns, suggest robustness measurements that agree with the problems characteristics and emphasize the differences between individuals' solutions and their performances on different objective.

A Portfolio-Based Decision Model for Optimal Investment in Solar Powered Communities

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Inherent in large-scale photovoltaic (PV) investments is volatility stemming from a unique set of spatial factors that significantly affects their finical decision making. In order to systematically assess and manage such volatility factors, the present study aims to develop a quantitative model based on modern portfolio theory (MPT) to determine optimal investment strategies for communal PV investments. The model presented in this paper supports analytical processes that serve two purposes: (1) to maximize the expected electricity generation of PV panels for a given portfolio volatility (i.e., risk), or (2) to minimize the volatility for a given level of electricity production. As a proof-of-concept, a residential community in Corvallis, Oregon, USA was selected as a case study and respective data regarding hourly irradiation and electricity production for each house was obtained from the US Department of Energy. In order to determine optimal investment strategies, various portfolios of the selected houses were created and contrasted to determine the efficient frontier. Subsequently, optimal weights for efficient portfolios were calculated by using the Lagrangian method. Results show that by accounting for roof tilt, shade, and orientation of the houses as sources of volatility, the optimal portfolio that maximizes electricity production or minimizes volatility is achieved when PV panels are installed in accordance with the weightings obtained from the MPT analysis and not from the equal allocation of panels on each house.

Probabilistic, Seismically-Induced Landslide Hazard Mapping of Western Oregon

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Earthquake-induced landslides can generate significant damage within urban communities by damaging structures, obstructing lifeline connection routes and utilities, generating various environmental impacts, and possibly resulting in the loss of life. Reliable hazard and risk maps are important to assist agencies in efficiently allocating and managing limited resources to prepare for such events. The proposed poster presents a new methodology for communicating landslide risk to scale traditionally site-specific approaches to a regional scale.

This includes calculating the probabilities of exceeding landslide displacement thresholds (e.g. 0.1, 0.3, 1.0 and 10 meters) to generate regional seismic induced landslide hazard maps. These maps integrate a variety of data sources including: recent landslide inventories, LIDAR and photogrammetric topographic data, geology maps, mapped NEHRP site classifications based on available shear wave velocity data in each geologic unit, and USGS seismic hazard curves for this analysis. Soil strength estimates were obtained by evaluating slopes present along landslide scarps and deposits for major geologic units. Code was then developed to integrate these layers to perform a rigid, sliding block analysis to determine the amount and associated probabilities of displacement based on each bin of peak ground acceleration in the seismic hazard curve at each pixel. The methodology was applied to western Oregon, which contains weak, weathered, and often wet soils at steep slopes, which presently have a high potential for landslide hazard even without seismic activities. A series of landslide hazard maps highlighting the probabilities of exceeding the aforementioned thresholds were generated for the study area. These output maps were then utilized in a performance based design framework enabling them to be analyzed with in conjunction with other hazards for fully probabilistic-based hazard evaluation and risk assessment.

Factors Affecting Owner's Decision to Revitalize Brownfield Properties

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Former industrial or commercial sites that have been left unused are typically referred to as brownfield sites, or simply, brownfields. Many communities have such properties that are abandoned, idle, or underused. Despite public efforts to facilitate brownfields revitalization, the rate of remediation remains unexpectedly slow. Efforts to resolve this nationwide problem have included legislative liability relief, federal grants and loans to facilitate revitalization, state and other local government initiatives for economic development assistance, and others. Nationally, the EPA has reported that only 4% of the hundreds of thousands of brownfield properties have been assessed, and less than 1/4 of 1% have been cleaned up. The slow process of revitalization of brownfield sites reduces the economic value of these properties, thwarts development of neighboring properties, and poses a substantial danger to human health and the environment — causing suppression of economic growth of entire communities in general. The EPA estimates that on average $17.79 are leveraged for each brownfields dollar expended and 7.30 jobs are leveraged per $100,000 of brownfields funding. Multiplying these amounts by the number of sites currently laying fallow results in a substantial economic boost to communities nationwide. This paper provides insight into the decision making process of the property owners at these brownfield sites, who are faced with funding uncertainty, legal liability questions, potential property use, clean-up technologies and costs, public health effects, and others. Their decision is inherently based on balancing the perceived benefits vs. the costs of the remediation. This purpose of this research is to identify the major factors in this cost/benefit discussion.

Wave Forecasting Using Nautical Radar for a Feed-Forward Controls System of Wave Energy Converters

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Feed-forward controls systems are a common application to renewable energy technologies because of their ability to increase power production in varying environmental conditions. In the early stages of Wave Energy Converter (WEC) development, studies show that short-term wave forecasting can improve device performance by 100-300%. The proposed study aims to forecast a wave field using marine radar as a remote sensing technique, coupled with a predictive wave model. Marine radar is a low-cost technology that could be mounted unobtrusively to individual WEC devices, or used throughout WEC arrays. The radar will monitor the phase-resolved wave field for a length of time on the order of minutes, and use this as a boundary condition to a physics-based wave model. Several types of wave models will be tested, using linear and nonlinear wave theory. The results of the study will be an algorithm that predicts the phase-resolved wave field over roughly 30 seconds. The scope of the study will involve field based in-situ sensors to test the accuracy of the wave forecast.

Low-Cost Wireless Sensors for Real-Time Lifeline Condition Assessment

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The Pacific Northwest is at risk for significant seismic and tsunami events, which are capable of severely damaging lifeline transportation infrastructure, particularly bridges. This research focuses on developing a low-cost wireless sensor network for monitoring the condition of lifeline bridges, which will allow for rapid evaluation after a natural disaster. Rapid evaluation of critical bridges will increase community resilience by allowing first responders to assess the condition of transportation routes and respond more effectively. Wired sensors have typically been used in structural health monitoring, but the cost and labor involved with these systems make widespread use challenging. This research will develop a low cost wireless sensor with increased ease of installation that will make widespread deployment realistic. Several low cost platforms, such as those provided by the Arduino project, are widely available and will be used as the foundation for the wireless network. Software will be developed for an off-the-shelf platform to adapt it to use in structural health monitoring of lifeline bridges, and strain gauges will be used to assess local member demands. The low power consumption of available platforms will allow for multiple year deployments using a combination of battery and solar power. After a natural disaster, a real-time overview of the transportation network will be available by collecting and presenting the data from wireless sensors.

Seismic Enhancement of URM Walls and Infilled Reinforced Concrete Frame with Embedded Reinforcing Steel

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A simple and cost-effective retrofit solution for URM infill walls is proposed herein, in which embedded reinforcing steel bars are placed in pre-cut grooves made on the surface of the infill walls. The proposed retrofitting method can be applied efficiently and causes minimum disruption to occupants as well as little architectural impact. The modeling approach implemented here utilizes smeared crack elements to model the behavior of concrete and masonry units while the zero-thickness cohesive interface elements are used in the modeling of cracks in the concrete members, brick-brick interface (modeling splitting of bricks) and mortar joints. Embedded reinforcing bars are modeled using the nonlinear truss elements. The numerical results, in general, show great potential for embedded reinforcing bars in upgrading the seismic performance of URM infilled RC frames under the action of in-plane loading but testing need to be done prior to making a conclusion on the efficiency of the proposed retrofitting technique. In order to validate the modeling approach implemented in the numerical analysis, a couple of experimental works will be conducted, which are:.(a) Pull out test of #3 60 ksi bar that is embedded into the groove of 1 inch depth cut on the surface of wall, (b) Diagonal compression test of masonry prism (4'X4' two wythe wall) with and without retrofit and (c) In plane cyclic test of two wythe wall (8'X5') with and without retrofit. In all test cases mentioned above, clay bricks of size 7.75"X3.75"X2.25" will be used.

Stress-Strain Response and Dilatancy of Sandy Gravel in Triaxial Compression and Plane Strain

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The strength and stress-dilatancy of uniform sands has been studied extensively in geotechnical investigations, and practitioners can draw on a wealth of previously reported data for the estimation of their volumetric response. However, the suitability of accepted stress-dilatancy theory and empiricism has not been evaluated for well-graded gravelly soils. Axisymmetric, isotropically consolidated drained compression and pure shear, plane strain quasi-K0 consolidated drained tests were performed on well-graded Kanaskat gravel using confining pressures ranging over three orders of magnitude to determine its stiffness, strength, and stress-dilatancy response. The plane strain stiffness, strength, and stress-dilatancy of Kanaskat gravel is observed from tests performed using a large cubical true-triaxial device with flexible bladders. The observed response is interpreted with a view of experimental boundary conditions and their effects, such as the development of multiple shear bands within the specimens. The findings suggests that the onset of crushing in well-graded gravelly soils may occur at lower confining pressures (~100 kPa) than uniformly graded soils (~1000 kPa), and consequently this impacts the stress-dilatancy response. Existing empirical and modified stress-dilatancy expressions proposed for low confining pressures under-estimate

the observed dilation response, however, another common empirical approach appears to adequately capture the dilatancy. The data reported herein should help practitioners estimate the plane strain behavior of sandy gravel mixtures.

Effect of Cross-Laminated Timber Floor Diaphragm Orientation on Shear Stiffness and Strength

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Cross-laminated timber (CLT) brings the forest industry to new heights with its ability to build taller wooden structures. Wood buildings in the US have typically and historically been light- frame wood construction under five stories. CLT provides the structural strengths and stiffnesses to potentially replace steel and reinforced concrete in more environmentally sustainable structural systems for mid-rise and possibly high-rise buildings. The "Toward Taller Wood Buildings" national symposium (November, 2014, Chicago, IL) brought together a group of leaders, firms, and organizations that are already deeply involved with the development of CLT in the US. Two researchers who attended the symposium had a significant impact on the proposed direction of the research. Doug Rammer, Research General Engineer at the US Forest Service, and John van de Lindt, Professor at Colorado State University, both feel strongly that looking at how CLT floor diaphragms transfer lateral loads would lead to design provisions in the National Design Specification for Wood Construction and the IBC. CLT floor diaphragms experience lateral loading along both their strong and weak axes depending on the direction of earthquake ground motions or wind loadings and on the orientation of the panels. We will determine how lateral loads parallel to either axes are transferred through the diaphragm due to different strengths and stiffnesses in the two directions. The goal is also to develop preliminary estimates of design values for shear strength and stiffness based on ASTM E455, so that structural engineers will be able to confidently use CLT in lateral-force-resisting systems.

Students and Practicing Civil Engineers' Understanding of Fluid Mechanics Concept Inventory Questions

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The fluid mechanics concept inventory (FMCI) is used to measure a person's ability to use fundamental concepts of fluid mechanics (FM) to answer questions. A study utilizing engineers and the FMCI to test the validity of the concepts in engineering practice has not been done before. Theories of situated cognition suggest that the usefulness of these concepts should be examined with practitioners. The goal of this research was to compare responses of students and engineers on the FMCI. 29 practicing civil engineers and 22 civil engineering students were interviewed using a subset of FMCI questions. This setting allowed the research to acquire both the response and the logic for choosing a particular response. The PEs had on average 18.6 years of experience and were recruited from 4 different engineering firms. Students were recruited from OSU's junior level fluid mechanics class and represented the entire range of achievement in the class. The PEs average score was 73% with a range from 46% to 100% and the students was 84% with a range from 46% to 100%. PE's performed the worst on pressure changes in horizontal pipes and for students it was pressure drops in smooth pipes. The question for which the engineers and students scored the highest on was the concept of velocity change in horizontal pipes. Results indicate that practicing civil engineers who practice in water have misconceptions in areas that do not pertain to their professional experiences and that students and engineers have different misconceptions.

Potential Changes to Travel Behaviors and Patterns: A Fuzzy Logic, Demand Modeling Approach

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The future of travel will be affected by a number of factors, including advancements in vehicle technology, such as automated vehicles, changes in population demographics and the economy, and changes in lifestyle. It is difficult to say just how much each factor will change the amount and type of travel in the future, especially given the amount of uncertainty there is regarding factors such as the development and deployment of autonomous vehicles. The authors examined factors that are likely to affect transportation behaviors in the future, developed a conceptual model of the relationships between those factors, and used the model to investigate how each factor and the interactions between factors might affect future travel, energy consumption and crashes. From a literature review of the key concepts, the development of a fuzzy cognitive map (directed graph) of the factors affecting future travel, their outcomes, and the relationships between factors was created. The authors worked with an advisory committee to determine the initial values of nodes, the link elasticities, and the forms of the sensitivity functions. The model, implemented in the R programming language, was used to model over 200,000 scenarios that were built as combinations of changes to each factor. The results are helpful to planners and policy makers because they show the potential impacts of changes on future travel, may help in targeting limited research funds on the most consequential potential changes.

Modeling the Potentials of Autonomous Vehicle as a Subscription of Transportation Services and the Impacts on Household Vehicle

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The advent of autonomous vehicles will cause a major change in society by changing the various aspects of transportation ranging from travel behavior, safety, emission and parking. With car manufacturers already setting the foundation work and testing self-driving cars it is a matter of when rather than if. The inherent communication and cooperation between vehicles will enable cars to travel with much shorter headway resulting in higher volumes and speeds consequently altering the basis for traffic models that have been the standard so far. The urban structure as well as household location choice will greatly be affected as

the in vehicle time become less of a disutility but could be used productively. Moreover the portion of individuals previously barred from driving either due to age or disability can now benefit from a reality where personal driving skills are not mandatory creating additional travel demand. As demonstrated by car sharing services the availability of a reliable nearby of a fleet of autonomous vehicles can obviate the need to own a vehicle. This would result in a shift from ownership to a subscription based transport services. The aim of this paper is to address the potential impacts of subscription based autonomous vehicles in household car ownership. The potential impact of different market penetration scenarios of the autonomous vehicles will be assessed in relation to household vehicle ownership. Currently held household car ownership models will be reviewed and the adequate subscription business model will be used to model this phenomenon. The research will address the following questions: 1. How household vehicle ownership will change with changing autonomous vehicle market penetration? 2. What household attributes will greatly influence the shift to a subscription based transportation services? 3. Which factors will delay or hinder the shift to the subscription based transportation services?

Use of Virtual Visual Sensors in Obtaining Natural Frequencies of Timber Structures

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Dynamic properties of structures are already used to obtain quantitative structural health data; however, most current data collection is limited to localized damage on the structure rather than global response. Recent research involves the use of commercially available digital video cameras, or virtual visual sensors, to observe and measure structural dynamic response on a more global scale. These virtual visual sensors require only a few seconds of structural dynamic behavior. This project focuses on the determination of natural vibration frequencies by monitoring the intensity value of a single pixel coordinate over time in these recorded videos, and then applying a fast Fourier transform to these values to extract the frequencies. Natural frequencies of structures can be used to observe changes in stiffness properties of materials and systems. The focus here is primarily on the application of the virtual visual sensor technique to wood structures in an attempt to obtain objective structural health information. The experiments focus on verification of the method to extract vibrational frequencies in various scenarios, taking advantage of naturally occurring color gradients in wood structures. Additionally, the effects of moisture content and simulated damage on natural frequencies are observed in the lab on simply-supported beams of dimensional lumber. Applications are also made to an in-place US Forest Service pedestrian bridge. Preliminary results show high accuracy in determining vibrational frequencies by comparing with other techniques, successful observation of vibrational frequencies in a timber bridge, and good use of naturally occurring color gradients in both lab and field tests.

Engineering Countermeasures for Right-Hook Crashes at Signalized Intersections with Bicycle Traffic

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A right-hook crash is a bicycle-motor vehicle crash between a right-turning motor vehicle and an adjacent through-moving bicycle. Between the year 2007 and 2011, right-hook crashes made up 18% of the total bicycle-motor vehicle crashes in Oregon and 47% of the total bicycle-motor vehicle crashes at signalized intersections in the Portland Metro (Kittelson and Associates, Inc., 2013). However, even with these statistics, there is no clear understanding of which engineering countermeasures are the most effective in preventing right-hook crashes from occurring. This study focuses specifically on right-hook crashes that occur at signalized intersections during the latter stage of a circular green indication. The overall objective is to evaluate and identify engineering countermeasures that are effective in reducing the frequency and severity of right-hook crashes. By leveraging the Oregon State University (OSU) Driving Simulator and Mobile eye tracking technology, this research aims to: evaluate and compare engineering countermeasures as well as identify engineering countermeasures that effectively reduce the frequency and severity of RH crashes The areas of engineering countermeasures that will be considered are as follows: signage, pavement marking, bicycle infrastructure, bicycle signal and warning beacons, and geometric design. Additionally, practicing ODOT design engineers will be engaged early in the countermeasure selection process to ensure the constructability of selected countermeasure designs. Hopefully this study will result in effective, implementable solutions that will help to save the lives of many cyclists in the future.

Radiometric Calibration of Bathymetric Lidar Data for Seafloor Vegetation Classification

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Hurricane Sandy impacted the U.S. East Coast in late October 2012, causing extensive damage along much of the Eastern Seaboard and particularly in the mid-Atlantic region. Topobathymetric lidar data collected by USGS with the new EAARL-B system in Barnegat Bay, New Jersey, just days before and after Sandy made landfall may assist in evaluating the storm's impacts to shallow-water coastal ecosystems. However, as the EAARL-B system is designed to scan back-and-forth across the swath passing nearly through nadir, gridded raster images created from peak amplitudes of bottom returns (i.e., bottom return "intensities") exhibit a strong incidence-angle dependence, as well as seamlines and other artifacts. This research focuses on developing and testing new methods of correcting these data, such that they can be used in benthic habitat mapping. Currently a script is being developed to apply a polynomial incidence-angle correction to the data. A method to exclude near-nadir saturated returns is

being developed and assessed. Procedures for visually analyzing the corrected data in GIS area also being created. Once these procedures are developed and tested, they can be applied to the EAARL-B data collected before and after Sandy to assist marine ecologists in evaluating seagrass habitat change resulting from the storm.

Effects of Wave Nonlinearity and Lateral Obstruction on Wave Attenuation by Vegetation

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Wave attenuation by vegetation is an important topic for understanding the ecosystem services provided by estuaries to mitigate coastal storm hazards. There are many factors to consider such as the wave nonlinearity and vertical variation of the vegetation biomass when modeling the wave attenuation. To our knowledge, this is the first attempt to investigate the role of wave nonlinearity and lateral obstruction in wave attenuation by vegetation. Our work shows that wave nonlinearity can have a large effect on the damping factor and the associated drag coefficient. In general, the damping factor doubled when ak was doubled and the drag coefficient decreased by approximately 23% when ak was approximately doubled over the range of kh values tested. Moreover, we show that wave damping is frequency-dependent in shallow water. We relate our work to other investigations on wave attenuation by vegetation, including parameterization of the drag coefficient using Reynolds, Keulegan-Carpenter, and Ursell parameters. In addition, wave attenuation through vertical varying vegetation plays an important role of research. From this study, we observed that the damping factor in uniform vegetation is twice of that in vertical varying vegetation in nearly deep water condition and that the drag coefficient increased by approximately 54% between uniform vegetation and vertical varying vegetation from the shallow water condition to deep water condition.

Wave Generation Studies of the Three-Dimensional Wave Basin

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Generation of water waves in a laboratory has been studied comprehensively in account of its fundamental applications in many fields. In the O.H. Hinsdale Wave Research Laboratory of Oregon State University, the three-dimensional wave basin is used for physical model testing under different wave conditions, such as: the periodical waves, the random waves and the solitary waves. In this experiment, series of waves are generated using the wave generation system in the three-dimensional wave basin; and the water surface elevations at different locations in the basin are recorded by the wave gauges for time history analysis. The experiment is divided into three parts: firstly, a series of periodic waves are generated using the traditional linear wave making method, the time histories of the waves are studied using linear wave theory and nonlinear wave theory to show the accuracy of this generation method. Another series of waves are generated using the second order wave generation method to remove the second order free mode to improve the accuracy; secondly, in order to simulate the real sea environment in the three-dimensional wave basin, the random waves can be generated by controlling the movements of the wave-maker paddles with prescribed motion. The performance of the random wave generation is studied with spectrum analysis; and lastly, the wave heights and the propagating velocities of the generated solitary waves are calculated and compared with the theoretical values. The conclusion of this experiment shows the wave generation capabilities of the three-dimensional wave basin and can be considered as a guideline for the future basin users.

