DEPARTMENT NAME	Aerospace and Mechanical Engineering
PROJECT TITLE	Theory guided search for materials with low hysteresis
FACULTY NAME	Ananya Renuka balakrishna
WEBSITE	https://ananyabalakrishna.github.io/
DESCRIPTION	In our research group, we use theoretical and computational tools to identify how specific combinations of material constants and microstructures can drastically enhance material properties. For example, using in-house codes we recenlty discovered how a specific combination of magnetic material constants can cause a drastic decrease in magnetic hysteresis. Likewise, we are currently investigating how microstructures and crystallography of battery materials can be engineered to enhance lifespans and energy storage capacity of lithium batteries. We look forward to involving undergraduates in our ongoing research work.
PREREQ	N/A
RELATED BACKGROUND	Coding experience (preferably C++).

DEPARTMENT NAME	MFD - Materials Science
PROJECT TITLE	Quantum Nanostructures for Quantum Information Processing / Computing
FACULTY NAME	Anupam Madhukar
WEBSITE	http://nanostructure.usc.edu
DESCRIPTION	Quantum nanostructures are the central players that exploit the laws of quantum mechanics to securely communicate information, sense and image entities / objects beyond the classical limits, and compute. This project involves:(1)site-selective synthesis of quantum dots using ultra-high vacuum vapor phase deposition (molecular beam epitaxy) of semiconductors on nano-templated substrates;(2)their characterization using atomic force microscopy and photoluminescence;(3) quantum optical measurements of single photon emission behavior, & (4)calculations to analyze the data.
PREREQ	Junior level engineering math, basic physics and chemistry, modern / quantum physics,
RELATED BACKGROUND	Electrical Engineering; Engineering Physics, Physics, Materials Science, Chemistry A one semester introductory course in quantum mechanics is helpful background for project oriented towards either solar energy conversion or quantum computing.

DEPARTMENT NAME	MFD - Materials Science
PROJECT TITLE	Quantum dots for solar energy conversion
FACULTY NAME	Anupam Madhukar
WEBSITE	http://nanostructure.usc.edu
DESCRIPTION	Synthesis of nanocrystal quantum dots and characterization by optical methods. Study of the quantized energy levels of electrons as a function of the quantum dot size.`
PREREQ	Finishing Junior year in Chem. Eng., EE, or Physics, with some knowledge of quantum mechanics
RELATED BACKGROUND	Materials Science or Chemistry as UG major.

DEPARTMENT NAME	MFD - Chemical Engineering
PROJECT TITLE	Measuring oxidation-induced cell membrane damage
FACULTY NAME	Noah Malmstadt
WEBSITE	
DESCRIPTION	Reactive oxygen is known to alter the chemical structure of the cell membrane. Here, we use synthetic cell membranes to study how these changes to chemical structure alter the transport properties and mechanics of cell membranes.
PREREQ	Introductory classes in chemistry, biochemistry, chemical engineering, or bioengineering.
RELATED BACKGROUND	Introductory classes in chemistry, biochemistry, chemical engineering, or bioengineering.

DEPARTMENT NAME	MFD - Chemical Engineering
PROJECT TITLE	Mechanics of membranes with integral proteins
FACULTY NAME	Noah Malmstadt
WEBSITE	https://lab.malmstadt.org/
DESCRIPTION	The mechanical properties of cell membranes control many important physiological processes, such as the release of neurotransmitters at synapses and docking and budding of viral particles. While there have been significant previous efforts to understand how the lipid bilayer composition of the cell membrane alters membrane mechanics, little is known about how the protein component of the bilayer contributes to mechanical properties. This project focuses on using a variety of mechanical characterization approaches to measure the properties of lipid bilayers with integral membrane proteins.
PREREQ	Lab experience, some familiarity with organic chemistry and mechanics of materials would be useful
RELATED BACKGROUND	Mechanical, chemical, biomedical engineering, physics, applied physics, or materials science background.

DEPARTMENT NAME	MFD - Chemical Engineering
PROJECT TITLE	Complex oxide Thin films for Electronics and Photonics
FACULTY NAME	Jayakanth Ravichandran
WEBSITE	http://alchemy.usc.edu
DESCRIPTION	We are exploring advanced device applications of epitaxial complex oxide heterostructures. For example, we are working on developing low power phase change oscillators for neuromorphic computing and electro-optic oxide heterostructures for lossless photonic modulators. Students with interest in materials solutions for electronic and photonic devices are welcome to join this project.
PREREQ	Basic Materials science related classes (Physics/Chemistry/Engineering)
RELATED BACKGROUND	Candidates will have a background in materials science, physics, chemistry, or related engineering disciplines. Coursework in thermodynamics and solid state physics is typically helpful.

