UAV Assisted Energy Delivery

DESIGN DOCUMENT

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List of figures/tables/symbols/definitions (This should be the similar to the project plan)

1 Introduction

1.1 Acknowledgement

With Gratitude and Enthusiasm, we thank Dr. Geiger, Dr. Chen, and the assistance from the ECpE department for the excellent advice that we were given over the project.

1.2 Problem and Project Statement

At the current pace of technological advancement, more and more devices are requiring more energy to operate. Unfortunately, batteries and other energy supplying technology aren't advancing as rapidly. There is even the issues of a device might not even be connected to the power grid, which can be quite costly to connect. This is where our group comes in.

The goal of our team is to solve this energy problem and UAVs or drones are an excellent solution. The basic idea is for a network of drones to deliver energy to these remote devices. Our plan is to acquire a drone which we can customize and reprogram for automated flight. This drone will need to be able to fly from one location to another, assuming no obstacles, land safely, deliver lasting energy to an electronic device, and return home. This project will also require the design of a charging station for the drone, as well as a method for the drone to dock with a device in order to supply energy.

1.3 Operational Environment

The UAV will be expected to survive and operate weather conditions more harsh than our problem statement assumes. Harsh conditions are such: high winds, rain, cold and hot temperatures, etc. However, that is beyond our scope for now. The goal of our group is more proof of concept, than actually implementing weather safety.

1.4 Intended Users and Uses

There are several different users who will have their own specific uses for the UAV. The main users will be individuals in industries who need to deliver energy and data to multiple tethered and untethered nodes. They may want to have more options than an private individual user as to how the drones deliver their energy and data, such as specific ordering of which nodes are delivered first, specifying efficiency of delivery, and delivering to multiple nodes with multiple drones on a large scale.

Additionally, there will also be private, individual users who will be able to call for use of a drone at any time. A drone will then come directly to the user's location, and perform whatever action the user specified. Most often, the action will be to deliver energy to and charge some kind of electronic device.

1.5 Assumptions and Limitations

Assumptions:

- Drones will be able to navigate, dock, and deliver energy or data fully autonomously
- Drones will be able to deliver to multiple nodes before having to return to its base and charge back up

- Power stations for drone recharging can be assumed to be able to gather energy without needing to be recharged themselves, such as connected to the power grid

- System will be low-cost to implement

Limitations:

- Drones must follow regulations already in place, such as avoiding emergency response teams and avoiding no-fly zones

- Drones must avoid obstacles like power lines and buildings

- Due to regulations, we cannot fly the drone within the school zone

1.6 Expected End Product and Deliverables

The end product will be a drone that can fly, unassisted, to and from both tethered and untethered nodes. The drone will then attach to the node, transfer either data or energy, and either continue on its delivery path or return to a power station, which will recharge the drone. By the end of the first semester, we will have a prototype of the drone which can autonomously fly from one point to another at a distance of approximately 100 yards. We will also have a prototype of the power transfer system, and will have made visible progress on the autonomous docking system. By the end of the second semester, we will have completed the autonomous docking feature, and the drone will be able to shuttle data or energy between multiple tethered and untethered nodes.

First Semester:

- Autonomous flying prototype: December 3, 2018

- Power transfer prototype: December 3, 2018

Second Semester:

- Final UAV: May 1, 2019

2. Specifications and Analysis

2.1 Proposed Design

Our project consists of programming a drone to autonomously fly to a node land and then transfer power. This involves having our group divide and conquer most of the time. One group mainly is focused on coding, and the other group on design and power transfer.

The coding focused group is working on finding a drone API to code with and making the drone autonomous for flying and landing with it. Once they find the API, they will be in charge of making the drone autonomous by GPS coordinates or another method. They are making sure that the drone can land to the respective spot smoothly were it will transfer power. This group needs strong coding and testing skills. They will also need to learn quickly as motor control and GPS flying might be new to the group members. They should also be able to generate ideas to try and solve the problems and put their ideas into code.

