MultiBee Autonomous Quadrotor for the 2016 International Aerial Robotics Competition

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ABSTRACT

MultiBee team has designed an air vehicle for IARC 7and reports the detailed analysis of quadrotor in this report. Outdoor navigation systems have been easily accessible for a long while. MultiBee team for International Aerial Robotics Competition designed unique and creative solution for IARC 2016 without using GPS or SLAM technology. Our air vehicle preference is DJI M100 with the visual sensing system DJI GUIDANCE for safely cruising around the competition area. Our air vehicle is also contained with PIXY camera for rapidly detecting and enumerating ground robot.

1. INTRODUCTION

1.1 Statement of the problem

2016 International Aerial Robotics Competition is the third year of mission 7, that will be held in Atlanta, Georgia from August 2 to 4. Highly intelligent aircraft that can navigate indoor and interact with semi-random moving ground robots and herd these ground robots across the green line. UAV also must be able to keep away from obstacle robots.

1.2 Conceptional Solution

We would apply the mission with DJI MATRICE 100 with the visual perception system DJI Guidance. To navigate the UAV in 20*20 m area we will counter the grid lines both x and y direction. Aircraft will chase on the ground robot which one is selected because of its location for not making a route map in the area, attitude stabilization will be done by DJI N1. We would apply the collision avoiding with DJI Guidance.

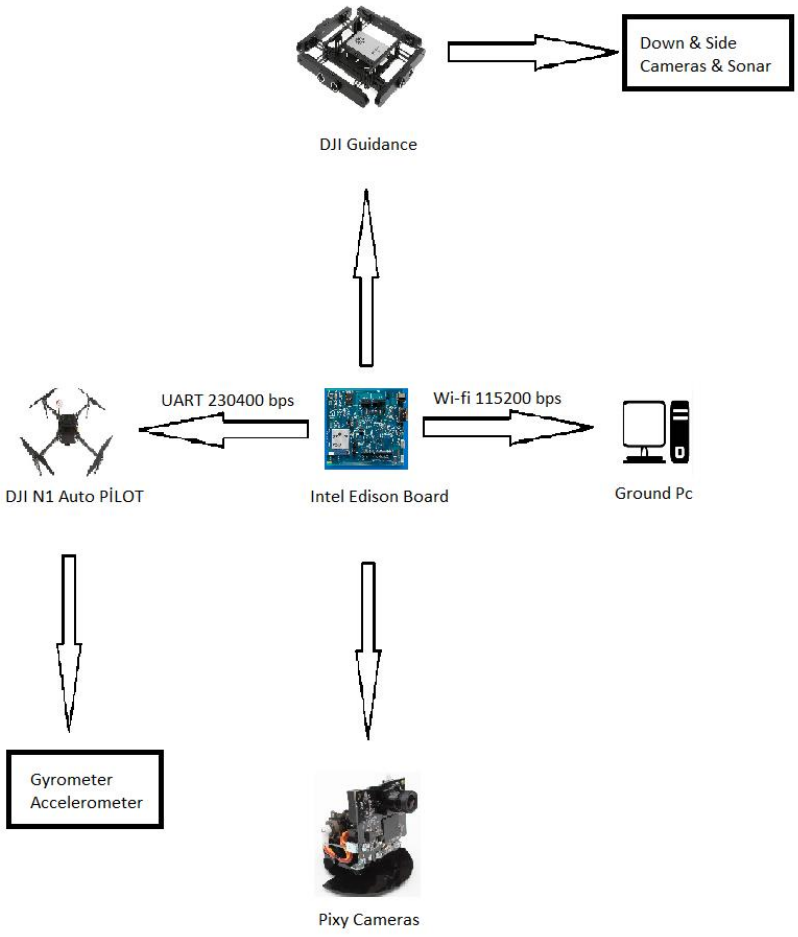

Figure 1: Figure of overall system

1.3 Yearly Milestones

MULTIBEE team is entering first time as a competitor to IARC. Navigational software has been designed to detect all ground robots simultaneously and selecting one of them to herd it through the green line then it will

2. AIR VEHICLE

A quadrotor is basically helicopter that is lifted and propelled by four rotors. Quadcopter uses two identical propellers that two of them clockwise (CW) and two of them counterclockwise (CCW). Building a quadrotor with identified qualities are depends on torque load, thrust/lift ratio, etc. In this part, the qualifications are used by selecting quadcopter.

2.1 Propulsion and Lift System

2.1.1 Frame

Four arm carbon fiber frame will be used in competition. Carbon fiber chosen because of high stiffness to weight ratio. Also carbon fiber arms have soft vibration absorbing material to reduce vibration and increase stiffness. Take-off and landing phase will be more stable using with spring landing gear. Frame can provide us extendable parts for increasing payload. Quadcopters wing span is 65 cm and +3 cm for protection cover. All of these qualifies supplies us adequate quadcopter for competition requirements.

2.1.2 Brushless DC Motors

In order to make the system more efficient, more trustworthy and less noisy the recent trend has been to use brushless DC motors. They are also lightweight compared brushed motors with the same output. DJI Matrice 100 has 4 DJI 3510 350KV brushless motors. When brushless motors are controlled and supplied, they need ESCs and we use DJI E680D ESCs.