DEPARTMENT NAME	MFD - Chemical Engineering
PROJECT TITLE	Developing complex materials for optoelectronic applications
FACULTY NAME	Jayakanth Ravichandran
WEBSITE	http://alchemy.usc.edu
DESCRIPTION	We are exploring a novel class of semiconductors with large density of states (high absorption coefficient and carrier density) with tunable structure and composition. We have already demonstrated materials with a world record high birefringence (different refractive index along the optic axis and other principal axis) and properties suitable photovoltaic applications. We use crystal growth to produce high quality materials for these investigations. We are expanding our efforts to thin film growth of these materials now.
PREREQ	Basic Materials science related classes (Physics/Chemistry/Engineering)
RELATED BACKGROUND	Candidates will have a background in materials science, physics, chemistry, or related engineering disciplines. Coursework in thermodynamics and solid state physics is typically helpful.

DEPARTMENT NAME	Civil/Environmental Engineering
PROJECT TITLE	Automated Ergonomic Assessments of Office Workers
FACULTY NAME	Burcin Becerik
WEBSITE	https://www.i-lab.usc.edu/
DESCRIPTION	Office workers spend the majority of their work time at desks and computer stations. Prolonged sedentary working postures will lead to musculoskeletal discomfort and pain in the neck, shoulders, back, and arms. This research focuses on an automate the ergonomic assessment system to provide in-time feedback to office workers on posture adjustments when onsite in-person ergonomic consultations are not available. This project involves the detection of office workersâ€™ postures using non-intrusive sensing technologies and the evaluation of postures using custom-built ergonomic assessment algorithms on the backend. This study will contribute to the promotion of occupational wellbeing and minimize the risks of musculoskeletal disorders in office workers.
PREREQ	Knowledge in calculus, linear algebra, and statistical analysis. Past experience in programming (Pyt
RELATED BACKGROUND	STEM background

DEPARTMENT NAME	Civil/Environmental Engineering
PROJECT TITLE	VR-based ergonomic behavior training for construction workers
FACULTY NAME	Burcin Becerik
WEBSITE	https://www.i-lab.usc.edu/
DESCRIPTION	As the construction industry has the highest rate of non-fatal injuries among all industries, this project aims to develop a virtual reality (VR) based postural training for construction workers using wearable sensors, virtual reality, and machine learning (ML) techniques. The idea behind the study is to track workers' postures during the handling of tools and materials commonly used in construction tasks and provide real-time feedback about ergonomic risks the worker may be exposed to using ML. Contributions of the study include the understanding of how effective VR training and real-time feedback can be to training construction workers in safer ergonomic behavior during construction tasks.
PREREQ	Basic programming experience. Past experience with virtual reality and/or machine learning is a plus
RELATED BACKGROUND	STEM background

DEPARTMENT NAME	Civil/Environmental Engineering
PROJECT TITLE	VR-based Training for Emergencies
FACULTY NAME	Burcin Becerik
WEBSITE	https://www.i-lab.usc.edu/
DESCRIPTION	This research effort examines how built environments influence human responses and the impact of training on human responses during emergency scenarios (i.e. fire and active shooter emergencies). This study involves experimentation for the purpose of improving human preparedness for building emergencies and integrating human behavior into the design, operation, and use of buildings. The study will contribute to the understanding of emergency training and provide insights into whether VR technology can be widely adopted by individuals and public agencies as an effective training method.
PREREQ	Past experience with VR technology. Knowledge in computer science and data analysis is a plus.
RELATED BACKGROUND	STEM background

DEPARTMENT NAME	Civil/Environmental Engineering
PROJECT TITLE	Expanding the water treatment arsenal with heterogeneous catalysts
FACULTY NAME	Daniel McCurry
WEBSITE	https://www.mccurrylab.com/
DESCRIPTION	Despite >100 years of drinking water disinfection, the environmental engineering â€˜toolboxâ€™ contains only six commonly used chemical disinfectants, which are also often used for oxidation of trace organic contaminants. Among the dozens of oxidants employed by chemists, most are unsuitable for drinking water treatment, due to their cost or toxicity. However, one promising option could be the application of Group 10 metal (e.g., Pt, Pd) catalysts to oxidize molecules while using dissolved oxygen as the terminal electron acceptor. Oxidation of alcohols to aldehydes and oxygenation of alkanes have all be demonstrated under mild conditions (room temperature water) with Pt and/or Pd on the surface of solid supporters. Dissolved oxygen is typically present in surface waters near its solubility (8 mg/L), which is approximately five to ten times higher than the molar concentration of chlorine typically used for water disinfection. This research aims to identify new, safe, and sustainable oxidation technologies, informed by an organic chemistry perspective. The student on this project would specifically be assisting a PhD student in performing experiments on oxidation of trace aldehydes (e.g., acetaldehyde) in recycled wastewater. Day-to-day tasks would involve setting up batch reactor and column experiments, and doing analytical chemistry (e.g., HPLC, GC/MS) to measure the concentrations of reactants, intermediates, and products
PREREQ	Year of general chemistry
RELATED BACKGROUND	Organic chemistry and any additional laboratory experience is helpful.

