UAV For Human Detection And Geolocalisation

PROJECT REPORT

Submitted in partial fulfillment for the award of the degree
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SUBMITTED BY

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Bonafide certificate

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This is to certify that the Project Report entitled

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is a bonafide account of their work done under our supervision

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Abstract

Recent advances in the field of Unmanned Aerial Vehicles (UAVs) make flying robots suitable platforms for carrying sensors and computer systems capable of performing advanced tasks. We presents a technique which allows detecting humans at a high frame rate on standard hardware onboard an autonomous UAV in a real-world outdoor environment using tensorflow. Detected human positions are geolocated and a map of points of interest is built. Such a saliency map can, for example, be used to plan medical supply delivery during a disaster relief effort. The technique has been implemented using DroNet: a convolutional neural network that can safely drive a drone through the streets of a city. We propose to train a UAV from data collected by cars and bicycles. It allows a UAV to successfully fly at relative high altitudes and even in indoor environments, such as parking lots and corridors.

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List of Abbreviations

CNN - Convolutional Neural Network

GPS - Global Positioning System

PID - Propotional Integrative Derivative

UAV - Unammed Aerial Vehicle

NMEA - National Marine Electronics Association

PDB - Power Distribution Board

ESC - Electronic speed control

BEC - Battery Eliminator Circuit

BLDC - Brushless DC electric motor

Chapter 1

Introduction

1.1 Problem Statement

Unammed Aerial Vehicles have become more and more common and are able to perform missions with increasing levels of complexity. At the same time, they require less human operator involvement due to the increase in autonomous behavior. Flying robots can perform a wide range of tasks which are considered dirty, dull, or dangerous by humans. Missions such as search and rescue or surveillance, where camera coverage of a given area must be guaranteed, are examples of such tiresome tasks. They require high precision and endurance from human pilots. In the case of emergency situations such as natural disasters, finding potential survivors requiring medical attention is of utmost importance. Such missions require high flight precision and long operation times and this is tedious for human pilots. Our UAV systems can collect video footage of every square meter of an area of interest. In order to further reduce human involvement and speed up the process of finding causalities, the task of analyzing collected video can be delegated to an automated algorithm which analyzes the video footage in real time, on-line. An algorithm which can identify and geographically locate places where human bodies can be found is required to achieve such a task.

The technique presented in this paper takes advantage of a video camera. Detecting human bodies is done with the help of tensorflow libraries and obstacle detection, which is done with the help of "DroNet" a convolutional neural network.

1.2 Motivation

Developing an unmanned aerial vehicle has been one of the main points of concern by many counties all over the world; about 70 different countries have some sort of UAV technology. UAV expenditures reached more than US 3 billion and constituted a growth of more than 12 in 2010. Approximately 70 of global growth and market share is in the US. UAVs are used to gather information from the air in hostile areas. They can also be used in devastated areas where man support may not be available. These types of UAVs must be portable by ground and very reliable for recurrent use. With these types of uses by the military the UAVs designed are very costly and have very specific uses designed for each. The goal for the UAV design is to provide a cheaper alternative to these very costly military products. The UAV will be equipped camera with target recognition and a GPS guided semi autonomous flight control.

1.3 Proposed Model

The model that we put forward is a quadcopter which is remotely controlled to go to a location to detect human presence and record the GPS location. The GPS location can be sent to any device with the android app. Inorder to relieve the human pilots from tiresome tasks a semi-autonomous mechanism is implemented using "DroNet" ,it is a convolutional neural network for Obstacle detection and provides suggestions to the pilot along with real-time processed video which is remotely accessed from the camera onboard the quadcopter.

Chapter 2

Literature Survey

2.1 Introduction

The structural design of UAVs has changed over their developmental history in order to serve a variety of purposes. UAV design and advancement is a global activity. As technology and needs change, UAVs can be improved to serve these needs. There are several design considerations that are constant. The first of these design criteria is the degree of autonomy. Early UAV designs were mostly set to fly a specified path until they ran out of fuel. They carried a camera onboard, which would be recovered after the UAV landed. Later, the advent of radio control systems allowed UAVs to be piloted from the ground. Modern UAVs often combine these two basic functionalities. These two modes of operation signify a state of semi-autonomy. True autonomy suggests the ability of the aircraft to operate without human interaction. In this regard, UAVs are still very immature. UAV autonomy technology is divided into the following categories:

- Sensor fusion: On board the vehicle a combination of sensors are used.
- Communications: Communication and coordination will be handled between multiple sources in the existence of curtailed and imperfect information
- Motion planning (also called Path planning): Determining the optimal path for the vehicle in accordance with specific objectives and constraints such as obstacles go
- Trajectory Generation: Designed for optimal control and maneuverability to follow a particular route or to go from one place to another.
- Task Allocation and Scheduling: Set the optimal distribution of tasks between a group of agents, with time constraints and equipment
- Cooperative Tactics: The optimal sequence and spatial distribution of activities between agents in order to make the most of the chances of success in any case or situation.

