Drone Assisted Energy Delivery

DESIGN DOCUMENT

Team Number: 40
Advisers: Randall Geiger & Degeng Chen

Team Members/Roles:
Garrett Lies: Embedded Systems - Drone Automation
Drew Underwood: Embedded Systems - Drone Automation
Abdullah Al-Obaidi: Power Systems - Energy Delivery
Khalifa Aldaheri: Power Systems - Energy Delivery
Ahmed Al-Hulayel: Control Systems - Energy Delivery

Team Email: sdmay18-40@iastate.edu
Team Website: http://sdmay18-40.sd.ece.iastate.edu

Revised: Oct 12, 2017

Table of Contents

List of figures/tables/symbols/definitions

1 Introduction

1.1 Acknowledgement

Thank you to Dr. Geiger and Dr. Chen for your advice throughout this project. You have, and will continue to be a huge help in designing and drone automated energy delivery system.

1.2 Problem and Project Statement

The number of electronic devices is increasing at a rapid pace. With so many new devices, it is becoming more and more difficult to supply energy to each one. Some of these devices may be located far away from the power grid, have no practical methods of supplying energy, or may be too expensive to connect to the power grid. A new method of energy delivery is required to power this increasing demand of electronics.

Our team is working on solving this energy crisis through the use of drone automated energy delivery. In the near future it is possible that a large network of drones will be used to delivery energy to surrounding devices. We will begin working on a simple proof of concept to bring this idea to life. Our plan is to acquire a drone which we can customize and program 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 Drone Automated Energy Delivery system will be expected to survive harsh weather conditions. A final goal would be to have inexpensive smaller drones, which if destroyed, would easily be replaced. These drones still need to be able to navigate under harsh weather conditions such as: high winds, rain, low and high temperatures etc. Our goal is more of a proof of concept, and we will not be focusing on this aspect of the project unless time allows it.

1.4 Intended Users and uses

Two broad types of users are intended for the use of this product. The first user type is a typical consumer. A consumer will have the ability to call a drone for energy delivery at any given time. The drone then flies to the consumer, charges their electronic device, and leaves.

A second type of user is Industry. Industry users will be wanting to delivery energy to many stationary and non-stationary devices. An industry user may want additional customizable options to allow more efficient energy delivery, and delivery on a large scale.

Bringing energy delivery to an Industry user will require a large network of drones all working together.

1.5 Assumptions and Limitations

This product has no scaling limitations. The end product will be flexible, allowing for large networks, and various sizes of drones. Power stations for recharging the drone will be assumed to have connection into the power grid, or some other means of gathering energy. Each device needing to be charged will require a nearby docking station for the drone to land on while delivery energy. Due to drone regulations, the use of drone automated energy delivery must follow all of these regulations. For example, these drones cannot fly within five miles of an airfield.

Assumptions:

1) **The internet of things will expand rapidly:** Our project is built on the idea that the rapid expansion of IoT will continue and nodes will be placed in locations far away from the power grid.

2) **Autonomous Drone flights will be legal:** We expect that the US government will remove the ban on autonomous drone flights in the near future.

3) **Drone prices decline:** Drone technologies is improving continuously which is leading to prices dropping steadily. Cheapness of drones makes our project economically feasible

Limitations:

1) **Weight carrying ability:** Our drone can carry a maximum of 2 extra lbs. This limit the weight (size) of battery it can carry, and in turn limit the amount of power we can deliver.

2) **Obstacles:** Our focus in this project is on the energy delivery, so will use an obstacle-free flight paths. Maneuvering around object is difficult to account for in an autonomous system and we do not want our senior design to turn into a drone coding project.

3) **Extreme conditions:** We will be utilizing an uncovered magnetic device to establish an electric connection to transfer power. Conditions that can destroy our magnet includes extreme heat, presence of a strong magnetic field, etc.

1.6 Expected End Product and Deliverables

The final end product will consist of a drone which can automatically fly from one location to another. The drone will be able to land, charge a device, and return to the original location. The charged device will continue to be powered after the drone leaves through the use of a battery. In order to accomplish this, a custom docking station will be built to allow the delivery of energy to the drone and electronic device. Lastly, a proposal will be made to guide the next group through a list of tasks which will need to be done next.

Drone automation: Drone automation will be an ongoing process. We will first focus on very basic drone automation such as taking off and landing. Next we can focus on getting the drone to fly from one location to another. Once the drone arrives at its location it will need to be able to accurately land on the target location. After a reliable connection is made, there will need to be a time frame where the drone charges the device before leaving. When the device is done charging, the drone should take off, and return home.

