DEPARTMENT OF COMPUTER SCIENCE

COLORADO SCHOOL OF MINES
EARTH • ENERGY • ENVIRONMENT

Honors Research Program

Project Advisor: Neil Dantam
Project: Learning collisions to accelerate robot planning
Project Description: The computational bottleneck for motion planning is by far collision-checking. While modern collision checkers are highly-efficient, checks with large meshes still present computational challenges. This project will apply machine learning to accelerate motion planning through approximate collision checking. Ideally, an analysis will characterize the completeness and convergence properties of the approach.

Project Advisor: Neil Dantam
Project: Robot Panning with Real-World Constraints
Project Description: Robots performing physical tasks must adhere to physical constraints: a glass full of liquid must be kept upright, drawers must slide linearly, doors must rotate at the hinge, etc. This project will incorporate physical constraints into a robot planning system, enabling robots to plan actions and trajectories for our everyday task.

Project Advisor: Neil Dantam
Project: Robot Planning using Modern Constraint Solvers
Project Description: Constraint-based planning leverages solvers for Boolean SAT to solve the NP-hard planning problem. Traditionally, this approach converted a first order logic (FoL) description to Boolean logic for the SAT solver. Modern constraint solvers for Satisfiability-modulo theories support FoL (and more) directly. By fully using the built-in capabilities of SMT solvers, we can leverage these highly-engineered tools to improve planning performance and simplify implementation.

Project Advisor: Neil Dantam
Project: Automatic Plan of Study Generation
Project Description: Identifying and following a suitable plan-of-study is critical to the timely and successful attainment of a college degree. However, many issues---complex prerequisite chains, scheduling conflicts, selectively-offered courses, etc.---limit students' ability to define and follow a plan-of-study. Nontraditional, underrepresented, and first-generation students may face disproportionate challenges due to additional constraints, reduced family support, and other factors.
This project will apply planning and constraint-satisfaction techniques to identify and optimize plans-of-study. Ideally, this project would ultimately lead to a tool that will assist future Mines' students in completing their degrees.

Project Advisor: Qi Han
Project: Enabling Smart Irrigation using Internet of Things
Project Description: Public and private lawns make up the single largest irrigated crop in North America. On such a large scale, minor inefficiencies in irrigation control techniques can cause an immense amount of wasted water. Improper irrigation of lawns can lead to many problems. Too little water can lead to the death of the lawn and instability of the soil, and too much water can cause the roots of the plant to rot, leading to unattractive lawn coloration and death. This project will use IoT devices to monitor soil moisture of various locations of lawns. The collected data will be then used to enable adaptive irrigation.

Project Advisor: Qi Han
Project: Improving Underground Safety via a Cyber Physical System
Project Description: Underground settings (e.g., human-made tunnels, underground mines, subway systems, and natural cave networks) are becoming increasingly relevant to global security and safety. To improve underground safety, better situational awareness needs to be supported. This project is to design, prototype, and test a wireless cyber-physical framework of low-cost, energy efficient, and reliable sensor nodes and commodity smartphones for monitoring, tracking, and communication to improve safety in underground environments.

Project Advisor: Qi Han
Project Title: Environmental Monitoring using Drone Swarms
Project Description: The success of many environmental applications hinges on real-time monitoring of time-varying and geographically distributed phenomena. The monitoring can be conducted using a large team of drones. This project aims to develop a system for a network of self-organizing drones to be highly collaborative among themselves for this application.

Project Advisor: Hua Wang
Project Title: Developing Robust Brain Imaging Genomics Data Mining Framework
Project Description: The research objective of this project is to address the computational challenges in an innovative big data application on neuroinformatics. This project will study the problem of integrating multi-level data with the emerging key computational techniques: large-scale non-convex sparse learning models with linear convergence algorithms and linear computational cost multi-task multi-dimensional data integration algorithms.

Project Advisor: Hua Wang
Project Title: Learning Guided Catalysts Discovery and Synthesis
Project Description: The research objective of this proposal is to help designing new robust data mining and machine learning algorithms for solving the computational challenges in complex materials genome data mining. The major computational challenges are the bottlenecks for comprehensive materials genome data analysis due to unprecedented scale and complexity. To address this, this project will perform preliminary assessment to help developing new data mining algorithms for Material Genome data.

Project Advisor: Tom Williams
Project Title: Augmented Reality for Human-Robot Interaction
Project Description: Augmented Reality provides new means by which robots may communicate with human trammates. In this project, students will prototype different Augmented Reality visualizations to enable more natural human-robot interaction, and design experiments to evaluate the effectiveness of those cues during human-robot interaction. Preferred prerequisites: either Computer Vision or Computer Graphics. Spots available: three (3).

Project Advisor: Tom Williams
Project Title: Group Reference

Project Description: In previous work, we have developed algorithms to allow robots to understand and generate references to individual objects within their environments (e.g., "the red box"). In this project, students will investigate new ways in which robots might handle references to *groups* of objects. (e.g., "the red boxes").

Project Advisor: Tom Williams
Project Title: Goal Reference
Project Description: In previous work, we have developed algorithms to allow robots to understand and generate references to individual objects within their environments (e.g., "the red box"). In this project, students will investigate new ways in which robots might handle references to a robot's own actions and goals (e.g., "*groups* of objects. (e.g., "the red boxes").

