Exploring Decentralized Swarm Algorithms for Drones
(Technical Paper)

Should Drones Be Used by Police in US
(STS Paper)

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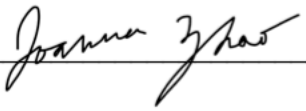
On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Signature  Date 2/7/2021
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Introduction

Drones (UAVs) are gradually becoming part of peoples' daily lives as drones improve technologically and reduce pricewise. They were developed originally for the military but are now increasingly used by common people for hobbies, by professionals as tools for photography, by companies, and by law enforcement agencies. Given how powerful even one drone is, one can imagine how much more powerful it is when multiple drones combine and work together as one unit. This is known as a drone swarm. My technical project is on the simulation of those drone swarms. Although drones are powerful, they can be misused or can introduce a lot of novel concerns. For my STS research, I am going to study a small part of the ongoing debate regarding concerns on whether drones should be used by police in the US or not.

Technical Project Details

My technical research project is on drone swarms. As most drone swarms and drone swarm formations are currently centrally controlled, my project is to make the drone swarms a distributed system. This means that each drone is controlled individually by itself instead of being controlled collectively by one computer or drone. Drone swarms implemented with a distributed system are resilient and hard to fail, destroy, or manipulate. This means that there are no single points of failure because all the drones are independently controlled. Distributed systems also by definition move all the processing that computers do - avoiding obstacles and calculating all the destination and positional controls of drones - to individual drones. The only things the drones would have is sensors that detect the outside environment. Each one finding out how far other drones are from itself and obstacles coming up as opposed to direct connection with other drones and knowing maps of the environment it is in.

The initial work for my project is that by giving individual drones a destination, a minimum distance (from other drones), and a maximum distance (between itself and furthest drone in group) the drone swarm would move together cohesively, not crashing into each other or too far apart from each other. During the next step of the project, the drones should be able to collectively travel to multiple waypoints, or destinations, as a swarm. After which, obstacles should be taken into consideration, and the drone swarm as a whole has to either split up to go past an obstacle or wait to go through an obstacle in sequence. Finally, I should be able to evaluate the quality of the algorithm with a set of standards and conditions. This involves finding and modifying a ROS, robot operating system, simulation to be able to support the modeling of multiple drones at the same time in the same frame.

The plan is to first implement the drone swarm algorithm in simulation and later test the algorithm in real drones called Crazyflies. However, due to the Covid-19 crisis, I cannot continue with the physical implementation of the swarm algorithm on Crazyflies as I do not have access to the research building anymore.

I am basing off of my algorithm on Craig Reynolds' papers: "Steering Behaviors For Autonomous Characters" and "Flocks, Herds, and Schools: A Distributed Behavioral Model". As many algorithms are derived from nature, those models Reynolds researched draw from nature as well, imitating bird flocks and fish schools as they are seen in their natural habitat. In order to simulate these natural formations, each drone in a swarm would calculate and combine different steering forces, or calculated velocity force vectors from sensor environment, together to get a final velocity vector to proceed in, which would cause the swarm to collectively perform the desired behavior. The steering forces I want to use are "seek", "obstacle avoidance", "separation", "cohesion", and "alignment" (Reynolds, n.d.). Seek is the "pursuit of a static

target" (Reynolds, n.d.). In my case, I use the seek steering force to attract each individual drone towards the goal, or towards the next destination in the overall path. Obstacle avoidance can be implemented two ways: one way is to always repel off of the obstacles depending on how far the drone is from it, the other way is only changing paths when the obstacles comes into the path the drone is heading in (Reynolds, n.d.). Separation force helps drones maintain a set distance apart from each other while cohesion helps make sure the drones are not too far from each other (Reynolds, n.d.). Lastly, alignment force nudges the drone to go in the average direction of all the drones nearby (Reynolds, n.d.). This is because I implemented all those forces based off of the drones' nearby neighbors just as in nature birds only know about the birds next to them and adjusts based off of their neighbors' behavior (Reynolds, n.d.).

In the end, each drone's final velocity vector is determined by the combination of all those forces. All the forces will be controlled by parameters that determine how much weight each steering force, or force vector, gets. By adjusting those parameters, one can control how much each component of the steering force imposes on the drone.

STS Project Details

Using drones for security and surveillance significantly improves upon the traditional approaches like fixed security cameras, especially in terms of minimizing risk ("Drone Surveillance", 2020). "Drone Surveillance" (2020) lists that drone provides "cost savings" (compared to helicopters), does not have blind spots, "cover more ground", "handle hostile situations safely", "track and follow intruders", provides rapid response, etc. The list goes on and on, emphasizing the safety, effectiveness, and savings drones can provide. However, just as Leo Marx (1987) asks: "does improved technology mean progress?", we should consider what we are

progressing towards with this technology and think about what is to be achieved with it. I do think improved technology gives humans more power and ability to achieve things but whether it is progress or not or brings benefit to society is not straightforward.