KV (rpm/V):	350
Max Thrust:	2100 grams
Weight:	106 grams
Operational Voltage:	22.6 V
Stator Size:	35×10 mm
Recommended Battery:	6S
Recommended Propeller:	13*4.5 inch
ESC(A) :	20A

Table 1. Specifications of a brushless motors

2.1.3 Propellers

Each brushless motor has an own propeller. They are mounted, two of them clockwise(CW) others counter-clockwise(CCW) propeller the reason is that motor torque and physics law will make the UAV spin around itself if propellers rotate same

way. When propellers' diameter choose, two point is substantial. These are brushless motor KV (rpm/V) and thrust/weight ratio. For more stabilization and high thrust/weight tall propellers are more efficiency.

2.2 Flight Termination System

There are three ways to achieve flight termination. First way is the vehicle changed to manual pilot via RC transmitter and safety landing with manual control. There is also emergency button in our ground stations if someone click the button the vehicle will be landing to decided area. The third way is that the referee can switch off the device via the kill switch.

3. PAYLOAD

3.1 Sensor Suite

3.1.1 Target Identification Camera *Pixy (CMUcam5)*

One pixy CMUCam5 camera is mounted at the bottom of the quadcopter. Pixy is a fast vision sensor which can detect and distinguish the similar objects. When DJI N1 Autopilot keeping stable, pixy camera and pan-tilt mechanism make us sure we are chasing the identified robot

3.1.2 Navigation and Threat Avoidance Sensors *DJI Guidance*

Outputs rich sensor data, including ultrasonic sensors, images and IMU readings. These are provided on demand enabling us to explore unlimited usage of Guidance in indoor areas. DJI Guidance was used as a four obstacles in the arena turning around a 5-m Radius circle detection and avoidance. DJI Guidance which can sense the 3D World by calculating the dense depth images in real time. The depth of most pixels in the field of view are depicted to an accuracy of within a few centimeters. Although we can apply the safety distance option.

3.2 Communication

We have used UART which speed is 230400 bps, for communications beetween Intel Edison Board and DJI M100 autopilot. We have got Wi-Fi module which speed is 57600 bps, module for communications between Intel Edison Board and ground station. Wi-fi module provides us connection beetwen aerial vehicle and ground station.For Communications between Pixy Camera and Intel Edison Board we have used I^2C protocol. In order to communicate DJI M100 autopilot and Intel Edison Board we have used protocols which are based on DJI M100 data link protocol.

3.3 Power Management System

We have got four DJI 3510 kv motor in DJI M100 and we have got one ESC for each motor. In order to supply sufficent power to whole UAV system without Intel Edison Board and Pixy camera, we've selected 5700 mAh 22.8V 6S Lipo battery.Power distrubutor card which is supplied by 6S Lipo battery, distirbutes energy to each component without Intel Edison Board and Pixy camera. Intel Edison Board and Pixy camera energy demands are provided by 5V regulator which is supplied by 3S Lipo battery.