- Automate takeoff and landing - 10-27-17
- Automate flight to another location - 11-17-17
- Sequential flight paths/Return Home - 12-8-17
- More accurate landing - 2-2-18
- Testing with power and docking stations - 2-23-18
- prepare for final presentation - 3-30-18
- Propose improvements - 4-6-18
- Document improvements and set new goals - 4-30-18

Docking station: The docking station is necessary for the drone to land at the target device and make a reliable connection to delivery energy. To do this, we will first need to create prototypes for establishing a reliable connection. Once connection can be made, that connection must also be broken so the drone can take off. Once these tasks are achieved, the physical docking station can be designed.

- Research power methods - 10-6-17
- Connection Made - 10-27-17
- Connection Broken 11-17
- Physical docking station designed - 12-10-17
- Docking station built - 2-2-18
- Testing with Drone - 2-23-18
- Polish stations for presentation and practical use - 3-15-18
- Prepare for final presentation - 3-30-18
- Propose improvements - 4-6-18
- Document improvements and set new goals - 4-30-18

2. Specifications and Analysis

2.1 Proposed Design

Drone Energy Delivery project:

Our project will be divided into two categories, programming the drone to go from point A to B, and deliver the energy from the charging portable is the second category. As a result of knowing what our focuses and capabilities are, we have divided ourselves into two teams.

First team is consisted of Computer E students so they have been working on what type of drone is the most suitable to us and their future task is to program the drone automatically to go from point A and land on the particular point B. This part will take a while because they will need to know how to use the drone, what are the important stuff they need to keep in mind in order to make it fly smoothly. So this team is required to have strong programming skills to implement their ideas into codes.

The other team is responsible of figuring out a way to deliver the energy from the charging portable to the ioT devices. This team will gradually make the connection the drone and the devices become automatically using any technique they like, it seems that they have used magnets to do that. However, they are trying to make sure that it can connect and disconnect smoothly. This team is required to use what they learned in circuits and use different strategies and ideas to make the connection easy and proficient.

2.2 Design Analysis

Since the beginning of the semester until last week, we have done multiple tasks.

First, we have made an intense search on drones and their functionality; as a result, we were able to find a suitable drone that could make our project more interesting and fun. Also, in order to use the drone, we had to make sure that we order the right components that will make the drone function as we need it, so we have made a list of all components that we need to purchase in order to get the drone work perfectly. After that, we have convinced our advisors that this drone is the best of all we found by comparing and contrasting their functionality. After we got the approval to purchase the drone from our advisors, we have made the order, and the drone will be delivered by this Friday (10/13/2017) and we will be able to explore with it. While we have been waiting for the drone to be delivered, we have searched on useful likes to know how to get the drone to work and learn how to fly it since none of us have used it before.

Another team have been working on the wire connection and between the charger and LED by placing the LED in billboard that we had in circuit 201 class. In order to successfully work it out, we have made a gradual progress in our work. First of all, we had explored the USB wire and found the + and – sides of it, then we made a simple circuit consisted of LED and resistor in series. Then we have connected the wires to the nodes; the circuit worked perfectly. After we got it work, we needed to develop our work to make the USB and the wires from the voltage and ground of the circuit connect without our help. So our idea was to use magnets in each side, and we attached magnets in each side of the circuit and the USB wires. We successfully got it to work if they are around 3.5 inches apart. Now, we are working on disconnecting the magnets after it delivers the electricity to the LED. For this part, we have given the advisor two different ways to do that, and we will be working on them and see which one is better in terms of accuracy and quality by next week.

Our observation is that our programming team has already started highlighting the possible problems that might encounter, such as whether we should use C language or Python, but since most of the team members used C, we have decided to use C language as our main way to program the drone. Also, we need to have magnets that can easily go off and have low weight because the drone can lift limited weight. so we need to make sure that we purchase a light charging portable.

3 Testing and Implementation

For the Intel Aero Ready To Fly Drone there will be a major focus of testing in the areas of flight automation and stable connections. However, before even beginning the process of automation and energy delivery we need to ensure our drone is in -our- control.

Initial testing will consist of proper maintenance and handling of our drone.

