MIT PDA

Postdoc Symposium

2025

- **Date:** Thursday, May 15
- **Time:** 4:00 – 6:00 PM
- **Location:** W20-307

Poster number: 1

Presenter: Emanuele Sansone

Department: CSAIL

Title: Discovering the World through Unsupervised Statistical Relational Learning

Abstract:
Machine learning is popular nowadays, thanks to the impressive results achieved by systems like DeepMind's AlphaGo, OpenAI's language prediction model GPT-X or Amazon's speech recognition system Alexa. At the basis of these successes, there is representation learning, which enables training deep neural networks in an unsupervised fashion and provides the starting conditions for subsequent task-specific training. However, current representation learning strategies use large neural networks and consume large amount of data, thus being data and energy inefficient. In contrast, humans learn from limited data in a very efficient way. This is due to the fact that humans are able to perform reasoning, while representation learning strategies lack such capability. This research project aims to overcome these limitations by providing the mathematical foundations for the integration between unsupervised learning and reasoning AI systems based on logic. Specifically, the aim is to devise algorithms enabling the discovery of symbolic representations from noisy/ambiguous data together with their relations and being able to adapt the acquired relational knowledge over time.

Poster number: 2

Presenter: Olawale Salaudeen

Department: EECS

Title: Towards Well-Specified Domain Generalization Benchmarks

Abstract:
Spurious correlations hinder robust decision-making by misleading models under distribution shifts. Conventional wisdom suggests that models relying on these correlations will fail in out-of-distribution (OOD) settings, yet naive in-distribution risk minimizers often achieve the best OOD accuracy on popular benchmarks. We argue that this paradox arises because current benchmarks are misspecified; they do not capture shifts in spurious correlations that significantly affect OOD generalization.
We establish conditions under which a distribution shift can reliably gauge a model's reliance on spurious correlations. Under these conditions, the phenomenon known as "accuracy on the line", defined as a strong positive correlation between in-distribution and OOD accuracy, should not occur. Yet most benchmarks exhibit this pattern, indicating they do not measure true robustness. We call for a rethinking of robustness evaluation and for designing benchmarks that accurately reflect the impact of distribution shifts.

Poster number: 3

Presenter: Kendrik Yan Hong Lim

Department: Mechanical Engineering

Title: Building Resilient Supply-Production Systems: AI-Driven Digital Twins for Disruption Mitigation in an era of hyper-personalization.

Abstract:
A digital twin-driven framework is proposed to enhance resilience in supply and production systems facing disruptions from market volatility, geopolitical shifts, and climate risks. Industries managing multi-echelon networks struggle with cascading delays, material shortages, and rigid workflows, exacerbated by demand for mass-customized goods requiring precision in small-batch production.
The framework integrates modular digital twins with industrial knowledge graphs to map interdependencies across design, manufacturing, and supply chains. Predictive analytics identify risks, while prescriptive tools suggest adaptive strategies like dynamic rescheduling, supplier reallocation, and circular material reuse. This system enables real-time, context-aware disruption mitigation by unifying siloed lifecycle phases.
Validated through case studies, the approach demonstrates how digital twins and knowledge graphs enhance resilience planning. Modular architecture bridges data visibility gaps, and graph-based reasoning tackles knowledge incompleteness in supply networks, positioning these technologies as critical for building adaptive, sustainable ecosystems to navigate uncertainty.

Poster number: 4

Presenter: Shengnan Huang

Department: KI

Title: A programmable nanovaccine platform based on M13 phage for personalized cancer therapy

Abstract:
Nanovaccines that co-deliver antigens and adjuvants can elicit strong immune responses but often require complex synthesis and post-processing steps. Here, we present a programmable nanovaccine platform based on the M13 bacteriophage, enabling scalable vaccine production with single-step modular control over adjuvanticity, length, and antigen density. By reprogramming the noncoding phage genome, we precisely tuned the Toll-like receptor 9 (TLR9) activation and controlled phage length. Through a novel molecular engineering strategy, we adjusted the antigen density from 13.5% to 70.3%. The nanoscale dimension of M13 promoted efficient lymph node drainage and uptake by antigen-presenting cells. Systematic optimization revealed threshold values for antigen density and adjuvanticity that maximize anti-tumor $CD8^+$ T cell responses. This M13-based nanovaccine elicited durable memory immunity lasting over a year and enhanced neoantigen-specific $CD8^+$ T cells by 24-fold. When combined with anti-PD-1 therapy, it eradicated established MC-38 tumors in 75% of treated mice. These findings make M13 phage a powerful and versatile nanovaccine platform for personalized cancer immunotherapy.

