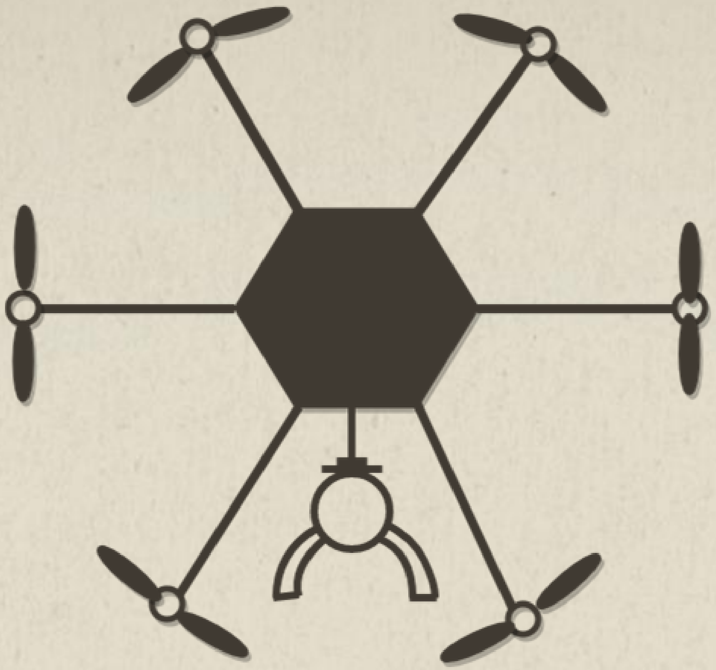

SCUAV

SAFE CONSTRUCTION UNMANNED AERIAL VEHICLE

GROUP 13
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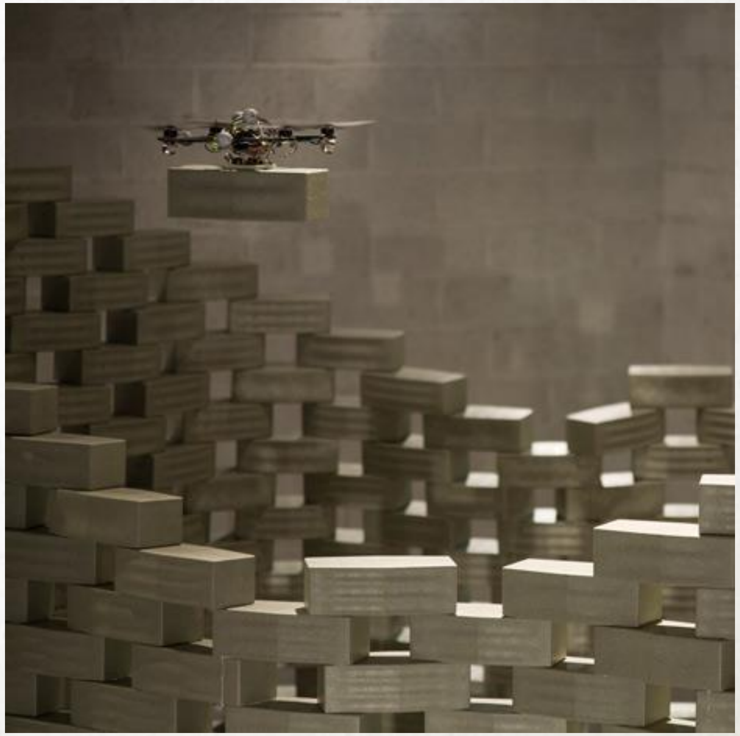
Project Overview

Safe Construction Unmanned Aerial Vehicle (SCUAV) seeks to revolutionize the construction industry through the use of autonomous drones capable of constructing in metropolitan areas, addressing the issues of safety and cost in the modern day. This project would implement the use of a drone capable of picking up prefabricated blocks no larger than the drone itself from a construction material site and assembling a structure.

Short version:
Design and build a drone capable of picking up blocks and assembling them in such a way to build a structure.

Motivation

- Raffaello D'Andrea - Dynamic Works
- Drones are the future
- One in ten construction workers are injured every year
- Falls are the leading cause for fatal construction injuries
- Last semester, let's make it interesting



Goals

- Provide a flying drone
- Carry a payload, i.e the block
- The drone has to detect blocks, path, and build site
- The drone must navigate to the raw material/build site
- The drone must stack blocks to build a structure
- The status of the drone will be alerted
- Provide a secure means of authentication for controlling

Specifications

Qualifications	Expected
Fly time	14 mins
How high to fly	4 feet
Payload weight	0.5 lb
Battery life	6,000 mAh
Drone weight	4.9 lb
Time to complete structure	10 mins.
Height of completed structure	3ft

