CHAPTER 1

INTRODUCTION

The project is to design an autonomous flying drone, specifically a quadcopter. The drone is fitted with a GPS tracking system and programmed to be able to autonomously fly from one location to another using GPS coordinates. Significant consideration is given to safety and ruggedness due to the possibility of collision with a variety of objects. In addition to collisions, the drone is also rugged enough to operate during moderately windy conditions. The goal of the project is to act as a proof of concept for small scale autonomous aerial vehicle which could work as a modular drone which can be used for any purposes without a full customization. This drone can be used in almost every area. For example it can be used as a delivery drone as well as a survelliance drone in agricultural field.

We built an autonomous control system for a drone that tracks and follows an object. Our system is capable of switching control of the drone between the Raspberry Pi and a handheld radio controller as well as switch between hover and autonomous flight where the drone follows a red object below it. The Raspberry Pi 3 is used as the decision making unit to read data from multiple sensors and control outputs from a PWM generating chip to the onboard flight controller using a relay. We successfully integrated the necessary hardware to control the quadcopter and track a target. Additionally, we met the goals we set for ourselves within the scope of the embedded system.

There is a wide range of applications for Unmanned Aerial Vehicles that have been made possible through recent advancements in technology. One application uses a quadcopter for surveillance of a region. In this project, we attempted to automate a quadcopter for tracking targets. The goal was to have the quadcopter continuously follow and hover directly above the target at a predetermined height. And for avoiding the obstacles in the moving path. Drone

Is also modular which means it can the re programmed from any where in the world for any purposes.

CHAPTER 2

LITERATURE REVIEW

In recent years, unmanned aerial vehicle (UAV) and micro aerial vehicle (MAV) have been an active area of research. They have been used for military applications but also are useful for many civilian applications such as terrain and utilities inspection, disaster monitoring, environmental surveillance, search and rescue, and trac surveillance. However, most of them are still semi-autonomous and guided by human who is not on board. There are lots of challenges to turn an UAV into fully autonomous control. The control of UAV during autonomous flights relies on knowledge of variables like position, velocity and orientation, which can be partly calculated using information provided by on-board inertial sensors. However, the drift of inertial sensors leads to errors during time-discrete integration, making a steadily accurate estimation of the absolute pose nearly impossible. Therefore, an absolute reference is needed. An early autonomous navigation system for a model-scale helicopter (the Hummingbird) was developed at Stanford University (Conway, 1995). The unique feature of this system was the sole use of GPS as the navigation sensor replacing the Inertial Measurement Unit, which is conventionally favored as the primary navigation sensor. However, indoors, the GPS will not be available, where a visual tracking system could be applied. In (Gurdan, Stumpf, Achtelik, Doth, Hirzinger, & Rus, 2007) a position controller for a quadcopter was implemented using an optical tracking system by VICON in the Holodeck lab at MIT. This intelligent space is nevertheless very expensive and not transportable. A notable vision-based technique used in autonomous 4 helicopter control, the visual odometer (Amidi, 1996), provides accurate navigational information such as position and velocity which is then combined with inertial measurements. However, outdoors, it still needs GPS for positioning. While several techniques have been applied for vision-based control of UAVs, none of them have shown an fast, fully on-board vision-based control and positioning system. Our approach, presented here, di↵ers from prior approaches in three ways. First, our vision system is real-time with low latency image processing (30 FPS). Hence, the UAV positioning can be done very fast and accurately. Second, the front camera vision system has a FOV of 178 which can easily detect object in a large range. Third, our autonomous control system works both indoors and outdoors without relying on any other external positioning devices like GPS.

CHAPTER 3

BLOCK DIAGRAM

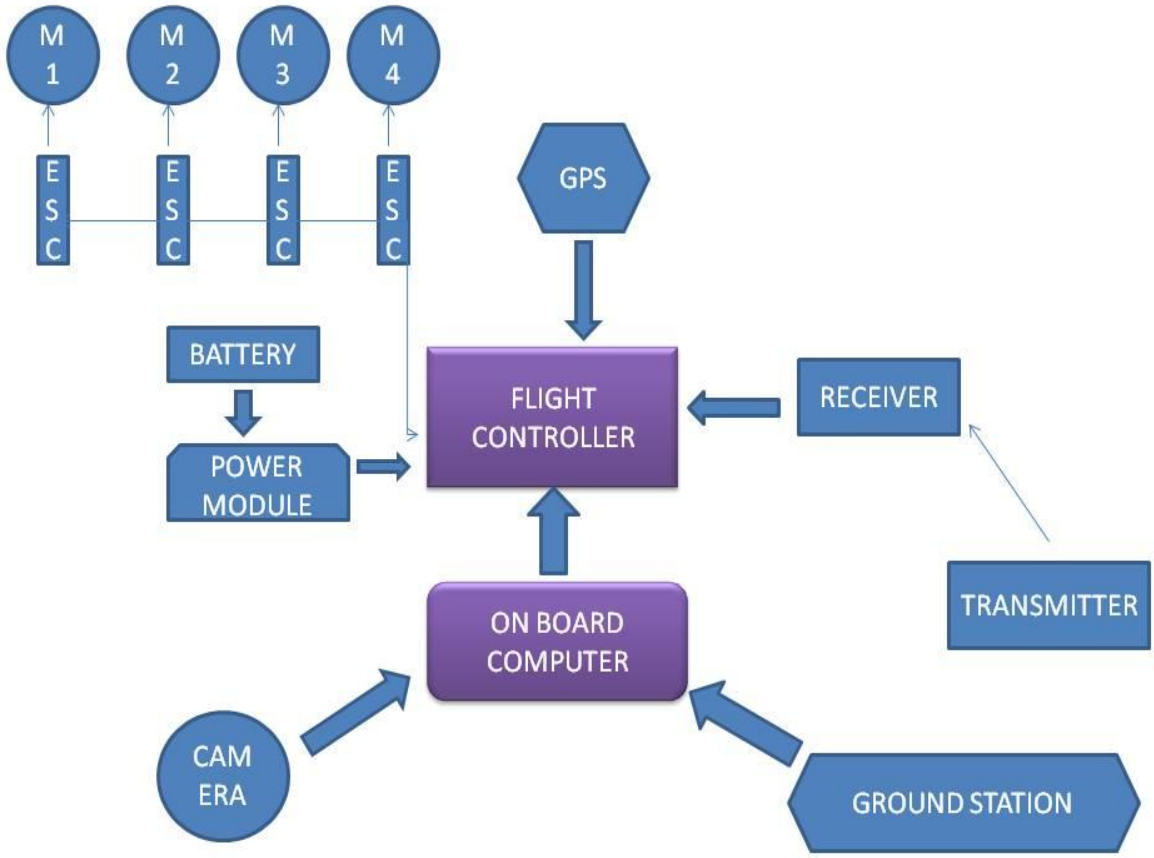

Fig 3.1 Blockdiagram of autonomous drone

3.1 DETAILED DESCRIPTION

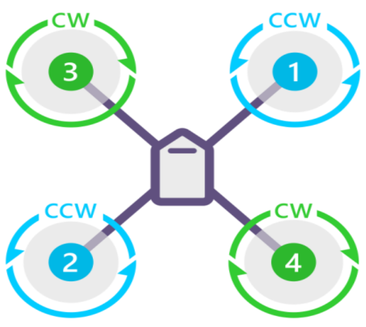

Fig 3.1.1 quadcopter

The quadcopter (or quadrotor) represents one example of an emerging class of vehicles called MAVs (Micro Air Vehicles), which are a subclass of the vehicles called UAVs (Unmanned Aerial Vehicles). Like other MAVs, the quadcopter has already demonstrated myriad applications. First designed a century ago, modern quadcopters have evolved into small, easily maneuverable vehicles. Having proved their usefulness in aerial photography, current experimentation is allowing quadcopters to communicate intelligently with other intelligent machines, to investigate unexplored environments, and to maneuver in dense surroundings with speed and precision. These recent advances will allow quadcopters to be adapted to long-term surveillance and serve invaluably in search-and-rescue missions. Furthermore, if innovative developing technologies are combined into the quadcopter, it will be capable of advanced autonomous missions that are not currently possible with any other vehicle. (Johnson, 1994.) Any type of UAV is popularly called a drone, though the term actually refers to any type of robot-controlled vehicle – in the case of a UAV, one that flies, but drones may also refer to other types of robot-controlled vehicles which operate on land or under water. The quadcopter is a subclass of UAVs, which are divided according to their type of flight. In the copter-type vehicles, the propellers are arranged vertically and thus flight is due to the thrust of the propellers, whereas fixed-wing UAVs fly like a conventional airplane with the lifting force caused by the shape of the wing. The quadcopter has four motors mounted on the four arms of the frame, with each arm positioned at a 90-degree angle to the others. There are two sets of CW and CCW propellers mounted on the motors to create opposite force and thus avoid unwanted rotation during horizontal flight.

Fig 3.1.2 Autonomous Drone

CHAPTER 4

MECHANICAL DESIGN

The quadcopter's most visible component is its frame, which must be strong enough to withstand the varying degrees of stress exerted on it during flight. At the same time, the frame must be lightweight in order to reduce the load on the motors and to increase flight time. There are three main axes of movement, for which the standard aerodynamic terms are pitch, roll and yaw. The following figure illustrates these axes as they apply to a fixed-wing airplane.

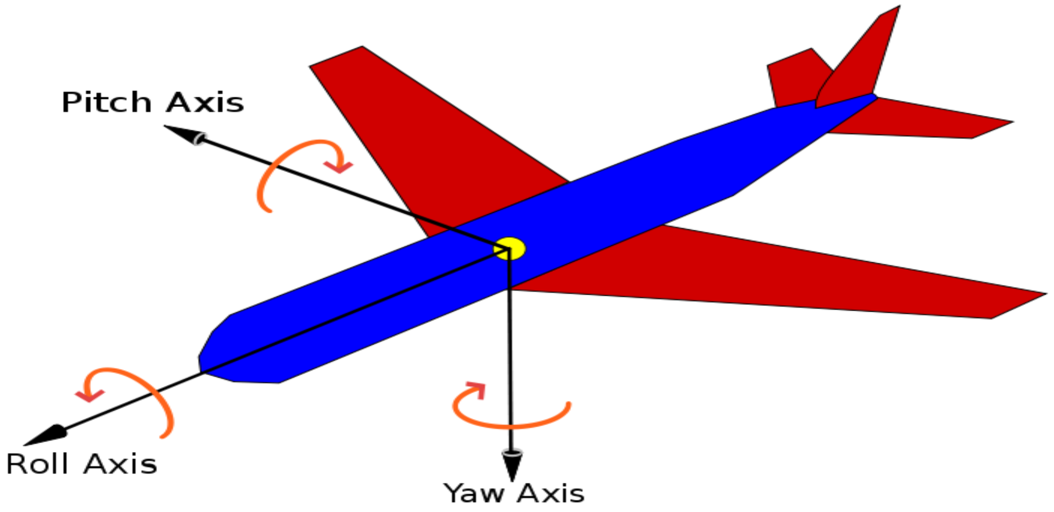

Fig 4.1 Axis Movement

A quadcopter differs from other aircraft designed for vertical takeoff and landing in that the pitch, yaw and roll axes are controlled by the pilot applying varying degrees of thrust between the four motors. As quadcopter uses four motors with four propellers to create thrust and give lift, two of the motors must rotate clockwise and the other two anti-clockwise. Thus, with two pairs of motors, this configuration results in the torque from one motor being equal to that of the corresponding motor rotating in the opposite direction. (Pri, 2015.) To make a motor rotate clockwise or anti-clockwise on the yaw axis, the corresponding pair of motors must increase their rotation speed. If the pilot-controller directs the craft to tilt to the right or to the left, the corresponding pair of motors must start to spin faster.

