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Women in Engineering Program

How do contextual factors impact students' academic motivation?

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In the materials and energy balances course, an introductory chemical engineering course, students learn how to integrate multiple complex concepts to solve chemical engineering problems. Students' overall learning experiences and performance in this class significantly impact their ability and intention to persist in the chemical engineering program. Many students in this typically large, introductory engineering class are at risk of changing their major, especially systematically minoritized students (women, Black, Latinx, and Indigenous students) who face additional obstacles when navigating engineering disciplines. Because students' academic outcomes in the introductory course influence their degree pathways, it is vital to conceptualize their learning experience and unique assets that help them overcome adversity in this class. We interviewed five chemical engineering students who had completed this course by the time of the data collection (Fall 2021 – Spring 2022). We plan to address the following research questions in analyzing the interview data: (1) How do students enrolled in an introductory chemical engineering course describe their learning experiences? (2) How do these students interpret their learning experiences via their motivation (attitudes, beliefs, and values)? Our results will identify the relationship between students' contextually situated learning (classroom experiences and social interactions) and future motivation and goals. By focusing on students who have already completed this course, our results will highlight the different assets that students bring with them while navigating challenging engineering coursework. This research will be 'for researchers studying students' motivation and academic outcomes in introductory engineering courses and course instructors interested in supporting students' academic performance in the classroom.

Systematic Framework for Model Based Digital Design of Polymorphic Crystallization

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Polymorphism is prevalent in pharmaceutical manufacturing, and it is a challenging issue during crystallization as it affects the properties of the active pharmaceutical ingredients (API) significantly. Different polymorphs of the same API can have different bioavailability, stability, solubility, and manufacturability. In this work, a study on a chemotherapeutic agent, Imatinib Mesylate, is demonstrated to show the potential of selective crystallization for its two polymorphs: the needle-shaped metastable α-form and the cubic-shaped stable β-form. The polymorphic transformation of imatinib mesylate is investigated using a systematic experimental design together with population balance modeling. In-situ Raman spectroscopy was used to detect the polymorphic transformation during experiments. The performance of cooling crystallization, antisolvent crystallization, and a combination of both methods for the two different polymorphs is assessed using the yield and the amount of solvent as decision parameters. This study aims to reduce experimental efforts and resources by utilizing the validated polymorphic model for in-silico design of experiments to study the effect of various process parameters on product quality. The results yield a feasible design space for the crystallization of the desired polymorph. This work demonstrates the potential of model-based digital design in rapid process development for polymorphic crystallization.

Improving Air-Source Heat Pump Thermal Comfort by Modifying Equipment and Controls

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In cold climates, air-source heat pumps (ASHPs) are known for occasionally blowing lukewarm air at high flow rates, commonly called the "cold blow" problem. This issue can lead to user discomfort due to the sensation of a draft. Current solutions to this problem include modifying the thermodynamic cycle and/or introducing auxiliary electric resistance heat to deliver warmer air at lower flow rates. However, relying solely on equipment modifications may not consistently achieve sufficient air temperatures in all conditions, and the use of auxiliary heat can compromise energy efficiency. Therefore, there is a need for a novel control logic that can achieve thermal comfort while optimizing energy usage.

This project aims to implement an advanced dynamic control system to enhance ASHP performance and improve thermal comfort for users who may experience cold drafts while saving energy simultaneously. The modeling framework comprises a Detailed Modelica-based ASHP model linked to a virtual building generated using EnergyPlus and utilizing weather data from the TMY3 file for Indiana state in cold months. The core elements of the control system adjust supply air fan speeds, and pulse-width modulate (PWM) currents through the auxiliary heater to minimize electricity use while ensuring thermal comfort.

The study compared two design scenarios: (A) business as usual and (B) auxiliary heat PWM. The results demonstrate a significant improvement in user experience, energy efficiency, and system performance. After implementing the new control logic in scenario B, it was observed that there was a 91% reduction in cold blow, a 1% increase in COP, and a 27% reduction in peak compared to scenario A.

Getting the Team Sync: Exploring Engineering Students' Coordination Commitments during Computational Modeling Projects

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Team-based approaches are integral for solving complex problems and fostering innovation in both engineering in academia and industry. The focus of this study is on team coordination, a crucial aspect of engineering practice that is often underemphasized in education. Team coordination involves establishing a shared understanding among team members regarding interdependencies, individual contributions, work structures, schedules, and deliverables. To delve into this area, the research posed the following research questions:

1. What are the team's coordination commitments in three computational modeling assignments across different projects?

2. How do these commitments change across the three projects?

The theory of coordination by Malone and Crowston provides a lens through which these questions are examined since it emphasizes the collaborative dynamics of teams and the essential components of effective coordination. The theoretical framework guides the exploration of how students, as actors in a team, align goals, activities, and navigate interdependencies to achieve collective objectives.

The study employs a qualitative approach, utilizing self-reported data from reflections completed by 24 teams of undergraduate biomedical and agricultural engineering students. Each team worked on three two-week-long computational modeling assignments. A thematic analysis unveiled four critical themes: Scheduling and Meeting Coordination, Task Management and Delegation, Collaboration and Teamwork, and Time Management. These themes form the basis for a comprehensive investigation into the coordination commitments expressed by 24 teams across three distinct projects.

The findings show distinct characterizations of team coordination commitments. Scheduling and Meeting Coordination emphasize the importance of timely communication and the use of tools like When2Meet for effective meeting scheduling. Task Management and Delegation reveal the significance of equitable workload distribution. Collaboration and Teamwork underscore the students' commitment to leveraging collective strengths and fostering collaboration through regular meetings and group work. Time Management emphasizes the need for proactive planning, early project initiation, and effective use of time to optimize project progress.

The progression of teamwork commitments across the three projects highlights shifting emphases. Task Management and Delegation take center stage in Project 1, followed by Scheduling and Meeting Coordination in Project 2, and Collaboration and Teamwork in Project 3. Additionally, Time Management remains prevalent in Projects 2 and 3.

While these findings offer valuable insights into the coordination commitments of engineering students, it is crucial to acknowledge study limitations. The reliance on self-reported data introduces potential biases, and the binary categorization process may be subject to interpretation differences. The study's context-specific nature emphasizes the need for caution in generalizing outcomes beyond the studied institution and course.

In conclusion, this research not only contributes to the understanding of team coordination in engineering education but also holds implications for pedagogical practices. Educators can leverage these insights to tailor support mechanisms that address students' identified coordination challenges. As future work, exploring technical improvements based on lessons learned can further enhance the effectiveness of collaborative efforts in computational modeling projects.

Improving Cellular Infiltration and Regulating the Release of Growth Factors in a Tailored 3D-Printed Composite for Bone Grafts

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Objectives/Goals: Annually, 1.5 million patients undergo maxillofacial reconstruction worldwide. The conventional gold standard, employing bone particulate, lacks consistency. Our innovation involves a custom 3D-printable, porous cover-core design implant to enhance reproducibility. This study focuses on optimizing hydrogel core properties and growth factor (GF) release to improve bone regeneration.

Methods/Study Population: We experimented with varying ratios of Methacrylated Gelatin (GelMa), Methacrylated Alginate (AlgMa), and tricalcium phosphate (β-TCP) to enhance cell viability, GF sequestration, and mechanical stability. Material characterization involved a rheometer to assess viscoelastic properties, ELISA kits for quantifying FGF release from PLGA microparticles, and SEM to measure hydrogel porosity. In vitro studies employed NIH 3T3 murine fibroblasts in Corning Transwells, while 96-well plates were used for immunofluorescent, metabolic, and osteogenic assessments of cell infiltration, adhesion, viability, and differentiation.

Results/Anticipated Results: Manipulating the AlgGelMa ratio altered matrix properties. GelMa exhibited durability and enhanced cell adhesion through RGD-binding motifs. AlgMa increased swelling by 30%, GF sequestration by 50% in 24 hours, and matrix storage modulus without elevating the loss modulus, preventing unwanted cell migration. Adjusting AlgGelMa ratio affected pH, promoting cell infiltration and reducing fibronectin accumulation. Incorporating β-TCP is expected to enhance cell differentiation towards osteogenesis by improving elastic modulus and increasing calcium and phosphate ion concentration for enhanced mineral deposition.

Discussion/Significance of Impact: These findings suggest that our composite can increase early cell infiltration and promote FGF release, contributing to improved osteointegration. The porous cover-core design ensures efficient clot integration and early cell infiltration, enhancing osteointegration through FGF release.

Assessment of crew mental workload, situational awareness, and attention in multiple sUAS BVLOS operations

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Background: Small Unmanned Aircraft Systems (sUAS) have widely been used in the military. In recent times, there has been a tremendous growth in both, the sUAS technologies, and their use cases beyond military applications. This growth of sUAS can be attributed to an increased level of automation within these systems. However, this technological growth is accompanied by sUAS-specific human factors challenges. It is imperative to address these challenges to allow smooth and safe integration of the sUAS into the National Airspace System (NAS). Current regulations allow operating sUAS within the visual line of sight (VLOS) of the operator (pilot). To be able to achieve scalability of sUAS operations efficiently, industries aim at operating multiple sUAS simultaneously (m:N; m is the number of crew members managing N number of sUAS) beyond visual line of sight (BVLOS) of the operator. Operating BVLOS provides the capability to cover larger distances, thus maximizing the sUAS's usability. In BVLOS operations, instead of a pilot, a remote operator (RO) operates the sUAS remotely from a ground control station. Thus, RO is subjected to reduced sensory cues that hamper their situational awareness (SA). Additionally, when multiple BVLOS sUAS are managed simultaneously by one or more ROs the level of complexity of the operation increases which has implications on the crew's mental workload (WL), SA, and attention (ATTN).