Project Advisor: Tom Williams
Project Title: Virtual Reality for Autonomous Vehicle Interaction Design
Project Description: Virtual Reality presents new opportunities to explore the ways in which autonomous vehicles (such as autonomous cars or autonomous wheelchairs) may interact with their users, without the need for physical robots. In this project, students will develop virtual environments for exploring such interactions, and design an experiment to test different robot behaviors within that environment. Preferred prerequisites: prior experience with 3D game design or virtual reality.

Project Advisor: Bo Wu
Project Title: Mitigating GPU Contention for Serving Deep Learning Models
Project Description: GPUs (Graphics Processing Units) are widely used to accelerate deep learning workloads. A server in a cloud computing system may use a high-end GPU to perform inference for multiple deep learning based applications. The applications thus contend for both the GPU computation resource (i.e., the GPU cores) and the GPU memory resource (i.e., the device memory). In this project, the student will conduct experiments to understand the nature of the contention and design a runtime to mitigate the contention.

Project Advisor: Dejun Yang
Project Title: PhoneGuard: An Antitheft System for Smartphones
Project Description: Almost 75% of all Americans now own a smartphone, and that number keeps climbing, despite their also-increasing price tags. Their portability and value, combined with their small size, make smartphones ideal targets for thieves. Stolen and lost smartphones can result in some important and valuable data, such as photos and contacts, from never being recovered. In addition, personal data can lead to identity theft and fraud. To combat this, we aim to develop a smartphone theft detection app based on users' behavioral biometrics to alert users on the spot.

Project Advisor: Dejun Yang
Project Title: MaskCall: A Sound Masking System for Private Calls
Project Description: Oftentimes we come across a situation when we need to answer or to make an important call but we don't want people nearby to tap our conversation. In this project, we plan to design, MaskCall, a sound masking system to protect users' speech privacy. MaskCall will send noise signals along with user's voice, so that people around the user cannot hear the user's conversation. MaskCall needs to guarantee that the selection of the noise will not affect the user's experience and the person on the other end of the call can still hear the user clearly.

Project Advisor: Dejun Yang
Project Title: Detecting Driver Phone Use to Prevent Distracted Driving
Project Description: Driver distractions caused by smartphones have been a major factor in high profile car accidents. In 2013, 3,154 people were killed in smartphone distraction-related crashes. Existing solutions either do not distinguish between the driver and passengers, like iPhone's Do Not Disturb While Driving feature, or requires the control of the car. In this project, we plan to develop an application to determine driver phone use, utilizing sensors equipped in smartphones, mainly Bluetooth and magnetometer. Our approach does not require the installation of extra hardware inside the vehicle or the control of the vehicle.

Project Advisor: Chuan Yue
Project: Attacking and Defending Robotic Systems
Project Description: Traditionally, robotic systems were designed without considering the potential adversaries that may attack the systems. This project aims to quantify the adversaries' capabilities of attacking robotic systems from both the system perspective and the algorithm (especially machine learning algorithm) perspective, and design simple yet effective solutions to defend against the potential attacks. Good programming skills as well as basic machine learning or robotics knowledge are expected for students who are interested in this project.

Project Advisor: Chuan Yue
Project: Understanding and Securing the Web
Project Description: The Web has never been a secure place, especially due to the pervasive vulnerabilities incurred by developers to Web applications and the persistent threats imposed by attackers for various purposes. This project aims to design new systems, algorithms, and studies to analyze and address the security and privacy risks on the Web. Good programming skills as well as basic Web systems or machine learning knowledge are expected for students who are interested in this project.

Project Advisor: Chuan Yue
Project: Security and Trust in IoT Systems
Project Description: The rapid adoption of smart, adaptive, and connected devices is taking us to the IoT (Internet of Things) era. IoT systems including Smart Home, Smart City, and Smart Grid bring significant benefits to us; however, they also quickly become the attractive targets of a variety of security and privacy attacks. This project aims to quantify the security and privacy risks in IoT systems, and foster the trust in IoT systems. Good programming skills as well as basic cryptography or machine learning knowledge are expected for students who are interested in this project.

Project Advisor: Hao Zhang
Project Title: Robotics Demonstrations for STEM Education and Outreach
Project Description: The project objective is to create robotics demonstrations such as robot dancing, robot soccer, speech interaction, and tic-tac-toe playing, and use the demonstrations for outreach and STEM education to inspire and attract the future generation of roboticists. Students will have the opportunity to access the fully interactive, versatile, and fun robots, work on cutting edge robotics educational applications, learn robot programming, and obtain experience of system development that is highly relevant to graduate education and systems jobs.

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Project Advisor: Hao Zhang
Project Title: Developing a Natural Multimodal Human-Robot Interface
Project Description: As smart robots are transforming many industries and becoming an integrated part of our daily activities, humans and robots will inevitable interact more regularly. The objective is to develop a multimodal human-robot interface that can intuitively convey the information collected by robots and reduce robot control complexity, thereby enabling natural human-robot collaboration in robot-assisted inspection applications. Students will have the opportunity to access modern robotics systems, collaborate with graduate students and faculty on cutting edge robotics applications, and develop work experience of system design that is highly relevant to graduate education and industry positions.