Modular Aerial Vehicle (ModAV)

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INTRODUCTION

Over the last few years, multirotor vertical takeoff and landing (VTOL) vehicles have gained huge popularity in the aerial vehicle community. As the multirotor aerial vehicles have 6 degree of freedom, it is favorable for many challenging missions which involves high agility and fast execution of tasks like mapping, target tracking. So, there is a lot of focus to improve the design of the multirotor aerial vehicles. It is desirable to make an aerial vehicle more agile and compact in size which is easy carry anywhere and deploy in the target location.

Recently, researchers from ETH Zurich presented the concept of Distributed Flight Array (DFA) [1] which extends the horizon of VTOL vehicles to multi-rotor platform. However, the whole platform is custom built at ETH Zurich with their own sensors and controllers which are not available to the general aerial vehicle community. Inspired by the same concept, we have modified the system design and configuration (named as Modular Aerial Vehicle) so as to leverage the available sensors and controllers from the market which is capable to configure in any number of rotors (quad, hexa, octa, etc). We have built a prototype of one such configuration (quadrotor) to demonstrate the practicality of the novel system design.

DELIVERABLES

- Modular docking robots in controlled environment.
- Aerial Vehicle capable of delivering light weight objects (payload of 10-50 grams) to a distance of around 5 m.
- Flight height of more than 5 meter
- Flight time of more than 1 minutes.

OBJECTIVES

Design a modular configurable aerial robot which would address following problems and is a remedy of such problems :

- Optimum resource allocation for given payload.
- Different configurations of the aerial vehicle can be advantageous for different applications.
- Scalable to payload needs and capacity requirements.
- Compact packing and transportability of the aerial vehicle.

Modular Aerial Vehicle (ModAV) is one solution for different types of configurations of multi-rotor vehicles. It can be build in any of the desired configurations, be it a quadcopter, hexacopter or an octocopter (see figure 1 for different types of configurations). It is off the shelf system using the commercially available Pixhawk flight controller, rotors, battery, servos and Arduino Uno.

