# Project Brief

Title: Simulation of an Indoor Drone for Assisting Police in Mass Shootings

Author: Rumaisa Abdulhai

Date: 10/19/19

## Background

For the last several years, school shootings have claimed hundreds of innocent people's lives in America. One can never tell when and where the next school shooting will happen, inciting fear among parents, students, and school administrators as well as worshippers in churches, synagogues, and mosques. With lawmakers sharply divided on gun control, there are no effective laws or procedures to prevent mass shootings. After the Parkland High School shooting in Florida where 17 students were fatally shot by a lone 21-year-old gunman, I have been thinking about how technology can be used to protect my school if a shooting were to happen there. Particularly, I wondered how drones or unmanned aerial vehicles (UAVs) could be used to fight school shooters. The goal of this project is to create a UAV application to help during mass shootings.

With the advent of autonomous drones or UAVs, there have been various outdoor applications in fields such as agriculture, cinematography, and delivery. Drones have reduced time for crop and soil inspection, and have made the process more consistent. One drone, amely the Agras DJI octocopter, can spray fertilizer with its 4 nozzles on up to 6000 meters of land in 10 minutes (Puri, Nayyar, & Raja, 2017). Drones are also being used for delivering medical aid. The Zipline Company uses drones to deliver blood packages to hospitals in Rwanda. Not only have these drones, using GPS technology, cut normal delivery time from hours to minutes, but they have also saved the lives of patients who suffer from blood loss during surgery (Ackerman & Strickland, 2018). The true feat of autonomous drone technology can be seen in the new Skydio 2, which has the capability to follow an individual participating in extreme outdoor sports at high speeds, while avoiding obstacles and recording high quality footage at the same time. Autonomous drones have made an enormous impact on these industries and have the capability to do so much more. If drones are currently capable of working in these areas, they can be utilized to save the lives of students, teachers, and worshippers in mass shootings.

However, building an indoor drone application has its challenges: the drone must navigate through narrow and tight spaces while avoiding obstacles and fly in a GPS-denied environment (Khosiawan & Nielsen, 2016). Therefore, there must be an alternative to a GPS system, and this is where SLAM, or Simultaneous Localization & Mapping, comes into play. SLAM is the methodology of estimating the location of a robot in an environment while trying to form a map of the environment, using sensors such as lasers, monocular cameras, or binocular cameras (Li & Bi, 2016). Once a map is established and the drone is aware of its position in the environment, a path planning algorithm is needed for the drone to be able to efficiently arrive to its destination from its starting point.

The purpose of an indoor autonomous drone in this project is to assist law enforcement in saving people's lives during mass shootings. When an intruder is detected in a building, the drone will navigate to the point of disturbance and serve as a first responder to the scene. The drone's onboard cameras will be able to capture and relay live footage to law enforcement in real time and immediately call for help when there is a danger. This way, police are well aware of the scene before they arrive, which may reduce setup time and increase communication between the victims and responders. This project will solely focus on the navigation aspect of the described problem.

# Project Definition

The goal of this project is to simulate an indoor drone in a school environment to collect real-time information about the visual location and the perpetrators of a mass shooting and relay it to law enforcement to enable them to save precious human lives. The school environment and drone will be simulated in Gazebo and have a drone be able to navigate itself. When a point of disturbance is given to the drone, the drone must be able to navigate that point of disturbance without colliding into obstacles such as walls, doors, or lockers. The drone will use a laser sensor and binocular camera to navigate itself around the corridors of the building.

The drone's onboard cameras will be able to capture and relay live footage to law enforcement in real time and immediately call for help when there is a danger. This way, police are well aware of the scene before they arrive, which may reduce setup time and increase communication between the victims and responders.

The project will be divided into 3 phases. The first phase will involve building or importing a 3D map of the indoor environment, such as a school. This phase will also involve the discovery and mapping of the 3D environment using a stereo camera and a laser sensor. The second phase will require implementing a path planning algorithm, such as A*, to allow the drone to navigate to a manually identified point of disturbance efficiently. If time allows, the third phase would be to capture live images and videos using the onboard camera on the drone and relay the footage to law enforcement. If implemented, the third phase would be a stretch challenge.

## I. Criteria

The overall goal of this project will be to autonomously navigate a drone inside a building in simulation. Given the point of disturbance, the drone must be able to travel to its destination without colliding into obstacles along the way. The simulator that will be used for this project is Gazebo, a well-known platform for developing realistic 3D simulations of robots in both indoor and outdoor environments. It provides support for real sensors in the market such as monocular or stereo cameras, and 2D or 3D lasers (OSRF). This simulator is highly integrated with the Robot Operating System, otherwise known as ROS. ROS, supported by the Open Source Robotics Foundation, provides the infrastructure for building autonomous robots. It is a powerful tool for autonomous robotics programming as it is open source and is applicable to multiple programming languages including Python, Java, and C++. ROS also makes available various libraries for building and writing code. With a subscriber/publisher system, multiple parts of the robot can listen to sensor output by subscribing to topics where the information is published, and can take appropriate action based on these measurements (OSRF). Both ROS and Gazebo will be used for this project.