DEPARTMENT NAME	Communication Sciences Institute
PROJECT TITLE	Machine Learning for Localization
FACULTY NAME	Andreas Molisch
WEBSITE	https://wides.usc.edu/
DESCRIPTION	Machine Learning has opened up a new frontier for localization in GPS-denied environments, such as indoor or in street canyons. We recently performed an extensive review of the literature (Burghal et al. 2020, ArXiv), and have ideas for new and significantly improved algorithms that better take physical propagation into account. The UG student will implement these algorithm and bring in ideas of their own on how to select the deep learning architectures, train the parameters, and improve robustness.
PREREQ	Any ML course
RELATED BACKGROUND	Experience with implementation of Machine Learning algorithms, e.g., in TensorFlow or Pytorch is the key requirement. Knowledge of fundamental localization methods (trilateration, fingerprinting) is beneficial but not required. The project is suitable for both EE and CS students.

DEPARTMENT NAME	Computer Science
PROJECT TITLE	Haptic Feedback for Medical Simulation
FACULTY NAME	Heather Culbertson
WEBSITE	https://sites.usc.edu/culbertson/
DESCRIPTION	The Haptics Robotics and Virtual Interaction (HaRVI) Lab at USC creates and programs haptics devices that provide artificial touch sensations to the user. Our lab combines human perception, electronics, mechanical design, and programming to create devices that can recreate the sensations you feel when touching real objects. This project will focus on creating realistic haptic feedback for virtual medical simulation using data that is recorded from real-world interactions. The student will use tools with attached sensors to measure force, vibration, and position produced during common medical procedures such as inserting a needle, cutting tissue, and suturing. They will then work to create mathematical models of these signals, which can be used to generate haptic feedback when a user performs virtual procedures in a medical simulator.
PREREQ	Some programming experience, Matlab
RELATED BACKGROUND	Background in computer science, electrical engineering, mechanical engineering, or related majors. Experience with circuits and mechanical design a plus, but not required.

DEPARTMENT NAME	Computer Science
PROJECT TITLE	Assurance for Perception Systems in Self-driving
FACULTY NAME	Jyotirmoy Deshmukh
WEBSITE	https://viterbi-web.usc.edu/~jdeshmuk/research.html
DESCRIPTION	Self-driving cars use sensors such as stereo cameras and LIDAR to understand the environment around them. The perception task remains a challenging one as errors in perception can lead to dangerous errors by downstream components for planning and decision-making. In this project, we will work on techniques to test perception systems using a variety of techniques. A mid-project goal is to have a tool to assess the quality of temporal predictions made by perception components. The ultimate goal would be to use the research findings to obtain better deep learning artifacts for perception. Possible topics for consideration include generative adversarial networks, variational autoencoders, and spatio-temporal logic using geometric primitives. This is not a project in computer vision or deep learning, but rather in the area of formal methods to assess safety of autonomous systems.
PREREQ	Basic background in deep learning
RELATED BACKGROUND	Computer vision, Deep Learning, Tensorflow/PyTorch, Temporal Logic, Jetson TX2 programming, Carla, Apollo or other simulators in the research area of self-driving cars

DEPARTMENT NAME	Computer Science
PROJECT TITLE	Interpretable Controllers from RL
FACULTY NAME	Jyotirmoy Deshmukh
WEBSITE	https://jdeshmukh.github.io/research.html
DESCRIPTION	We wish to learn symbolic representations of deep neural network based controllers obtained using deep reinforcement learning techniques. This will significantly boost the explainability/interpretablity of deep RL algorithms. Our approach is to tackle this problem with a combination of computational learning theory and formal methods ideas such as model checking. The researcher will be expected to digest papers related to automata learning and integrate existing open source libraries for automata learning to create such interpretable controllers.
PREREQ	Reinforcement Learning, Automata Learning
RELATED BACKGROUND	Basic Knowledge of finite state machines

DEPARTMENT NAME	Computer Science
PROJECT TITLE	Learning from Demonstrations
FACULTY NAME	Jyotirmoy Deshmukh
WEBSITE	https://jdeshmukh.github.io/research.html
DESCRIPTION	There is considerable research on teaching robots to do complex tasks through user demonstrations. In state-of-the-art, such demonstrations are expected to be given by an expert, and ergo expected to be perfect. We have shown in recent work that robots can learn effective control policies from even imperfect and incomplete demonstrations as long as the user specifies a high-level task description for the robot in a formal specification language (such as signal temporal logic). In this project, we want to study the extension of this work in two directions: (1) we want to test the existing theories on actual robots, (2) we want to extend the theory to stochastic environments. The undergraduate researcher will be paired with a Ph.D. student mentor and will receive hands-on experience on creating a successful research project that leads to publication at a top AI or Robotics conference. The student can expect to learn how to develop safe control policies and some background on safe AI/robotics from a formal methods perspective.
PREREQ	Basic knowledge of robotics, AI
RELATED BACKGROUND	Hands-on experience with robots e.g. manipulator robots - Hands-on experience with starting and running simulators such as Gazebo, Webots, Carla etc. - Knowledge of Reinforcement Learning, Inverse Reinforcement Learning, Learning from Demonstrations is a bonus - Background Knowledge of formal methods ideas such as temporal logic, monitoring, would be terrific

