Autonomous movement framework

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Abstract

The goal of the Autonomous Movement Framework for Unmanned Aerial Vehicles (uAMF) is to allow calling drone carriers to specific locations via a smartphone app, and have a central server process the orders, queue the orders up, and distribute the orders to waiting drones. The drone delivers the package to a certain location, drops it, and then returns to its home location without human intervention. This was partially accomplished in an earlier prototype. In this paper we aim to enhance the actual prototype by allowing the server to deploy the missions to a fleet of drones by the use of a single radio antenna.

The framework application will take place in a broad range of areas, including Farming, Help after Disasters, Blood delivery, Small equipment delivery to oil rigs, Taco delivery etc.

Keywords: Autonomous movement, Drones, Framework, Delivery.

Introduction to Autonomous Movement Framework's operation

The Autonomous Movement Framework consists of three main operational components, namely the Android client application, the Python server, and the PixHawk controller. The Android mobile app is responsible for sending location commands to the drones. It contains a map that shows the device's location, and a pin that is used to mark the location where the drone is requested. The idea of the mobile app is that they will be available to the persons in need. The request from mobile app is handled by the server. The server forwards the movement plan to the drones respectively, and the drone executes the mission.

Use case scenario

In this section we will describe a scenario where a request for drone is processed. The first step is to open the Android mobile app. The screens as shown in Figure 1 will be displayed.

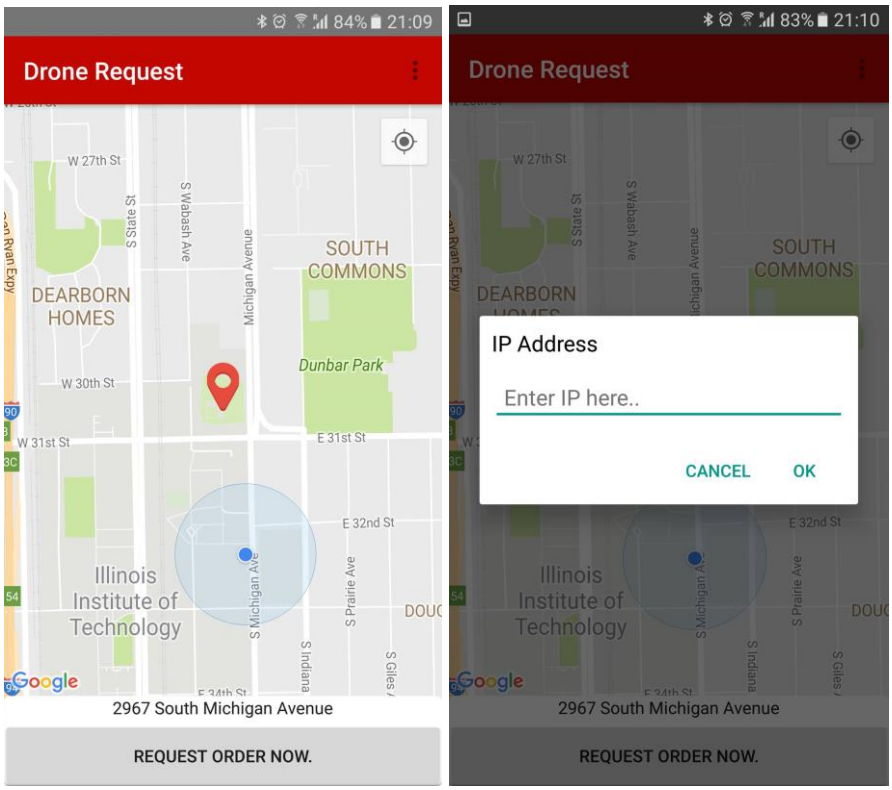

Figure 1. Android mobile app
a) Starting Screen, b). IP configuration screen.

The blue dot on screen a) shows the location of the actual user, whereas the red pin represents the requested location for the drone. As we move the along the map, the pin follows the center of the screen while updating the address in the white bar. Before proceeding with the request, we first define the IP address of the server as shown in Screen b). Once ready, the "Request Order now" button is clicked, and an informational message is showed informing that the request is sent to the server.

On the server side a message appears in the terminal acknowledging the recipient of the request. A screenshot of this message is taken, and it can be seen in Figure 2.