To find out if drones should be used by police in the US, one should first think about the question from the police's perspective. As in if the use of drones would benefit them or aid them in achieving their goal, not only in improvement of current equipment and efficiency. Thus, the first step in research is to define what the police's goals are and what progress means to them. When defining terms and goals, I will keep in mind the differences between state police and federal police. For now, I am assuming that the police forces' goal at least includes serving the people of the United States, maintaining societal order and ensuring the safety of the people. After defining police, I should also define drones that are considered for use by the police. In a general sense, I am using the term drones as UAV, unmanned aerial vehicle.

To determine if drones should be used by police in the US, one also needs to account for the interests of a variety of groups other than police themselves, such as state legislatures, the public, and scholars. Among those groups, most are nonusers who do not personally use the drones but are still significantly impacted when police use drones. It is important to analyze the non-users of drones and take into account minorities who might be affected by the drones seriously. Sally Wyatt (2003) mentions in "Non-Users Also Matter: The Construction of Users and Non-Users of the Internet", that "acknowledging the existence of non-users accentuates certain methodological problems for analyzing socio-technological change" and avoids traps that are "associated with following only the powerful actors".

I see three ways to conduct and structure this research. One way, as stated above, is to analyze all the different interest groups and their opinions/ works, keeping in mind their

motivation as I analyze the papers or journals they write. Another way is to approach this research through analyzing the important questions that need to be answered to determine if police should utilize drones. A third method is laying out the important events' timelines and important cases related to police use of drones. By analyzing the cases that actually happened, I would be able to get a better view of what actually happens when certain policies are used and see peoples' actual reactions instead of just theorizing. I think in the end the three methods are intercorrelated and a healthy combination of those methods would work well, I just have to figure out how. Maybe in the process of researching one method will become prominent.

Considering the second way of research, looking at important questions, which are inevitably posed by different interest groups, one main issue jumps out. One of the main concerns with the use of drones is privacy. This can be viewed from the perspective of the public or from a lot of groups like ACLU, EFF, Brookings, and CATO.

A group of researchers have investigated the topic of public perception of drones and privacy and found that people "were less concerned about hobbyists, construction and real estate companies, and more concerned about drones owned by the government, military or law enforcement. Unmarked drones generated the most privacy concerns" (Rice, 2019). As Schwartz (2017) from Naval Postgraduate School wrote in his thesis "while the use of drones for aerial surveillance may often be legal, it may not be acceptable to the public, and the police need the public's trust to serve them effectively". He looked into how to gain trust from local community for drones to support public safety and tested the validity of "drone-specific recommendations of groups like the International Association of Chiefs of Police, American Civil Liberties Union, and Community Oriented Policing Office of the United States Department of Justice" (Schwartz,

2017). I would need to research further on similar studies and find out public acceptance of drones and privacy concerns.

Another perspective of privacy is from groups like ACLU, EFF, Brookings, and CATO. As "Electronic Frontier Foundation" (n.d.) states, some drones can "stay in the air ... for hours or days at a time, and their high-tech cameras can scan entire cities, or alternatively, zoom in and read a milk carton from 60,000 feet. They can also carry wifi crackers and fake cell phone towers that can determine your location or intercept your texts and phone calls." This already shows how advanced drones are, not even including the artificial intelligence or computer vision part which makes this technology even more powerful and invasive. In addition, these technologies are actually being used as shown by American Civil Liberties Union, exposing the fact that the "FBI was deploying aerial surveillance to record the activities of protesters in Baltimore" (Electronic Frontier Foundation, n.d.). Along with agility, precise zoom, and vision, drones can perform facial recognition technology and license plate reading (Laperruque, Janovsky, 2018). The groups all recognize the benefits and uses of drones but emphasizes the potential issues especially concerning the Fourth Amendment and suggests regulations to preserve privacy. This leads into the third way of conducting this research, looking at history, cases and events that have occurred.

Fourth Amendment privacy issues such as GPS, thermal scanners, and smartphones have been addressed by the Supreme Court before, but they have not tackled the questions raised by drones yet (Feeney, 2016). However, there are new legislations being passed in states along with old existing legislations that generalize to cover drone use. In 2013, Florida, Idaho, Virginia, along with five other states passed the first ever drone-related legislation (McNeal, 2014). It

would be useful to research into the related court cases that involve actual conflicts with drones along with relevant legislations to construct a timeline of events.

All the research seems to thus lead to the answer that yes drones can be used by police in the US, BUT ... followed by strong restrictions. A lot of the concerns with use of drones are plausibly solvable with appropriate regulations. The question that follows then is how much capability of drones should the police be able to utilize and how do we set up restrictions and protections to ensure it.

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