DEPARTMENT NAME	Computer Science
PROJECT TITLE	Predictive monitoring
FACULTY NAME	Jyotirmoy Deshmukh
WEBSITE	https://jdeshmukh.github.io/research.html
DESCRIPTION	Cyberphysical systems such as autonomous aerial and ground vehicles, industrial control systems, medical devices, power grids and many others are highly complex. In very limited scenarios, formal verification techniques can digest the scale and complexity of such techniques, and even then verification guarantees correctness of a software model of the system, and not the actual deployed system. Runtime monitoring is a valuable tool to check dynamic correctness of such systems, and coupled with runtime safety enforcement can be a powerful method to assure system correctness. In particular, we are interested in monitoring temporal and logical requirements of such systems. While there are many flavors of monitoring, we are interested in "clairvoyance", can we predict the behavior of the system in the future from either data or system models and use that to compute the probability of satisfaction or violation of a given property of the system? This project will involve learning from time-series data for forecasting and prediction using stochastic process models and deep neural network models such as LSTMs. The student will be expected to write code in Python or Matlab and do basic proofs using statistical and probabilistic reasoning techniques.
PREREQ	Stochastic Processes, Markov chains, Probabilistic reasoning, LSTMs
RELATED BACKGROUND	Knowledge of finite state model checking with respect to temporal logic specifications - Knowledge of runtime monitoring on actual hardware platforms

DEPARTMENT NAME	Computer Science
PROJECT TITLE	Extending Robotics and Education Through Augmented Reality
FACULTY NAME	Maja Mataric
WEBSITE	http://robotics.usc.edu/interaction/projects/desc2.php?name=expressiveteaching
DESCRIPTION	The Interaction Lab is a USC Viterbi research lab dedicated to developing socially assistive robotics (SAR), algorithms and methods that enable robots to help people achieve behavioral goal through social interaction. For this project in particular, the Lab is looking at how using augmented reality can be used in tandem with a robot in order to increase student curiosity. The project will consist of designing and implementing Hololens visualizations for differing robot actions and sensors. These include laser scans, video, and facial recognition data, and movement heat maps, as well as robot virtual actions that will include moving and interacting with student content. These visualizations will be used in the Interaction Lab for three purposes: 1) during human user studies; 2) to visualize post-study data; and 3) to be a part of K-12 STEM outreach demos. The involved students can expect to learn the Robot Operating System (ROS), the Holotoolkit, and reading/visualization sensor data. Students can also expect to acquire research skills, communication skills, and design skills.
PREREQ	None
RELATED BACKGROUND	Unity (C#/.NET), c++ or Python, ROS experience a plus, MRTK experience a plus, Linux experience a plus, Networking experience a plus

DEPARTMENT NAME	Computer Science
PROJECT TITLE	Sensing Physiological Signals over Zoom
FACULTY NAME	Maja Mataric
WEBSITE	http://robotics.usc.edu/interaction/areas/desc.php?name=embodied
DESCRIPTION	The Interaction Lab is a USC Viterbi research lab dedicated to developing socially assistive robotics (SAR), algorithms, and methods that enable robots to help people achieve behavioral goals through social interaction. For this project, in particular, the lab is looking at how to sense physiological signals over Zoom to administer breath-sensitive respiration exercises for socially assistive interactions for various user populations (sterss, anxiety, etc.).
PREREQ	None
RELATED BACKGROUND	Python, data science, machine learning ROS experience a plus, Linux experience a plus, Networking experience a plus

DEPARTMENT NAME	Computer Science
PROJECT TITLE	Trust in Multi-Party Human-Robot Interaction
FACULTY NAME	Maja Mataric
WEBSITE	http://robotics.usc.edu/interaction/projects/desc2.php?name=multiparty_support
DESCRIPTION	The Interaction Lab is a USC Viterbi research lab dedicated to developing socially assistive robotics (SAR), algorithms, and methods that enable robots to help people achieve behavioral goals through social interaction. For this project, in particular, the lab is looking to understand how a robot can increase trust in group members when interacting with multiple people. This project will consist of designing dialog and multimodal interaction between a robot and group members. This may include analysing data of prior interactions and developing models of turn taking.
PREREQ	None
RELATED BACKGROUND	Python, data science, machine learning ROS experience a plus, Linux experience a plus

DEPARTMENT NAME	Computer Science
PROJECT TITLE	Visualizing and Describing the Design Space of Socially Interactive Robots
FACULTY NAME	Maja Mataric
WEBSITE	http://robotics.usc.edu/interaction/projects/desc2.php?name=design_metaphors
DESCRIPTION	The Interaction Lab is a USC Viterbi research lab dedicated to developing socially assistive robotics (SAR), algorithms, and methods that enable robots to help people achieve behavioral goals through social interaction. For this project, we are interested in investigating the ways in which people describe robots in terms of their physical embodiment affect the way people feel about these robots, and how these findings can inform robot design. This project will consist of interpreting and visualizing data that has been previously collected on Mechanical Turk. These findings will be used to come up with design recommendations and explanations that can be used by researchers who design socially interactive robots for different scenarios. Visualizations can also be used as an educational tool to help explain complicated concepts in an intuitive manner.
PREREQ	None
RELATED BACKGROUND	Python or Javascript experience, knowledge of statistical techniques (ANOVA, t-tests, etc.) a plus, experience with web design a plus, experience with d3 (or other data visualization libraries and techniques) a plus.