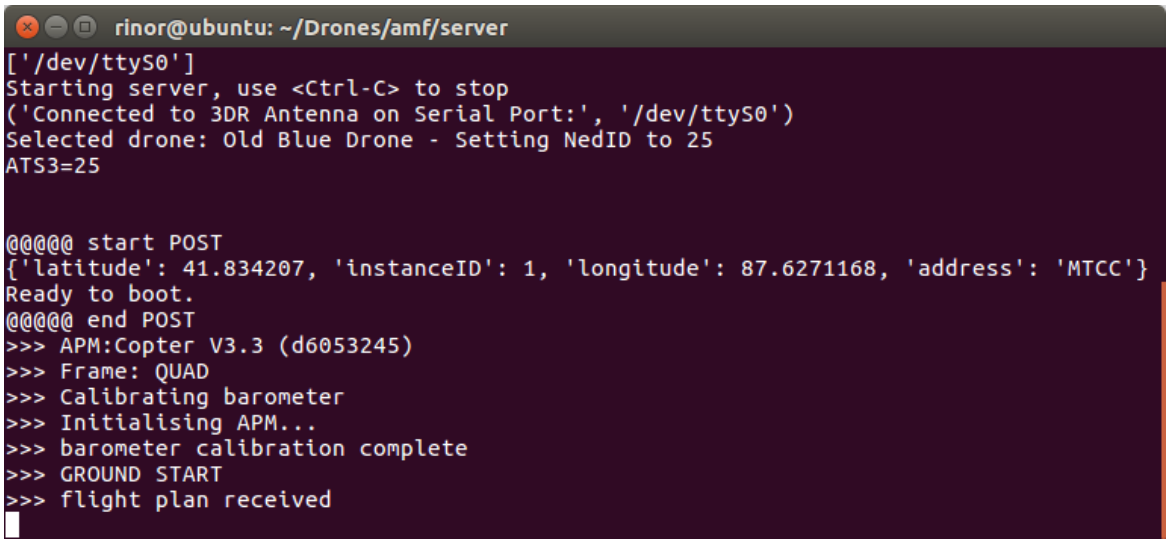

Figure 2. Screenshot from the server.

Then the mission is deployed to the drone's PixHawk controller, which is identified by a NetID. Figure 3 shows the drone pending to receive a mission. Once the mission is uploaded, a light is flashed confirming that the drone is ready to fly, and immediately the mission begins. The drone starts flying towards the destination.

Figure 3. Drone receiving the mission from server.

The communication between the drone and the server is realized using telemetry with 3DR radio antennas (3D Robotics, 2013). This is an alternative to the XBee telemetry, and offers a great range of operation. The 3DR antenna, together with the GPS module and PixHawk controller are depicted in Figure 4.

Figure 4. Pixhawk controller, GPS module, and 3DR radio antennas.

Problem description

The actual software system received by the team could be used with multiple drones, however there was an issue. In order to deploy the mission to the drone, a pair of antennas was needed. Each drone has a 3DR antenna mounted, and for each of them an extra antenna was necessary to be mounted on the server side. The setup was as depicted in Figure 5.

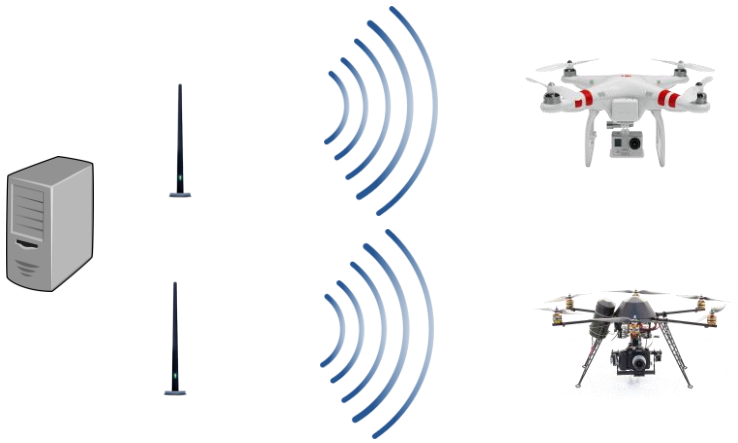

Figure 5. Received setup, with one server, and a pair of 3DR antennas for each drone.

