DOMINANCE: Drone Mine Obstacle Avoidance

ECE Senior Design 1 Fall 2019
Group 18

Photo by Kaleb Kendall on Unsplash

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Project Objectives

A drone is an unmanned aerial vehicle (UAV) that can be controlled remotely or act autonomously. Drones can be used to transport supplies without need for a professional pilot or collect data in places that are hard to reach or dangerous to humans. Applications of drones include airlifting medical supplies to wilderness locations and searching for hostiles in a combat zone. Whether controlled remotely or acting autonomously, there is a chance that there may be environmental interference that could affect a drone in flight. A person flying a drone may be unable to spot and maneuver around obstacles, and if it's connection is lost, the drone may not be able to return to the user. If acting autonomously, navigating around objects is essential to ensure the success of its objective. For this reason, in order to preserve the success of a drone's mission and the drone itself, these devices must have the ability to control themselves by using cues from the environment.

This project aims to create a drone that can perform actions upon recognizing an object, as well as avoiding obstacles that would compromise the drone's ability to finish its mission. Our team will create a small, portable drone that can autonomously track and detect obstacles, navigate towards them, and maneuver around them. After maneuvering, the drone will then search for the next obstacle within its field of vision and repeat the same process until it reaches the end of the obstacle course. All navigation and maneuvering must be done without the use of GPS navigation. The drone must also be able to detect acoustic waypoints and land in front of them before continuing on. Additionally, the drone must have the ability to identify, approach, and navigate around the obstacles regardless of their orientation or location. The obstacles in the course include pylons and rings (Figure 1).

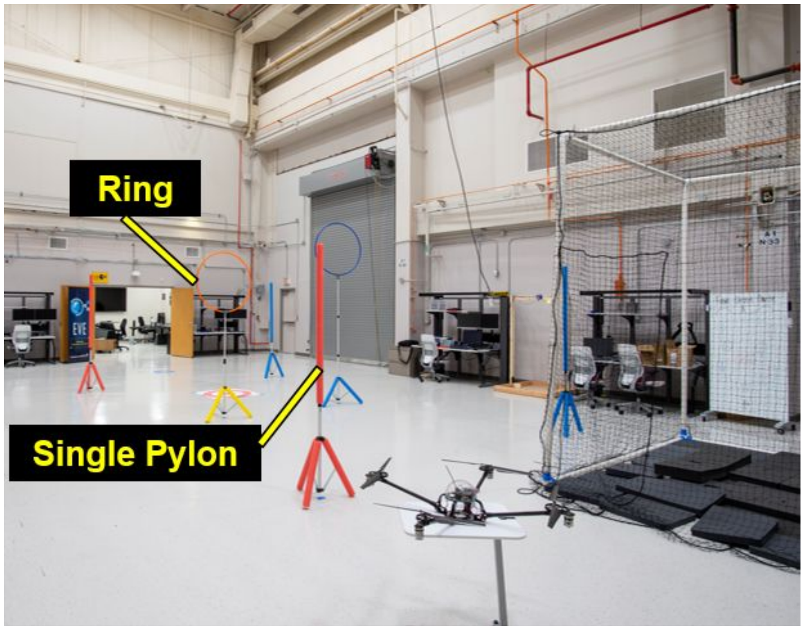

Figure 1: Lockheed Martin IRIS Drone Lab with Pylons and Rings

Several key components to implementing these features include a camera to detect objects, a sonar sensor to detect proximity, and a microphone to detect acoustic signals. The video feed from the drone will be broadcasted back to the computer where a red X will overlay the identified object (Figure 2). In addition to identifying the object, the drone's identification confidence level, distance to the object, and the drone's estimated arrival time to an object will be displayed for the end user to see. The drone's communication with the host computer will allow the user to test and control the drone manually, if needed. This channel of communication will be done wirelessly, either through WiFi or Bluetooth technology.

Figure 2: Symbology Example Metadata box and Red X for Target Identification

In addition to navigating obstacles, one other team's objective to create a set of adversarial "mines" to disrupt our drone's ability to navigate the course. These mines will be designed to track our drone's position and attempt to knock our drone off course using projectiles. In addition to launching projectiles, the mines may use other techniques to try to impede the ability of the drones to navigate. These mines will be placed throughout the course in unannounced locations, and our objective is to ensure our drone is sturdy and adaptable enough to avoid or withstand any attacks from these mines, allowing us to complete the obstacle course.