Purpose: We conducted a human factors study as a part of the FAA-BAA project 'Standards for Piloting Multiple, Simultaneous UAS BVLOS'. The purpose of this study is to understand and characterize how the crew's mental WL and other human factors aspects get influenced while managing multiple sUAS simultaneously BVLOS.

Methods: We collected data with simulation and flight tests using direct observations, the NASA Task Load Index (TLX) subjective measure of WL, and semi-structured crew interviews. Next, we computed the overall NASA TLX workload scores for each crew member. The scores were mapped with the results of the qualitative thematic analysis of the responses from semi-structured interviews. The inferences from the mixed method data analysis were confirmed using the observations made by us as human factors observers who witnessed the simulation and flight test operations.

Results: Our study indicates that age and prior video gaming experience influence crew SA, WL, and performance. Further, we found that Level 3 automation (where the RO only supervises the sUAS operation but has the authority to intervene and control the sUAS in case of any off-nominal event) was reported to be adequate for conducting m:N operations by the crew members. We also identified the areas specific to piloting multiple, simultaneous sUAS BVLOS that need improvement and standardization such as crew communication protocols.

Conclusions: We found out which and how factors of semi-autonomous m:N sUAS BVLOS operations influence RO's mental WL, SA, and ATTN which consequently affect their performance and operational safety. This work can be a baseline for sUAS companies aiming to advance their operations BVLOS and for regulatory agencies to devise standards for m:N sUAS BVLOS operations.

CFD Modelling of Droplet Fragmentation Using Planar Shock Waves in a Shock Tube

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A hybrid VOF-Lagrangian with a coupled level-set method is used to simulate shock wave loading by passing travelling shock waves of increasing shock strength on a water droplet in a shock tube to study and mathematically formulate the aero-breakup characteristics. The multiphase VOF model tracks the volume fraction of the primary and secondary phases, the water droplet and air, respectively. This feature, coupled with Discrete Phase Modelling, reports the dynamics of the droplet fragments on interaction with high-speed air. A two-dimensional transient computational fluid dynamics model is used to record the droplet fragmentation until the final stage of mist formation by employing the Unsteady Reynolds Averaged Navier Stokes equations. The study distinguishes between the two modes of fragmentation, namely the Rayleigh-Taylor and Kelvin Helmholtz method, by varying the Mach number from 2MPa to 7Mpa. Changes in parameters like spatial characteristics such as shape, change in diameter and temporal characteristics such as drift distance, break-up time, and distance traversed until mist formation are noted.

Coupling an Olfaction Chamber with Proton Transfer Reaction Mass Spectrometry for Evaluating Human Response to Scented Product Emissions

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Household and personal care products are important sources of indoor air pollution. These products are often classified as volatile chemical products (VCPs). Those that are intentionally fragranced are considered scented volatile chemical products (sVCPs). Humans as consumers incorporate sVCPs into their daily lives in the form of deodorants, detergents, soaps, colognes, air fresheners, and cleaning agents, with familiar scents such as lavender, lemon, mint, and rose. These alluring smells and associated feelings create desired smellscapes for the consumer. These sVCPs are known to release VOCs, some of which are highly reactive with indoor oxidants, causing the VOCs to undergo complex transformations in built environments over time. It is established that inhalation exposure to sVCP emissions can impact human health, however, there is limited knowledge on how VOC emissions from sVCPs alter the chemical composition of indoor air and how olfactory detection of sVCP emissions influence human phycological and emotional response. This study aims to develop a controlled olfaction chamber for concurrent evaluation of VOCs emitted from sVCPs and human response to those VOCs as evaluated through odor assessment and biometric data. The human response to emitted VOCs is evaluated through odor emotional assessment and while physiological data of the human subject is collected for the purpose to identify and evaluate physical response to the inhaled VOCs.

Impact of Variability of Haptic Feedback in Virtual Reality (VR) during Task Performance

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Task performance is considered an important field in the world of HCI. Researchers are continuously exploring how to enhance human performance in a digital space (Wang et al 2011). There have been several research studies carried out to investigate ways to optimize human performance and also richly uncover factors that affect human performance negatively and positively (Asan et al, 2015). In the field of HCI emerging technologies are being employed in research studies to assess the cognitive behavior of humans while carrying out a task with a particular digital medium. With the emergence of advanced technologies such as Virtual Reality (VR), it is important to understand how individuals are able to utilize this tool for productive task performance. Researchers are actively exploring how our sensory experiences contribute to creating a positively immersive environment for users, as indicated by Ghosh et al. (2018). To enhance VR's immersion for users, it's essential to comprehend how to engage the human senses to optimize cognitive performance. Typically, in a VR setting, three primary senses are engaged: visual, auditory, and tactile (haptic). However, there is a gap in literature on how the availability of haptic feedback and intensity of haptics feedback through the VR controllers affect users during task performance. Hence this research study seeks to understand the cognitive performance of users in VR when exposed to varying levels of haptic feedback via the VR controllers. Results from this research reveal that participants perceived their performance to be higher and frustration to be lower when they were exposed to moderate and consistent availability and intensity of haptic feedback. Overall, the impact of this research study is to add to an existing body of literature in the domain of haptic feedback for extended reality-based experiences.

Accurate Assessment of Fracture Toughness in Human Bone

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Bone toughness has often been evaluated using either linear elastic fracture mechanics (LEFM) concepts or a J-integral approach. However, bone exhibits several behaviors that negate the assumptions for both approaches. Most prominently, bone has been shown to have a fracture process zone (FPZ) of significant size. An FPZ is the volume in front of the crack tip where some damage has occurred, but the material is not fully fractured. To most holistically assess toughness, the FPZ size must be accounted for relative to the specimen dimension. Quasi-brittle fracture mechanics (QBFM) incorporates these measures, which has been applied to bovine bone but not in humans. Raloxifene (RAL), a selective estrogen receptor modulator, which has been found to change bone hydration and improve toughness in human, canine, and murine specimens. This work evaluates changes in bone toughness in response to RAL treatment in both the linear elastic and quasi-brittle framework. Human cortical femur tissue was obtained through the Indiana School of Medicine Anatomical Donation Program from a 75-year-old male. Bones were into nominally 4 x 4 x 24 mm3, a 200 μm notch was cut into the marrow side of the beam. Here, 8 beams are considered under 3 treatment conditions: 3 beams treated in a 2 μM RAL solution, 2 beams treated in a vehicle control solution(VEH), and 3 beams in their native (NAT) state only exposed to PBS. An in-situ loading and 3D imaging approach was used for fracture experiments. Notched beams were loaded under four-point in a Zeiss XRADIA 3D X-Ray Microscope. Loading was stopped at peak load and the displacement was held constant while a 3D X-Ray image was obtained. Images from the 3D scan were reconstructed and analyzed in Simpleware ScanIP to determine the size of the FPZ. The LEFM toughness, GLEFM, is calculated with respect to the initial crack length, a0. For QBFM, toughness, GQBFM, is computed from an effective crack length, aeff. FPZ length was highest with RAL. A tortuous crack is observed that interacts with the osteon structure. The median GLEFM for RAL, VEH, and NAT samples were 0.87, 1.02, and 0.68 N/mm, respectively. The median GQBFMimg for RAL, VEH, and NAT samples were 1.84, 1.54, and 1.19 N/mm, respectively. The significance of the difference for: GLEFM between RAL and NAT is $p = 0.32$; GQBFMimg between RAL and NAT is $p = 0.13$. The current results are limited to a small cohort; additional experiments are on-going. The FPZ size is significant relative to the size of the beam and the osteon microstructure (FPZ ≈ 3×On.Dm) which indicates dependence of toughness on the FPZ. The quasi-brittle approach indicates a higher toughness as compared to LEFM. Fracture process zone size is larger in RAL-treated samples in both methods of determining an effective crack length. These results indicate that RAL appears as to enhance the quasi-brittle toughening mechanisms in human cortical bone. QBFM methods can also be translated from engineering to be used as a discussion tool with clinical and translational medical professionals.

Stopping the Revolving Door: MDP-Based Decision Support for Community Corrections Placement

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The incarceration population in the U.S. has grown significantly over the past three decades and there is a pressing need to resolve the overcrowding issue. One viable approach is to divert individuals from jail to community corrections (CC). However, naively sending all eligible individuals to CC may shift the crowding from jail to CC and cause negative societal consequences. As such, analytics-informed decision support is necessary to help decide the priority of whom to divert to CC while accounting for various system- and individual-level factors balanced among intricate tradeoffs. We collaborate with the Tippecanoe County Community Corrections (TCCC) to co-develop and implement an interpretable analytics-enabled decision support tool. This tool presents a unique combination of theoretical advancement and tangible impact.

Aligning Consumer Preferences in the Shifting Landscape of Nursing Home Accessibility

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According to a 2022 American Health Care Association report, more than 1,000 nursing homes (NHs) have closed since 2015 regardless of their quality score due to rising care costs, Medicaid underfunding, a decreasing share of private pay residents, nonprofit status, and rural location. As a result of the COVID-19 pandemic, over 44,459 residents have been displaced due to escalating NH closures and an ongoing historic workforce crisis that has yet to be fully addressed. With a growing elderly population and only three new NHs opening across the U.S. in 2023 up to now, it is crucial to understand, from a patient's perspective, how the shifting landscape of NH accessibility impacts consumer demand and preference fulfillment for skilled nursing home (SNF) care. This study develops a weighted utility-based modeling approach used to estimate the distribution of NH preferences of Arizona older adults seeking long term care. The methodology is validated over a microsimulation created to assess the impact of SNF openings and closures on NH accessibility, patient displacement and placement satisfaction. In the microsimulation, patient transitions are considered to capture the dynamic shifts in patient flow from one setting to another. Accessibility is quantified by measuring the distance consumers must travel for a certain quality of care, while satisfaction is determined by the degree to which consumer placements align with their preferences. By accounting for facility location and quality, the microsimulation and its results provide policymakers with valuable insights into how the closure or opening of NHs impacts consumers holistically.

