# Electronic Control of the Midair reconfiguring Drone

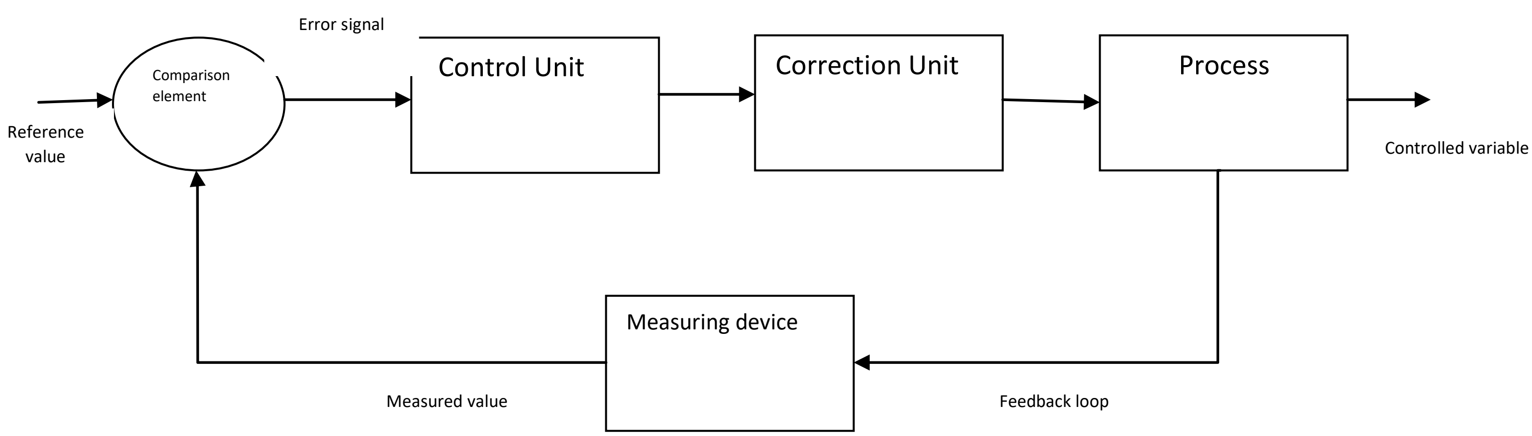
The main control components of the drone would be

- A flight control interface that controls the entire functioning of the drone which include

a) Maneuvering ie, executing motion about the 3 axis, namely pitching, yawing and rolling
b) Hovering, ie holding a particular altitude and flying stably
c) Switch between the quad, hexa and octa configurations in mid-air. This includes raising/lowering the arms of the zero torque groups; starting and stopping the motors and giving necessary control inputs to the speed control units to execute stable flight in the different configurations.

- 8 Electronic Speed Control (Esc) units to control the speed and to alter the speed of rotation of the motors to necessary speeds.

The control of the flight control unit can be explained by a simple closed-loop model system as sketched below.

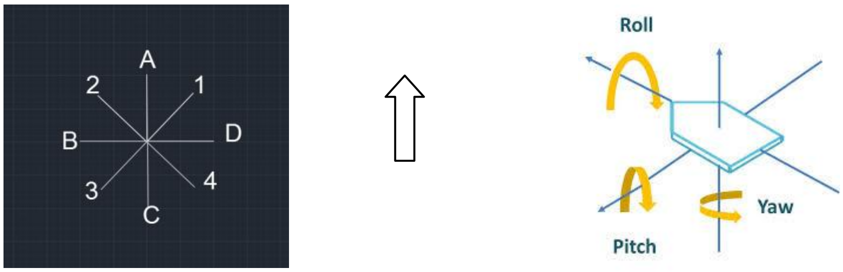



The various components of the closed loop are as listed below.

1) **Controlled Variable** : The speed of the motor is the controlled variable
2) **Measuring device** : It includes the various onboard sensor systems that obtain the altitude, axial orientation, force acting etc on the drone at each instance of time
3) The **comparison element** is the onboard computer that process and compares the set and measured values. It calculates the error in the values and sends it out to the control unit.
4) The **control unit** is again the on board computer that sends out correction inputs
5) The **correction unit** consists of the ESCs which help alter the speed of the motor according to the need.
6) The **process** that causes the flight control board to function is either
   a) The inputs given by the operator

b) The inputs due to unstability that arises when moving from one orientation to the other
c) The inputs that are given to change the configuration of the drone from Quad to Hexa to Octa and viceversa.

## Control algorithm for the escs of each motor




The above schematic represents the numbers and alphabets of the motors as viewed from the top. The direction of the arrow is the direction of forward flight of the drone.

Motors 1,2,3 & 4 are the main motors that function during all the 3 different configurations. They basically represent the conventional X-configuration Quadcopter, wherein motors 1&3 have a Counter Clock Wise (CCW) rotation and motors 2&4 have a Clock Wise(CW) rotation.

Motors A&C and B&D consist the zero torque group. As proposed, these 2 groups would contribute predominantly to the lifting and stability factor of the drone alone.