Numerical Analysis of Geosynthetic Reinforced Retaining Wall with Stress-Dependent Soil Model

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Abstract: Numerical analysis for Geosynthetics reinforced retaining walls with high stress condition or flexible facing should include a stress-dependent soil model, which can capture postpeak strain softening behavior. A numerical model was developed to evaluate the behavior of a surcharged geosynthetics reinforced retaining wall. In this model, Lade's soil model, which can capture strain softening, was calibrated to experimental plane strain test data. In addition, a perfect plastic constitutive model was used for geosynthetics. Parametric analysis was conducted to demonstrate the influence of various design parameters, such as reinforcement spacing, strength, footing setbacks, surcharge load and so on. These design parameters optimization may provide significant economic benefits.

Risk Management in Construction Through Mitigation and Alternative Assessment

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This study will examine major risks in construction projects as well as mitigation methods and possible alternatives construction managers may take. To perform this study, employees of different levels from construction workers and project engineers to project managers and superintendents at leading construction firms will be interviewed and asked to complete surveys. In addition, statistics will be used to analyze existing data from cases on performance, physical, economical, societal, and managerial risks within the field of construction. The information collected from the responses of construction employees will be combined with statistical modeling of historical data in order to draw conclusions concerning risk management within the construction industry. This will lead to a more thorough assessment of risks based on feedback from current construction employees in conjunction with previous construction risk management situations. From this work, firms will be able to assess a number of risk factors and alternatives before selecting the best approach in building or renovating future projects.

Effects of Soil Fabric on Earthquake- and Tsunami-Induced Liquefaction Susceptibility

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Soil liquefaction due to dynamic and tsunami loading is causing catastrophes around the world every year. Significant research has been carried out through field tests, laboratory experiments, and numerical simulations. However, the evolution of soil fabric governing the macroscale behaviors during the initiation of liquefaction has not yet been understood comprehensively. In our work, a discrete element method (DEM) model was employed as a powerful tool to study the effect of initial state (void ratio and effective consolidation stress) on the liquefaction susceptibility. Spherical histograms of contact orientation, normal contact forces, and shear contact forces were created to quantify the fabric and force anisotropy during dynamic loading induced liquefaction. We found that contact anisotropy decreased when the global void ratio increased. Local void ratio contours were plotted and the distributions of local void ratio were also calculated based on the gamma, Weibull and lognormal distributions. Results show that after liquefaction initiation, the local void ratios became more uniformly distributed. In addition, the increase of initial global void ratio decreased the uniformity of local void ratio after liquefaction initiation. Finally, the contact force networks were plotted. The influence of initial confining stress will be analyzed similarly. Additionally, the focus of next step will be on the liquefaction initiation due to the removing of tsunami loading. Pore water pressure fields will be created and the evolution of soil fabric will be mainly investigated.

Contact Identification in a Granular Assembly Using the Harris Corner Detector

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Stress is transmitted through granular assemblies via forces that arise at particle contacts. Indeed, the stress tensor may be constructed based on information about material fabric (e.g., contact orientations) and the magnitudes of the forces at these contact points. It is not readily possible to know the magnitudes of the forces transmitted at each contact, the ability to identify the number and location of contacts within a granular specimen takes on increased importance. In this study, synthetic granular assemblies comprised of spherical particles are used as a test bed for particle contact identification algorithms. Considering the assemblies as 3D images, particles and voids have different features and thus, different intensities. These features changed sharply around contact zones which could be detected. Good corners have large intensity changes in all directions. Harris corner detection is employed to detect the points around the corner zone and their coordinates. The contact numbers and locations can thus be obtained by counting point cluster numbers and averaging point coordinates of each point cluster. The method detects the contacts well when the image resolution is high enough. The Harris corner detector detects corner points which can be thought as the indicator of particle contacts.

SCHOOL OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

Plasma Enhanced Atomic Layer Deposition of Low Voltage Nonlinearity Al_2O_3/SiO_2 Metal-Insulator-Insulator-Metal (MIIM) Capacitors

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Back end of line (BEOL) metal-insulator-metal (MIM) capacitors reduce the need for discrete off-board components and have become a core passive device in integrated circuits. To enable continued scaling, capacitance density must be increased while maintaining low leakage and low voltage nonlinearity (characterized by the quadratic voltage coefficient of capacitance (αVCC)). ITRS 2020 projections call for αVCC < 100 ppm/V^2, capacitance density = 10 fF/μm^2, and leakage current < 10 nA/cm^2 at 1V. Capacitance density can be increased either by introducing higher dielectric constant (κ) materials or by reducing the insulator film thickness. However high-κ materials, typically have a large positive αVCC and a small metal-insulator barrier height that leads to increased leakage. Decreasing insulator film thicknesses also increases both leakage current density and αVCC. It is therefore very difficult for a single dielectric to meet all three requirements. A promising approach to simultaneously meeting these competing requirements is to use a bi-layer insulator stack to combine materials with complementary properties (e.g. a high-k, positive αVCC insulator with a low leakage, negative αVCC insulator).[1] Although there are reports of MIIM structures that meet the ITRS 2020 projections for capacitance density, to date the reported devices that meets all three projections either employ complex and uncommon materials not found in an IC fab or are processed outside the BEOL temperature limits of 400 ºC.[2,3]

In this work, MIIM capacitors using Al_2O_3/SiO_2 bilayers were deposited at 200 ºC via plasma enhanced atomic layer deposition (PEALD) on TaN bottom electrodes. PEALD allows for low deposition temperatures, precise thickness control, and conformal coverage over high aspect ratio structures. Al_2O_3 and SiO_2 are attractive due to their common usage in IC fabrication, large metal-insulator barrier heights, and high dielectric breakdown strength. In addition SiO_2 is one of the few materials that exhibit a negative αVCC. It will be shown that bi-layers of ~3.3 nm Al_2O_3/~2.3 nm SiO_2 (40 Al_2O_3/17 SiO_2 PEALD cycles) meet the projections for ITRS 2020 with 10.1 fF/μm^2, -20 ppm/V^2, and 6.79 nA/cm^2 at 1V.

[1] S. Van Huylenbroeck et al, *IEEE Electron Device Lett.*, vol. 23, no. 191, 2002.

[2] C.-C. Lin et al, *IEEE Electron Device Lett.*, vol. 34, no. 11, 2013.

[3] J.H. Lee et al, *ICSICT 2010 10th IEEE Int. Conf. on Solid-State Integr. Circuit Technol.*, 2010.

Sensor Compression for Internet-of-Things

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Recent sensor systems have enabled significant advances in energy-efficiency, incorporating various micro-powered building blocks, including low-power analog amplifier front-end, ADC, sub/near-threshold DSP, and radio. Unfortunately, most of these sensor systems have ignored the problem of sensor data storage and/or transmission, where the power consumed by storing (or transmitting) the data greatly exceeds the power consumed by the rest of the system. For example, a 14-day 10uW ECG patch sampling at 100Hz will require over 2Gb of data storage. Storing this large amount of data in the off-chip FlashRAM or transmitting it all via the wireless radio (e.g. Bluetooth, Wifi) are non ideal methods because of the high power consumption associated with both. A similar problem exists for other sensor applications, such as environmental monitoring or smart buildings. In recent years, compressed sensing (CS) has been proposed as a method to achieve significant sensor data compression, achieving compression rates from 5-20x, depending on the signal sparsity. Unfortunately, these CS systems assume an a-priori, blind compression rate that may miss important input signal information. The sensor input is negligible in general, but when an event occurs, it should not be overlooked by the CS compression. In this research, we propose on-chip signal processing that estimates sparsity of the sensor input data, thereby controls the compression rate. Our goal will be to show the trade-offs that exist between the power consumed by performing the on-chip "input statistics" signal processing with adaptive feedback vs. blind input sampling and CS.

Measurement of Picometer-Scale Acoustic Deformation Using Laser Interferometry

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Piezoelectric materials change their shape when in an electric field, an effect that can be used to generate acoustic waves that travel through a device. These acoustic devices are widely used as RF filters, as well as in more novel applications such as acoustic assisted magnetic recording. Measurement of the exact acoustic deformation is useful for optimizing device design by detecting leakage of acoustic energy or the excitation of higher order resonances. We have constructed an interferometer that can measure both amplitude and phase of picometer-scale deformation caused by both bulk and surface acoustic waves at frequencies between 100 MHz and 6 GHz. Our heterodyne interferometer uses two laser beams at slightly different frequencies; one beam is reflected off the sample with acoustic vibrations before being combined with the other at a photodetector. Analysis of the resulting beat frequencies provides an absolute measurement of the vibration amplitude without need for calibration. As this approach measures both the amplitude and phase of the acoustic wave, by scanning the laser beam across the sample, we can construct an image of the acoustic waves and create time resolved videos of the surface oscillation. Measurement of picometer-scale deflections with micrometer spatial resolution is possible.

3D Printing Magnetic Material with Arbitrary Anisotropy

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Many modern devices that use inductors, electromechanical motors, or antennae, are dependent on magnetic materials to guide and amplify the magnetic field they rely on. The ideal materials have a high effective permeability and low hysteresis to reduce losses. Materials that meet these requirements are referred to as 'soft' magnetic materials. Many soft magnetic materials are anisotropic, and have lower losses when the direction of the applied field is perpendicular to their preferred direction of magnetization. Conventional deposition and lithography techniques, do not allow for deposition of material with varying anisotropy direction. We present 3D printing of magnetic materials, which allows for on-demand fabrication of fully customizable magnetic components with arbitrary anisotropy. Our approach allows for alignment by inkjet printing magnetic particles in a UV curable and jettable solution. Upon deposition, the ink droplet on the substrate is subject to a magnetic field to align particle anisotropy. A brief exposure to UV light then hardens the solution fixing the magnetic particles in the desired orientation. By moving the substrate and repeating this process, 3D magnetic structures with controlled anisotropy can be printed.

Modeling of Tires Rolling on Roads in Wintry Weather with Material Point Method

Alexander Clucas, Prathik Sannecy, Eugene Zhang, and Yue Zhang

School of Electrical Engineering and Computer Science

Wintry weather makes driving difficult and dangerous. When tires skid on snow or ice, accidents happen. How much control a driver has over the vehicle largely depends on the tire traction, which is directly determined by the tread design. The designs are responsible for creating enough contact between the tire treads and the roads to enable the vehicle to maneuver. Simulating tires on roads in wintry weather can be challenging due to the difficulty in characterizing snow and ice as well as the convergence issues in modeling fluid-structure interactions. In our work, we utilize the Material Point Method to model the snow in order to determine the amount of snow that is being expulsed by the different tread designs. We also implement various nonlinear elastic models to capture the various snow conditions such as fresh and slushy. Rendering of the snow is implemented with implicit surface reconstruction and ray-tracing to add in visual realism. Our ultimate goal is to create a realistic representation and visualization of tires rolling on snow and ice to contribute to the multidisciplinary research among vehicle, tire, traffic design communities, as well as computer graphics and animation research communities.

Pseudoknow: a Machine Learning tool for RNA Pseudoknot Detection

Padideh Danaee, Shawn X. Wang, and David Hendrix

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Several algorithms have been developed in the literature to predict well-nested RNA secondary structures (Pseudoknot-Free) with high accuracies. However, most of these algorithms either do not work for RNA with Pseudoknots or the accuracy decreases dramatically. We have developed a Machine Learning (ML) tool to detect possible Pseudoknots in an RNA primary sequence. Determining in advance whether an RNA primary structure has Pseudoknots can help in choosing an appropriate tool for prediction, consequently avoiding misleading results. We extract a set of useful features from all aspects of an RNA primary sequence as the Machine Learning (ML) model inputs. Our high accuracy results from the classification verify that our features selection approach and ML design are indeed a possible solution to the detection of Pseudoknots in RNA structures.

Visualizing Covering Space

Sanaz Golbabaei and Eugene Zhang

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Covering Space is a complicated mathematical concept that is hard to understand without any tools. Having some techniques for visualizing it would help us to get a better understanding of Covering Space. We might all know the mathematics of it, but we do not know the geometry of it very well. In this paper we are presenting a method to visualize covering spaces. Another reason that we think visualizing covering space would help us is that we can use this technique in order to create non-orientable surfaces. Creating non-oreintable surfaces and surfaces with self intersection could get really difficult and tricky and graphics people do not have a defined algorithm to construct them. Along this problem,we are proposing a new technique to cut a mesh open and stitching it back together. We realize that our last challenge is rendering the covering space itself; hence,we are using smoke surface visualization in order to represent covering space.

NNMREC PMEC-SETS Grid Emulator and Wave Energy Resource Assessment

Scott Harpool, Annette von Jouanne, Ean Amon, and Ted Brekken

School of Electrical Engineering and Computer Science

A grid emulator enables the testing of WECs as if they are connected to the power grid, maintaining electrical isolation, while still allowing full control of the testing conditions. While protecting the grid from instabilities, this allows for the testing of grid synchronization and device performance under simulated grid fault conditions. The grid emulator would be installed at the Northwest National Marine Renewable Energy Center (NNMREC) Pacific Marine Energy Center (PMEC) South Energy Test Site (SETS) to allow safe testing of WECs, without potentially damaging impacts to the power grid during the validation phase. The impact on the WECs of various grid conditions can be safely studied, and beneficial information for the permitting phase of future WEC installations can be obtained. The grid emulator provides an emulated grid interface for one or more WECs under test, providing a filtered (power conditioned) path for transferring WEC power to the grid. This is performed using AC/DC/AC power conversion, where four inverters on the WEC side are used to enable increased short duration peak power testing. Energy storage systems could also be integrated in order to smooth the power before delivery to the grid. On November 8th, 2014, two wave monitoring devices, a TRIAXYS surface wave and currents measurement buoy and a subsurface acoustic wave and current (AWAC) instrument, were deployed at the PMEC-SETS to obtain a full year of site characterization data. This research poster will present both the PMEC-SETS grid emulator and the wave energy resource assessment data collected.

The Draft Genome of European Hop (Humulus lupulus var. lupulus)

Steven Hill, David Hendrix, and John Henning

School of Electrical Engineering and Computer Science

The family Cannabaceae is an unstudied clade of the Rosids which contains dioecous plants that are morphologically and genetically different from many other Rosids. For this project, we selected the female variety Teamaker of the agriculturally and medicinally important crop Humulus lupulus. Hop is one of the four primary ingredients in beer and is a major crop in the Pacific Northwest. Hop is a diploid outcrossing plant that can also be clonally propagated through its Rhizome (root). The Hop genome will provide many tools to aid in plant breeding for brewing applications and the anti-microbial properties of Hop. By including a genome wide association study and a complete transcriptome assembly it will be possible to identify and influence the genes involved in the flavoring and aroma of various hop varieties. In addition, Humulus lupulus, Humulus japonicus, and Cannabis sativa are all closely related dioecous plants, in that male and female plants are different. With development of genetic resources for these three plants it will be possible to study the evolution of dioecous plants.

A 3.6 cm^2 Wirelessly-Powered UWB SoC with -30.7dBm Rectifier Sensitivity and Sub-10cm Range Resolution

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In this work, we present a batteryless wirelessly-powered ultra-wideband (UWB) system-on-a-chip (SoC) tag for insect-tracking and internet-of-things (IoT) applications. Tracking the spatial position of miniature objects in three dimensions is important for many applications, such as inventory management and asset tracking. Furthermore, achieving small sensor-tag size and low weight are critical for potential applications such as insect tracking. Currently, typical integrated sensor weight and size are dominated by the weight/size of the battery. RF energy-harvesting from a beacon can eliminate the battery and achieve low-form factor and weight, while providing a robust mechanism for powering the sensor tag. UWB-based transmitters and receivers can provide cm-scale positioning - therefore, combining UWB operation and RF-energy harvesting is attractive for miniature-object sensor tags. In this work, we integrate the RF energy harvester and a UWB-Transmitter SoC in a commercial CMOS process to achieve low sensor costs. Our design approach increases the RF-energy harvester range under the constraints of small antenna size, leading to state-of-the-art >10m range with only 1.3cm^2 antenna area. We have measured the wirelessly-powered SoC along with antennas in typical office environments - We are able to demonstrate a range of 20m in an office corridor, as well as >6m operation inside a conference room. The low-voltage (0.8V) UWB transmitter is capable of achieving sub-10cm range resolution for IoT positioning applications.

Realtime Power Flow Estimation on Oregon State University Campus using Phasor Measurement Units

Janhavi Kulkarni and Ted Brekken

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A Phasor Measurement Unit (PMU) is an instrument for measuring electrical grid voltage and current magnitude, phase and frequency in real time with high resolution. When PMUs are installed at critical points in the electrical grid, they can provide data about grid status and stability at a much higher rate that has been historically available. But it is impractical to install PMUs at each of the thousands of nodes that make up a large power grid. The goal of this Bonneville Power Administration (BPA) funded project is to utilize sparse deployment of PMUs to obtain the realtime measurements and estimate the power flow on the Oregon State University (OSU) campus. The first step towards power flow estimation is to perform a set of power flows of the entire campus consisting of 286 buses to build a library and have the load composition in terms of industrial, residential and commercial, prior to the installation of the PMUs. With the limited number of PMUs, the measurements obtained provide incomplete observability of the system and in order to determine the complete power flow on the campus, we use the concept of Singular Value Decomposition (SVD). SVD is a technique most commonly used for data reduction and similarity matching. This work demonstrates the implementation of SVD- to obtain an accurate power flow model of the OSU campus in terms of industrial, residential and commercial load at realtime using the PMU measurements.

Symmetry Based Design of Effective Tire Tread Patterns

Prashant Kumar, Eugene Zhang, and Yue Zhang

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Tires are the only contact between the vehicles and the roads. Much design effort is required to produce optimal performances under various driving conditions. Automotive industries invest significant resources to create and refine tread patterns that meet aesthetic and functional standards. Most of the final designs show strong symmetry patterns that inspired the current research, i.e., developing a software that allow the representation of well known plane symmetry groups that are prominent in architecture and decorative art on torus shapes like tires. The aim of this tool is to first allow design freedom for drivers and consumers with no engineering background to personalize their tire tread patterns and then to model and calculate tire footprints on grounds to analyze functional effects such as contact area and non-skid depth that are key to tire traction and wear.

Software Engineering for Humans

Sandeep Kuttal

School of Electrical Engineering and Computer Science

End users with little formal programming background are creating software in many different forms, including spreadsheets, web macros, mobile applications and web mashups. End-user programming environments allows end users to create programs, but end users still face various programming barriers due to lack of software engineering support in these environments. One source of support known to be beneficial for professional developers with their programming ventures is variation management. Variation management deals with managing program variants over time and space. We believe that by leveraging variation management we can help end users with programming tasks, including program exploration, program understanding, verification and debugging. This research intends to provide novel ways of integrating variation management into the existing work flow of end users and help them create programs more effectively and efficiently. To leverage the benefits of variation management, we added support for versioning to a web mashup environment. The analysis of two user studies revealed that the versioning support helped study participants by reducing learning barriers, helping them reuse parts of pipes, and improving their debugging performance. The results of our studies underscored the need for debugging support in mashup programming environments. This motivated us to classify the faults found in mashup environments and create automatic fault detection mechanisms for localizing faults. We also added support for feedback to help mashup programmers locate and fix faults efficiently and effectively. Our study shows that our debugging support helped end users effectively and efficiently locate and fix faults. Further, analysis of results from an Information Foraging Theory (IFT) perspective helped us better understand the foraging behavior of end users. Based on our analysis, we developed a model and offered recommendations for designers and practitioners. To leverage the full benefits of variation management and explore the generalizability of our approaches, we added variation over space support to an Android mobile application development environment. Analysis of our study results revealed that our support helps end users with their reuse and exploration tasks. The study also helped uncover new design requirements for variation management support systems.

