Building a Cost-Effective Autonomous Unmanned Aerial Vehicle with an Integrated Sonar and Visual Based S.L.A.M. (Simultaneous Localization and Mapping) Algorithms to Allow for Increased Obstacle Avoidance Capabilities.

PROBLEM STATEMENT

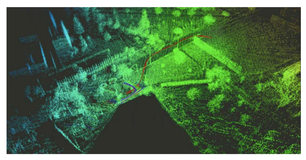
Thousands of lives are lost yearly due to events such as forest fires and burning buildings. Along with that, there are many inaccessible and remote areas where humans can't deliver or or drop off items like medical kits, water, and food to ones who need it. Many of these problems can be reduced by the use of UAV's. However, the most useful UAV's excel in 3 areas: speed, range, and battery life. Commercially manufactured UAV that excel in these areas are too expensive and break easily.

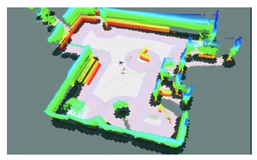
ENGINEERING DESIGN

Design Parameters
Customized racing drone, motor that reaches speeds over 40km/hr, transmitter and receiver with > 3km distance, autonomy system (cameras and sonar system), & battery life = 19+ min

Design Improvements
Making a modular FPV system. A major improvement made is the FPV system, because now u can change out the type of cameras on the drone that you want to see through. Ex. Infrared, regular camera, etc.

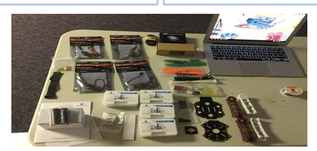
Design Result
As a result, a sub-$350 build that excels in all the areas I need it to. The autonomy system will reduce the # of drones broken, proving long-term sustainability.





MATERIALS

- Solder iron & rosin core solder
- Wire cutters
- Bottom and top power distribution boards (PDB)
- SunFounder quadcopter frame
- 2x EMAXX ccw motors
- 2x EMAXX cw motors
- 4x Electronic speed controller (ESC)
- 1300mAh lithium ion battery
- 2cm x 15cm cw props
- 2cm x 15cm ccw props
- CC3D flight controller
- 10x Arduino sonar sensors
- 8x Nano-cameras
- Bread board jumper wires
- Double sided tape & zip ties
- Dampening tubes
- 12 Banana plug male bullets
- 12 Banana plug female bullets
- 32 K2.0 screws
- Allen wrench
- Velcro
- GoPro camera & adhesive mount
- Transmitter and receiver
- Safety goggles
- Key ring
- Heat shrink tubing
- Male t-plug adapter
- Infrared camera
- ESP8266 NodeMCU