Assessment of K-12 Students' Microelectronics Understanding and Awareness

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Background: Microelectronic and semiconductor manufacturing is being heavily invested in by the United States, Taiwan, South Korea, Japan, and China. However, these careers are new to western countries and the majority of jobs are currently dominated by Asia. Many young people in the United States have had little or no opportunity to consider the integral role microelectronics plays in our lives, nor the various career paths related to microelectronics. Therefore, students need a space to learn about the societal impact of microelectronics and consider relevant careers of interest.

Research Question: How do students conceptualize microelectronics and its meaning for engineering and society after completing an integrated STEM unit embedded with microelectronics contexts?

Methodology: Curriculum units will be implemented in middle and high schools throughout the state of Indiana during the 2023-24 academic year. Changes in students' understanding of relevant information is measured through identical content pre- and post-assessments. These content assessments include two questions concerning microelectronics knowledge and awareness: 1) What does the term "microelectronics" mean?, and 2) How are microelectronics used in field?, with the field being the subject of the class in which the unit is taught. Each student's answers to the two questions will be compared to determine if it was successful in improving microelectronics knowledge and awareness.

Findings: This work in progress will assess curriculum units implemented during the 2023-24 academic year.

Implications: The increasing prevalence of microelectronics and semiconductors in everyday life necessitates early exposure to these topics and relevant careers. Implementing integrated STEM curriculum embedded with microelectronics content will increase student awareness and knowledge. This unit will serve as an example for how microelectronics content can be embedded into existing K-12 curriculum as the US continues to invest heavily in this industry.

Coupling Gullah Ontologies with Scientific Exploration

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There is a blatant need to act on reimaging not only land use, but water use and quality sustainment in Indiana. Due to the uncertain future of the abundance and resilience of water and land in Indiana, scientists have investigated water resources, their use, and challenges to managing water quantity, quality, and availability in the state of Indiana. The current state of resource management for Indiana remains indigent of the cultural institutions and values of those who came before them, the ways they lived and existed, and how powerful their stories and ontologies are in shaping our future within water governance. My framework proposes learning the land and its history as a potential solution to the issue of management and economic security and sustainability. In order to bolster my proposal, I seek to establish an example of livelihoods that can be drawn on to reflect on this overall understanding with a review on the Gullah peoples as the framework is developed from Indigenous ontological practice. The review's purpose is to use what is known—terminology and practices—within the Gullah community to create abundance, to reproduce that abundance in scientific exploration and the reimagination of systems and structures that not only shape engineering, but environmental stewardship and the lexicon of STEM education. This work represents an earnest effort to connect the published literature of heritage to interpret environmental and ecological assets that emerged via the societal and cultural values of this group that contains a repertoire of inputs in cooperative labor, self-determination, and community. The Gullah have fostered resiliency for generations and it has produced moral lessons that we can impart on the search for scientific revelation, problem resolution, and our resistance to climate change. Public scholarship is more important now more than ever and we must show, as engineers, how we can integrate things not only into curriculum and industrial operation, but the very fabric of society.

An Efficient Approach to Securing Open-Source Software Ecosystem

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"In the rapidly evolving landscape of open source software, ensuring robust security is paramount. Our project aims to fortify this ecosystem against vulnerabilities by leveraging state-of-the-art tools and methodologies from the Open Source Software Foundation (OSSF). At the heart of our initiative is the Omega Analyzer, a sophisticated OSSF-endorsed scanner, designed to conduct comprehensive security assessments across a wide range of open source projects.

Our approach is multi-faceted. Initially, we focused on enhancing the precision of the Omega Analyzer. This refinement process involved integrating a specialized parser that evaluates security reports both qualitatively and quantitatively. The culmination of this process led to the development of a seamless Github workflow. This workflow empowers developers to independently assess their projects, providing them with clear, digestible feedback that is crucial for timely remediation of security flaws.

A testament to the efficacy of our methodology is its application to over 5,000 open source projects. In these applications, we meticulously sifted through security reports, effectively distinguishing between actual vulnerabilities and false positives. In instances of genuine security concerns, our team actively collaborates with project developers through Github pull requests to address and rectify these issues.

Currently, we are focused on developing a more streamlined infrastructure for security evaluations of Github repositories. This development aims to offer a holistic front-end and back-end solution for automated checks, incorporating the OSSF Scorecard into our arsenal. This integration promises a more comprehensive and automated approach to security assessments.

As our project continues to evolve, we remain committed to our goal of mitigating the frequency and impact of security vulnerabilities in open source software. We are optimistic that our proactive and innovative approach will significantly contribute to enhancing the safety and reliability of software deployments on a global scale."

Agent based model of TB-HIV Coinfection to Uncover Mechanisms of Synergistic Pathogen-Pathogen Interactions

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Tuberculosis (TB) and human immunodeficiency virus (HIV) are both significant global health problems despite available treatments for both individually. Individuals with HIV are 15-21 times more likely to develop active TB and TB is the leading cause of death in HIV+ individuals. Understanding how TB and HIV work together to overcome the host immune responses is crucial to develop treatment strategies geared towards treating coinfection rather than each individual infection. However, studying the interactions between TB and HIV is challenging in vivo. In vitro experimental methods are a useful alternative that allow for more mechanistic and dynamic investigations into the interactions between TB and HIV. Specifically, an in vitro model of TB-HIV coinfection has shown that coinfection increases both viral and bacterial load compared to solo infections and forms larger granulomas (clusters of immune cells and bacteria commonly referred to as the hallmark of TB infection). But identifying the mechanisms driving the growth of both pathogens is challenging using experimental methods alone. Here, we present a complementary approach using an agent-based model (ABM) to elucidate mechanisms during in vitro TB-HIV coinfection. Our goal is to determine the synergistic mechanisms that allow both pathogens to thrive and identify potential coinfection treatment strategies.

Our computational model mimics TB-HIV coinfection through interactions between virtual macrophages, TB-and HIV-specific CD4+ and CD8+ T cells, TB and HIV. Mechanisms include bacterial growth, macrophage phagocytosis resulting in bacterial death or macrophage infection, macrophage and T cell activation, T cell proliferation, cytokine/chemokine diffusion and degradation, and CD8+ T cell cytotoxic killing. HIV is modeled as a continuous diffusing field and infects macrophages and CD4+ T cells. Calibration data will include in vitro experimental data for granuloma number and size over time, HIV load, and TB growth during solo infections and coinfection. Experimental evidence from literature will be used as qualitative validation. The ABM is implemented using Repast Simphony.

We expect that TB-HIV coinfection will have increased HIV and TB growth compared to solo infections. We anticipate that coinfection will have larger sized granulomas compared to either solo infection. Several observations have been identified individually as being potential factors towards pathogen-pathogen success during coinfection and we aim to validate our ABM with these various observations from literature into one single framework. These observations include mechanisms such as viral replication, probability of HIV infection, cytokine secretion rates, macrophage phagocytosis rates, the threshold for TNFα induced apoptosis, and CD4/CD8 T cell activation probabilities. A sensitivity analysis will help determine how strongly these mechanisms and parameters affect coinfection outcomes.

This ABM will be the first spatial computational model of TB-HIV coinfection. The ABM will explore how various experimental observations from different sources and setups may combine in one framework to synergistically favor TB and HIV expansion during TB-HIV coinfection.

Towards Modeling of Virtual Reality Welding Simulators to Promote Accessible and Scalable Training

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The US manufacturing industry is currently facing a welding workforce shortage which is largely due to inadequacy of widespread welding training. To address this challenge, we present a Virtual Reality (VR)-based training system aimed at transforming state-of-the-art-welding simulations and in-person instruction into a widely accessible and engaging platform. We applied backward design principles to design a low-cost welding simulator in the form of modularized units through active consulting with welding training experts. Using a minimum viable prototype, we conducted a user study with 24 novices to test the system's usability. Our findings show (1) greater effectiveness of the system in transferring skills to real-world environments as compared to accessible video-based alternatives and, (2) the visuo-haptic guidance during virtual welding enhances performance and provides a realistic learning experience to users. Using the solution, we expect inexperienced users to achieve competencies faster and be better prepared to enter actual work environments.

Optimizing Thermal Comfort: Predictive Models for Sustainable Indoor Environments

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Thermal comfort is a crucial aspect of building management, directly impacting the well-being and productivity of occupants. Given the projection that by 2050, more than 70% of the world's population will reside in urban areas, it becomes increasingly essential to understand and improve indoor conditions within densely populated regions. As more people spend 80% to 90% of their days indoors, achieving optimal thermal comfort in such environments is crucial, but it poses challenges due to diverse occupant preferences and ever-changing external conditions. Another gap in this field is the limitation of predictive models that can provide occupants with insights into indoor environmental conditions, ensuring thermal comfort while addressing sustainability concerns. A broad spectrum of scholarly works and practical applications, the research synthesizes insights from various disciplines, including architecture, environmental science, and human factors, were analyzed to understand the development of a holistic occupant-centric interface for thermal comfort. This study proposes an innovative solution of an occupant-centric interface that integrates real-time environmental data and thermal distribution information, empowering individuals to align their seating preferences with their unique thermal comfort needs. This research presents a comprehensive framework for the integration of IoT sensors, microprocessor, Cloud services, and a data visualization platform. The research methodology involves data collection from various indoor settings, capturing environmental parameters and occupant feedback. The study's findings contribute to the advancement to prioritize occupant satisfaction and investigate the potential energy savings through optimized thermal comfort management. By bridging the gap between individual comfort and sustainable building practices, this research strives to create a more adaptive and eco-friendly approach to indoor thermal management in urban environments.

