Prospectus

Fly-Crash-Recover: A Sensor-based Reactive Framework for Online Collision Recovery of UAVs
(Technical Topic)

The Personification of Political Ideologies within Drones
(STS Topic)

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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Introduction

Thermal imaging cameras, advanced telecommunication technologies, data collecting equipment, all of these sensors and more are present within the innovative framework of drones due to the driving desire to meet ever-evolving needs and uses (Cavoukian, 2012). Drones allowed journalists to gather aerial shots of Typhoon Haiyan and its aftermath in the Philippines (Jarvis, 2014). Ecologists use drones to traverse difficult terrains to gather data samples with little disturbance to the ecosystem (Ivosevic et al., 2015). With their ever-growing number of enhancements, drones are increasingly used to traverse unknown or dangerous environments, thus necessitating the development of drones to react and respond appropriately if unexpected crashes occur (Tomic and Haddadin, 2014).

This capstone project aims to analyze how drones react to collision with various objects. Tests will be conducted by flying unmanned aerial vehicles into several different objects. Data on how drones respond to collision will be collected using specialized cameras adept at tracking exactly how the crash occurred. After sufficient data has been analyzed, recovery methods will be discussed and programmed into the drones. These methods will be tested and judged on how they are able to react and recover from a crash. The capstone team will then present the most appropriate method for drone recovery to the MITRE Corporation who are the direct sponsors.

Understanding how useful it is to improve upon the resilience of drones, it is important to note the impact that drones have on society. In the military, drones embody a new age of warfare tactics used to subdue threats with merciless precision (Franke, 2014). Mass production and delivery companies like Amazon revel at the opportunity for drones to deliver products at the doorsteps of customers (Jarvis, 2014). Drones can even aid in protective surveillance for venues ranging from small playgrounds to large sporting events (Lin, 2011). Although there are many

positive impacts to drone usage, there are several noticeable drawbacks. Drones used for surveillance could lead to impingements of citizen's rights, while drones in the military may represent an unnecessary and excessive use of force (Wilson, 2014). These negative drawbacks may tarnish how society perceives drones and possibly put at stake their ability to be used in the future (Franke, 2014).

Therefore, as drones evolve and are deployed by many new and intrigued users, their resiliency to inevitable collisions must be developed and the different ideologies they personify must be understood. The technical project aims to analyze drone behavior in order to develop a method to effectively respond to crashes through repeated experiments. The following discussion and resulting research question on the relationship between drones and society aim to identify how drones embody the political ideologies of their users in how they aid them in carrying out their goals. This discussion will then shed light to several moral and ethical dilemmas that both drones and drone users face. Addressing these issues will allow for a deeper understanding to drones and their role in society.

Technical Topic

For this capstone project, two quadrotor drones will be used, the DJI Tello and the Crazyflie. Michael et. al (2010) denotes that quadrotors are designed in a cross shape with four motors that turn propellers located on each branch. Two internal controllers, the position and attitude controllers, aid in the overall motion of the drone. The position controller determines translational motion in 3D-space, while the attitude controller determines orientation and the angle it travels (Michael et. al, 2010). Tomic and Haddadin (2014) note that quadrotors are growing in popularity, and many are being flown into unknown or complex environments to

collect data that would otherwise be unattainable. From unexplored caves to abandoned buildings, flying drones into these environments may lead to unwanted collision and termination (Tomic and Haddadin, 2014). With that in mind, this technical project addresses this problem through programming a recovery solution that mitigates the likelihood of collisions and increases response efficiency at the event of a crash.

The technical solution will be split into three main tasks: research, experimental testing, and implementation. First, research will identify previous work that provide insight into the current state of drone research and crash recovery. Second, experiments will be designed to test drones in different situations. On top of advice and opinion, MITRE provides aid in Professor Bezzo's research budget to make these experiments possible. Both drones will be flown in an enclosed space, on short-distance missions with obstacles that drones will be pre-designed to be flown into. Tests will consist of varying flight patterns, angles of collision, and types of obstacles. Results will be recorded using an advanced motion capture system called Vicon consisting of several cameras across the walls of the laboratory. Third, based on the data collected in these experiments, implementation will involve coding potential solutions within the drone and judging performance of recovery. This process will be done using mainly C++ and MATLAB. Tomic and Haddadin (2014) outline one potential solution to drone recovery that involves reworking the two internal controllers that impact the orientation and position of the drones. At the moment of impact, the solution switches the state of the drone controls from these two controllers to a new controller specifically designed to react to collision. When in this state, the drone is capable of analyzing which part of the drone impact occurred, at what angle, with what force, and if any damage occurred. In doing so, the controller then makes the appropriate adjustments to recover from the collision before shutting down and crashing to the floor. In

addition, GPS location and tracking techniques allow the drone to identify where the collision occurred in the environment and mark the location of the crash to avoid future crashes at that location. This potential solution is useful as it offers the ability to recover from collisions effectively while aiding efforts to prevent collisions altogether (Tomic and Haddadin, 2014).

