Project: Drone

Introduction

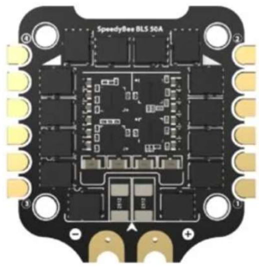
Mobility has been a major driver for engineering growth. Therefore, any project related to a mobile equipment will excite the students, more so a flying one. The significance of drones and the excitement they give to both the young and old need no emphasis. Therefore, the students are to develop a drone of about 500mm in this course. While students will successfully develop, test and fly a drone safely under our guidance in this course, students will continue, during their remaining period here as well as in future, to build on this exposure to come up with innovative & groundbreaking configurations in terms of structures (geometry & materials), kinematic configurations, size (toy to ambulance), endurance (nonstop range & duration), level of control (manual to total autonomy and power plants (battery to IC engines to Fuel Cells and their hybrids). Students will also come up with great applications.

Figure 1 Drone

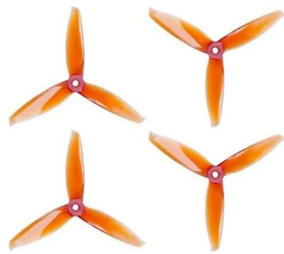
List of the parts involved in the making of Drone

The following is the list of parts involved in the making of a quadcopter drone of <500mm superscribing circle.

BLDC Motor



ESC

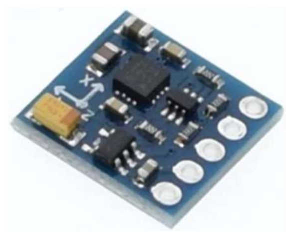


Propellers

Battery

Charger

Sensor - IMU

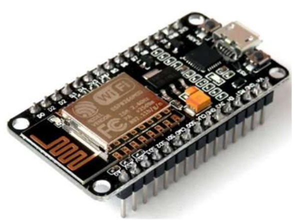


Sensor - Compus

Sensor - GPS

Sensor - Barometer

Arduino Uno



WiFi unit

Control screen on phone

Figure 2 List of the parts involved in the making of Drone

Safety Protocols

- Propeller guard shall be mandatory.
- Testing will be done only indoor.
- Height shall not exceed waist level.
- There shall be a minimum of 3m distance between the drone being tested and any human being.
- At least 2 persons shall be present during any fabrication, assembly or testing.
- Only one will operate at any time.
- Talking with the pilot will be to the absolute minimum.
- Throttle shall be at zero and disarmed condition before powering.

Specifications of the items involved in making of the drone

Sl. No.	Item & Specification	Qty
1.	BLDC Motor: A2212 10T 1400KV Brushless Motor	4
2.	Electronic Speed Controller (ESC): SimonK 30 A	4
3.	CW & CCW propellers pair: Orange HD propeller 1045 pair (10” dia x 4.5” pitch)	2
4.	Battery (LiPo 3S): Bonka 2200mAh	1
5.	Charger (3S): IMAX B3 AC compact balance charger for 3S	1
6.	Sensor: Inertial Measurement Unit (IMU): MPU-6050 3-axis accelerometer and gyro sensor	1
7.	Sensor: Magnetic sensor (compus):	1
8.	Sensor: Geographic Positioning System (GPS): NEO-6M GPS Module with EPROM	1
9.	Sensor: Pressure sensor:	2
10.	Onboard micro-controller: Arduino Uno	1
11.	Onboard WiFi unit (2,4GHz):	1
12.	Transmitter on ground (Smart phone of the students): Suitable "android" app to create the control screen is required. These are available in public domain. Students can also develop them.	1
13.	Structure: To be fabricated by the students	1
14.	Cables including a USB cable and connectors:	1

At the end of the course, the students should submit a PPT consisting of several photographs and videos of their drone. After the final evaluation, students may be asked to dismantle and return the items so that the parts can be stored for use in the next semester. The grades of the students will be declared only after the students return the parts/drone issued to them.

Methodology

3 rotations (roll, pitch and yaw) and throttle are the 4 manoeuvres in any flying object. While these are achieved through control surfaces in planes, the same are using differential & dynamic pitch of the rotating main and tail rotors in helicopters. Unlike these, the blades of the drones have fixed pitch and the 4 manoeuvres are achieved by the dynamic control of the speeds of the rotors. Therefore, drones are far more robust and reliable. The multiple rotors of the drone permit wide CG variations. Drones typically use pairs of CW & CCW rotors in order to balance their torque reactions mutually. The manoeuvres in the drone is achieved by the speed control of the fixed-pitch propellers.

<u>Issue of materials in the beginning</u>

The students will be issued the following with appropriate entry:

Sl. No.	Item	Qty
1.	Motor	4
2.	ESC	4
3.	Propeller pair	2
4.	Battery	1
5.	Charger	1
6.	IMU sensor	1
7.	GPS sensor	1
8.	Magnetic sensor	1
9.	Pressure sensor	2
10.	USB cable	1
11.	Miscellaneous cables as required	-

Structure:

Building the structure is very challenging which will test whatever students have learnt in design and manufacturing. Students need to use their innovations to decide the configuration and suitable positions and mountings for Landing gears, propeller guard, motor mounts, ESCs, battery, micro-controller, sensors and WiFi receiver. Structure optimization has influence on safety, endurance, payload, maneuverability etc. Students should go through trade journals, Internet and brainstorm a lot on various aspects. Some sample questions are:

- How is the flight dynamics? Does it enjoy Newton's 3rd law right from take off? Or, does it suffer ground effect?
- How can we define a drone or distinguish it from other flying objects?
- Is it necessarily electric?
- What is the minimum number of rotors to build a drone? Should it be necessarily even?
- Drones typically fly as X. Why not +?
- Can motors act as landing gears?
- Can the propeller hubs be used as the landing gears?
- Should all propellers be below the structure or above or inbetween?
- Should the ESCs be closer to the motor and below the propellers for generous cooling?
- Propeller guard is very essential but is a dead weight that reduces endurance and payload. So, it needs to be optimized for the safety of the propellers and the people around. What should be the geometry of the propeller guard? Should it cover the propeller 360^{o} or partial? How will it be vertically and how thick should it be? If it is broken, how will it be quickly replaced?
- Should the structure be made of circular tubes or other sections? Should it be milled? Should we use sheet metal and bending? What should be the material?

Students should make the mechanical design of the structure in CAD. This will involve several iterations. Students will start the fabrication only after the mentor and instructor approves the design.

Control:

Each of the 4 manoeuvres are related to a control surface in plane and same with the different pitch controls in helicopters. But any of these manevres requires speed control of all rotors. Therefore, each of the 4 joystic controls of the transmitter cannot be mapped onto a rotor speed. Therefore, the drone has to have onboard sensors to infer attitude (IMU), yaw (magnetic sensor), altitude (pressure sensor) and speed (pressure sensor). This dynamic sensory data is used in the control logic to determine the differential speeds of the propellers. The control logic can be simulated using packages like Simulink of Matlab. Fortunately, these control logics are well-established today and are available in flight controllers such as A3 or PixHawk. However, as we will use Ardino, a generic micro-controller, these control logics have to be embedded by the students. This too is not so difficult, thanks to the public domain software and freeware.

We shall not use expensive transmitters with joysticks for the control. Instead, the students shall use their mobile phone to control the drone. Students will have to develop suitable Android app to create the screen and communicate with the WiFi of the drone. A lot of Android freeware too are available for this purpose.