Acoustically Assisted Magnetic Recording

Weiyang Li, Albrecht Jander, and Pallavi Dhagat

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We have developed a new paradigm of magnetic recording technique, acoustically assisted magnetic recording (AAMR). It addresses the need for inexpensive and reliable memory to store ever increasing information being generated by users and systems worldwide. It uses the idea of employing strain effected by surface acoustic waves to temporarily "soften" magnetically hard media at the time of recording information, and then removing the strain to restore hardness for ensuring long-term stability of the recorded information. In break-through results, we recently demonstrated proof-of-principle of this technology and now, in partnership with industry, are seeking to advance it towards a practical device. The experimental device is fabricated on a piezoelectric quartz substrate, consisting of a pair of interdigitated transducers for surface acoustic wave generation. Galfenol, a high magnetostriction material, is deposited onto the acoustic path serving as the recording medium. The acoustic waves strain the galfenol film as they transit and lowers its coercivity by up to 60%. In the proof-of-principle experiment, otherwise unwriteable with preset writing field, data tracks are successfully recorded in the medium while applying acoustic waves. The medium becomes writeable at progressively smaller writing field as the acoustic power is increased. In additional experiments we demonstrate that acoustic waves can be focused with a spot size around 3 micrometer to selectively write a bit on the recording medium.

An Artificial Intelligence for PMU Data Streams

Benjamin McCamish and Eduardo Cotilla-Sanchez

School of Electrical Engineering and Computer Science

Phasor Measurement Units are becoming more prevalent throughout the electrical grid. PMUs have the ability to gather information of the grid around their locations such as Voltage and Phase Angle. We are installing a PMU network on the OSU Campus that is capable of sending data at 60Hz. We will be analyzing the limits of data transfer between the PMU/PDC and other algorithms using the PMU data. The method we are developing will be able to send data to these algorithms in real time, determining how much data they need to make an accurate evaluation and whether they can receive the data on time, accounting for losses and the physical limitations of the PMU and the network. These decisions will enable us to know given certain network restriction how accurate the results of the other algorithm will be at any given time while trying to maximize this accuracy be sending the appropriate data.

A Policy-Switching Implementation for Automated Power System Emergency Control and Decision-Making

Rich Meier, Jesse Hostetler, Eduardo Cotilla-Sanchez, and Alan Fern

School of Electrical Engineering and Computer Science

In today's operation of the electric power system there is a significant threat of large cascading outages due to both exogenous (natural phenomena, cyberattacks, etc.) and endogenous (congestion, variable supply, etc.) factors. Costs associated with extended recovery times, complex repairs and maintenance, demand-side production halts, and even societal and political fallout compel power system engineers to mitigate these occurrences. Unfortunately, an advanced methodology for automatically responding to network contingencies is not available to support operators in decision-making and implementation of Remedial Action

Schemes (RASs). This work proposes and investigates policy switching in the context of automated power system outage prevention both during and after a contingency. Fundamentally, policy switching selects and begins executing the RAS policy that exhibits the best performance according to Monte-Carlo simulations. However, rather than simply choosing and executing a single RAS this approach may switch between multiple policies depending on the specific way that the grid system evolves. Thus as time progresses, policy switching provides a prescribed, algorithmic methodology for selecting RASs while still maintaining strong performance guarantees. The algorithm is first demonstrated on a small 39-bus topology. Then, in order to show scalability and applicability to real-world power networks, time-domain simulation and experimentation, using Siemens PSS/E, is performed on a dynamic model of the Polish power system (≈ 2300 buses). The results confirm the potential for using this algorithm as an automatic decision framework for emergency protection and control on real power system networks.

Multi-Style Rendering of 3D Shapes Using Pen-and-ink

Botong Qu and Eugene Zhang

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We described three main Non-photorealistic Rendering (NPR) methods including Hatching, Stippling and Scumbling, Which all own the properties of efficiency and product compelling rendering result. That means all these methods could applied on real-time render researches and applications. Hatching and Stippling methods have been a hot spot for decades, which we will only abstractly introduce the main ideas and improvement applied in this paper. However, the scumbling, which uses spiral curves instead of streamlines to render the shadow, introduced in this paper is a novelty and heuristic research topic. At last, we also provide a multi-style rendering application provide interactive from users to create artistic desirable NPR results, which could combine the Hatching, Stippling and Scumbling Rendering at the same real-time rendered picture.

Where Do Experts Look While Doing 3D Segmentation

Anahita Sanandaji,[1] Cindy Grimm,[2] and Ruth West[2]

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3D Image segmentation is a fundamental process in many scientific and medical applications. Even for an expert, the process of manual segmentation is still laborious, time consuming, and prone to errors. Previous research has focused on how to create effective automatic and interactive segmentation tools, with some success. Unfortunately, current 3D segmentation design and evaluation methods pay little attention to the role of humans, their mental models and how they perform low-level tasks and define the higher-level criteria while doing 3D segmentation. We believe that by studying the users and determining the perceptual and cognitive tasks of 3D data segmentation, we can improve the process both in terms of efficiency and accuracy. As a preliminary step we conducted a field study over four different participants, ranging from a few months to many years of experience in 3D segmentation. By studying video and eye tracking data of the participants, we developed a novel taxonomy and coding scheme to describe where experts are looking and what their low-level tasks and actions are while doing 3D image segmentation. Initial results show that participants have two different strategies for segmentation: Region-based and boundary-based. The next step for this study is to investigate whether these results can be generalized to a broader range of subjects doing segmentation.

Visualizing Large Medical Data Sets on Memory Constrained Mobile Devices

Chris Schultz and Mike Bailey

School of Electrical Engineering and Computer Science

Graphics hardware in mobile devices has become more powerful, allowing rendering techniques such as volume rendering to be done at interactive rates, giving desktop capabilities combined with the portability of a tablet. Volume rendering often requires large amounts of memory, depending on the discipline and the data to be visualized. In medical imaging, volume datasets can be around 2-4 gigabytes of data for an MRI or CT scan. Tablets on the market today contain from 1 – 3 gigabytes of memory, which will either barely meets or is below the memory limit required by such datasets. This memory limitation would require data handling such as dividing the data into chunks or downsizing the data, neither of which are acceptable. Viewing certain chunks of the data at a time requires us to load each separate data chunk into the rendering algorithm and thus would give poor performance. Downsizing the data would allow the data to fit, but at the cost of losing potentially useful information. This research project provides a method that allows for the entire dataset to be visualized while maintaining the integrity of the data. It combines both downsizing and data division to create an experience that allows the user to view the entirety of the dataset at once or zooming in on the detailed areas. Future work includes investigating how this method scales up into larger machines, such as more powerful desktop systems and servers, and dealing with much larger data sizes.

Mode Surface Extraction Using A-Patch

Ritesh Sharma and Eugene Zhang

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Finding isosurface inside a 3D Geometry is one of the difficult task in Computer Graphics and it becomes even tougher when the isosurface is defined by a polynomial of degree greater than two. The most commonly used method for isosurface extraction is marching cube or marching tetrahedron. But these method without any modification cannot extract surface defined by polynomial of higher degree. The mode surface is the isosurface defined by the mode value of a 3D Symmetric Tensor. The algebraic function for finding mode surface is defined by a polynomial of degree six. Since the general method cannot be used to extract the surface of polynomial of degree greater than two, we propose A-Patch method to find the mode surface. A-Patch is a Bernstein representation of an algebraic surface defined over a simplex. In this method, the weights (mode of a tensor in our case) at the grid points of a simplex is checked to determine existence of the surface. If the surface is found, the simplex is tessellated and then root finding algorithm is used to find the mode surface inside the simplex. If the surface cannot be found, the simplex is subdivided into smaller simplexes and then the method is repeated. The main advantage of A-Patch is that it insures the existence of a single sheet inside the simplex.

Laboratory Validation of a Wave Energy Converter Simulation Tool

Asher Simmons and Ted Brekken

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WEC-Sim Version 1.0, released in Summer 2014, is an open-source wave energy converter (WEC) development tool capable of simulating devices with arbitrary geometries subject to operational waves. Custom library components, developed in Mathworks SimMechanics platform are used to model WECs as a combination of rigid bodies, joints, and linearly damped power take-off (PTO) and mooring systems. These components contain hydrodynamic parameters that are imported from the results of boundary element method (BEM) simulations. WEC-Sim 1.0 features were initially validated against data created during the DoE Reference Model, and proved the basic functionality and tool utility. However, there are tool features that are incompletely validated due to limitations with the original data sets. The limitations, including lack of data and data confidentially, have prompted additional work aimed at creating a complete and public data set. The experiments needed to gather the validating data will be performed in the Hinsdale Wave Research Laboratory (HWRL) with the help of researchers from Oregon State University (OSU). One of these features will then be used as an example to illustrate the experimental validation process. Experimental considerations, such as equipment selection, statistical analysis, and model development will be discussed. Procedures for ensuring data quality and applicability will be explained, and the utility of the verification data will be addressed. The poster will conclude with plans for future work and a general discussion of the utility of the work in the field of wave energy conversion.

Models of Editing

Karl Smeltzer, Xiangyu Wang, and Martin Erwig

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Software development requires developers to not only create new code, but also to edit existing code. These changes are sometimes complex and can involve undoing or redoing previous edits in nonlinear ways. Development tools such as version control systems and editors, however, often enforce a linear history of edits, or else require manual intervention to disambiguate dependencies among them. This mismatch can lead not only to unnecessary work on the part of the developer, but also to a loss of potentially useful information about the history of changes made to the code. We present ongoing work on a general editing model to support the systematic study and comparison of different editing regimes found in practice and to support more general editing operations such as selective undo and redo, as well as a new form of undo, the partially selective undo.

Development of PTO-Sim: A Power Performance Module for the Open-Source Wave Energy Converter Code WEC-Sim

Ratanak So

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Sandia National Laboratories (SNL) and the National Renewable Energy Laboratory (NREL) have collaborated to develop WEC-Sim (Wave Energy Converter-SIMulator), an open-source wave energy converter (WEC) code capable of simulating WECs of arbitrary device geometry subject to operational waves. The code is developed in MATLAB/Simulink using the multi-body dynamics solver SimMechanics, and relies on Boundary Element Method (BEM) codes to obtain hydrodynamic coefficients such as added mass, radiation damping, and wave excitation. WEC-Sim Version 1.0, released in Summer 2014, models WECs as a combination of rigid bodies, joints, mooring systems, and a power take-off (PTO) as a simple linear damper. A collaborative effort between SNL and the Energy Systems group at Oregon State University (OSU) has resulted in the development of PTO-Sim (Power Take Off-SIMulator), the WEC-Sim module responsible for accurately modeling a WEC's conversion of mechanical power to electrical power through its PTO system. This poster outlines the development of PTO-Sim which consists of a Simulink library of PTO component blocks that can be linked together to model different PTO systems. Two different applications of PTO-Sim such as a hydraulic PTO system model and a direct drive PTO system model will be illustrated in this poster. Hydraulic PTOs are one of the most popular PTO systems used in wave energy devices. The main advantage of using a hydraulic system is the inherent energy storage capability. Alternative to hydraulics, direct drive PTOs have less moving parts which allow a generator to capture power directly from the WEC movement.

Dynamic Modeling of Cascading Failure in Power Systems

Jiajia Song and Eduardo Cotilla-Sanchez

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Recent blackout events consistently show that a variety of mechanisms are involved in cascading outages. These cascading mechanisms are irregularly modeled, simulated, and validated within the existing literature and industry practices. Understanding the relative significance of these different mechanisms is important for choosing which mechanisms need to be modeled for particular applications. In this work, a cascading failure simulation model that captures fundamental dynamics of power networks and protection systems was developed in order to evaluate the usefulness of dynamic models for cascading outages. The results from a batch of N-2 contingency simulations reveal that the distributions of blackout sizes and event lengths from the proposed simulator correlate well with historical trends. In addition, we compared the new model with a quasi-steady state (QSS) model and found that the wider set of dynamic cascading mechanisms are critical in the definition of later stages of the cascades. However, the early stages of cascades show similar paths independently of the relative number of mechanisms implemented. The proposed model also allows one to test the impact of different load and protective device assumptions on cascading failure risk.

Increasing Power Capture from Wave Energy Conversion Systems using Model Predictive Control

Mike Starrett and Ratanak So

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This study presents an advanced control scheme capable of significantly increasing power production from wave energy conversion (WEC) systems. This control scheme is built upon a Model Predictive Control (MPC) framework and is capable of optimizing power capture while also respecting machine constraints (e.g. velocity, maximum force, etc.). It is applicable to any WEC (or array thereof) equipped with a power take off (PTO) which can deliver power — as opposed to absorbing alone — and it can be applied both in simulation and production. Results from this study show that improvements in average power capture of up to 500% vs. passive damping are possible without exceeding reasonable machine constraints. These results were obtained in simulation using an array of five representative WECs in a realistic sea state.

Virtual Dog Head: Using 3D Models to Teach Complex Veterinary Anatomy

Matt Viehdorfer,[1] Sarah Nemanic,[2] Serena Mills,[2] and Mike Bailey[1]

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This research project brings engineering computer graphics visualization and interaction to bear on a problem in medical science, in particular, veterinary medicine. Current veterinary academic programs utilize traditional means of teaching: the presentation of textual information, images with labeled structures, and dissection. This work presents a new means of interactive learning through the incorporation of 3-dimensional computed tomography (CT) scan generated models of the larynx and hyoid apparatus in dogs using OpenGL and the Oculus Rift. Data was generated by scanning a dog cadaver with an advanced computed tomography (CT) machine owned by Oregon State University's College of Veterinary Medicine. Raw scans were loaded into Vitrea, an imaging and analysis suite for medical data. Vitrea generated 3D polygonal surfaces for each structure that were finally converted into OBJ format. Within the program a trainer loads, labels, and positions anatomical models for a structure. They then export a scene file that defines the models, labeling and connection parameters, and the next sequential scene. Students begin by identifying individual structures within an apparatus. Once they are correctly labeled, students manipulate each structure to build the complete apparatus. When objects are within a predefined distance and degree of rotation from connecting objects they snap together and share further transformations. Added support for the Oculus Rift and controller-based input devices enables a greater degree of immersion to further enhance learning. These stereoscopic views allow students to better understand the 3D spatial relationships of separate and assembled structures that will translate to real world procedures.

SensorStream: A Distributed and Scalable Data Acquisition, Archival, and Analysis System

Alex Wiggins, Nels Oscar, and William Dillon

School of Electrical Engineering and Computer Science

As the Internet of Things and remote data sensing technologies advance, a persistent question is how to enable storage and analysis of the data collected by a large volume of heterogeneous end-points. This work examines a distributed web protocol based client-server architecture for enabling ad hoc data acquisition and near real time analysis. In addressing this problem, there are additional constraints that considered — including client side software stack and capabilities, data storage structures, and data retrieval and monitoring. Given the temporal nature of most sensor data, we primarily address temporal data, and support for near real time access and monitoring via standard protocols. This architecture is able to handle arbitrary or user-defined data types and supports scalar and multidimensional data including image and video data. Scalability is a primary goal for this pipeline allowing for data collection, distribution, an analysis for networks ranging from a handful sensors to thousands of sensors in order to accommodate the current explosion of remote sensing devices. This architecture enables myriad applications from end-user visual analytics tools for home monitoring or quantitative self-applications, to scientific data collection, or even data center asset monitoring.

SCHOOL OF MECHANICAL, INDUSTRIAL, AND MANUFACTURING ENGINEERING

ATRIAS: Robotic Agility in an Uncertain World

Andy Abate and Jonathan Hurst

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Legged locomotion in our dynamic world is the key to enable robotic search-and-rescue in dangerous environments and surveillance in mines and underneath forest canopies where UAVs cannot see. The ATRIAS bipedal robot is designed specifically to work in the real world; by including compliance in the legs to passively smooth out disturbances, just like the compliant structures seen in biology, we allow robust operation in a way which is unattainable by classical rigid robots.

Developing a Comprehensive Emergency Management Model

Sami Al-AbdRabbuh and Ken Funk

School of Mechanical, Industrial, and Manufacturing Engineering

The purpose of this study is to evaluate usefulness of proposed model in understanding emergency management functions for a comprehensive categories of hazards. A model have been developed and validated through subject matter experts. The validation process was conducted to evaluate if the model is an accurate representation of emergency management processes and if the model can be useful for training. Finally, the study proposes a utilization for the model in developing training needs analysis.

Grasp Quality Prediction using Machine Learning Algorithm

Sai Krishna Allani and Ravi Balasubramanian

School of Mechanical, Industrial, and Manufacturing Engineering

Mechanical hands were developed to give robots the ability to grasp objects of varying geometric and physical properties. Even though hands are designed with great dexterity, they fail to grasp objects precisely. In order to improve grasping, we present a novel approach of grasp quality prediction where we use Gaussian process technique using Takktile sensors data to predict grasp quality. After collecting grasp data (700 grasps), we fed this data into machine learning algorithm, where it used techniques like Gaussian-process classification, Principle Component Analysis, T-test to remove noise and classify between good and bad grasps. After running the algorithm we have seen a significant improvement in grasp quality prediction. Specifically, the algorithm is able to predict good grasps at a true-positive rate of 77% TRP at a 20% false positive rate.

Using Molecular Fingerprinting to Infer Dynamic Function

Ryan Arlitt

School of Mechanical, Industrial, and Manufacturing Engineering

Metal Organic Responsive Frameworks (MORFs) are a theoretical type of material that can change their shape and porosity in response to light. These materials combine Metal Organic Frameworks (MOFs) with photoisomerizing materials to produce new materials that behave as stochastic linkages. However, it is a significant challenge to computationally identify MORFs that are both feasible and useful. The work presented in this poster is part of a project to develop a framework for the systemic invention (as opposed to discovery) of new MORFs. This framework will iteratively generate new candidates, evaluate their properties, and then guide the generation of the next set of candidates. The result of this iterative generation process will be a rough map of the types of structures, substructures, and behaviors in the MORF design space. A material designer could then leverage this knowledge to generate structures or substructures with specific functional goals in mind. To further this goal, this poster addresses the challenge of computationally guiding the generation of candidate MORF structures into high-value areas of the search space. Molecular fingerprinting (used frequently in de novo drug design) is a structural representation that enables fast screening and clustering of molecules, but it is unknown whether this representation is useful for predicting functions that result from dynamic behavior. Using electromechanical product data from the Design Repository, it is demonstrated that these fingerprints can be used to infer function information from purely structural information, supporting their use as a screening and clustering technique in MORF design.

Customer Needs Extraction for Inclusive Product Design

Jessica Armstrong

School of Mechanical, Industrial, and Manufacturing Engineering

This NSF supported project, referred to as KINdReD (Knowledge and Methods for Inclusive Product Design), is meant to develop inclusive product design guidelines. Inclusive design specifically for products has not yet been adequately addressed. The poster contains some information on why inclusive design is important, the challenges faced in applying this to product design and the methods we are using to attempt to address this gap. A lot more information is needed about the customer needs of people with disabilities for products. We are studying disability simulation as a means of collecting this information more easily. We have designed a disability simulation suit and are running tests to determine its validity as both a data gathering and empathic design tool. The poster presents some first run results addressing the suit's usefulness and the overall research hypothesis of using modular design techniques for inclusive product design as well as future plans for project expansion and application.

