Divide & Conquer 2.0

Object Detection Drone

University of Central Florida EECS
Senior Design 1
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GROUP 13

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Public Event Vendors - Customer

Project Narrative Description

Unmanned radio controlled aircraft have been in development since the early 1900's. The term drone has even been in use as early as the 1920's, but these early drones were not like what one imagines flying through the sky today. In fact they were full sized planes used primarily for target training by the military. A drone is now thought of as a 4 rotor design called a quadcopter. These designs rapidly developed when electronics were able to keep up with the lightweight, cheap sensor packed boards used for flight control. These flight control boards are the brains to every modern drone, but even then this boom only started around the mid 2000's. The consumer market really started to take off in 2013 with larger drones directed at film makers.

Here we are today in 2020 and drones can be found in a multitude of industries. Google and Amazon have been pioneering drones for delivery, while first responders are conducting rescues and scene surveillance. Drones controlled by your phone with live camera feed can even be purchased for less than $100 dollars.

Concurrent to the drones development in the past decade, computer vision has been making its rise as a forefront topic in research and industry. Computer vision publications have been rising rapidly especially in fields, such as object detection. Just last year the amount of publications containing *Object Detection* in the title surpassed 2000. Companies like Uber and Tesla are funding and developing advanced computer vision systems for cars in a race to create fully autonomous vehicles. Even walking into your local Walmart you will see security monitors tracking your face as you walk through the doors. So what does this all mean?

To us, drones are a modern technology that have only broken into the consumer market as of very recently. This provides us the ability to explore creating a drone in an era where there is a lot of previous research and information, but still many more new things to discover. Additionally, computer vision has seen its own rise in popularity in today's industry. Computer vision and object detection have been featured in drones before, but there are many problems that can still benefit from this duo. We want to start from the ground up, building a drone, computer vision detection system, and pilot application.

The goal is to utilize our drone system to count dense objects and relay them back to the pilot. Some examples of dense objects we have proposed are, cars at a busy intersection, crowds of people, boating ways, etc. The detection systems currently on the majority of consumer drones are meant for object avoidance and tracking people for photography. By using the drones aerial view capabilities we can capture video and images of the scene. The proposed detection system will utilize these images and videos to detect objects, as well as determine the density of these objects. The system can be developed to be a single class or multiclass detector allowing either a specific class of objects to be considered or a set of objects. The pilot application will be developed for a smartphone and will present the live camera view for navigation as well as onboard touch controls for piloting. Once the camera is situated over the dense object field the pilot will see bounding boxes or an object density gradient.

Application for the proposed drone system includes first responders, military, and public event handlers. For instance, first responders could utilize the drone system for navigating traffic at intersections, as the density of the traffic ahead of time would provide a quicker and safer journey. Additionally, event organizers could use the system to count visitors as well as popular attractions. Lastly it is a fun engineering project that encompasses both CPE and EE knowledge!

Requirements Specifications

General Requirements

- A quadcopter aerial drone capable of carrying our camera detection system.
- Wireless communication with the drone via a remote controller and phone application.
- A program that analyzes camera/sensor feed to be relayed and displayed through a phone app.

Engineering Requirements

- Detect object in real time which is within 2 minutes
- Counting detected objects with 80% or greater accuracy
- Main components of drone should be easily replaceable /modular
- Flight time greater than or equal to 10 minutes
- Flight altitude less than or equal to 400 feet

Hardware Specifications

- **Frame:** Frame size measured from two opposing motors. Our drone project will most likely fall under the medium to large drone size.
    - 80 - 100 mm nano-drone
    - 100 - 150 mm micro-drone
    - 150 - 250 mm small-drone
    - 250 - 400 mm medium-drone
    - +400 mm large-drone

- **Flight Controller:** Acts as the pilot of the drone which handles flight response by controlling the direct RPM of each motor in response to input.

- **Electronic Speed Controller:** Four Electronics Speed Controllers (ESC) will be needed. The ESC accepts a DC input voltage and produces three out of phase voltages that feed the motor's inputs.

- **Motors:** Four brushless motors will be used. Brushed motors, though cheaper, are not as efficient and wear faster.
    - Motors specs
        - Size, KV rating

- **Propellers:** Standard propellers will be bought and size will be determined by the estimated frame size, weight, and motors.

