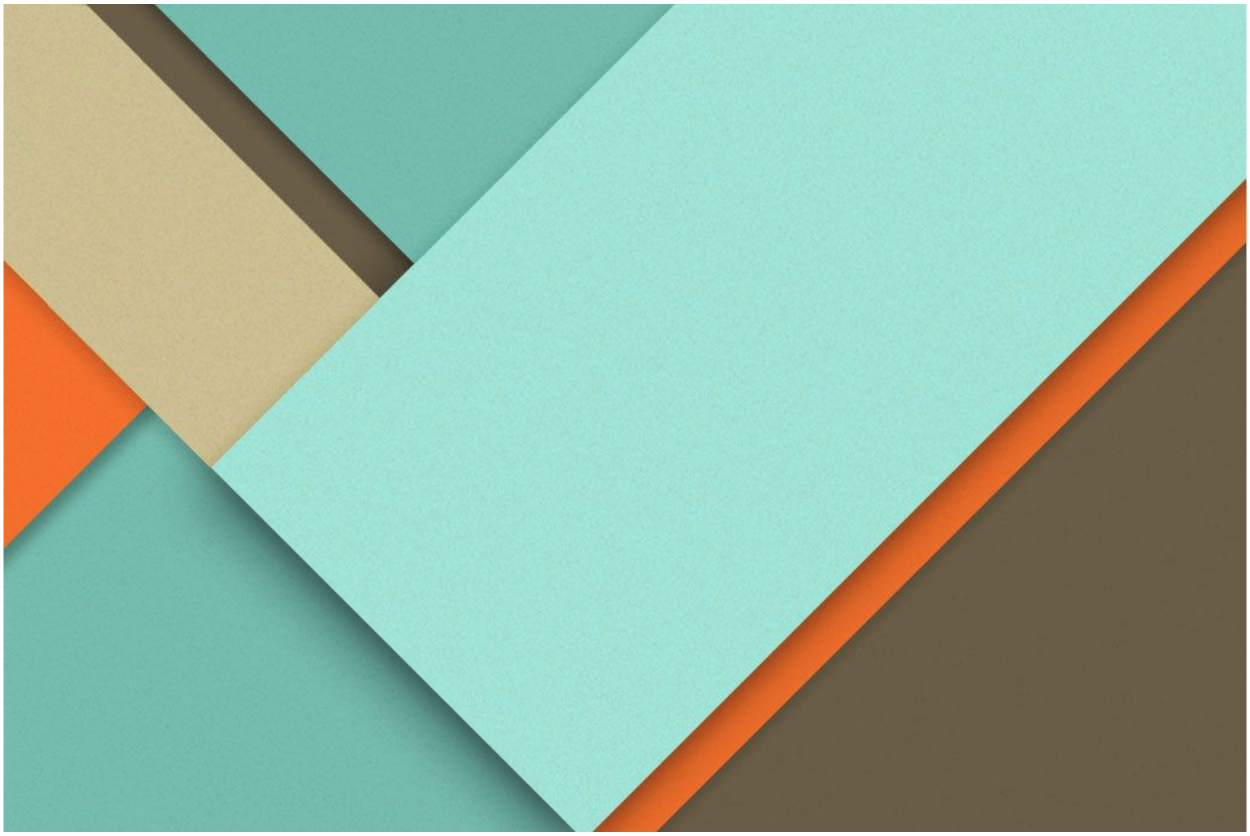


Reactionary Targeting Defense System (RTDS)

Group 19
Joseph Musante - Computer Engineer
Chance Reimer - Computer Engineer, Electrical Engineer
Calvin Sands - Computer Engineer

Project Narrative

Motivation

Unmanned Aerial Vehicles (UAVs), or drones, have quickly leapt from the defense industry and aeronautics research labs to the commercial sector. The great demand for maneuverable, light-weight drones such as the quad-copter in particular has led to many incredible advancements in their design. In turn this has massively increased their availability and capabilities, and subsequently decreased their cost. They can be equipped with live-feed cameras with a wide selection of image qualities, and the controls can be refined to make the drone extraordinarily agile. Nowadays, drones such as these are purchased by remote-control ("RC") hobbyists, photographers and journalists. An entire sport has even been conceived in the past couple of years around high-speed drone racing. These common quad-copters—equipped with live-feed cameras and capable of close to an half hour of flight time—can easily be purchased for under a hundred dollars. Conversely, more sophisticated models, such as those commonly used in agriculture for pesticide spraying, can cost tens of thousands of dollars.