A Theoretical Framework for the Design of an Energy Analysis Collaborative Structure Using Soft System Methodology

Tanida Chongvilaiwan, Javier Calvo-Amodio, and Joseph Junker

School of Mechanical, Industrial, and Manufacturing Engineering

The objective of this project is to present a methodology for exploratory survey design and analysis through the use of Systems Thinking. The methodology is presented through a case study to explore the strategic design of an organizational structure to assist E3 (Economic, Energy, and Environment) practices and principles. The identification of beliefs, motivators, and barriers to work with project stakeholders are the main constructs of the survey. The survey was designed and questions generated using CATWOE and DSRP analysis tools. Results of the survey are presented after being applied to the potential technical assistance partners in E3 program. After analysis the necessary information to formulate useful network relations and possible solutions to the E3 program is presented. This information will assist researchers to understand the current state and baseline requirements regarding beliefs, motivations, and barriers in order to conclude the future state model. The results of the survey will be used to develop a theoretical framework for the design of an energy analysis collaborative structure using Soft System Methodology (SSM). The result of theoretical framework should assist the collaborative leaders to perform a systemic analysis of process to improve internal communication through the understanding of social, psychological, and cultural perspective of each stakeholder. The resulting model will help engineering managers confronted with the creation and management of collaborative efforts on key aspects to observe.

In Search of Sustainability

Scott Campbell

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Environmental impacts (population x affluence x technology) are increasing as the world's population increases, and economies in large population countries such as China and India grow. Serious consequences await if things continue status quo — scarce resources cannot support the entire world's population at an affluence level to which Americans are accustomed. One solution to this problem is to cap affluence — reduce people's expectations of living standards. This will likely be imposed due to lack of resources if the status quo continues. Another approach is to find better use of resources. Sustainability can be achieved if products can be made that: enhance the user's standard of living; are made from renewable resources; and comfortably support those in the supply chain. This research is an investigation to a see if a particular product (wooden bicycle frames) can meet these criteria. As a first step, a comparative LCA was performed to determine the relative impacts of wood and steel bike frames. GaBi software was used with emphasis on the early life cycle phases (resource extraction to raw frame material). Assumptions include that steel was produced in China and wood was produced in the Pacific Northwest. Results clearly show that impacts of steel bike frames are hundreds of times that of wood in impact areas of GWP and resource depletion. Future work includes: refining LCA to more accurately convey impacts in manufacturing and use phases; structural analysis to determine if wood is an appropriate material for bike frames; develop manufacturing methods to support the supply chain.

Investigating the Use of Deep Structure and Surface Features to Represent a Problem in an Authentic Process Development Task

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Problem solving is an important skill for successful engineers. When engaging in problem solving activity, the solver has to construct a "problem representations" from the basis of his or her domain related knowledge and its organization. There are multiple reports stating that problem representations are constructed from the "deep structure" and "surface features" of the problem. However, there are few studies on how engineering experts construct their problem representations from "deep structure" and surface features" in a novel problem. In this study, we examine transcripts from three expert engineering teams comprised of members with varying background knowledge and experiences. Each team engaged in an authentic process development project to develop a semiconductor process to satisfy new device specifications. Transcripts of team meetings prior to proposing an experimental approach were examined. Each utterance was examined and coded for the presence of deep structure and surface features. The results showed that the chemical engineering team with extensive industrial experience constructed their problem representations mainly from the deep structure of the problem. The second chemical engineering team with extensive academic experience used deep structure when constructing their problem representation. However, their construction process was not as fluent as the first chemical engineering team. On the contrary, the industrially experienced mechanical engineering team constructed their problem representations mainly from surface features of the problem because they didn't have the knowledge on the phenomenon that occur inside the chemical reactor.

As Autonomous As Possible: POMDPs for Risk-Aware Reinforcement Learning

William Curran, Cameron Bowie, and William Smart

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Autonomous approaches are effective, but do not work in every environment. Autonomy suffers in situations when computer vision fails, or when the learned task is too dissimilar to the current task. Knowing the risk of using an autonomous or alternative approach is important when deciding how to perform a task. In this work, we introduce A^3P, a risk-aware task-level reinforcement learning algorithm. A^3P represents a task-level state machine as a POMDP. In this POMDP tasks are states and approaches are actions. Failures are represented in the learned solution as additional state-action pairs, allowing the user to make more informed decisions when choosing between different approaches. We demonstrate A^3P in a corridor domain problem and test the true learning distributions to the learned. We find that A^3P learns an accurate and risk-aware policy for the corridor problem domain.

Laboratory for Robotics and Applied Mechanics

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Controlling unique dynamic systems through an understanding of their fundamental dynamics is the unifying theme of the LRAM group here at OSU. We study wildly varying phenomena, from the undulations of the sand-swimming lizard, Scincus scincus, to the acrobatics of the jumping spider. Through examining these systems' underlying principles of motion we can create unique and powerful methods of locomotion and manipulation, further evolving the field of robotics. For instance, to understand the motion of a sand swimmer, we examine a three-link system in a granular media. We consider the different shape velocity and shape change of the system to find the optimized gait based on minimum power consumption. By understanding the fundamentals of the motion for this three-link system, we gain a powerful understanding of similar systems like snake robots and sand swimmers. Our other work has been focused around casting manipulation and takes the form of two projects. The first entails understanding the dynamics around the rebound of a tethered projectile. Our second project seeks to explore the dynamics of throwing and wrapping a tethered projectile around a cylindrical target. To this end we have created robots for exploring these fundamental phenomena.

The Effects of Heat Treatments on Blade Performance Characteristics

Cody Fast, Sidi Lian, Hector Vergara, David Kim, Martin Mills, and Julie Tucker

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Knife blade performance is affected by several characteristics including, but not limited to, the cutting edge geometry and surface finish, the bevel geometry, the blade profile, and the parent material properties as well as the heat treat parameters used. In this project, the effect of changing heat treating parameters of CPM-M4 steel, a common knife blade material, was studied. The project objective is to better understand how knife blade steel heat treating parameters can be controlled and subsequently optimized to enhance specific knife blade performance features, such as edge retention, edge strength, and corrosion resistance. The approach utilized will be experimental and will utilize hardness, impact toughness, 3-point bend, and CATRA tests to characterize knife blade performance, as well as scanning electron microscopy (SEM) to characterize the alloy microstructure. The knowledge and data generated in the project can then be utilized to evaluate the ideal heat treatment combination for a given set of desired knife blade properties. Based on the heat treatments studied, a treatment using lower austenitizing and tempering temperatures proved most ideal, producing average values for hardness and edge retention and slightly decreased performance in the 3-point bend test but with a significant increase in the impact toughness of the steel.

Reverse Engineering Informed Model Selection for Design Optimization

Tim Foglesong, John Parmigiani, and Rob Stone

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Reverse engineering is generally used for benchmarking or to reveal the design decisions made to accomplish the given task. Part of this information extraction process is a planning stage during which the difficulty of extracting design information is calculated. If extracting such information is necessary to perform a numerical optimization, then these reverse engineering calculations can be used to determine which quantities are most economical to obtain and, as an extension, which numerical model will require the lowest cost (time and resources) to implement. The poster presents a framework for applying reverse engineering planning calculations to model-based design optimization. The application of this framework is illustrated with an 'artifact-only' optimization, based on the university-industry collaboration project which inspired this research. This specific optimization is based largely on reverse engineering, and aims to optimize a product about which no quantitative design knowledge exists; the numerical values behind the design, specifically spring and damping values of the dynamic components, are not documented. The goal of this optimization is to maximize redesign benefit with minimum change to the current design. This goal suggests a simple model with detail focused on the most important dynamic components, which are likely to be where the highest impact design improvements can be made.

Autonomous Modeling and Control of Advanced Hybrid Power Generation System

Andrew Gabler, Mitchell Colby, and Kagan Tumer

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Increasing demands for energy are driving development of new technologies for power generation with high efficiency. Direct fired fuel cell turbine hybrid systems are one new development which promise to drastically increase plant efficiency, lengthen fuel cell lifetime, respond to transient loads quickly, and offer quick start up times. However, such systems are notoriously difficult to control as non-linear dynamics, coupled control variables, and inaccurate, incomplete models limit the applicability of traditional modern control techniques. In this work, we use evolutionary algorithms to train a non-linear neural network controller for the power plant. The key to this work, is the simulator derived from real plant runs, which allows us to assign fitness to controllers based on their performance in the plant. The simulation runs much faster than any current model of the system, thus we can evaluate the many controllers involved in the evolutionary algorithm without the prohibitive run-time required by other methods or costly live power plant experiments.

Spinodal Decomposition and G-Phase Formation in Duplex Stainless Steel

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Due to the increased presence of duplex stainless steels (DSS) in power generation systems, more extensive research is needed in determining the relationship between DSS embrittlement and high temperature aging conditions. Thermal embrittlement in DSS is caused by the spinodal decomposition of the ferrite grains resulting in α-α’ separation. The resulting chromium-rich and a chromium-depleted regions lead to a loss in toughness in the ferrite grains. Additionally, a precipitate called g-phase will form after aging in some alloys. The purpose of this project is to determine the effect on spinodal decomposition and g-phase formation that can be induced by varying the compositions of alloying elements in various alloys. This was quantified through impact toughness testing as well as hardness testing for various alloys subjected to different aging conditions. Additionally, Atom Probe Tomography was utilized in order to quantify changes in material microstructure.

A Unifying Methodology for Sustainability Assessment of Manufacturing Processes

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In spite of the recent advances in sustainability assessment, design and manufacturing engineers must apply assessment methods and tools in an ad hoc manner. This not only increases the engineering time but also limits the utility of the assessment results. An integrated methodology and practical approach to sustainability assessment is reported. The approach combines the upstream process data along with the models of in-house manufacturing processes to conduct cradle-to-gate product sustainability assessments. By linking individual manufacturing process models to represent a sequential process flow, assessments can made to support decisions at the product, process, and supply chain level. The utility of the approach is demonstrated using a software prototype tool developed to assist the design for manufacturing efforts for an aeronautical metal product assembly.

A Transit Stop Location Methodology to Optimize Accessibility

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The location of transit (i.e., bus) stops has a large influence on the efficiency of a transit system. When locating transit stops, several factors need to be accounted for such as stop spacing, transfer points, safety, and service area, to name a few. One of the main difficulties in locating transit stops is considering the effect of walking distance on stop location. The main challenge in this area is to determine feasible walking distances that represent a valid walking path across the street network. In this paper, a methodology that focuses on optimizing people's accessibility to transit stops is presented. The key contribution of this methodology is a newly developed facility location algorithm, which is able to find the optimal location for every transit stop based on the shortest walking distance. The methodology relies entirely on open data sources such as the General Transit Feed Specification, census data, and map data available to developers for the continental United States and most other countries in the world. As a case study, the urban area of the city of Corvallis, Oregon, was used to demonstrate the feasibility of the methodology.

Integrated Intermodal Logistics Network Design

Mohammad Ghane Ezabadi and Hector Vergara

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In intermodal freight transportation, at least two different modes of transportation are used to move freight that is in the same transportation unit (e.g., a shipping container) from origin to destination. An important strategic planning decision related to intermodal freight transportation is the design of an intermodal logistics network. An intermodal logistics network is formed by the collection of physical locations used for transferring freight loads from one transportation mode to another; and the connections between these physical locations based on the transportation modes that are available at each one of them. While intermodal logistics network design is a strategic planning decision, it has interactions with other tactical and operational level decisions. Therefore in this research, the hub location problem was integrated with the freight load routing and the transportation mode selection problems in a single mathematical model to design logistics networks that are optimal under several limitations and more applicable in practice. Two different mathematical formulations were developed for this problem; an arc based formulation and a route based formulation. The arc based formulation

proved to be intractable for large size problem instances and a heuristic method that combines both a genetic algorithm and the shortest path algorithm was developed to solve the problem in reasonable times. Alternatively, composite variables were used to improve tractability given a route based formulation. In this case, optimal solutions for non-trivial size network problems were obtained in reasonable time applying a decomposition algorithm.

Particle-Resolved DNS of Turbulent Oscillatory Flow Over a Layer of Fixed Particles

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Particle resolved direct numerical simulations are performed using fictitious domain approach (Apte et al., JCP 2009) to investigate oscillatory turbulent flow over a layer of fixed particles representative of a sediment layer in coastal environments. Five particle Reynolds numbers in the range, Re_D = 660 to 4240 are studied and results are compared against available experimental data (Keiller & Sleath, JFM 1976). Flow is characterized in terms of coherent vortex structures, Reynolds stress variation, turbulent cross-correlations and PDF distributions. The nature of the unsteady hydrodynamic forces on particles and their correlation to sweep and burst events is reported. The net lift coefficient remains positive over the cycle and is well correlated with phase averaged near-bed velocity. Maximum in the lift coefficient occurs when the strength of the horseshoe vortices is maximum. At this phase the lift fluctuations are correlated negatively with pressure and positively with velocity fluctuations in the region above the particle bed. Statistical analyses show that the near-bed velocity and pressure fluctuations fit poorly with Gaussian distributions. Instead, a fourth order Gram-Charlier distribution model is proposed that may have consequences on the Gaussian descriptions of sediment pick-up functions typically used in quantification of turbulent transport of sediment particles.

Direct Numerical Simulation of Flow in Porous Media

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Porous media flows have been emerged to be very influential and widely used in diverse scientific researches, as well as industrial and environmental disciplines in recent years. In this study, DNS (direct numerical simulation) of flow through two different geometry porous media is performed using a fictitious domain approach [Apte et al, J. Comp. Physics 2009]. The first case was conducted in a randomly packed bed using uniformly sized spherical particles at Reynolds number of 3.47. Detailed comparison of the numerical simulation with experimental measurements are presented by attention paid to the statistical distribution of velocities, and their deviations. The axial velocity results are within 12 percent and the normal velocity within 9%. The second case simulates the flow through a 3D, periodic, face centered cubic (FCC) unit cell geometry at Reynolds number of 300 and 950. This low porosity arrangement of spheres is characterized by rapid flow expansions and contractions, and thus features an early onset to turbulence. The results are used to investigate the structure of turbulence in the

Eulerian and Lagrangian frames, the distribution and budget of turbulent kinetic energy, and the characteristics of the anisotropy of the flow in complex packed porous media. Specifically, the data generated is being used to understand the important turbulence characteristics in low porosity packed beds of relevance for heat transfer applications in chemical/nuclear reactors.

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Restoring Hand Function By Designing Implantable Artificial Tendon Networks

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With the goal of advancing hand function following tendon-transfer surgery, we investigate the design of implantable artificial tendon networks for attaching muscles to tendons. The key idea is that the implanted artificial tendon network will enable the scaled distribution of forces and movement from one muscle across multiple tendons, leading to better hand function for the patient when compared with the current practice of using sutures for connecting the muscle to the tendon(s). For example, in the tendon-transfer surgery for restoring finger flexion following median-ulnar nerve trauma, the suture is used to attach one wrist muscle to all four finger flexor tendons. This results in a coupling of the movement of the fingers, which adversely impacts hand function in fundamental physical interaction tasks such as grasping since the fingers cannot individually conform (adapt) to the object's shape during grasping. This procedure is one of the most common tendon-transfer surgeries and is used as an exemplar in this work. We have recently shown through biomechanical simulations that using an implantable artificial tendon network to connect one muscle to multiple tendons significantly improves hand grasping capability. Specifically, the tendon network enables the fingers to adapt naturally to object shape to create multi finger power grasps at lower actuation forces when compared with the suture-based procedure.

Experimental Validation of Design-Stage Function-Based Failure Analysis

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For many complex systems, a risk informed approach to design is critical to assure both robust safety and reliability. By exploring the functional effect of potential failures, designers can identify the preferred architectures and technologies before detailed physical behavior is known. A few research methodologies have been developed to support this design-stage analysis. However, the abstraction necessary for design-stage implementation leads to challenges in validating the analysis results. There is yet no formal scientific approach for validating the prediction of early functional failure analysis. Presented here is initial work in the development of an experimental testbed and exploration of the metrics that can be used as a validation framework for function-based failure analysis. Specifically, the potential functional losses of a robotic arm are compared with experimental findings of the same failure scenarios. In this preliminary work, several of the challenges of simulation validation are presented and potential metrics are demonstrated. Future analyses will introduce the methods to more complex systems and interactions between independent rovers, utilizing multi-tiered models with individual and system functional health assessed concurrently. This work supports the objective of developing a science of design theory validation with the specific focus on function-based failure prediction theories.

Material Properties In Ceramic Injection Molding Design

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Powder injection molding (PIM) is used for manufacturing high volume ceramic and metal parts that have complex shape. In order to get defect free parts it is necessary to understand the effect of process parameters on mold filling behavior and part quality. Usually, mold filling behavior and part quality can be linked to the power-polymer (feedstock) composition and its material properties. In the literature, there is a limited database of PIM feedstock material properties that can be used in computer simulations to aid part and mold design. In this paper, typical structural properties obtained from PIM ceramics was identified. Additionally, a literature survey was carried out to identify typical applications, various ceramic material systems used in PIM. Moreover, material properties of various PIM feedstocks in literature were compared with estimated feedstock material properties using predictive models. These predictive models estimate material properties using feedstock composition, filler and polymer property data as input parameters. A literature search was conducted to compile a filler property database for the various ceramic feedstocks under consideration. Moreover, the literature and estimated property of aluminum nitride feedstock were used as input parameters in conducting computer simulations to study mold filling behavior as a typical case study. An attempt is made to assist PIM design by using predictive models and literature data that in turn can help reduce trail and error experimentations prevalent in PIM industry.

Dynamic Design Using the Kalman Filter in Reconfigurable Systems with Epistemic Uncertainty

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The traditional way of designing a multi-user system is to optimize the design for a specified capacity. This approach is based on a forecast of the expected number of users, which is highly uncertain. This can lead to economic failure if the actual demand is significantly different than the one predicted. This paper presents an alternative flexible approach. The idea is to optimize the design after resolving epistemic uncertainty by applying Kalman filter. In the presented case study, the number of users for a satellite is monitored at discrete time steps. In each step, the reconfigurable design vector, including the inclination and altitude of the satellite, is obtained by applying the Kalman filter. It is shown how the Kalman filter deals with epistemic uncertainty such as an unpredicted change in demand as a result of new technology, funding or competitor activity. The approach, in effect, provides the optimal demand estimation for the next step and optimizes the design based on the estimation. The benefits of the approach demonstrably increase with greater levels of demand uncertainty. A generalized framework is proposed for reconfigurable systems facing high demand uncertainty where demand has a one-sided influence on design. In other words, the design is adjusted based on the demand, however, design does not have an effect on the demand.

Analyzing the Effect of Partial Observability on the Multi-Robot Coordination

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Teams of intelligent robots have great potential for many real world applications such as space exploration, and search and rescue. These tasks could be accomplished with less cost, higher reliability and higher flexibility by multi-robot systems. However, having these multiple autonomous devices acting simultaneously leads to a problem of coordination: to achieve a coherent and high performance, robots need to work together by taking into account the actions executed by other agents. This is not a simple task, achieving optimal coordination in a computationally tractable manner is typically a difficult problem particularly when the number of agents increases. Moreover, coordination of multiple robots can be more problematic when robots have not the perfect perception of the world. In this case, robots cannot determine the complete state of the system by observing or communicating with other agents. This partially observable information can largely impact the coordination of multiple robots since agents cannot see how the unobserved agents are acting in the environment and thus it cannot ascertain about its actions. In this paper, we present the impact of partial observability on system performance by reducing the range of observability for each robot given different credit assignment structure. Furthermore, we also seek to estimate the unobserved states approximately in order to improve the system performance in a tractable manner.