Hardware

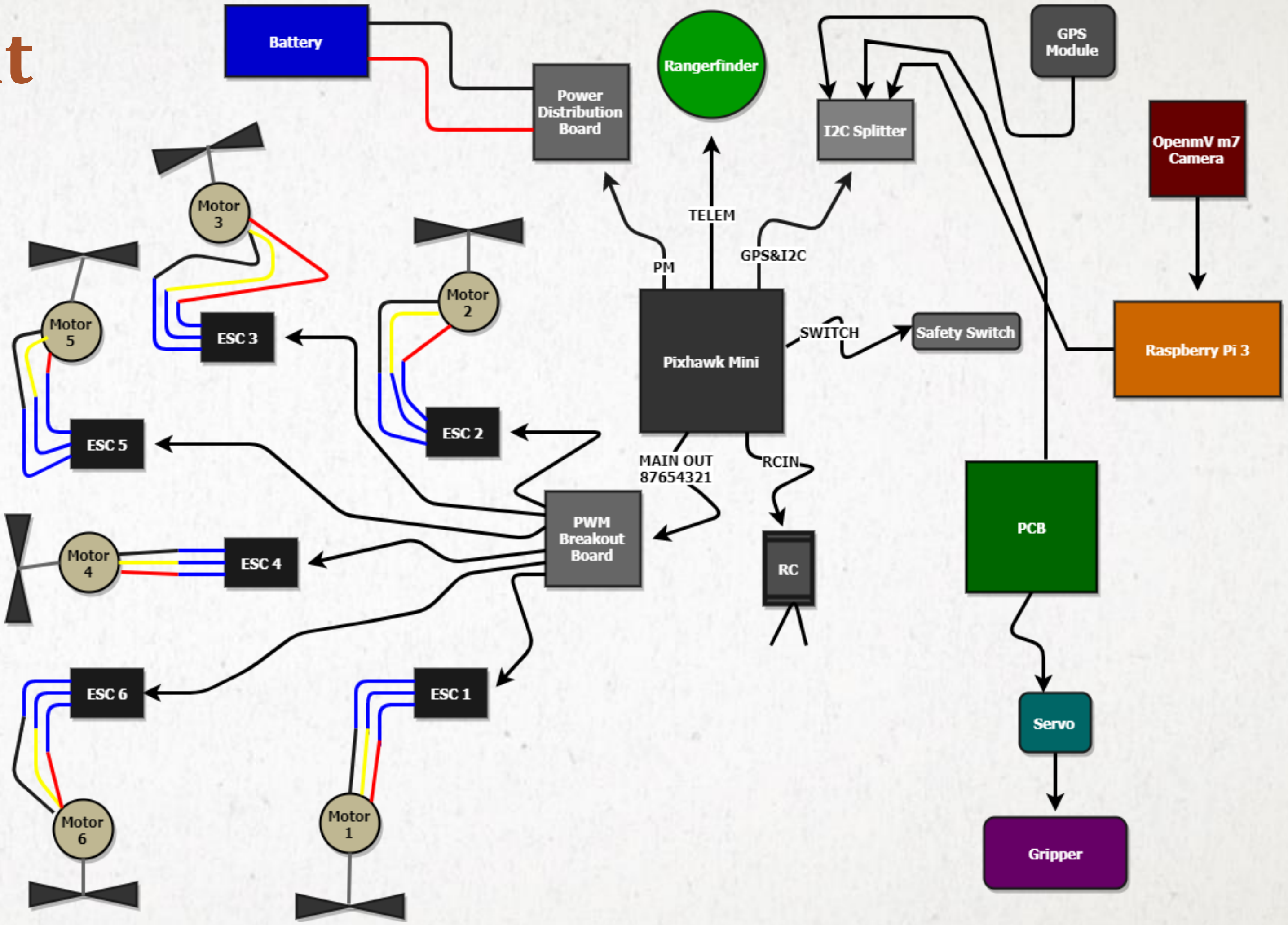
Hardware List

- Raspberry Pi (x2)
- OpenMV m7 Camera
- Drone Frame
- Power Module
- Motors (x6) & ESCs (x6)
- Propellers (x6)
- Pixhawk Flight Controller and Its Components
- Range Finder
- Lipo Batteries (x2)
- Portable Battery Bank
- PCB
- Claw and Servo attachment

Drone Design Layout

OPTION 1: Initial Design

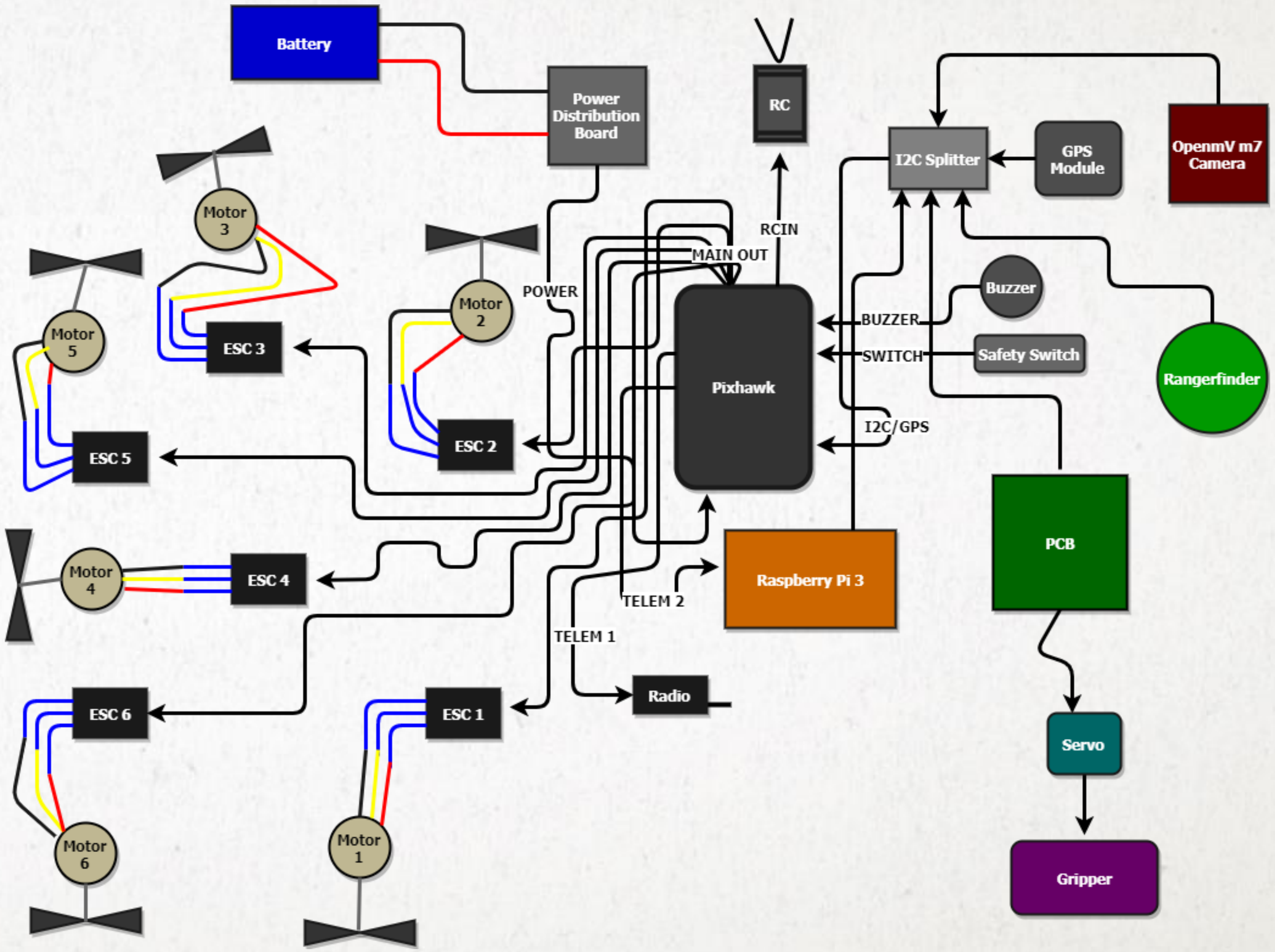
- GPS, Raspberry Pi, PCB, and rangefinder would be connected via I^2C.
- PCB will control the servo and the gripper claw and tell the status of the drone.
- Raspberry Pi needs all the information the flight controller receives to send back to the base station computer via Wi-Fi.