The ultimate goal of UAVs is to replace human pilots altogether. Another major design criterion is UAV endurance (range). Since there is no human pilot onboard, there is no concern for pilot fatigue. UAVs can be designed to maximize flight times to take advantage of this fact. Different systems can afford a wide variety of maximum range. Internal combustion engines require relatively frequent refueling and inflight refueling is a major obstacle for this type of propulsion system. Photovoltaic UAVs offer the potential for unlimited range and there is much research in this field. One more type of fuel system is hydrogen, which is proposed for use with certain models of stratospheric persistent UAVs. The AeroVironment's Global Observer is one such UAV. This aircraft runs on hydrogen and has a range of 7 days. The idea is for two of such UAVs to be used in tandem to provide continuous, uninterrupted operation 365 days a year.

With the sophistication that these systems have arrived at, the market for them has grown astronomically. While the United States still has the largest stockpile of unmanned aircraft, the rest of the world is beginning to follow suit. More than 50 countries have purchased surveillance drones, and many have started in-country development programs for armed versions . More than two-dozen different models were shown at a recent aviation show in China . Due to the changing landscape of the theater of war, many nations are leaning toward unmanned aircraft to handle delicate situations in which human lives need not be put at risk. Also, taking into account the fact that drones sell for a fraction of the cost of manned airplanes, the amount of UAVs a nation can purchase at once has enticed many nations into entering the drone zone. In general, UAVs fall into one of six functional categories:

- Target and Decoy: simulating enemy missiles or aircraft for ground and air gunnery
- Reconnaissance: battlefield intelligence gathering
- Logistics: cargo and logistics application
- Research and Development: used for UAV technology development
- Civil and Commercial: specifically designed for civil and commercial applications

This quadcopter project required extensive research into similar systems. By reviewing others work, we used this insight to develop our system. To this end, research papers from various quadcopter groups were used as guides in the early development of the dynamics and control theory. Quadcopter platforms used in research remain somewhat the same, having four electric motors pointed vertically upwards and equally spaced in a square fashion. However, there were some groups who designed their own platforms, where as commercial models available to the consumer were the DraganFlyer, the X-UFO and the MD4-200.

2.2 Quadcopter

Unmanned Aerial Vehicle (UAV) commonly used for various missions, such as aerial surveillance, remote sensing, transport or search and rescue. UAV with four propeller, known as Quadcopter, is one of UAV known for high flexibility and mobility in narrow area. Lukmana, M. A., Nurhadi, H. T in their paper "Preliminary study on Unmanned Aerial Vehicle (UAV) Quadcopter using PID controller."[2] studies the response of a quadcopter with internal disturbance for rolling, pitching, yawing and altitude. The attitude data of quadcopter are numerically simulated. After integrating PID controllers into the systems.

2.3 STARMAC

Gabe Hofiann, Dev Gorur Rajnarqan in their paper "STARMAC"[5] uses a modified DraganFlyer IV quadcopter. Their system uses LQR techniques as well as Integral Sliding Mode (ISM) control. The STARMAC also incorporated an onboard micro controller/IMU. STARMAC is an outdoor testbed for testing and validating multi-agent algorithms and control schemes. It comprises a set of autonomous quadcopter helicopters that can follow prescribed waypoint trajectories using GPS and IMU sensing. The testbed could be extended to operate indoors by incorporating vision based position and velocity estimation or other indoor positioning system.

2.4 Human Body Detection

Piotr Rudol and Patrick Doherty in their paper "Human Body Detection and Geolocalization for UAV Search and Rescue Missions Using Color and Thermal Imagery"[3] discusses the technique which takes advantage of two video cameras.One of them delivers thermal video and the second one is a standard color camera. Commercially available, low-cost thermal cameras are not sufficient to classify humans at larger distances (40 meters) because of low image resolution and quality. A human body becomes just a blob and it is hard to distinguish it from any other object of the same size. Human detection algorithms working with color imagery also give best results at low distances and often have to rely on downsizing of images to achieve high rate of detection. The technique presented detects humans at a rate up to 25Hz (sporadically lower for scenes with high numbers of potential bodies) by first analyzing an infrared image to find human-temperature silhouettes and then using the corresponding color image regions to classify human bodies.

2.5 Tensorflow

TensorFlow is an open-source API from Google, which is widely used for solving machine learning tasks that involve Deep Neural Networks. Tensorflow Object Detection API is an open-source library made based on Tensorflow for supporting training and evaluation of Object Detection models. "Tensorflow Detection Model Zoo", is a collection of pre-trained models compatible with Tensorflow Object Detection API.

Tensorflow Detection Model Zoo consists of 16 Object detection models pre-trained on COCO Dataset. Top 12 from this list of models provide "boxes" as output and they are compatible with the code linked to this article. These models are capable of detecting 80 types of objects including humans. TensorFlow provides stable Python for version 3.7 across all platforms. Using this library for human detection is more efficient as it can be implemented without a thermal camera.

2.6 DroNet

DroNet[1] (introduced by Antonio Loquercio, Ana I.Maqueda , Carlos R. del-Blanco, and Davide Scaramuzza) is a convolutional neural network(implemented with the help of tensorflow), whose purpose is to reliably drive an autonomous drone through the streets of a city. Trained with data collected by cars and bicycles, our system learns from them to follow basic traffic rules, e.g, do not go off the road, and to safely avoid other pedestrians or obstacles. Along with automatic localization in a given map using GPS and computation of control commands the policy learned by DroNet is highly generalizable, and even allows to fly a drone in indoor corridors and parking lots.