Poster number: 5

Presenter: Muhammad Zeeshan

Department: Department of Mechanical Engineering

Title: Electromagnetic-field Based Regeneration of CO2 Reactive Porous Composites for Direct Air Capture

Abstract:
Motivated by our recent findings on dielectric heating of porous composites using microwave irradiation (higher end of electromagnetic spectrum), we now aim to capitalize the lower end of the electromagnetic spectrum, such as radio frequency (RF), to desorb the captured CO2 in a porous material via dielectric heating. To prepare the composite, we loaded a reactive IL, into porous material via wet impregnation method, followed by detailed characterization. CO2 breakthrough measurements were performed to examine the potential of IL/MOF composite sorbent for direct air capture (DAC) using a gas feed of 500 ppm of CO2 balanced with N2 at 30 °C. The CO2 capacity of the prepared composite improved significantly compared to the pristine porous material, which showed no quantifiable CO2 capacity at the corresponding conditions. To regenerate the sorbent, an RF applicator at 300 MHz frequency was employed, which quickly warmed the IL-porous composite and released the captured CO2. This study demonstrates a new non-thermal way of regenerating CO2 sorbents using low frequency electromagnetic radiations for DAC application.

Poster number: 6

Presenter: Hongkai Ning

Department: RLE

Title: In-Memory Sparsity: Enable efficient unstructured element-wise sparse training from the bottom

Abstract:
The fine-grained dynamic sparsity in biological synapses is an important element in the energy efficiency of the human brain. Emulating such sparsity in an artificial system requires off-chip memory indexing, which has a considerable energy and latency overhead. Here, we report an in-memory sparsity architecture in which index memory is moved next to individual synapses, creating a sparse neural network without external memory indexing. We use a compact building block consisting of two non-volatile ferroelectric field-effect transistors acting as a digital sparsity and an analogue weight. The hardware, which is comprised of 900 ferroelectric field-effect transistors, is based on wafer-scale chemical-vapour-deposited molybdenum disulfide integrated through back-end-of-line processes. With the system, we demonstrate key synaptic processes—including pruning, weight update and regrowth—in an unstructured and fine-grained manner. We achieve 98.4% accuracy in an EMNIST letter recognition task under 75% sparsity. Simulations on large neural networks show a 10-fold reduction in latency and a 9-fold reduction in energy consumption.

Poster number: 7

Presenter: Will Milner

Department: Physics

Title: In situ imaging of the thermal de Broglie wavelength

Abstract:
We report the first in situ observation of density fluctuations on the scale of the thermal de Broglie wavelength in an ultracold gas of bosons. Bunching of 87Rb atoms in a quasi two-dimensional system is observed by single-atom imaging using a quantum gas microscope. Compared to a classical ensemble, we observe a 30 percent enhancement of the second-order correlation function. We show the spatial and thermal dependence of these correlations. The reported method of detecting in situ correlations can be applied to interacting many-body systems and to the study of critical phenomena near phase transitions.

Poster number: 8

Presenter: Rabab Alomairy

Department: CSAIL

Title: Accelerating Gaussian Processes for MLIPs with Mixed-Precision and Parallel Matrix Computation

Abstract:
Gaussian Processes (GPs) are powerful machine learning models used in regression, uncertainty quantification, and parameter estimation. In computational materials science, they help quantify uncertainty in interatomic energy and force predictions by machine learning interatomic potentials (MLIPs) trained on quantum mechanical (QM) data. However, GPs struggle with scalability due to the high cost of constructing and inverting large covariance matrices. This poster presents a novel, accuracy-preserving mixed-precision approach to accelerate GP regression. By rethinking matrix construction using parallelized matrix-matrix operations and solving linear systems with mixed precision, we improve speed and efficiency. Our results show substantial computational savings in GP-based uncertainty prediction, enabling practical use of GPs on large QM datasets for training MLIPs.