- **Remote Controller:** Pre bought or self made controller. A standard bought controller is ideal. An attachment to mount a phone on the controller can be made via 3D printing. The phone will display the aerial feed from the camera systems on the drone. The physical

controller will allow more precise control of the drone.

- **Battery:** Our battery pack will have to sustain all of the drone functions from motors to sensors. The size of the battery will depend on multiple things.
    - Desired flight Distance
    - Desired flight speed: Dependent on motor power
    - MCU Power: AI process
    - Weight: the bigger the drone and the heavier components will affect the battery size necessary to reach desired flight distance. Battery weight must also be taken to account.

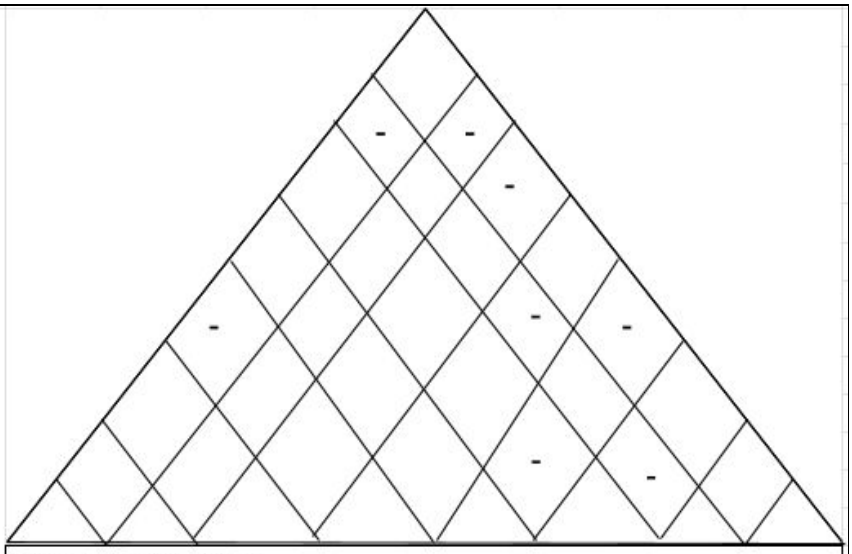
Software Requirements

- **Camera Detection System:** Processed within chosen microcontroller in drone. The system will have to see the lower surroundings of the drone while hovering and detect obstacles (people or otherwise) via Artificial Intelligence/ Machine Learning.

- **Phone Display Feed:** The user's phone will display the camera feed from the drone in a landscape style that will occupy the entirety of the user's phone screen. On the camera feed will be a visual representation of what the board is seeing through the use of Artificial Intelligence/Machine Learning. A color coordinated indication system will be in place to alert the user of detections by the drone.

- **App:** The app will display the camera feed of the drone with the features of the phone display feed. The camera feed will not have any user interactivity. On top of the camera feed will be a translucent set of control areas that will have touch sensitivity to control the drone. The controls will control the height, the movement, and the camera of the drone.
    - The translucent control buttons through the app might not offer as precise of control of the drone compared to using a physical controller made for drones.

House of Quality



			Engineering Requirements							
			Flight Time	Object Count Accuracy	Object Distance Accuracy	Power Consumption	Object Detection Accuracy	Object Detection Time	Flight Height	Software Size
			+	+	+	-	+	-	+	-
User Requirements	Cost	-				↓				↑
	App Usability	+		↑	↑		↑	↑		↓
	Control Reactivity	+	↓						↓	
	Delay	-		↓	↓		↓	↑↑		↑
	Output Accuracy	+		↑↑	↑↑		↑↑			↓
Targets			>= 10 minutes	> 80%	> 80%	~100 W	> 80%	< 2 minutes	< 400 ft	< 512 MB

