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College of Engineering and Computer Science

Computer Engineering

1. Dr. Ankita Mohapatra

Research Interests: embedded systems, printable electronics, signal analysis and optimization.

Projects available:
Forest fires leave an unwanted consequence of massive economical, fiscal and sociological imprint on the community. Given the recent increase in the frequency and scale of fires, there is an urgent need for finding better, smarter technologies to assist California's existing fire control capabilities. This project intends to explore a smart, low-power, unmanned early-detection system that can be deployed in remote locations, and alert the authorities about probable forest fires. The student will get an opportunity to work with sensors in low power circuits and sensor data interpretation.

Desired preparation for this lab: Students should have a basic knowledge of working with microcontrollers and programming with C/C++, if possible. The student must also have an interest and motivation to work with embedded systems.

Modality: Hybrid or Virtual

Technology Needs: Reliable internet and desktop or laptop computer

2. Dr. Rakesh Mahto

Research Interests: My research interests include ASCI design, low power design, reconfigurable FPGA design, photovoltaics, renewable energy and mixed signal design and testing.

Project Available: Currently, I am working on creating reconfigurable solar cells. This kind of solar cells can be used for powering micro-autonomous drones and CubeSat. You will get chance to understand the working of solar cells and learn programing of Arduino or Raspberry Pi boards.

Desired preparation for this lab: Some courses related to C and C++ programming should be sufficient.

Modality: Hybrid or Virtual

Technology Needs: Reliable internet and desktop or laptop computer

3. Dr. Yu Bai

Research Interests: Dr. Bai's research interests include neuromorphic computing, big data analysis, machine learning, computer vision, smart robot, and low power hardware design.

Projects Available:

Titan Providence: Self-navigation drone goes where no GPS can!

Data and analysis of information have become a crucial aspect in society's current development, allowing accurate awareness of our environments, benefitting maintenance, safety, and overall innovation. However, being informed in some situations require extensive and intensive manpower and are generally costly and dangerous, with situations ranging from inspecting power lines to plotting potholes within an urban area's road system. Titan Providence is a drone project that utilizes machine learning and 3D printing with improved accessibility and maneuverability to enable applications in various fields that would otherwise be prohibitive given previous limitations. Differing from common Unmanned Aerial Vehicle (UAV) systems, Titan Providence implements edge-based bottom-to-top design method to implement efficient machine learning algorithm and customized 3D- designing and printing bypass the limitations of required human control and environmental systems, such as GPS, allowing for fully autonomous completion of extensive analysis of environments that are otherwise inaccessible, vast, hazardous, monotonous, or a combination thereof, in addition to having the benefits of an overall lowered cost in finance and labor.

With the increasing desire for efficiency and effectiveness, in having the ability to give a UAV a task that would be otherwise too resource-demanding or risky for human involvement, Titan Providence provides a significant alternative for surveying and environmental awareness through multiple scheduled assignments and real-time automated problem solving that may be attuned for countless situations and applications.

Efficient AI system on Self-driving Robotic

Land, air, and sea robots have become ubiquitous assets. According to the Boston Consulting Group, worldwide spending on military robotics is expected to more than double from $7.5B in 2015 to $16.5B by 2025. Motivations for such trends range from cost to capability to safety. As new unmanned devices with enhanced features for reconnaissance and support are developed, the massive quantities of data that they transmit have necessitated new machine learning methods and computing platforms to perform higher-level reasoning computations at the edge of the computing network. To address challenges of AI processing and analysis of remotely gathered real-time imagery and video, the Edge-Based Machine Intelligence Architecture for In-Situ Video Processing using Binarized Neural Networks project proposes to design, prototype, and refine novel neural network frameworks which minimize hardware resources, energy consumption, and execution time for edge-of-network processing. Innovative algorithm refinements, hardware implementations, and cross-layer optimizations will result in FPGA-prototyped frameworks demonstrating a reduction in throughput degradation, runtime latency, area cost, and energy consumption using currently available FPGA synthesis toolchains.

Desired preparation for this lab: No additional preparation is required. Dr. Bai will take the responsibility to ensure that the students have sufficient background during the summer research activities to fully benefit from their participation in the projects.

Modality: Hybrid (potentially in-person)

Technology Needs: Reliable internet and desktop or laptop computer

Mechanical Engineering

4. Dr. Sagil James

Research Interests: Research areas include advanced manufacturing, smart and intelligent manufacturing, and clean-energy manufacturing. Several projects are currently being undertaken. The focus of the projects is to study and develop smart technologies needed to reduce the time and cost required to translate design innovations into commercial processes and products.