1. Preliminary testing
   a. Prep for Takeoff
      i. Battery charging and attachment
      ii. Stable power supplied for drone, safe connection

        iii. Get familiar with remote control, prior to attaching propellers ensure all systems are stable before any flight takes place.
    b. Flight Testing
        i. Attach propellers and begin simple testing
        ii. Indoor Takeoff/land within a few feet
2. Communication between ground and drone
    a. QGroundControl
        i. Connect to our drone
        ii. Understand proper instruction delivery to drone
        iii. Repeat preliminary flight tests with automated instruction
    b. Begin Mission testing
        i. Approach automated path guidance via pre-programmed instruction
        ii. Drone will takeoff, reach destination, and then return home
    c. Conclude Communications and Preliminary testing
        i. Drone can safely takeoff/land
        ii. Drone can reach destination and return home
3. Begin sensory testing
    a. Real-Sense camera
        i. Have a thorough understanding of Real-Sense library and how to relay proper instruction to drone when necessary
        ii. Repeat preliminary flight testing with Real-Sense data flow
        iii. Attempt non-hazardous obstacle detection
            1. Slowly approach a wall
            2. Approach a person
        iv. Ensure data feed is reliable and accurate
        v. Begin testing of obstacle detection, approach specified target
    b. Gyroscopic calibration
        i. Drone is equipped to self balance, but we will need to understand how to tell the drone to fix its ‘xyz’ and ‘yaw-pitch-roll’ coordinates when appropriate
    c. Height, Height of Interest
        i. Establish accuracy of height detection
        ii. Find limits of height detection within reasonable boundary
        iii. Understand how to utilize height of interest for obstacle avoidance and general landing precautions
    d. Conclude Sensory Testing
        i. Drone can now safely approach a destination with real-time input
        ii. Sensory data feed is accurate, reliable, and understood
4. Battery Attachment
    a. Separate battery attached to drone
        i. Reliably connected
        ii. Does not hinder drone performance
        iii. Make adjustments to modified battery life
            1. Fixed battery will bring us close to drone’s max flight weight
        iv. Repeat preliminary testing with attached battery

b. Battery fixed connectors
    i. Battery needs to be adjusted in such a way that it can attach to a specified target once the drone arrives
    ii. Modify Height of interest and “box” around the drone for in flight calculations if necessary
    iii. Repeat preliminary testing with battery connectors
c. Energy Deliverance
    i. Create appropriate destination for energy delivery
    ii. Repeat drone sensory testing on our created destination for delivery
    iii. Establish accuracy of drone automated guidance. Make adjustments if necessary
d. Conclude Battery Attachment and energy delivery testing
    i. Drone can reach destination accurately with sensory input
    ii. Drone and fixed battery can safely land and attach to specified charging target
    iii. Drone can safely remove itself from charging target and return home

5. (Best Case Scenario) Complete Energy Delivery Automation, proceed to obstacle avoidance
    a. Repeat Preliminary testing with obstacle detection and avoidance on fixed paths
    b. Proceed to moving obstacle detection
    c. Conclude obstacle avoidance

A lot of the challenges we expect to face will start as soon as we look to fly the drone. Most of the instructions and preparations are available to us so that we can ensure a safe approach to flying either through automation or manual instruction. We need to be sure to approach each new problem incrementally and safely. I’ve included in our test cases where there should be a point of receding to preliminary tests at each point we start on a new test so that we know proper precautions are being made.

3.1 Interface Specifications

Software specifcations:

1. QGround Control - Standard UAV communication tool which allows us to connect to our drone and issue flight instructions.
2. MavLINK Protocol - Standard air to ground communication protocol for relaying reliable and secure information

3.2 Hardware and software

Software:

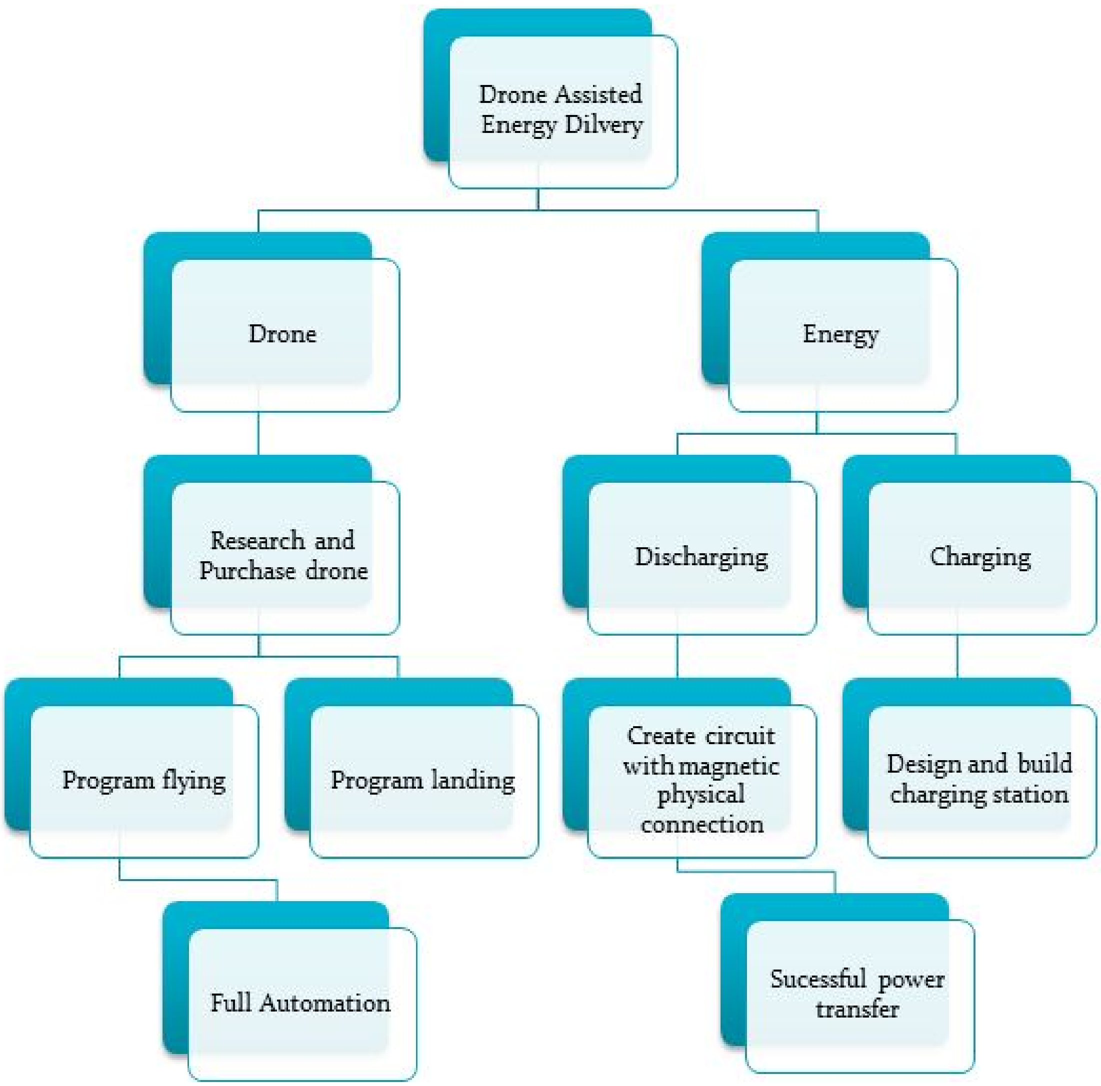
1. Real-Sense Camera library - These libraries will need to be second-hand knowledge to those of us who are going to be controlling the drone’s automated behavior once we reach sensory input testing.
2. Linux based OS - Open source software package allows us to flash our drone and construct the required software to achieve a particular task

3. C - Most customizations we wish to issue into our drone will be C instructions

Hardware:

1. LiPo Battery - Relatively compact and powerful, can be extremely dangerous if not handled properly and should be used responsibly
2. Intel Compute Board - Flexible piece of hardware which handles MavLINK information and can receive additional inputs should we deem it necessary

3.3 Process



3.4 Results

- – Drone delivery proceeded as planned
    - Point A to Point B navigation
    - Sensory input is reliable
    - Obstacle avoidance in preliminary testing
- – Drone sensitivity can vary depending on direction and weather
    - Should establish testing for stabilization during flight procedures

4 Closing Material

4.1 Conclusion

In conclusion, our project is going great and going along the timeline we created to help us focus on our goals and finishing our tasks. Our goal is to improve energy delivery in a way it's never been done before, we will use a drone that will fly automatically from one location to a another location in order to charge a certain device (deliver energy), then the drone returns to the original location (charging station) so the drone can recharge itself and go to a different location where energy delivery is needed. This is the best solution possible for energy delivery because it involves no human interaction, the drone will fly automatically by programming it to do so, this will involve flying from point A to point B then back to point A and landing the drone probably. When the drone lands safely, it needs to connect to the device and disconnect when needed, we can do that by having magnetic connections, meaning the drone will connect and disconnect smoothly from a certain device using magnets without any human intervention.