Drone Design Layout

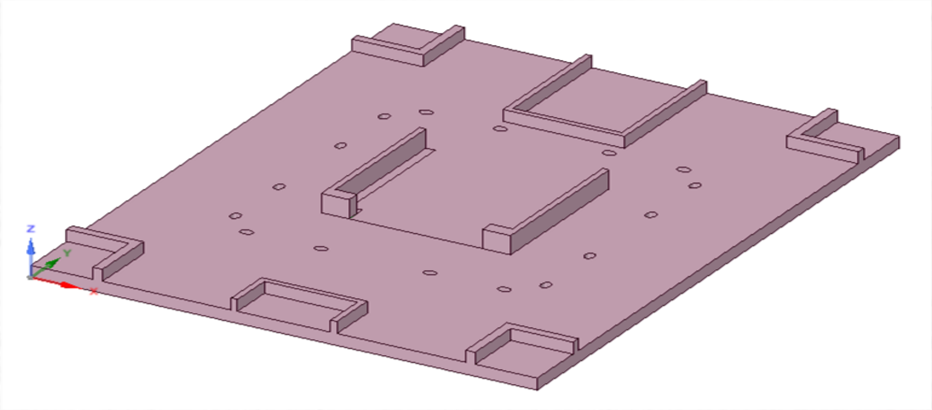
OPTION 2: Current Design

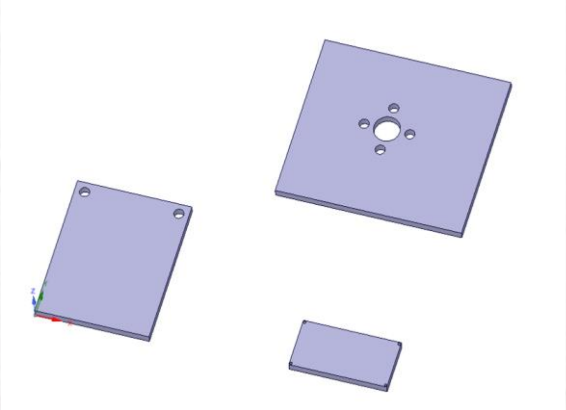
- GPS, PCB, Camera, rangefinder, and Raspberry Pi connects via I^{2}C.
- Buzzer to signal low battery.
- Raspberry Pi also connects to Telem port.
- PCB layout still stays the same.

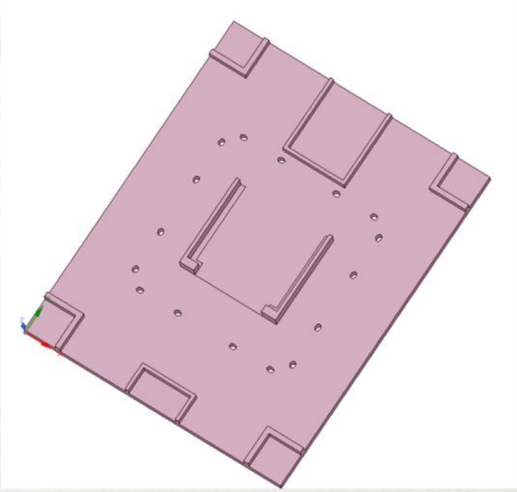


3D Frame Attachment Design

- The frame will be attached to the bottom of the drone.
- Design to securely attach claw, rangefinder, camera and legs without causing damage to the bottom of the drone's frame.
- Simple Slide-N-Screw design
- 3D printed frame
- Legs- 3D Plastic/Wood







Component Decisions

Flight Controller Decisions

Pixhawk

- 2 Telem ports
- Size and weight are heavier
- Buzzer
- IMU sensors are built inside

Pixhawk Mini

- 1 Telem port
- Size and weight is lighter
- More upgraded features
- IMU sensors are built inside

Gripper Decision

Traditional Claw

- Lightweight
- easily implemented
- Commonly used

	Suction Cup	Magnetic Gripper	Claw Gripper
Advantages	•Commonly used	•Quickly pick up objects easily controlled	•Commonly used •Easily implemented •Light weight
Disadvantages	•Surface has to be flat •Cannot create contact with porous material •Items can slip out of suction grip	•Can only lift ferromagnetic materials	•Object has to fit within the claw

Motor, Propeller, Battery Combination

- **Motors:** 13 amp draw, 1000 KV, voltage level able to handle: 11.1V

- **Propellers:** 10 inch diameter 4.5 inch pitch (lower KV with larger propeller)

- **Battery:** mAh(3000mAh)*C(26) > total amp draw (78A)
  mAh: milliamps supplied per hour, The capacity.
  C rating: max rate battery can safely discharge
  80% rule gives 2 minutes (full capacity) 7 minutes (normal capacity)

- Possibly have two batteries with same rating in parallel

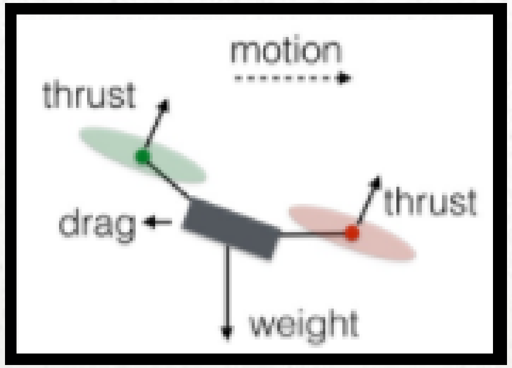
Thrust and Weight

- Thrust-lift of drone at full throttle

  TWR=1: for steady flight

  TWR>1: more for take off, more for tilt angle

- TWR of at least 2:1
- 6*28.29g per motor= 4812 grams thrust
- slightly over 2:1



Drone Component	Weight (grams)
Pixhawk, buzzer, GPS, and power module	181.437
Drone Frame	478 g
LiPo battery	266g
IR Range Sensor	25 g
Drone Gripper	123 g
Motors	318 g
OpenMV Camera	16 g
ESCs	150 g
Claw, rangefinder, camera plastic frame	≈ 255.19325 g
Propellers	54 g
Raspberry Pi	45 g
PCB Weight	≈ 50 g
Styrofoam load	≈ 200 g
Telemetry Receiver	13 g
Motor for Gripper	42 g
Total weight	2216.63025 grams

PCB Function

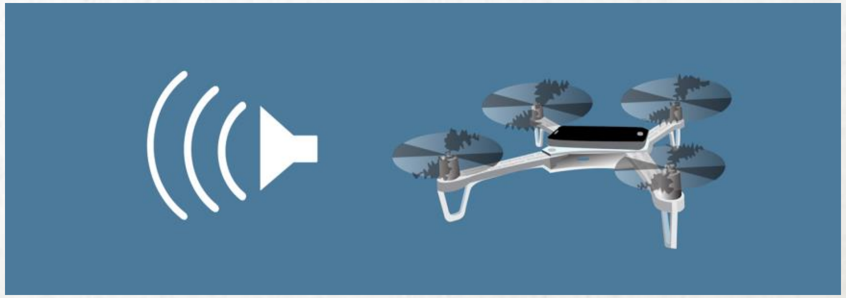
- Obtain I2C commands from Raspberry Pi to start all PCB tasks
- Send PWM for claw position
- Blink LED and play audio from SD card through speaker for 3 phases based on location and task