Project Available:

1. Smart manufacturing and PLC-based industry automation
2. Internet-of-Things (IoT) enabled Remanufacturing
3. Bionic design principles for intelligent manufacturing
4. Advanced composite fabrication and assembly
5. The transition from 3D printing to 4D printing technology

Desired preparation for this lab: No additional preparation required.

Modality: Virtual

Technology Needs: Reliable internet and desktop or laptop computer

College of Natural Sciences and Mathematics

Biological Sciences

5. Dr. Alison Miyamoto

Research Interests: We are interested in how proteins on the surface of mammalian cells communicate with each other and with their environment. Specifically, we are studying: 1) the mechanism of Notch signaling (Notch is conserved in all animals, required for proper development of the embryo, and defects in Notch signaling are associated with birth defects and cancer), and 2) how MAGP2, a protein of the extracellular matrix (ex. cartilage, bone), affects the activity of at least two different signaling pathways. We are also involved in a collaborative project tracking the localization of a RNA splicing factor, PTBP1, that is important to neural cell maturation.

Projects Available:
1. For the Notch project, we want to generate a human cell line that expresses a Notch1 receptor fused to Green Fluorescent Protein (GFP) that fluoresces green in live cells. These cells could be used in live cell imaging assays for Notch receptor cell signaling.

2. For the MAGP2 and PTBP1 projects, we have ongoing antibody-based assays (keywords: immunofluorescence, microscopy) to track their signaling/localization in mammalian cells.

Desired preparation for this lab: We will train students in all required techniques.

Modality: In-person

Technology Needs: None

6. Dr. Maria Soledad

Research Interests: My research focuses on mechanisms of antibiotic resistance, their dissemination and evolution, and their impact on the morbidity and mortality of bacterial infections. The increase in infections caused by antibiotic-resistant bacteria is a serious threat to human health, and the problem has attracted the attention of diverse government and agencies that are trying to establish strategies to increase research and design of new therapies. In the past few years, we have explored various aspects of a major nosocomial pathogen -*Acinetobacter baumannii*- that has a particular ability to acquire antimicrobial resistance traits and survive in the hospital environment. In addition, recognizing the importance of interactions among multiple pathogens and pathogens with the host, our lab expanded the scope to study pathogen-pathogen interaction such as *Staphylococcus aureus*, *Klebsiella pneumoniae*, and *Burkholderia cepacia* complex, as well as, pathogen-host interactions exposing *A. baumannii* to different human fluids.

Projects Available:

1. Pathogen-pathogen interactions
2. Discerning the role of HSA on *A. baumannii* behavior
3. Genomic and phenotypic analysis of Multidrug-resistance strains
4. Synergy of Beta-lactamase inhibitors combinations to inhibits the growth of *Acinetobacter* spp.
5. Searching for novel strategies to combat Multidrug-resistance strains

Desired preparation for this lab: No preparation/skills required. We will provide the corresponding training and knowledge required for a dedicated and enthusiastic student.

Modality: In-person or hybrid

Technology Needs: Reliable internet and laptop or desktop

7. Dr. Nilay Patel

Research Interests: Niclosamide is an FDA-approved drug that is being considered as an adjuvant chemotherapeutic agent for cancer treatment. Our collaborators have synthesized compounds similar to niclosamide and our goal is to characterize how these compounds reduce cell proliferation. We have used microarray technology to identify which genes are differentially regulated by these compounds and we plan to evaluate role of these genes using cellular and molecular biology techniques such as quantitative PCR, immunocytochemistry, overexpression, knock-down along with drug treatments, and CyQuant cell proliferation assay.

Projects Available: We are currently investigating whether certain genes (p21, HINT1, RanGAP1, and RanBP) are important for mediating our compounds' anti-proliferative action.

Desired preparation for this lab: No additional preparation required

Modality: Hybrid

Technology Needs: Reliable internet and desktop or laptop computer

8. Dr. Parvin Shahrestani

Research interests: We study the evolution and genetics of health-relevant traits, such as longevity and immune defense. Our lab uses a fruit fly model system.

Projects Available:

1. Understanding the relationship between aging and immunity (In-person). Individuals in populations vary in their rate of aging and also in their immune defense. Are there overlapping

genes that determine the variation in these two traits? Students will perform immune defense assays on populations of fruit flies that have evolved lifespan differences.