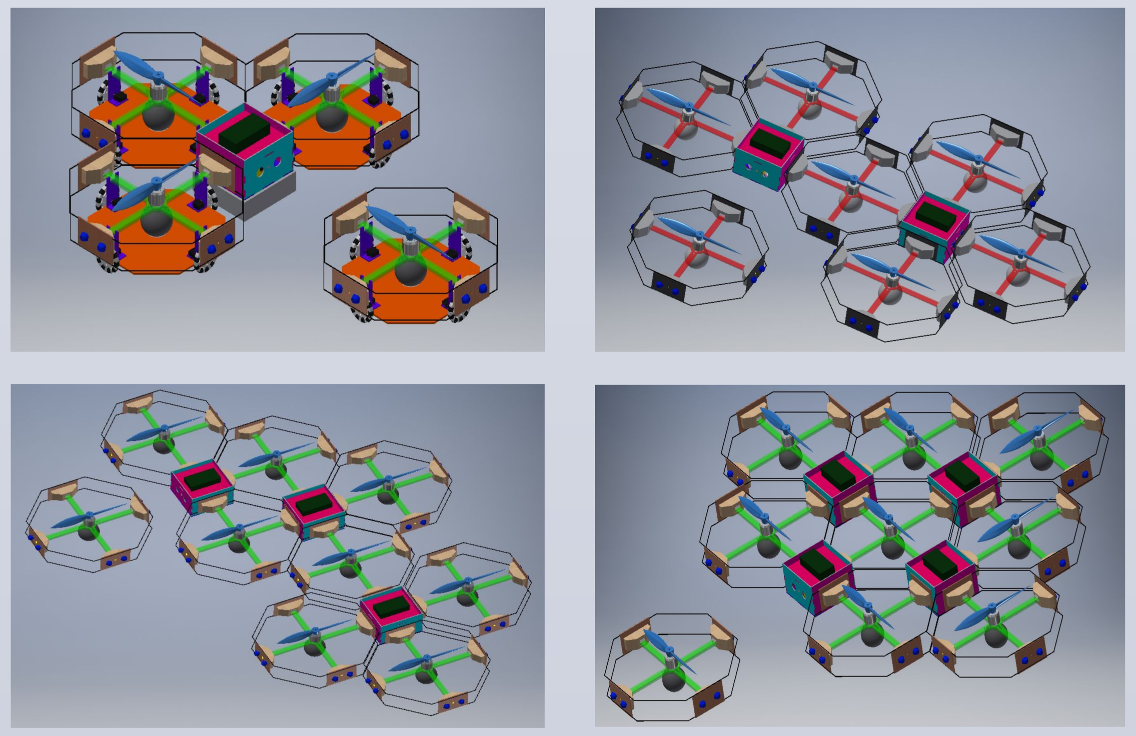

Figure 1

MATERIALS & METHODS

Balsa Wood Frame (Central Unit + Rotor Units)

- Both central and rotor units are made of balsa wood. 24” x 12” sheets are cut using laser cutting.
- Various parts drawings are converted to Dxf file format for cutting.
- Fig. 1 and Fig.2 shows rotor unit and central unit respectively.
- Cutouts are joined together with industrial grade adhesives.

Rotor Unit Stand

- Stands are made of Aluminium. Base is cut from 5mm thick sheet while the holder are cut from 2mm thick aluminium sheets.
- Base also has a 48mm hole at the center. Fig. 4 shows all the four rotor unit stands.

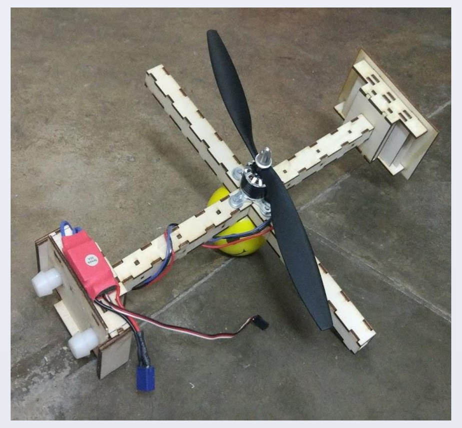

Figure 2

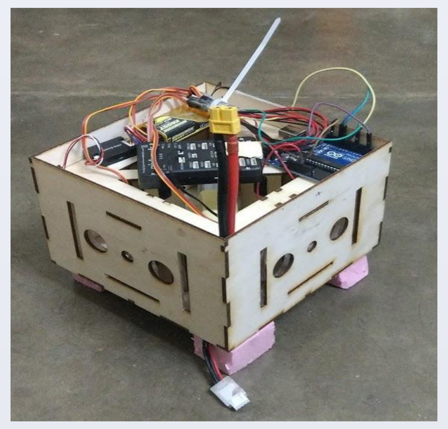

Figure 3

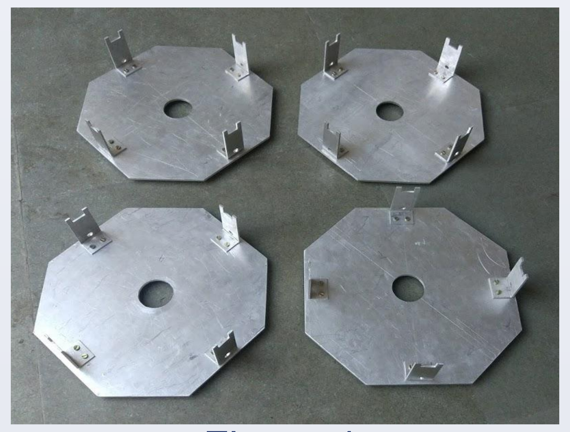

Figure 4

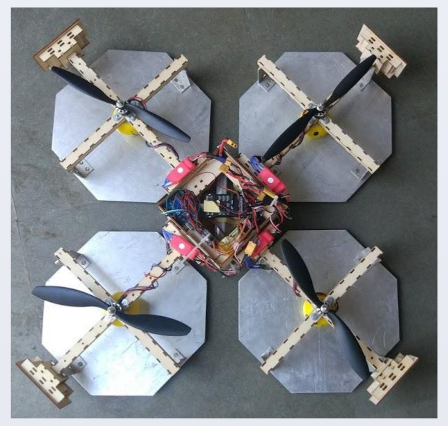

Figure 5

SYSTEM OVERVIEW

Connections:

The whole system consists of PIXHAWK flight controller 2.4.8 which is the core of the system. PIXHAWK is used to send the control command received from the binded RC transmitter to the rotors (KDE brushless motors of 965 kV) via Electron Speed controller (ESC). ArduPilot Mega is flashed onto the PIXHAWK. The system is powered by a 5500 mAh LiPo battery using a Power Module. The servo motors attached to the locker is connected to the Arduino Uno pin ports for signal transfer and is powered from the servo rail of the PIXHAWK.

