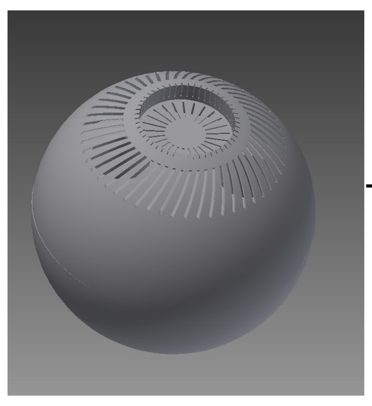
SentiBots– smart centimeter-sized robots

Project by: Sundaramahalingam Sudharshan and Isaac Tay

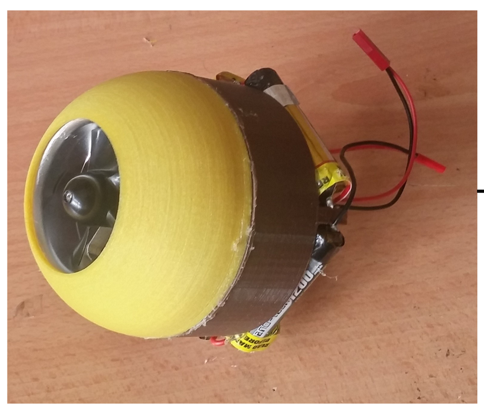
INTRODUCTION

This project aims to achieve a hardware and software ideal swarm flight platform that allows for swarm developers to have an easier time developing and using swarm platforms in real life applications.

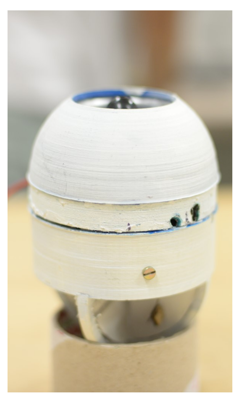
DESIGN METHODOLOGY



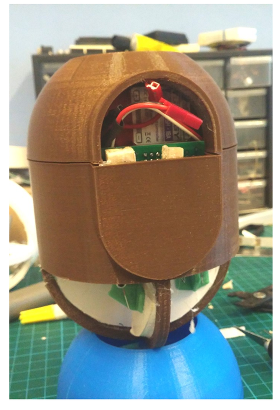
GEN 0– SPHEREICAL VEHICLE



GEN 1– PRIME



GEN 2– SNOW WHITE



GEN 3– SENTINEL

HARDWARE

SIZE

The innovative small bean-shaped shell design combined with the single motor propulsion system allows for the SentiBot to retain the form factor of a small drone. By enabling the SentiBot to remain small, we allow for it to fly in close proximity to each another with minimal aerodynamic interactions and without protruding propellers from the frame. Unlike similar projects which use a single motor and 4 control surfaces, this robot is able to achieve this size due to its **E**lectric **D**ucted **F**an (EDF) motor which generates a lot more thrust per space it occupies allowing us to implement it in a smaller form factor.

COST AND EXPANDABILITY

The expandability of a system refers to the ability of the swarm system to expand in the number of robots without having production problems. Using a single motor, this robot has an advantage over a quadcopter in which the cost is up to 25% lesser due to the motors and ESC's.. The case is designed using Autodesk Inventor software and made using a 3D printer which allows any research institutions to replicate it with ease and without requiring special manufacturing materials or tools.

MODULARITY

The system can be easily added on to due to the Edison board and the ATMEGA 328 which allows for sensor expandability which is important for a platform like this as it offers the ability for each robot to serve multiple purposes with different sensors. The SentiBot can easily be modified and more sensors can be added to provide swarm researchers with a variety of sensor options and combinations.

SPECIFICATIONS:

Dimensions	: 100mm x 100mm x 250mm
Flight time	:10 - 15min
Motor thrust	:450g
Payload weight	:100g
Top speed	: 20km/h