Advancements in Capsule Endoscopy: Innovative Solutions for Safety, Effectiveness and Trackability Limitations

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This symposium presentation talks about a the procedure of Gastroendoscopy and its limitations in the safety and effectiveness of the current innovations. It unveils groundbreaking strides in the realm of healthcare through the development of an innovation in the already existing Capsule Endoscopy project tailored specifically for the safety of the patients.

Gastrointestinal (GI) disorders refer to a group of conditions that affect the digestive system and can range from mild to severe. Endoscopy is a common diagnostic and therapeutic tool used in the assessment and management of many gastrointestinal disorders like Gastrointestinal reflux disease GERD, peptic ulcers, Inflammatory Bowel Disease IBD, Colorectal polyps and cancer, Irritable Bowel Syndrome, Celiac disease, Gastrointestinal Bleeding, Gastrointestinal motility disorders and Gastrointestinal Infections.

An endoscope is limited by the depth it can be inserted into a patient. Because it is unable to reach the entire digestive tract. While endoscopy is a valuable tool, it has some limitations such as limited field of view, may lack depth perception, invasiveness, operator dependent, limited access and equipment limitations. To overcome these limitations, we have the advancement in the form of capsule endoscopy.

Capsule endoscopy is a non-invasive diagnostic procedure that uses a small, swallowable capsule equipped with a tiny camera to capture images of the gastrointestinal (GI) tract. This technology allows for the visualization of areas that are challenging to reach with traditional endoscopic methods. Capsule endoscopy offers several advantages over traditional endoscopy as its Non-invasive (There is no need for sedation or insertion of an endoscope), Comprehensive (allows for visualization of the entire small intestine, an area that is challenging to access with conventional procedures).

Being a very valuable diagnostic tool, capsule endoscopy still has some limitations like Limited therapeutic capabilities as it does not allow for therapeutic interventions, such as biopsies or polyp removal. Since there is a lack of real-time control, the operator cannot control the capsule's movement once it is ingested, which may limit the ability to focus on specific areas of interest.

Our initiative sought to overcome critical limitations associated with the image transmission, and trackability of conventional capsule endoscopy devices. Focused on enhancing safety and effectiveness, this project aims to revolutionize diagnostic procedures for gastroenterological conditions. It implies a Bluetooth device that can do a real time tracking of where the capsule is currently. This solves a huge problem, since in a number of cases the capsule remains in the body without evidence and is never propelled out which can lead to sepsis, or the when the capsule is not tracked its leaves the physician in a doubt if even it was propelled out or not.

Topological wave energy harvesting in bistable lattices

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The conventional energy harvesters depend on the resonant frequency of the structures. The resonant frequency is inversely proportional to the size of the structure. So, it is difficult to harvest the low frequency range energy. However, most of the vibration frequencies that are occurring around our life are very low frequencies. From this point, we put the soliton propagation concept so that we can harvest the broadband frequency of the energy apart from the size and mass of the structure. This idea is applied to broaden the bandwidth of the energy harvesters. The particle-like characteristics of the solitons in metamaterials can improve this problem. Metastructures with bistable elements make the transition waves which are transferring the energy, and it can be a strong way to minimize the size of the energy harvester in the broad frequency range. This phenomenon is named solitonic resonance.

In this study, we investigated an input-independent energy harvesting mechanism which is composed of discrete bistable unit cells. We show numerically and experimentally that when the transition waves are triggered, the most dominant frequency of the phonon at each unit cell is independent of the input forces. We applied impulsive, quasi-static, and sinusoidal input types and different frequencies. This invariant frequency provides a means to harvest the phonon energy efficiently through resonant transduction allowing for a fundamentally different route for broadband energy harvesting.

For the continuous transition waves, we put the grading on the stiffness of the on-site and inter-site springs of our model. It can reduce the potential energy barriers. Also, we use the magnetic mass in our element so that the motion of the unit cells can occur the electromagnetic conversion and make the energy harvesting system.

A Meta-Reinforcement Learning approach and explainable AI for building HVAC control policy

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"Energy efficiency improvements of existing buildings can be achieved through advanced control strategies. However, developing a customized control policy for a specific building is time-consuming and often requires information for many inputs that are unavailable. Data-driven approaches show potential in policy development, but the embedded black-box models lack accountability and explainability, making them difficult to evaluate, diagnose and implement. These obstacles hinder the commercialized deployment of algorithms proposed in research. In this paper, we present an Artificial Intelligence (AI) framework that integrates new ways of combining data-driven machine learning and model-based learning, fusing different sources of available information to automate the discovery of optimal policies for controlling energy-related aspects of the built environment with minimal engineering effort.

The AI framework consists of three main components: (i) autonomously generating the model universe, (ii) auto-discovering the optimal control policy via meta-reinforcement learning (meta-RL), and (iii) explainable AI (XAI) that extracts and analyzes the decision-making process of the meta-RL control policy. Unlike conventional RL, which allows training only from a specific environment (i.e., a single building energy model or BEM), meta-RL learns from multiple environments, known as the model universe. The model universe is a set of models representing all possible dynamical systems for a target building. In (i), we propose a physics-informed machine learning framework that employs a statistical approach to fuse various sources of available information, automating the generation of BEMs for a target building. To calibrate our approach, we use reference and prototype buildings from the U.S. Department of Energy (DoE) as ground truth and perform Bayesian Inference. In (ii), we adapt a Model-agnostic meta-learning approach (MAML) and formulated the meta-RL problem for building control scenarios. In (iii), we developed an XAI framework that summarizes policies and provides human-readable explanations of the trained agent's predicted outcomes and decision-making process.

The simulation results demonstrate that the meta-RL approach (1) outperforms agents trained with conventional RL using building dynamical models with empirical parameters and (2) achieves more than a 20% reduction in energy use compared to a baseline rule-based controller while successfully maintaining thermal comfort within the first week of deployment."

Siting Solar Charging Stations for Shared Electric Bikes

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This study aims to address the challenges faced by theing bike share systems that are incorporating electric bikes (e-bikes) into their fleets. Compared with traditional shared bikes, E-bikes offer improved performance, range, and speed, making cycling more attractive. By enabling longer trips, Tthey also have the potential to reduce greenhouse gas emissions by replacing cars. However, the manpower required to replace and charge batteries increases the financial and operational costs of the system. To address this, researchers have proposed incorporating photovoltaic (PV) panels at bike share stations to charge e-bikes. However, previous studies have not taken into account the geographical and temporal variability of solar accessibility in urban areas. Additionally, adding large PV panels and batteries to all bike sharing stations would be costly and environmentally impactful. Optimizing charging capacities in different stations and leveraging existing bike share stations equipped with small PV panels can be a more cost-effective approach.

This study develops a solar charging solution for shared e-bikes that considers the spatiotemporal variability of solar PV potential in urban areas and optimizes the installation of PV panels at existing bike share stations. The study will estimate solar PV potential and energy consumption using real-world data and incorporate these into a location-allocation model to maximize coverage of the system's energy needs and minimize travel distance to charging stations. The study provides a modeling and optimization framework for implementing solar-charging stations for e-bike share systems and demonstrates the potential for using solar energy to improve the sustainability of shared transportation systems.

Driving within a Teammate, Your Car and You: Investigating drivers' perception of teaming with semi-autonomous vehicles

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Human-autonomy teaming (HAT) is a rapidly emerging research field that seeks to combine human and artificial intelligence (AI) agent capabilities to enhance performance, efficiency, and safety of mutual tasks across various domains. In the driving context, the idea of a driver 'teaming' with a semi-autonomous vehicle (AV) is a fairly novel concept. However, this framing could significantly help to shape the design of highly autonomous vehicles, thereby promoting safety in surface transportation systems. To date, there have been no investigations of whether drivers of semi-AVs perceive their vehicles to be teammates or simply intelligent tools. To address this research gap, in this study, we developed and deployed an online survey via a crowdsourcing platform to identify potential barriers preventing current owners of SAE Levels 2 and 3 (conditionally automated vehicles) from seeing themselves as teammates with their semi-AVs. The survey was approximately 20 minutes in length and presented questions pertaining to general driving experiences and behaviors, perceptions of driver roles when using semi-AVs, and current and desired in-vehicle communication formats and interface designs. There were N=251 responses recorded (Male = 63%, Female = 36%, Non-binary = 1%) with a mean age of 41.55 years (SD = 13.55; Range: 21 – 77 years). Selected results: (1) approximately 35% of current semi-AV owners view their car as a teammate, however 56% of those do not grasp the significance of why it should matter whether they view their car as a teammate or not; (2) approximately 82% of drivers who utilize the semi-AV features believe that doing so improves their overall comfort, stability, safety, and awareness while reducing mental/stress, fatigue, and effort; (3) 92% of semi-AV owners believe that they at least somewhat understand what their vehicle is and is not capable of with approximately 87% stating that they have at least a moderate level of trust currently in their vehicle; (4) though when asked who is to blame for driving difficulties, 96% of drivers blame either the vehicle or the external environment/other drivers as the cause; (5) yet 54% of semi-AV owners admit that if their vehicle provided more information about its own actions along with its ability to successfully execute said actions, it would enable them to better view their car as a teammate. Results such as these exemplify the need for AV designers and algorithm developers to consider the mental models and needs of the drivers along with the inherent levels of coordination, cooperation, and collaboration that exists within a driver – automated driving system (ADS) teaming context when creating the next generation of commercial autonomous vehicles. This survey provides valuable insights into the psychology of drivers of semi-AVs, which could be used to ultimately support the development of collaborative strategies in driving.