By modifying the logic that is used for deploying the mission to the server, it was possible to use only one antenna on the server side. The solution is described in the following section.

Solution

For our solution, we exploit an ability of the 3DR Antennas which enables them to communicate on different channels (as to avoid interference). By further examining the software used to configure the 3DR Antennas, we notice that they have a total of 500 channels configurable, which means that we can have one such device be sending information into any of the 500 channels – which in turn means that we can operate 500 drones with a single antenna.

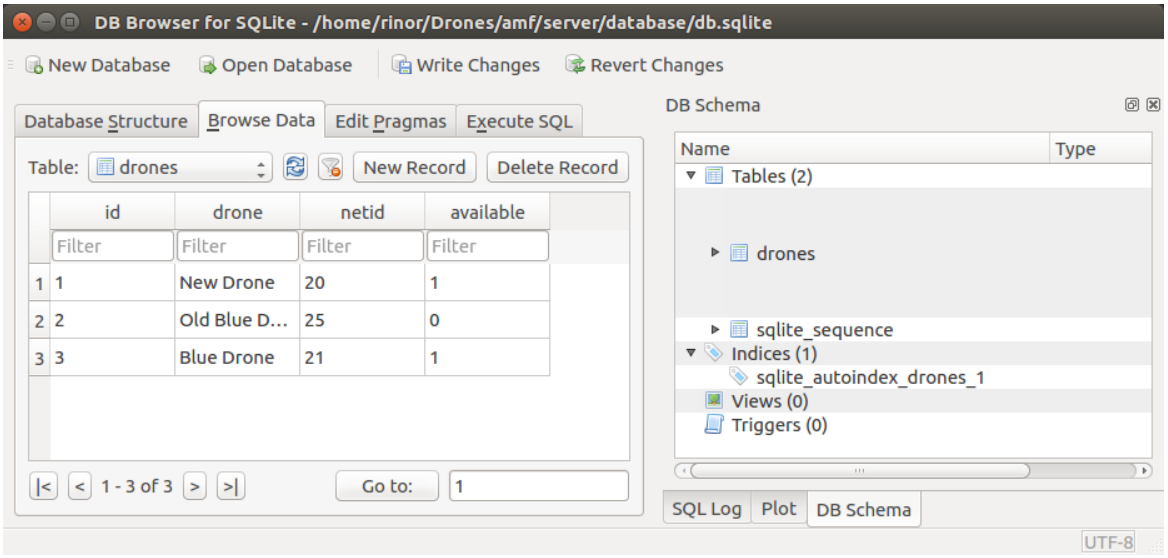

Figure 5. Drones database.

We edited the server code of our application to include a part that enables the dynamic channel switching. Each of our drones is configured with a different NetID (utilizes a different communication channel) and all this information is recorded into a database that is used by the server application. The database contains additionally information such as a drone name (useful to identify which drone is physically referred to into the database), the NetID of the drone as well as a field that indicates whether a drone is available anymore or not (e.g. A drone initially has a package to deliver – once it is sent to deliver its package, it may no longer be available for re-use

until the package is again mounted on the drone). Figure 5 displays the data stored on the database.

Before a request is sent to one of the drones, the application looks up the database and randomly selects one of the available drones (marked explicitly as available). The 3DR Antenna is configured to the correct NetID (channel) and the request is sent to the drone via the Mavlink protocol as it is done normally. Once the command has been sent to the drone, the drone is then marked on the database as not available anymore, until an operator edits it again. Currently for database editing / viewing we recommend any free tool that supports the SQLite database system (such as DB Browser for SQLite on Ubuntu / Windows) (DB Browser for SQLite, 2016).. The communication with the 3DR antenna is based on a publicly available tool (SiKset - Github, 2016) that offers a command line tool for programming 3DR Antennas.

Applications, and targeted audience

Our project focuses on providing the customer with the necessary framework of hardware and software solutions required to operate multiple UAVs in an organized and systematic fashion. Our prototypes also have the added ability of transporting lightweight objects between points with the help of catch-and-release hardware.

Private and federal rescue organizations may have an interest in our project because we could help them locate people lost in remote forested areas or citizens stranded amidst natural disasters. With the help of our UAV framework and fleet, the agencies could identify people in danger, as well as provide individuals with care packages and first aid supplies. Our framework could save government agencies thousands of dollars in manpower and liability.