The prevalence of such an accessible technology raises many questions regarding the ethics surrounding their use, especially since up to this point their regulation is largely unstandardized. It's clear that oftentimes they are restricted from being flown over private property (as per the wishes of the property owner) or certain public facilities such as airports and schools; Nonetheless, the means of enforcing these restrictions are very limited, mostly relying on hopefully finding the drone's owner and confronting them personally.

Project Goals and Objectives

In an effort to help enforce flying restrictions, answers to the actual drone itself exist, most notably in circumstances where the property owner or law enforcement is not even aware yet of the intrusion flying overhead. The design of a system that could be used to spot and disable drones in restricted airspace would help to act as a "first-responder" to their unwanted or illegal presence.

A device—such as a form of autonomous anti-drone turret—capable of this would create a virtual protective bubble over the property, preventing a commercial quad-copter drone from entering the space. Should a drone enter the protected air, the turret could be equipped with any variety of detection tools to identify and track the drone, communication tools to notify the operators of the turret, and launchers or emitters to interfere with or halt the flight of the drone. Furthermore, given a significantly large market presence, the potential of the presence of this turret would further act as a deterrent, much in the way that modern surveillance psychology works.

Existing forms of drone detection systems exist currently, with one such product, the “Drone Detector”, capable of video identification of a drone from up to 100 meters away. This product focuses on simply detecting the drone, however, and includes other detection methods as well such as audio detection from up to 40 meters away, and even radio frequency detection up to 1000 meters away.

Additionally, many methods for manually disabling a drone exist. The goal of Battelle’s DroneDefender device is to jam the GPS and Industrial, Scientific and Medical (ISM) radio frequencies of the drone, causing it to fall from the sky (this technology is still awaiting authorization from the FCC, however). Although it is mired in legal complications, civilians shooting down intruding drones with privately-owned firearms is another method that state courts have had to deal with recently as well.

Our goal is to pioneer a platform on which the drone-detection and drone-disabling technologies could be fused together, with high-powered machine learning at its core. We intend to accomplish this by demonstrating the unison of a rudimentary detection system autonomously providing identifying information about a drone to an integrated targeting system.

Functionality

Our project proposes the design and implementation of an intelligent anti-drone turret.

The turret will be equipped with a high-definition camera atop a double-jointed articulation, allowing it to scan its immediate surrounding airspace for intruding quad-copters. The turret would be trained to identify drones at different altitudes and distances using machine learning. Upon detection, the turret’s camera will “lock on” to its target, maintaining the drone in the center of its vision using a reactive tracking algorithm, following its path as it continues to fly. To demonstrate its high precision targeting, a low-powered laser would be used to mark its target and would be signalled to turn on or off by an operator. The turret would be relatively small, with a base area approximately the size of a shoe-box, making it both discrete and portable.

The focus of the system is responsiveness, and its ability to rapidly interpret sensor data to acquire targets, simultaneously creating range estimates for engagement. The system should send updates to an operator specifying what current mode it is in, and battery level. The system will be capable of displaying its video feed to an operator during all three modes, and will show the post-processed image with any possible or engaged targets enclosed within a color coded box. The modes that should be supported by the drone are: Idle, Engaged, and Possible Target.

During Idle mode, the operator should only receive relevant data such as the system status including current battery level, and orientation of the camera feed including azimuth and degrees of rotation.

During Engaged mode, the operator should receive the processed video data enclosing the target in a red rectangle, with the hardware's estimation for distance, and its confidence rating for a successful shot. The hardware will also estimate the movement of the drone, displaying velocity and direction. Upon firing of the target with laser, the system will also notify the operator, with number of shots, including metrics of successful hits. The system will also notify the operator if the drone was downed.

During Possible Target mode, the system should notify the operator, and display the target enclosed with a purple box. The operator will have an opportunity to send a command to the system to engage or to go back to an idle state. The system will maintain a lock on the specified target until it is no longer in view, an object with a higher confidence rating of being a target comes into view, or until an operator sends the idle/attack command.