Assessment of Seizure-Like Activity in Neuronal Networks Post-Traumatic Brain Injury Utilizing Novel TBI-On-A-Chip Model

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Traumatic brain injury (TBI) is a leading cause of death and long-term disability worldwide. Further, seizure development is one of the most serious sequalae post-TBI. Unfortunately, the underlying mechanisms linking TBI and seizures are not well understood. Identifying cell-scale pathophysiological changes in the brain post-injury will be paramount for identifying therapeutic targets. While animal models offer crucial insight, it is often difficult to precisely control the extent of internal brain injury in animals (e.g., degree of deformation or pressure exerted on tissue) even with the ability to command injury application (e.g., rate of rapid acceleration injury or weight-drop), which could account for the variation produced between approaches. Furthermore, it is often not possible to accurately isolate distinct injury types by using these methods, which can adversely affect subsequent modeling of the resulting symptoms, such as seizures. Taken together, these limitations likely contribute to the continuous failure of clinical trials investigating TBI therapies that showed promising results in preclinical studies. In response, we utilized our unique TBI-on-a-chip system to investigate seizure-like activity (SLA) in neuronal networks (i.e., interconnected groups of neurons) post-TBI, with the ability to manipulate multiple factors in a highly controlled environment, minimizing systemic confounding variables. This novel system simulates the pathophysiology of concussive TBI by applying clinically relevant, rapid acceleration injuries to murine cortical networks on custom microelectrode arrays (i.e., chips) that measure the electrical activity of neurons, while providing real-time, cell-scale monitoring of electrophysiological and morphological changes. Utilizing extracellular recordings of neuronal network electrical spike activity, we reveal the spontaneous appearance of SLA in networks exposed to 10 rapidly (4-6 seconds) administered 30 g impacts. Furthermore, we attempt to better characterize SLA and burst features to gain critical information about post-injury electrophysiological changes. While we observed significant increases in the synchronization of neuronal networks post-injury, a generally accepted measure of SLA, we also have identified additional metrics for SLA characterization in networks using bicuculline (a GABA receptor antagonist) for SLA induction, such as the presence of a “transition period” and a “spike-free interval” immediately preceding synchronized activity initiation. In summary, our TBI-on-a-chip model could provide

vital insights into functional and morphological changes post-TBI, while enabling the investigation of underlying SLA mechanisms, which could lead to the identification of potential therapeutic targets.

Process Design and Intensification of Modular Autonomous Crystallization Systems

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Recently there has been a transition from batch to continuous manufacturing to further intensify the standard manufacturing process. Continuous processes in general have shown many promising results such as increased product uniformity, quality, and safety due to minimal human involvement and no batch-to-batch variation. As well as easier scale-up and reduced operating volumes allowing for better control and reduced overall footprint and cost (Su et al., 2019). Using process intensification to further improve the robustness of these processes leads to the idea of modularizing processes to be as efficient as possible with the space given. The concept of modular manufacturing has gained recognition recently in various academic and industrial communities. Containing continuous manufacturing processes in reconfigurable, automated modular units can eliminate defects in the supply chain, that the current batch manufacturing system cannot do due to the piecewise operation and various locations requiring complex logistics for transferring and storing the active ingredients. These systems are customizable through the reconfigurability aspect by being able to work with numerous materials and adhere to the respective design needs in the same unit.

Current literature has shown few modular manufacturing units, including a Pharmacy on Demand (PoD) portable continuous manufacturing factory containing downstream units for producing battlefield medicines instantly and locally (Capellades et al., 2021). Our unit is currently designed to house a continuous crystallization process consisting of a mixed-suspension mixed-product removal (MSMPR) cascade system. This unit was designed for energetic materials with the motivation of improving personnel safety by eliminating the transport of the energetic compound due to local manufacturing and only requiring raw material transportation. The modular unit is constructed with increased safety including blast-resistant plexiglass, sensors, cameras, and alarms for process monitoring and automated fault detection. It is controlled via LabVIEW software for remote management of all enclosed equipment and allowing the ability to switch between closed-loop (automated design of experiments) and open-loop operation (end-to-end manufacturing). In-situ process analytical technology (PAT) tools are also being utilized in this continuous crystallization system for further control to ensure the desired critical quality attributes (CQAs) are being achieved. Applying this modular design to continuous crystallization achieves robust, efficient, and flexible manufacturing.

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Bioelectric and mechanical interaction in cartilage extracellular matrix remodeling

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Despite the prevalence of osteoarthritis (OA), a degenerative musculoskeletal disease affecting more than 650 million individuals worldwide, there is no cure, and treatment alternatives to joint replacement are mostly palliative. One characteristic of OA is the degradation of the articular cartilage, a tissue that mainly functions as a smooth, compressible cushion for the bones in the synovial joint. During the progression of OA, cartilage loses functional efficacy which may lead to joint dysfunction, pain, and a drastically decreased quality of life. Because the articular cartilage is comprised of only 5% chondrocytes, most mechanical characteristics of articular cartilage (resistance to compression, low surface friction) can be attributed to the constituent molecules of the extracellular matrix (ECM), particularly aggrecan, collagen, and hyaluronan. In vitro models with bioreactors have been used to understand the isolated effects that in vivo mechanical conditions can have on the regulation of matrix components and the efficacy of potential new treatments of OA without using animal models. Capacitively-coupled electrical stimulation – the method of positioning two parallel electrodes on either side of a culture medium, separated by an insulating layer – has been shown to up regulate the production of matrix components in in vitro studies, but the translation to clinical applications is limited due to a lack of understanding of the combined effects of electrical stimulation and the in vivo mechanical conditions. Therefore, I propose an in vitro study with the objective of investigating the effect of electrical stimulation on extracellular matrix reconstruction in the presence of mechanical compression and shear. Using a finite element model and custom bioreactor, I will examine the effects of capacitively-coupled electrical fields (CCEFs) on the production of extracellular matrix components.

Understanding Engineering Practitioners' Conceptions of DEI

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Introduction: Minority engineers often experience discrimination, bias, and feel a lack of belonging in the workplace. Similarly, engineering companies often face recruitment and retention issues when related to underrepresented minorities in the field. Both of these issues can be due to a lack of Diversity, Equity, and Inclusion (DEI) initiatives at the company. Promoting DEI initiatives in the workplace is key to creating a sense of belonging and bettering engineers' experiences.

Research Significance: The term DEI has taken on many different meanings in engineering education literature and is still new to some in industry. We must understand engineering practitioners' conceptions to gain more insight into how they perceive and experience DEI in the workplace. Understanding these conceptions will allow us to further implement DEI into engineering culture in effective ways.

Methodology: This work is part of a larger study aiming to understand the relationship between DEI and ethics in engineering. We collected 25 interviews with engineering practitioners from different disciplines. We recruited these participants via a recruitment survey wherein they self-identified their levels of experience and expertise with DEI. Through thematic analysis, we seek to identify common themes between practitioners' conceptions

Key Findings: The findings are preliminary, but we have identified four emergent themes. First, through thematic analysis, we found an emphasis on Diversity and Inclusion (as opposed to DEI as a whole) in corporate settings. Second, we found that practitioners often conceptualize DEI through different analogies including a party, a box for people, and a Band-Aid. Third, we observed that practitioners differ in assigning weight/importance to the individual components of DEI. Fourth we found that some practitioners identify a sequential order of the individual components of DEI.

Implications: This work will enable engineering educators to prepare students better for the workforce and engineering companies to implement DEI initiatives that build on practitioners' conceptions and experiences. This will allow for the creation of better initiatives to decrease the misalignment between their conceptions and experiences. Future work will explore the alignment (or lack thereof) between DEI conceptions and experiences which can help understand how what practitioners say aligns with their experiences. Our emergent coding suggests that (1) there is much variation across practitioners' conceptions, (2) practitioners' DEI conceptions often do not align with their own experiences, and (3) practitioners often define DEI differently than seen in Engineering Education literature.

Process Intensification and Integration of the Continuous Manufacturing of Atorvastatin Calcium Using Spherical Agglomeration

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Traditionally, Atorvastatin calcium (ASC), like most pharmaceutical ingredients, has been manufactured using batch processes. However, in recent years, the pharmaceutical industry has increasingly adopted continuous manufacturing, where all process operations are seamlessly integrated under one roof. This approach offers several advantages, including enhanced manufacturing flexibility, reduced batch-to-batch variations, and the capacity to handle large production volumes for high-demand drug molecules. In our recent research, we noted that the ASC crystallization process is primarily nucleation dominated, resulting in the formation of very small crystals that impede the efficiency of the filtration step. To address this issue, we propose implementing spherical agglomeration for ASC. Two critical factors in this process are the impeller stirring rate, affecting mixing and mass transfer between liquid and solid phases, and the volume of bridging solvent used, expressed as the bridging solvent ratio. Our goal was to identify the most effective operating conditions for producing spherical and uniformly sized crystals through Design of Experiment (DoE). This intensified DoE approach grants control over crystal size and shape, simplifying downstream processes by eliminating the granulation step during the manufacturing process. The integrated two-stage setup is followed by the incorporation of a continuous filtration-washing- drying unit, seamlessly linked with an upstream continuous reactor, creating a complete end-to-end continuous ASC manufacturing system.