Poster number: 9

Presenter: Tamara Rossy

Department: Mechanical Engineering

Title: Exploring targeted muscle stimulation as a therapeutic strategy against ALS in a human in vitro neuromuscular model

Abstract:
Amyotrophic lateral sclerosis (ALS) is a fatal disease marked by motor neuron degeneration and NMJ denervation, leading to loss of motor control. While therapies target the ~10% of cases with known mutations, treatments for sporadic ALS are urgently needed. In mice, we found that stimulating denervated muscle promotes motor neuron growth. We hypothesize that direct muscle stimulation, bypassing NMJs, may encourage reinnervation in ALS patients. To test this, we developed an in vitro neuromuscular model derived from human induced pluripotent stem cells (hiPSCs). Differentiating muscle on soft hydrogels extends its longevity and maturity compared to conventional approaches. To co-culture mature hiPSC-derived muscle and neurons, we 3D-printed a device that temporarily separates the two cell types during early differentiation. After removing the separator, neurons extended neurites toward the muscle, and preliminary data show neuron-induced muscle contraction, indicating functional NMJs. We now aim to compare how muscle stimulation affects neurite outgrowth and NMJ formation in neurons from healthy versus ALS donors.

Poster number: 10

Presenter: David Walter

Department: Laboratory for Nuclear Science (LNS)

Title: SubMIT: A Next-Generation Data Analysis Facility

Abstract:
Various fields in physics requiring increasingly powerful tools to analyze the massive datasets produced by experiments like the Large Hadron Collider. Other fields such as string theory getting increasingly computational, demanding substantial computing resources. The recently developed SubMIT platform is a functioning prototype of a next-generation data analysis facility operated by the basic computing services in the physics department at MIT. It consists of servers that provide interactive access to substantial data samples at high speeds, enabling sophisticated data analyses with very fast turnaround times. Additionally, it seamlessly integrates massive processing resources for large-scale tasks by connecting to a set of powerful batch processing systems. A minimum of 100 Gbps networking per server, a large NVMe storage, and spinning-disk Ceph file system are included. The platform integrates a diverse set of high multicore CPU machines for tasks benefiting from the multithreading and GPU resources e.g. for neural network training. SubMIT also provides and supports a flexible environment for users to manage their own software needs for example by using containers.

Poster number: 11

Presenter: David Simonne

Department: NSE

Title: Multi-scale Imaging of Corrosion and Hydrogen Embrittlement in Irradiated Nuclear Materials

Abstract:
Structural materials in nuclear reactors degrade due to hydrogen embrittlement (HE) and corrosion, both worsened by radiation, high temperature, pressure, and stress. This study investigates how radiation-induced defects influence these degradation processes using Bragg Coherent Diffraction Imaging (BCDI), Dark Field X-ray Microscopy (DFXM), and Transmission Electron Microscopy (TEM). Controlled defect structures are introduced via heavy ion irradiation and nano-indentation, then exposed to hydrogen and corrosive environments in simulated light water reactor conditions.
BCDI maps nanoscale strain, DFXM captures grain-scale changes, and TEM reveals atomic-level defects. By comparing indented, irradiated, and pristine Ni/Ni-Cr samples, we track hydrogen-defect interactions and corrosion onset. Density functional theory supports experimental findings, linking hydrogen behavior to crystallographic facets. This multi-scale, multi-technique approach reveals how specific defect structures affect material performance, guiding the design of radiation- and corrosion-resistant alloys for next-generation nuclear reactors.

Poster number: 12

Presenter: Jet Lem

Department: Mechanical Engineering

Title: High-throughput microscale extreme mechanics: From quasi-static to ballistic impact

Abstract:
The development of materials for performance under a range of conditions requires equally diverse experiments. Towards this goal, we developed a host of microscale techniques to characterize the mechanical responses of samples across decades of strain rates. Miniaturization of classical techniques enhances experimental efficiency by minimizing required sample volumes and allowing for facile benchtop testing. Using microscale uniaxial compression, we can investigate responses ranging from the quasi-static up to intermediate strain-rates. Ballistic impact responses are investigated using laser-induced particle impact testing, firing microparticles up to 1000 m/s speeds. Combined, these capabilities allow high-throughput cost-effective characterization, representing significant potential for the rapid screening novel high-performance materials.
Within our group, we investigate mechanical metamaterials, a class of material whose properties are defined by their microstructure, rather than their constituent material. Through these techniques we have been able to build intuition for the mechanical design principles that define high-performance energy absorbing metamaterials.