Throttle control is carried out by increasing or decreasing the rotation speed of each set of the motors. Figure 5 demonstrates the various quadcopter movements that result from changing motor speeds. Direct-current brushless motors are usually chosen to power model-sized quadcopters because they produce minimal friction as compared to brushed DC motors. They are also more effective due to their high-speed range and high power output. With this type of motor, a special controller, called Electronic Speed Controller, is mandatory. The ESC is used in DC brushless motors to control the rotation speed by changing the PWM signal coming from the transmitter and converting it into tri-phase AC power output. The subsequent chapters will present detailed descriptions of the motors and ESCs.

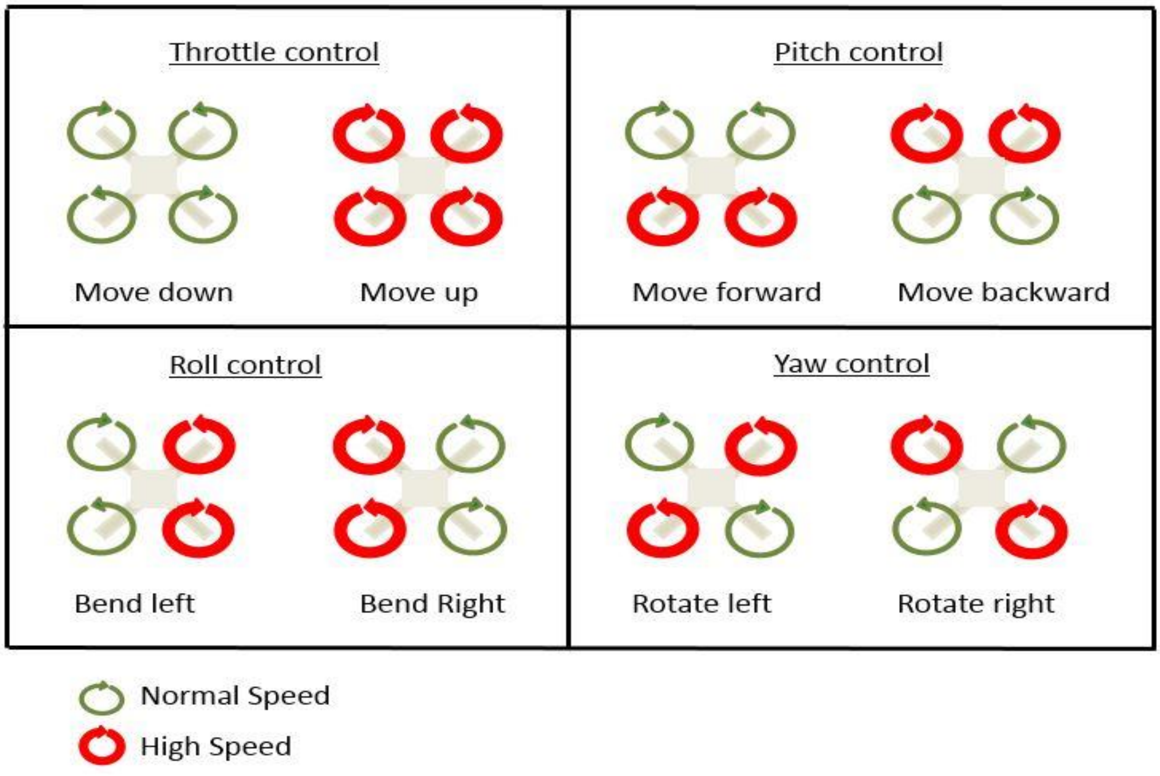

Fig 4.2 Varoius Quadcopter Movements

CHAPTER 5
HARDWARE AND SOFTWARE DETAILS

5.1 FRAME

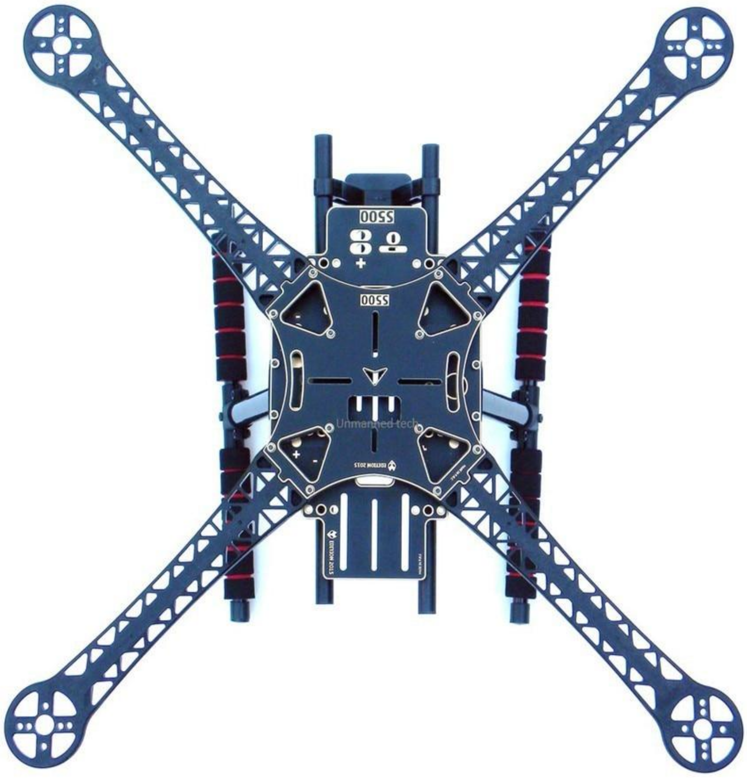

Fig 5.1 Frame Of Drone

The main great advantage of this frame is the arms have a slight upsweep, this gives the Quadcopter a dihedral effect which helps to make it very stable, especially when descending from altitude. The arms have a carbon fibre rod through the centre for making the strongest arms we have seen to date in this style of frame. The Blue and black arms make orientation much easier and there is no need for different colour props.

This S500 Quadcopter Frame is made from Glass Fiber which makes it tough and durable. They have the arms of ultra-durable Polyamide-Nylon which are the stronger moulded arms having a very good thickness so no more arm breakage at the motor mounts on a hard landing. The arms have support ridges on them, which improves stability and provides faster forward flight.

It has an adjustable battery mount to achieve the perfect weight distribution and the bottom frame is ready to take a whole host of camera mounts and gimbals making it perfect for FPV and filming projects.

The S500 has strong, light, and have a sensible configuration including a PCB(Printed Circuit Board) with which you can directly solder your ESC‘s to the Quadcopter. So, making the Quadcopter build fast and easy. So, it avoids the use of extra PDB(Power Distribution Board) and makes the mounting clean and neat. The S500 Quadcopter Frame is highly flexible frame during mounting of various components like flight controller, battery etc.

The frame has the wheelbase of 500mm and weighs around 400gm. It features mounting tabs at the front and rear end on the bottom plate of the mainframe for mounting cameras and other accessories.

The landing gear has the ground clearance of 200mm and allows the mounting of the camera and other accessories at the bottom of the mainframe. The landing gear has plenty of height making it suitable for gimbals. The Plastic Landing Gear can withstand sudden crashes during flying of FPV Quadcopters.

The added lift capacity makes this frame ideal for carrying larger payloads such as camera systems and other electronic components.

The frame comes with pre-threaded brass sleeves for all of the frame bolts, so attaching the arms to the mainframe is done within few minutes. Also, it requires one size of bolt for the overall build and thus a unique one-size hex wrench which makes hardware mounting very convenient. This feature of S500 Quadcopter Frames makes them so easy to assemble and disassemble

5.2 BRUSHLESS DC MOTOR

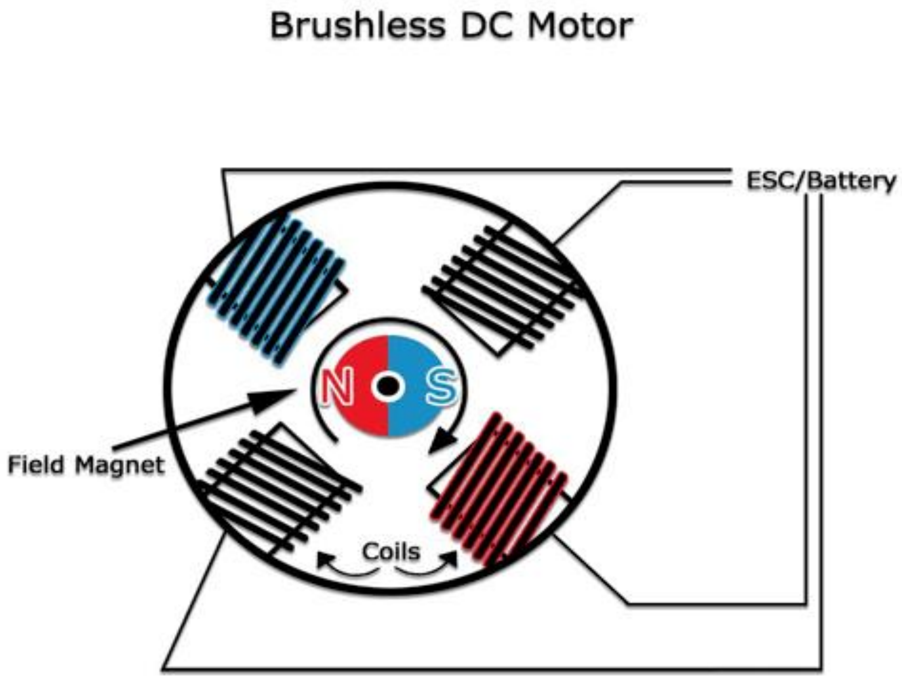

Fig 5.2.1 Brushless Dc Motor

The brushless motor can be effectively divided into two separate components; the rotor and the stator. The stator is the central unit into which the rotor is mounted. The stator is made up of a network of radial electromagnets that alternatively power on and off to produce a temporary magnetic field when a current is passed through the windings. The rotor holds a collection of permanent magnets which are positioned in close proximity to the semi-permanent stator electromagnets. Attractive and repulsive interaction of the stator and rotor magnets is translated into rotational movement. When assembled, the shaft of the rotor is inserted into a pair of ball bearings located in the stator that maintain linear, smooth revolution of the rotor.