Optimization of gas lift system for well performance improvement in Asmari formation: A techno-economic perspective

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Well productivity in the Asmari carbonate formation of southwest Iran has decreased in recent years as a result of production issues. The production rate must be maintained below 1500 STB/day to prevent water coning. In this study, a gas lift well is modeled using data from one of the producing wells of this field. Nodal analysis is performed using lift-gas injection rates and wellhead pressures at different reservoir pressures and water cut conditions to optimize production. Economic aspects are considered to optimize the artificial gas injection rates at different tubing head pressures and water cut conditions. Increasing the lift-gas injection rate from 0.4 MMscf/day to 1 MMscf/day enhances the oil production rate by 37.71% and 43.89% for 10% and 30% water cut conditions, respectively. Gas injection rates of 5.2 MMscf/day and 5.4 MMscf/day are determined to be economically optimal for 30% water cut with tubing head pressures of 260 psig and 270 psig, respectively.

Challenges of doing research outside the planet Earth

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Civil engineering is a discipline that focuses on the study, design, construction, and maintenance of infrastructure, focusing on solving problems of society. However, some of the future challenges may take place outside planet Earth. Unlike aeronautics and astronautics engineers who understand that Earth is not the main focus, civil engineers, especially geotechnical ones, are commonly expected to know essential Earth components and parameters, like Ottawa sand and granite rock characteristics. When new advances in science offer the opportunity to design new habitats outside the Earth, any engineer will take advantage of the opportunity to explore new horizons. Nevertheless, the resources commonly used are based on Earth's characteristics.

NASA aims to bring the first woman to the Moon by 2024 with the Artemis project. The final objective is to implement a human settlement on the Moon for a future step towards Mars. Studies have shown that lava tubes, the underground rock structures formed billions of years ago due to volcanic activity, are present on the subsurface of the Earth, the Moon, and Mars. These natural rock formations could be an option for a future human settlement on the Moon, with the final objective to learn and move forward to Mars. The lava tubes could provide shelter to astronauts and protect them from a challenging lunar environment that presents colossal temperature fluctuations, meteoroid impacts, solar flares, lunar dust, and moonquakes, among others.

To simulate the lunar lava tubes numerically and evaluate the stability of those rock tunnels under the presence of seismic events, it is necessary to input the characteristics of the lunar Basalt and its environment. Starting with the basic concept of gravity, the commonly used Geotechnical engineering software PLAXIS assumes and calculates the Earth's gravity as a fixed value. Tring to back-calculate the results of the software, altering different parameters to simulate the Moon's gravity, was a tedious and unsuccessful job.

Accepting the reality that the resource is not suitable for the task, changing directions, learning new software, and facing challenges individually, as most of your research group is working with different problems and resources, adds to the pressure. Like astronauts facing a new world, researchers must be open to change and adapt to the unique. After exploring new possibilities, the challenge seems small compared to immense professional growth.

Virtual Matrix Metalloproteinase Inhibition in Computational Model of in vitro Tuberculosis Infection

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Tuberculosis (TB) continues to be a global health threat. Although TB is curable, many cases result in pulmonary dysfunction as a result of lung damage, i.e. cavitation or fibrosis. Cavitation, specifically, is also associated with poor disease outcomes, increased transmission, and a higher chance of antibiotic resistance. Yet, the development of these cavities is incompletely understood. Cavitation involves the destruction of lung extracellular matrix (ECM) in which matrix metalloproteinases (MMP) breakdown ECM components such as collagen. Because of their role in collagen destruction, MMPs were then targeted with the goal of limiting ECM destruction and subsequent cavitation. However, inhibition of MMPs has resulted in conflicting impacts on TB infection outcomes. We use computational modeling to explore the interaction of collagen, MMPs, and immune cells in the context of an in vitro TB infection model. We expand on a previous agent-based model of interactions between bacteria, macrophages, CD4+ T cells, and CD8+ T cells to include MMP secretion, pro-TNF-α dynamics, and collagen. These mechanisms are added through rules that dictate behaviors and equations that define reaction kinetics. Briefly, MMPs are secreted by macrophages, with different rates relative to activation and infection status. These MMPs, along with TNF-α converting enzyme (TACE), cleave membrane bound pro-TNF-α to soluble TNF-α, an important inflammatory cytokine that drives macrophage activation. MMPs can also cleave collagen, which in turn impacts IFN-γ secretion and cell movement. These rules are then used to simulate infected immune cells in collagen microspheres. It is important to expand the model since we hypothesize that the conflicting experimental results of MMP inhibition could be due to off target inhibition of TACE, a proteinase that is responsible for a majority of the production of TNF-α. This model is then calibrated to experimental data from alginate-collagen microspheres then used to explore inhibition of MMPs with and without off target impacts. This work will help in improving understanding of the mixed experimental results of current MMP inhibitors and can provide insight into the interactions that lead to clinically relevant cavitation.

Designing mechanically robust thermal interface materials

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Thermal Interface Materials (TIMs) in electronics are typically used between the heat source and heat sink to enhance heat dissipation. TIMs are continuously exposed to harsh conditions such as temperature cycling, mechanical stress, humidity, vibration, and shock, which can lead to failure and hinder efficient thermal conduction. Both thermal and mechanical properties are equally important for electronic reliability and performance. However, mechanical properties are often overlooked in the literature compared to thermal properties. This study emphasizes the fabrication of TIMs based on polymer blend nanocomposites with mechanical robustness and sufficient thermal conductivity. The form factor of the TIM is Type II, an elastomeric/thermal pad. Mechanical robustness in the TIMs is achieved through pseudo-bicontinuous morphology of polymer blends i.e., polystyrene (PS) and polyisoprene (PI). PS and PI are glassy and rubbery polymers that respectively provide stiffness and prevent significant deformation. Thermal conductivity of these robust films can be enhanced by incorporating thermally conductive nanofillers. The thin films are fabricated through spin coating. Functionalized 2D boron nitride (BN) nanosheets, industrially relevant fillers for thermal pads, are used as thermally conductive nanoparticles. In this study, we present results of morphological and thermo-mechanical characterization of the nano scale TIMs. Insights into the properties will be presented utilizing transmission electron microscope (TEM), in situ mechanical testing coupled with optical microscopy, and various thermal characterization techniques at the nanoscale. We expect that the results obtained through this research will offer valuable insights for scaling up the processing to an industrial scale.

AD Ray-Optics: Auto Differentiable Ray Tracing Framework

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Ray tracing is the act of determining a ray of light through an optical system simulating a variety of optical effects. There are many solutions to simulate complex optical systems. However they are not differentiable. In ray tracing, conventional gradient calculation techniques become computationally expensive when the number of parameters in an optical system goes high. It's also prone to numerical error.

In contrast to that in case of Automatic Differentiation, optical parameters are calculated together with their derivatives.

We present Auto Differentiable Ray Optics (AD Ray-Optics), a computationally efficient framework for differentiable ray tracing on multi-layer refractive and diffractive optics design. It builds on the existing Python Ray Optics Library and Google Jax. RayOptics is a Python geometrical optics and image forming optics library (https://ray-optics.readthedocs.io/en/latest/). Jax is a framework for high-performance numerical computing including large-scale machine learning research (https://github.com/google/jax). Via grad JAX can automatically differentiate and via jit JAX provides XLA-optimized kernel. Through these functionalities the proposed framework improves the speed and stability of calculating gradients.

Given the sequential model of a lens design, AD Ray-Optics precompiles a computational graph that computes gradients of light rays w.r.t. lens parameters via automatic differentiation.

We validate AD Ray-Optics against finite difference gradient calculation through experiments and show that AD Ray-Optics achieves at least 30 times faster speed than finite difference gradient calculation.

In our work we demonstrate several use cases of AD Ray-Optics, including single lens optimization, cascade lens optimization, and hybrid refractive and diffractive optics optimization. The AD Ray-Optics is published online for the community to use at https://tinyurl.com/ad-rayoptics.

It could be a useful computational backbone for end-to-end computational imaging and photography.

Capacity degradation study of sodium ion batteries (NVP/Sn_HC)

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Introduction

Rechargeable batteries are substantially prevalent in modern society, be it in portable electronics or stationary energy storage applications. Lithium-ion batteries have been ruling the industry for the past few decades and its demand is expected to skyrocket in the upcoming years. This is due to the substantial transition of automotive market towards EVs (electric vehicles). Hence, alternative materials need to be developed to balance the supply-chain of energy storage devices.

Important parameters to consider while fabricating a battery are: price, lifetime, and power. Sodium metal belongs to the same alkali metal group as lithium. The similarity of its properties with lithium and its abundant availability in earth's crust, places it in a position of prominence in battery research.

Research Significance

Sodium ion batteries are a sustainable alternative; however, their storage capacity and performance are not up to the expected market standards. Hence optimizations need to be carried out at the anode/cathode/electrolyte (cell components) to achieve the required performance.

Sodium Vanadium phosphate (NVP) is employed as the cathode in this study. It is one of the most sustainable materials with reasonably high capacity. A composite mixture of Tin(Sn) and Hard Carbon(HC) is chosen as anode. Tin and Hard carbon have the advantage of providing high storage capacity and great reversibility respectively. The objective of our research is to extract the advantages of both the materials by employing a composite mixture of anode. Another important aspect of our study is to examine the effect of electrolyte on the degradation of battery capacity. Two different electrolytes are chosen:(a) Carbonate electrolyte (propylene carbonate) (b)Ether electrolyte (Diglyme). These are commonly used electrolytes in lithium batteries which is explored here for a full cell sodium battery.

