Undergraduate Thesis Prospectus

How can a Robot be Taught to Autonomously Map an Indoor Space?
(technical research project in Systems Engineering)

The Gig Economy: A Haven for Workers in Transition
(STS research project)

By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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General Research Problem: the automation of simple, repetitive tasks

What effect will automation have on society?

One way to enhance productivity is to automate simple, repetitive tasks through technology. While new technology can enhance productivity, it also tends to displace workers, especially in low-skill jobs. Artificial intelligence may accelerate automation. At the 2019 World Artificial Intelligence Conference in Shanghai, Tesla CEO Elon Musk hypothesized that "probably the last job that will remain will be writing AI software, and then eventually the AI will just write its own software" (Musk, 2019). Society will either adapt to keep workers relevant, or slip into the Player Piano-like world that Musk suggests (Vonnegut, 1952).

Indoor Mapping and Navigation for an Autonomous 3D Printed Robot

How can a robot be taught to autonomously map a space?

This project is sponsored by the MITRE Corporation and advised by Professor Madhur Behl of the Systems Engineering department. For my capstone, five other students and I are writing software to allow a robot car to map a space.

Knowing the layout of a space before entering can make a first responder's job safer. Unfortunately, obtaining this information isn't always easy. Public records or research can often turn up useful building designs, but this process degrades as the age of the building increases. Some law enforcement agencies have used "radar devices that allow them to effectively peer through the walls of houses" (Heath, 2015). However, these raise privacy concerns about the ethics of their use, making them a less than ideal solution (Heath, 2015).

The MITRE Corporation (MITRE) has developed a prototype for a low-cost, 3D-printed system for ISR applications. Such a system has the benefit of being easily constructed and

repaired in the field, without the need for stocking a large inventory of parts. In addition, by giving operational personnel access to the design, the systems can be modified in the field to meet unforeseen mission requirements, essentially enlisting the operators as “hackers” to improve the design. A typical mission for the system would include deployment in an indoor space, where a remote operator could direct the ground robot around the space, for the purpose of exploring. The end result would be a map of the space, as well as video capture of objects and possibly people within the space. Time is a critical element of such missions, so the ground robot would need to be relatively fast and maneuverable. In recent work, MITRE has developed a prototype of a remote-control ground robot with sensors capable of observing its surroundings, including LiDAR and a camera. A key challenge is to enable the system to operate autonomously to generate maps of indoor environments and navigate to desired goals/waypoints within the map.

Our research plans are outlined in the following three sub-sections:

1. Testing of system capabilities

We will determine the capabilities of the hardware in specific scenarios, which will be used to assess the overall performance and shortcomings of both the initial (existing) prototype and additional iterations. We will work with personnel at MITRE to identify important design requirements and constraints.

2. Implementation of software for communication control

Implementation of software for communication and control. We will explore open-source frame-works, including the Robot Operating System (ROS) and ArduPilot, to improve the

system's ability to explore and create maps of unknown spaces, transmit images and other data, and provide robust control, particularly in the face of latency issues.

3. Integration of new hardware with the existing system

We will identify and evaluate potential improvements for sensing and communication, and integrate new hardware with the existing system, as needed. Activities will include designing and specifying interfaces for physical, electrical, and control systems.

Final product and potential future plans

At the end of the project, we aim to have a fully-functional hardware-software suite that will allow the robot to map any space autonomously. An extension of this work could be to modularize the components to allow for transfer between different robots (i.e. cars, drones, etc.).

The Gig Economy: A haven for workers in transition?

How is the gig economy filling the employment gap for workers displaced by automation?

Technology is disrupting employment. Automated systems can often complete tasks more efficiently than their human counterparts. A Brookings report on automation forecasts that "over the next few decades, approximately 25 percent of U.S. employment (36 million jobs in 2016) will have experienced high exposure to automation" (Muro, 2019). Workers without college degrees may be at greatest risk of displacement (Sterling, 2019). As roughly one third (as of 2016) of the workforce in the United States lacks a college degree, a large proportion of the workforce is at risk (Brundage, 2017).

Education can help displaced workers find jobs, giving educators a unique opportunity (Sterling, 2019; Muro, 2019). The U.S. Department of Labor and online degree programs can meet some of this need (Sterling 2019). Online learning companies also aim to meet this need. The CEO of Coursera stated that the company aspires "to reduce skills gaps and spread opportunity widely" (Maggioncalda, 2019). Coursera's blog touts stories suggesting that with the company's courses, workers have achieved higher paying, more skilled jobs. Sandra M. went from "managing a restaurant to managing I.T." (M. S., 2019).

According to Deloitte senior partner Angus Knowles-Cutler, "ensuring that the workforce of the future has the right skills and education is [vital]." Displaced workers must learn new skills in order to find sustainable work because employers "feel that the skills required" for industry "are changing" (Deloitte, 2015). According to a report by Deloitte (2015), 800,000 jobs in the U.K. were lost from 2001 to 2015, but 3.5 million new ones were created. The new jobs generally required more skill and offered better pay than the lost jobs (Deloitte, 2015). Automation isn't reducing the number of jobs, it is redefining the types of jobs that are available. When low-skill jobs become redundant, high-skilled jobs become essential.

Displaced workers must often find new jobs quickly, before they can reeducate themselves for higher-skilled, more secure jobs. Low-skilled workers can find themselves being repeatedly displaced as automation develops. **Online certificate programs can offer.**

The gig economy may be the haven displaced workers need to earn an income while reeducating themselves. While automation makes low-skilled jobs redundant, the gig economy is growing (Brustein, 2019). According to Muhammed (2018): "The workforce share of gig work rose from 10.1% in 2005 to 15.8% in 2015." Gig economy employers, such as Uber, show

sustained demand for workers (Vock, 2018). Gig work tends to be flexible, permitting education and income to be pursued simultaneously.

Upwork and the Freelancer's Union (2019) found that over half of gig workers had participated in skills training while freelancing, taking advantage of gig work's flexibility (Upwork, 2019). According to the study, the vast majority of freelancers say that technology has simplified finding gig work (Upwork, 2019), shortening income interruptions. Though gig work can be unstable, many gig workers believe that "having a diversified portfolio of income from multiple clients is more secure than having one employer" (Ozimek, 2019). By developing a diverse gig portfolio while retraining for higher-skilled jobs, gig workers displaced by automation can manage economic uncertainty.

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