Although the brushless motor is powered by DC current, it can't be driven directly. Instead, the brushless motor is wired to the control electronics, effectively eliminating the need for brushes or a commutator. Longevity of the brushless motor is excellent as there is no physical contact between the rotor and the stator. The brushless motor is also more efficient than the brushed motor. The brushless motor is extensively used in mini and some micro multicopter applications, where high power outputs and efficiency are prioritized.

Motor Sizing and Identification

The size of a brushless motor is identified by a four-digit code that details the dimensions of the stator in millimeters, for example: 2206. The first two numbers in the series determine the diameter of the stator, in this case, 22mm. The final two describe the height of the stator, the last two numbers in this series are “06” therefore the stator unit is 6mm tall. It is important to remember that these numbers do not describe the external dimensions of the brushless motor itself

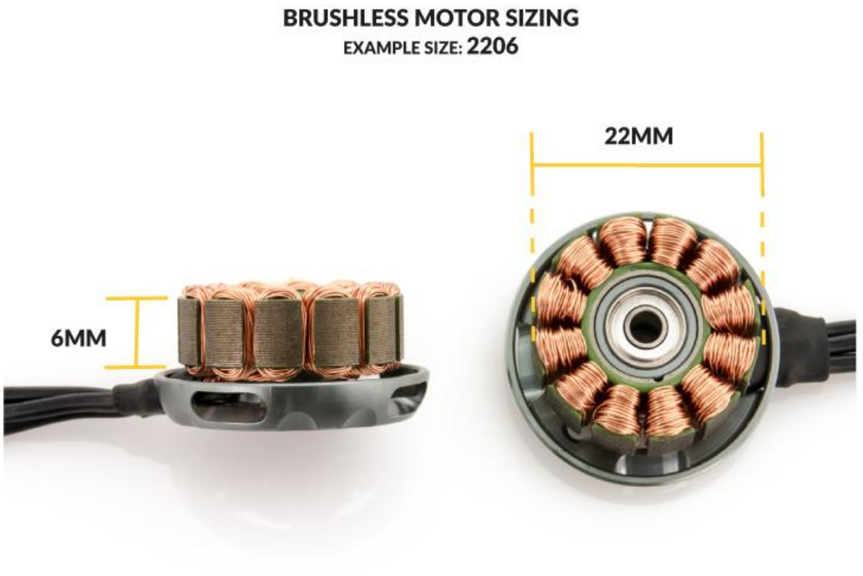

Fig 5.2.2 Sizing Of Brushless Motor

The Velocity Constant — How fast a Motor Spins

kV=RPM per 1 Volt

k = The kV rating of the motor e.g. 2300

V = Voltage input e.g. 16.8v

Example: 2300(kV rating) X 16.8(Voltage) = 38,640(Revolutions Per Minute)

The velocity constant (kV) determines how many rotations a motor can make within a minute without a load (no propeller) and at a constant current of 1 Volt. Simply, kV is a representation of how fast the motor can potentially spin. The kV of a motor is defined by the strength of the magnetic field at the stator and the amount of turns in the windings. A motor with a lower kV is best suited for efficiently driving heavy propellers. A high kV motor is optimized for lightweight propellers.

Thrust

Thrust is one of the key factors to consider when choosing a motor. The thrust output of a motor is usually measured in grams and varies depending on how fast the motor is spinning and the propeller that it is rotating. Before a multicopter can begin to accelerate, a certain amount of thrust is required to overcome drag, as well as the pull of gravity.

5.3 PROPELLERS

Fig 5.3.1 Propeller

A PROPELLER “LIFTS” AN AIRPLANE FORWARD

Think of a propeller as a spinning wing. Like a wing, it produces lift, but in a forward direction—a force we refer to as thrust. Its rotary motion through the air creates a difference in air pressure between the front and back surfaces of its blades. In order for a propeller blade to spin, it usually needs the help of an engine. In cross section, a propeller is shaped like a wing to produce higher air pressure on one surface and lower air pressure on the other.

1. PROPELLERS AND PITCH
2. Angle of attack is the angle a wing makes with the oncoming airflow. Pitch angle is the angle a propeller blade makes with its plane of rotation. A wing has nearly the same angle

of attack across its entire length. But a propeller blade has a twist, so its pitch angle varies along its length.

3. On a controllable-pitch propeller, the pitch of the entire blade can be altered during flight to give the best performance at different air speeds.

Fig 5.3.2 Propeller Pitch

5.4 ELECTRONIC SPEED CONTROLLER

The Drone Electronic Speed Controller (ESC) on a drone is a hard-working, powerful component. The ESC connects the flight controller and the motor. Given that each brushless motor requires an ESC, a quadcopter will require 4 ESCs. The ESC takes the signal from the flight controller and power from the battery and makes the brushless motor spin. Although it sounds simple, it is anything but! Although some micro drones use brushed motors, the mini quads used in racing and freestyle rely on brushless motors. Like the name implies, a brushless motor lacks contacts, or “brushes” inside the motor. The brush acts as what is called a commutator, which uses physical contact of the motor’s windings to spin the motor. Because they lack the brush, brushless motors use a different way to turn direct current (DC), the one-way flow of electrons, into a type of alternating current (AC). This is performed externally, through the use of an ESC.

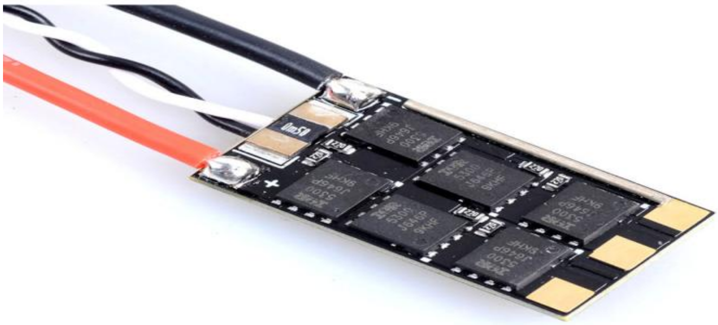

Fig 5.4 Typical View Of Electronic Speed Controller

ESCs are rated based on how much current they can pass to the motors. The job of the ESC is to switch on power to the motor coils at incredibly fast rates. This switching is controlled by a microprocessor and carried out by transistors called MOSFETs, commonly referred to as FETs.

Amperage

The size and quality of these FETs determines how much current (amperage) can pass through the ESC. Most ESCs will have ratings such as ’30 amps’ or ’25 amps’. These numbers generally represent the sustained current the ESC can handle. For short periods of time, generally less than 10 seconds, ESCs can handle slightly more current. It is common to see an ESC labeled a ’30 amps’ ESC that is capable of a 40 amp ‘burst.’ The amp rating is an important consideration when purchasing an ESC. It is far better to get an ESC capable of more current, at the cost of size or expense, vs. an ESC that might be damaged by too large a current. Larger motors tend to draw more current, and larger propellers, or propellers with a greater pitch will also draw more current. Currently with 4-cell batteries (4S) a 30-amp ESC will suffice for most pilots.

Voltage

Most drone operators currently use 4S that operate at 16.8 volts. This, however, recently started changing. A few race organizers are encouraging pilots to use higher voltage 5S and 6S batteries. In addition to amperage, ESCs are also rated in their ability to handle voltage. Some ESCs are rated for 3S-4S, while others can handle up to 6S. The power of the motors can be measured in watts, which is voltage multiplied by amps (volts x amps = watts). Therefore, interestingly, as voltage increases, amperage can decrease to keep the total power output of the motor the same.

This means that higher voltage batteries can provide the same motor output power at a lower current draw. Alternatively, if the voltage is increased, and the pilot chooses to give a lot more throttle, the amperage will increase and the total power (watts) of the motor will increase and thus the higher voltage drone will fly faster vs a lower voltage drone.

5.5 POWER MODULE AND CONNECTORS

The Mini APM 3.1 requires a 5VDC power supply to operate. Due to this lower voltage, it cannot draw power directly from a 12V Li Po battery (attempting to power the FC up with 12V will fry it). To provide power to the FC, you will need to install an APM power module. The power module provides power to the Mini APM through a 6-pin molex cable.

The power module can also provide a 5.3V output for other devices such as GPS and radio telemetry. Besides providing power, the module allows the Mini APM to monitor current consumption and voltage measurements through the 6-pin cable.

Fig 5.5.1 Power Module

APM power modules typically come with XT60 connectors — male for output and female for input. I prefer keeping things neat and simple, so I've decided to remove the output connector and solder the wires directly onto the power distribution board. This eliminates the need for a second female XT60 connector and pair of wires to connect the power module to the PDB.

CONNECTORS

Fig 5.5.2 XT60 Connector

These are high-current XT60 connectors commonly used in the RC hobby industry.These connectors are made from high-temp nylon with gold-plated spring pins or sockets molded in. The shape of this generic XT60 prevents reverse polarity, and when plugged in the connection is super-solid.

BULLET CONNECTOR

Fig 5.5.3 Bullet Connector

Bullet connectors from Waytek Wire are simple, durable wire connectors used in many electrical applications. Designed to ensure safe and convenient automotive electrical wiring connections, bullet terminals are available in any size and quantity. Our bullet connectors are offered in a variety of insulation styles, including vinyl, nylon, and heat shrink insulated, as well as non-insulated.

5.6 GPS MODULE

Fig 5.6 GPS Module

The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. The system provides critical capabilities to military, civil and commercial users around the world. It is maintained by the United States government and is freely accessible to anyone with a GPS receiver.

The GPS is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense. GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use. GPS works in any weather conditions, anywhere in the world, 24 hours a day. There are no subscription fees or setup charges to use GPS.

A GPS module measures your drones location by measuring how long a signal takes to travel from a satellite. A GPS modules is also able to give an estimation of your drones altitude. However GPS modules are rather inaccurate and will only give you a position to within 5m. However as discussed before, by combining measurements fro other sensors the flight controller can get a better picture of what the drone is doing. The main feature used by the GPS module is that you can autonomously fly your drone to way-points, so your drone can potentially fly on its own from takeoff to landing.