2. Understanding the genetic basis of longevity (In-person). In this study, we are evolving populations of fruit flies to become long lived. We then compare the long lived populations to short lived populations genetically, in order to identify genes that influence longevity. Students will impose selection pressure to increase the lifespan of fruit fly populations.

3. Understanding the relationship between longevity and the microbiome (In-person). Gut bacteria affect not only immune defense, but also longevity. But which microbes increase lifespan? Which ones decrease lifespan? How do populations that differ in longevity compare in their gut microbes? These are some of the questions we are exploring.

4. Establishing fruit flies as a model to study antibiotic resistant infections (In-person). The antibiotic resistant bacterium *Acinetobacter baumannii* is a major health concern. Students will use fruit fly to test the pathogenicity of various strains of *A. baumannii*.

5. Writing about the impact of the microbiome on healthspan (virtual). Students will complete a literature search about the impact of fruit fly microbiota on healthspan and will summarize their findings.

Desired preparation for this lab: We will train students in all aspects of the experiments.

Modality: In-person or virtual

Technology Needs: Reliable internet and desktop or laptop computer, webcam and microphone necessary for virtual meetings.

Chemistry & Biochemistry

9. Dr. Allyson Fry-Petit

Research Interests: Research interests are in solid state inorganic chemistry, focused on the rational design of new materials through the use of data mining, synthesis, structural characterization and optical and vibrational probes.

Projects Available: Solid materials make up all of the technologically important items we use every day, such as cell phone batteries, computers, and medical equipment. However, finding a new solid that will be useful has for hundreds of years been driven by serendipity. The Fry-Petit lab is working at the interface of machine learning and solid-state synthesis to rationally design new materials that will improve the quality of life for humans. Students working with us will focus on database creation and management so that they can perform machine learning algorithms towards the identification of materials. Students will be integrated into the synthetic portion of the lab if they are interested in learning how new solids are made.

Desired preparation for this lab: Interest in chemistry, physics, math, engineering, and/or computer science.

Modality: Hybrid or Virtual

Technology Needs: Reliable internet and desktop or laptop computer able to run VPN access software

10. Dr. Andrew Petit

Research interests: The Petit lab uses computational chemistry to answer fundamental questions about the mechanisms through which chemical reactions take place as well as photochemistry (i.e., what happens after molecules absorb light and become excited).

Projects Available:

1. Photobases: Using Light to Transform a Weak Base into a Strong Base: A series of recent studies performed in the Dawlaty lab at USC have explored the properties of a small family of photobases – molecules that are normally weak bases but become strong bases after absorbing light and becoming electronically excited. We are using computational chemistry to greatly expand the family of known photobases and make predictions about how adding different functional groups affect their properties. Such compounds have potential applications as light-activated catalysts.

2. The Chemistry of Reactive Carbene Intermediates: A recently published study reported the light-driven activation of alcohols via aryldiazoacetates. The mechanism was originally thought to be involve photobases but previous work in the Petit group has strongly suggested that this is not the case. Instead, we believe that the key player is a carbene intermediate generated when the aryldiazoacetate decomposes after absorbing light. We are using computational chemistry to validate this hypothesis and explore the mechanism.

Desired preparation for this lab: This project will be a good fit for students who are planning to major in chemistry, biochemistry, or physics. It would be good if the student has completed either general chemistry or introductory physics. Experience with organic chemistry would be useful but not necessary. Experience with calculus and/or coding are helpful but not required.

Modality: Hybrid or Virtual

Technology Needs: Reliable internet connection. Laptop or desktop that can run Microsoft office and lab specific software. Chromebooks/tablets are not supported.

11. Dr. Joya Cooley

Research Interests: The Cooley Lab is a solid-state inorganic chemistry lab interested in structural and functional materials. Urban heat islands, such as Los Angeles, are overall hotter than surrounding rural areas because of infrastructure (such as buildings) absorbing heat and driving up energy costs. We are interested in developing "cool" pigments, pigments that not only display pleasing colors, but can also reflect heat away from buildings. We use a combination of traditional synthesis in a furnace and a novel, rapid synthesis in a domestic kitchen microwave.

Projects Available: 1 project available synthesizing lithium-based pigments using conventional furnace synthesis and rapid microwave-assisted synthesis

Desired preparation for this lab: Have taken at least 1 semester of General Chemistry

Modality: Hybrid (in-person lab work, various virtual meetings and assignments)

Technology Needs: Reliable internet and a laptop or desktop computer

12. Dr. Marcos Ortega

Research interests: The Ortega lab is a biochemistry lab that focuses on viral assembly and replication. We week to study how proteins interact with each, and with viral DNA, to assemble a mature virus. The Ortega lab uses structural, kinetic, and biophysical studies.

