Personal Statement

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1 Experience

I have been active in research since high school and have published 4 first-author papers in robotics. I participated in the FIRST Tech Challenge and FIRST Robotics Competition during high school. I was accepted as a high school research assistant at the Computational Robotics Laboratory at the Catholic University of America (CUA) following my high school graduation in June 2012. At CUA, I developed interfaces for controlling the iRobot Create that included moving the robot using hand gestures interpreted using the Microsoft Kinect, and with an Android application that could interpret natural spoken language. After my first year of university in 2013, I participated in a National Science Foundation Research Experience for Undergraduates (REU) site at the University of Notre Dame. At Notre Dame, I developed a computer vision library for JavaScript that can be used to determine where a user is looking on the screen. For this project, I received the Best Poster Prize for the REU site.

Once I returned to university after the summer, I became a research assistant in the School of Psychology where I configured a novel experiment that involved three active-shutter 3D displays of different sizes that can be viewed simultaneously through beam splitters. The goal of this set-up was to determine how people perceive 3D imagery. In parallel with working for the School of Psychology, I worked as a research assistant for the School of Computer Science developing computer vision algorithms that can translate monocular images into series of impulses that can be relayed to a haptic interface. The goal of this software was to allow people with sight impairments to perceive the real-world using haptic feedback.

During the summer of 2014, I was part of the Naval Research Enterprise Internship Program at the Naval Center for Applied Research in Artificial Intelligence at the Naval Research Laboratory in Washington DC. I worked in the Distributed Autonomous Systems group developing motion planning algorithms that enable a group of unmanned aerial vehicles to provide persistent surveillance of a given area. Each robot maximizes the quality of the sensory information being collected whilst minimizing the risk of damage to the vehicle and the risk of being detected by a hostile target on the ground. I have continued to be affiliated with the Computational Robotics Laboratory at the Catholic University of America as an undergraduate research assistant developing path planning algorithms that enable swarms of robots to go from an initial configuration to a goal configuration in highly dense dynamic environments. Most recently, I have been working as student contractor for the Naval Center for Applied Research in Artificial Intelligence at the Naval Research Laboratory developing algorithms that allow swarms to accomplish several high level tasks given topological maps of the environment. The experience I have gained through my participation in research during my studies has prepared me well for a PhD; it has taught me how to solve difficult problems with little supervision, to be independent and self motivated, and how to present my work to the scientific community.

I would like to attend the University of Bristol to solve problems whose solutions can have a major impact for good in the world. Working with Dr. Hauert will allow me to participate in cutting edge research in swarming nanosystems for cancer applications. I also look forward to working at the Bristol Robotics Laboratory, which is one of the best robotics laboratories in Europe. My previous research experience in swarm robotics and emergent behaviour provide me with the needed background to take on challenges in swarm engineering.

2 Project Aims

Under the supervision of Dr. Hauert, I will be working on the control of large robot swarms by dynamically modifying the environment.

Swarm behaviours arise from the interaction of robots and their local environment. Each robot is typically given a controller that determines its individual behaviour. The challenge is to design the robot controllers given a desired emergent behaviour.

As swarms become larger in number and smaller in physical size, our ability to control individuals in a reliable manner diminishes. Nanobots for cancer applications for example work in the trillions and are only able to diffuse and react to their environment [1]. Instead of designing controllers for individual robots, we aim to change their environment dynamically as a way to control the swarm.

This could enable very large numbers of minimal agents to perform controlled swarm behaviours through the actuation of limited elements in their environment.

There is no obvious relation between the design of the environment and the emergent behaviour of a swarm. The challenge is to understand how the environment should actively be controlled to achieve a desired swarm behaviour. We hope this will result in a paradigm shift in the way swarms are engineered by enabling few entities to control the outcome of large numbers of limited robots. Applications include nanomedicine or the deployment of large scale robotic systems for environmental monitoring.

In the scope of this project, we aim to control a swarm of 1000 kilobots [2] through the modification of their environment projected as light pools on the kilobot arena. This will require an overhead camera to observe the state the swarm and update the projected environment accordingly. An algorithm will be designed to determine how the environment should change for a given desired behaviour.

References

[1] S. Hauert and S. Bhatia, "Mechanisms of cooperation in cancer nanomedicine: towards systems nanotechnology," *Trends in biotechnology*, vol. 32 (9).

[2] M. Rubenstein, A. Cornejo, and N. R., "Programmable self-assembly in a thousand-robot swarm," *Science*, vol. 345 (6198), pp. 795–799, 2014.