SatelliteNetworks

Recently there are mode GPS modules that are abe to communicate on more than on GPS network such as the Russian GLONASS network. This just means that your GPS receiver can pickup more satellite signals which improves teh reliability and performance. The nice thing is that they are not much more expensive. Common modules that support both GPS and GLONASS networks are the Ublox Neo 7N modules.

5.7 BATTERY

Fig 5.7 Li-Poly RC Battery

Lithium polymer batteries, more commonly known as LiPo, have high energy density, high discharge rate and light weight which make them a great candidate or RC applications.

Battery Voltage and Cell Count (S)

LiPo batteries exist in cells, each LiPo cell has a nominal voltage of **3.7V**. If higher voltage is required, these cells can be connected in series to form a single battery.

1S = 1cell = 3.7V

2S = 2 cells = 7.4V

3S = 3 cells = 11.1V

4S = 4 cells = 14.8V

5S = 5 cells = 18.5V

6S = 6 cells = 22.2V

LiPo battery is designed to operate within a safe voltage range, from **3V to 4.2V**. Discharging below 3V could cause irreversible performance lost and even damage to the battery. Over-charging above 4.2V could be dangerous and eventually cause fire. The capacity of a LiPo battery is measured in mAh (milli-amp hours). "**mAh**" is basically an indication of how much current you can draw from the battery for an hour until it's empty. Increasing your battery capacity might give you longer flight time, but it will also get heavier in weight and larger in physical size. There is a trade-off between capacity and weight, that affects flight time and agility of the aircraft. I wrote a guide about building a simple mathematics model to find out optimal Lipo capacity for longer flight time, which you might find interesting.

Higher capacity could also give you higher discharge current as you will see in the next section.

Note that, 1000mAh = 1Ah.

5.8 ULTRASONIC SENSOR

Fig 5.8 Ultrasonic Sensor

As the name indicates, ultrasonic sensors measure distance by using ultrasonic waves.
The sensor head emits an ultrasonic wave and receives the wave reflected back from the target. Ultrasonic Sensors measure the distance to the target by measuring the time between the emission and reception.

Ultrasonic sensors work by sending out a sound wave at a frequency above the range of human hearing. The transducer of the sensor acts as a microphone to receive and send the ultrasonic sound. Our ultrasonic sensors, like many others, use a single transducer to send a pulse and to receive the echo. The sensor determines the distance to a target by measuring time lapses between the sending and receiving of the ultrasonic pulse.

5.9 FLIGHT CONTROLLER

The flight controller is the brains of your drone. The flight controller reads all of the sensor data and calculates the best commands to send to your drone in order for it to fly.

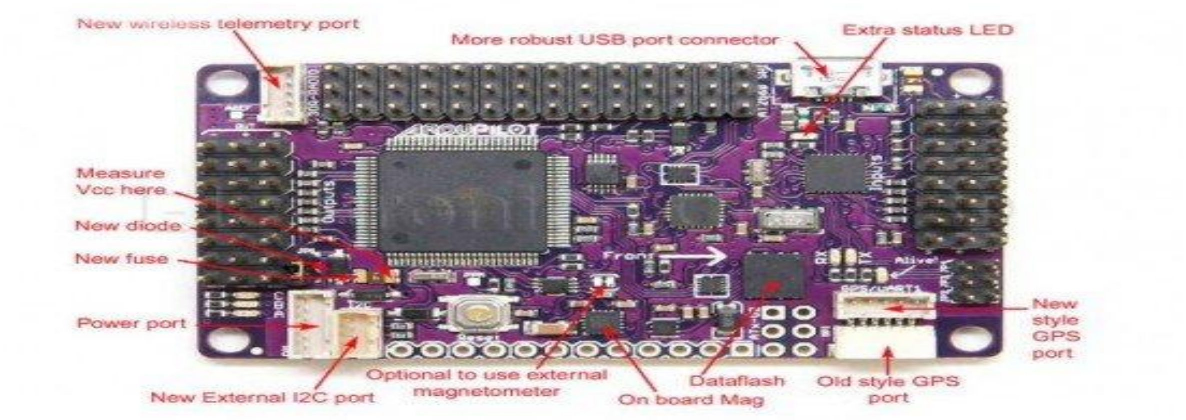

Fig 5.9.1 flight controller

This is the central unit that runs the autopilot firmware and performs all the calculations. Most flight controllers have 32bit processors which are more powerful that than 8bit systems.

ACCELEROMETERS AND GYRO

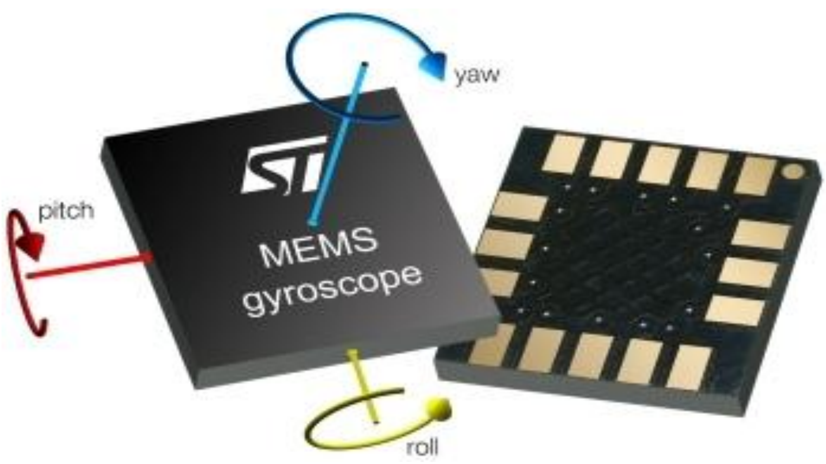

Fig 5.9.2 Gyroscope

These are the intertial sensors on your drone. The accelerometer measures acceleration forces, and the gyro measures rotational forces. By combining these measurements the flight controller is able to calculate the drones current attitude (angle it is flying at) and perform necessary corrections.

COMPASS (MAGNETOMETER)

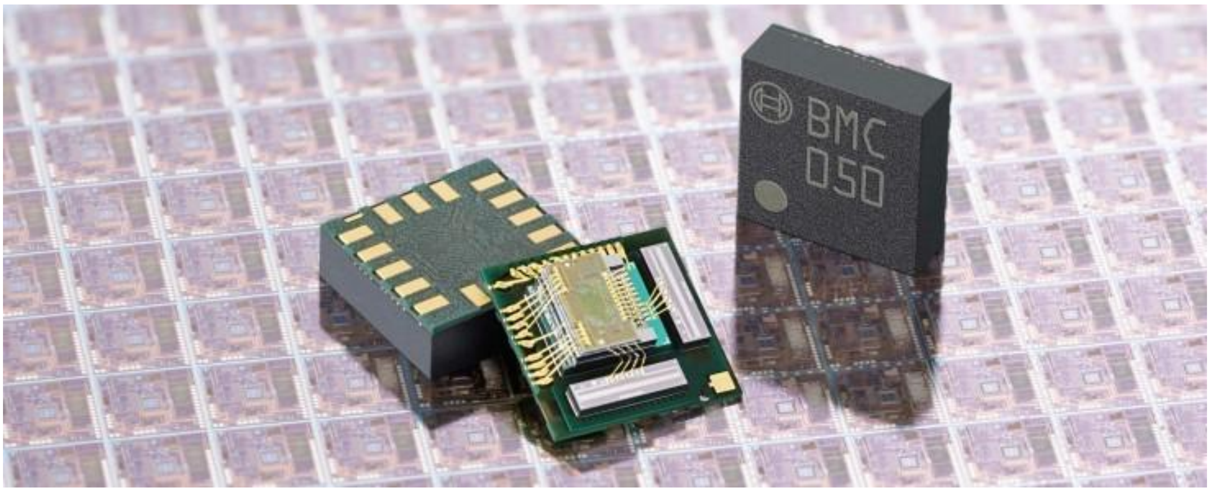

Fig 5.9.3 Magnetometer

The compass sensor, or magnetometer if you want to sound fancy, measures the magnetic force, just like a compass. This sensor is important for multi rotor drones because the accelerometer and gyroscope sensors are not enough to let the flight controller know what direction the drone is facing. On fixed wing drones this easy since it can only fly in one direction. Compass sensors are very sensitive to magnetic interference. Things such as wires, motors and ESC’s can all cause magnetic interference. so that is why you will often have an additional compass sensor mounted on the GPS module as the GPS module is usually mounted far away from all the other equipment. You will also need to calibrate the compass when building your drone for the first time

BAROMETER

A barometer is a pressure sensor that you use to measure the aircrafts altitude. These pressure sensors are so sensitive that they can detect the change in air pressure when your drone moves a few centimeters.

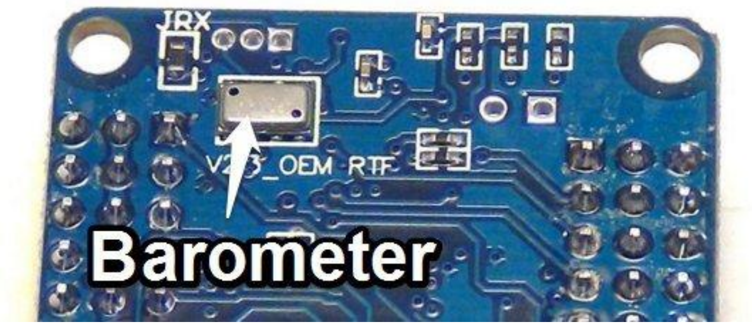

Fig 5.9.4 Barometer

5.10 RASPBERRY PI

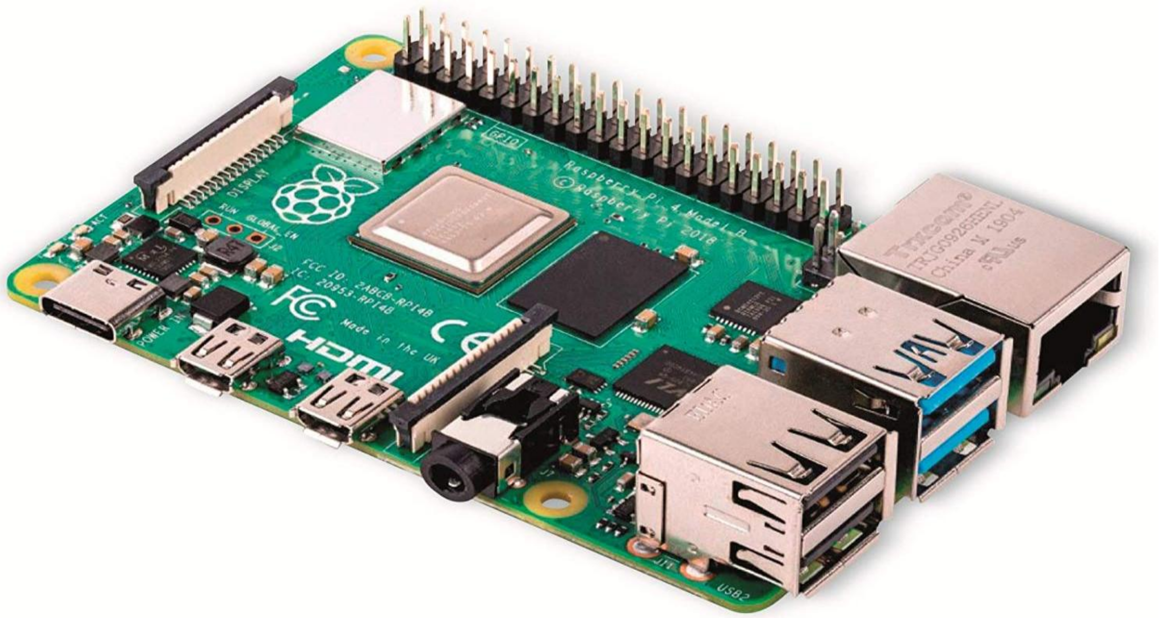

Fig 5.10.1 Raspberry pi

The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. It's capable of doing everything you'd expect a desktop computer to do, from browsing the internet and playing high-definition video, to making spreadsheets, word-processing, and playing games.