The design and power transfer focused group is working on getting the power in a battery pack the drone is carrying to a specified landing pad and ensuring there is a connection from the drone to the landing pad. They are also in charge of making a holder for the chosen battery pack to be placed on the drone, as well as well as making sure that the battery will not throw off the way the drone flies. This group needs strong design and testing skills to make sure the carrier for the battery, the battery pack, and the cord are secured and do not cause adverse effects to the drone. They will need to quickly learn an AutoCAD software to design the carrier, as this is something they have limited experience in. They also need to communicate frequently with the coding group to ensure that any changes the power transfer parts do interfere with the coding.

2.2 Design Analysis

We started our project in August of 2018 and it will last until May of 2019. To accomplish our project, we will go through a series of tasks.

Our first task we had was to get all the documentation for the project and generate some ideas. Then we went out to test the UAVs or drones so we could pick out which drone we wanted to work with for our project. After doing some research on what can be used to code each drone, we made a selection. We chose the Intel Areo Ready Drone. Then we needed to pick and API to code the drone with, and we needed to start designing the plug and landing pad. We are currently in the process of designing the plug and the landing pad. We have starting both ideas, as we know we will be using a plug that will connect to the drone and landing pad somehow. We will also be using image recognition to find the landing pad. We will use colors for image recognition so the drone can auto align itself to land and connect to the plug. The main frame of the landing pad or dock has also been built. The next step would be to implement the plug onto the pad. As for the API, we have selected to work with DroneKit. We have also made an order for parts as there was damage to the drone before we received it.

As of our stance in the current semester, everything that follows will occur in the future. We will need to program the drone to have a take-off, navigate, and land phase or procedure. These will start being implemented around January 2019. The rest of this year, we would like to learn about how to control and code the motors on the drone. Find and restrictions for take-off and landing, and work with the GPS selection of the drone. We will need to take some time to research all these sections and then learn how to implement them. We also need to make sure everything is autonomous, but can be interrupted for manual control. As we continue throughout both semesters, we will need to do testing, and it will more than likely need to be done outside.

From our current standpoint, we know we will have many challenges and learning curves ahead. But we believe that if we stay on schedule, we will be able to conquer all the milestones we need. However, we know that coding will be a large important part we need to stay on top of. Overall, we expect the project to go well.

3 Testing and Implementation

1) Preliminary Testing
    a) Preparation for Takeoff
        i) Charging & Attachment
        ii) Stable and safely connected power supply
        iii) Ensure all systems are stable prior to flight
    b) Flight Testing

        i) Simple testing
        ii) Takeoff/Landing within a few feet
2) Interfacing between drone and device
    a) QGround Control
        i) Drone Connection
        ii) Familiarize with instruction delivery
        iii) Repeat flight testing
    b) Automation Testing
        i) Automated flight course through pre-programmed directions
        ii) Takeoff, reach destination and return
    c) Finish Preliminary and Communications testing
        i) Safe takeoff/landing sequences
        ii) Able to reach destination
3) Commence Sensory Testing
    a) Image-processing with on-board camera
    b) Gyroscopic Calibration
        i) Drone has self-balancing capabilities, we need to research into how to understand ways to communicate these changes to the drone
    c) Flight Height Limitations
        i) Height Detection
    d) Finish Sensory Testing
        i) Able to safely approach a destination with real-time input
        ii) Real-time data feedback; accurate and reliable
4) Battery Attachment
    a) Detach battery from drone
        i) Reliable connection
        ii) No performance hinderance
        iii) Adjust battery for payload weight requirements
    b) Battery Adjustments
        i) Battery needs to be adjusted in such a way that it can attach to a specified target once that drone arrives
        ii) Repeat testing with battery connectors
    c) Energy Deliverance
        i) Locate energy deliverance destination
        ii) Repeat drone sensory tests
        iii) Found accuracy of drone automated guidance
    d) Finish Battery connection and delivery testing
        i) Able to reach destination accurately with sensory input
        ii) Drone with adjusted battery can safely land and attach to a specified target
        iii) Drone can safely remove itself from charging target and return

3.1 Interface Specifications

Software specifications:

a. DroneKit - Open-source UAV communication tool. Allows us to connect to and provide flight and docking instructions for the drone.

b. MAVLink – Communication tool that allows us to use PX4 to connect to drone.