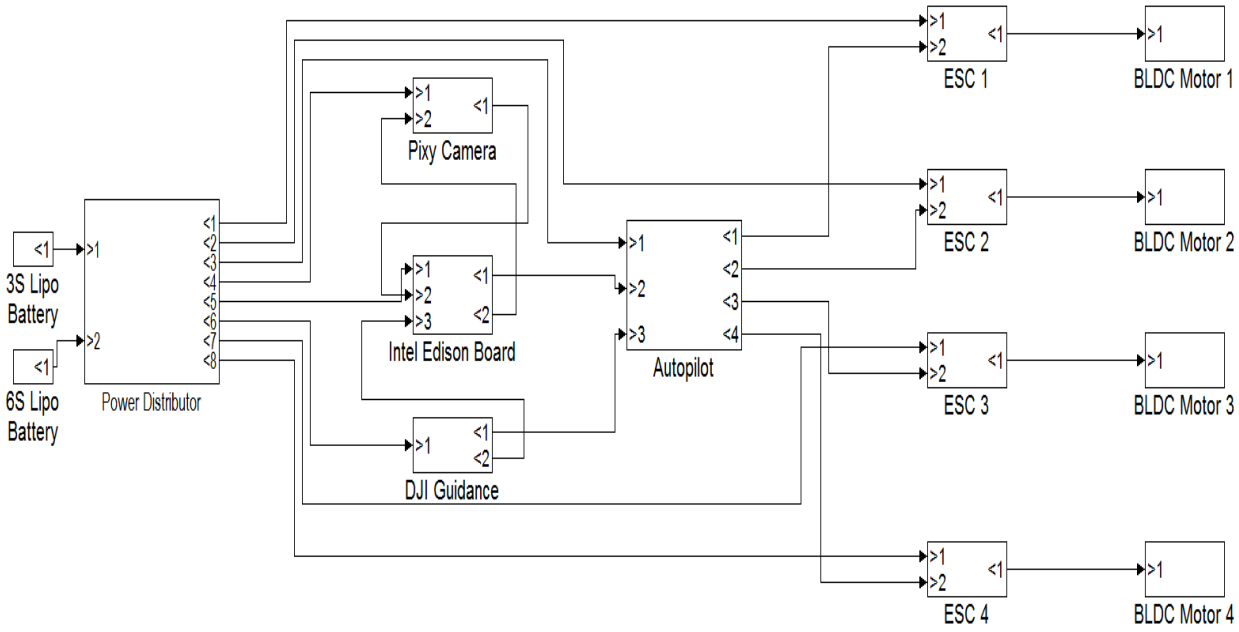

Figure 2. Figure of power management system

3.4 Sub Vehicle

There is no sub-vehicle

4. OPERATIONS

4.1 Flight Preparation

a. Check battery voltage level

b. Connect the ground station

c. Power up the guidance and matrice 100

d. Inıtialize the Wi-Fi network

e. Transferring the system, manual to autonomous mode

4.2 Man Machine Interface

MultiBee Graphical user interface(GUI) designed for three main applications. First of all, it manages to show all of the data's. These datas are containing location of quadrotor and camera, altitude data also it will show the battery level of quadrotor. Second role of GUI is transition between manual and autonomous mode. Last and critical role is system killing if it will be out of control. Information's of UAV will be recorded on ground PC during the competition.

5. RISK REDUCTION

5.1 Vehicle Status

Attitude, altitude, distance of nearest obstacle robot, velocity and video output will be streamed from air vehicle to ground station and displayed on ground computer.

5.1.1 Shock Vibration Isolation

To reduce vibrations, increase stiffness, and bring unmatched reliability, Matrice 100 is made of strong, lightweight carbon fiber. Each of the arms contains DJI's new soft vibration absorbing material that virtually eliminates feedback from the powerful motors, keeping your critical components stable and allowing unprecedented accuracy.

5.1.2 EMI/RFI Solutions

Sending informations to ground computer for processing and transmitting it back to onboard computer then to controller is complex because of RFI. For this reason, we will process all data with onboard computer, Intel Edison supply all data easily.

5.1.3 Software Risk Reduction

Software reliability is accurate in current tests.

5.2 Safety

The cage structure will encircle the four propellers to prevent people from fast spinning propeller.

5.3 Modeling and Simulation

MultiBee UAV team is using Creation Optimization Motivation Brilliance Studio's simulation model for competition strategy designing.

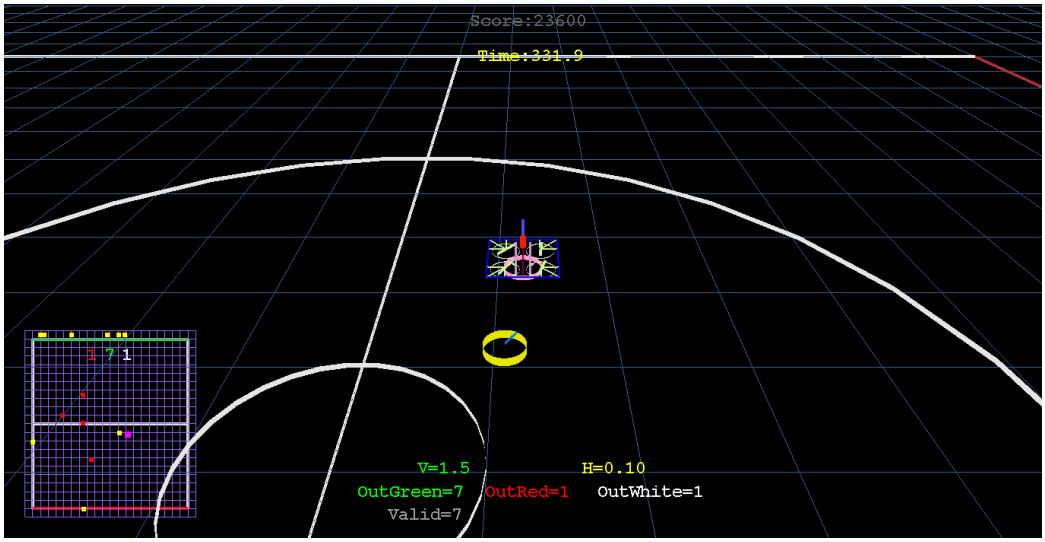

Figure 3. Simulation model

5.4 Testing

In order to test the performance of quadrotor we will use 10*10 m indoor square area. We have 6 IRobot Create 2 for making the conditions similar to completion rules. We would apply our stabilization, algorithm tests this corresponding area.

6. CONCLUSION

MultiBee UAV Team has designed and constructed a fully autonomous air vehicle system which is capable of navigating in an indoor area with a simple and creative solution. We are currently testing the air vehicle for herding the ground robots in the limited time.

Acknowledgements

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7. REFERENCES

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[2] DJI Guidance documentation retrieved from *http://www.dji.com/product/guidance*

[3] PIXY CMUCAM5 documentation retrieved from *http://charmedlabs.com/default/pixy-cmucam5/*