DEPARTMENT NAME	Computer Science
PROJECT TITLE	Reasoning on Temporal Knowledge Graphs
FACULTY NAME	Xiang Ren
WEBSITE	http://inklab.usc.edu/
DESCRIPTION	Large-scale knowledge graphs supports a lot of downstream natural language processing tasks like question answering, response generation. Knowledge graphs are evolving over time, but evolving knowledge graphs are not fully explored. This project aims to explore reasoning over time in dynamically evolving knowledge graphs that contain temporal information. In this research, we will develop novel machine learning algorithms for temporal dependency modeling, knowledge modeling which encodes rich graphical structures to predict links in a knowledge graph using both the existing facts and the temporal information of the facts. We aim to enable models to learn forecasting capabilities for time series predictions on structured (knowledge graphs) or unstructured (question answering) datasets. Our work will be published in a top-tier machine learning venue.
PREREQ	python, basic understanding on machine learning
RELATED BACKGROUND	solid understanding on linear algebra and probability - coding experiences on deep learning models - basic understanding on graphs

DEPARTMENT NAME	Computer Science
PROJECT TITLE	Equipping machines with common sense
FACULTY NAME	Xiang Ren
WEBSITE	http://inklab.usc.edu/
DESCRIPTION	Commonsense reasoning aims to empower machines with the human ability to make presumptions about ordinary situations in our daily life. In this project, we aim to develop novel textual inference methods for answering commonsense questions, which can effectively utilize external commonsense knowledge graphs to perform explainable inferences. In our prior efforts (including an EMNLP19 paper and an ACL19 submission), we propose graph network-based approach which retrieves a relevant subgraph from the external, gigantic knowledge graph and use it to augment the inference process. In this project, we aim to explore a few aspects of commonsense knowledge: 1) design algorithms and visualization methods for analyzing machine learning models in terms of their performance in commonsense reasoning â€”â€” including interpretability, robustness, generalization and error analysis. 2) build challenging and clean datasets with comprehensive data analysis for testing machine leaning models in their reasoning ability. 3) develop reasoning models for answering open-ended, multi-hop questions over a large text corpus. 4) design language models to learn commonsense knowledge from images, instead of limited raw text or knowledge bases. The motivation comes from the fact that an image is worth a thousand words, where richer image information could be leveraged to help distill the commonsense knowledge, which is often hidden in languages.
PREREQ	Strong programing skills, preferably on Python
RELATED BACKGROUND	Good knowledge about machine learning concepts and experiences with machine learning libraries - basic knowledge about deep learning and natural language processing - Prefer students who have involved in research projects and had contributed to research paper writing. Feel free to email xiangren@usc.edu to ask more information about the project.

DEPARTMENT NAME	Computer Science
PROJECT TITLE	Building machine learning models to learn from human instructions
FACULTY NAME	Xiang Ren
WEBSITE	http://inklab.usc.edu/
DESCRIPTION	Vast amount of unstructured text data are emerging everyday, carrying rich human knowledge, but are hard to be digested and processed by machines. Information extraction aims to turn such unstructured text data into machine-actionable structures such as entities and their relationships. While deep neural models have gained successes on information extraction tasks, they become less effective and reliable when the amount of labeled data is limited. Our prior efforts have explored alternative sources of supervision, such as knowledge bases, for training neural models (i.e., distant supervision). In this project, we plan to study high-level human supervision, such as natural language explanations, trigger phrases, and even abstractive constraints about the task, for guiding the model training process. We aim to largely lower the amount of labeled data required for building a model that can perform equally well as models trained by large amount of traditional labels. We aim to enable models to learn from high-level human supervision such as explanations, instructions and task descriptions; directly map a human input to a model ready to deploy. This goal may sound ambitious right now, so we'll start with simplified settings/datasets.
PREREQ	Strong programing skills, preferably on Python
RELATED BACKGROUND	Good knowledge about machine learning concepts and experiences with machine learning libraries - basic knowledge about deep learning and natural language processing - Prefer students who have involved in research projects and had contributed to research paper writing. Feel free to email xiangren@usc.edu to ask more information about the project.