Methodology

Coin cells of 19mm diameter have been fabricated for lab-scale study. The internal constituents typically are: cathode/separator/anode in the order. 10 different full cells have been tested with the variable parameters being: (a)5 anode combinations[Sn, Sn:HC (50:50), Sn: HC (70:30), Sn:HC (30:70), HC] (b)2 electrolytes

Full cells were subject to Charging and Discharging for 500 times in the Neware battery tester. Scanning Electron Microscope imaging has been carried out to visualize the changes in the electrode morphology and particle fracture before and after charge-discharge cycles. Evolution of resistance of the battery has been recorded through electrochemical impedance spectroscopy.

Key findings and implications

The capacity degradation of the battery over time under different anode and electrolyte combinations is an important metric influencing the performance of the battery. Ether electrolytes is observed to exhibit an increased capacity retention in sodium ion batteries. This is corroborated by the smooth surface of cathode through SEM images. An enhanced performance of the cell is observed in carbonate electrolyte when the anode is a composite mixture of Tin and Hard carbon(50%:50%). Hence combination of anode materials might be a way to go for the sodium batteries!

From conductivity imaging to mechanics imaging: the evolution of inverse problems in self-sensing materials

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A forward problem involves predicting the effects of a particular cause, whereas an inverse problem is a process of determining causes from an effect based on a relevant set of observations. Inverse problems play a central role in diverse and far-reaching areas of engineering, including structural design, tomography/noninvasive imaging, and many others. Recently, self-sensing materials (materials that exhibit coupling between electrical properties and external stimuli) have received increasing attention in areas such as nondestructive evaluation, biomedicine, and structural engineering. Significant research into techniques like electrical impedance tomography (EIT), itself an inverse problem, has been made to understand how external stimuli influence the conductivity changes in these materials. That is, EIT can be used to noninvasively map conductivity-changing effects in self-sensing materials. However, this approach has a critical limitation: conductivity is generally not directly a parameter of interest. For example, structural engineers would rather know the underlying stresses and strains of a material that cause an observed conductivity change. For this, we introduce a new inverse problem, which is referred to as the self-sensing materials inverse mechanics problem. This new inverse problem seeks to determine the mechanical state of a material given its conductivity distribution and a model relating conductivity to strain. To make this a stable and a robust well-posed problem, this research intends in making use of the physics-based constraints (kinematic and constitutive relationships), mixed regularization, structural prior methods and optimization methods utilizing global-search algorithms. To help advance the state of the art, we believe that employing these methods will make determining/imaging the mechanical state in these materials possible.

The Effect of Pack-out Corrosion in Compression of Built-up Steel Bridge Components

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Pack-out corrosion is a localized rust found between steel plates. This type of corrosion affects built-up members, especially old bridges under poor weather conditions. Pack-rust is unlike the other corrosions because it induces local distortion to the structural member where no displacement was intended or designed for. Additionally, this corrosion can change how the connection between the steel interacts as well as the instability of the structure. It can be found at many built-up connections and has different effects, but this project focuses on the steel members under compression forces only.

Experimental studies have been performed to test the fatigue life of steel members under compression with pack-out. The fatigue analysis was conducted via cyclic loading on the beam. This was done to determine if failure would occur either locally, meaning creating a crack, or globally, meaning complete failure of the member. Additionally, a strength test was performed on similar samples. The results showed pack-rust corrosion affects yield strength and maximum capacity of the member and minimally affects the member's stiffness. The shape of the steel member, the rust formation, the forces applied, the deformation and the stresses recorded during the experimental data was documented and used as benchmarks for modeling these tests on a finite element analysis (FEA) software (ABAQUS).

Knowing experimental data matches with the analytical, it proves the reliability of the FEA software. This allows for more models to be created to investigate different variables of built-up steel members under compression loading. A large factor affecting the pack-rust formation and the capacity of the old steel member is the shape of the built-up member, the fasteners used (rivets or bolts), and the method of attachment (straight, staggered, pre-tensioned, or post-tensioned). The goal is to be able to model structures that are still in-service to determine if the pack-rust corrosion will require maintenance.

Melatonin detection using Lignin-based electrodes for wearable sweat sensors

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Melatonin is a hormone produced by the pineal gland in response to darkness that regulates various physiological actions in the brain, ranging from circadian rhythms and sleep/wake cycle to neurodegeneration. Several studies have shown that irregularities in melatonin secretion may indicate underlying sleep disorders. Its effectiveness has been highlighted across numerous publications as a treatment for different types of sleep and neurological disorders, such as Alzheimer's and Parkinson's disease. Detecting Melatonin in sweat could provide more insights into its physiological roles and therapeutic effects. Monitoring the melatonin levels can help us assist in the identification of conditions such as insomnia, delayed sleep phase syndrome, or circadian rhythm sleep disorders, facilitating targeted interventions and treatment strategies. Further, it has also been linked to mood regulation, and it has been noted that alterations in its secretion may be associated with mood disorders such as depression and seasonal affective disorder. Several publications have also reviewed the metabolic and cardiovascular effects of melatonin, highlighting its potential benefits in addressing oxidative stress, diabetes mellitus, obesity, hyperglycemia, and metabolic syndrome. Although various electrochemical methods have been used to detect Melatonin in human sweat, however, by using a highly porous network of laser-induced graphene with high effective surface area, we engineered the wearables for detecting melatonin and were able to detect very low concentrations of Melatonin. By leveraging lignin, a biocompatible and sustainable material, as the electrode platform, this study seeks to enhance the sensitivity and reliability of melatonin detection in wearable sensors. We found the SWV (Square Wave Voltammetry) peak at approximately 0.69V for a very low concentration. Monitoring melatonin levels can contribute to understanding the interplay between circadian rhythms and mental health. Therefore, as we aim towards more accurate detection of Melatonin, we will lead to a better and more efficient tomorrow.

Automated Detection and Classification of Cardiac Abnormalities from Electrocardiogram (ECG) and Photoplethysmogram (PPG)

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Electrocardiogram (ECG), and Photoplethysmogram (PPG) signal analysis pave the way to non-invasive detection of cardiac complications, which is crucial to lowering the mortality rate of heart patients. In most cases, the outcomes are clinically relevant even in emergency environments. Hence, the features of cardiac cycles extracted from ECG signals combined with highly correlated PPG signals are pivotal for the precise prediction of cardiac diseases as well as for making the system robust and resilient. So far, numerous models have been proposed to utilize these features to represent the whole disease diagnosis process in a time and cost-effective way. For example, supervised machine learning techniques combined with traditional signal processing tools are a great way to deal with unprecedented and large datasets in an automated manner. However, in order to improve existing model design schemes, researchers need to be able to interpret the features and the results. In the existing literature, most of the methods are dependent on a single-time, forward propagation pattern between inputs and outputs. To encounter this issue, a novel method has been proposed in this literature study to measure individual feature significance, and then feed the weighted features into the compressed and optimized classifier model via a feedback loop. Moreover, this extra scheme will aid the researchers to make the predictions of their models more aligned with clinicians' diagnoses. Last but not the least, if the extracted and weighted features can be correlated with their physical significance, the healthcare workers will be more inclined in incorporating these techniques in clinical settings and use them as support tools for decision making manner.

Process Control and Design of the Continuous Crystallization of a Polymorphic Agrochemical

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Crystallization is an essential process of solids manufacturing and is left inadequately designed in several fields, including agrochemical manufacturing. Inadequately designed crystallization protocols can lead to particles with undesired physical or chemical characteristics, such as particle morphology, polymorphism, crystal size distribution/aspect ratio, manufacturability, and overall crystal quality.

In this work, we demonstrate the multi-objective process control and design of an agrochemical crystallization by i) controlling the produced polymorphic form via combined cooling and antisolvent crystallization, ii) controlling the final crystal size distribution (CSD) and resultant manufacturability with wet milling, and iii) designing the continuous crystallization for industrial manufacturing of the model system. Variations in combined cooling and antisolvent crystallization operating trajectory can have a dramatic impact on the generated polymorphic form (Kshirsagar et al., 2023). A polymorphic form design space was generated by a data-rich design of experiments (DoE) enabled by the inclusion of in-situ process analytical technology (PAT) tools. This design space allowed for informed crystallization operating trajectory design. Following the isolation of the singular polymorphic forms, concerns about manufacturability arose from the presence of a high aspect ratio (AR) morphology. High AR crystals are challenging to industrial processes in terms of poor mixing and filtration time, the inclusion of wet milling with specific crystallization operating trajectories improved both product CSD and AR regarding manufacturability (Eren et al., 2021). Using the polymorphic design space, wet milling, and targeted antisolvent and cooling crystallization operating trajectories, manufacturing in the presence of high AR morphology was greatly improved. Further applying this process control, design, and system information to the continuous crystallization of the model system reduces manufacturing time and variability during industrial manufacturing.

Impulse-Excited Transition Waves in Bistable Mechanical Metamaterials

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Mechanical metamaterials are materials designed to manipulate elastic waves. Their applications include energy harvesting, sound absorption, and damping. This presentation focuses on how impulse excitations generate transition waves in a mechanical metamaterial comprising a one-dimensional chain of bistable elements. As the transition wave propagates through the metamaterial, the bistable elements snap from one stable state to another.