Figure 1: House of Quality

Strong Positive Correlation	↑↑
Positive Correlation	↑
Negative Correlation	↓

Strong Negative Correlation	↓↓
Positive Polarity	+
Negative Polarity	-

Block Diagrams

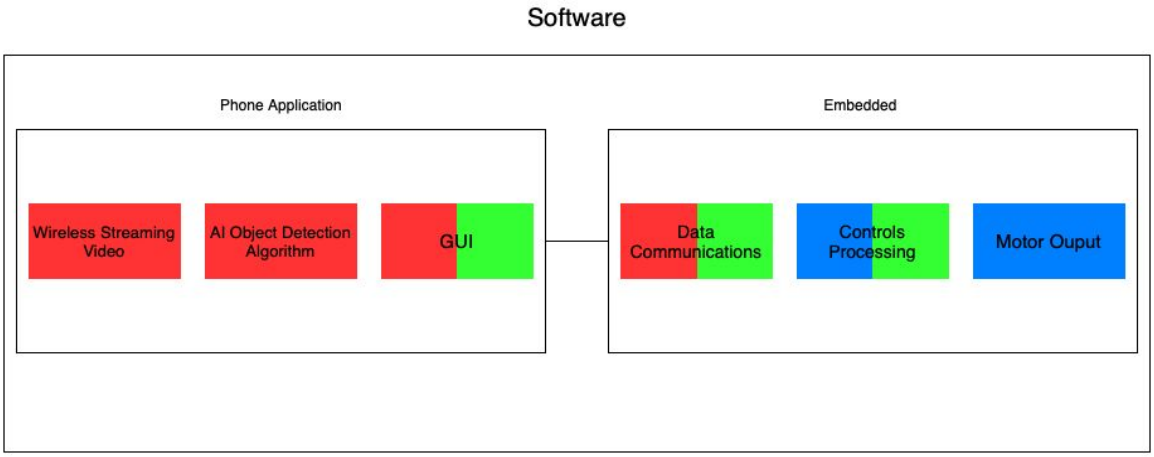


Figure 2: Software Block Diagram

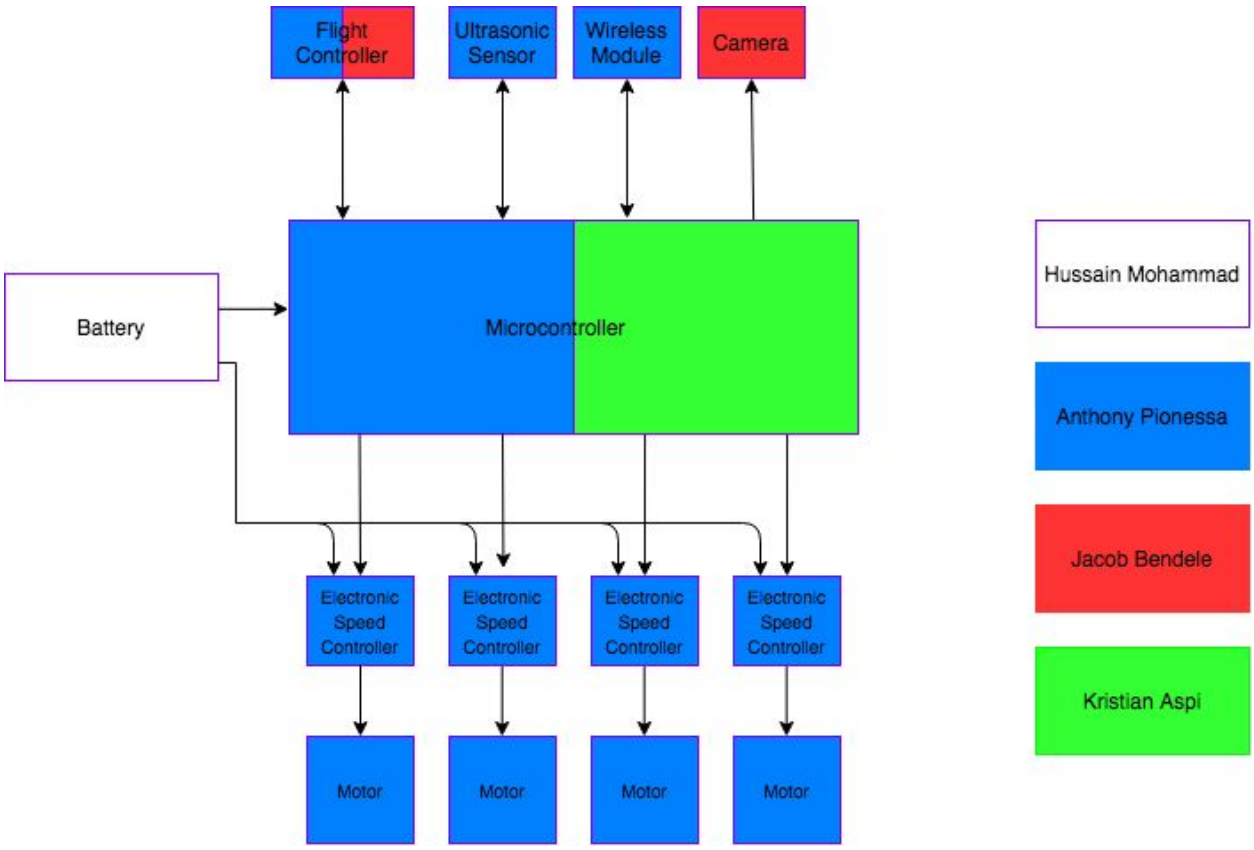


Figure 3: Hardware Block Diagram

- To be acquired - All blocks are to be acquired
- Acquired - None have been acquired
- Research - Microcontroller block is being researched as a choice has not been made yet
- Design - None are being designed
- Prototype - None are being prototyped
- Completed - None are completed

Group Member Roles

Kristian: Software, CAD
- Will lead in any CAD designing for rapid prototyping
- 3D printing prototyping with Jacob
    - Finite Element Analysis (FEA) with SolidWorks
    - Drone frame design
- Will assist Jacob in data processing software for drone detection system

Jacob: Software, Embedded, Machine Learning
- Will lead AI / Machine learning aspect of camera detection system
- Data communications
- Drone design lead
- Will assist in any other hardware or software aspects

Hussain: Electronics, Circuit Design, PCB
- Will lead in hardware aspects of the drone project
- Circuit schematics , PCB, battery, soldering, etc.

Anthony: Software, Embedded
- Will lead in embedded programming for drone
    - MCU communications with sensors, motors, controller
- Wireless phone application, GUI
- Will assist in any other hardware or software aspects

Project Budget and Financing

Any expenses will be divided evenly among the four members.

Estimated Budget		
Item	**Price Estimate ($)**	**Purchased from**
Drone Frame	75	Amazon
Controller	50	DroneNerds