DEPARTMENT NAME	Computer Science
PROJECT TITLE	Empowering language models with reasoning abilities
FACULTY NAME	Xiang Ren
WEBSITE	http://inklab.usc.edu/
DESCRIPTION	1) Enable the reasoning model to identify the knowledge gap between what it knows and what is needed to derive the answer. 2) Analyze the effect of reporting bias issue of LM on downstream QA tasks (will it lead to wrong answer?). Overcome the reporting bias of LM for better downstream tasks (e.g. QA) performance or more reasonable generation. 3) Comparative reasoning for multiple choice QA tasks.
PREREQ	Strong programing skills, preferably on Python
RELATED BACKGROUND	Basic knowledge about natural language processing and machine learning - experience with Python programming - basic knowledge about deep learning techniques and tools

DEPARTMENT NAME	Computer Science
PROJECT TITLE	Freight Volume Modeling
FACULTY NAME	Cyrus Shahabi
WEBSITE	https://imsc.usc.edu/
DESCRIPTION	This project is to design, develop and validate an analytical platform to allow modeling freight traffic volume over an extended area. We are developing algorithms to infer truck volume over major highways from multimodal sensor observations. We consider data from a variety of sensors including traffic sensors (e.g., loop detectors, weight stations) data, RFID data and surveillance video data. We apply AI and machine learning to detect truck type from overhead surveillance video. The algorithm consolidates potentially weak observations to estimate traffic flows (origin-destination matrix). We validate the algorithm using a synthetic data modeled based on actual traffic data with the goal to apply it to a full real-world dataset to be collected by local traffic authorities.
PREREQ	Python and or javascript programming. SURE participants will be embedded in a larger team including graduate students that is currently developing the analytics, therefore it is expected the students work well in a group.
RELATED BACKGROUND	Some understanding of one or more of the following topics: machine learning and artificial intelligence, image machine learning, data analytics, data management, web programing in node, web frameworks, visualization, map-making.

DEPARTMENT NAME	Computer Science
PROJECT TITLE	TVDP (Translational Visual Data Platform)
FACULTY NAME	Cyrus Shahabi
WEBSITE	http://mediaq.usc.edu:8080/TVDP/
DESCRIPTION	This project is to design and develop a platform, dubbed â€œTranslational Visual Data Platform (TVDP)â€ to collect, manage, analyze urban visual data which enables participating users connected not only to enhance their individual operations but also to smartly incorporate visual data acquisition, access, analysis methods and share results among them. Specifically, we focus on geo-tagged visual data since location information is essential in many multimedia applications and provides a fundamental connection in managing and sharing data among collaborators. Furthermore, our study targets an image based machine learning platform to prepare users for upcoming era of machine learning and AI applications. TVDP will be used to pilot, test, and apply various visual data intensive applications, especially for smart cities.
PREREQ	Python programming.. SURE participants will work in an existing team with graduate students, not as an individual study. So, a good team member is expected.
RELATED BACKGROUND	Some understanding of one of the following topics â€“ image machine learning, data management, mobile programing, multimedia system, augmented reality

DEPARTMENT NAME	Electrical Engineering Systems - Computer Engineering Group
PROJECT TITLE	Algorithms and Applications of Internet of Things, Blockchain and AI
FACULTY NAME	Bhaskar Krishnamachari
WEBSITE	http://anrg.usc.edu
DESCRIPTION	Design and Analysis of Algorithms, Protocols and Applications for the Internet of Things, Blockchain, and Artificial Intelligence. Projects will be tailored to individual students' interest and ability. Former undergrad interns working in this group have gone on to grad school at top places including MIT, Stanford, Princeton, USC, UIUC, Michigan, Columbia.
PREREQ	Strong programming and mathematical ability
RELATED BACKGROUND	Undergrad in EE, CS, Math and other STEM disciplines.

DEPARTMENT NAME	Electrical Engineering Systems
PROJECT TITLE	Massively Multi-input Electromagnetics Solver
FACULTY NAME	Chia Hsu
WEBSITE	https://sites.usc.edu/hsugroup/
DESCRIPTION	Maxwell's equations describe phenomena over the full electromagnetic spectrum from visible light to radio waves. Numerous problems, such as optical computing, metasurface design, inverse-scattering imaging, and stealth aircraft design, require computing the scattered wave given a very large number of distinct incident waves. However, existing Maxwell solvers scale poorly--either in computing time or in memory--with the number of input states of interest. The student will take part in our development of a new class of Maxwell solvers that can readily handle millions of distinct input states with orders-of-magnitude speed-up versus existing solvers.
PREREQ	Programming; Maxwell's equations
RELATED BACKGROUND	Programming experience. Familiarity with the differential form of Maxwell's equations (or wave equations in general).

DEPARTMENT NAME	Electrical Engineering Systems
PROJECT TITLE	Phase retrieval for volumetric 3D imaging
FACULTY NAME	Chia Hsu
WEBSITE	https://sites.usc.edu/hsugroup/
DESCRIPTION	We are developing computational imaging methods that can reconstruct volumetric 3D images even inside an opaque scattering medium that typically cannot be seen through. One component of this work is phase retrieval. Given the intensity images of a field in real space and in Fourier space (taken by cameras), we need to reconstruct the phase of such field. The standard Gerchbergâ€“Saxton (GS) algorithm is not good enough. The student will be given experimental data that we measure in the lab, and will be tasked to develop phase-retrieval algorithms that retrieve the phase from the data. The work can be done remotely.
PREREQ	Familiar with MATLAB
RELATED BACKGROUND	Able to code and to debug with MATLAB. Able to conduct literature search. Knowledge of Fourier optics is a plus but is not a requirement.