What's more, the Raspberry Pi has the ability to interact with the outside world, and has been used in a wide array of digital maker projects, from music machines and parent detectors to weather stations and tweeting birdhouses with infra-red cameras. We want to see the Raspberry Pi being used by kids all over the world to learn to program and understand how computers work.

The Raspberry Pi device looks like a motherboard, with the mounted chips and ports exposed (something you'd expect to see only if you opened up your computer and looked at its internal boards), but it has all the components you need to connect input, output, and storage devices and start computing.

You'll encounter two models of the device: Model A and Model B. The only real differences are the addition of Ethernet and an extra USB port on the more expensive Model B.

Here are the various components on the Raspberry Pi board:

ARM CPU/GPU -- This is a Broadcom BCM2835 System on a Chip (SoC) that's made up of an ARM central processing unit (CPU) and a Videocore 4 graphics processing unit (GPU). The CPU handles all the computations that make a computer work (taking input, doing calculations and producing output), and the GPU handles graphics output.

GPIO -- These are exposed general-purpose input/output connection points that will allow the real hardware hobbyists the opportunity to tinker.

RCA -- An RCA jack allows connection of analog TVs and other similar output devices.

Audio out -- This is a standard 3.55-millimeter jack for connection of audio output devices such as headphones or speakers. There is no audio in.

LEDs -- Light-emitting diodes, for all of your indicator light needs.

USB -- This is a common connection port for peripheral devices of all types (including your mouse and keyboard). Model A has one, and Model B has two. You can use a USB hub to expand the number of ports or plug your mouse into your keyboard if it has its own USB port.

HDMI -- This connector allows you to hook up a high-definition television or other compatible device using an HDMI cable.

Power -- This is a 5v Micro USB power connector into which you can plug your compatible power supply.

SD cardslot -- This is a full-sized SD card slot. An SD card with an operating system (OS) installed is required for booting the device. They are available for purchase from the manufacturers, but you can also download an OS and save it to the card yourself if you have a Linux machine and the wherewithal.

Ethernet -- This connector allows for wired network access and is only available on the Model B.

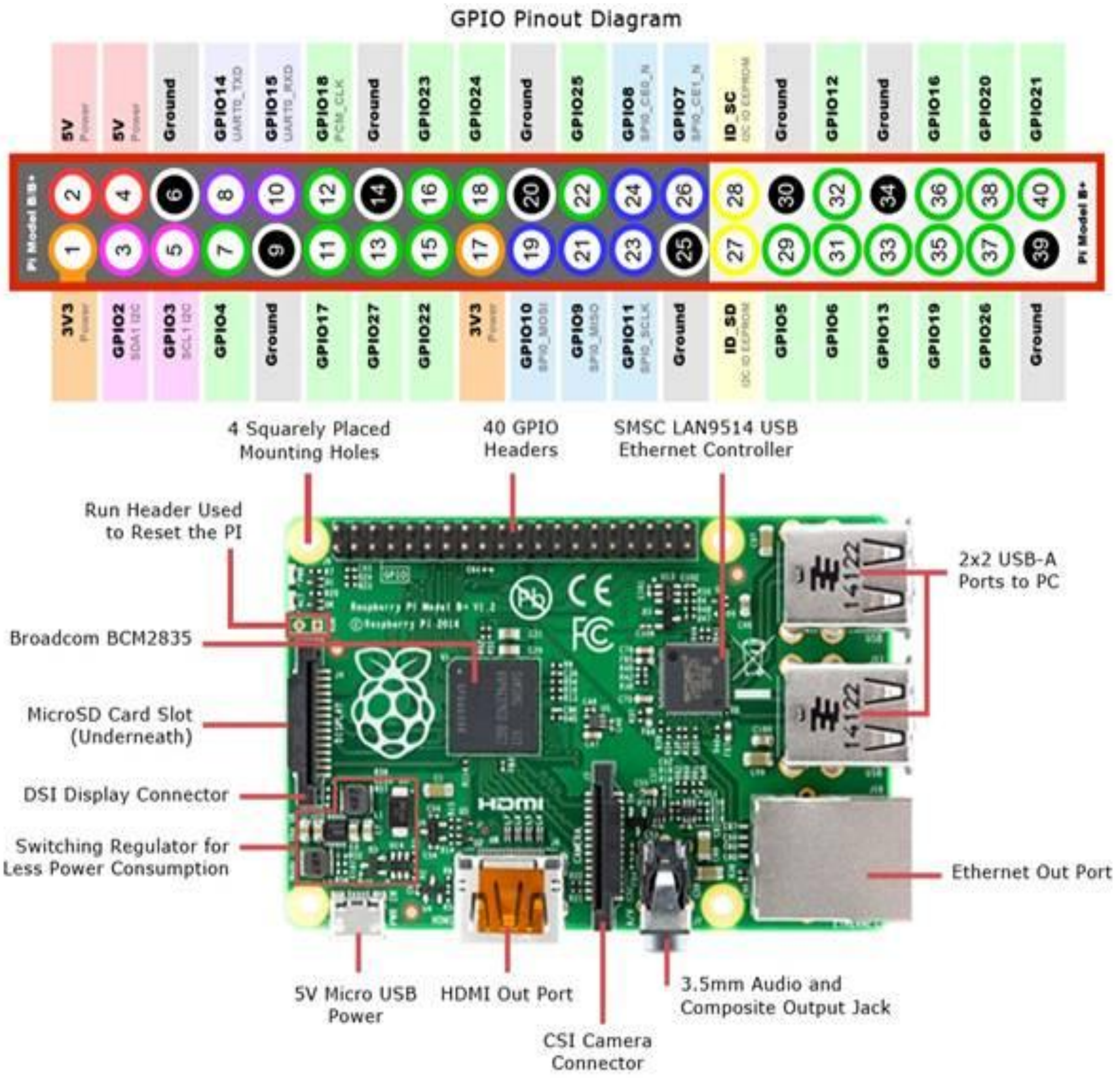

Fig 5.10.2 Pin Diagram

5.11 TRANSMITTER AND RECEIVER

Fig 5.11.1 Typical Radio

Drone Radio Transmitter is an electronic device that uses radio signals to transmit commands wirelessly via a set radio frequency over to the Radio Receiver, which is connected to an aircraft or multirotor being remotely controlled. In other words, it's the device that translates pilot's commands into movement of the multirotor.

In some radios there is an option to connect an external transmitter module. This makes it possible to use a different frequency (for instance, 900MHz in a 2.4GHz radio) or a different receiver from another

Drone Radio Transmitter transmits commands via channels. Each channel is an individual action being sent to the aircraft.

Throttle, Yaw, Pitch and Roll are the four main inputs required to control the quad. Each of them uses one channel, so there is minimum of four channels required. Every switch, slider or knob on the transmitter uses one channel to send the information through to the receiver.

The following is an example of the typical channel setup for FPV Racing: a switch for arming the aircraft, a switch for turning on the buzzer and a switch used to select different flight modes. For this reason, it is advised to have a 6 channel radio.

Frequencies

An FPV Drone Radio Transmitter commonly use the following frequencies: 27MHz, 72MHz, 433MHz, 900MHz, 1.3GHz and 2.4Ghz

433Mhz, 900Mhz and 1.3GHz are typically used in long range FPV and RC systems.

27Mhz and 72Mhz are older frequencies which were being used for many years in RC. Equipment operating on those frequencies used crystals to bind the Transmitter with a Receiver. Apart from a few RC toys still available on the market, they are rarely used.

2.4GHz is most popular frequency. It is a newer technology and it offers "frequency hopping" which does the job of managing multiple users frequency transmitting at the same time. This id done by scanning the frequency band and finding the best available channel during the transmission. 2.4GHz antennas are very compact as well. Generally speaking the lower the frequency, the larger the antenna. For that reason, 2.4GHz quickly became the "go to" frequency.

Radio Receivers

A Radio Receiver is the device capable of receiving commands from the Radio Transmitter, interpreting the signal via the flight controller where those commands are converted into specific actions controlling the aircraft.

