Thesis Project Portfolio

Co-Navigational Aquaculture Vehicle System Design

(Technical Report)

Bureaucracy in Defense and the Emergence of Digital Engineering in a New Era

(STS Research Paper)

An Undergraduate Thesis

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Bachelor of Science, School of Engineering

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Sociotechnical Synthesis

Introduction

The design of new military hardware systems coupled with digital engineering goes hand-in-hand with the research and development of non-military autonomous systems. Utilizing technologies like artificial intelligence (AI) and machine learning (ML), additive manufacturing, and advanced software development in defense has led to the production of newer, more successful autonomous military vehicles, as well as exponential business growth. Both my technical and STS projects are connected to vehicle autonomy and digital engineering. My mechanical engineering (ME) capstone explores how autonomy and independent vehicle operation are crucial in facets like agriculture and aquaculture. My STS research paper is related, but deviates with a different approach—rather, the thesis focuses on how autonomy and digital engineering in defense is encouraging and creating more effective products and entrepreneurial activity in industry.

Technical Capstone

The goal of the technical project in the ME design course is to design and develop a co-navigational two-robot system that autonomously runs and can clean aquacultural fish pens independently. The inspiration of this project derives from a need the to improve the safety hazards surrounding current approaches to fish pen cleaning, highlighted by the United States Department of Agriculture (USDA)—the current processes involve workers performing dangerous manual labor underwater, removing algae and other harmful debris. The technical project was deconstructed into numerous parts to help divide and conquer the work, with a group member (or pair) focused on each of the following: surface vehicle development, underwater

vehicle navigation, and the cleaning mechanism to be implemented with the underwater vehicle. The ideal system would operate autonomously and would be able to run for extended periods of time while effectively removing debris from the fish pens.

As this is a project that will likely be passed down to future ME Design I/II groups, a focus of our group was on foundational groundwork. The surface vehicle is currently fully designed and built and can operate via remote control. Due to time constraints, we recognized that autonomous development may not be feasible for our team, and instead we aimed to make the entire system remotely operable, as this is a crucial step in progress towards full automation. Similarly, the underwater vehicle is remotely operated and bears a cleaning mechanism that that pumps the surrounding water at a high velocity into the pen netting. Ideally, the goals of groups following our work should be to (*a)* automate both vehicles, and (*b)* utilize wave energy from the environment to power the system, as this reduces sustainability concerns.

STS Research Paper

Understanding the implications of utilizing new technologies in defense is the core of my STS thesis. Traditional defense conglomerates have struggled to release truly effective products for the battlefield—this dilemma has been compounded by problems including bureaucracy, corporate stagnation, and poor practices. The question to be answered is how the United States will combat such R&D issues, especially when considering recent global conflicts (including the Ukrainian conflict and the ominous threat of China invading Taiwan). Fortunately, various startups and growth companies harnessing digital engineering and AI have shown monumental success – both in creating great products, receiving funding, winning contracts, and growing their businesses. I explore a plethora of factors surrounding these firms like privatized funding (venture capital), digital engineering and AI, new business models, and engineering talent shifts.

The goal of this research is to shed light on the broken system of innovation in this country and argue that implementing the newest digital technology is the key to fixing our defense industry.

Conclusion

Completing both my hands-on, technical capstone and STS thesis has provided me with invaluable insight into industry that I otherwise may not have learned. Having worked in defense before, I am familiar with the bureaucracy and sluggishness that is often present in R&D at large defense conglomerates. I have been interested and passionate about digital engineering in design, and the application in new technologies in defense is particularly intriguing to me considering the emerging startups and autonomous vehicle systems. Although the United States has fallen behind in innovating effective battlefield technology compared to our adversaries, our defense industry is beginning to reestablish its global military prowess in deterring war. From working on my capstone project, I have also learned that developing similar autonomous systems can be overwhelmingly complex and multi-faceted. Beyond creating effective hardware designs, harnessing the resources of digital engineering, robotic autonomy, and software development has yet to be fully understood. From vehicle path-planning, localization and mapping, perception, and other complex components of autonomous operation, I am now more familiar with the underlying concepts of a software-enabled vehicle hardware, and I hope to utilize this knowledge during my continued employment in defense.