DEPARTMENT NAME	Electrical Engineering Systems
PROJECT TITLE	Autonomous robot locomotion in cluttered environment
FACULTY NAME	Feifei Qian
WEBSITE	https://minghsiehece.usc.edu/directory/faculty/profile/?lname=Qian&fname=Feifei
DESCRIPTION	The selected candidate will work closely with our research group to support our mission in (1) understanding the mechanism of robot interaction with obstacles, and (2) creating innovative strategies for robots to take advantage of obstacle interactions to navigate in complex environments with minimal control effort In this role, the candidate will perform the following tasks: program simple robot gaits; perform systematic experiments to test performance of different gaits during obstacle negotiation; use MATLAB to perform simple analysis and create plots to communicate results; (optional) develop simple algorithms to adapt gaits through different environments.
PREREQ	Intro physics, basic programming, mechanical design
RELATED BACKGROUND	Sophomore or above, with major in Electrical Engineering, Mechanical Engineering, physics, or related areas â—Experience with Solidworks, MATLAB, and C++ is desired â—Experience with robotics is a plus

DEPARTMENT NAME	Electrical Engineering/Electrophysics
PROJECT TITLE	Light detection and ranging (LIDAR) Development
FACULTY NAME	Hossein Hashemi
WEBSITE	https://hhlab.usc.edu/
DESCRIPTION	Self-driving cars, drones, and other autonomous systems rely on a number of sensors such as cameras, radars, and ultrasonic detectors to observe their surrounding environments. Light detection and ranging (LIDAR), where a laser beam is rapidly steered in space, is among the most accurate sensors and enables creation of high-resolution 3D maps. Existing LIDAR systems are based on mechanical optical beam steering, and as such, are bulky, expensive, susceptible to mechanical failures, and consume large power. We have developed monolithic optical phased array integrated circuits that are capable to steer the laser beam electronically (without any mechanical movement). We are currently working on developing a LIDAR prototype using the developed optical phased array chip. Summer undergraduate researchers may work on improving the LIDAR (focusing on software aspects), signal processing, etc.
PREREQ	Analog Integrated Circuits
RELATED BACKGROUND	Required Background 1. Signals and systems: Fourier and Laplace Transforms 2. MATLAB & SIMULINK 3. Programming: Python or C++ or equivalent Recommended Background 1. Ray optics 2. Electromagnetic basics: Wave propagation 3. Electrical/optical measurement instruments: oscilloscopes, spectrum analyzers, signal generators

DEPARTMENT NAME	Electrical Engineering/Electrophysics
PROJECT TITLE	Millimeter-Wave Integrated Circuits
FACULTY NAME	Hossein Hashemi
WEBSITE	https://hhlab.usc.edu/
DESCRIPTION	Millimeter-waves correspond to a frequency range above 30 GHz with many interesting applications such as the the upcoming 5G wireless standard, automotive radar, etc. The undergraduate summer researcher will be working on transistor-level analysis, design, and simulations of mm-wave integrated circuits.
PREREQ	Analog Integrated Circuits
RELATED BACKGROUND	Required Background: 1. Transistor-level analysis, design, and simulations of analog integrated circuits (e.g., at the level of "Design of Analog CMOS Integrated Circuits" by B. Razavi). 2. Simulations using Cadence Spectre Recommended Background: 1. Analysis, design, and simulation of radio-frequency integrated circuits. 2. Electromagnetic basics: transmission lines

DEPARTMENT NAME	Epstein Dept of Industrial & Systems Engineering
PROJECT TITLE	Training robust neural networks for classifying misinformation in social media
FACULTY NAME	Meisam Razaviyayn
WEBSITE	https://sites.usc.edu/razaviyayn/
DESCRIPTION	The goal of this project is to train neural networks using measures of performance other than accuracy in the presence of content-shifts. This is particularly important in applications such as classification of hateful/misinformation posts on social media platforms. In this application, the number of positive samples (sample posts containing misinformation) is small compared to the entire number of samples. Hence non-decomposable measures of performance, such as AUROC or accuracy at the top, are needed for auto-enforcement of the integrity-related policies on social media platforms. However, these measures of performance are vulnerable to content shifts. Our goal is to develop scalable algorithms for training neural networks based on measures of performance related to accuracy at the top. Furthermore, the resulting model needs to be robust against content-shifts. This is because the topic of misinformation changes over social media platforms over time.
PREREQ	Machine Learning, PyTorch, TensorFlow
RELATED BACKGROUND	Basic knowledge of machine learning and neural networks. Being familiar with PyTorch and TensorFlow.

