SUMMARY

INTRODUCTION

This project aims to achieve a hardware and software optimized swarm flight platform that allows for swarm developers to have an easier time developing and using swarm platforms in real life applications. Current swarm platforms mostly use conventional quadrotors for their applications. However, conventional quadrotors have several problems when confronted with swarm activity. These problems inhibit the abilities of these swarm platforms as their structure inherently prevents the close interaction of swarmbots in swarm behavior. Our swarm platform, SentiBot, uses a new drone design to solve the inherent problems with the quadrotor while maintaining the versatility of the quad. The SentiBot platform also uses intelligent software which optimizes the performance by allowing the SentiBot swarm to pool information and computing power.By creating an optimized platform for swarm research, we hope to accelerate the progress in swarm research and allow for swarm research to be applied in industrial and civil applications.

HARDWARE

Our SentiBot is hardware optimized in 2 different aspects- electronics and frame-design. Looking at the electronics in the SentiBot you will realize that the brains of the SentiBot is the Intel Edison processor which provides **500 MHz** of processing speed. It also provides **512MB** of RAM and **4GB** internal storage. This allows the Edison to carry out high speed calculations on board and do complicated tasks like vision tracking and 3D mapping. The electronics also includes an **E**lectronic **D**ucted **F**an unit (**EDF**) for thrust and 4 ultra-micro servos all powered off an 11.1V 1300mAh battery. This along with a nominal draw current of 7A during a hover provides us with an approximate **10-15min of flight time**. To accommodate the Intel Edison we also designed and fabricated a custom PCB which has all the breakouts required for this platform.

All these electronics are cramped into an extremely functional and unconventional frame design. Conventional quadrotor type frame designs are not optimized for swarm platforms as they have many dangerous high speed moving parts which can be damaged in the case of a mid-air collision. Our frame design encloses all the moving parts in a sturdy 3D printed frame, making it a very resilient platform for environments like search and rescue. The concept of this unconventional frame design is that the air being blown out of the bottom of the drone can be directed to one side or another by the 4 control surfaces allowing the drone to move around. Working in the same principle as an airplane made to stand up, this design takes the versatility and **v**ertical **t**ake-**o**ff and **l**anding (**VTOL**) capabilities from the quadrotor and combines it with the resilience and simplicity of an aircraft.

The SentiBot is also extremely modular consisting of 2 halves that are joined together by 3 joining pieces. The top half contains all the power electronics- the electronics that drive the system. The bottom half on the other hand contains all the intelligence of the system including the processors and sensors. This allows for easy modifications to be made to the system and quick repairs to be done as getting to the internals is as easy as removing 3 bolts.

SOFTWARE

The making of a good drone is not only defined by the quality and versatility of its hardware but also by the integration of its software. Our SentiBot's control system is managed by the ATMEGA 328 chip onboard the custom PCB. The ATMEGA chip reads from the onboard **i**nertial **m**easurement **u**nit (**IMU**) and uses it to control a PID loop which stabilizes the SentiBot in flight. In manual control mode, commands are sent via the SSH protocol to the Intel Edison board which then transmits the information to the ATMEGA 328 chip via the UART connection.

In autonomous mode, the SentiBot uses the onboard single camera to carry out monocular **s**imultaneous **l**ocation **a**nd **m**apping algorithm (**SLAM**) using a **r**obot **o**perating **s**ystem (**ROS**) library. This allows the SentiBot to carry out 3D mapping and also know the position of itself relative to the surroundings.

As a swarm, there are many optimizations that can be made to improve the system as a whole. I have listed 2 such optimizations below. The first optimization is that as a swarm the computing power can be pooled and each SentiBot could be a node in a swarm wide supercomputer. This could enhance the overall performance of the SentiBots. By using a mesh network like architecture we could also enhance the range of the SentiBot as user commands can be relayed through the mesh network consisting of SentiBots.

CONCLUSION

We managed to design a hardware and software optimized swarm platform for use in research scenarios. 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. Furthermore, the drop tests were significantly positive showing that the SentiBot can survive drops from up to 3m high due to its flexible and rigid 3D printed PLA frame.

The other algorithms mentioned still being tested and so far has been giving consistent results. Having a durable frame design and compactness benefits the swarm platform a lot as it allows for close range flight with not much limitations.

Making these hardware and software optimized robots has proven that our hypothesis is accurate showing that an optimized platform could really improve performance of swarms by providing a better platform for research and application purposes.'

In conclusion, this was a successful project that shows how both hardware and software needs to be brought together to achieve he perfect swarm system and also highlights the lack of research into hardware optimization for swarm platform.