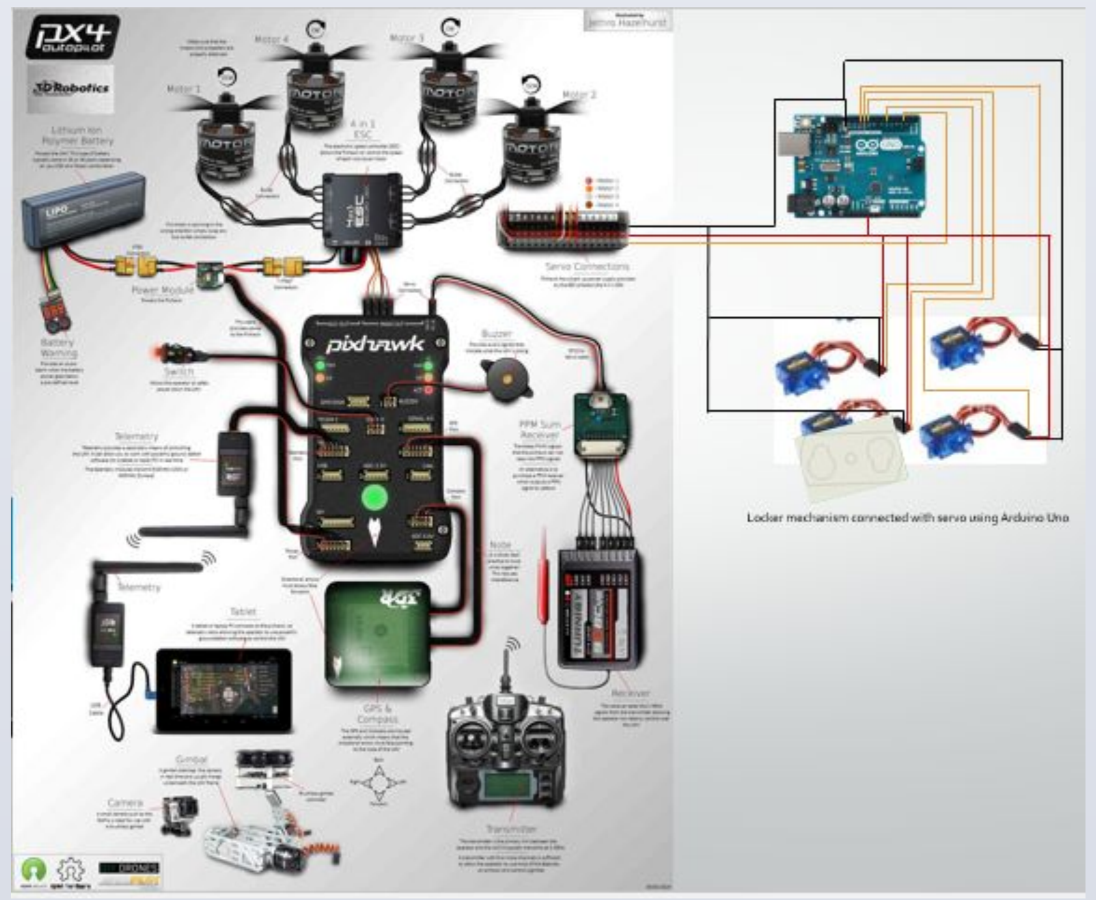

Figure 6

Docking Mechanism:

We have built a prototype modular quadcopter which is capable to lock the central unit with the rotor units by sending the PWM signal from the RC controller to Arduino Uno. The PWM signal is converted to the binary states of the locker (lock or unlock) by setting a threshold value (here 1000). Arduino Uno send the command to the servo according to the signal received from the controller via PIXHAWK. (see figure 6 for the connections)

Configuration:

We are using quad X configuration with alternating clockwise and counter-clockwise rotating rotors.

