Thesis Project Portfolio

Autonomous Obstacle Avoidance for Unmanned Aerial Vehicles (UAVs)

(Technical Report)

The Ethics of Autonomous Weapon Systems

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Patrick Hourican

Spring, 2023

Department of Electrical and Computer Engineering

Table of Contents

Sociotechnical Synthesis

With my technical topic addressing autonomous UAVs and the safety concerns that accompany autonomous control, I looked to explore a topic concerning autonomous systems that possess ethical concerns on a much larger scale. My technical topic surrounded safety concerns for the public as autonomous UAVs have a tendency to crash into obstacles and not only put people in danger, but become increasingly costly when they need to be replaced. With these issues, we designed a UAV under the control of shared autonomy, granting the system human control when needed, with autonomous features to avoid obstacles and improve safety. In relation to this, I addressed the ethical issues surrounding autonomous weapon systems (AWS) in the United States military. These concerns stem from similar concerns for autonomous control of these systems where they put civilians at risk and due to the autonomous control it becomes difficult to pinpoint the human operator that is responsible for it. Thus, I centered my research around the ethical dilemmas that these systems have and analyzed the way in which the United States is taking steps to address them, both through military personnel and directives published by government entities, like the Department of Defense.

My capstone project was chosen to address the common types of issues with fully autonomous UAVs. The goal of this project was to investigate and enable a form of shared autonomy that incorporates both capabilities – human controlled input and onboard autonomy. This compromise allows for desired human input (e.g., flying a drone to an area of interest), while keeping the system safe (or performing other tasks) through onboard autonomy and obstacle avoidance. To accomplish this my team designed and developed an aerial platform to enable shared autonomy and obstacle detection for unmanned aerial vehicles (UAV). A printed circuit board (PCB) was designed and manufactured to aid in UAV obstacle avoidance using a

series of 1-D time of flight light detection and ranging (LIDAR) sensors. A servo motor was utilized in order to increase the range and visibility of the front sensor. This allows obstacle detection within the range of the UAVs movements and simultaneously delivers real-time data through inter-integrated circuit (I2C) communication protocols. A 3-D printed tower was manufactured to physically mount the PCB, Lidar sensors and motor to the aerial platform. An embedded Robotic Operating System (ROS) was used to visualize real time Lidar data and simulate obstacle avoidance for UAV systems.

My STS research paper discussed the ethical dilemmas that accompany Autonomous Weapon Systems (AWS) in the United States Military. The concerns stem from the autonomous functions of AWS and the lack of clarity in identifying the people that should be held accountable for war crimes and civilian casualties that are caused by them. My paper discusses the advantages and disadvantages of the military using these systems, and the motivation behind using them. I utilized the STS framework Actor-network Theory to analyze the ethical dilemmas within these systems and the government entities that make decisions in relation to them. This framework provides a useful lens into the actors that are affected by these systems and the network they exist in, allowing for a clear display of the chain of responsibility that is the basis of these systems. These actors in the network include the public, the media, military personnel, government entities and politicians all inscribed together in a network, with the AWS identified as the ‘actant’. Overall, my STS research paper addresses these ethical concerns with a myriad of research, using the STS framework Actor-network theory to analyze the use of AWS.

To reflect on the work I’ve done on both my technical project and my STS research paper, working on these projects simultaneously gave me great experience in both researching and hands-on work. I was able to see the building and production of the systems my research

targeted, but on a simplistic level. Working on my technical project allowed me to utilize the knowledge I've gained through my coursework at UVA and apply it to something I am passionate about. While working on this technical project, researching the ethical dilemmas that are caused by the large scale production of what I worked on gave me a new perspective on how engineers need to take into account ethical consideration when designing and testing a system. Overall, I found that working on these projects simultaneously allowed me to gain hands-on experience in not only designing a system from scratch, but also seeing how ethical considerations must be considered when working on any new technology. These small-scale projects reflect projects as large as AWS and I was able to make that connection while researching this topic.