Real Time Estimation and Prediction of Wave Excitation Forces on a Wave Energy Converter

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Wave energy converters (WECs) face many technical challenges before becoming a cost-competitive source of renewable energy. The levelized cost of electricity could be decreased by implementing real-time control strategies to increase average power produced by a WEC. These control strategies typically require knowledge of the immediate future excitation force, caused by the waves. This paper presents a disturbance prediction methodology that is independent of the local wave climate and can be implemented on a wide range of devices. A time-domain model of a generic heaving WEC is developed with the Cummins equations. The

model is simulated with measured water surface elevation data collected off the Oregon Coast. A simplified linear frequency-invariant state-space model is used in conjunction with a Kalman filter to estimate the current excitation force with measurements of the WEC's motion. Future excitation forces are then predicted multiple steps in the future with a recursive least squares filter. The results show this approach makes accurate predictions of excitation force over short time horizons (up to 15 seconds), but accurate predictions become infeasible for longer horizons.

Neutron Activation Analysis of Niobium for Characterization of Impurities

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High purity niobium metal is used in the construction of superconducting radio frequency (SRF) cavities for particle accelerators. For this material to function as an SRF resonant cavity, it is required to have extremely low levels of impurities. At present, the impurities remaining in the high purity niobium used in this application are not well known. Neutron Activation Analysis (NAA) is a nuclear process that can be utilized to determine the concentration of elemental components in a wide variety of materials. In this process, neutrons bombard a sample material, causing the formation of radioactive isotopes of the elements in the sample. Each radioactive isotope emits a unique spectrum of radiation, which allows for identification of the elements present in the sample. After the activation of the sample, the radiation emitted from the sample is measured using radiation detectors. The data gathered by these detectors can be analyzed to ascertain the elemental composition of the sample. In the analysis of the high purity niobium, samples will be activated in the TRIGA reactor at Oregon State University, and then a detection system will analyze the resulting radiation for a determination of the elemental composition.

Small-Scale Hybrid Energy Network Optimization

Jonathan Luc and Matthew Campbell

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This paper describes a search method for determining small-scale off-grid energy systems. Such systems are comprised of components such as solar panels, residential-scale wind turbines, batteries, inverters and charge controllers. These disparate components are assembled into feasible networks through the use of graph grammar rules. The evaluation of candidates is done through the use of ensemble forecasting, while the search is accomplished by A*. Resulting networks are intended to provide users with optimal configurations that are cost-effective and reliable.

Environmental Assessment of a Novel Additive Manufacturing Process

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Additive manufacturing has emerged as an arena that is receiving intense interest from numerous technology domains and traditional and non-traditional manufacturers. With this growing interest, concerns have arisen regarding the relative performance of these novel processes compared to conventional techniques from economic, environmental, and social perspectives. Sustainability-related benefits can be realized through additive manufacturing, and it is often promoted as a sustainable technology. For appropriate future development and application, however, it will be important to understand relative costs, environmental impacts, and human health effects of the processes and materials. Prior research addressing sustainability and additive manufacturing is briefly reviewed. A life cycle assessment is then conducted to understand the environmental performance of a novel additive manufacturing process known as fast mask-image-projection based stereolithography (Fast MIP-SL). In Fast MIP-SL, projection light is patterned by a digital micromirror device as a mask image to selectively cure liquid photopolymer resin, and a two-way movement design is adopted to quickly recoat material. The cradle-to-gate life cycle assessment considers the impacts related to the curing of one resin type and the consumption of electricity in the production of parts of various geometries. Using the ReCiPe 2008 method (hierarchist weighting), it is found that damage to resource availability dominates ecosystems and human health damage types for each part assessed.

Functional Design of Photoresponsive Molecular Frameworks

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Metal Organic Responsive Frameworks (MORFs) are a proposed new class of smart material consisting of a Metal Organic Framework (MOF) with photoisomerizing beams (also known as linkers) that fold in response to light. These would permit new light responsive materials with properties such as photo-actuation, photo-tunable rigidity, and photo-tunable porosity. However, conventional MOF architectures are too rigid to allow isomerization of photoactive sub-molecules. We propose a new computational approach for designing MOF linkers to have the required mechanical properties to allow the photoisomer to move by borrowing concepts from de novo molecular design and engineering design automation. Here we show how this approach can be used to design compliant linkers with the necessary flexibility to be actuated by photoisomerization and used to design MORFs with desired functionality.

The Augmentation of System Dynamics to Increase Usability in Non-Experts

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The art of good business is the ability to comprehend and react to changes in new and existing complex systems in order to better meet a customer's wants or needs. In the 1950's this need lead to the creation of system dynamics. The problem with system dynamics is that in order to implement it correctly the user must be well trained. If this is not the case, it may lead to incorrect findings and bad decision making. The goal of this project is to create a methodology that can be the foundation for an application that will help augment the user, allowing non-experts to create models that are as accurate as one created by an expert. Artificial intelligence and statistics can be used to analyze data and find basic causal structures frequently found in nature. The validity of these relationships can then be analyzed by an enlightened user to create the model. This will allow the utility of system dynamics to be expanded into smaller projects and middle management where it can assist more people with complex decisions.

Identifying Potentially Catastrophic Failure Scenarios with Latent Class Analysis

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Identifying potential failure paths and potentially unsafe scenarios resulting from failures is a challenge in the early design process. Additionally, designers may recognize that some failure paths lead to unsafe scenarios; however, they may not be able to identify all potentially unsafe scenarios due to the large number of potential failure paths and the inherent complexity in most engineered systems. Function failure reasoning is a potential approach to help designers identify unsafe failure scenarios early in the design process. This research investigates the use of latent class analysis as a method for focusing results generated by a functional failure reasoning tool. A functional failure reasoning tool analyzes a component-level, qualitative functional model by injecting failure into every component function and combination of functions. This exhaustive simulation produces a very large number of failure scenarios. Expertly defined rules can identify a subset of these scenarios as hazardous or catastrophic, and thus in need of special attention by engineers. A latent class analysis of the failure scenario data with the predetermined rules as covariates creates scenario classes with varying levels of known hazard membership. Classes containing pre-identified catastrophic scenarios warrant further investigation to determine the hazard level of their remaining members. This method is successfully applied to an electrical power system model. Furthermore, limitations to the number of classes that may be reliably identified by latent class analysis in this case are presented.

Incorporating Cultural Considerations in Interface Design: Developing a Malaria Diagnostic Support Tool for Sierra Leone

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The globalization of companies has resulted in engineers from one country designing products to be used by individuals in another. Culture consists of attitudes, beliefs, mental models, and social constructs that influence how users interact with others and their surroundings. The success or failure of a product can hinge upon whether it complies with cultural constructs. Much of the current research has focused on methods to create cross-cultural interfaces. While these methods can create products for use in multiple countries, they also do not take advantage local perspectives, metaphors, and mental models to meet specific community needs. This project seeks to develop a methodology for collecting pertinent cultural information to generate product specific requirements. This methodology will be used to develop a malaria diagnostic support tool for medical workers in Sierra Leone. Malaria is a parasitic infectious disease that kills thousands of Sierra Leoneans every year. A lack of medical infrastructure and properly trained medical workers in Sierra Leone has resulted in limited availability of laboratory or rapid diagnostic tests that are the only way to definitively diagnose malaria. There is a need to develop a diagnostic decision aid to help local medical workers distinguish malaria symptoms from other infectious diseases to efficiently utilize available lab tests. Multiple interfaces will be developed for this tool, one of which will be designed utilizing cultural specific requirements. Usability tests will be performed using representative users to determine if the culturally informed interface results in better performance and usability by the participants.

A Network Model to Optimize Upstream and Midstream Biomass-to-Bioenergy Supply Chain Costs

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Growing awareness and concern within society over the use of and reliance on fossil fuels has stimulated research efforts in identifying, developing, and selecting alternative energy sources and energy technologies. Bioenergy represents a promising replacement for conventional energy, due to reduced environmental impacts and broad applicability. Sustainable energy challenges, however, require innovative manufacturing technologies and practices to mitigate energy and material consumption. This research aims to facilitate sustainable production of bioenergy from forest biomass and to promote deployment of novel processing equipment (mobile bio-refinery units). The study integrates knowledge from the renewable energy production and supply chain management disciplines to evaluate economic targets of bioenergy production with use of qualitative and quantitative techniques. The decision support system method employs two phases: (1) classification of potential biomass harvesting sites via decision tree analysis and (2) optimization of the supply network through a mixed integer linear programming model that minimizes the costs of upstream and midstream supply chain segments. While mobile units are shown to reduce biomass-to-bioenergy supply chain costs, production and deployment of the units is limited due to undeveloped bioenergy supply chains and quality uncertainty. It is reiterated that future research must address process-related and systemic issues in pursuit of sustainable energy technology development.

The Proper Durability Assessment Criteria of Wood Resins

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Wood and wood composites are susceptible to lose mechanical properties due to moisture exposure. Resins play an important role in determining the durability of wood based materials. Several wood resins, including PVA, EPI, PF and PRF, were used in this study to bond veneers, and their performance before and after cyclic wetting and drying was observed. Various mechanical properties such as stiffness, peak load and toughness were studied. Conventional methods in wood industry are closely related to determining modulus and ultimate load carrying capacity, while toughness test is a newer approach. The property degradation trends of solid wood as well as wood composite samples made out of the same wood species and various resins were analyzed statistically. To gain insight into the proper durability assessment criteria, the retention percent of different properties were compared after up to 24 cycles of moisture exposure. Based on the results of this study, all properties significantly decline due to moisture exposure, however the rate of degradation considerably varies among different materials and properties. The pluses and minuses of each approach to study dry and wet durability are discussed.

Truckload Relay Network Design Under Uncertainty

Zahra Mokhtari and Hector Vergara

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In this research we study the strategic truckload relay network design problem under uncertainty. A mixed fleet dispatching configuration is used to allow loads to be dispatched either point-to-point or via a relay network. This problem integrates the strategic decision of locating relay facilities as well as the tactical decisions of determining the appropriate dispatching method and finding routes for truckloads from origin to destination. When incorporating uncertainty into the problem, some of the input parameters are considered to be random such that they might follow a particular probability distribution, lie within pre-specified intervals, or take discrete values described as scenarios. We attempt to find solutions that perform well under any possible realization of the random parameters instead of generally optimizing the problem assuming the most likely value of the parameters. A robust optimization approach with controllable level of conservatism is applied in this study considering demand uncertainty. This approach was used to develop the robust counterpart of an existing mathematical model for deterministic truckload relay network design with mixed-fleet

dispatching. In this approach, the trade-off between conservatism and optimality is a measure for identifying the performance of the solutions. The results obtained for different network instances indicate how incorporating uncertainty affects the total cost of the system, network design, and routing of the loads.

Applying the Viable System Model, Knowledge Management, and Lean Principles to Achieve a Holistic Sustainable Management Model

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The Oregon State University (OSU) Energy Efficiency Center (EEC) performs energy, waste, and productivity assessments throughout the northwestern United States. The EEC is a small, non-profit organization with rapid turnover of the workforce. The work of the EEC is based on analyst experience and expertise. When analysts leave the EEC, their skills and knowledge are lost. Due to these characteristics, the management style at the EEC is reactive. Over the long term, operations are inconsistent due to these reactive management techniques and frequent workforce turnover. A sustainable management structure facilitates viability of an organization beyond the tenure of any manager. Such management will result in organizational viability, effective employee knowledge management, and delivery of value to stakeholders. Viability, according to Stafford Beer, is the capability of independent existence. Viability combined with the theories of knowledge management and lean manufacturing will yield the development of a sustainable management model. Knowledge management is concerned with the retention and utilization of employee knowledge. Lean manufacturing focuses on the delivery of value to customers; this often implies waste reduction. Synthesizing VSM, knowledge management, and lean principles will be accomplished using Peter Checkland's Soft Systems Methodology (SSM). SSM is a systems thinking technique that can be used to combine multiple frameworks to a real world scenario. This methodology will be applied to the EEC to improve its operations. After the proposed methodology is applied and validated at the EEC, opportunities for expansion to suit other organizational types will be explored.

Manifestation of Human Error in Helicopter Cockpits

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Helicopters are essential for completion of critical missions that are impossible for fixed wing aircraft since they can operate around rough terrain and require minimal ground infrastructure, yet they are thought to be unsafe by the general public. Like many complex environments, human error is thought to be at least partially responsible for seventy to eighty percent of helicopter incidents and accidents. This ongoing research seeks to identify underlying causes of human error that lead to helicopter incidents and accidents through the utilization of task

analysis models of single and dual pilot helicopter operations across various mission types and two incident and accident report analysis studies. The initial incident and accident report analysis study will be performed using three existing human error frameworks on a stratified subset of helicopter incident and accident reports to identify major areas of human error within and across helicopter mission types based on existing frameworks. The initial analysis will also evaluate human error frameworks to identify their similarities, differences, and shortcomings for evaluation of helicopter mishaps. The second incident and accident report analysis study will be performed using a single framework created to best capture human error within the helicopter domain. This analysis will allow for a robust study of errors found within specific helicopter applications. By understanding human errors contributing to helicopter incidents and accidents, researchers and industry are better equipped to design and implement methods to reduce future accidents.

Temperature Evolution of Spark Kernels Under Cross-Flow Conditions

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Understanding the temperature evolution of spark kernels has the potential to improve current gas turbine engine design and performance. Within these engines exists a dynamic flow field. Thus, kernels were investigated under cross-flow conditions in an attempt to simulate these flow fields. A comparison was made against kernels exiting into a quiescent environment. A pulsed plasma gas turbine igniter was used to generate spark kernels. Radiation emitted by the kernels was measured via a high speed infrared camera. A procedure was developed to calculate the kernel temperature by solving the radiation transfer equation for a non-scattering participating medium and then comparing the solution to the measurements. Time resolved images reveal that kernels exiting into a cross-flow bifurcate whereas in quiescent conditions, this was not observed. Peak kernel temperatures decreased approximately 30% between time steps, which was found to be in good agreement with results in the literature.

Ineractions of Turbulence and Sediment Particles in an Open Channel Flow

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Interactions of glass particles in water in a turbulent open channel flow over a smooth bed is examined using direct numerical simulation (DNS) together with Lagrangian Discrete-Element-Model (DEM) for particles. Unlike several studies on wall-bounded turbulent flows with particles, in this work, the gravity is perpendicular to the mean flow, resulting in interesting dynamics between the destabilizing lift forces on the particles and stabilizing effects of graivty. The turbulent Reynolds number based on the shear velocity is 711 corresponding to the experimental observations of Righetti & Romano (JFM, 2004). Particles of size 200 micro meters with volume loading of 0.001 result in a single layer of non-touching particles at the bottom wall. The entrainment and deposition mechanisms of particles and their interactions with the near wall turbulence structure are studied in detail. For the particle concentration

studied, the particles affect the flow field in both the outer as well as inner region of the wall layer where particle inertia and concentration are higher. The effect of these interactions on the wall events is being explored.

Hierarchical Primitive Surface Classification from Triangulated Solids for Defining Part-to-Part Degrees of Freedom

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Mesh segmentation is the process of organizing a set of data points by dividing them into connected areas that can be defined by known surface primitives or surface equations. Our approach is a hierarchical method based on clustering and Mamdani's fuzzification system. First, a clustering algorithm is used to isolate regions of small and irregular oriented triangles, which make up a large portion of the total polygonal faces. Then, using fuzzification rule sets, the remaining triangles are gradually grown to make meaningful primitives: cylinder, cone, sphere and flat. The end goal of this work is to use the primitives to define the degrees of freedom between mating parts in an assembly. The result of this process has proven to be accurate with well-defined borders with no need of additional post-processing steps.

Scalable Sensor Network Coordination in Advanced Systems

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Many real world sensing applications require coordination of distributed sensing devices in order to collectively optimize their network attenuation, area coverage, or sensing schedules. Recently, advances in sensor technology have enabled some level of decision making directly at the sensor level. However, coordinating large numbers of sensors, particularly heterogeneous sensors, to achieve system level objectives such as predicting efficiency, reducing downtime or predicting outages requires sophisticated coordination algorithms. A critical issue in such systems is how to ensure the interaction of a large number of heterogonous system components do not interfere with one another which leads to undesirable behavior. In this work we seek to provide sensor deployment, coordination and networking algorithms for large numbers of sensors to ensure the safe, reliable, and robust operation of advanced systems. We study the problem in Defect Combination Problem (DCP) domain. First, we derive sensor performance metrics for heterogeneous sensor networks. Secondly, we introduce a general algorithm using Cooperative Coevolutionary Algorithms and Evaluation Functions to address coordination problem. We demonstrate effectiveness, scalability and reconfigurability of this approach to heterogeneous sensor networks in advanced systems. Distributed sensor coordination has myriad applications ranging from sensor placement to heterogeneous sensor coordination and sensor network control. All of these problems share one crucial underlying problem and that is how to ensure the interactions of a large number of heterogeneous agents lead to coordinated system behavior. This work describes a new paradigm that addresses that very issue in a systematic way.

Autonomous UAV Control for Free Flight Using Path-Planning and Multiagent Learning

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With the increase in popularity of UAVs for commercial applications, controllers must handle a much higher level of traffic in the airspace. There is a limited number of human air traffic controllers, so this control must become increasingly autonomous and decentralized. To function in an urban setting, air traffic control algorithms must execute safely within a dynamic and uncertain environment. The use of fast and reliable path planning algorithms is essential for the safe use of UAVs in areas with obstacles such as buildings and other UAVs. Just as important is the effective management of congestion across the airspace, to reduce risk of conflict between UAV trajectories. Previous work in multiagent air traffic flow management has focused on the metering of air traffic flow through fixes. We present an air traffic control strategy that manages plane density in map zones using a multiagent learning algorithm, and accommodates free flight using fixed path-planning algorithms. We present results with simulated air traffic across an obstacle-filled map, with several path-planning algorithms. We then analyze the interplay between the higher and lower-level control methods, and how different low-level control algorithms impact the safe throughput of the higher-level system.

A Shared Autonomy Interface for Operating Household Devices with a Robot

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As robots begin to enter our homes and workplaces, they will have to deal with the devices and appliances that are already there. Unfortunately, devices that are easy for humans to operate often cause problems for robots. In teleoperation settings, the lack of tactile feedback often makes manipulation of buttons and switches awkward and clumsy. In the autonomous setting, perception of small buttons and switches is often difficult due to sensor limitations and poor lighting conditions. In this paper, we present a shared autonomy approach to the operation of physical device controls. A human operator gives high-level guidance, helps identify controls and their locations, and sequences the actions of the robot. Autonomous software on our robot performs the lower-level actions that require closed-loop control, and estimates the exact positions and parameters of controls. We describe the overall system, and then give the results of our initial evaluations, which suggest that the system is effective in operating the controls on a physical device.

Bi-Criteria Batch Scheduling on Unrelated-Parallel Machines

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This paper addresses a sequence-dependent batch scheduling problem on a set of unrelated-

parallel machines where the objective is to simultaneously minimize the sum of the total weighted completion time and total weighted tardiness. The former implicitly minimizes work-in-process inventory, and the latter maximizes the customers' service level. In particular, it disregards the group technology assumptions by allowing for the possibility of splitting groups of jobs into batches to improve the objective function value. Since the problem is shown to be strongly NP-hard, a meta-heuristic algorithm based on tabu search is developed to find an optimal/near optimal solution at three levels, which moves back and forth between batching and scheduling phases. Comparing the optimal solutions found by CPLEX and the tabu search shows that the tabu search algorithm could find solutions, at least as good as CPLEX but in incredibly shorter computational time. In order to trigger the search algorithm, two different initial solution finding mechanisms have been developed and implemented. To the best of our knowledge, this is the first time that splitting of jobs belonging to a group into batches has been considered in the investigation of unrelated-parallel machine scheduling problems. Also a data generation mechanism has been developed in a way that it fairly reflects the real world situations encountered in practice. The machine availability times and job release times are considered to be dynamic and the run time of each job differs on different machines based upon the capability of the machines.