RESULTS

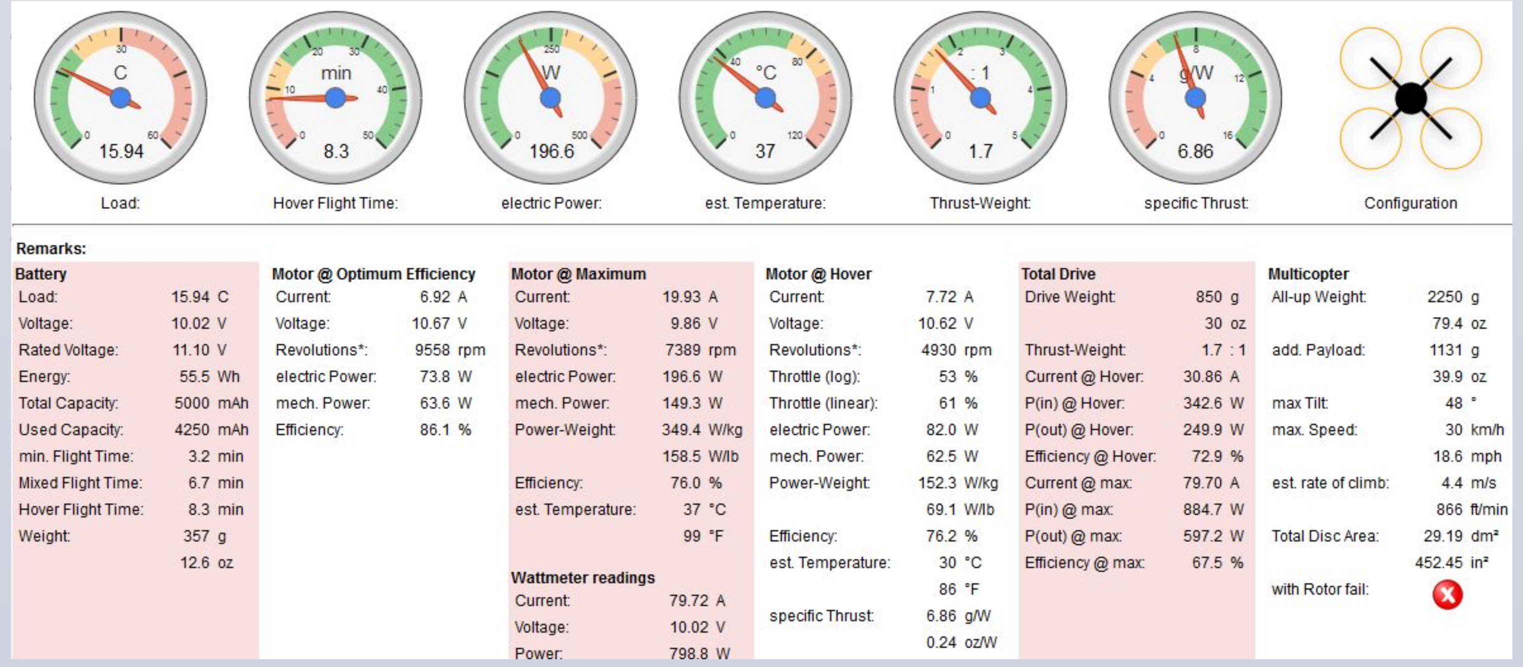

Figure 7

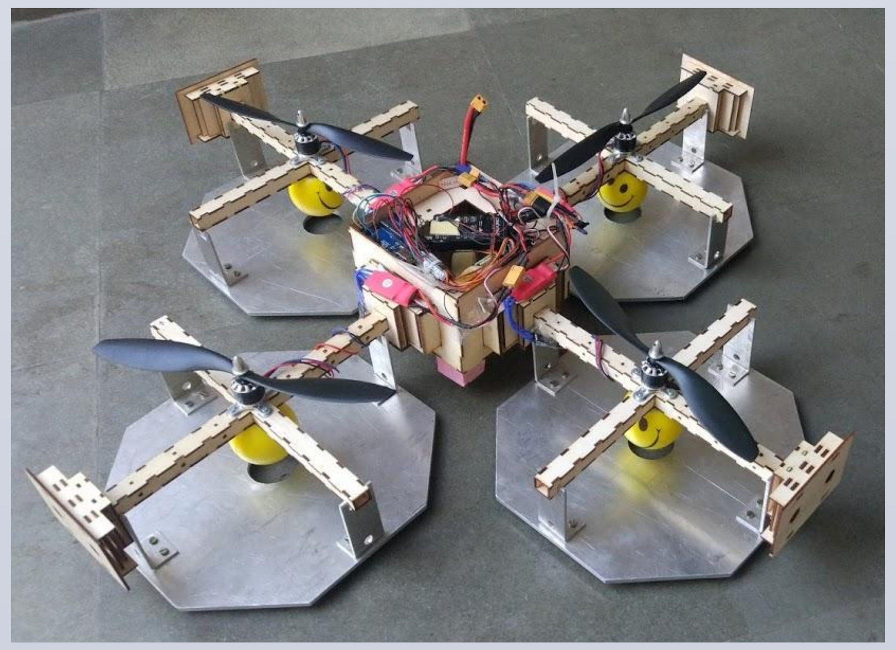

Figure 8

CONCLUSIONS

After the flight test of the prototype of the Modular Aerial Vehicle (see figure 10), it was found that the system design is foolproof and can be the next multi-rotor platform for the aerial vehicle community. It has the potential to deploy the ModAV in any challenging environments like collapsed building after the disaster as a quadcopter or an octocopter to lift heavy packages to deliver.

However, it was found that due to slipping of gears in servo motors (using servo with metal gears can solve the problem), the locking mechanism was not stable enough to bear the dynamic loads occurring in flight.

Better quality motors would have improved the locking of the rotors units. Further improvements can made to the locking mechanism. This project has proved the concept of modularity.