Poster number: 13

Presenter: Jianlu Zheng

Department: Materials Science and Engineering

Title: Revealing Hypoxic Sickling Kinetics in Sickle Cell Disease via Microfluidics

Abstract:
Sickle cell disease (SCD) arises from a β-globin gene mutation, replacing glutamic acid with valine in hemoglobin (HbS), which polymerizes under hypoxia, distorting red blood cells (RBCs) and causing vaso-occlusion, stroke, and organ damage. Current therapeutic approaches encompass both curative (gene therapy, hematopoietic stem cell transplantation) and symptom-alleviating (chronic transfusions, pharmacologic agents including hydroxyurea and voxelotor) strategies. While emerging genetic therapies show promise, their clinical implementation remains constrained by substantial costs and uncertain long-term safety profiles. Furthermore, intercellular variability in sickling propensity complicates drug treatments. To address this challenge, we employ precision microfluidics to quantitatively map sickling kinetics across heterogeneous erythrocyte populations, providing a platform for evaluating individualized treatment strategies in SCD.

Poster number: 14

Presenter: Hratch Baghdassarian

Department: Biological Engineering

Title: scLEMBAS: Context-aware signaling pathway modeling at single-cell resolution

Abstract:
Signaling pathways sense and propagate information from the extracellular environment to dictate a cell's response, governing functions such as cell growth, differentiation, and apoptosis. By integrating multiple signals, the underlying network of interacting components can achieve context-specificity and multicellular coordination. However, signaling pathway activity is difficult to decipher due to the vast combinatorial space of possible interactions, the nonlinearity of these interactions, and pathway crosstalk. Here, we develop a computational approach to model this complexity. Specifically, we develop a model that provides (a) genome-scale, (b) mechanistic signaling pathway simulations across (c) multiple contexts and at (d) single-cell resolution. To do so, we adapt LEMBAS (PMID: 35654811), which predicts transcription factor (TF) activity from ligand concentration in bulk omics, for single-cell predictions (scLEMBAS). scLEMBAS generalizes to multiple contexts and captures the heterogeneity within cell subpopulations. We demonstrate that scLEMBAS can accurately predict transcription factor activity in immune cell subpopulations subjected to cytokine stimulation.

Poster number: 15

Presenter: Xiaoteng Zhou

Department: Mechanical Engineering

Title: Thickness effect when water drop wets nanocoatings

Abstract:
Thickness can be a reliable predictor of drop velocity on nano-scale polymer coatings. Several interfacial interactions, observed through molecular-level measurements, exhibit similar trends as friction changes with thickness. We attribute this to the nano-scale thickness, which is comparable to the interface thickness, and the inherent flexibility of the polymer. These factors alter the arrangement of the interface due to varying Van der Waals forces, which affect the stabilization of the interfaces in this system. Additionally, due to the high flexibility of the polymer, the formation of a capillary ridge must also be considered once a critical thickness is reached.

Poster number: 16

Presenter: Laurence Willemet and Haoshu Fang

Department: CSAIL

Title: The Minimal Sense of Touch: Exploring the Limits of Tactile Information for Dexterity

Abstract:
Tactile feedback is crucial for dexterous object manipulation, yet the minimum amount of tactile information required for effective performance remains poorly understood. In this study, we investigate how progressive degradation of tactile sensitivity affects human performance in simple manipulation tasks. Participants completed a series of dexterity tests—such as peg transfers—while wearing finger cots of varying thickness and diameter to systematically reduce tactile input. Each condition was first assessed through dedicated tactile perception tests to quantify the degree of sensory attenuation. Results show that moderate reductions in tactile resolution do not significantly impair task performance, but more severe degradations lead to measurable declines in speed and accuracy. These findings suggest the presence of a perceptual threshold below which tactile information becomes insufficient for efficient manipulation. This work provides empirical benchmarks for designing wearable haptic interfaces and robotic tactile sensors.

