Tufts UNIVERSITY | School of Engineering

Department of Electrical and Computer Engineering

UAV Autonomous Control Search and Rescue

Team Mahogany Senior Design Project Proposal

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Mission Statement

Team Mahogany seeks to augment commercial UAVs for the purposes of disaster response. By late April 2018, we will develop a custom attachment to monitor harmful radiation in the vicinity of the drone. This system will remotely interface with open-source autopilot software modified for our application. When completed, the project will offer the disaster relief community a simple, effective, low-cost solution to radiation measurement and mapping after a catastrophic event.

Background

In the wake of a disaster, the goal of first responders is to find and secure affected civilians as quickly as possible. In cases where radioactive material is released, such as a nuclear meltdown or a dirty bomb attack, relief workers are highly impeded by harmful radiation. Uncertainty in contamination levels slows rescue efforts, and trapped or injured survivors often wait hours before responders are cleared to help.

Over the past couple decades, many agencies and organizations have been using unmanned vehicles to assess and react to dangerous situations. With the recent explosion in popularity of commercial UAVs, their application in disaster response has become much more financially and technologically feasible. As the drone community has continued to grow, it has provided open-source solutions for GPS tracking, video streaming, and even autonomous flight. However, the ability of a UAV to sense and map harmful radiation for civilian use has yet to be explored outside of Tufts.

The UAV Autonomous Search and Rescue project has been ongoing in Dr. Panetta's lab for several years. In the past, a standalone system was developed and tested which demonstrated the feasibility of the project on an older UAV. Team Mahogany will improve upon this work by using newer hardware and leveraging open-source software. In order to provide a meaningful solution, we will focus on four major components: automation of a flight system, recording and transmitting of radiation data, mounting of sensors in a compact form, and developing an easily understood user interface. If the team has the opportunity to explore additional capabilities, we will investigate the identification of survivors with thermal imaging.

Figure 1: Concept Diagram

Stakeholders

The primary customers that would benefit from our radiation mapping via a UAV are first responders working at the sites of dirty bomb attacks and radiation leaks. To better understand the associated challenges, the team has contacted a member of the disaster response community for an interview. In addition, the Department of Homeland Security has expressed interest in the project, and has volunteered the use of one of their facilities for testing. If this UAV can accurately detect radiation levels, the US Government may be interested in the technology as an added level of protection for the United States.

Challenges

Fortunately, we already have access to a 3DR Solo drone, Geiger counters, and some other required hardware via the Tufts EE department. Although we have access to these materials, the system requires significant alterations to produce a working prototype and as such may result in additional costs as the design is finalized. Another constraint to consider is the range on the devices we're adding to the drone. For example, the Geiger-Mueller Tube is the Geiger counter that will be mounted on the drone. If we fly too high, then it may not be as accurate. It's important to make sure the range on this device is sufficient.

We need to develop a system that is capable of being tested onboard a drone. This issue of creating a portable solution means that we will need to minimize the form factor of our radiation sensor equipment as well as all supporting electronics to ensure that the entire system will be able to be carried by the drone. This task is not trivial given the fact that we want to be able to transmit live data regarding radiation which involves additional circuitry beyond the data acquisition package. The payload of the drone is limited since it's a small UAV. We may need to create a removable mounting for different cameras, if we would like to incorporate thermal or other imaging.

In addition to the difficulties of packaging our solution we have the critical challenge of setting up a test location and safe methodology for releasing and testing the prototype on real radiation. Preparing for this final test is the most challenging part of the project. The Department of Homeland Security has given us permission to do a final testing on their facility, but we'll need to figure out a way to test the radiation detector without releasing amounts of radiation every time we want to test functionality.

Technology

Expertise will be acquired by putting in the time required to understand the technologies being utilized here. We can evaluate proficiency in our respective domains (hardware and software) through our ability to teach each other and communicate the requirements of our designs. It is important that we not only understand the pieces that compose our working solution, but truly understand how all parts work together. In particular, we must understand the limitations of the Geiger counters, the drone, and the processing power on the chips residing on the sensors and drone itself.

As a team, we also need to demonstrate mastery of C and C# to modify the quite complex open-source code bases for the drone firmware and Mission Planner reporting software, respectively. Familiarity with MS Visual Studio, C build tools, and Git will be of utmost importance, especially in a team setting. Each team member should be able to attach the Geiger counter to the drone, deploy the firmware, and use Mission Planner to run the drone successfully.

Risks

There are numerous risks associated with the project. First and foremost, we are not yet experts with the expensive technology that we will have to utilize. We must take great care of the materials we have been loaned, and be extremely attentive because they may not be replaceable within our budget. Furthermore, it will be challenging to run a final demo of our prototype given the difficulty of finding a location to perform a live radiation test on a large scale. Fortunately, Homeland Security has indicated that we will be able to test at the end of the project, but this poses further problems since this will be a one-shot deal. It must work on that day, or we may not get a another chance.

Learning how to fly the drone with a graduate student, Victor, from Dr. Karen Panetta's Lab is a necessary precursor to operating the expensive machinery (drone, thermal camera, Geiger counters, etc.) that we have been given access to. In addition, simulating the drone until we are comfortable flying the real one is a way to mitigate the aforementioned risks. It will also speed up software development if we were to simulate Geiger counter readings.

Ethics

Whenever one works with drones, there are privacy and airspace issues. We must be certain that we avoid airspaces that are no-fly zones, used commercially or by the military. Fortunately, the open-source software typically provides some level of autonomous detection. In addition, whenever using drones to image public areas, we must be mindful to respect civilian privacy whenever possible.

Even more important than privacy issues are ethical issues with our conclusions. It is of vital importance that we collect accurate data, with appropriate error ranges. The single most challenging ethical issue is that of endangering first-responders with inaccurate or false data. To address this, we need extensive testing as well as clear communication regarding the true situation and risks at stake so responders can make the most informed decisions.

Success Criteria

A successful solution is one that allows a regular drone-enthusiast to easily pick up familiar software (Mission Planner) to control their drone, but with the added functionality of reporting radiation data. A reach goal would include a separate, highly visual (outside of Mission Planner) reporting mechanism for radiation data, such as OpenDroneMap to create a 3D model of a target.

The project is expected to have the largest impact for the disaster relief community. A variety of factors will influence our solution's acceptance, including cost, ease-of-use, and effectiveness. These goals will be more clearly identified by interviewing practicing disaster responders.

We will test our prototype in the field in the Spring of 2018. At that time, we will have the opportunity to explain the problem/solution (outlined above) to our sponsors, and get their feedback on the progress made. They will test the functionality and ease-of-use of our prototype.

References

3DR Solo (Developer Information). (n.d.). Retrieved September 28, 2017, from http://ardupilot.org/dev/docs/solo.html

Corrado, C., Panetta, K. (2016). Unmanned Aerial Vehicles for First Responders. *Research poster.*

Building for Pixhawk/PX4 using Eclipse on Windows. (n.d.). Retrieved September 28, 2017, from http://ardupilot.org/dev/docs/editing-the-code-with-eclipse.html#editing-the-code-with-eclipse

Building Mission Planner with Visual Studio. (n.d.). Retrieved September 28, 2017, from http://ardupilot.org/dev/docs/buildin-mission-planner.html

OpenDroneMap. (n.d.). Retrieved September 28, 2017, from http://opendronemap.org/

Simulation. (n.d.). Retrieved September 28, 2017, from http://ardupilot.org/dev/docs/simulation-2.html