Private corporations may have an interest in buying our solution because we could provide them with a roadmap of how to develop and utilize a system of UAV transport. Companies are constantly trying to get their product to the consumer faster. With a UAV framework, customers could have their order delivered to their doorstep within hours without the added cost of human labor. Our team would work with the company and the FAA in organizing a standard "highway" of UAV deliveries. This would maximize efficiency and profits as well as optimize customer satisfaction and convenience. It would also help the customer save on shipping charges.

According to current federal regulations in the United States, public operation of drones is very restricted. Drones and UAVs must stay within the operator's line of sight and must not fly higher than 400 feet. Also, drones are naturally restricted from areas such as airports. As such, drone delivery of consumer goods, like Amazon's Air Prime concept, are not possible. Additionally, there are significant concerns about the safety, security, and privacy of drones, which could crash, be hacked, or be intrusive. Instead we are focusing on two other applications:

- Rescue and disaster relief missions
- Development of services for companies.

Rescue and disaster relief missions take place in very difficult environments, whether locating lost hikers or sending first aid to flooded areas. Currently, manned vehicles like helicopters and boats can access these areas, but such missions are limited by cost, fuel, and the relatively small number of vehicles and pilots available. The Autonomous Movement Framework provides a navigation and control system that can be easily adapted to different missions and UAVs. Because the drones themselves need not be proprietary, the different organizations can provide diverse aircraft to fit several roles. Finally, the regulations that challenge consumer delivery are

less restrictive in these critical situations, easing commercialization of the AMF. Finally, if the reliability of autonomous drones is proven in emergency situations, perhaps drone legislation will evolve, allowing for new uses of unmanned aircraft.

If autonomous drone technology is proven reliable, AMF can be expanded if legislation evolves to allow greater use of unmanned aircraft. Many companies could benefit from drone delivery services. For example, a company like GrubHub, which specializes in food delivery to homes, could use drones instead of drivers to deliver meals directly from the restaurant to the customer. This would reduce costs in gas and payroll.

This is the beginning of drone service development. Many companies, such as Amazon, have already expressed their interest and have begun to develop their own Autonomous Movement Framework. Our team wants to provide agencies, organizations, and companies with the UAV framework that could take their businesses to the next level.

The size of our target audience varies as it could range from small, local emergency services to large private corporations.

Proposed commercialization model

The AMF would be first commercialized either in partnership with a larger software firm or as an independent startup. To reduce operating cost, we would begin by mainly selling the AMF software as a service in addition to the equipment for the base station, while providing support and updates. As our group expands, we can also sell AMF integrated drones.

In our project, we propose 3 types of commercial use:

1. The sales of UAVs along with the framework.

- Companies can buy the drone hardware and software licenses and use the framework to develop their own services.

2. The development of services with the framework

-A company may be interested in the framework, but may not have the skills to develop and build upon it. We could propose contracts to develop services for those companies.

3. Maintenance and assistance

- Once companies have the framework in place and functioning, we could provide them with ongoing logistical and software support for any problems they may encounter.

At this stage the projected revenues are still under consideration, as the applications vary widely, and the service offered is highly customizable. The cost for building the prototype drone is about $850, without any profit margin or software costs.

However, taking into consideration the enormous cost spent for aid equipment like helicopters, the cost of using drones would be much more affordable, and still allow us to generate a profit. According to (Groves, 2016), $3 million was spent on helicopters during the Nepal earthquake, yet they could not be used because of their size, and locals feared that the surrounding building would get damaged by them.

Conclusion

The Autonomous Movement Framework project seeks to commercialize unmanned aerial vehicles not by standardizing aircraft, but by offering a flexible, autonomous navigation system.

Slight hardware modifications on the drone, coupled with the server, web interface, operators, and user apps allow easy drone mobilization that can be adapted to many uses.

Single 3DR Antenna can be utilized to control a large fleet of drones (up to 500 in total) from a single point, while being able to track which drones are available and can be utilized, and which ones have already been sent on a mission.

Disaster relief is the initial application because it overcomes many current obstacles, but the AMF itself is not limited to a single mission or aircraft

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