Based on the initial velocity imparted to the first element, transition waves propagate through the metamaterial until a certain depth. The depth varies cyclically with the initial velocity, with alternating ranges of initial velocities where the transition wave propagates throughout the material or is not generated at all. We show that these distinct ranges of initial velocities are intricately linked to the generation and collision of solitary waves called kinks and antikinks. For instance, in the first range of initial velocity, the initial kinetic energy is sufficient to generate a kink, which travels through the metamaterial, whereas the second range generates both a kink and an antikink that collide and annihilate as breathers. This pattern continues with the generation of an extra kink or antikink in subsequent ranges. This shows the existence of windows of initial velocities for the propagation of transition waves, with moving breathers occurring between two consecutive windows.

Using energy-based arguments, we predict the initial velocity ranges for the propagation of transition waves and demonstrate its dependence on a crucial design parameter – the onsite stiffness of the metamaterial. We also observe multiple sub-windows at the boundaries of the velocity ranges, resembling the 'n-bounce' resonance windows found during kink-antikink collisions. In this manner, we demonstrate that the mechanism behind the generation of transition waves due to impulse is linked to the well-understood phenomenon of kink-antikink collisions. Unveiling how impulses generate transition waves in bistable acoustic metamaterials can help design materials that effectively absorb and dampen energy due to impact.

Physics Informed Neural Networks for Improved Data Processing and Analysis

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A metrology tool based on 2D Laser Angstrom Method has been developed for the characterization of anisotropic thermal conductivity in the in-plane direction for thin material sheets. While the experimental setup enables us to obtain the Infrared thermal data, a data-processing algorithm is needed that processes the given data and predicts the values of the thermal properties. The existing post-processing technique involves applying least squares fitting method to obtain the necessary predictions. However, the existing method introduces a lot of uncertainty in the extracted parameters in the case of noisy data. Our goal is then, to minimize the error in the predictions by incorporating high-accuracy computational algorithms. This study talks about one of the solutions: Physics Informed Neural Networks (PINNs). These are a method used to solve ordinary and partial differential equations (ODEs and PDEs). They combine the computational advantages of the machine learning algorithms with the universality of the underlying Physics governing differential equations, to predict the values of thermal conductivity efficiently and accurately. The study demonstrates the exceptional performance of PINNs model in data with varying levels of noise, thus mitigating its impact on the accuracy of predictions. The parameter values predicted by PINNs are within 0.5% of the true values. In addition, it also investigates the impact of different neural network parameters on the accuracy and the computational time.

Localized Residual Stress Measurements via Energy-based Nanoindentation in Titanium Alloys processed with Laser Powder Bed Fusion

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Metal additive manufacturing can produce intricate components, but the complicated thermal history can result in substantial residual stresses. We present a method for analyzing localized residual stress in powder bed fusion titanium alloys. Experimental evaluation of localized residual stresses was conducted using the energy envelope from nanoindentation load-displacement curve, which describes the total work of the indents. Residual stress calculations were performed by comparing the printed materials to annealed materials with same composition and processing method. This experiment provides uniaxial residual stress profile and mechanical properties along the building direction of two Ti alloys, ATI-Titan 23TM and Ti-64. Tensile stresses can reach up to 0.5GPa at the free surface and building support, balanced by a compressive stress of -0.5GPa at center along the printing direction within a 2.5cm coupon. Differences in the hardness of the alloys and their heat treatment response will be discussed.

Opioid Diversion Monitoring

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Prevalence of opioid use and abuse is a current widespread problem in the United States. There are many aspects to this problem that make it complex including but not limited to diversion. Diversion is any act of illegal distribution or abuse of prescription drugs, or their use for purposes not intended by the prescriber. In this research, we focus on the problem of identification of diversion points of these controlled drugs occurring at many levels including suppliers, prescribers and patients. The problem of flagging suspicious behavior involved in diversion is complicated as it can depend not just on the absolute quantity of the controlled drug distributed or consumed, but also on factors like geographical location of the suppliers and consumers, seasonal variations in demand of the drugs and co-occurring medical conditions in consumers, which makes it harder to differentiate between outliers and anomalies. We develop a network based framework to model this supply chain and associated context factors to identify suspicious nodes and output an optimal selection of nodes to be flagged. We model this supply chain as a directed network with nodes representing prescribers, pharmacies and patients; and the node attributes representing the aforementioned context factors associated with the different types of nodes. The edges represent the flow of the controlled drugs between the different nodes. A mixed-integer optimization is formulated and solved to identify the optimal set of suspicious nodes that should be flagged, given regulatory and budget constraints. We anticipate our method to be able to differentiate between an anomaly and an outlier, while providing an optimal set of nodes to be flagged. This work is of immediate practical significance to government agencies like the Drug Enforcement Administration (DEA), as they sift through the immense supply chain of controlled drugs for identifying behavior of concern in real time. In this presentation, I would like to bring to focus a fundamental challenge with working on social and human centered problems, especially involving illicit or undesirable behavior at scale. In many such situations, the undesirable behavior is not easily observable/classifiable as either good or bad behavior due to the complexity arising from the context of the behavior and the actions taken. In other words, black and white rules can not differentiate the many gray shades in people's behavior.

Learning Dissipative Neural Dynamical Systems

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We consider the problem of learning a neural dynamical system model for an unknown nonlinear system that is known a priori to be dissipative. The objective is to learn a neural dynamical model that approximates this system, while preserving the dissipativity property in the model. Dissipativity is an input-output property that generalizes the notion of energy storage in circuit theory to a general quadratic form that is applicable to any nonlinear system. It is an attractive property because dissipative systems are stable and generally robust to perturbations. Further, dissipativity provides a general framework to guarantee several crucial properties like L2 stability, passivity, conicity, and sector-boundedness. On the other hand, system identification, even in linear settings, does not automatically preserve properties like dissipativity and passivity without explicit constraints, even if the original system is known a priori to possess such properties. In general, imposing dissipativity constraints during neural network training is a hard problem for which no known techniques exist. In this work, we address the problem of learning a dissipative neural dynamical system model in two stages. First, we learn an unconstrained neural dynamical model that closely approximates the system dynamics. Next, we derive sufficient conditions to perturb the weights of the neural dynamical model to ensure dissipativity, followed by perturbation of the biases to retain the fit of the model to the trajectories of the nonlinear system. We show that these two perturbation problems can be solved independently to obtain a neural dynamical model that is guaranteed to be dissipative while closely approximating the nonlinear system.

Towards personalized product and treatment design: Integrated digital design of efficacy and optimal treatment of oral drugs

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The formulation of orally solid dosage forms is crucial for the pharmaceutical industry as it significantly impacts drugs' performance. Formulation factors like active pharmaceutical ingredients' (API) particle size, excipient type, and crystallinity affect oral bioavailability. Manufacturers develop various drug formulations to control release and enhance bioavailability (drug efficacy) during drug development. To develop drug formulations, scientists must bridge the in vitro formulation disintegration and dissolution and the in vivo absorption. Several methods were proposed to do that. In vitro-in vivo correlation (IVIVC) is the most common method for bridging the gap. However, a high number of dissolution tests and preclinical trials for animal and human studies are needed for this method. Recently, several studies have attempted to combine physiologically based pharmacokinetic (PBPK) modeling with dissolution to guide formulation, while there are still some limitations due to the lack of a direct connection between the properties of formulation and absorption modeling. In our work, we aim to combine the PBPK model for drug absorption, distribution, metabolism, and elimination (ADME) in vivo with the population balance model (PBM) for particle disintegration and dissolution. This combined model allows us to predict the plasma concentration from the formulation properties, this combined model allows us to predict the plasma concentration based on the formulation properties, which in turn helps us optimize the drug efficacy on the basis of product design and facilitate the formulation development process. This model will be validated and trained based on different patient groups' pharmacokinetic data, to predict the average response to treatment and formulation, paving the road towards personalized medical treatment. In preliminary results, we demonstrate the impact of dissolution effect on drug plasma concentration profile. The global sensitivity analysis indicates that the parameters of particle size distribution influence the drug plasma concentration. We further illustrate several scenarios to show how particle size distribution impacts the drug concentration in different organs under different drug solubility, absorption mechanisms, and different amounts of initial liquid in the stomach.

Model transfer across tellurene nanomanufacturing processes via mean effect equivalence

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Tellurene is a novel material for transistors with reliable attributes that enhance the performance of electronics (e.g., nanochip). As a solution-grown product, two-dimensional (2-D) tellurene can be manufactured through a scalable process with low cost. Thus, it is critical to learn the effects of process factors on the production yield and dimensions (e.g., thickness) in its manufacture. As experimentation evolves over time it is possible for method creep to influence results, for example a change in autoclave size to scale up the amount of product being produced. It is important to account for this potential source of bias to avoid false positives and it is desirable to get as much information from earlier experimental runs as possible, especially when the financial or time cost to experiments is high. We apply transfer learning in the analysis of tellurene manufacturing from a new experiment (process B) using the established linear regression model from a prior experiment (process A) from a similar study to combine the information from both experiments. The key of this approach is to incorporate the total equivalent amount (TEA) of a lurking variable (experimental process changes) in terms of an observed (base) factor that appears in both experimental designs into the prespecified linear regression model. For this approach to work well, process A and process B must be distinguishable by different settings of the lurking variables (e.g., the size of autoclave). We use a blocked Gibbs sampler to compute the posterior distribution of TEA conditional on direct draws of mean and variance parameters. Based on the exploratory analysis, we proposed the design of validation experiments. With the validation data, we model TEA based on the visualization of posterior draws. Then we incorporate the TEA model in the base model to complete the model transfer. We use Hamiltonian Monte Carlo for inference on the parameters in the transferred model.