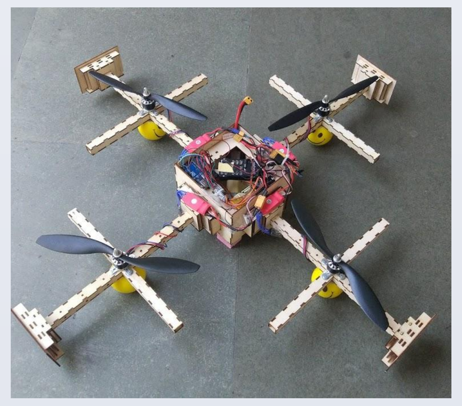

Figure 9

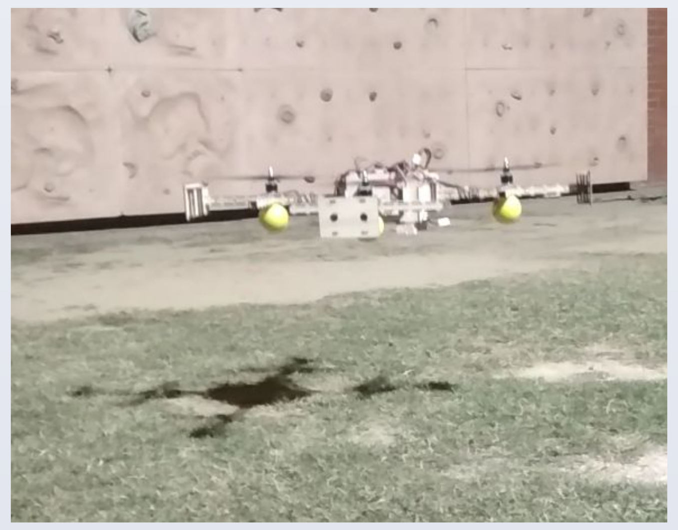

Figure 10

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[1] R. Oung, F. Bourgault, M. Donovan and R. D'Andrea, "The Distributed Flight Array," 2010 IEEE International Conference on Robotics and Automation, Anchorage, AK, 2010, pp. 601-607.
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[2] L. Meier, P. Tanskanen, F. Fraundorfer and M. Pollefeys, "PIXHAWK: A system for autonomous flight using onboard computer vision," 2011 IEEE International Conference on Robotics and Automation, Shanghai, 2011, pp. 2992-2997.
doi: 10.1109/ICRA.2011.5980229

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Flight video:
https://drive.google.com/file/d/1kdYxtvwSitWiluTpoQa8fBGeJ67cu5kQ/view?ts=5ac7c569