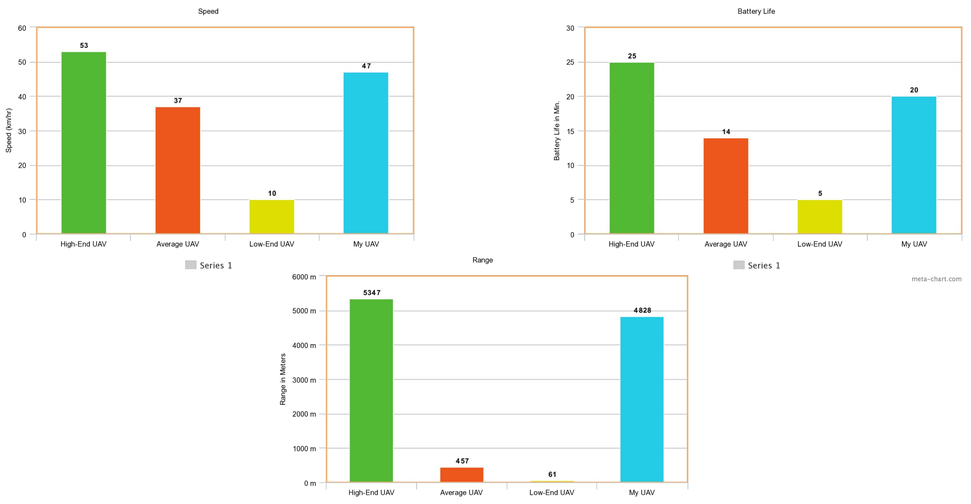


BUILDING PROCEDURE

1. **Soldering ESCs to PDB and Building Frame**
   - Solder all four ESC's and male T-plug adapter to the bottom PDB
   - Solder three banana plug female bullets to the three end wires on the other end of the ESC's, repeat this for all other ESC's
   - Using the K2.0 screws, attach the SunFounder frame to the bottom and top PDB's
2. **Connecting ESCs to Motors**
   - Take each motor and on each of its three wires, solder a banana plug male bullet
   - Take each motor and screw them on with the K2.0 screws so that the the front right motor and back left motor have silver tops and the other spots have motors with black tops
3. **Final Connections**
   - Use double sided tape to stick the CC3D Flight Controller and receiver to the top of the top of the SunFounder frame.
   - Then connect the wires from the drones ESC's to the to the CC3D Flight Controllers speed control ports
   - Using the binding key, that came with the receiver, to bind the radio and the CC3D Flight Controller
   - Lastly attach the propellers and GoPro adhesive mount
4. **Installing the Components Needed for the S.L.A.M. Technology and Autonomy on the UAV**
   - Take the ESP8266 NodeMCU and wire it to the CC3D flight controller
   - Attach all 10 Arduino sonar sensors to the UAV (in there specific locations)
   - Attach all 8 nano-cameras to the UAV (in there specific locations)
   - Use bread board jumper wires to connect all sensors and cameras to the ESP8266 NodeMCU
5. **Creating the Algorithms to Enable S.L.A.M. Capabilities, Obstacle Avoidance, and Overall Autonomy**
   - All algorithms will be uploaded and run on the ESP8266 NodeMCU
   - The first algorithm tells the drone to stop moving and avoid any obstacles that are detected by the sonar sensor within a 2ft. range
   - The second algorithm takes all the video from the nano-cameras, and stitches them together to creates a nearly 360 degree live feed
   - The third algorithm gives depth detection to these camera, so now the 360 degree like video feed will be able to show you approximately how close or far the UAV is from any physical object
   - The next algorithm maps out the location of the environment in which the UAV is in and can show where the UAV is within this environment
   - The last algorithm takes an input from the software and it will make the UAV follow or find and recognize this input. Usually the input is something like a human
6. **Connecting the Main Camera/Infrared Camera to the UAV**
   - Right now the UAV uses a GoPro as it's main camera for FPV and for the object recognition algorithm. However, the design allows for this part of the drone to be modular, so the GoPro can be replaced with an infrared camera quickly and have the same FPV and recognition capabilities
   - When using the GoPro, connect it via micro-USB to the UAV, and slide it into the adhesive mount
   - When using the infrared camera, connect it micro-USB as well, and use the given adhesive tab

TEST RESULTS

These tests compare the UAV being manually flown against other commercially manufactured UAV's at different price ranges.



TESTING ENVIORMENT AND PROCEDURE

- The tests were all done in the same weather, with little to no wind
- All tests were performed 5 times and then averaged to get final results
- The tests were all performed with the UAV's being manually flown, no autonomy in use

COMPARABLE PRODUCTS ON THE MARKET

Currently, only one company has tapped into the market of fully autonomous drones through the utilization of S.L.A.M. A company called Skydio, started by some MIT grad students, created the first prototype right out of college and have been advancing it since. One problem is that their product is so expensive, reaching prices of over $1000 dollars. Along with that their UAV has a stronger focus on cinematography.

PRACTICAL APPLICATIONS

- Use the drone to deliver to areas where it would be hard for humans go to
- My UAV could be used as a blueprint to create a system to survey the inside of dangerous buildings before emergency personnel enter to reduce the number of casualties
- New attachments would enable them to do more actions like put out fires or break things
- They can be used in swarms or herds for various needs

FURTHER INVESTIGATIONS AND IMPROVMENTS

- Make the UAV cheaper
- Test how much weight the UAV can hold and how it will effect the speed
- Make the UAV more versatile
- Create more modules for the UAV