The type of drone that will be used for this project in Gazebo will be a research drone instead of a commercial drone. The major difference between a commercial drone and a research drone is that a research drone has an onboard computer that makes decisions on navigation on its own. Many commercial drones are remote controlled and therefore do not possess the capabilities or potentials of a research drone. In addition, commercial drones do not have an environment for developing and running code. Research drones can also be modified with the addition of various sensors such as stereo cameras, laser sensors, or ultrasonic sensors. However, commercial drones can only serve the purpose they were designed for.

## II. Possible Risks/Safety Concerns

At the current time of writing this proposal, this project is expected to be only conducted in simulation. However, if the goals described above are achieved, there may be a real-life testing component to this project. If it is possible for WPI to purchase a research drone in mid-January or February, the code for the mapping and localization, and potentially path-planning code will be tested on the drone. Currently, the professor from WPI overseeing this project, Dr. Cowlagi, has said that at WPI there are limited testing locations in indoor and outdoor locations. It is not currently possible to test the drone in the hallways of a WPI building. However, it may be possible to test this project at another university. If the project is tested in the hallway of a building, the access to the hallway will be restricted to others. If possible, the experiment will be conducted at a time where people are not usually present in the building such as weekends. The drone will also have a propeller guard to prevent eye injury and anyone present in the hallway will be wearing appropriate safety gear.

### III. Required Skills

The required skills for this project are knowing how to use ROS, the Gazebo simulator, Linux/Bash commands, and an Ubuntu Operating System. In addition, knowing how to use a programming language such as Python or Java is necessary. A basic understanding of the components of a drone is also required in order to be able to simulate it in Gazebo. Attending the MIT Beaver Works Summer Institute (BWSI) UAV Racing course this past summer has taught me the basic principles of autonomous drones. In working with an Intel RTF research drone, I have been exposed to computer vision, the Robot Operating System (ROS), and programming (i.e. Python) necessary to program a drone to autonomously follow a directed path and avoid obstacles. I hope to leverage the knowledge I gained at BWSI to develop a drone application that can assist law enforcement and save precious lives. I plan to start small with building simple capabilities at first into my drone application and adding more complex capabilities later on.

## Bibliography:

Puri, V., Nayyar, A., & Raja, L. (2017). Agriculture drones: A modern breakthrough in precision agriculture. *Journal of Statistics and Management Systems, 20*(4), 507-518. doi:10.1080/09720510.2017.1395171

Puri, V., Nayyar, A., & Raja, L. (2017). Agriculture drones: A modern breakthrough in precision agriculture. *Journal of Statistics and Management Systems, 20*(4), 507-518. doi:10.1080/09720510.2017.1395171

Khosiawan, Y., & Nielsen, I. (2016). A system of UAV application in indoor environment. *Production & Manufacturing Research, 4*(1), 2-22. doi:10.1080/21693277.2016.1195304

Li, J., Bi, Y., Lan, M., Qin, H., Shan , M., Lin, F., & Chen, B. M. (n.d.). *Real-time Simultaneous Localization and Mapping for Uav: A Survey*. *Real-time Simultaneous Localization and Mapping for UAV: A Survey*.

OSRF. (n.d.). Beginner: Overview. Retrieved from http://gazebosim.org/tutorials?tut=guided_b1&cat=.

ROS Wiki. (n.d.). Retrieved from http://wiki.ros.org/ROS/Introduction.

## Timeline & Project Milestones:

| | |
|---|---|
| October 5 | • The first goal is to know all sources available to me, including professors and college students I can ask for guidance.<br>• The second goal is to begin reading directed papers on the topic.<br>• The third goal is to identify if this project requires a swarm drone or single drone application, and if the project will require a simulation or an actual research drone. This will depend on whether WPI can provide the drone or not.<br>• The fourth goal is to begin learning about the interface of the simulator or drone that will be used for this project, and establish regular meetings with professors or college students. |
| Before October Break | • The first goal is to be familiar with the Gazebo simulator.<br>• The second goal is to have a basic environment developed in the Gazebo simulator. |

| | |
|---|---|
| After October Break | • The first goal is to officially start project work at Dr. Cowlagi's lab.<br>• The second goal is to begin developing code on the navigation aspect of the project. I will learn in depth about what localization method I will use for my project. I will work with various sensors in the simulator to localize the quadcopter.<br>• I will continue learning more about Gazebo and ROS through the process of working on the project.<br>• I will work on achieving this localization method in order to achieve a map of the environment that the drone can use to navigate itself. |
| Before December Fair | • Complete the development of the localization method and successfully create a map of the desired 3D environment. |
| January | • Implement the desired path planning algorithm (navigation part) |