Specifications and Requirements

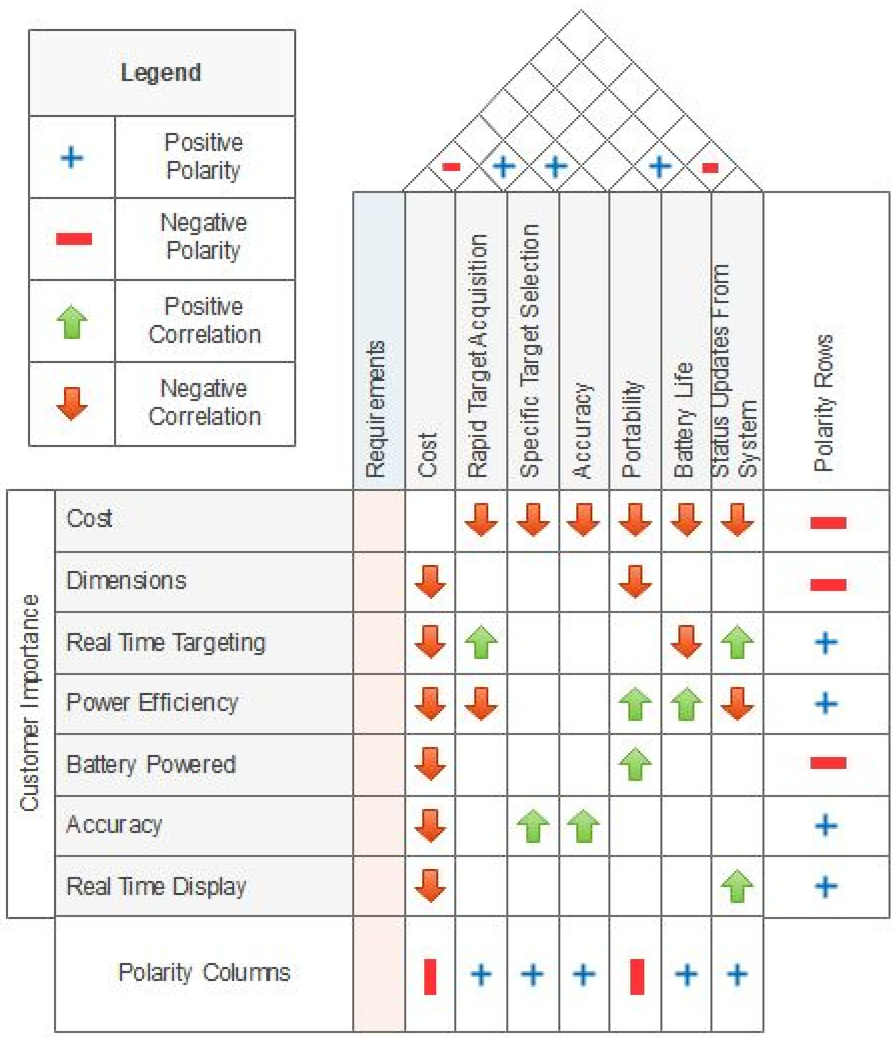
1. Tracking Algorithm	
1.1	Hardware must be able to autonomously detect targets using an on-board camera
1.2	Hardware must be able to track targets within a 360-degree, 5 ft radius confidence range
1.3	Hardware must be able to predict target movement for accurate firing
1.4	Hardware must determine successful hits, and adjust for failed shots
1.5	Hardware must determine when target is successfully "downed"
2. Display and Communication	

2.1	Hardware must display the camera feed and contain target within a red rectangle
2.2	Displayed feed must display estimated distance from target
2.3	Displayed feed must show when system will fire
2.4	Displayed feed must show processed sensor data in real time
2.5	Hardware must support ethernet or wireless connectivity for display feed
3. Firing Apparatus	
3.1	Firing apparatus must accept commands from hardware to modify firing power
3.2	Firing apparatus must be able to move in 360 degree radius
4. Power	
4.1	Hardware is battery powered, with a lifespan of at least 1 hour
4.2	Hardware must monitor battery level