The drone will have several operational modes available for use. Auto-Navigation will be used to detect, approach, and autonomously navigate around objects. Auto-maneuver will be used to perform specific autonomous actions around identified objects. Manual mode will be used in the event that the previous two modes fail to work correctly during demonstration. E-Stop will be used in emergency situations where in which the drone fails to operate correctly and cannot be controlled manually. Lastly, Take off/Land mode will be used to start and end the drone's mission. In order to ensure that the drone can successfully perform its desired mission, it will have the power to sustain flight and it's onboard components for at least 15 minutes.

Our drone will be assessed on its ability to navigate to and around obstacles in the course. Moreover, the performance of our drone will be compared to the drone's of other teams with the same objectives during two rounds. The first round will only involve navigating around identified obstacles as required, while the second round will include the adversarial mines. Each team will receive points for being able to successfully complete the course during the two rounds. An inoperative video data feed or uncontrolled UAVs will result in forfeiture of the round.

Requirements Specification

1. The maximum drone size shall be 1.5 ft. x 1.5 ft. x 1.5 ft.
2. The drone shall be able to fly through a 3 ft diameter ring
3. The drone shall not fly higher than 45 ft above ground level.
4. The drone shall weigh less than 5 pounds
5. The drone shall navigate without use of GPS
6. The drone must be able to respond to commands from a station transmitter within at least 100 feet from the transmitter.
7. The drone will have 5 flight modes:

    a. Auto-Navigation (AutoNav)
    b. Auto-Maneuver
    c. Manual
    d. E-Stop
    e. Take Off and Land
8. In AutoNav flight mode, drone will detect, identify, and navigate to an obstacle
9. In Auto-Maneuver flight mode, drone will autonomously perform obstacle-specific maneuver
10. In Manual flight mode, all vehicle autonomous control will be released, and drone controls will be transferred to the human pilot
11. In E-Stop flight mode, the drone stops all lateral movement and reduces the thrust of the propellers to initiate a controlled crash landing
12. In Take-Off/Land flight mode, the drone shall perform a controlled take off and/or landing at the beginning or end of a round.
13. The drone will be able to identify and distinguish between the following obstacles:
    a. Rings
    b. Single Pylons
    c. Double Pylons
    d. Acoustic waypoints
14. When a drone encounters a ring, it will fly through it.
15. When a drone encounters a single pylon, the drone will loop once around it.
16. When a drone encounters a double pylon, the drone will loop around both pylons and then proceed between them
17. When a drone senses an acoustic waypoint, the drone will land for approximately 5 seconds before continuing on.
18. The drone will stream video wirelessly to a ground station laptop from at least 100 feet away.
19. Drone obstacles will be identified with a red “X” overlayed on the video stream.
20. A metadata box will be displayed on the computer detailing the following information on the currently identified obstacle:
    a. Type of obstacle
    b. Confidence of identification
    c. Distance to obstacle
    d. Approximated time to arrival
    e. Height Above Ground Level(AGL)
21. The drone will be able to detect approximate distance to an object.
22. Microphones to detect acoustic waypoints will be implemented to detect landing and takeoff zones.
23. Minimum flight time is 15 minutes under normal autonomous operation.

24. If obstacle detection is lost while in AutoNav flight mode, the drone shall sweep to find last logged obstacle.

House of Quality

In Figure 3 below is our house of quality. This chart demonstrates the compromises to be considered while designing this project.