Overall, the proposed technical solution will take form in the following deliverables that will be given to the MITRE Corporation at the conclusion of this capstone project. A robust literature review of all relevant work researched and discussed will offer knowledge on the current state of unmanned aerial vehicle crash resiliency. In coordination with the vast array of data sets collected on how the drones reacted to impact during testing, a document summarizing all experiments and summary statistics will provide insight to the results found. In addition, any code or simulations developed will be compiled and stored for access. Finally, a designed recovery technique will be proposed and documented within the technical paper submitted to the SIEDS conference.

This technical research will hopefully shed light on ways to improve efficiency and resiliency for a technology that society is growing more accustomed with. As different users find new and different ways to apply drones to meet their needs, drones have the opportunity to embody the political ideologies that its operators believe in. How this is currently taking shape will be the main discussion in the proceeding sections.

The Impact of Drone Usage in Society

With the evolution and advancement of drones over time, it is relevant to explore the relationship that this intricate technology has with the society around it. Langdon Winner (1980) examines different frameworks that focus on determining the relationship between technology

and society. He notes that while many theorists believe that technology develops entirely on its own and ultimately shapes the society around it, others believe that technology has no part in its own growth and that the needs of society bring forth its development. Both arguments have their flaws but can be improved through their incorporation within technological politics. This theory argues that technology can have an active role in society, and that it can even personify the political ideology or agenda of the entity using it. One way this can be seen is in how technology helps resolve problems or issues that particular users have within society. Although this is an effective way that technology can have political components, the more compelling example of technological politics is seen in cases when technology and the political ideologies of its users seem to be strongly aligned and correlated. In these instances, while users adopt the technology and develop it to meets their needs, new social conditions to maintain the environment of operation of the system are created in response to the technology. Thus, while society impacts technology through its desire to meet its political agendas, technology impacts society through its inherent capabilities (Winner, 1980).

Drone usage in society is a great case that supports the framework of technological politics. The following examples show how they can be used to resolve specific issue that its users have, even so significantly that it can begin to embody their political ideologies. In the United States military, drone strikes in foreign countries effectively subdue terrorists with little risk to troops (Franke, 2014). With names like Global Hawk, Predator, and Reaper, drones now symbolize the future of modern warfare tactics (Franke, 2014). Commercially, drones can be used by companies like Amazon to reduce delivery time and improve efficiency through data and analytics (Jarvis, 2014). Thus, drones embody the movements towards automation (Jarvis, 2014). Ivosevic et. al (2015) note that in the realm of science, drones have begun to embody the

possibility of advanced exploration. They detail how they used drones to traverse complex landscapes, identify endangered species, and take samples with little impact on the ecosystem. In doing so, they offer one use ecologists and researchers can have for drones and leave it up to the imagination of the reader to think of all the infinite possibilities that drones can be used for in the future (Ivosevic et. al, 2015). Clearly, there is an ever-expanding development of how drones can be used in today's society.

However, there are drawbacks to drone usage, and they are serious causes of concern. Whetham (2013) notes that in the military, there is a moral disconnection when drones are used for targeting militants. The physical distance between the hunter and the hunted creates an emotional distance from enemies, dehumanizing them to mere targets. In addition, while drones decrease significantly the chance of endangering US troops, this emotional disconnection may lead to post-traumatic stress disorder within the operator after consistent strikes on targets are carried out through looking at a high-resolution screen. In addition, opposing armed defenses, facing these faceless assassins and knowing they are outmatched, might be further inclined to retaliate through other means such as fighting local governments or targeting civilians.

It is clear that if not addressed, drones will become less of a resemblance of modern warfare tactics and more an unnecessary form of brutality (Whetham, 2013). Cavoukian (2012) describes, in addition, that as drones become more applicable for public uses such as surveillance, they may begin to impinge on the right to privacy. She describes the concept of the Panopticon prison, a facility capable of monitoring all aspects of its prisoners with egregious precision, removing all forms of privacy and reclusiveness. Drones have the potential to resemble panoptic structures that could reside invisibly throughout society. Clearly, such a technology threatens civil liberties, creating resistance in their usage (Cavoukian, 2012).