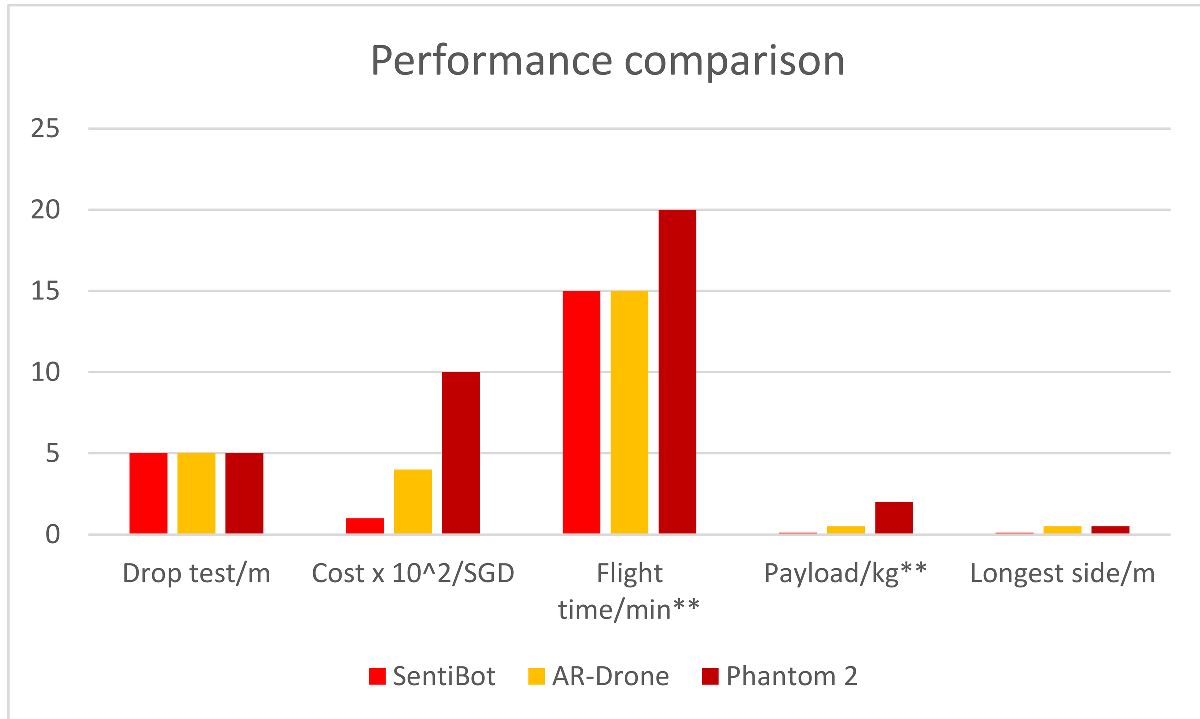


*Figure 1: Performance graph**

SOFTWARE

ALGORTITHMS

The main algorithm running in the SentiBot is the PID loop. The PID loop is and essential part of the SentiBot as it allows the SentiBot to remain stable flying in the air and maintain a constant hover. PID tuning was accomplished though a combination of systematic trial and error and base values found on the internet for similar platforms. The dual processor CPU in the SentiBot allows for higher level vision and swarm algorithms to be run in the Edison while control level tasks like PID to be run in the ATMEGA 328 which reduces load on the Edison freeing it up for other purposes,.