Drone Brushless Motors (4)	25	DroneNerds
Propellers (4)	10	DroneNerds
PCB	30	PCBshopper
Microcontroller	100	Amazon
Wireless/Bluetooth Module	20	Amazon
Camera Module	200	DroneNerds
Ultrasonic Sensor	20	Amazon
Flight Controller	60	Amazon
Electronic Speed Controller (4)	40	Amazon
Li-po Battery	30	Amazon
Total Estimate	660	

Table 1: Estimated Budget

Project Milestones

Senior Design 1		
Description	**Duration**	**Date(s)**
Generate Ideas	1.5 weeks	May 14 - May 26
Divide & Conquer 1.0	1 week	May 22 - May 29
Divide & Conquer 2.0	1 week	May 29 - June 5
Finalize group member roles	2 weeks	May 22 - June 5
Begin extensive research based on assigned roles	2 weeks	June 5 - June 19
60 Page Draft Documentation	4 weeks	June 5 - July 3
Choose Components	3 weeks	June 12 - July 3
Begin design for PCB	3 weeks	June 12 - July 3
100 Page Documentation Updated	2 weeks	July 3 - July 17
Begin ordering parts		TBD
Final Document	1.5 weeks	July 17 - July 28
Senior Design 2		
Description	**Duration**	**Date(s)**
Prototype Building	4 weeks	Aug. 24 - Sep. 21
Testing	2 weeks	Sep. 21 - Oct. 5
Final Prototype	2 weeks	Oct. 5 - Oct. 19
Peer Presentation		TBD
Final Report		TBD
Final Presentation		TBD

Table 2: Estimated Timeline

Decision Matrix

Ideas	Pros	Cons
Drone Detection (Primary)	● Interesting project that encompasses many CPE and EE aspects ● AI object detection concept interesting	● Potentially expensive ● Potential flight constraints
Automated Chess (Secondary)	● AI detection concept for the pieces interesting	● Been done before ● Not much else to add hardware wise
Automated Cornhole (Secondary)	● Fun use case ● Is something a lot of people know/enjoy	● Might not be enough software aspects (for 3 CPE)