Commercially, with all the potential risks to public safety at the event of a crash in a crowded area, there is concern on how these vehicles will fill the airspace around us (Wilson, 2014). Hopkins (2017) adds on to this by noting the threat that automation might have on the working force. By automating delivery and hiring tech-savvy drone operators, this new technology-based business model takes away jobs from the working class of delivery people and other members of the industry who may have no interest whatsoever in learning how to fly a drone other than to get a job (Hopkins, 2017).

Clearly, there are positives and negatives that comes with the rise of drone usage, and it is clear that both sides need to be addressed. With little communication present for citizens in foreign countries as to why drone strikes are occurring in their neighborhood, misperceptions of the meaning behind their presence surely abound (Franke, 2014). In addition, short-term goals such as targeted drone strikes may impact overarching long-term campaigns such as the war on terrorism or global public opinion (Kennedy, 2013). Drones themselves may be the cause of anti-American sentiment, and questions of their legitimacy must be answered to avoid backlash (Kennedy, 2013). Finally, the lack of airspace regulations and the liabilities that come from civil operations need to be addressed in order for people to feel more comfortable about the presence of drones in day-to-day life (Cavoukian, 2012). These examples show the necessity of discussing the ethics and moral repercussions of drones, and their adoption is reliant upon accurately representing how they are being used to carry out tasks.

Research Question and Methods

Using this description of the way drones can embody the political ideologies of its users, the research question I will address is: how do the political ideologies that drones personify

influence adoption as seen through their usage in the military, sciences, commercialization, and public surveillance? In allowing the possibility of multiple different entities to carry out their political ideologies and agendas, the evolution of drones necessitates the thorough examination of how drones personify specific ideologies based on their usage. In doing so, misperceptions of drones can be addressed more directly so that their usage can be secured in the future.

This question will be addressed through several case studies:

- its usage as a means of surveillance
- its integration into the military
- its development within commercial automation
- its development within scientific exploration

With regards to drones being used as methods for surveillance, I will conduct an extensive literature review and analysis of several legal rulings and policy documents concerning citizen's right to privacy. Cavoukian (2012) specifies that there are several Supreme Court cases that shed light on a citizen's rights against invasion of privacy. There are also several actions taken by the Federal Aviation Administration and the American Civil Liberties Union to protect civil rights. These rulings and actions identify how policymakers are currently trying to stop drones from taking on the ideology found within the Panopticon prison (Cavoukian, 2012). With regards to military use of drones, I will use an ethical assessment on various case studies of drone strikes. Franke (2014) describes, for example, that drone strikes are often used in Pakistan, although neither United States nor Pakistani government have tried to explain to Pakistan citizens the purpose behind such strikes. Discussing the moral and ethical implications behind these strikes will shed light to how people perceive this new embodiment modern warfare tactics (Franke, 2014). For drone usage in commercialization, I will conduct a content analysis on various case

studies to show how drones are embodying advanced automation movements. Finally, a content analysis on how scientists and researchers use drones will be conducted to see how drones embody the new age of exploration.

Conclusion

Thus, drone resiliency to external collision factors and its absorption of the political ideologies of its operators must be understood. The technical project aims to analyze and offer potential solutions to mitigating the likelihood of crashes through programming a modified control system. This solution will improve drone efficiency and resiliency, allowing society to find more meaningful and complex uses for them. The corresponding research paper explores how society currently uses them by examining how drones personify the political ideologies of its users and how this influences their overall adoption. The overall timeline of its completion is found in the proceeding table. Case studies will highlight not only how users impose their ideologies, but also how drones in return aid in efforts to complete specific agendas due to their unique capabilities. By highlighting this relationship between drone and operator, expected results will offer insight on how drones are being integrated within the fabric of society and how society in turn is responding to that. By shedding further light upon this relationship, public adoption of drones can be secured so that future use will not be in question.

1/1/20 – 2/8/20	2/9/20 – 2/29/20	3/1/20 – 3/31/20	4/1/20
Research papers and articles are collected and outlined to determine relevancy.	Analysis of all evidence is conducted. Framework for thesis is completed.	Thesis paper is written, edited, and reviewed.	Thesis is submitted to Professor Foley for review.

Table 1. Timeline for STS Thesis. (Created by Remias, 2019)

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