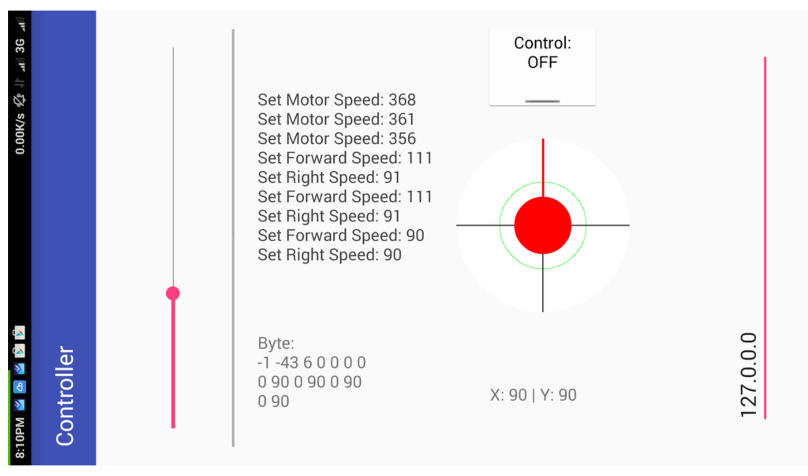


*Figure 2: Android App screenshot**

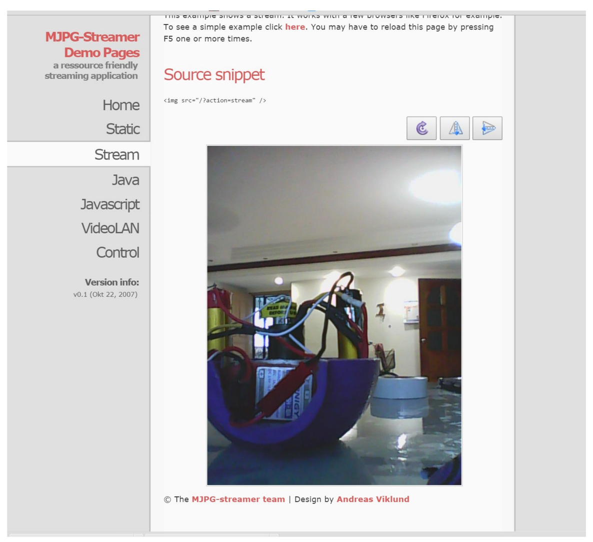


*Figure 3: Streaming webpage**

COMMUNICATION

Communication is critical to the control of the SentiBot. The control is done using an android app which communicates to the Edison via the UDP protocol which increases speed of communication as compared to TCP/IP. This is then relayed to the Arduino via a custom serial protocol which further increases the speed and reduces control lag. Thus, the SentiBot and the android phone need to be connected to the same Wi-Fi network for this to work. On the other hand, the SentiBot has a camera attached to it for surveillance purposes which needs streaming services. This is achieved by using the mjpeg-streamer package which causes the Edison to open a web based application which allows the camera stream to be viewed as long as they are on the same network.

RESULTS & CONCLUSION

RESULTS

The results of initial testing were quite positive. The SentiBot is able to remain in constant flight even without any PID stabilization algorithms and remain in relatively oscillation free flight when there is PID stabilization.

FUTURE WORKS

Research into software side could be deepened with more optimized protocols and research into applying SLAM on this platform. Using the idle Edison's to aid with processing and allowing distributed computing is another idea we had but didn't implement.

CONCLUSION

The SentiBot project set out to bring a solution to swarm researchers worldwide. The results seem to indicate that we have made considerable progress towards that goal but there is further testing and tweaking to be carried out in the following years. The results also seem to indicate that the hardware side of swarm research is just as important as the software side as the hardware optimization solved many problems with current flying swarms. We hope that this report can act as a kick starter for hardware development in the field swarm research.

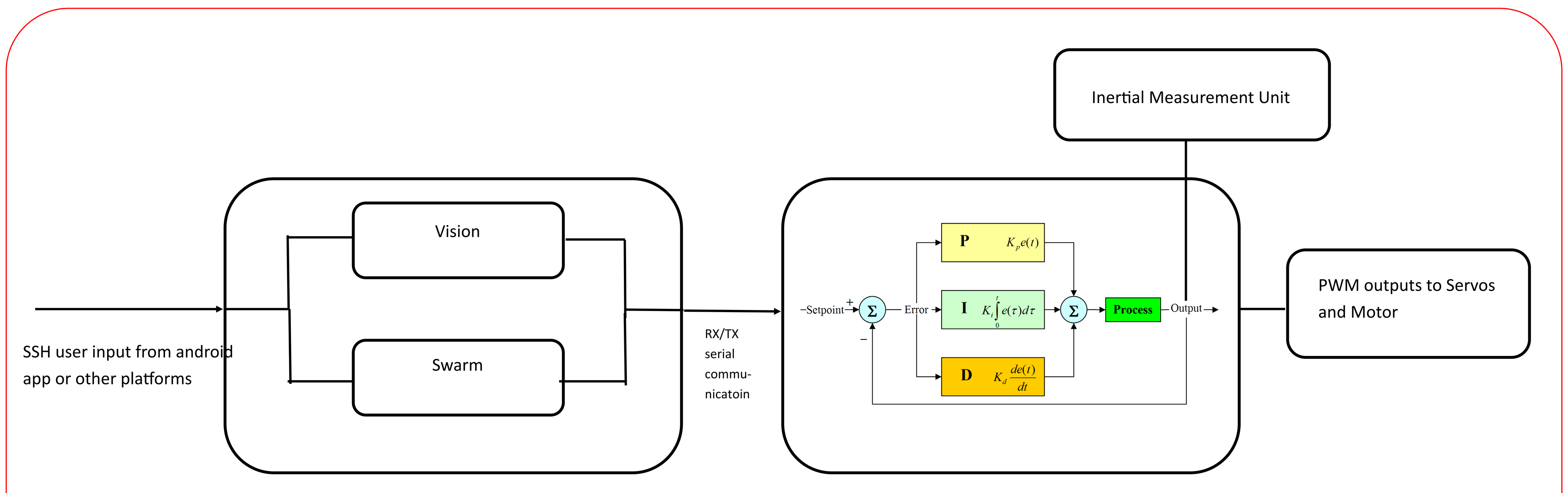


*Figure 4 Software Flowchart**

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*All images were self generated except for the PID loop of the flowchart (https://en.wikipedia.org/wiki/File:PID-feedback-loop-v1.png)

** Estimated values