Wave Energy Converter Array Optimization

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Ocean wave energy is currently a source of electricity that is projected to potentially serve as a primary energy source in coastal areas. However, for wave energy converters (WECs) to be applicable on a scale that allows for grid implementation, the devices will need to be placed in close relative proximity to each other. From what's been learned in the wind industry of the U.S., the placement of these devices will need optimization considering both cost and power. Current research regarding optimized WEC layouts only considers the power produced. We are developing a genetic algorithm (GA) to suggest optimized layouts where the objective function considers both the economics involved in the array's development as well as the power produced. In the current stage of our GA's development, crossover, mutation and elitism are utilized. The tool is being developed such that the user can either constrain the number of WECs to be evaluated or allow the algorithm to define this number. To calculate the objective function, the potential arrays are evaluated using cost information from Sandia National Labs Reference Model Project and the power is calculated such that WEC interaction affects are considered. This work first presents what needs consideration in the optimization of WEC arrays for realistic application. Then the layouts produced by our optimization method are compared to layouts produced by previous WEC array optimization work. Finally, we will present our layout results once cost is considered and the number of WECs is not limited to a singular value.

Reinforcing Piezoelectric Films with Cellulose Nanocrystals

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The favorable properties of poly(vinylidene fluoride) (PVdF) make it an interesting polymer for many different applications including flexible sensors, actuators, batteries, filters and magnetoelectric devices. It is a non-reactive and thermoplastic semi-crystalline polymer with five different crystal structures (α, β, γ, ε and δ) depending upon its chain conformation. The β phase is more desirable because its all trans (TTT) planar structure provides the highest remnant polarization and thus has higher piezoelectric properties than the other crystal phases. There are some limitations regarding the use of PVdF. For instance, producing high piezoelectric properties requires multistage processing (mechanical stretching under field from the α-phase). This is incompatible with micro fabrication. Solution cast PVdF films can have high β phase content, but usually show a high degree of porosity, and are fragile. Several literature reports have shown improved properties in solution cast PVdF by incorporating nano particles. Cellulose nanocrystals (CNCs) have very high stiffness and have been used to increase the mechanical properties of various polymers, including PVdF. In the present study we introduce a new solution casting technique to increase the mechanical properties of PVdF using aligned CNCs and compare the results to the Nairn Model

Flow Energy Harvesting of an Oscillating Flexible Wing

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The increasing global gesture to reduce dependency on fossil fuels has provided significant motivation toward the development of alternative energy conversion methods and new technologies to improve their efficiency. Recently, oscillating energy harvesters, in contrast to rotary designs, have shown promise as highly efficient and scalable turbines which can be implemented in areas where traditional energy generators are either unfeasible or cost prohibitive. In addition to scalability, oscillating energy harvesters have shown to be capable of operating at much lower velocities, resulting in a low impact on wildlife while still being able to extract energy from smaller resource sites, such as tides, rivers and streams. Past research efforts have been focused on studying the effect of wing surface flexibility on thrust generation flying and swimming animals. It was shown that some degree of flexibility enhanced thrust generation of natural flyers and swimmers. Therefore, the objective of this study is to experimentally investigate whether surface flexibility of an oscillating wing enhances the energy harvesting capabilities. The oscillation kinematics are composed of a combined heaving and pitching motions. Surface flexibility is attained through the use of elastically mounted leading and trailing edge actuators. Instantaneous and mean power output are shown for a range of wing surface flexibility. Additionally, flow visualization techniques are used to document the flow field around the oscillating wing, and important flow features that are responsible for energy extraction are identified and discussed. The results show that increasing the surface flexibility of the wing results in an increase of effective angle of attack of the

oscillating wing. Increasing the effective angle of attack enhances the aerodynamic lift and moment, and thus the energy extraction magnitude. Furthermore, flow visualization shows that the wake behind the oscillating wing is a drag-type wake, and the wavelength of the shed vortices is reduced as surface flexibility increases. A decrease in the wavelength implies that the kinetic energy of the fluid flow decreases, and therefore the energy absorption of the oscillating wing increases.

Aerial Vehicle Path Planning for Monitoring Wildfire Frontiers

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This paper explores the use of unmanned aerial vehicles (UAVs) in wildfire monitoring. To begin establishing effective methods for autonomous monitoring, a simulation (FLAME) is developed for algorithm testing. To simulate a wildfire, the well established FARSITE fire simulator is used to generate realistic fire behavior models. FARSITE is a wildfire simulator that is used in the field by Incident Commanders (IC's) to predict the spread of the fire using topography, weather, wind, moisture, and fuel data. The data obtained from FARSITE is imported into FLAME and parsed into a dynamic frontier used for testing hotspot monitoring algorithms. In this paper, points of interest along the frontier are established as points with a fireline intensity (BTU/f/s) above a set threshold. These interest points are refined into hotspots using the Mini-Batch K-means Clustering technique. A distance threshold differentiates moving hotspot centers and newly developed hotspots. Three algorithms are tested for minimizing the sum of the max time untracked J(t). The results show that simply circling the fire performs poorly, while a weighted distance metric gets similar results to a greedy algorithm.

Coactive Learning with a Human Expert for Robotic Information Gathering

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We present a novel coactive learning algorithm that combines estimates of a human expert's preferences with prior information about the environment to generate trajectories for autonomous scientific data collection in marine environments. The algorithm learns these preferences by iteratively presenting solutions to the expert and updating an estimated utility function based on the expert's improvements. We applied this algorithm, in the context of underwater information gathering, using a pair of risk and reward maps. In simulated trials, the algorithm successfully learns the underlying weighting behind a utility map used by a human planning trajectories. We also present experimental field trials demonstrating the algorithm using a temperature and depth monitoring task in an inland lake with an autonomous surface vehicle. In these trials, the algorithm plans trajectories that yield similar results to those planned by a human operator. This work shows that it is possible to learn and design algorithms for autonomous navigation with reward functions that capture the essence of a human's preferences.

Design of an Autonomous Robotic Manufacturing in Space Lands

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This research presents a multi-agent systems based design approach for designing a self-replicating robotic manufacturing factory in space. Self-replicating systems are complex and require the coordination of many tasks which are difficult to control. This paper presents an innovative concept using multi-agent systems to design the robotic factory for space exploration. Specifically presented is an approach for coordinating a conceptual model of a self-replicating system. The arrival of a set of agents on an unknown planet is simulated, whereby these simple agents will expand into a self-replicating factory using the regolith gathered from the surface of the planet. NASA is currently investing in space exploration missions that consider using the resources on the surface of other planets, meteorites or satellites. The challenge of the project is in the implementation of a learning algorithm that allows a large number of different agents to complete simultaneous tasks in order to maximize productivity. The robotic factory needs to solve two problems simultaneously: multi-agent systems and complex system design. The simulation in this work is able to present the coordination of the agents during the construction of the factory as the parameters of the learning algorithm are changed. System performance is measured with a pre-programmed method, using local and difference rewards. The presented results open the door for parallel research areas such as analysis of failure propagation and the application of multi-agent systems for designing complex engineering systems.

Home Generator Benchmarking Program

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Motivation: Over the past ten years, the United States' average electrical losses from transmission and distribution were 6%. In 2012 this meant a loss of 210 terawatt-hours nationally, equating to an estimated loss of $23.2 trillion. In the typical American household, space heating and water heating combine for 19% of the homes electrical consumption. However, more American households are choosing electrical space heating over other methods, exacerbating transmission losses. Satisfying these heating requirements without relying on electricity transmitted via the grid would reduce electrical loss by 39.9 terrawatt-hours, an estimated savings of $4.41 trillion. A technology utilized internationally offers a solution. Natural gas fueled micro cogeneration units provide homes with electricity and heat independent of the electrical grid.

Objective: The goal of this research is to benchmark commercially relevant, residential, natural gas fired, electrical generators along with micro cogeneration units available in the U.S. This program will collect previously unavailable thermal efficiency, exergy efficiency, lifetime, and levelized cost of energy data for the selected home generators. Representative generators will be selected for testing in the 3kWe and 7 kWe output ranges to cover varying power requirements in U.S. homes. To characterize the potential of the current generator fleet for micro-combined heat and power (mCHP) applications, a 1 kWe micro cogeneration unit will also be tested. These data will be disseminated and used to determine the practicality of using current-fleet natural gas fired generators for residential combined heat and power applications, resulting in less electrical transmission losses.

Corrosion of Energy System Materials in Supercritical Carbon-Dioxide

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The corrosion of energy systems alloys is being examined in a high temperature, high pressure, supercritical carbon dioxide (SC-CO_2) environment. The goal the Oregon State University (OSU) SC-CO_2 project is to determine what materials are the most applicable, cost effective, and corrosion resistant. These goals will need to be evaluated at the varying temperatures and pressures that one would expect to see in the different parts of a power production facility. A large portion of the past year's efforts has consisted of the design, fabrication, and assembly of the testing apparatus. To date, the majority of research that has been performed has been on unstressed wafer specimens. Future areas that will be examined are the corrosion of tensile loaded specimens, the corrosion of joints, and corrosion under differential pressure.

Role of Stoichiometry on Ordering in Ni-Cr Alloys

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Mechanical property degradation due to ordering phase transformation is of potential concern for alloys based on the Ni-Cr binary system (e.g., 690, 625), particularly in nuclear power applications where component lifetimes can exceed 40 years. In the present research, the disorder-order phase transformation has been studied in Ni-Cr model alloys with varying stoichiometry by a combined experimental and computational approach. The multiscale modeling framework utilizes grand canonical and kinetic Monte Carlo simulation techniques based upon density functional theory calculations to treat both the thermodynamic and kinetic aspects of the phase transformation. The simulation results are used to generate a simple model for the ordering kinetics based upon the Kolmogorov-Johnson-Mehl-Avrami equation. Experimental measurements of the change in lattice parameter and hardness as a function of aging time and temperature are obtained in order to assess the model accuracy. Diffraction pattern by TEM is also used to identify the ordered phase.

Human Task Prioritization Behaviors In a Time-Pressured Aviation Multitasking Environment

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How do pilots prioritize multiple task in time-pressured and dynamic situations? Funk (1991) developed Cockpit Task Management (CTM) theory to describe "the process by which the flight crew manages an agenda of cockpit tasks." Based on the CTM framework, Chou, Madhavan, and Funk (1996) reported 23% and 49% of all accidents and incidents were rooted in task-management errors, respectively, in National Transportation Safety Board aircraft accident reports and NASA Aviation Safety Reporting System incident reports. Colvin, Funk, and Braune (2005) surmised that pilots gave lower priorities to Aviate tasks as precursors to accidents, and hypothesized that pilots prioritize tasks by six task-related factors: importance, urgency, performance status, salience, and workload. In order to test these hypotheses, n=16 pilots participated in a low-fidelity flight simulation experiment, and rated the priority of four tasks (Aviate, Navigate, Communicate, and Manage Systems) as well as six factors for each task (importance, urgency, performance status, salience, workload, and expectancy) 8 times per flight. The obtained data indicated that two perceived factors (importance and salience of tasks) significantly affected the rated priority of tasks. However, flight video data indicated some discrepancy between the perceived priority of tasks and actual functional attendance of tasks. We discuss possible mechanisms behind the above phenomena based on cognitive resource limitations and concurrent / sequential multitasking behavior considerations.

A Dynamic Model of Job Satisfaction

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Employee retention has become an increasing focus in engineering management, as corporations have begun to recognize the value of people as individuals, as well as the value of their cumulative knowledge and skills. Although a substantial amount of study and investment has been done in order to measure and predict the causes of voluntary employee turnover, there still remains a high variability in predicting patterns of workforce behavior across various industries. For example, some companies have found the existence of amenities such as gyms or internet cafes tend to increase job satisfaction; however, the effects can be short term and the next hired "generation" might not find these amenities provided as attractive. Hence, the ability to maintain and encourage employee loyalty is rooted in the understanding of the complex system of factors that affect their decisions. The ability to capture these factors and their behaviors will be critical to future development of engineering management approaches in support of employee retention. Visual representations of changes over time can be especially valuable to decision makers. The objective of this study is to develop a robust dynamic model that can represent and anticipate changes in employee job satisfaction through the use of system dynamics methods. With the use of statistical analysis and system dynamics, statistically significant parameters can be selected and then varied to observe their effects

on the behaviors of the main variables. Conclusions are drawn to provide decision support to management toward the goal of employee retention.

Technique Development for Visualizing Two-Phase Microscale Phase Change at Low Mass Flux Conditions

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Modeling multiphase flow phase change heat transfer in microchannels is critical for designing terrestrial and space systems for power generation, heating, cooling, and advanced manufacturing. Microchannel technology is attractive for reducing component size and weight, and improving system efficiency. As channel size decreases, the importance of body (i.e., gravity) forces decreases, and surface tension and viscous forces dominate. This change in governing forces has led to the observation of different multiphase flow regimes which affect the transport of mass, momentum and energy in small channels compared to conventionally sized tubes. To understand these differences, multiphase microchannel flow has been the subject of increased recent study. However, the available work has focused primarily on adiabatic, air/water flows at relatively high superficial velocities. These conditions are not consistent with those expected in actual microchannel based systems. There has also been limited investigation of the condensation and vaporization of low surface tension fluids at low mass fluxes. Thus, the present study demonstrates a technique for experimentally characterizing two-phase flow regimes at mass fluxes from 10 to 100 kg/m2 for a wide range of quality of R134a in 0.5 mm channels. The low mass flow visualization data of this low surface tension fluid will support the development and verification of new heat transfer and pressure drop techniques, enabling the design of more efficient microchannel components for terrestrial and space energy conversion systems.

Oxidation of Aluminum Alloy 6061 for Nuclear Applications

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The growth rate of oxide on aluminum alloy cladding is an important factor for the operational safety of select experimental nuclear reactors. The aluminum cladding exposed to coolant water will corrode and form an oxide layer reducing the heat transfer. The heat generated inside the fuel will accumulate and eventually cause a safety concern. The experimental conditions in this project are new compared to the existing experiments in the open literature. The oxide growth rate is studied at lower temperature and lower pressure for times up to one year. The aluminum oxide will be characterized by SEM (Scanning Electron Microscope), XRD (X-ray Diffraction) and weight gain. The data will be used to establish a new empirical correlation to predicate the oxide grow rate on aluminum alloy 6061 as a function of time with constant temperature and pH.

Development of a Non-Isotropic Membrane Wing Material

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Current membrane wing research for micro air vehicles focuses on the behavior of isotropic membrane materials, while studies of natural filers and gliders show non-isotropic properties. This research focuses on the development of a new material tailored to provide a non-isotropic material similar to the membranes found in the natural world for use on micro air vehicles. By designing a material that offers varying stiffness relative to direction, membrane wing architects will have more control to optimize wing deflection for better aerodynamic characteristics. A multifaceted approach for design and manufacturing of the material was used to optimize the resulting product. The quality of the material was refined through development of a new manufacturing process for the material while separate analysis on the optimum composition of the material refined the desired properties. Predictions of the stiffness characteristics of various compositions were developed using traditional micromechanics equations for composite materials. Digital image correlation used in conjunction with a tensile testing machine allows researchers to accurately measure the deflection of membranes under load to characterize the stiffness properties of the new material. Specimens were prepared and tested at different orientations within the material to characterize the non-isotropic stiffness of the material. The properties of this material offer promising results in the micro air vehicle field and it has the potential to be used in other applications as well with further development.

Yield Estimation Model for Low-Enriched Uranium Fuel Fabrication

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The objectives of this research are to model the baseline process yield for the fabrication of low-enriched uranium fuel foils, and optimize the variables within the fabrication process steps to reduce waste and scrap. A decision support tool was developed to evaluate how selected values for fabrication process parameters affect the yield of the input material. Heuristic methods were also developed and implemented in the decision support tool to minimize the amount of waste and scrap produced at different process steps by developing cutting templates for the production of multiple fuel foils. Results for several test cases are presented along with future research directions.

Electronic Properties of Passive Films on Carbon Steel Rebar in Simulated Concrete Pore Solutions

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In the highly alkaline environment of concrete, carbon steel rebar is protected against corrosion by a passive oxide/oxyhydroxide film. Understanding the characteristics of this passive film, and how it depassivates, is the key to mitigate problems associated with steel corrosion in concrete. Although a large number of electrochemical and analytical studies have been conducted on the passivity of steel in concrete, current mechanistic models do not explain all experimental observations about the chloride-induced depassivation process. One area that is not studied extensively is the electronic properties of passive films which show semi-conductive properties; a better understanding of these properties will provide additional information to improve the mechanistic models for chloride-induced depassivation of carbon steel in concrete. The present study uses Mott-Schottky (M-S) analysis along with other electrochemical techniques to study the electronic properties of passive films that form on carbon steel exposed to simulated concrete pore solutions. Both passivation and chloride-induced depassivation processes are investigated, and changes in electronic properties during these processes are monitored. The main parameters of the study include the concrete pore solution composition, pH, and chloride amount. Challenges of using M-S analysis to study the electronic properties of passive films will also be discussed.

The GREEn Quiz: Developing an Early Design Tool for Sustainable Product Design

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The GREEn Quiz is an online quiz for assisting product designers in making sustainable design choices in the early design phase. The quiz is formed from sustainability guidelines from current literature. The purpose of the GREEn Quiz is to be a useful medium to inform product designers on how to make a potential product more sustainable during the early stages of the design. To test the viability of the tool, the GREEn Quiz was tested by OSU Mechanical Engineering 382 (Introduction to Design) winter term students. Up until ME 382, mechanical engineering students have little to no experience when dealing with sustainability and designing with sustainability in mind. The students received a questionnaire after the completion of the GREEn Quiz as a means to gauge how well the GREEn Quiz works with helping the user retain sustainability guidelines. The questionnaire presents students with four questions asking whether Product A or Product B is more sustainable based on a small table of various information. From the results of the questionnaire it is possible to gauge the effectiveness of the GREEn Quiz by showing it is more useful than a list of guidelines or nothing at all.

PaCcET in Real-World Problems

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PaCcET is a promising new algorithm for optimization in the face of multiple simultaneous objectives (multi-objective problems). These multi-objective problems can be found in various types of applications, from air traffic control to urban planning to satellite surveillance to personal finance. They occur whenever a single objective cannot capture the full task, and instead tradeoffs between more than one objective must be considered simultaneously. This occurs in almost every real-world application. In this work we showcase the usefulness of PaCcET in two very different real-world application problems. First, the control of an advanced power system with the potential of double the efficiency over traditional power systems on their own. Second, the control of a team of rovers performing an exploration mission on the surface of an alien planet. In both of these domains, PaCcET provides a tenfold reduction in computation time versus state-of-the-art multi-objective evolutionary algorithms, with minimal loss in solution quality.

Application of Microscale Devices for Megawatt Scale Concentrating Solar Power Plants

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Concentrated solar power (CSP) plants have the potential to reduce consumption of non-renewable resources and production of greenhouse gas emissions. A field of sun-tracking mirrors reflect and concentrate incident solar radiation to a receiver surface located at a central tower, where the thermal energy is transferred to a power block and/or thermal storage system. Present plants have implemented both circular towers and cavity receivers using molten salt, water, and air as the working fluids. However, surface fluxes were low (40 to 80 W/cm^2) with high thermal losses. This results in high cost and reduced efficiency, which has limited the market penetration of CSP systems. Recently, small (~ 4 cm^2), laminated micro-channel devices have shown potential to achieve concentrated surface fluxes up to 100 W/cm^2 using supercritical CO_2 as the working fluid. The present work investigates the feasibility of using these microscale devices as building blocks for a megawatt scale concentrating solar receiver. An analytical sub-model of a 1 m^2 module consisting of smaller microchannel unit cells that considers the multi-mode effects of convection, conduction and radiation heat transfer is introduced. The sub-model is then integrated into a full supercritical-CO_2 solar receiver (~ 100 MWe) model. The effects of incident radiation, receiver orientation, working fluid temperature and ambient conditions on the global receiver efficiency are explored. The results show that the microscale unit-cells have the potential to be scaled to megawatt applications while providing high heat flux and thermal efficiency while also reducing the cost per kWh of electricity.