Poster number: 17

Presenter: Saugata Barat

Department: MIT Kavli Institute

Title: Exoplanets through time: First glimpse of the atmospheres of young transiting planets

Abstract:
Demographic studies exoplanets have revealed population level trends, such as the exoplanet 'radius valley'. A widely accepted hypothesis to explain these demographic features is that exoplanets on compact orbits undergo early evolutionary processes (such as mass loss) over the first few 100 million years of their life, which is expected to significantly alter their atmospheric properties.
Therefore, young transiting planets (< 100Myr old) represent the earliest phase in the lifetime of exoplanets and are promising targets to reveal their evolutionary history. However, it is not known how the primordial atmospheres of these planets look like.
To address this, we will present the first observations of the atmospheres of young transiting planets with the Hubble Space Telescope and the James Webb Space Telescope. We characterize the atmospheres of two young planets (20-30 million years old) in the same system, V1298 Tau to measure their mass, atmospheric composition and internal entropy using transmission spectroscopy and compare them with their mature counterparts to observationally understand the role of early evolutionary mechanisms.

Poster number: 18

Presenter: Juan Pierella Karlusich

Department: Department of Biology

Title: Clusters of protein structures reveal novel remote homologs between eukaryotes and their closest prokaryotic relatives

Abstract:
The origin of the eukaryotic cell was a major evolutionary event that led to a significant increase in cellular complexity, enabling specialized compartments and a partnership with mitochondria, and allowed the emergence of multicellular life. The eukaryotic cell is hypothesized to have originated from a symbiotic relationship between an Asgard archaeal host, which evolved into the nucleus, and an α-proteobacterium, the progenitor of the mitochondrion. Phylogenetic analyses identify Asgard archaea as the closest prokaryotic relatives to eukaryotes, with sequence similarity searches revealing eukaryotic homologs in their genomes. To determine whether additional homologs remain undetected, we employ structural alignment methods to identify novel eukaryotic homologs in Asgard archaeal genomes.

Poster number: 19

Presenter: Abhishek Soni

Department: Department of Materials Sciences and Engineering

Title: Accelerated development of materials for CO2 electrolyzers

Abstract:
We present AdaCarbon, a high-throughput automation system designed to accelerate the development of gas diffusion electrodes for CO2 electrolysis. AdaCarbon comprises seven collaborative robots that automate GDE fabrication, characterisation, and zero-gap CO2 electrolysis testing. Using this platform, we fabricated and tested 90 GDES with varying mixed-metal and ionomer compositions to optimise ethylene production at industrially relevant current densities. Furthermore, AdaCarbon accelerates gas diffusion electrode development by a factor of three compared to manual workflows, demonstrating its potential to significantly enhance CO2 electrolysis research for machine-learning-driven closed-loop optimization of catalyst and reaction conditions.

Poster number: 20

Presenter: Juan Felipe Torres Gonzalez

Department: Chemistry

Title: Influence of Pore Guest and Topology on the Performance of Rhodium Hydroformylation Catalysts Supported on Metal-Organic Frameworks

Abstract:
Using metal-organic frameworks (MOFs) for the development of heterogenous Rh-catalysts for hydroformylation is attractive thanks to the molecular nature of these materials. However, current strategies for Rh incorporation in MOFs are unsuitable for industrial applications due to poor retention or high-cost. Herein, we studied the heterogenization of a Rh complex in low-cost anionic MOFs, via cation exchange, for the hydroformylation of 1-octene. We evaluated the series of MOFs X-SU-102 (X= exchangeable cation) with the same anionic framework but different cations. The cation inside the pore of the material affects significantly the performance of the catalyst, with differences in the distribution of products observed. Additionally, we also studied the influence of the topology of the framework on the performance of the catalyst by using other members of the SU family, displaying different structures, as support. Our findings indicate that anionic-MOFs are promising materials for the synthesis of MOF-based catalyst that are relevant for industrial applications, with low-cost materials required for the synthesis and easily tunned properties.