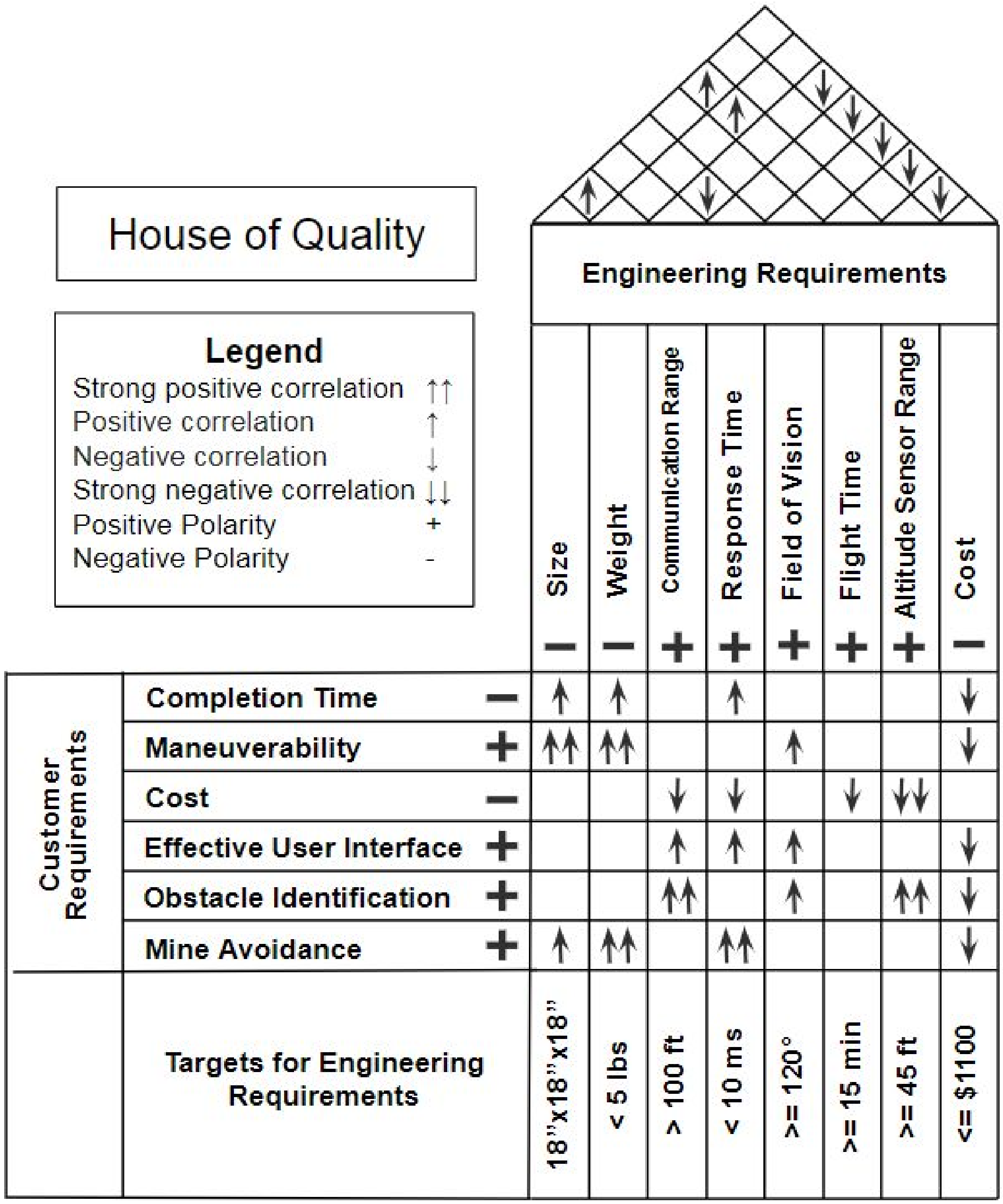

Figure 3: House of Quality

Block Diagram

Our block diagram outlining our subsystems and basic design of our project is shown in Figure 4.