Radiation Characteristics of Turbulent Diffusion Flames Burning Alternative Aviation Fuels

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School of Mechanical, Industrial, and Manufacturing Engineering

Aviation's share of greenhouse gas emissions from fossil fuels is poised to grow to a net 3% of the total global greenhouse emissions by 2050 (IPCC). Alternative aviation fuels are now being created to have lower net greenhouse gas emissions compared to conventional fuels, while not affecting engine performance. Another potential benefit is an increase in the life expectancy

of combustor liners because of lower radiation emissions (less soot) when alternative fuels are burned. Less radiation would yield lower temperatures of liners. The objective of this study is to compare the radiation emissions of Jet-A fuel with alternative fuels. The experimental arrangement includes a turbulent diffusion burner with a radiometer and an infrared camera (IR) to measure the radiation emissions. A premixed pilot flame is used to ignite the central diffusion flame and to prevent flame liftoff. The burner design was created by Sandia National Laboratories (2011). Reynolds number of 20,000 is used for three different alternative fuels and one control fuel of Jet-A. Analysis is performed by determining the radiant fraction of the flames for different fuels. This gives insight into the propensity of a fuel to radiate energy during the combustion process. Radiation intensities, as measured by the IR camera, provide comparisons between the different fuels at different heights within the flame. Anticipated results from the flames are that each fuel will have varying flame structure, as indicated from the radiation intensity measurements. The radiant fractions will vary for each fuel tested, with alternative fuels having reduced values.

Intelligent In-Orchard Bin-Managing System for Apple Production

Yawei Zhang and Geoff Hollinger

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As the amount of seasonal workers in the tree fruit industry becomes increasingly limited, harvest poses a challenge due to its labor-intensive nature. Thus, technological innovation is required to assist in the process in order to face growing competition in the global marketplace. We propose to utilize a robotic system with scalable auction-based coordination to help human workers in expensive tasks during harvest. Experimental results show potential improvement in productivity by using intelligent approach to better manage in-orchard fruit bins.

Inertial and Turbulent Range Investigations of Flows in Randomly Packed Porous Media

Reza Ziazi and James Liburdy

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Flows through a low aspect ratio porous bed is studied experimentally to explore the dispersive characteristics of the flow field in a randomly packed porous structure. These flows occur over a wide range of applications in different engineering disciplines such as catalytic reactors, advanced heat exchangers, petroleum engineering (flow of oil through the rock), and combustors, to name a few. Experimental data in these flows is difficult to obtain due to the geometrical complexities and the difficulty of interrogation access. The approach used in this work relies on refractive index matching of the fluid and solid phases allowing the use of time dependent particle image velocimetry (TR-PIV). A two and three-component time resolved stereoscopic particle image velocimetry is used to study the physics of refractive index matched flow within the randomly packed porous bed. Statistical characteristics of the flow are studied in discrete planar locations of a test bed with porosity of approximately 0.45 for pore Reynolds number in the range of 3 to over 3000. The data have been analyzed with care to address the unique set of uncertainties associated with refractive index matching methods. The unsteady and turbulence statistics of this flow field have been analyzed to determine the flow structures in this transitional Reynolds number range as the flow evolves from inertia dominated to fully turbulent. The dispersive nature of the flow has been quantified to include the identification of the range of scales within the flow and to determine asymptotic limits for high Reynolds number conditions. This is useful in understanding dispersion and mixing characteristics within the porous bed. In addition, these data provide a benchmark for future computational simulations of the flow field.

DEPARTMENT OF NUCLEAR ENGINEERING AND RADIATION HEALTH PHYSICS

Multiphysics Simulation of TREAT Core for Experiment Validation

Anthony Alberti

Department of Nuclear Engineering and Radiation Health Physics

With the advent of next generation reactor systems and new fuel designs, the U.S. Department of Energy (DOE) has identified the need for the resumption of transient testing of nuclear fuels at the Transient Reactor Test Facility (TREAT) at Idaho National Laboratory (INL). The DOE and INL are developing a simulation capability that will accurately model the experiments before they are irradiated at the facility, with an emphasis on effective and safe operation while minimizing experimental time and cost. The multiphysics platform MOOSE, has been selected as the framework for this project. The goal of this research is the development of a three-dimensional, full-core transient neutronic computational simulation of the TREAT facility. Geometrical models and their corresponding meshes were developed within Cubit – a program developed by Sandia National Laboratories. These models were then tested in RattleSnake, the neutronics package of MOOSE. Rattlesnake solves the neutron transport equation deterministically with a finite element spatial discretization, various options for angular discretization, and multigroup nuclear data. Initially, single fuel assemblies in 2D were modeled and then cross referenced with DRAGON for accuracy. The 2D models generated a multiplication factor of 1.76202, 9.25 pcm below that of the DRAGON results. More complex 3D full fuel assemblies have been simulated and these results are being compared with KENO-IV Monte Carlo simulations. Quarter and full-core models are currently under development.

A Low-Cost, Compact, FPGA-based Gamma Spectrometer

Eric Becker and Abdollah Fasroni

Department of Nuclear Engineering and Radiation Health Physics

A compact, low-cost, gamma-ray spectrometer is a tool with a wide range of applications, such as emergency response, national security, and personal dosimetry. A prototype device fitting this description has been constructed in the Advanced Radiation Instrumentation Laboratory at Oregon State University. The prototype uses a CsI(Tl) scintillator coupled to a solid-state photomultiplier and a 40 MHz, 12-bit, FPGA-based digital pulse processor to measure gamma radiation energy, and is able to be accessed wirelessly by mobile phone.

The prototype device consumes roughly 420 mW, weighs about 28 g (not including battery), and measures 2.54 x 3.81 cm2. The prototype device is able to achieve 5.9% FWHM energy resolution at 662 keV.

Application of the Modified Microdosimetic Model to Evaluate RBE in the vicinity of Proton Bragg Peaks

Michael Butkus and Todd Palmer

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In addition to their advantageous physical dose profiles, heavy charged particles (HCPs) have shown increased relative biological effectiveness (RBE) in the treatment of cancers. Despite this advantage little has been done to accurately characterize the RBE of HCPs. In the case of proton therapy a constant RBE of 1.1 compared to conventional photon therapy is assumed in treatment planning and dose prescriptions. However, there is speculation that RBE may be elevated in both the buildup and falloff regions of the protons Bragg Peak due to an increase in densely ionizing delta-ray production. This increased RBE could further exploit the therapeutic benefit of the Bragg Peak, but could also be disadvantageous depending on the proximity of critical organs. We use the PHITS Monte Carlo Code to simulate the microdosimetric lineal energy probability densities in sub micrometer domains near the Bragg Peak of protons with energies of 80, 117, 147, 174, 197, and 219 MeV (Corresponding to Bragg Peak depths of 5, 10, 15, 20, 25, and 30 cm in water). We apply this data to the modified microdosimetic kinetic model to estimate cellular survival curves. These curves can then be used to evaluate RBE relative to photon therapy. This research will either help validate the constant 1.1 RBE assumption or show the need for more advanced treatment planning and dose prescriptions in proton therapy.

Radioecology and the Development of Tools for Radiation Dose Calculations

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Department of Nuclear Engineering and Radiation Health Physics

Recent events have shed light on concerns regarding the radiation protection of the environment. There is a dearth of data on the environmental transfer of both anthropogenic and naturally-occurring radionuclides present in the environment. The dose-response relationship for humans at low doses is still not well understood, however, a linear no-threshold model has been established as reference. Additionally, scientific data on radiation dose-response relationships for non-human biota at low doses of ionizing radiation are still undergoing scientific study, and available data is inconclusive. Efforts are currently underway to create comprehensive models that can be used to determine dose rates experienced by non-human biota in a variety of ecosystems. Computational advances have allowed researchers to apply reverse engineering techniques to create detailed models of radiation interactions within organisms. Voxel models are anatomically detailed phantoms reconstructed using data obtained via medical imaging techniques that contain organs and other relevant anatomical features that can be identified and segmented using imaging processing software. The result is a 3D model that is used in Monte-Carlo calculations to obtain absorbed fractions (AF). AFs are then coupled with environmental concentration data from contaminated sites (e.g. nuclear test sites, Chernobyl, Fukushima, etc.), allowing for accurate calculations of radiation dose rates for organisms present on site. Such calculations can provide vital information to decision-makers to determine necessary remediation and/or protection actions. Ultimately, comprehensive models allow us to simulate and manipulate organisms in ways that are impossible in the environment, expanding the boundaries of our capabilities as scientists and researchers.

Shielding for Nuclear Propulsion on the Mars Transfer Vehicle

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Radiation shielding design and analysis for a nuclear propelled Mars mission is currently in progress and preliminary results have enabled consideration for critical interfaces in the reactor and propulsion stage systems. Early analyses have highlighted a number of engineering constraints, challenges, and possible mitigating solutions. Performance constraints include permissible crew dose rates, radiation heating flux into cryogenic propellant, and material radiation damage in critical components. Design strategies in staging can serve to reduce radiation scatter and enhance the effectiveness of inherent shielding within the spacecraft while minimizing the required mass of shielding in the reactor system. Within the reactor system, shield design is further constrained by the need for active cooling with minimal radiation streaming through flow channels. Material selection and thermal design must maximize the reliability of the shield to survive the extreme environment through a long duration mission with multiple engine restarts. A discussion of these challenges and relevant design strategies are provided for the mitigation of radiation in nuclear thermal propulsion for a crewed mission to Mars.

Stochastic Radiation Transport through Renewal Statistical Media Using Monte Carlo Methods

Kyle Combs

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Particle transport and radiation transfer can be simulated computationally by either deterministic or stochastic means. For analyses of homogeneous or atomically mixed media, a deterministic approach is typically more appropriate; however, radiation transport through a heterogeneous medium is often better modeled via a stochastic approach. In 1994, Zuchuat et al. studied one dimensional deterministic particle transport and radiative transfer in planar geometries in renewal statistical media with scattering. Our present research will attempt to extend the work performed by Zuchat et al. by analyzing the progression of particles and radiation through a medium that is statistical and renewal in nature utilizing Monte Carlo methods. Each of the materials in the heterogeneous medium was allowed to have its own spatial size distribution function. This is accomplished by allowing variation in the mean chord length between the material components. The mean chord length is the probabilistic size of a segment of material with which an incident particle is interacting. Our

research involves incorporating different material mixing statistics, using a mean chord length sampling algorithm, into a Monte Carlo particle transport solver. Ultimately, particle density distributions, and the reflection and transmission of particles within a stochastic mixture of two materials with differing statistical distributions will be computed and compared to benchmark simulations.

Natural Convection and Boundary Layer Behavior of Heated, Vertical Slender Cylinders

Sam Goodrich and Wade Marcum

Department of Nuclear Engineering and Radiation Health Physics

While there was already an accelerating interest in passive cooling systems in the nuclear industry, events associated with the tsunami and subsequent reactor cooling problems at Fukushima in 2011 caused an abrupt shift in design priorities wherein passive cooling systems have become a required design element in new nuclear installations. This shift has naturally led to enhanced scrutiny of the current body of knowledge surrounding the phenomena of natural convection. The large majority of nuclear power reactors in the world are light water reactors (LWRs). One common feature of these LWRs is fuel in the form of long, narrow cylindrical rods. In order to better understand passive heat removal from a nuclear fuel rod (or any vertical, heated slender cylinder), several aspects of natural convection in this particular geometry require further investigation. In this work, some of these aspects are studied experimentally in order to further refine understanding in this area. These include the following (1) the effect of vertical cylinder diameter on boundary layer thickness and its impact on the heat transfer coefficient (Nusselt number), (2) the effect of vertical cylinder diameter on regime transition from laminar to turbulent under prescribed buoyant conditions (Rayleigh numbers), and (3) the effect of surface roughness on both (1) and (2). While some knowledge of these particular aspects of natural convection in this geometry exists in literature, there are still many questions to be answered in order to support design efforts for a new generation of passively cooled nuclear fuel systems both in the reactor and out.

Metal Complexation in Mixed Extractant Used Nuclear Fuel Reprocessing Schemes

Brian Gullekson and Alena Paulenova

Department of Nuclear Engineering and Radiation Health Physics

Used Nuclear Fuel (UNF) is a diverse chemical and radiological system containing over half of the periodic table. In order to reduce waste decay times, it is advantageous to isolate minor actinides for transmutation in nuclear reactors. Minor actinides are very difficult to separate from fission product lanthanides however, and have previously required a two-step separation process for adequate partitioning. Solvent extraction processes have been proposed in recent years to combine these individual stages into a single processing step, coextracting actinides and lanthanides and performing a selective strip for separation. This has proved problematic however, as complex inter-ligand interactions lead to anomolous extraction behavior and decreased separation factors. In this investigation, several new extractants are investigated to display their tendency to form mixed ligand metal complexes, which could reduce the ability to perform adequate separations. IR spectroscopy has been utilized to display inter-ligand interactions prior to extraction, while UV-Vis spectroscopy has been used to show the metal bonding environment prior to complexation. This investigation can be used to justify advancements in the development of mixed extractant systems, as well as explain any unexpected results in bulk separations of radionuclides in UNF.

Comprehensive Characterization of Motion of a Helical Structure Due to Flow Induced Vibration

Paul Harmon and Wade Marcum

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Mechanical vibrations compromise the integrity of key components of thermal power plants. Without careful design, strong resonances during steady state operation can wear these components to the point of failure, leading to an unsafe situation that may force a plant to shut down. The purpose of this research is to further the understanding of the vibrations induced in a helical structure, or coil, subject to steady coolant flow. A helical coil steam generator, such as that found in most integral pressurized water reactors, appears to eliminate many flow-induced vibration concerns when compared to traditional steam generators; however this has yet to be clearly demonstrated experimentally. The objective of this work is to develop a method of characterizing the motion of a helical coil in an annulus subject to external cross-flow of water. This is accomplished by observing the motion of a helical coil mounted to an inner opaque cylinder through an outer glass tube using a high speed video camera. A mirrored image-pair is used to observe this structure from two perspectives simultaneously, allowing for three-dimensional characterization of the coil motion. The experimental facility is described in detail. The method of identifying specific points on the coil from images and mapping them to the coil location using the law of refraction is described. A MATLAB code conducts temporal measurement of the coil motion. An uncertainty analysis of the coil position measurement is conducted based on geometry and refractive index which can be readily applied to measurements obtained using this method.

Uncertainties Effects on Different Radiotherapy Treatment Modalities

Taylor Harry and Todd Pawlicki

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Intro: Uncertainties arise from all activities through simulation to the completion of treatment in Radiotherapy. The degree that treatment failures increase as uncertainties vary in each activity has not been well studied. In this work, we present a theoretical study on the effects uncertainties have on treatment outcomes.

Methods: The effects of precision and accuracy on treatment outcomes were analyzed using Taguchi's analysis of the impact of uncertainty in the production process. The composite effects of uncertainties in radiotherapy are modeled by a normal distribution; where the standard deviation and mean of the normal distribution corresponds to the precision and accuracy of the implementation for that course of treatment, respectively. Radiobiological models (EDU-based TCP and NTCP) constructed from dose volume information are used to quantify a function and expectation value for treatment outcomes given these various uncertainties. 3D 4-field box and IMRT prostate plans were evaluated using this model and compared to ascertain a quantitative analysis for the variation between the two plan modalities.

Results: 18 prostate patient 3D 4-field box and IMRT plans were evaluated. The average decrease in expected failure probability from the 3D 4-field box plans to the IMRT plans for equal uncertainties was 14.8%. A 3D 4-field box treatment with a 5% uncertainty and an IMRT treatment with 11% uncertainty have the same treatment outcome expectation value. Discussion: Increased uncertainties in the delivery of a treatment can negate the benefits produced through new techniques and technologies. New modalities do not guarantee improved treatment outcomes.

Characterization of Thermal Conductivity using Deterministic Phonon Transport in RattleSnake

Jackson Harter

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Determining the thermal conductivity of nuclear fuel is an important aspect of the safe operation of nuclear power plants or research reactors. In the past, knowledge of thermal conductivity in nuclear fuel has been based on empirical calculations. A first principle, physics-based calculation of thermal conductivity must involve factors such as the microstructure of nuclear fuel, which constantly changes during the fission process through the formation of isotopic decay products. Impurities in the bulk material influence the transport of energy on the fundamental scale, altering the scattering behavior of phonons and electrons. Idaho National Laboratory has developed a sophisticated framework for solving coupled partial differential equations, the multi-physics object oriented simulation environment (MOOSE). Within MOOSE are a number of modules which solve the equations for specific physics applications. One of these modules, RattleSnake, is a neutron transport solver for the Self-Adjoint Angular Flux formulation of the transport equation. The goal of our research is to construct a module for MOOSE which simulates phonon transport using RattleSnake as the particle transport engine. We will use phonon transport solutions to bridge the gap between molecular dynamics and engineering scale simulations and better predict thermal conductivity in bulk heterogeneous nuclear fuels with fission product defects (UO_2, PuO_2). Using RattleSnake, we have replicated phonon transport results from a bulk homogeneous material phonon transport problem solved via a finite difference approach. We are now in the process of creating new geometries (investigation of size and impurity effects) and conducting 3D transport simulations of heterogeneous media.

Separation of Trivalent Lanthanides and Actinides from Used Nuclear Fuel Using the ALSEP Method

Vanessa Holfeltz and Alena Paulenova

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Separation of the trivalent lanthanides and minor actinides in used nuclear fuel is an active area of research in advanced chemical reprocessing, and is paramount to the transmutation of the long-lived minor actinides. Application of a separation method at the engineering scale requires adequate description by a chemical thermodynamic model to achieve accurate predictability and reproducible performance of the process. Many problems still persist in this area for previously studied Ln(III)/An(III) separation methods, prompting the development and investigation of new separations. The ALSEP solvent extraction process, currently investigated for Ln(III)/An(III) separation, combines a neutral N,N,N',N'-tetraalkyldiglycolamide (TODGA or T2EHDGA) extractant with the acidic extractant 2-ethylhexylphosphonic acid mono-2-ethylhexyl ester (HEH[EHP]). Understanding the ALSEP system necessitates studying the role of each extractant under various conditions of both the organic and aqueous phases of the solvent extraction system. To determine the role of each ALSEP extractant, a wide range of extractant ratios were studied at a wide range of aqueous phase acid concentrations. Results of extraction experiments of Am(III) and Eu(III) by combinations of ALSEP extractants suggest interaction between HEH[EHP] and the DGA. We present results of ALSEP system performance under various conditions.

