## TASK 2-Basic Electronic Components

### 2.1 Electronic Components

**Flight Controllers**

A flight controller is the "Brain of the drone". It's the component where all the sensory information is inputted and it outputs a stable flight.

It's like a CPU in computers and laptops (Just like how a processor is responsible for processing data and is called the "Brain of the computer")

All the drone's hardware will plug into the flight controller. With all of it plugged, it acts as the ideal hub where it can fuse sensory input and output a steady flight.

**Working Principle of FCs**

The flight controller runs a special software (ArduPilot or Betaflight) that reads data from its sensors. It then processes the data several times to understand the drone's orientation. This orientation is then compared to the desired state and then the drone makes the necessary adjustments to achieve the desired state.

**Use-Cases**

- Stabilizing flight
- Autonomous Navigation
- Acrobatic Maneuvers

**Advantages**

- Provides stability needed for flight
- Able to integrate multiple sensors in one drone
- Highly configurable

## Limitations

- Limited processing power for high-level tasks
- Sensitive to vibrations which can reduce performance

## Integration Challenges

- Connecting all peripherals such as ESC,GPS and OC to correct ports can be complex
- Figuring out dampening techniques to reduce impact of vibrations (as sensitive to it)


## Electronic Speed Controller

An Electronic Speed Controller (ESC) is an electronic device that is responsible for regulating and managing the speed of the drone in response to signals from the flight controller.

## Working Principle

The ESC works by switching the flow of power to the motor on and off. This process is known as Pulse Width Modulation which allows precise control over the motor's speed. The longer the pulses of electricity, the faster the motor will spin and faster the drone will fly.

## Use-Cases

- Maintaining the motor on a multirotor at a precise speed
- Changing the speed of rotor

## Advantages

- Makes the motor control and management efficient
- Modern ESC can provide data such as RPM, Temp and current back to FC

### Limitations

- Can overheat under high loads thus requires ventilation
- Low computational capacity which affects the maximum achievable speed of motors

### Integration Challenges

- Must be calibrated so that FC's signal is interpreted precisely.
- Managing increased moment of inertia due to ESCs being mounted away from the center of the drone

### Global Positioning System

GPS is the system that is used in drones to allow it to navigate its environment and determine their precise geographical location.

In today's world GPS is extremely common, being used in apps like Google Maps, Order Tracking and Ride services. With the help of GPS, a drone can fly with complete freedom, follow predefined routes with precision and maintain a stable flight.

### Working Principle

The GPS works due to a network of satellites orbiting the Earth that transmits signals to receiving devices, which use these signals to determine the exact location on the planet.

### Use-Cases

- Navigating the way in unknown environments
- Determining the location of the drone

### Advantages

- Enables autonomous flight over large distances.

- Important for recovery if drone is lost

## Limitations

- Requires a clear signal from satellites
- Standard accuracy can be several meters

## Integration challenges

- The GPS system can be affected by electromagnetic interference from wires in drones
- The drone must be still for a period of time to acquire signal from the satellite

## Onboard Computer (NVIDIA Jetson)

Onboard computers (or also known as Companion computers) is a device whose role is very similar to the flight controller. It processes data from GPS, cameras, and other sensors to control flight paths, stability, and mission-specific tasks.

 A Flight controller is responsible for the fundamental aspects of flight: stability, navigation, and responding to pilot commands whereas much complex tasks require companion computer systems.

Among the most powerful and popular of these is the NVIDIA Jetson series, which brings the power of Artificial Intelligence and computer vision to the skies.

## Working Principle

The onboard computer runs a software (Linux) on it just like the flight controller and takes in data from sensors (like LiDARs, Depth Cameras and Optical Flow Sensors), processes this data accordingly and then sends commands to FC for execution.

**Use-Cases**

- Drone can avoid obstacles due to sensors detecting it
- Using camera to navigate in case GPS is not working

**Advantages**

- Brings desktop-like computing power in a drone.

**Limitations**

- OCs generally consume a lot of power which affects flight time
- Since they are power hungry, they also generate a lot of heat

**Integration Challenges**

- Requires a reliable communication with the FC
- Needs a good and reliable power source

## *2.2 Sensors*

**LiDARs**

LiDAR (also known as Light Detection and Ranging) is a sensing

technology that uses lasers to measure distances and created detailed 3D models of the surroundings. When used in a drone, it becomes a handy tool for capturing precise spatial data.

It works by emitting a pulse of laser towards a target and measuring the time it takes for the light to reflect and return to the sensor. These pulses are emitted in a sweeping pattern in a circular radius to get an accurate data.

**Depth Cameras**

Depth Camera is an important tool in drones where it captures a 2D image where each pixel stores a value which represents the distance of that pixel from the camera. This gives the drone an idea of how far each point in the image is.

Depth Cameras are crucial for navigating in a cluttered environment and in environments where GPS is not available.

## Optical Flow Sensors

An Optical Flow Sensor allows a drone to hold its position relative to the ground without a GPS. It works with the help of a small, low resolution camera pointed downwards that captures the images of the ground and tracks the movement of drone relative to it. It then calculates the speed and distance needed to maintain that position relative to the ground. This tool is important for maintaining height and low-altitude flights(GPS signal might be weak at low altitude).

## IR Sensors (from Oscar Liang's Articles)

An Infrared Sensor consists of an emittor and a detector. The emittor sends out IR beam of light which bounces back after reflecting off a surface and then is detected by the detector that calculates the distance between the sensor and the surface based on the time taken by the beam of light to reflect. This working principle is very similar to the one seen in LiDARs.