Poster number: 21

Presenter: Akshat Dave

Department: Media Lab

Title: NeST: Neural Stress Tensor Tomography by leveraging 3D Photoelasticity

Abstract:
Photoelasticity enables full-field stress analysis in transparent objects through stress-induced birefringence. Existing techniques are limited to 2D slices and require destructively slicing the object. Recovering the internal 3D stress distribution of the entire object is challenging as it involves solving a tensor tomography problem and handling phase wrapping ambiguities. We introduce NeST, an analysis-by-synthesis approach for reconstructing 3D stress tensor fields as neural implicit representations from polarization measurements. Our key insight is to jointly handle phase unwrapping and tensor tomography using a differentiable forward model based on Jones calculus. We develop an experimental multi-axis polariscope setup to capture 3D photoelasticity and experimentally demonstrate that NeST reconstructs the internal stress distribution for objects with varying shape and force conditions. Additionally, we showcase novel applications in stress analysis, such as visualizing photoelastic fringes by virtually slicing the object and viewing photoelastic fringes from unseen viewpoints. NeST paves the way for scalable non-destructive 3D photoelastic analysis.

Poster number: 22

Presenter: Jiaji Li

Department: CSAIL

Title: 3D printing cable-driven mechanism for actuation, deformation, and manipulation

Abstract:
In this paper, we present Xstrings, a method for designing and fabricating 3D printed objects with integrated cable-driven mechanisms that can be printed in one go without the need for manual assembly. Xstrings supports four types of cable-driven interactions—bend, twist, coil, and compress—which are activated by applying an input force to the cables. To facilitate the design of Xstrings objects, we developed a design tool that allows users to embed cable-driven mechanisms into the object geometry based on the desired interaction by automatically placing joints and cables at the respective locations. We investigate the effect of different printing parameters on the maximum tensile strain and the extent to which the interaction is repeatable without the cables breaking. The application potential of Xstrings is demonstrated through examples such as advanced input devices, bionic robot manufacturing, and dynamic prototyping.

Poster number: 23

Presenter: Leonardo Bianchi

Department: MechE

Title: A Multimodal Imaging Framework to Advance Phenotyping of Living Label-free Breast Cancer Cells

Abstract:
We introduce a multimodal approach combining confocal Raman micro-spectroscopy (RS) and tomographic phase microscopy (TPM) for rapid, label-free morpho-chemical phenotyping of live human breast cancer cells (MDA-MB-231). These non-perturbative techniques capture detailed molecular and morphological data in a native environment. Hyperspectral Raman imaging (600–1800 cm^{-1}) reveals diverse molecular bonds and structures, while 3D refractive index tomograms provide nanometer-resolution metrics like cell volume, surface area, thickness, dry mass, and density. Using unbiased data processing pipelines, we quantitatively demonstrate the power of this multimodal strategy in revealing unique and correlated subcellular features. This method offers significant potential for advancing live-cell phenotyping in biomedical and clinical research.

Poster number: 24

Presenter: Rebecca Masline

Department: Plasma Science and Fusion Center

Title: Helium enrichment and tritium burn efficiency in simulations of divertor plasmas

Abstract:
The connection between projected fusion reactor performance and helium enrichment in the edge plasma is explored using the plasma edge code SOLPS-ITER. Recently, it was proposed that the tritium usage in steady state, equilibrated fusion reactors could be characterized by a generic, dimensionless figure of merit: the "Tritium Burn Efficiency", or "TBE" which connects the reactor performance with the permitted helium gas fraction in the divertor. This study addresses the applicability of TBE for characterizing fusion devices through evaluation of helium transport and enrichment in the divertor plasma, in both existing experiments and for next-step devices using SOLPS-ITER, matching reported experimental conditions to assess the validity of the helium physics models in the code. A helium enrichment value defined as fHe,exh/fHe,core of 1.0 is achieved in the simulation, in good agreement with the reported value of 1.1 in the experiment. This simulation acts as a validated baseline for further physics studies on divertor helium enrichment in the DIII-D tokamak as an injected impurity as fusion-born alpha particles.