Diversion Detection Using Cherenkov Light

Thomas Holschuh and Wade Marcum

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The implications of uncontrolled nuclear materials located throughout the world have been identified by the International Atomic Energy Agency (IAEA) Safeguards department and the U.S. National Nuclear Security Administration (NNSA) as a real and present concern regarding nuclear proliferation. The IAEA and NNSA have proactively created specific programs and initiatives that directly align to address this concern whose general mission is to (1) reduce and protect vulnerable nuclear material and radiological materials located at civilian sites worldwide, (2) deter potential non-compliers with costly penalties, and (3) help all parties demonstrate non-proliferation undertakings. Continuing the proactive nature of the IAEA and NNSA, one must continue to identify potential future risks which may occur near and long term. One component that has continued to be difficult for both programs is the non-invasive inspection of on-line research reactors with the objective of identifying the quantity of fissile materials in such facilities. Recently, novel techniques for remote inspection have advanced third parties' abilities to make quite accurate predictions on the intensity of ionizing radiation being emitted from an activated specimen through the emission of the Cherenkov light that is off put from said specimen. This study seeks to leverage the existing technology of the Cherenkov detector and attempt to relate its intensity signature to quantity of fissile material. The outcome of this work will lead to a detector that quantifies, in an idealized setting, material

signatures in research reactors from remote distances through the (Cherenkov) light that such a facility emits.

A Novel Approach to Modeling Plate Deformations in Fluid-Structure Interactions

Trevor Howard and Wade Marcum

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As computational power increases, so does the desire to use computational simulations while designing fuel plates. The downside is multi-physics simulations – or more specifically, fluid-structure interactions (FSI) as addressed herein – require a larger amount of computational resources. Design work for nuclear fuel plates, for test and research reactors, is conducted using FSI simulations. Current simulations of a single plate can take weeks on a desktop computer, thus requiring the use of multiple servers or a cluster for FSI simulations. While computational fluid dynamic (CFD) codes coupled to computational structural mechanics (CSM) codes can provide a wealth of information regarding flow patterns, there should be some skepticism in whether or not they are the only means of achieving the desired solution. When the parameters of interest are the onset of plate collapse and the associated fluid channel velocities, coupled CFD-CSM simulations provide superfluous information. The research provides an alternative approach to solving FSI problems using a 1-D, semi-analytical model derived from first principles. The results are compared and contrasted to the numerical and experimental work performed. The results of the computational model compare well to the results from the experimental work and reduce the computational cost by at least 2 orders of magnitude.

Endurance Flow Loop

Griffen Latimer and Wade Marcum

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The Global Threat Reduction Initiative (GTRI) is a National Nuclear Security Administration (NNSA) nonproliferation program which aims to convert research reactors from the use of highly enriched uranium (HEU) to low enriched uranium (LEU). While the conversion to LEU for many research reactors is a relatively simple operation, there are five high performance research reactors (HPRR) in the US which use unconventional fuel geometries that may not be converted as easily. These reactors have high power densities and high coolant flow rates which require the use of an ultrahigh density Uranium-Molybdenum alloy. Prior to conversion this alloy must be extensively tested to be qualified for use. Oregon State University is contracted by the Idaho National Laboratory (INL) to aid this qualification using the Hydro-Mechanical Fuel Test Facility (HMFTF), which is a testing facility at OSU designed to simulate the hydro-mechanical conditions the fuel will experience. As part of this testing, it will be necessary to look at the long-term effects of the operating conditions on the fuel in the reactor, more specifically the flow-induced deflection of the parallel reactor fuel plates. To supplement this, our research group has designed and built the Endurance Flow Loop (EFL), which is essentially a miniature

HMFTF. The EFL will measure the temperature and pressure and run a constant flow rate of water over the fuel for an entire year, and the fuel will be removed on a monthly basis to record the plate deflection. Testing is planned to begin in the near future.

Design of a Cosmic-Ray Muon Tomography System for Dry Storage Cask Imaging

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The overarching goal of this project is to develop an imaging system to monitor the content of a dry storage cask (DSC) with cosmic ray muons. Muon tomography was demonstrated to be a good non-destructive assay method for high-Z materials, such as used nuclear fuel assemblies in DSCs. In this paper, a scaled-down prototype muon imager is firstly designed and thoroughly studied via simulation. The prototype design contains four identical position sensitive muon detectors, forming two muon trackers: one above the imaging cavity and one below it. Within each position sensitive detector, two orthogonal detection planes, which are respectively for x and y position measurements, comprising a single layer of 32 scintillator strips (1cm by 1cm by 32cm), created an active area of 32cm by 32cm. EJ-200 was chosen as the scintillator material for muon detection. Each scintillator strip is read out with an embedded Saint-Gobain BCF-92 wavelength shifting (WLS) optical fiber. The fibers are coupled to two Hamamatsu H8500C MAPMTs. The PMT signals are then measured with multi-channel QDCs or ADCs. The Point of Closest Approach (POCA) and Maximum-Likelihood Expectation-Maximization (ML-EM) algorithms are both used for image reconstruction. The reconstructed image showed good spatial x-y resolution and good material discrimination ability, though the detector has only 1cm by 1cm position resolution. Some preliminary experiment results about scintillators, WLS fibers and associated circuits are also presented.

The Application of Integrated Stochastic Spatial Temporal Model in Radiation Risk Assessment

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Radiation induced bystander effect, as a non-target effect, have been substantially studied during the past twenty years. However, there are still many questions concerning this issue. Examples include finding a unified mechanism to explain effects in traditional radiation biology which takes target theory as a dogma. In this study, an integrated stochastic spatial temporal (ISST) model used for radiation risk assessment was introduced to study radiation induced bystander effects. The ISST model was used to simulate radiation risk using an integrated physical and bio-modeling method. The approach entailed a multiple biological scale problem, incorporating cellular effects, tissue effects, organ effects and in the end the whole body effects using a spatial and temporal perspective. The detail process for simulating the radiation induced bystander effect in this study were: (1) building a cell and tissue model, (2) calculating the spatial dose distribution using Monte Carlo methods on the cell model, (3) calculating the bio-parameters based on the calculation by the Monte Carlo method, (4) calculating the cellular and tissue radiation response using bio-modeling method based on the calculated bio-parameters; and, (5) calculating the radiation risk in a comprehensive way including direct damage and in-direct damage to cells. All these processes (which consist of radiation physics simulation and biological simulation) are the key steps towards building a comprehensive mechanism for understanding radiation induced bystander effect. In this study, a published actual experiment for radiation induced bystander effect was simulated by ISST model, and the simulation results and experiments results were compared. The comparison showed that the ISST model is a promising model for the study of radiation induced bystander effect. And that further development of the ISST model as a radiation risk assessment tool should be continued.

Feasibility and Safety Assessment for Advanced Reactor Concepts Using Vented Fuel

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Recent interest in fast reactor technology has lead to renewed analysis of past reactor concepts such as Gas Fast Reactors and Sodium Fast Reactors. In order to reach the 30-year lifetime requirements of some reactor designs, the fuel pins must have a vented-type design to allow the buildup of fission products to escape. The quantity and quality of currently available information concerning the modern safety analysis of a system using vented fuel is currently lacking, though it is necessary to enable the evolution of our current reactor fleet to more advanced reactor systems. The present work aims to progress the understanding of the feasibility and safety issues related to gas reactors that incorporate vented fuel. The work was separated into three different work-scopes; 1) Quantitatively determine fission gas release from uranium carbide in a representative helium cooled fast reactor; 2) Model the fission gas behavior, transport, and collection in a Fission Product Vent System (FPVS); and 3) Perform a safety analysis of the FPVS. Each task relied on results from the previous task, culminating in a limited scope Probabilistic Risk Assessment (PRA) of the FPVS. Due to the complexity of fission gas release, empirical release rates were utilized. Simultaneously, steps were taken to progress a mechanistic model of release. A coupled systems model of the FPVS allowed explicit tracking of the volatile gases through a collection system. Finally, a PRA identified the weak links within the system and targeted future concerns in operating and FPVS.

Environmental Transport of Radionuclides

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Movement of radioactive atoms through the environment is critical for calculating the risk associated with a specific radionuclide. Movement of radionuclides is strongly element dependent, e.g., tritium (^{3}H) acts like hydrogen (^{1}H), radiocarbon (^{14}C) acts like stable carbon (^{12}C). Moreover, radioactive isotopes act similarly to stable isotopes; thus the rate of movement is not equal. As an example, plants preferentially absorb stable carbon dioxide ($^{12}CO_2$) to radiocarbon dioxide ($^{14}CO_2$) as increasing the molecular mass of adding two neutrons decreases the velocity of the molecule. Radionuclide movement is estimated by using equations that change based on the physical environment. The equations can be simplified based on physical attributes of a location, such as weather, soil type, and other physical characteristics. Location parameterization allows for movement estimates to be more precise at that location. Unfortunately, parameters from one location do not always give the best answer at a different location, indicating the need for site-specific parameterization. Oregon State University, has, and is currently, researching transport of radionuclides throughout the environment to better determine transport equation parameters. These include the movement of iodine-131 from thyroid cancer patients to drinking water after a round of treatment, chlorine-36 transfer through the biosphere to humans through ingestion, and the integration of carbon-14 into plants from groundwater sources.

Natural and Anthropogenic Radioactivity in Pacific Northwest Marine Life

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Following the reactor accident at the Fukushima Dai-ichi Nuclear Power Plant (FDNPP) in Spring of 2011, there has been a resurgence of interest in anthropogenic radioactivity in marine life in the Pacific. Oregon State University has a long history of pursuit of these figures from the Cold War era, when anthropogenic radioactivity from nuclear weapon programs was being released into the Pacific both as fallout, and from the Hanford site via the Columbia River. Much of the historic research into marine life radioactivity in the Pacific Northwest was focused on activation products with relatively short half-lives (a few years) and transuranic elements (Pu, Am). As the primary nuclide of concern from the FDNPP 2011 release is Cs-137 (half-life of 30 years), efforts have been underway at Oregon State University to collect and analyze a broad array of marine life from the Pacific Northwest to catalog existing concentrations of Cs-137 as well as natural occurring radioactivity, and monitor for the eventual introduction of FDNPP sourced radioactivity.

Vibration Modeling of a Liquid Sodium-Cooled Fast Reactor Fuel Rod and Design of an Experimental Vibration Test Facility

Chad Nixon and Wade Marcum

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The traveling wave reactor (TWR) is a long-life liquid sodium-cooled fast reactor (SFR) concept currently being developed by TerraPower. The core of the TWR concept leverages hexagonal fuel assemblies that contain densely packed wire-wrapped fuel rods. This geometry is significantly different than that used in light water reactors today and must therefore be adequately characterized before in-core operational use. The combination of large aspect ratio geometry along with the high flow rates that are exhibited within the SFR concept leads to the potential for phenomenon such as flow induced vibration (FIV) to potentially impact the safety of the reactor's design. Vibration sources are generated within local fuel rods and subassembly as a whole from the turbulent flow and lateral velocity components of the sodium coolant as the fluid passes axially through the core. These flow induced vibrations can fatigue and or yield components within the reactor. Due to the complexity of FIV in an SFR fuel assembly, experimental data must be used in conjunction with computational solutions to validate a reactor's stable-safestate. The compact geometry of an SFR fuel assembly precludes the ready installation of many traditionally utilized FIV instrumentation. Therefore, the ability to adequately characterize the dynamic response of the fuel rods under hydraulic loading prior to conducting a full-scale experimental flow induced vibration study must be demonstrated. The preliminary design of an experimental test facility to determine the vibration characteristics of SFR fuel rods and a theoretical model of their natural frequency are presented.

Monte Carlo Modeling of Criticality in HANARO Fuel

Lara Peguero and Todd Palmer

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Korean HANARO pin-type research reactor fuel is of interest for the redesign of the VVR-SM reactor at the Institute of Nuclear Physics of the Academy of Sciences of Uzbekistan. Currently, plate fuel for this high-power research reactor is fabricated and sold by a Russian supplier as a substantial financial cost. The goal of our research is to design replacement fuel elements for the INP reactor using the HANARO fuel pins, and to perform neutronic analyses to show that the safety and performance characteristics are equal to or better than the existing fuel. We have modeled an infinite water lattice of HANARO fuel using the Monte Carlo N-Particle Transport code (MCNP6) in an effort to quantify the neutronic impact of the aluminum fins on the surface of the pin. The bare pin without fins has been found to be slightly supercritical, with a keff of 1.09600 and an estimated standard deviation of 0.00047. The model of the single pin serves as the base for the further modeling of a full assembly, and ultimately for performance of the reactor with this new fuel.

A CZT-Based Beta-Gamma Coincidence Detection System for Nuclear Weapon Test Monitoring

Lily Ranjbar

Department of Nuclear Engineering and Radiation Health Physics

Detection of xenon radioisotopes (radioxenon) has proven to be an important method for detecting nuclear explosions and is particularly well suited to detecting undeclared underground testing. The radioxenon isotopes ^{131m}Xe, ^{133m}Xe, ^{133}Xe and ^{135}Xe are produced in significant amounts in nuclear explosions and have half-lives that are long enough to be measured a considerable time after any release. Therefore, they are of particularly high-value in identifying such events. The International Monitoring System (IMS) is a worldwide network of observational technology helping to detect and confirm violations of the Comprehensive Nuclear Test-Ban Treaty (CTBT). It currently deploys four radioxenon detection systems to monitor nuclear explosions around the world. However, these systems suffer from problems such as complexity, the need for high-maintenance cooling systems,

and the radioxenon memory effect. To overcome these problems, a new radioxenon detector is being developed based on room temperature semiconductor materials. Multiple CdZnTe (CZT) crystals will be used in this detector for coincidence detection of gamma/x-rays and beta/conversion electrons. CZT was chosen for this detector mainly due to its better energy resolution and detection efficiency to most conventional scintillation materials. Another advantage of this detection system is the absence of plastic scintillator which eliminates the memory effect problem. There is also no need for cooling with liquid nitrogen. Thus, our detection system requires much less maintenance, a key feature for a remote-monitoring situation. All these properties make the operation and maintenance of our detector easier than available radioxenon detection systems and we still can get better Minimum Detectable Concentration (MDC).

Proof of Concept of the Use of RAVEN and RELAP5-3D for Risk Informed Safety Margin Characterization

Thomas Riley

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This project was a proof of concept of the use of the RAVEN software, a tool developed for the Risk Informed Safety Margin Characterization (RISMC) approach, with RELAP5-3D. This novel approach combines older probabilistic and mechanistic approaches to look at how and why the complex systems of a nuclear power plant might fail in an accident scenario in greater detail than the older approaches allow. This is done by combining the mechanistic outcomes of RELAP5-3D with random sampling of stochastic parameters to account for the probabilistic elements of an accident scenario. Proof of concept was provided by modeling Station Blackout scenarios for both a generic Mark 1 Boiling Water Reactor (BWR) and for the Multi-Application Small Light Water Reactor (MASLWR) design. The research shows that RAVEN and RELAP5-3D can be used to collectively generate a reasonable and realistic failure space for numerous stochastic parameters, and in doing so allows for greater examination of which safety systems might fail, how they fail, and what can be done to most effectively improve them. The intent is that these insights will be used to more effectively examine power plant accident scenarios and allow for more informed decision making with regards to power plant safety margins.

Analysis of the LIFT Variance Reduction Method Applied to Monte Carlo Simulations of Realistic Nonproliferation Problems

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The Local Importance Function Transform (LIFT) method is a sophisticated automated variance reduction technique for Monte Carlo simulations of radiation transport problems. In previous publications, the LIFT method was tested on geometrically simple problems with a coarse representation of radiation energy dependence and the performance of the method was found to be promising when compared to traditional weight windows based variance reduction techniques. In this work, the LIFT method is tested on a spatially complex benchmark test problem with a more realistic representation of energy dependence (50 energy groups) and heterogeneous materials. The performance of the method in comparison with CADIS (Consistent Adjoint Driven Importance Sampling) based weight windows methods and an analog Monte Carlo simulation is studied. A multigroup Monte Carlo code that utilizes portion of the framework of the deterministic tool Attila has been developed such that the overhead time in implementing the variance reduction techniques is minimal. The Monte Carlo simulations are performed on an arbitrary tetrahedral mesh generated by the mesh generator in Attila. A method to transfer the deterministic solution generated on a finer mesh to a coarser mesh for implementing the hybrid simulations has been developed and the performance benefits of using a coarser mesh for the Monte Carlo simulations are quantified.

An Active Interrogation Technique Based on Photofission for Non-Destructive Assay of Spent Nuclear Fuel

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The determination of plutonium mass and isotopic composition in spent nuclear fuel assemblies is an urgent need as the demand to safely utilize nuclear energy rises. An active interrogation technique based on photofission has been identified as an effective approach. In our recent experimental study, the high-energy x-ray beam generated by a pulsed linac was used as the photon source. Delayed γ-rays emitted from induced fission reactions inside the samples were measured between adjacent linac pulses with several gamma spectroscopy systems. With list-mode operation, both energy and temporal information of these relatively short-lived fission γ-rays were recorded for further analysis. Each isotope provides unique temporal and energy distribution of delayed γ-rays due to their difference in fission yield. This serves as the basis for assessment on isotopic composition of the sample. The experimental outcomes were compared with Monte Carlo simulation results to demonstrate the capabilities and limitations of the currently available simulation code. To handle the extremely high rate in a pulsed mode photonuclear environment, the front-end electronics of the HPGe detector were modified to accommodate the high energy input rate. The modifications included moving the FET to warm side, changing the feedback resistor and the decay time constant of the output from the preamplifier. Advanced digital signal processing algorithms are also being developed to improve the throughput rate with only small sacrifice in energy resolution at ultra-high input rate. These algorithms are being implemented on the Virtex-6 FPGA in real-time to develop a customized high-throughput digital gamma spectroscopy.

High-Order Curvilinear Finite Element Thermal Radiation Transport

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We present initial results from an effort to create a radiation transport solver utilizing a high-order finite element spatial discretization. Recently, researchers at Lawrence Livermore National Laboratory have developed a high-order curvilinear finite element hydrodynamics code called BLAST. This shock hydrodynamics code allows for high accuracy and resolution of high energy density (HED) physics problems. These HED problems typically involve radiation hydrodynamics - fluid motion caused and influenced by the deposition of energy by the radiation field. Our emphasis is on the computation of the distribution of thermal photons on a spatial mesh with curved surfaces; the same spatial mesh that is used for the shock hydrodynamics. Our first step is the development of a linear algebraic system of equations for the discretized equations. Initially, we employ sophisticated linear solvers to investigate the behavior of the spatial discretization. Our next step is the construction of efficient iterative solution techniques that will allow rapid convergence of optically thick problems with absorption and reemission. Specific variations of the spatial discretization will be evaluated to optimize the accuracy of the transport method in the thick diffusive limit.

Fuel Particle Effects on TREAT Fuel Transients using MAMMOTH

Adam Zabriskie and Wade Marcum

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The Transient Reactor Test (TREAT) facility has tested new fuel designs under reactivity-initiated accident (RIA) conditions. The TREAT facility has the ability to subject an experimental fuel assembly to a large number of potential transient conditions. The TREAT fuel is a dispersion fuel with uranium dioxide particles suspended in a graphite matrix. The dispersion fuel particles add heterogeneity to the fuel which affects transients. Previous literary works have analytically shown, with simplifying assumptions, that the fuel particle diameter produces a moderator temperature time lag due to heat diffusion when fission energy is deposited in the fuel particles. The moderator temperature calculated with fuel particles (a heterogeneous model) lags behind a calculation without fuel particles (a homogeneous model). The small length scale of a heterogeneous model is a computational burden which the homogeneous model does not possess at the cost of fuel particle effects. The stochastic size, relative position, and shape of fuel particles will be simulated in MAMMOTH comparing homogeneous and heterogeneous fuel models of TREAT fuel. Under the multiphysics object oriented simulation environment (MOOSE) framework, MAMMOTH implicitly couples BISON, a fuel performance application, with RattleSNake, a neutron transport application. Coupling links the temperature feedback from temperature dependent cross sections with the temperature and fission power. The simulation data will provide relation corrections to homogenous model results increase simulations fidelity of the TREAT facility to actual performance. Higher fidelity increases confidence in experimental conditions which translate into realistic tests of RIA conditions to provide better guidance in nuclear fuel safety.

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