Radio Receivers can have the following features:

Telemetry (sending data back to transmitter)

*Redundancy function (two receivers connected together, if one loses connection, second one takes over)

*Easy removable antennas (more convenient with connectors if antenna is to be replaced)

*Possibility of firmware upgrades (for bug fixes)

Fig 5.11.2 Radio reacivers

CHAPTER 6

CONSTRUCTION OF DRONE

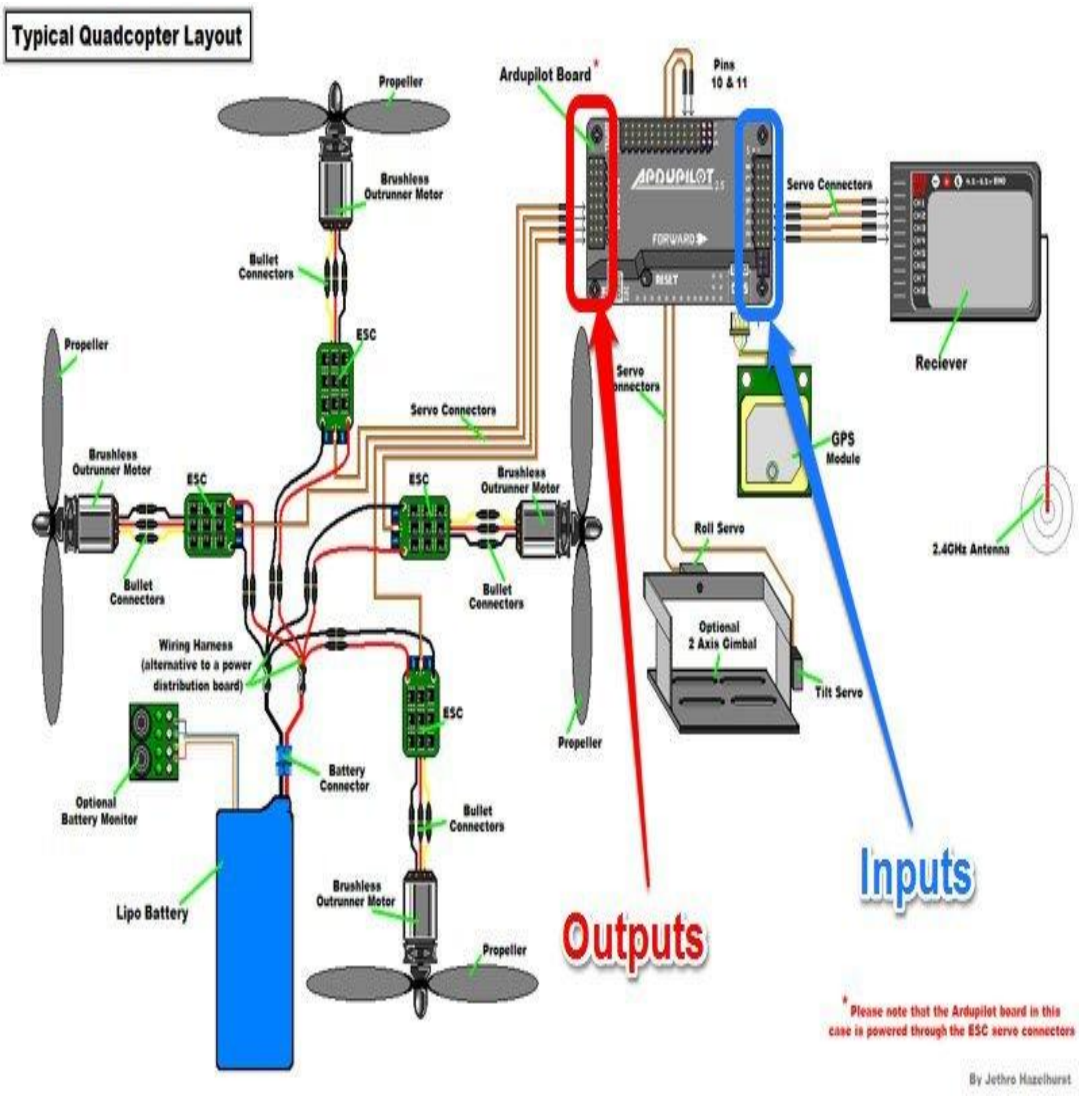

Fig 6.1 Typical Quadcopter Layout

Step 1: Assemble the Frame

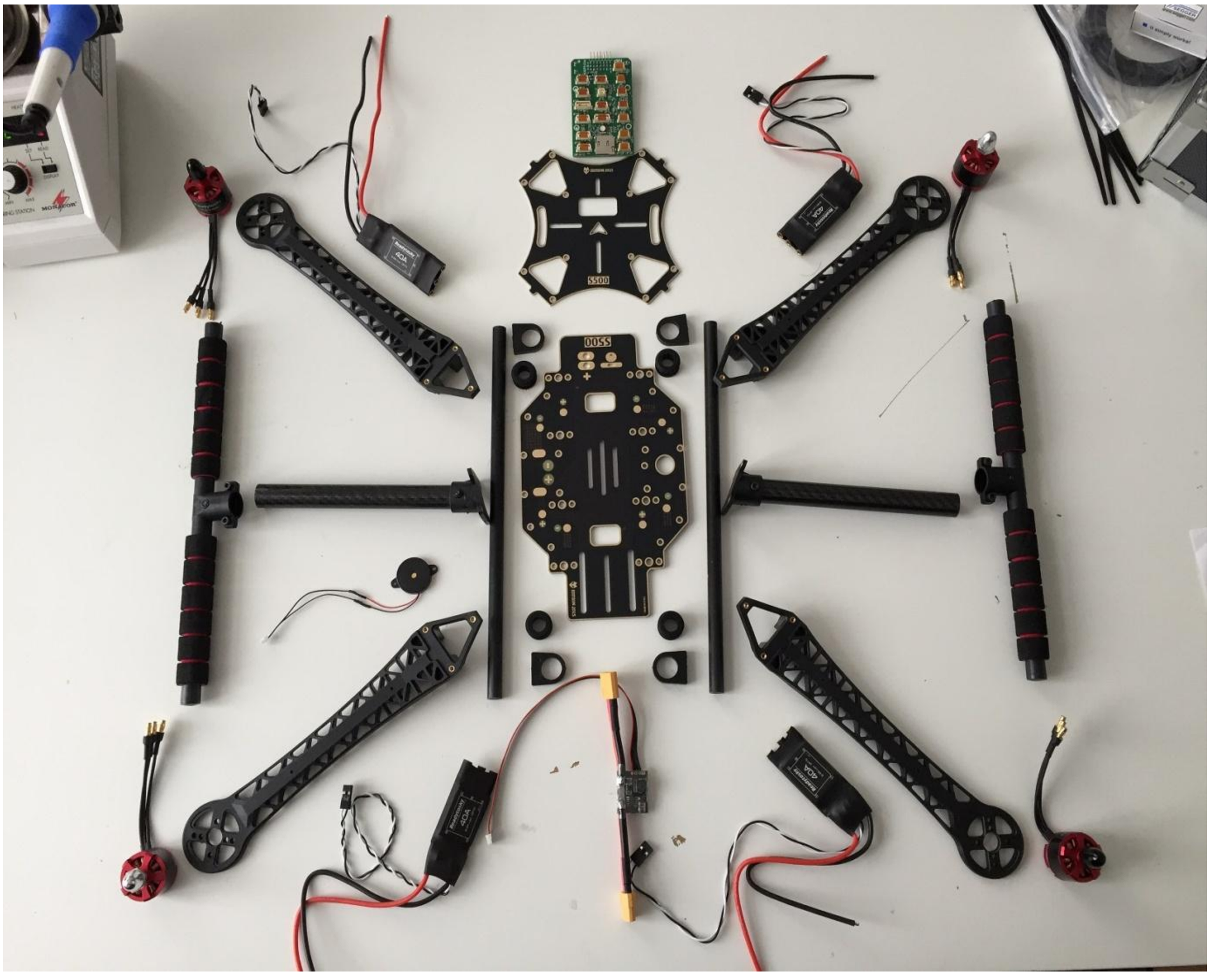

Fig 6.2.1

This step is fairly straightforward, especially if using the 3D printed frame. Simply use the included screws and put the frame together as shown, using an appropriate allen wrench or screwdriver for your frame. Make sure that arms are adjacent to each other (as in this picture), so that the drone has a clear front and back. Further, make sure that the long part of the bottom plate sticks out in between opposite arms.

Step 2: Mount Motors and Connect Escs

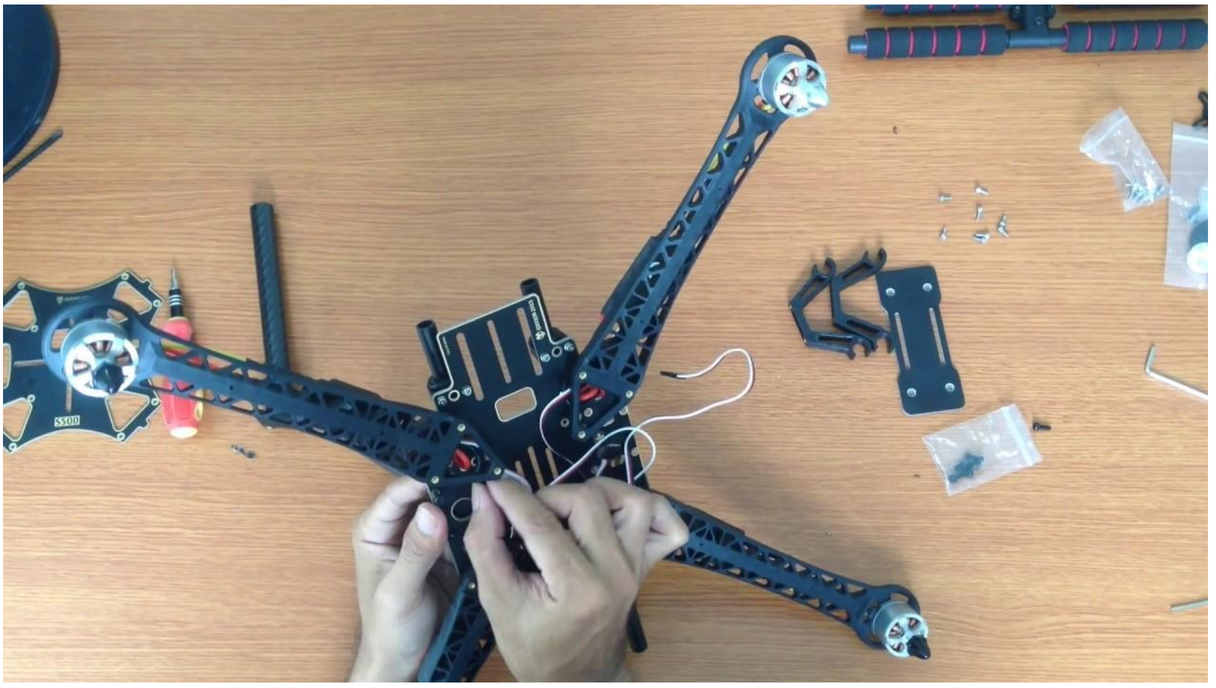

Fig 6.2.2

Now that the frame is assembled, take out the four motors and four mounting accessories. You can use either screws included in the mounting sets, or screws left over from the quadcopter frame to screw the motors and mounts in place. If you buy the mounts we've linked to, you will receive two extra components, pictured above. We have had good motor performance without these parts, so we left them off to reduce weight.

Once the motors are screwed in place, epoxy the power distribution board (PDB) in place on top of the top plate of the quadcopter frame. Make sure that you orient it such that the battery connector points (parallel with one of the long portions of the bottom plate), as in the picture above. You should also have four propeller cones with female threads. Set these aside for now.