Hardware specifications:

a. Intel Drone Aero Board – Board drone uses to interpret code sent to it

b. Remote controller for drone – RF controller used to manually control drone

3.2 HARDWARE AND SOFTWARE

Software:

a. Image Processing – A program to find our landing station on the ground by looking for a specific color that is painted on the landing station. Also allows us to view

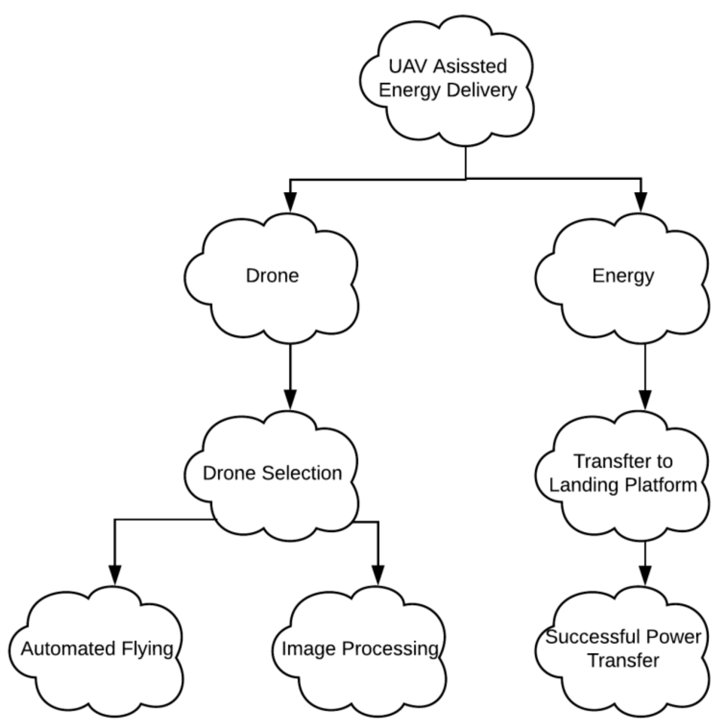
b. Python – Most instructional code is written in Python language

Hardware:

a. Battery Carriage – Holds the exterior battery onto the drone, and feeds the cord from the battery to the landing station.

b. Landing station – Square space elevated off of the ground for the drone to land on, has connector for the drone battery pack to plug in to.

3.3 PROCESS



3.4 Results

Testing is minimal so far, but present results include a possible calibration issue with the placement of the drone battery that causes the drone to lilt to one side at lift off. This can cause flight failure. We need to conduct more testing with manual flying, as well as search for forum answers about a possible Intel-provided solution to the problem.

4 Closing Material

4.1 Conclusion

Having the ability to transfer energy from one location to another with minimal to no manpower and with minimal set up is something that will change how energy issues are solved. Having the ability to send out a fleet of drones to deliver energy to a location at a moment's notice has not been done before. We have a drone that is able to autonomously fly to a remote node. Then transfer energy to that node followed by the drone returning to its base. All of this being done without any human input. This is composed of three pieces. The first being the drone is able to autonomously fly from one location to another. Next the drone is able to land on a remote node that asks for a charge. Once it has landed on the node it delivers energy to the node until it has expended its charge. Finally, it returns to its starting location so it will be able to recharge and start the process over again.

4.2 References

"DroneKit by 3D Robotics," *DroneKit*. [Online]. Available: http://dronekit.io/. [Accessed: 12-Oct-2018].

"Intel® Aero Ready to Fly Drone," *Intel*. [Online]. Available: https://www.intel.com/content/www/us/en/products/drones/aero-ready-to-fly.html. [Accessed: 12-Oct-2018].

4.3 Appendices