Commanding Unmanned Assets for Search and Rescue
(Technical Paper)

The Effect of Unmanned and Autonomous Military Technology on Society
(STS Paper)

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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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Introduction

In a search and rescue (SAR) mission, time is the enemy. It is vital to locate the lost individual within 24 hours and in some cases, such as mountainous operations, within 60 minutes to increase the likelihood of survival (Karaca et al., 2017). Because of this, strictly using ground personnel teams to locate the lost individual is not sufficient. Unmanned aerial vehicles (UAVs) enhance a SAR mission because they are easy to deploy, highly maneuverable, have a low maintenance cost, and provide for a safer search and rescue mission (Shakhatreh et al., 2019). To successfully utilize UAVs (drones) within a search and rescue environment, an operator must be able to understand what the drones are doing and intervene when necessary from a control station. Although the drones act autonomously, it is important to design the interface between the operator and the drones with as much transparency as possible. This meaning the operator must know what the drones are doing and why at all times. This will ensure the operator trusts the drones' actions and does not second-guess or override the drones' decisions. This is required for a resilient search and rescue mission (Schaefer et al., 2017). The capstone team will design the User Interface (UI) the operator will use to deploy and oversee a fleet of unmanned search and rescue UAVs. The UI will be designed to ensure the operator can understand the decision the drones are making and override the drones' decisions when needed to benefit the overall search and rescue mission.

Militaries across the globe are beginning to utilize and experiment with unmanned and autonomous systems as assets of war. Gary Merchant of the Center for Law, Science & Innovation at Arizona State University writes "...many experts believe that autonomous, and in particular lethal autonomous, robots are an inevitable and relatively imminent development." Because of the widespread use of these technologies is inevitable it is clear that they will affect

humans' place in war and how society views war (Merchant et al., 2008). In a 2008 report written for the US Department of Navy, the authors discuss that such systems can be used to both save human lives and are free from human biases such as emotions and rash decisions (Lin et al., 2008). But, taking the human out of war and replacing them with unmanned and autonomous systems does not come without consequences and changes to society. The growing use of unmanned and autonomous systems in militaries across the world will affect humans' place in war, how society views war, and policies surrounding the war.

Technical Topic

Search and Rescue (SAR) missions are complex, time-consuming, and are conducted 100,000 times each year in the United States. In normal weather conditions and terrain, these missions are complex and almost impossible when extreme changes to such conditions occur (Adams et al., 2007). Unmanned aerial vehicles (UAVs) coupled with traditional ground search and rescue teams can increase the likelihood of locating the missing individual in time. The UAVs are used to locate the missing individual and the ground team is then sent out to this location to rescue them. To successfully deploy the UAVs for the search mission, there must be an operator overseeing the drone's actions and relaying information the drone has collected to the ground search team. The connection between the drone and the operator is referred to as human-machine teaming.

There are two main challenges when designing human-machine teaming, building trust, and balancing semi-autonomous actions. For the operator to fully trust the drone's decisions, the interface connecting the two needs to allow for transparency of all drone actions. That is the operator must know the information the drone is using and what conclusions they are making (Schaefer et al., 2017). Semi-autonomous actions refer to the operator knowing what the drone is

doing at all times, but only directly controlling its actions when it is 100% needed. The challenge is finding the right amount of control the operator can have over the drones to ensure the mission is successful and that the operator can manage multiple drones at once (Hong et al., 2019). One such instance where an operator may need to step in during a mission is to solve a complex problem or scenario that the drone has never encountered before (Saenz et al., 2020).

The capstone team's project, Commanding Unmanned Assets for Search and Rescue (CUASAR), is sponsored by the John Hopkins University Applied Physics Laboratory. CUASAR is based on the idea that most missing individuals will have a cell phone on them even if they do not have cell service. Because of this, a constellation of drones equipped with phone sensors could be sent out to locate the missing individual by locating the phone signal. For the CUASAR mission to be successful a visual representation of the drone constellations activity and phone signal location collected by the drones must be relayed to the operator. The method the drones use to maneuver to locate phone signals is referred to as dynamic co-fields autonomy and is shown in Figure 1 (Lesniak et al., 2020).

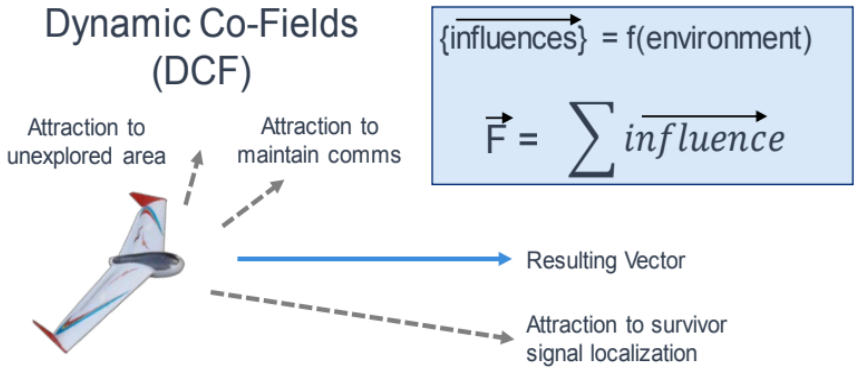

Figure 1. Drone Autonomy Algorithm: Individual drones navigate by using dynamic co-fields to balance multiple influences.