Now take out your ESCs. One side will have two wires coming out of it, one red and one black. For each of the four ESCs, insert the red wire into the positive connector on the PDB and the black into the negative. Note that if you use a different PDB, this step may require soldering. Now connect each of the three wires coming out of each motor. At this point, it doesn't matter which ESC wire you connect with which motor wire (as long as you are connecting all the wires of one ESC with the same motor!) You will correct any backwards polarity later on. It is not dangerous if wires are reversed; it only results in the motor spinning backwards.

Step 3: MOUNTING THE APM

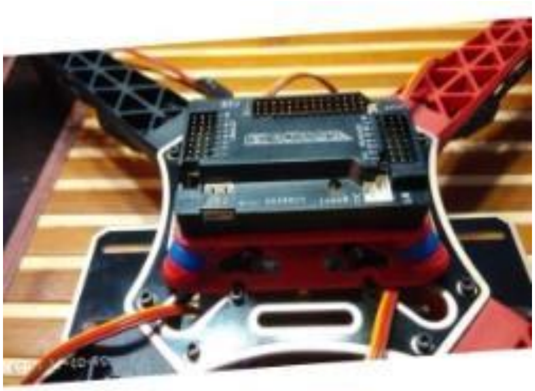

Fig 6.2.3

Mount the apm on the top plate with double sided tape and if u have a anti vibration plate mount the apm on it. Mount the apm in a way that the arrow on the flight controller points towards the side which u want your drone to face.

Step 4: CONNECTIONS TO THE RECEIVER

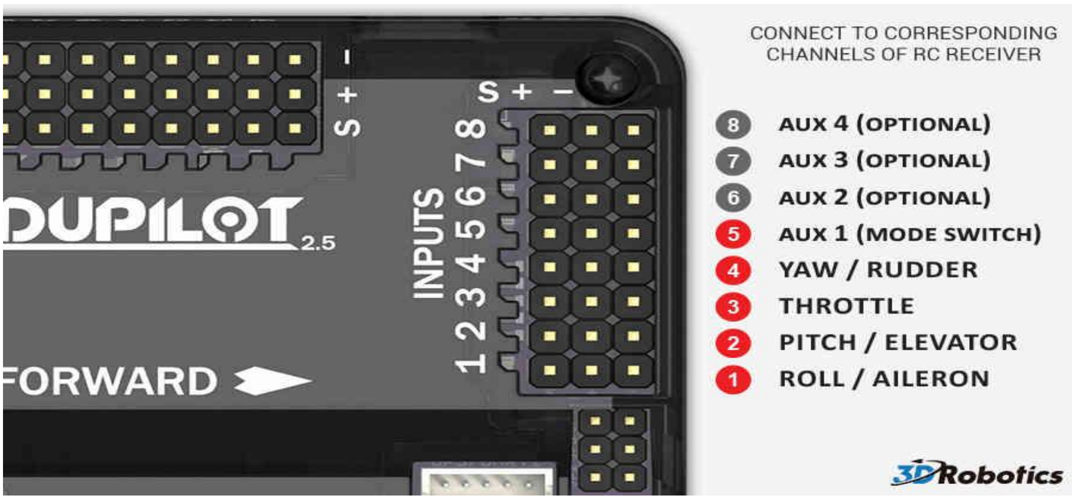

Fig 6.2.4

APM INPUT PIN 1 - RECEIVER PIN 1

" PIN 2 - RECEIVER PIN 2

" PIN 3 - RECEIVER PIN 3

" PIN 4 - RECEIVER PIN 4

" PIN 5 - RECEIVER PIN 5

THE APM INPUT PINS AND RECEIVER PINS ARE SIGNAL, +, - RESPECTIVELY FROM LEFT

Step 5: CONNECTIONS OF THE ESC

Fig 6.2.5

follow the motor layout given connect the esc's accordingly. the signal wires should face upwards (normally).

Step 6: CONNECTING THE GPS

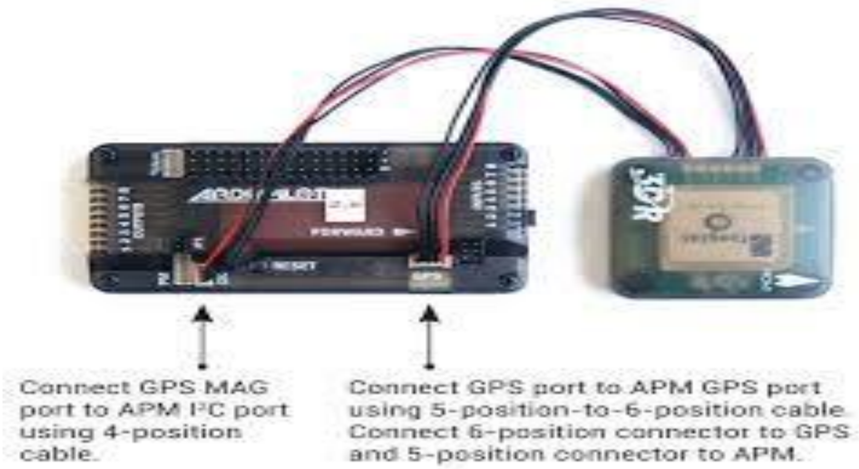

Fig 6.2.6

The wires from the compass cannot be interchanged as there is a difference in the number of pins. Fix the GPS module under the bottom plate. The arrow on the GPS module should point towards the direction which your APM faces.

Step 7: PROGRAMING THE APM

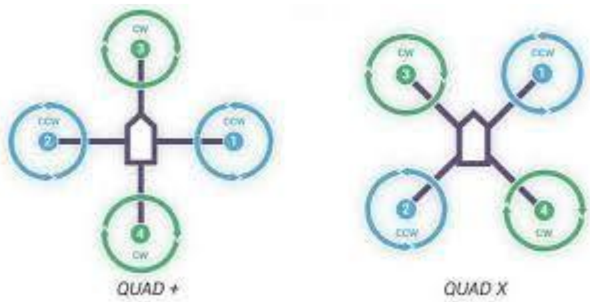

Fig 6.2.7

download the mission planner software and install it on your computer. connect the apm to the computer with a micro usb to usb cable. the easiest way to program the quad is by the wizard. program the quad accordingly to their instructions. after the programming make sure that the drone can be armed. next step is to check the direction of the motor spinning. mine is a x quad so my first motor should spin counter clockwise, second motor also counter clockwise, third motor clockwise and fourth motor also clockwise. if your motor is spinning in the opposite direction remove any 2 wire and interchange them and connect it again.

- Once the Firmware is installed , go to control panel–>devices and printers and make note of your com port that is your apm connected to . Again get back to mission planner and on the top right select your COM port and set the baud rate to 115200 and click connect .
- After connecting go to Initial seup–>Mandatory Hardware and you should be able to see a list of options there.
- Under Frame type — Select the second option .(first if you are using X orientation)
- Go to Compass Calibration and select APM with esternal compass and then select Live Calibration. Start moving your quad in all the directions possible (up, down, left, right, up, down, circle, etc.) until a message pop ups saying new offsets are set .Click Ok and compass Calibration is done .
- Go to Accelerometer Calibration and click Calibrate Accel. Follow the on screen instructions that tells you to place your quad level, back, left, right etc.
- Go to Radio Calibration and click Calibrate Radio. After a message pops up, move all your sticks and switches to their mean positions and click OK. Now move all the sticks and switches to their extreme positions and then again back to mean positions and click calibrate radio. Radio Calibration is Complete .
- Go to Flight modes and check that all the flight modes should be at Stablize. Leave them all at stablize for now until you get your hands on flying.

Step 8: COMMUNICATING WITH RASPBERRY PI

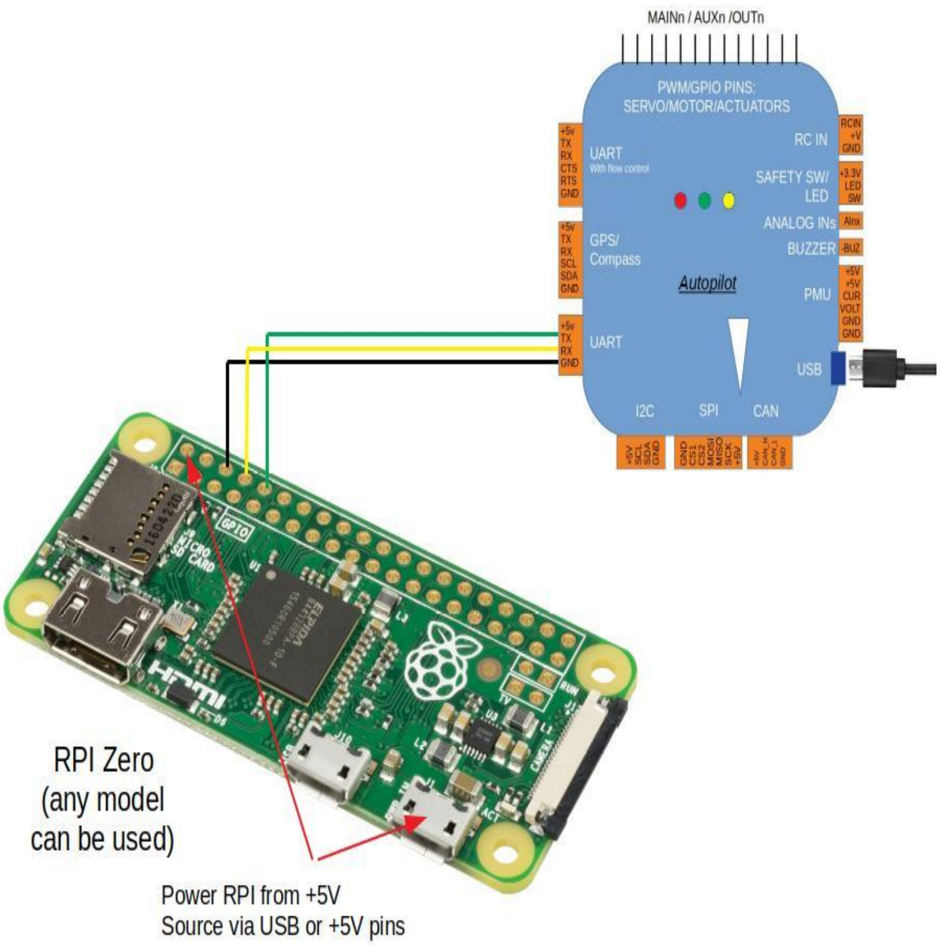

Fig 6.2.8

Connect the flight controller's TELEM2 port to the RPi's Ground, TX and RX pins as shown in the image above.