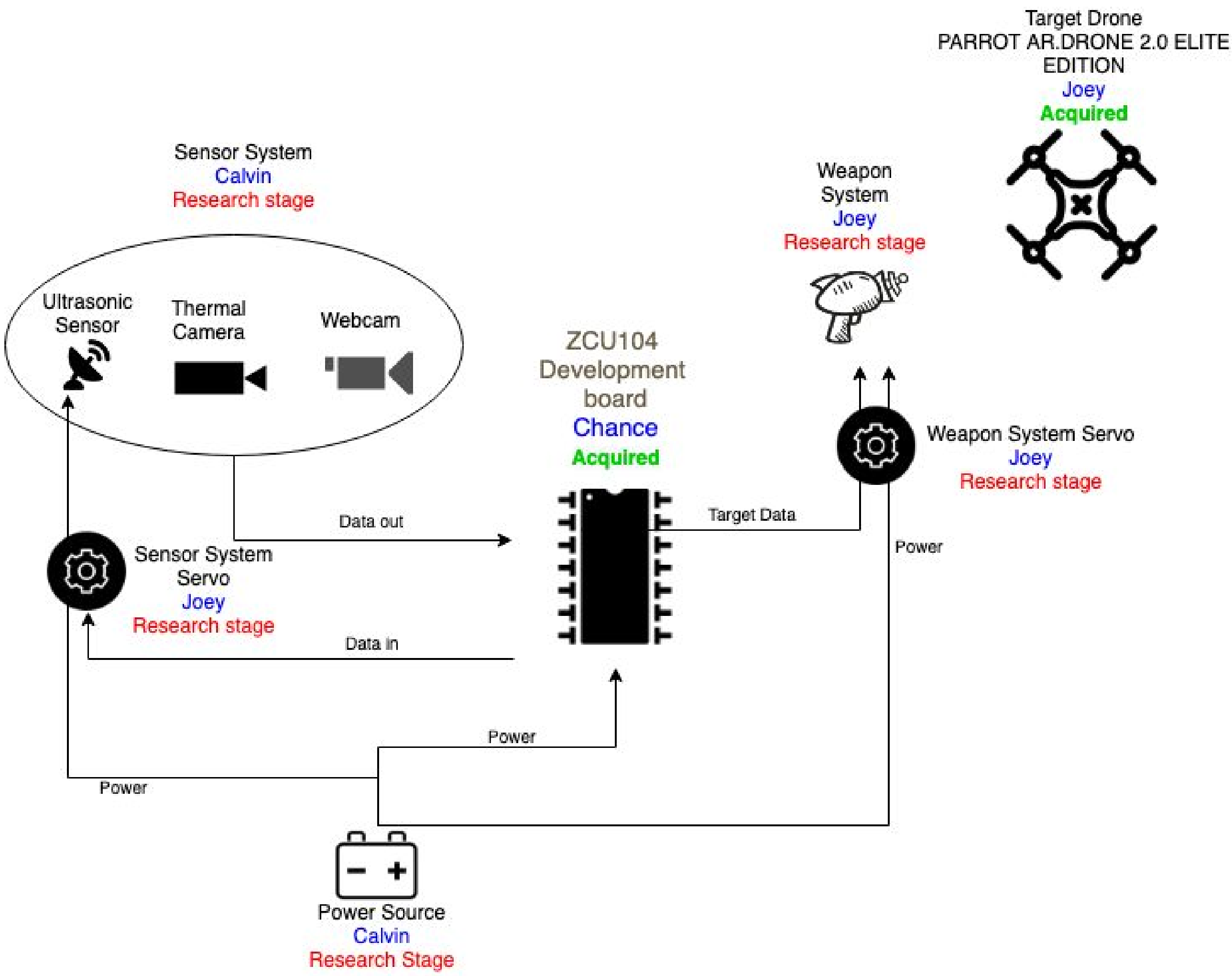
Constraints

Due to the main targeting sensor being a camera, the targeting system is constrained to operation during the day, and without obstruction of view of target. System must not be exposed to any inclement weather such as rain. Due to high data bandwidth needed to send live feed from system, it is assumed that the system is able to connect via a wired connection, or a wireless connection with sufficient speeds to view camera feed in real time. The drone will only have to target a maximum of one drone within it's confidence range.