The technical project itself focuses on designing the User Interface (UI) between the drone constellation and the operator. The team will not be designing the way the drones operate or maneuver within the search area. This UI will be designed with transparency between the drones' decisions and the operator in mind as well as maintaining semi-autonomous operation. The team will complete this work through a web-based interface design tool, Figma.

Deliverables for the technical project will be submitted to Gregory Gerling according to the descriptions and timeline released in SYS 4055. The project scope report was submitted on October 10. At the end of the Fall 2020 semester, the team will present the client with a working prototype interface that they can then use for user experience testing. At the beginning of the Spring 2021 semester, the team will finalize the interface design and handover to the client. The project team will also be participating in the IEEE Systems and Information Engineering Design Symposium, presenting an abstract and a conference paper, presentation, and poster, contingent on the abstract being accepted.

STS Topic

The strength of a country is oftentimes dependent on the strength of its military. This strength is not only the size of the standing army but the technological advancements in warfare a country makes and utilizes. Because of this, militaries will innovate new warfare technologies to utilize in warfare and deter their adversaries from starting conflicts. Unmanned and fully autonomous weapons of war are examples of such technologies.

In 2000, Lieutenant Colonel (LTC) David Glade predicted in an official report for the United States Air Force that military technology is headed in the direction in which unmanned aircraft will be able to perform duties such as transporting passengers, conducting air-to-air combat, and attacking mobile targets. These actions at the time were believed to be only reserved

for piloted aircraft. He predicted that increasing the research and development into these new technologies would lead to an era in which humans no longer make the decisions of war (Glade, 2000). This affects individuals at all levels, starting at governmental bodies themselves to soldiers on the battlefield and working its way down to civilian citizens.

International laws exist as a set of rules of war to ban certain categories of weapons such as chemical and biological weapons. But, laws against the use of autonomous robots of war are tricky to govern due to their not being one international conference with all superpowers present to agree on adding autonomous robots to the list of banned weapons (Merchant et al., 2008). Along with the governmental bodies themselves playing a role in the future of autonomous technology the individual soldiers are affected by the use of these assets. This is because the autonomous assets of war need to have someone to deploy them and oversee them. The asset is essentially added as another "team member" for the military operation (Giachetti et al., 2008). This brings up the question of who is responsible for the decisions the autonomous weapon makes: the governmental bodies, the individuals deploying them, or the ones who invented and programmed the technology? As innovations of unmanned and autonomous assets of war evolve they will shape societies' views or future warfare.

To determine the extent to which unmanned and autonomous military technologies play in shaping personnel, policies, and society the framework of Actor-Network-Theory (ANT) will be used. ANT is used to identify human and non-human actors that all come together to influence a system or network. It is most effective when analyzing small social systems as it is easier to identify all the actors and actants within the system (Crawford, 2020). ANT is sometimes critiqed as a method of analysis because it often time fails to explain each individual actor and instead focusses on the impact of the actors coming together in the network (Callon,

1999). Overall ANT as a theory maps shifting the shifting nature of relationships within social and natural worlds.

Methodologies

Research Question: To what extent does the increase in unmanned and autonomous technology affect military personnel, policies, and society?

To answer the research question Historical Case Studies, Document Analysis, and Literature Review methodologies will be used. The historical case study will start with the use of unmanned technologies in World War II and track the use of technologies through the present day. Elizabeth Quintana, Head of Military Technology & Information Studies Royal United Services', works regarding the innovations of unmanned military technologies through time and throughout Canada, Germany, China, and the United States will drive the case study (Quintana, 2008). The advancements in technologies will be compared to how society's view of warfare has changed over time.

Document Analysis and Literature Review will be used to review official documents written for the United States military and various scholarly opinions on unmanned and autonomous assets. Two examples of official military reports are LTC David Glade's 2000 report for the United States Air Force and the US Department of Navy, Office of Naval Research's official report in 2008. These official reports coupled with scholarly views will allow for the exploration of how various stakeholders and society view unmanned and autonomous military assets.

The research will be conducted starting the Fall 2020 semester and continue into the beginning of the Spring 2021 semester. The writing will occur during the Spring 2021 semester.

Conclusion

Autonomous technologies are on the rise, one such example is fully autonomous drones making flight decisions without operator intervention, after being launched into the sky. One application of these drones is in Search and Rescue Operations. The capstone team will create a User Interface (UI) for autonomous drone technology that utilizes phone signal sensors to locate lost individuals. The UI will allow the operator to successfully deploy the drones and provide drone decision transparency to the operator to ensure the operator trusts the decision the drones are making.

Another application for autonomous technologies is in military operations. This paper will explore how these technologies along with unmanned assets of war shape military personnel, policies, and society. Soldiers, governments, inventors, programmers, and civilian citizens all play a role in the application of autonomous and unmanned technologies in warfare. Ultimately, this research will identify ways in which these technologies have determined or shaped society.

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