Projects Available:
1. Large terminase expression, purification, and characterization.
In this project, students will express and purify a viral enzyme involved in viral replication. The protein will be screened for crystal formation and sent to a collaborator for further structural studies.

Desired preparation for this lab: Students should have completed general chemistry before entering the lab.

Modality: Hybrid (in-person/virtual)

Technology Needs: Reliable internet and a laptop or desktop computer

13. Dr. Michael Groves

Research interests: We work to understand how chemical reactions take place on surfaces and develop the tools necessary to quickly and accurately predict them. Our current projects include understanding the role of molecular handedness over metal alloy surfaces as well as hydrogen peroxide synthesis over modified graphene structures. We are also using machine learning algorithms to develop automated, and intelligent global optimization search protocols

for organic systems which are designed to increase the performance of the search for thermodynamically favorable structures. We intend to use them to search for novel modified graphene surfaces.

Project Available: Electricity can be used to drive reactions. These electrochemical reactions can be used to create precursors to plastics and hydrogen peroxide, an important chemical for several industrial processes. Before we can model these chemical reactions, we first need to determine the structure of the 2D carbon and boron surfaces that my lab will be use to catalyze these processes. The project you will participate in will involve modifying and using an evolutionary algorithm to determine the structure of physical hole defects in these 2D structures. In this computational research you will apply machine learning to chemical systems while learning about catalysis with novel 2D materials.

Desired preparation for this lab: I will teach the students all the computer programming they need to work effectively in the lab.

Modality: Virtual

Technology Needs: Reliable internet and a laptop or desktop computer

14. Dr. Niroshika Keppetipola

Research Interests: My laboratory studies the Polypyrimidine Tract binding Protein (PTB), an RNA binding protein that plays an important role in regulating the production of proteins from the genetic code in DNA (cellular gene expression). The addition of extra chemical groups to the PTB protein (chemical modification) has been correlated with uncontrolled growth in many cells, including cancer cells such as leukemia. Modifying RNA binding proteins that control mRNA composition allows cells to regulate gene expression not only at the level of DNA but also at the level of RNA.

Projects Available: To investigate the role of chemical modifications in RNA binding protein activity:

1. Generating mutants using recombinant DNA technology and generate mutants of modified residues.
2. Protein expression and purification using affinity chromatography.

Desired preparation for this lab: Students should have taken introductory biology and general chemistry courses and earned a B or higher.

Modality: Hybrid or Virtual

Technology Needs: Reliable internet and a laptop or desktop computer

15. Dr. Stevan Pecic

Research interests: Our main research interests are focused on the identification of novel inhibitors of enzymes involved in lipid metabolism and their evaluation as potential therapeutics. In our second project, we are aiming to develop DNA aptamer-based fluorescent biosensors for the detection of various antibiotics using a biochemistry method called SELEX. Read more at www.PecicLab.com

Projects Available: Alzheimer's disease (AD) Project: this project is focused on design, synthesis and evaluation of novel classes of acetylcholinesterase (AChE) inhibitors and their evaluation as potential therapeutics for Alzheimer's disease. AD is a debilitating neurodegenerative disorder in the elderly and according to the data from European Prevention of Alzheimer's Dementia, AD affects more than 40 million people worldwide and its prevalence is expected to double over the next 20 years. Moreover, AD is currently the fourth leading cause of death in people over 65 years old in the world, which makes it one of the major health, social, and economic concern of the society worldwide. One approach for AD treatment involves drugs that inhibit the activity of enzyme AChE- the main enzyme that metabolizes the neurotransmitter acetylcholine Through traditional medicinal chemistry techniques, including *in silico* drug design, organic synthesis, structure-activity relationship (SAR) studies and *in vitro* biological evaluations, our goal is directed toward elucidation of the pharmacology and biochemistry of neurotransmitters and pathophysiology of AD.

Desired preparation for this lab: Interest in medicinal chemistry - a bland of biochemistry and organic chemistry.