The RPi can be powered by connecting +5V source to the +5V pin **or** from USB in.

Addon boards such as the Pi-Connect can simplify the connection of the RPi by providing a power supply and telemetry port.

Step 9: OBSTACLE AVOIDING ALGORITHM

The main mission of this algorithm is to enable the quadcopter fly between predefined waypoints and to avoid obstacle between those waypoint if it exist. There are 5 mode for the algorithm from the quadcopter starts to take-off manually, fly autonomously, and avoiding the obstacle. Several parameters are made as switch between modes. First parameter is clear distance, defined as the minimum distance the quadcopter can fly autonomously. Another one is safe distance as the minimum distance the quadcopter can start scanning. On the avoidance mode where quadcopter aimed to fly forward and side at the same time, the distance to obstacle should've decreased. So another parameter is defined that is clear to avoid distance, which the quadcopter should not move any closer than this distance when avoiding the obstacle

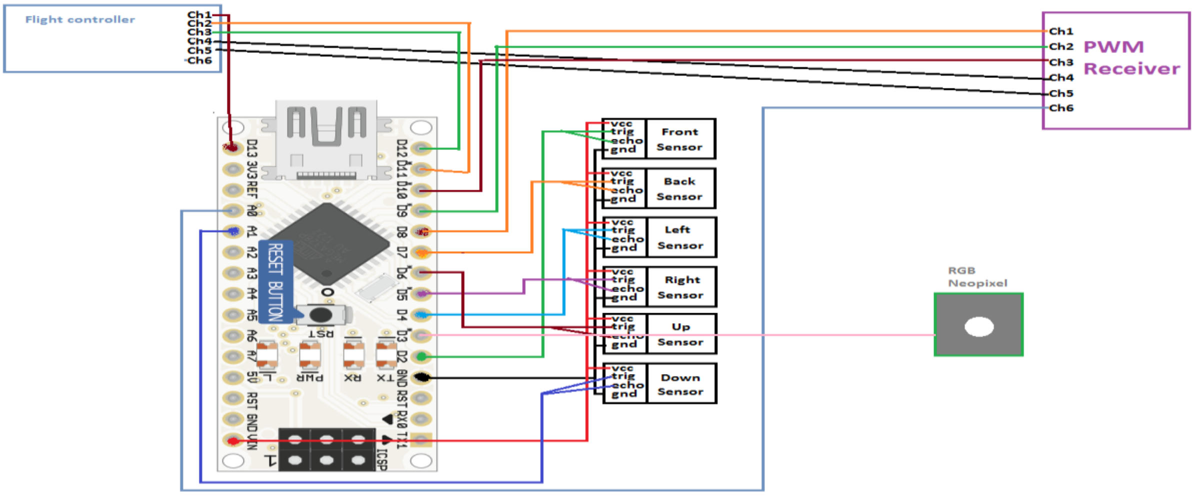

Fig 6.2.9

Step 10:OBEJECT DETECTION

This project involves real-time object detection for drones from the ground station using TensorFlow Object Detection API. The TensorFlow Object Detection API is an open source framework built on top of TensorFlow making it easier to construct, train and deploy object detection models. This results in machine learning models capable of localizing and identifying multiple objects in images streaming from drones to the ground station with more computational power.

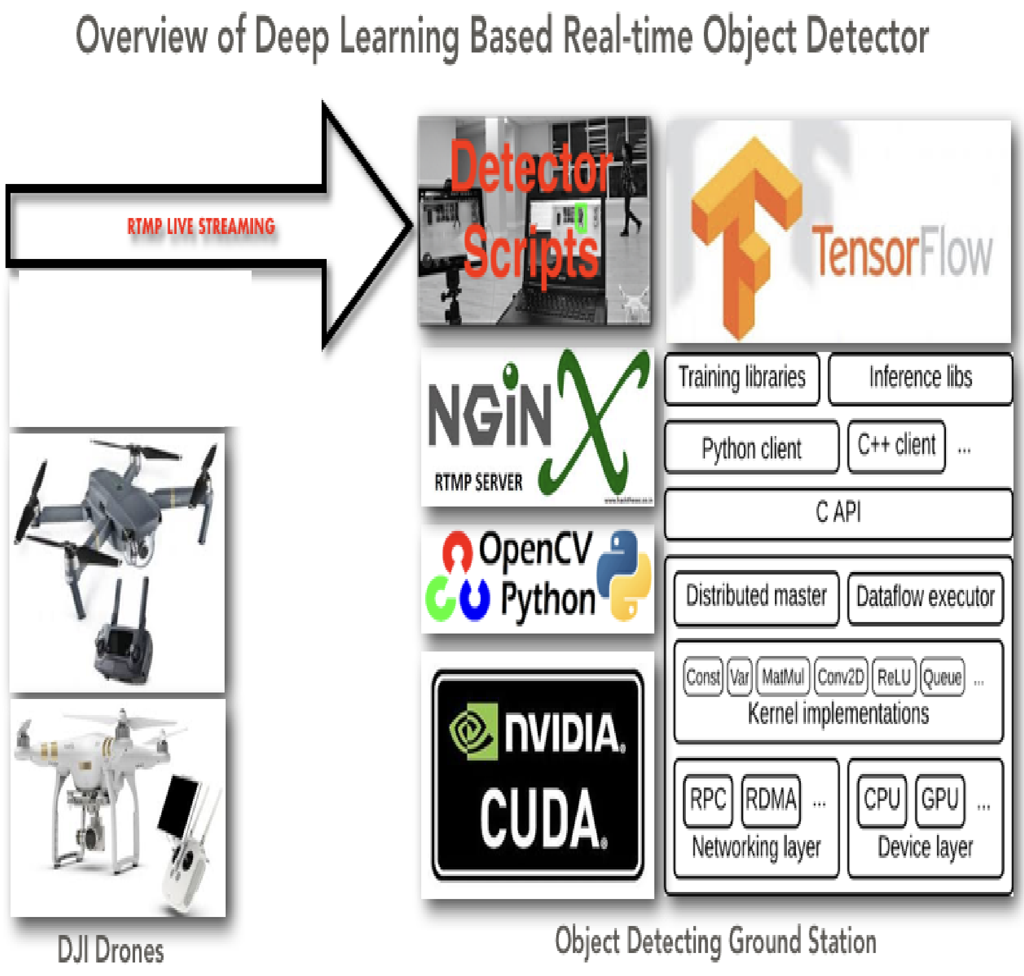
Overview of Deep Learning Based Real-time Object Detector
RTMP LIVE STREAMING
Detector Scripts
TensorFlow
NGINX
RTMP SERVER
Training libraries
Inference libs
Python client
C++ client
...
C API
OpenCV
Python
Distributed master
Dataflow executor
Const
Var
MatMul
Conv2D
ReLU
Queue
...
Kernel implementations
NVIDIA.
CUDA.
RPC
RDMA
...
Networking layer
CPU
GPU
...
Device layer
DJI Drones
Object Detecting Ground Station

Fig 6.2.10

CONCLUSION AND FUTURE WORKS

The categories around which the review was organized included infrastructures and structures inspection, transportation, cultural heritage monitoring, city and urban planning, progress monitoring, post-disaster, and construction safety. Authors consistently recommended UAV integration in the AEC domain by providing equal, if not, higher outcomes compared to conventional methods in terms of time, accuracy, safety, and costs. Other advantages included the UAV’s flexibility in reaching elevated or inaccessible areas. Issues reported were mainly environmental (weather and lighting conditions, wind speed and direction, sunlight reflectivity), and technical deficiencies in the employed sensors and platforms’ components (GPS-deficiency, magnetic interferences, UAV batteries, and image quality). Drone flying styles were almost equally divided between manual and autonomous navigation, with the latter considered as the most commonly used type of flight control. Few authors adopted the semi-autonomous navigation. Rotary, fixed wing, and blimps were the three different types of UAVs reported in the literature. Rotary platforms were the mostly deployed drone type retrieved in our analysis. They comprised helicopters, quadcopters, hexacopters, and octocopters. Those aerial platforms were equipped with typical and special sensors to achieve particular tasks. Of those sensors, commercial cameras were the most predominantly used type in the current literature, serving as the basis for images and videos acquisitions, processing, and 3D modeling. Other sensors included thermal cameras, laser scanners, radio frequency identification, and ultrasonic beacon system. Future research is warranted, and further studies should be conducted to enhance the applied visual algorithms, as well as the platforms’ onboard hardware and software components. Also, additional technological alternatives should be investigated to enhance these devices’ performances and overcome the presented environmental and technical challenges.

In the future, we plan to focus our attention on multi-UAV coordination and motionplanning. Since complex tasks will require more than one UAV and more than one ground robot, the coordination and motion-planning is important to prevent collision between UAVs and to allocate the tasks eciently

REFERENCES

1. Abdirad, H., and Dossick, C. S. (2016). BIM curriculum design in architecture, engineering, and construction education: a systematic review.
2. Journal of Information Technology in Construction (ITcon), 21, 251. Retrieved from http://www.itcon.org/2016/17
3. Achille, C., Adami, A., Chiarini, S., Cremonesi, S., Fassi, F., Fregonese, L., and Taffurelli, L. (2015). UAV-Based Photogrammetry and Integrated Technologies for Architectural Applications—Methodological Strategies for the After-Quake Survey of Vertical Structures in Mantua (Italy). Sensors, 15(7), 15520–15539. https://doi.org/10.3390/s150715520
4. Adams, S. M., Levitan, M. L., and Friedland, C. J. (2014). High Resolution Imagery Collection for Post-Disaster Studies Utilizing Unmanned Aircraft Systems (UAS). Photogrammetric Engineering and Remote Sensing, 80(12), 1161–1168. https://doi.org/10.14358/PERS.80.12.1161
5. Agung Pratama, L., Fardsosseini, F., and Lin, K. (2018). An Overview Of Generating VR Models For Disaster Zone Reconstruction Using Drone Footage. In 18th International Conference on Construction Applications of Virtual Reality . Retrieved from. https://www.researchgate.net/publication/329571731
6. **1.** R. D'Andrea, "Guest editorial can drones deliver?", *IEEE Trans. Autom. Sci. Eng.*, vol. 11, pp. 647-648, Jul. 2014.
7. D. Gross, Amazon's Drone Delivery: How Would it Work?, 2013, [online] Available: http://www.cnn.com/2013/12/02/tech/innovation/amazon-drones-questions/.
8. *NASA UTM 2015: The Next Era of Aviation*, 2015, [online] Available: http://utm.arc.nasa.gov/utm2015.shtml.
9. M. Gharibi, R. Boutaba and S. L. Waslander, "Internet of drones" in , 2016, [online] Available: http://arxiv.org/abs/1601.01289.