Flight path: **Red LED** and *“On flight path”* audio

Raw Material Site: **Orange LED** and *“searching for object”* audio

Base Station: **Blue LED** and *“aligning object”*

  - pause .wav file in software until reach next phase in task



PCB Components

Atmega328

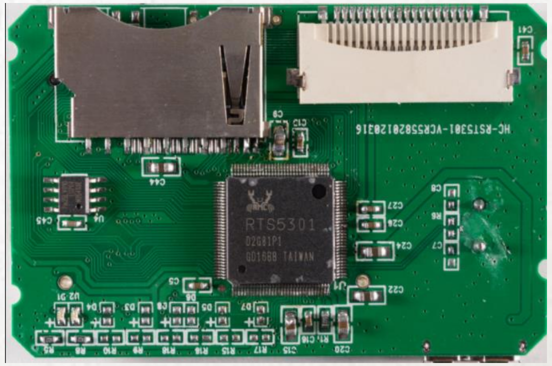
- 8-bit microcontroller
- 1K Bytes non volatile EEPROM
- I^2C, SPI compatibility

SD Card and Connector:

- House microSD card
- Reliable contact with card contact cards
- Has a low profile
- Fallout prevention
- Has grounding for EMI protection
- Save “.wave” file in card’s root directory, at 44100 Hz, 16-bit stereo quality

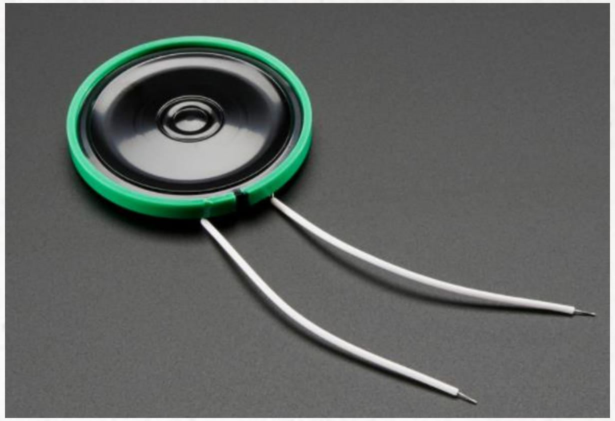
74HC125: Quad buffer/line driver 3-state

- Level shifting for SD card (from 3.3V to 5V)
- Quad bus buffer, provide 4 independent buffer states



PCB Components Continued

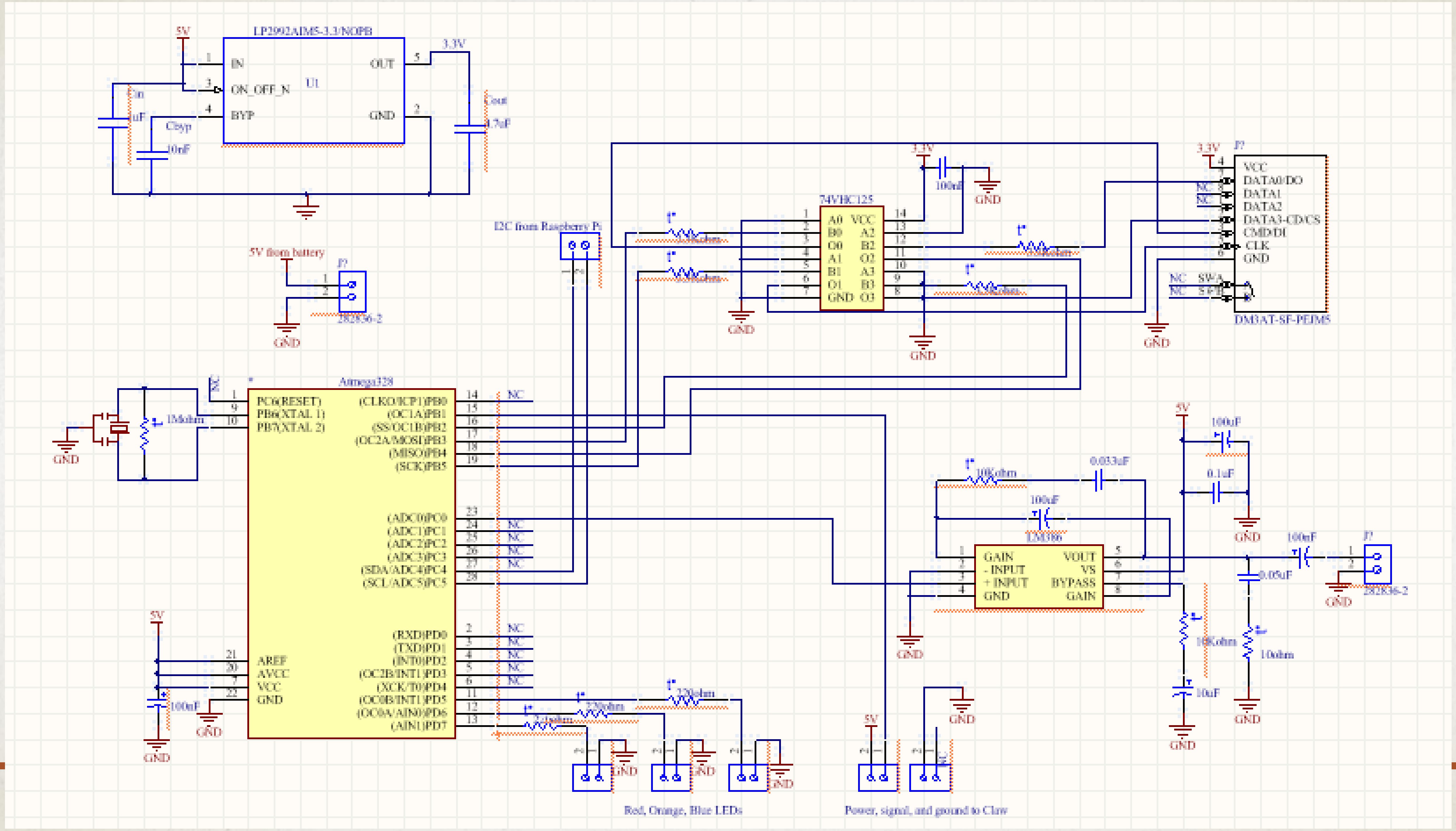
Thin Plastic Speaker:



- 8 ohm, input Power: 0.25 Watt
- 83 dB to 89 dB (88 dB would be a food blender)
- Sound Pressure Level (SPL): 96dB ± 3 dB (0.25W/0.1m)

LM386 Low Voltage Audio Power Amplifier

- Amplification: gain of 200
- Noise cancellation
- Connect to Atmega328 through DACO pin



LP2992AIM5-3.3/NOPB
5V
3.3V
IN
ON_OFF_N
BYP
OUT
GND
U1
Cin
Cbyp
10nF
Cout
4.7uF
I2C from Raspberry Pi
5V from battery
282836-2
GND
74VHC125
A0 VCC
B0 A2
O0 B2
A1 O2
B1 A3
O1 B3
GND O3
100nF
VCC
DATA0/DO
DATA1
DATA2
DATA3-CD/CS
CMD/DI
CLK
GND
NC
DM3AT-SF-PEJM5
Atmega328
PC6(RESET)
PB6(XTAL 1)
PB7(XTAL 2)
(CLKO/ICP1)PB0
(OC1A)PB1
(SS/OC1B)PB2
(OC2A/MOSI)PB3
(MISO)PB4
(SCK)PB5
(ADC0)PC0
(ADC1)PC1
(ADC2)PC2
(ADC3)PC3
(SDA/ADC4)PC4
(SCL/ADC5)PC5
AREF
AVCC
VCC
GND
(RXD)PD0
(TXD)PD1
(INT0)PD2
(OC2B/INT1)PD3
(XCK/T0)PD4
(OC0B/INT1)PD5
(OC0A/AIN0)PD6
(AIN1)PD7
1Mohm
220ohm
100uF
0.033uF
0.1uF
10Kohm
LM386
GAIN
- INPUT
+ INPUT
VOUT
VS
BYPASS
0.05uF
10uF
10ohm
282836-2
Red, Orange, Blue LEDs
Power, signal, and ground to Claw

Safety Considerations

- Possibility of having propeller guards
- On-board manual controller:
  - RC remote controller
  - Telemetry radio

Hardware Conclusions

Successes

- Drone frame put together
- 3D design finished
- Calibration of major components completed

Difficulties

- RC remote connection.
- Having the drone fly stable with all the components connected and the claw attached.

Software

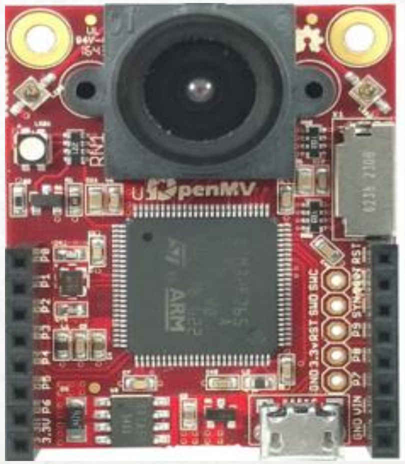
Camera Decision

CMUCam5 Pixy

- Requires Raspberry-Pi
- Uses OpenCV
- 1200 x 800 Resolution

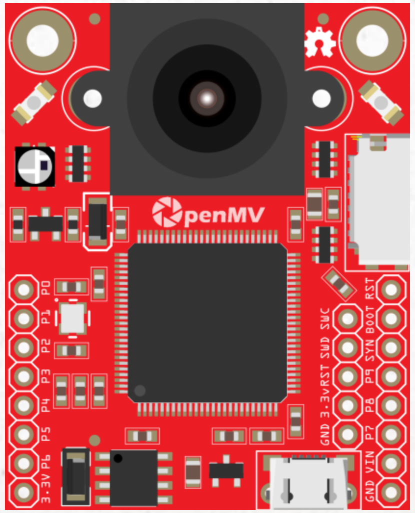
OpenMV Cam M7

- Runs on its own processor.
- Uses custom libraries
- 640 x 480 Resolution



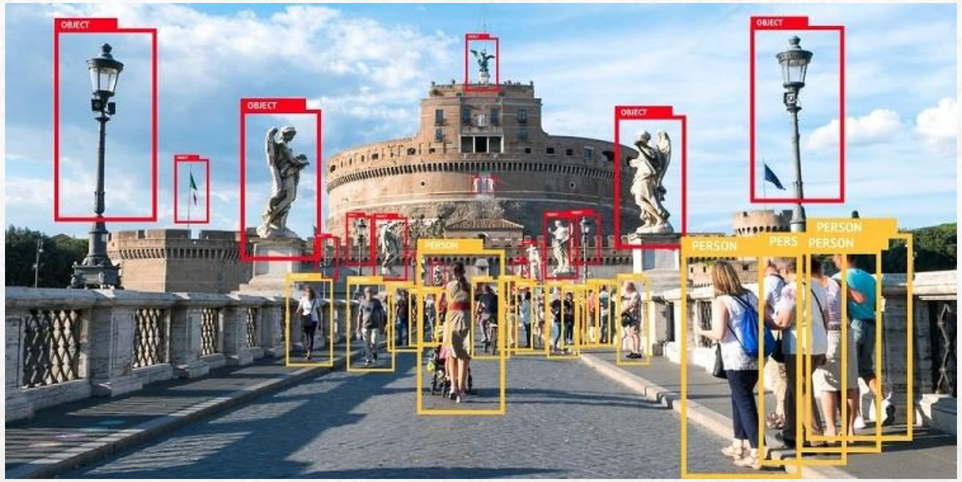
OpenMV Cam M7

- Image sensor that it open source that runs on its own custom library.
- Capable of connecting with any microcontroller.
- Three I/O pins for servo control.
- Uses customized IDE..



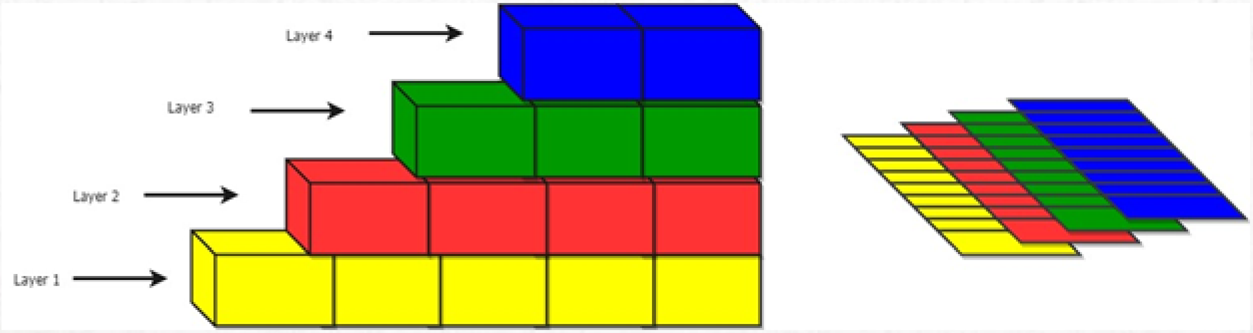
Object Detection

- Requires object detection Python scripts.
- Edge detection
- Color detection
- QR detection
- Needed for detecting the raw materials for building.