Modality: Fully in-person

Technology Needs: None

Geological Sciences

16. Dr. Joe Carlin

Research interests: Dr. Carlin's research is focused on coastal and shallow marine sedimentology over the recent geologic past (last ~3,000 years to the past several decades). The research primarily utilizes sediment cores to better understand the processes that have shaped coastal and marine environments over these times, and to better understand the connectivity between terrestrial (land) and ocean processes that come together at the coast and in the shallow ocean. By understanding how sediment deposits and coastal landforms have changed in the recent past, we can have a better sense of what to expect in the future as climate change, sea level rise, and human populations increasingly impact our oceans and coasts.

Projects Available:

1: This project will determine how an urban estuary (Tijuana River Estuary, CA) has evolved over

the past 100 years under the influence of humans.

2. This project will look at suspense sediment fluxes within a coastal wetland to assess the vulnerability of a wetland to sea level rise. For wetlands to keep pace with sea level rise, sediment delivery must be sufficient to offset the increased water lever from rising sea level

Desired preparation for this lab: No additional preparation required.

Modality: In-person

Technology Needs: NA

17. Dr. Matthew Kirby

Research interests: Late Quaternary paleoclimatology with a specific focus on the late-glacial/Holocene transition and the present Holocene Epoch. Lacustrine-based multi-proxy, multi-disciplinary research that incorporates historical records of climate change as a calibration tool for assessing past climate states.

Projects Available: Are you interested in the Environment? Climate Change? Ecological Change? Come work with Professor Kirby. He studies the geological history of California's past climate (floods, drought, fire) and ecosystems. To do this, he and his students examine long tubes of mud taken from lakes. Within this mud is a variety of materials such as charcoal, sand, and shells. Working with Kirby, help to reconstruct a history of floods, droughts, fire, and/or ecosystem changes for California. If you are interested in climate, the environment, and/or ecosystems, you will like this summer experience.

Desired preparation for this lab: No additional preparation required.

Modality: In-person

Technology Needs: None

18. Dr. Nicole Bonuso

Research interests: Invertebrate paleontology with an emphasis on the paleoecology of marine communities; combining field-based research with laboratory work, including multivariate statistics, to explore the paleoecological variation of biotas at different temporal and spatial scales.

Projects Available: Please add any information you can share about potential projects in your lab.

Desired preparation for this lab: No additional preparation required.

Modality: In-person

Technology Needs: None

Mathematics

19. Dr. Anael Verdugo

Research interests: mathematical modeling of disease transmission by using biology, computer programming, and differential equations.

Projects Available:
(1) Corona Virus. Building a data driven mathematical model using computer simulations.

(2) Zika Virus. Testing and analyzing a previously built model using dynamical systems theory and numerical methods.

Desired preparation for this lab: No additional preparation required.

Modality: In-person

Technology Needs: None

20. Dr. Jessica Jaynes

Research interests: Her research projects include the development of a new class of designs that provide higher efficiency, more in-depth analyses, and require a shorter time to run. She has applications in the biomedical field such as Herpes Simplex Virus Type-1 and KB Oral Cancer, as well as lipid accumulation for algae growth. More recently her research has been focused on survey design in the area of snack accessibility to understand children's snack choices and parental influences. She works in collaboration with the Department of Public Health and has been actively collecting and analyzing data from local Orange County schools.

Key Words: Statistical methods and applications; Experimental Design; Survey design known as Discrete Choice Experiments

Potential Projects: The research project will be focused on exploring novel experimental designs related to biomedical research.

Desired preparation for this lab: This project would be best for a student who is interested in focusing on statistics and has had at least Calculus I.

Modality: Virtual

Technology Needs: Reliable internet & laptop or desktop with Zoom capabilities and the ability to install programs such as RStudio.

21. Dr. Roberto Soto

Research interests: Our research group focuses on questions they find interesting that can be modeled and explored with mathematics. Currently we have two projects.

Projects Available:
Our first project focuses on studying variations of the classic game Peg Solitaire. Peg Solitaire is a classic game played in many cultures consisting of a board with pegs and one hole placed anywhere on the board. The goal of the game is to reach an ending state with only one peg remaining on the board by removing all other pegs. To remove a peg requires "jumps" similar to how checkers is played. We have created many different versions of the game and study its "solvability", in other words, when is it possible to reach an ending state with one peg.

Our second project involves literature and mathematics – Agatha Christie is renowned for being a great mystery writer and quite unpredictable. We would like to measure the unpredictability of Agatha Christie's writing using machine learning and statistics.

Desired preparation for this lab: Students should love looking for patterns in data.

Modality: Virtual (might meet once a week In-person starting in July)

Technology Needs: Reliable internet and desktop or laptop computer