Poster number: 25

Presenter: Carey Witkov

Department: Physics

Title: Phase stability in the ATP molecular motor

Abstract:
ATP synthase is composed of two coupled rotary motors, F_0 and F_1, with mismatched step sizes—15° for F_0 and 120° for F_1. This study investigates how stable synchronization is achieved despite this mismatch. The phase stability principle used in synchrotron particle accelerators is applied via two complementary models: a hybrid Adler equation that incorporates elastic filtering of torque through the central stalk, and a Van Slooten–type pulse map that captures discrete, event-driven synchronization dynamics. These models account for phase-locking, slippage, and dwell time via Nath's torsional mechanism, which posits that the elastic stalk stores and transmits energy between the two motors. Results show that both continuous and discrete synchronization regimes can coexist, and that elastic memory plays a key role in robust coordination. This unified framework offers new insight into the physical basis of energy-efficient rotation and adaptability in ATP synthase.

Poster number: 26

Presenter: Yeo Jung Yoon and Rolando Bautista-Montesano

Department: Mechanical Engineering

Title: TeleopLab: Accessible and Intuitive Teleoperation of a Robotic Manipulator for Remote Labs

Abstract:
Teleoperation offers a promising solution for enabling hands-on learning in remote education, particularly in environments requiring interaction with real-world equipment. However, such remote experiences can be costly or non-intuitive. To address these challenges, we present TeleopLab, a mobile device teleoperation system that allows students to control a robotic arm and operate lab equipment. TeleopLab comprises a robotic arm, adaptive gripper, cameras, lab equipment for a diverse range of applications, a user interface accessible through smartphones, and video call software. We conducted a user study, focusing on task performance, students' perspectives toward the system, usability, and workload assessment. Our results demonstrate a 46.1% reduction in task completion time as users gained familiarity with the system. Quantitative feedback highlighted improvements in students' perspectives after using the system, while NASA TLX and SUS assessments indicated a manageable workload of 38.2 and a positive usability of 73.8. TeleopLab successfully bridges the gap between physical labs and remote education, offering a scalable and effective platform for remote STEM learning.

Poster number: 27

Presenter: Arianna Bresci

Department: Mechanical Engineering

Title: Compact band-pass Raman spectroscopy unlocks non-invasive continuous glucose monitoring

Abstract:

Non-invasive blood glucose monitoring with precision comparable to standard finger-pricking has been a long-sought goal, especially as diabetes rates soar, with 592 million cases worldwide expected by 2035. Various optical and spectroscopic technologies have been explored for non-invasive continuous glucose monitoring (CGM), but most methods fall short in detecting physiological levels or lack the miniaturization needed for practical use.

Based on our previous success on observation of glucose signal from in-vivo skin, we developed a novel band-pass Raman spectroscopy method, enabling non-invasive, physiological-level CGM in a compact device. Using off-axis 830 nm near-infrared illumination and intra-spectrum reference, we eliminate most elastically scattered photons, revealing the glucose Raman signal through an amplified photodetector, while compensating for background variations.

Our approach overcomes bulky spectrometers, making portable Raman-based CGM devices a reality. This poster presentation will detail our innovative method validated both on tissue phantoms and clinical trials on humans. Our technology promises to be a game-changer for current diabetes management.

Poster number: 28

Presenter: Weiyin Chen

Department: NSE

Title: Flash recycling of spent batteries

Abstract:

Effective recycling of spent batteries is essential due to accumulation of battery waste and gradual depletion of battery metal resources. A closed-loop solution will lessen both the environmental impacts and economic cost of their use. However, <5% of spent lithium-ion batteries (LIBs) are recycled, and regeneration of graphite anodes has been mostly overlooked presently. Here, a pulsed dc flash Joule heating (FJH) strategy is proposed to recycle the electrodes. The reaction temperature can reach ~3000 K with a rapid heating/cooling rate of up to 105 K s-1, while the reaction duration is within seconds. Therefore, the graphite anode can be regenerated directly with structural integrity. The battery metals from cathode can be reduced to compounds with lower valance states due to carbothermal reduction, boosting the leaching efficiency. The electrochemical performances of regenerated electrodes are demonstrated, and they are comparable with the commercial counterparts. Furthermore, life cycle analysis versus present recycling methods shows that FJH significantly reduces the environmental footprint of spent LIBs processing while turning it into an economically attractive process.