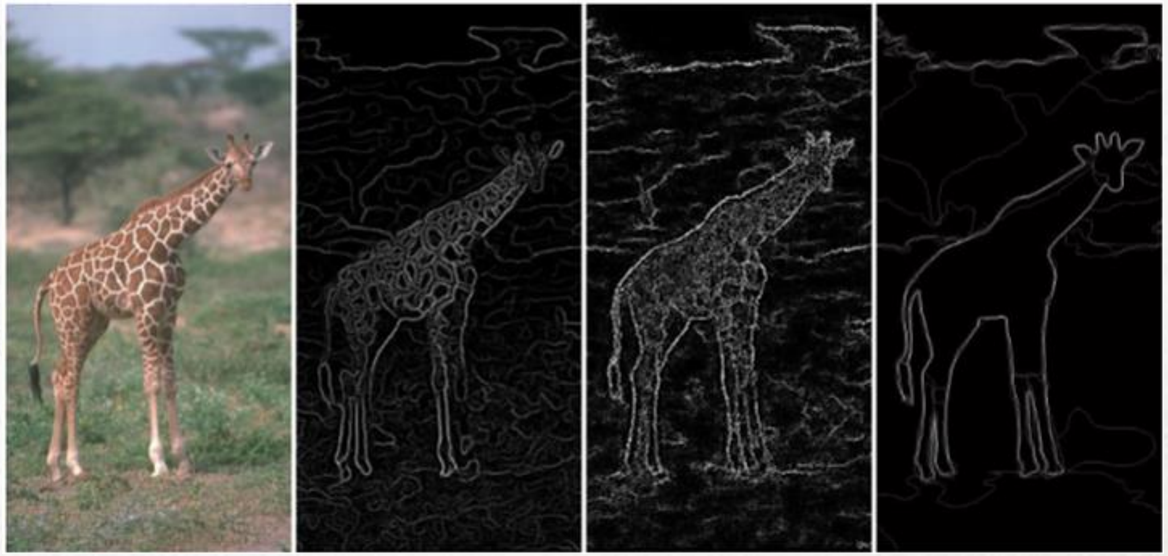
Color Detection

- Color code the blocks and stack them in layers based on their colors.
- Centering the objects to the middle of the screen is needed.
- Cons: Precision is not guaranteed.



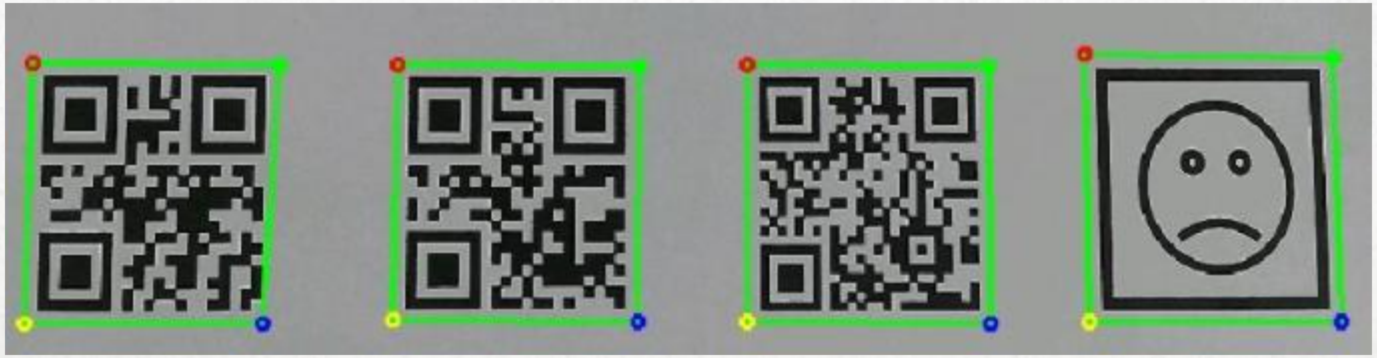
Edge Detection

- Helpful to find the edges of the blocks.
- Detect the gridlines of the building site.
- Can use Canny algorithms.
- Cons: could be very complex.



QR detection

- Blocks should have QR codes.
- QR codes would initiate a specific function for the drone such as:
  - Fly to the building site.
  - Grab object
- Simpler than other algorithms.