DEPARTMENT NAME	Information Sciences Institute
PROJECT TITLE	Concurrency challenges in cryptocurrencies and smart contracts
FACULTY NAME	Srivatsan Ravi
WEBSITE	https://sites.usc.edu/srivatsr/
DESCRIPTION	Such contracts not only provide a fundamental building block of digital currencies, they are also the cornerstone of future generations of market economy and online exchanges with applications beyond the financial sector. They represent the foundation of cryptocurrencies inexistence today, such as Bitcoin and Ethereum among many others. Both constitute a fully decentralized digital cryptocurrency network that is widely adopted today as an alternative monetary payment system. Instead of accounting payments in a ledger locally maintained by a trusted financial institute, these are logged in a blockchain, a distributed data structure replicated among mutually distrusted users around the world who update it by means of a global consensus algorithm. This project has two main conceptual contributions: (i) construct models and commensurate algorithms catering to emerging smart contract proposals and domain-specific industry requirements that do not adopt the prevalent fully (de)centralized model; (ii) a framework for reasoning about the scalability-security-privacy trade-offs in building smart contract platforms.
PREREQ	Algorithms, C/C++/Python programming
RELATED BACKGROUND	Distributed computing, network security, cryptography

DEPARTMENT NAME	Information Sciences Institute
PROJECT TITLE	Concurrent data structures for Non-Volatile Memory
FACULTY NAME	Srivatsan Ravi
WEBSITE	https://sites.usc.edu/srivatsr/
DESCRIPTION	It is expected that current volatile memory based on DRAM will be augmented by storage-class memories (SCM) that are non-volatile and byte-addressable. The primary advantage of this hardware development is that it removes the need for two distinct file formats: the in-memory object format and the persistent file format for the block-oriented traditional persistent storage Ã la NAND flash that is prevalent in todayâ€™s solid-state devices. Yet, whether the data structure is designed directly on NVM or via a combination of DRAM plus NVM, i.e., DRAM with a NVM backup on account of the DRAM crash failure, there remain several open questions concerning the design of efficient persistent concurrent data structures. Firstly, the data structure state must be constantly updated in the non-volatile memory so that in the event of a crash failure, the computation may re-start from the most recent consistent state of the data structure. This write-back to the NVM must be atomic so that the recovered data structure state is consistent. Secondly, this raises the following question: what must be representation of the data structure in the NVM? For e.g., in a sorted linked-list-based set, it may be sufficient to store the set of values contained in the set, as opposed to an unsorted one since the pointer references can not be deterministically re-created during the re-start procedure invoked after the crash-recovery. This project is the study of lower bounds and algorithms for concurrent data structures in non-volatile memory.
PREREQ	Algorithms, Data structures, C/C++ programming
RELATED BACKGROUND	Operating systems

DEPARTMENT NAME	Institute for Creative Technologies
PROJECT TITLE	Building AI for detecting human intent
FACULTY NAME	Mohammad Soleymani
WEBSITE	https://ihp-lab.org/
DESCRIPTION	Robots and artificial agents who collaborate with humans should be able to read their cognitive state and intent. In this project, the student will work with electroencephalogram data (EEG) in addition to behavioral data (videos) to train machine learning models that can predict human actions and identify cognitive states.
PREREQ	Python programming, familiarity with machine learning
RELATED BACKGROUND	Willingness to learn how to handle unstructured data Interest in machine learning Ability to program in python Linux shell and ability to work remotely on Linux servers using command line interface

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DEPARTMENT NAME	Institute for Creative Technologies
PROJECT TITLE	Intelligent agents
FACULTY NAME	Mohammad Soleymani
WEBSITE	https://ihp-lab.org/
DESCRIPTION	Virtual agents should be able to produce natural nonverbal behavior in human-agent interaction. In this project, you will help developing interactive agents that can sense and respond to nonverbal behavior, for example, they can smile back and nod to acknowledge hearing their user. The development involves building components for the Platform for Situational Intelligence (PSI) and our OpenSense framework in C#.
PREREQ	C#, Git
RELATED BACKGROUND	Ability to program in C# Experience working with .Net framework Interest in conversational AI

DEPARTMENT NAME	Neurology - INI
PROJECT TITLE	Epilepsy Bioinformatics Study
FACULTY NAME	Dominique Duncan
WEBSITE	https://epibios.loni.usc.edu
DESCRIPTION	The student will be working on the Epilepsy Bioinformatics Study for Antiepileptogenic Therapy (EpiBioS4Rx), the goal of which is to identify relevant biomarkers of epileptogenesis after traumatic brain injury to be used for antiepileptogenic therapies. Various analytic tools that have been developed at LONI will be used to analyze both EEG and MRI data collected from humans and rodents with the goal of identifying biomarkers of epileptogenesis. The student will work closely with Dr. Duncan and other investigators from the study. The student will read and summarize related literature, analyze multimodal data, and interpret the findings along with the rest of the international, multidisciplinary, collaborative team.
PREREQ	MATLAB, programming experience
RELATED BACKGROUND	Excellent analytical skills, strong written and verbal communication, experience with MATLAB, and basic knowledge of neuroanatomy, neuroimaging, and neuroscience.