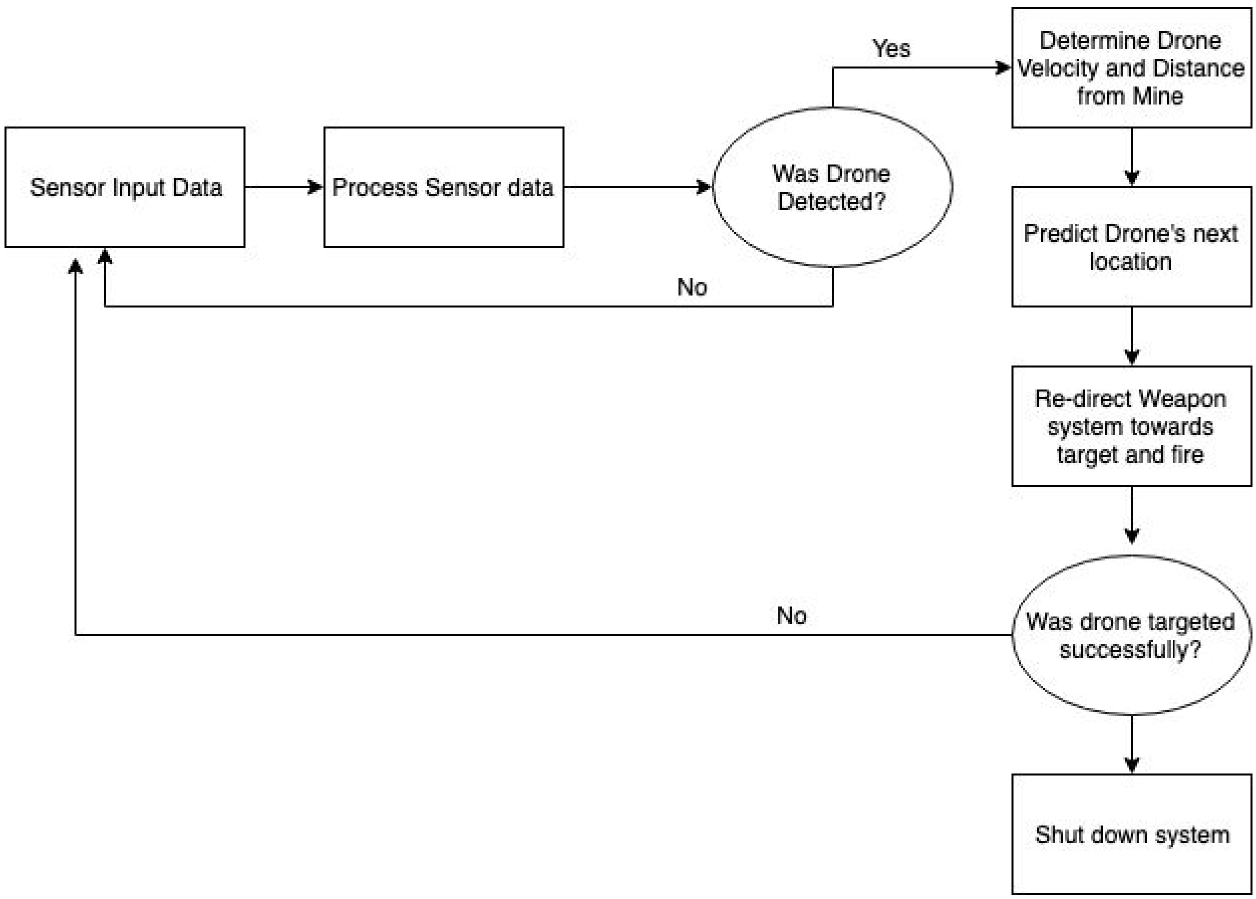
House of Quality



Hardware Diagram



Software Diagram



Estimated project budget and financing -- Joey

Component	Price	Status
ZCU104 Development board	$895	Acquired
Parrot AR.Drone 2.0 Elite Edition	$120	Acquired
Servo Motors	$20	Research Stage
Power Source	$50	Research Stage

Weapon System	$50	Research Stage
Ultrasonic Sensor hc-sr04	$5	Acquired
Camera System	$50	Research Stage
Miscellaneous Parts	$50	Research Stage

Tentative Total: $1240

Initial project milestone

Senior Design I

Task	Due Date
EEL4914 Initial Project Document - Divide and Conquer	September 20th
Initial Project Research	September 30th
Updated Divide and Conquer document (D&C V2)	October 4th
Design Research	October 10th
New Assignment on Standards	October 25th
60 page Draft Senior Design I Documentation	November 1st
100 page submission	November 15th
Final Document Due	December 2nd

Senior Design II

Task	Due Date
Order PCB	TBD

Parts Check/Order Parts	TBD
Hardware and Software check	TBD
Assemble Prototype	TBD
Test Final Product	TBD
60 page Draft Senior Design I Documentation	TBD
100 page submission	TBD
Final Document Due	TBD
Final Presentation	TBD