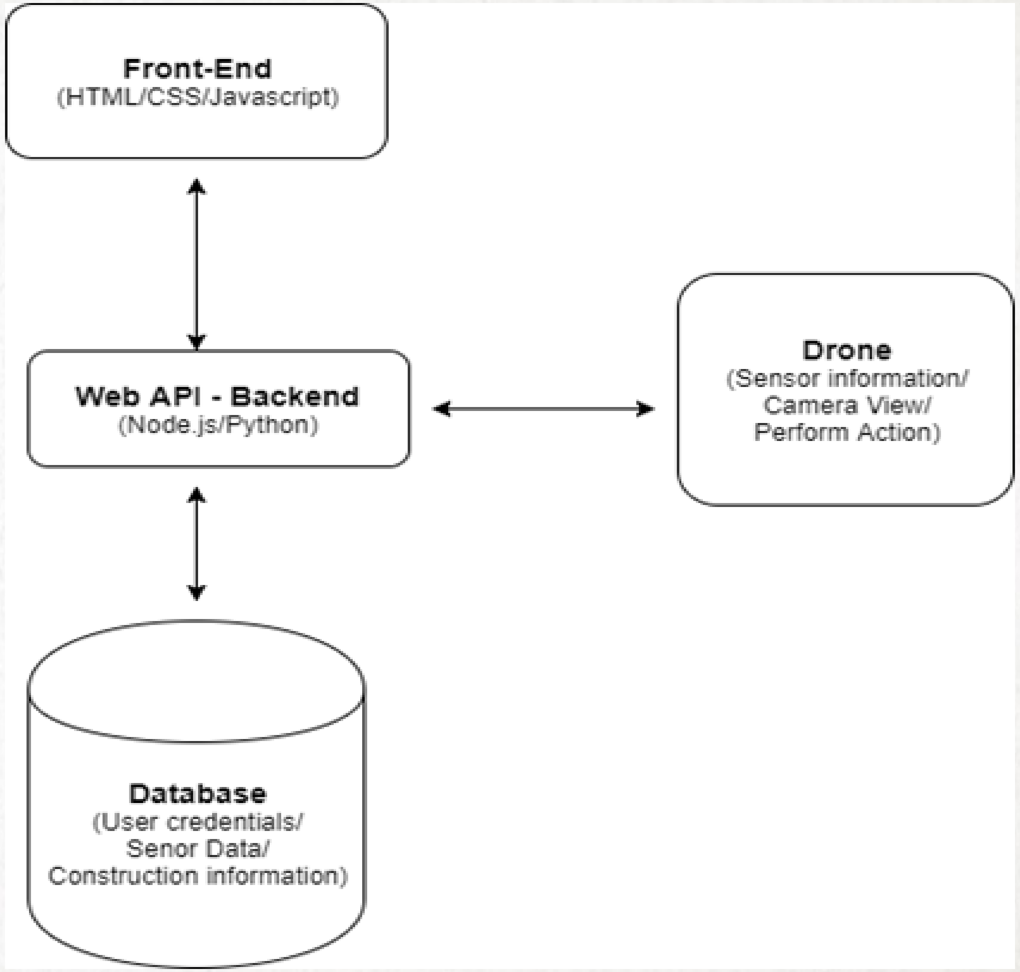


Communication

- Raspberry-Pi sends commands to flight controller via Dronekit
- Communicates with Flight controller, PCB, camera through I^2C
- Raspberry-Pi connects to base station computer through wi-fi
- Takes the data from the camera and sends to the web interface.

Web Application

- Written in JavaScript
- Will have authentication system that takes in a username and password..
- User will able to see all sensor data and drone's current function.
- Simple drone commands will be available to the user.



Web Interface

- The user is capable of communicating with the drone by sending commands.
- Commands include:
  - Start building
  - Suspend current operation
  - Emergency land
  - Return to base
  - Open/Close claw

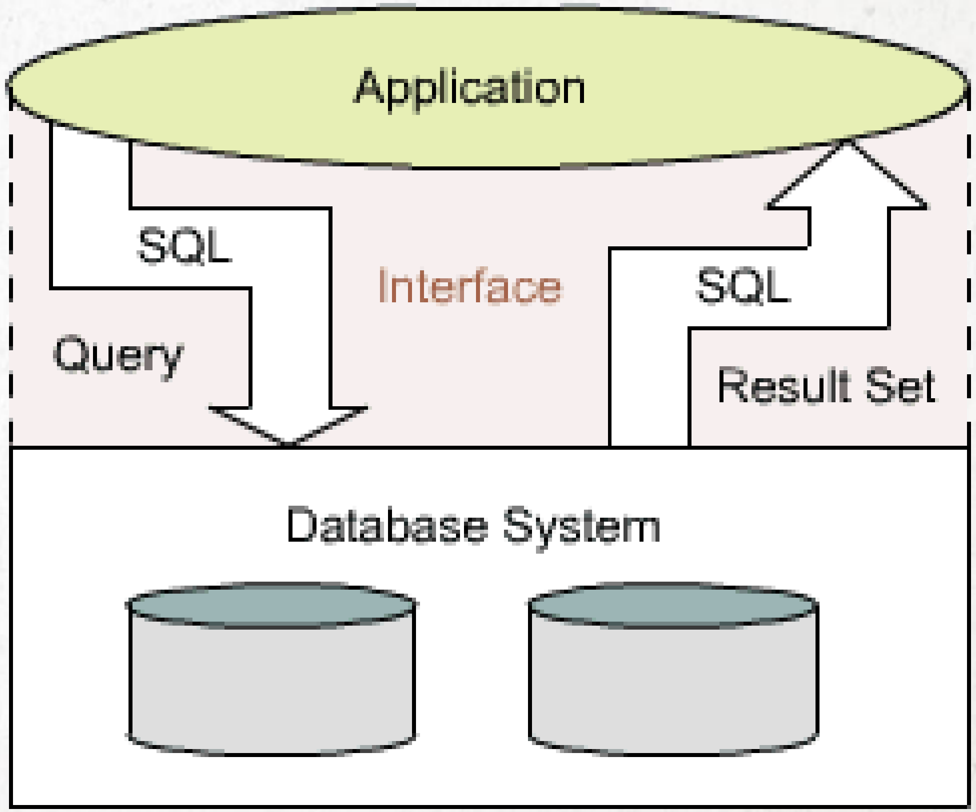
Login

- The login screen will take in the username and the password.
- Once accepted, the user will be able to see the list of commands as well as sensor data and live feed.
- All usernames and passwords are stored in a MySQL database.

Database

List of elements we want to store:

- User credentials
- Drone phase/progress
- Gripper position
- Battery
- Drone height
- Object detection status
  - If cube is detected
  - If path is detected
  - If material site is detected
  - If construction site is detected



Software Conclusions

- Camera can detect QR codes
- Need to be able to communicate between all the hardware.
- Precision is difficult.
- We need to make sure the location of the object is accurate.

Possible extra features

- Video streaming
- Drone swarm
- Custom structure selection
- Obstacle avoidance