The 3 motions of the drone about its centre of gravity would be, pitching, rolling and yawing. Apart from this the thrust input needs to be provided for each motor. Given below is the exact control inputs that need to be provided for each of the 8 motors.

A. Quad Configuration.

   Motor 1 i/p = Thrust+Pitch+Yaw+Roll

   Motor 2 i/p = Thrust+Pitch-Yaw-Roll

   Motor 3 i/p = Thrust-Pitch+Yaw-Roll

   Motor 4 i/p = Thrust-Pitch-Yaw+Roll

B. Hexa Configuration

In this configuration arms B&D will be actuated. One motor will spin in CCW direction, say B, while other in CW, say D, contributing a net zero torque about the centre.

Apart from the thrust input we also give a roll and yaw input to these motors. In This way we can obtain a greater degree of stability apart from the thrust capacity of the quad configuration. Therefore the control inputs of the motors B & D would be

Motor B i/p = Thrust+Roll+Yaw

Motor D i/p = Thrust-Roll-Yaw

C. Octa Configuration

In this configuration the arms A&C will be actuated. Let's have A in CCW and C in CW spin directions. Similar to the hexa they will constitute a zero torque group at most times and will contribute to lift. Apart from this they will have pitch and yaw inputs to provide more stability. The control inputs for them are

Motor A i/p = Thrust+Pitch+Yaw

Motor C i/p = Thrust-Pitch-Yaw

**<u>Control Unit Operation</u>**

Arduino UNO which has ATmega328P IC is used as the main controller. This is because the output given by receiver module will be either 0V or 5V which equals to the operating voltage of the above mentioned arduino board and also the clock frequency is 16Hz. The arduino will take input from receiver as PWM signals. By using that it will calculate the corresponding ADC value. Another set of values will be coming from the gyro and by combining those two values the arduino will provide an output waveform in form of PWM signals which is fed into the escs and dual shaft servos.

**<u>Communication between the ground and the Drone</u>**

<u>Initial Phase</u>

As an initial way we could fabricate the drone to operate from inputs obtained from a transmitter (T/X) receiver (R/X) modules that are used popularly in the RC hobby. The reconfiguring input would be connected to one of the Auxiallary channels of the T/X such that when a switching input is given it reconfigures mid air.

Flight control unit that controls the quad motors and the dual shaft servos that actuate the arms

Final Phase of Development

The actual problem statement that was provided wherein a farmer can utilize this product for spraying pesticides or this drone could be used to drop necessities during times of floods or so cannot be solved by a drone that is operated by humans. Therefore the drone must be automated.

The automation algorithm that we came up with is

a) To ensure that the drone is capable of carrying a variable payload

   To do this we will couple the output of the 9axis IMU sensor which gives the downward weight to the control unit.
   Assuming that the drone is moving from the octo to hexa and quad configuration, the control algorithm to be followed will be,

   Let the thrust produced by all motors at any point be T.

   Let $T_8$,$T_6$ and $T_4$ be the max thrust produced for the octa, hexa and quad configurations respectively

   Now the max payload of the quad in any configuration would be such that, 50% thrust of motors produced **in that configuration** would be sufficient for hovering the system.

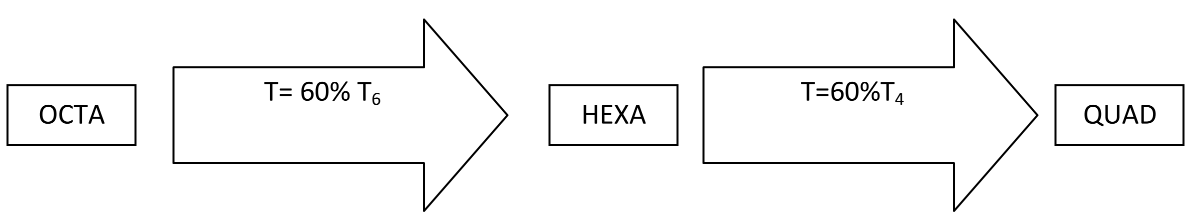
- Octa to hexa

   Now initially, T= about 75% of $T_8$, this is to indicate that the drone would be lifting of with an initial payload which is 75% of $T_8$.
   As the payload decrease, the value of T decreases.
   When T= 60% $T_6$, the motors in arms A&C stop spinning and the arms lower. Now while this transition occurs, the flight control board would ensure that the stability is maintained.

- Hexa to Quad

   Similar to above, when the T=60%$T_4$ the motors in arms B&D stop spinning and the arms are lowered.

   In this way the Drone is able to switch automatically between configurations while carrying a payload.



b) To ensure the drone is capable of executing stable flight in unstable weather conditions

To execute this, we will equip the flight control board to switch directly to the octa configuration form the current configuration, irrespective of quad or hexa, when an unstable condition is encountered.

To decide the unstable conditions, we will be relying on the roll and pitch inputs that the drone experiences which are obtained from the gyro. We will be defining 2 threshold values one to change the configuration to make it compatible to the unfavorable situation 'ON', and one to revert back to the original configuration once the conditions get back to favorable 'OFF' .