Research opportunities

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The purpose of this document is to summarize current (based on how recently this document was updated) research opportunities which exist is my group, and to present an overview of the typical skill-set that current/past students have had when they conducted research under my supervision. This is by no means an exhaustive list of ongoing research. I expect my students to define their interests and problems that they would like to work on.

However, if you are reaching out to me inquiring about the availability of a research position (graduate or undergraduate). I expect that you have gone through this document in its entirety.

Regarding research opportunities

I am always looking out and open to conducting research with both undergraduate and graduate students. This could occur in many forms - an independent research project over a single or multiple semesters, capstone projects (in groups, or individually), research assistant positions in my group, masters thesis, summer research position, self funded visiting researcher etc. Regardless of the logistics and means of conducting the research, the common denominator for the most successful researchers always boils down to:

1. Willingness to learn and pickup new skills,

2. Demonstrate independent thinking,

3. Desire and motivation to make major impact in an area, and

4. The ability to take risks - i.e. to invest in the process and not necessarily only think about a binary outcome or goal,

Remember, *The future belongs to those who learn more skills and combine them in creative ways.*

Current Opportunities

Sustainability impacts of cryptocurrency mining:
Designing an autonomous system which can decide in real time whether it is beneficial to use excess renewable electricity for mining cryptocurrency, as opposed to selling ti back to the grid or storing it in a battery. Research involves understanding the cryptocurrency reward mechanisms, the connection between expected reward and electricity consumption, modeling expected reward, working with a real ASIC miner to build a model for its electricity consumption. Experience with time-series modeling and model predictive control will be helpful. Experience with EnergyPlus simulations is a plus.

The internet of wasted things
While buildings are becoming increasingly aware of their energy and water usage, the capability to track waste and material use with the same ease has remained beyond the reach of most building facilities managers. Through the proposed work, we will develop a novel approach to waste tracking, and understanding waste behaviors of occupants and help close the loop for waste management for buildings. As organizations create new waste reduction goals, the proposed research methods will lay the foundation for - The Internet of Wasted Things (IoWT). We will use deep learning for waste detection and disposal. Can we detect everyday disposed objects in real time from video streams. Expertise in computer vision and DNN for object detection is required.

F1/10 Autonomous Racing Car
Its 1/10 the scale, but 10 times the fun! This is an exciting and fast paced project during which you will assemble, program, and then race a 1/10th scale autonomous racing car. You will learn about the principles of perception, planning, and control for autonomous cars. This project involves working with sensors (LIDAR, Camera), NVIDIA Jetson, Robot Operating System (ROS), and using Python. The promise of autonomous or self driving cars in the past decade has become quite popular. However accessibility to such vehicles as research instruments is still difficult due to several reasons. The goal of F1/10 racing is to enable research and develop algorithms for operating autonomous vehicles at the limits of their control. Please contact me if you are interested. Racing Video: https://www.youtube.com/watch?v=fyFycjFaLC4 . Familiarity with ROS is required.

Crashing cars for safety
With all of the hype around self-driving cars, it may seem like mass-market availability is just around the corner. The main obstacle can be boiled down to teaching cars how to operate reliably in scenarios that don't happen often in real life and are therefore difficult to gather data on. This project involves modifying a 1/10 scale RC car to be driven using a point-of-view (POV) headset. We we then use this setup to race the car around a track at high speeds to collect data for autonomous driving. Familiarity with ROS is required.

Measuring trust in autonomous vehicles
How can we measure, and improve human trust in autonomous vehicles? This project involves designing a graphic user interface (GUI) which can provide contextual and situational awareness for the passengers. The challenge is to best convey the "intent" of the autonomous vehicle for any given situation. We will conduct experiment on a full scale driving simulator. Any experience with GUI design, Unreal, Unity, or game design is preferred.

Deep Explanations
Work on implementing and developing an interesting algorithm which uses a clever mix of image captioning, and structured DNN to generate explanations for the predictions produced by a network. Applications in autonomous driving and autonomous surgical robots. Prior experience with deep learning, and natural language processing is required.

In addition, checkout research projects listed on my website: `http://www.madhurbehl.com/`. If you are a student at UVA, consider taking my research based special topics courses:

1. Fall-CS 6501/SYS 6582 **Principles of modeling for Cyber-Physical Systems** `https://linklab-uva.github.io/modeling_cps/`

2. Spring- CS 4501/SYS 4582 **F1/10 Autonomous Racing: Principles of perception, planning, and contro**l `http://www.madhurbehl.com/teaching.html#f1tenth`