4.2 References

Intel Aero Ready To Fly Drone

https://click.intel.com/intel-aero-ready-to-fly-drone.html

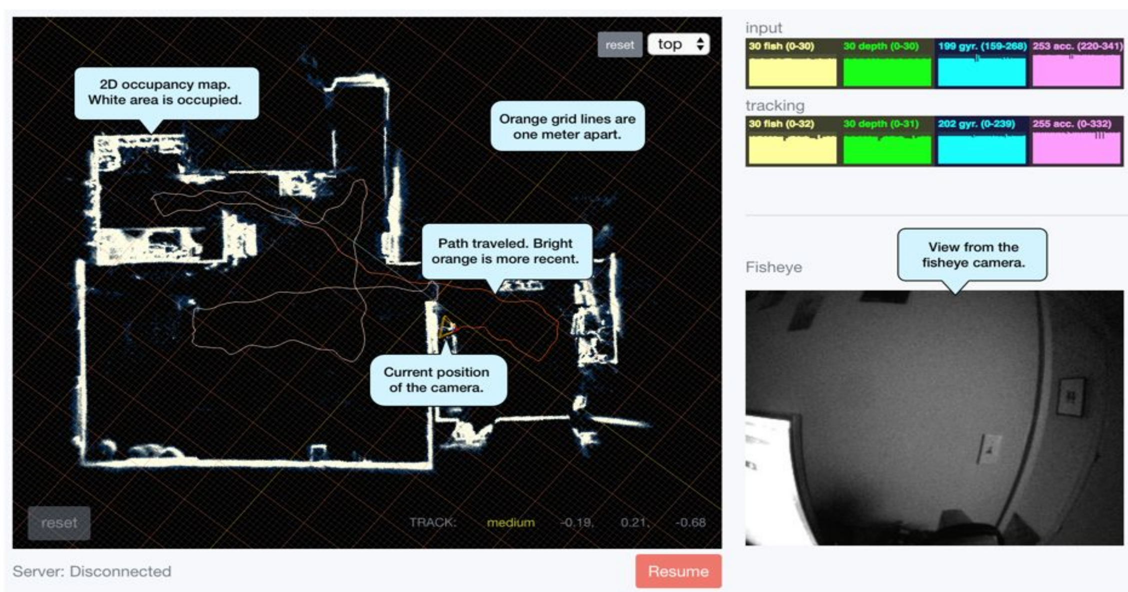
Guermonprez, paul G. “Autonomous Drone Programming in Python.”,GitHub, 8 July 2017, github.com/intel-aero/meta-intel-aero/wiki/04-Autonomous-drone-programming-in-Python

“Library Sense” ,GitHub, 3 Oct 2017, https://github.com/IntelRealSense/librealsense

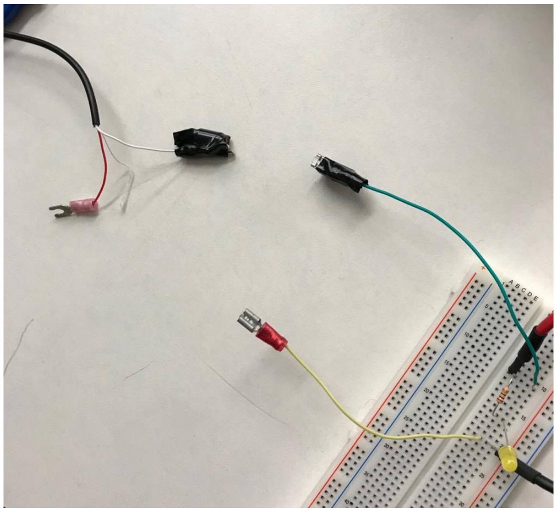
4.3 Appendices

Figure 1. Intel Aero Ready to Fly Drone

This is Intel Aero Ready to Fly Drone, this is the drone we will be using in the project.



Height of Interest allows the user to create a “Box” around the drone at any given height while flying. The Slam library provides the needed features to record the height of the drone with respect to the ground, then giving a measure on how much space the drone can be allowed to fly through.



This is the circuit for the magnetic connection, this will help the drone connect and disconnect from a device smoothly when it flies or lands.