Administrative Content

Budget

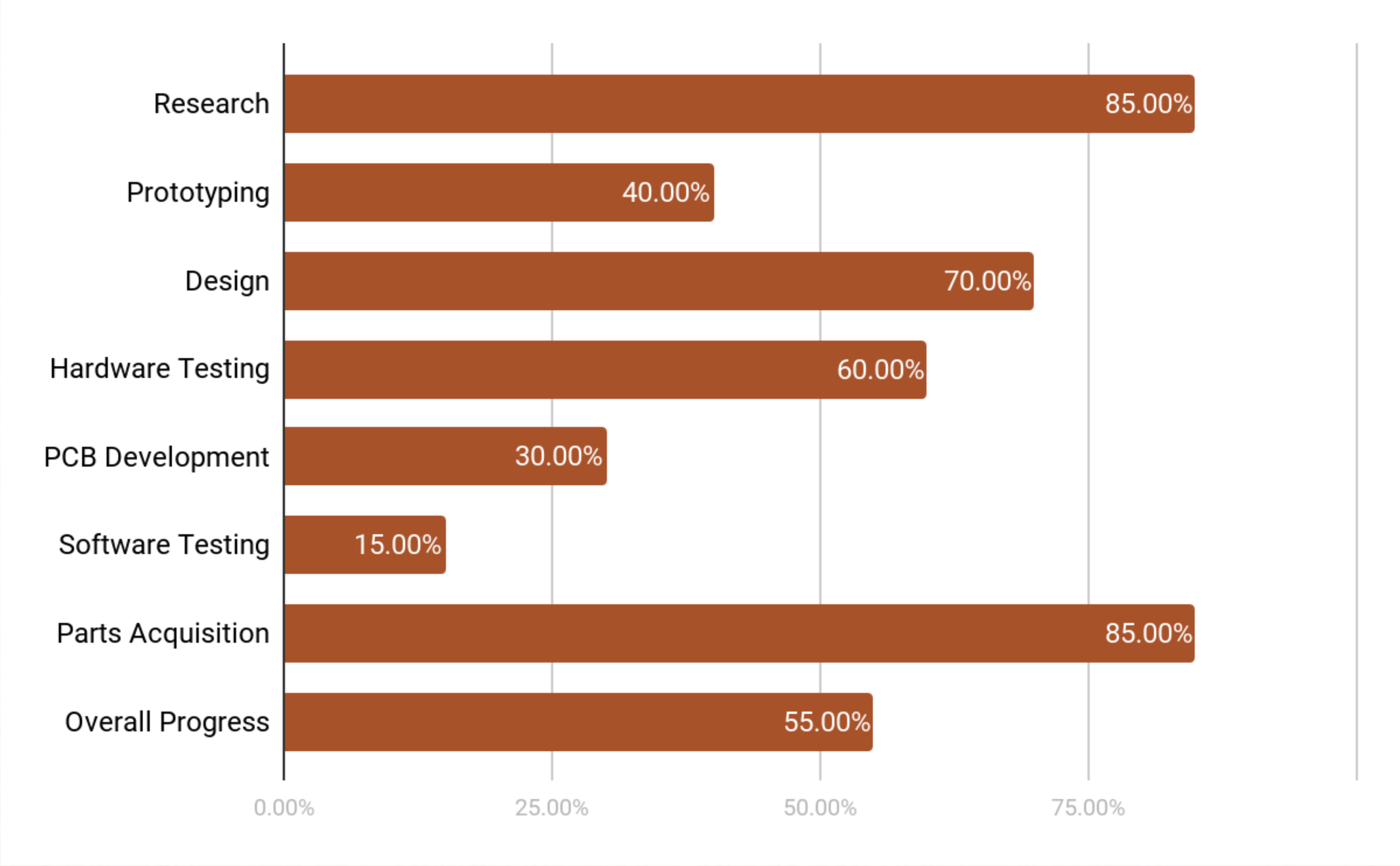
Component	Quantity	Price
Pixhawk Flight Controller	1	$95.23
Electronic Speed Controllers	6	$0.00
Motors	6	$0.00
Propellers	6	$0.00
11.1V 3000mAh 30C LiPo RC Battery	2	$49.99
Ultrasonic sensor	1	$3.00
Mechanical gripper	1	$17.00
OpenMV Cam M7	1	$65.00
Voltage Transformer	1	$20.00
Drone Set	1	$128.00
PPM Encoder	1	$12.89
Raspberry-Pi 3 Model B	2	$70.00
Power Module connector	1	$6.79
Power Module	1	$25.99
Remote Controller FlySky i6	1	$52.99
Telemetry Port	1	$23.99
Portable Battery Charger	1	$11.99
Total		$582.86

Work Distribution

Work Distribution

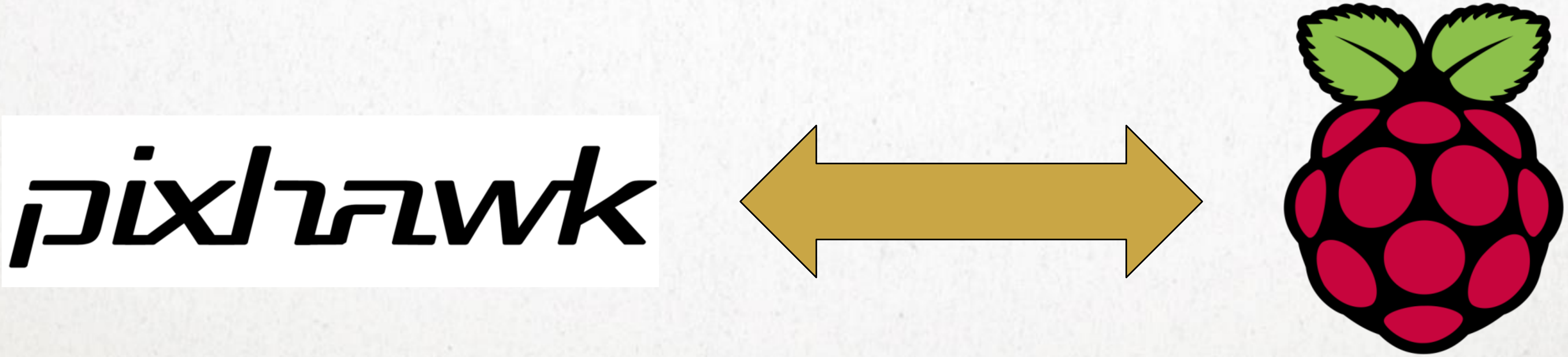
Names	PCB Design	Computer Vision / Web Development	Mechanical Design	Interproccess Communication
Alan				X
Baian		X		
Nicola			X	
Veronica	X			

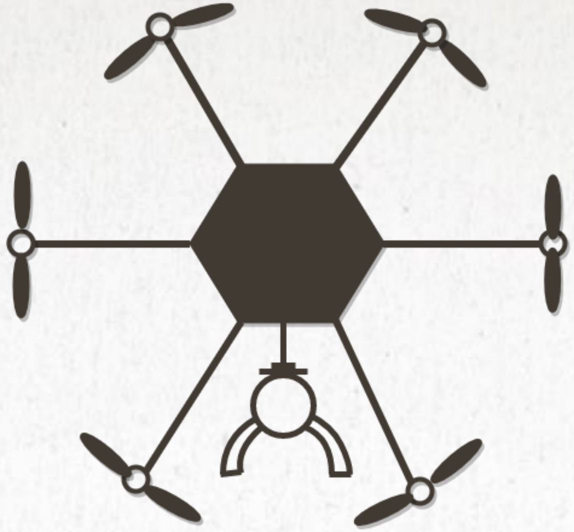
Progress


Research
85.00%
Prototyping
40.00%
Design
70.00%
Hardware Testing
60.00%
PCB Development
30.00%
Software Testing
15.00%
Parts Acquisition
85.00%
Overall Progress
55.00%
0.00%
25.00%
50.00%
75.00%

Final Comments

- Establish radio communication
- Test Flight
- Finish 3D modeling
- Communicate between flight controller and Raspberry Pi





Thank you! :)