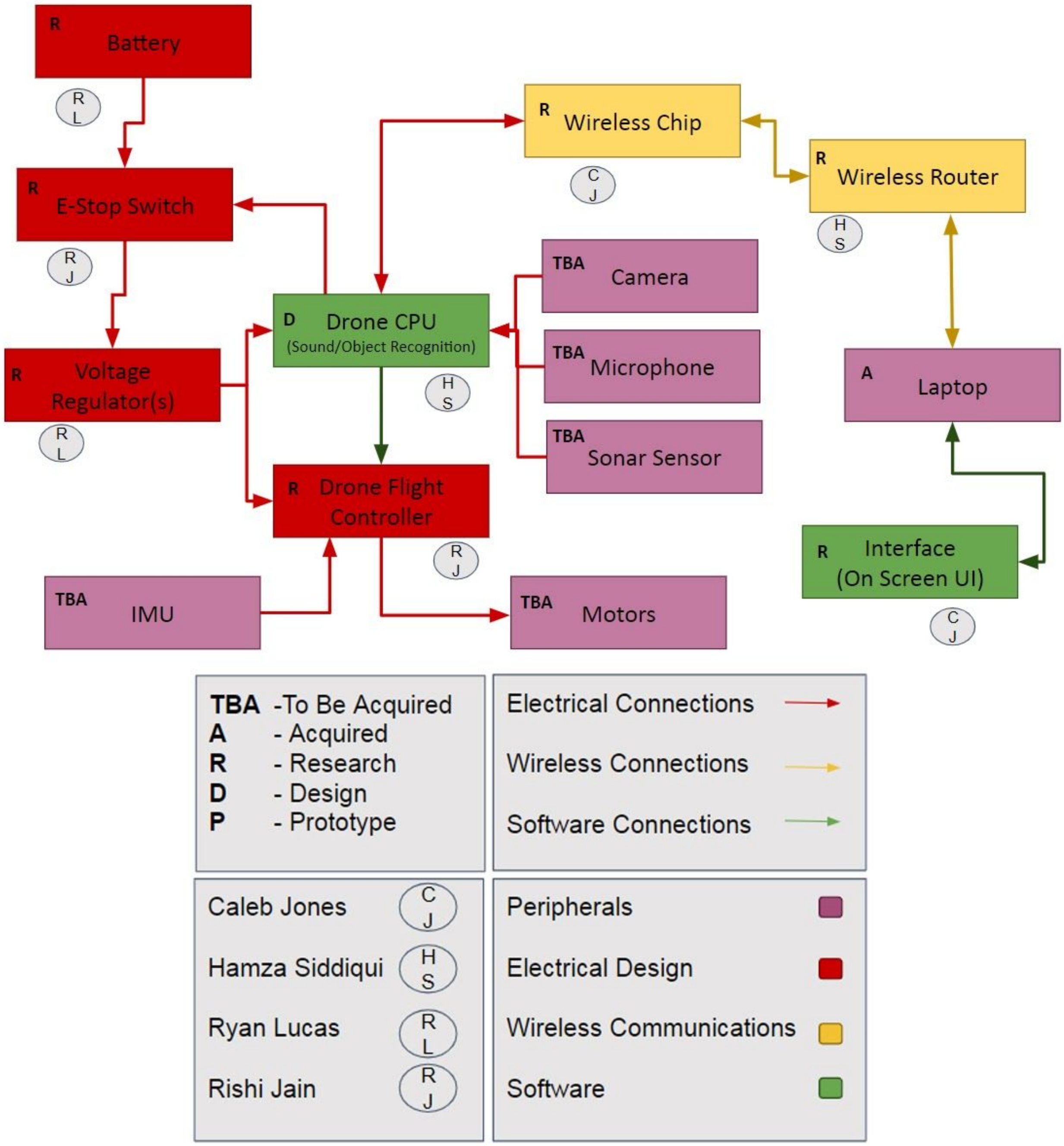

Figure 4: Project Block Diagram

The project block diagram shows that the drone CPU will take in information for the camera and microphone to make a determination as to what to do. Object recognition neural networks will process the image and based on the distance to an obstacle will either navigate towards said obstacle or attempt to maneuver around it. The CPU sends movement commands to the flight controller which carries out those commands. The flight controller maintains the stability of the drone using information from an IMU or gyroscope.

The drone sends video feed that shows object detection information from the camera to the laptop via wireless communication. The drone can also be controlled wirelessly from the laptop. The laptop can send commands to change modes, which can include an E-stop. If an E-stop occurs, the interrupted drone CPU will send a signal to power off to the E-stop switch.

Estimated Project Budget and Financing

Below in Table 1 is our estimated budget for this project.

Table 1: Estimated Budget

Part	**Estimated Price**
Motors (4)	$200 ($50 ea.)
Drone Body	$150
3D Depth Camera	$175
CPU	$100
Arduino Nano	$22
Lidar distance sensor	$60
Battery	$80
Microphones (4)	$20 ($5 ea.)
Custom PCB	$25
Electrical Components (transistors, resistors, capacitors, ICs, etc)	$25
TOTAL	$857

Lockheed Martin, the project sponsor.customer, is providing a total of $1650 dollars. $1100 of that total amount can be used for parts on the final product. The additional $550 will be used for prototyping.

Currently, we are significantly under budget. This provides wiggle room in case certain parts turn out to be more expensive than expected or replacements are needed. This will also allow for part of the budget to go into research and experimentation with potential sensors, propellers, drone frames, CPUs, and flight boards.

Initial Project Milestones

Moreover, this project is expected to take two semesters to complete. Table 2 and Table 3 outlines our project milestones and due dates for Senior Design I and II, respectively. These dates were selected to meet the UCF and Lockheed Martin requirements.

Table 2: Senior Design I Timeline

Milestone	**Due Date**
Divide & Conquer 1	9/20/19
Create detailed requirement list	9/29/19
Divide & Conquer 2	10/4/19
Drone CPU and/or Microcontroller Research Finished	10/11/19
Order CPU and/or Microcontroller for Prototyping	10/12/19
Order Drone Starter Kit	10/16/19
Begin Data Collection & Training	10/21/19
SD1 Documentation (30 pages)	10/21/19
SD1 Documentation (60 pages)	11/1/19
Finish Algorithm Training	11/4/19
SD1 Documentation (80 pages)	11/8/19
SD1 Documentation (100 pages)	11/15/19
SD1 Final Documentation	12/2/19

Table 3: Senior Design II Timeline

Milestone	Due Date
Initial Build	1/31/19
Testing and Design Changes Phase 1	TBD
Testing and Design Changes Phase 2	TBD
Final Build	3/15/19