2.7 Geolocalisation with GPS module

GPS stands for Global Positioning System and used to detect the Latitude and Longitude of any location on the Earth, with exact UTC time (Universal Time Coordinated). This device receives the coordinates from the satellite for each and every second, with time and date. GPS module sends the data related to tracking position in real time, and it sends so many data in NMEA format. NMEA format consist several sentences, in which we only need one sentence. This sentence starts from $GPGGA and contains the coordinates, time and other useful information. This GPGGA is referred to Global Positioning System Fix Data. We can extract coordinate from $GPGGA string by counting the commas in the string. Suppose you find $GPGGA string and stores it in an array, then Latitude can be found after two commas and Longitude can be found after four commas. Now these latitude and longitude can be put in other arrays.

NMEA format consist several sentences, in which four important sentences are given below. More detail about the NMEA sentence and its data format can be found here.

- $GPGGA: Global Positioning System Fix Data
- $GPGSV: GPS satellites in view
- $GPGSA: GPS DOP and active satellites

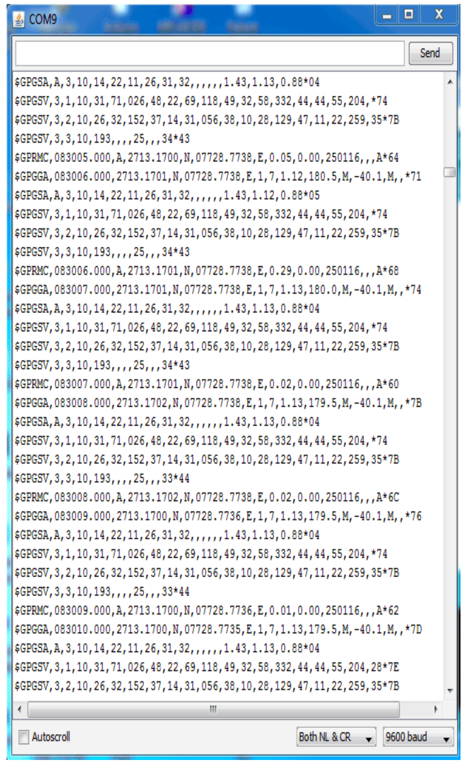

Figure 2.1: Sample data from GPS module in NMEA data

- $GPRMC: Recommended minimum specific GPS/Transit data

These strings contain many GPS parameters like: Time, Date, Longitude, Latitude, speed, no. of satellites in used, altitude and many other things.For any location coordinates and time, we can use $GPGGA and $GPRMC.For Date and time we can use $GPRMC string.When we use GPS module for tracking any location, we only need coordinates and we can find this in $GPGGA string. Only $GPGGA (Global Positioning System Fix Data) String is mostly used in programs.

Chapter 3

System Overview

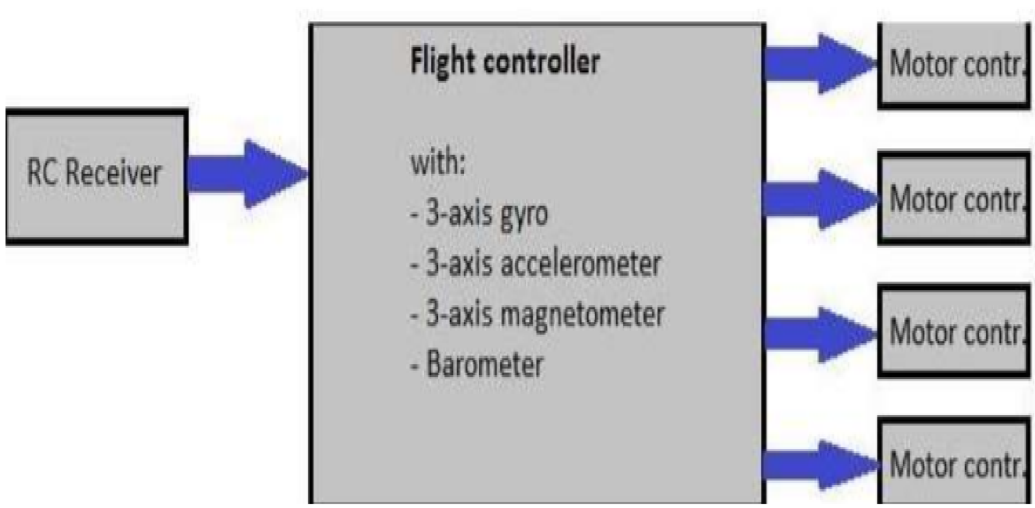

Figure 3.1: Flight control board

3.1 Controls

Roll – Done by pushing the right stick to the left or right. Literally rolls the quadcopter, which maneuvers the quadcopter left or right.

Pitch – Done by pushing the right stick forwards or backwards. Tilts the quadcopter, which maneuvers the quadcopter forwards or backwards.

Yaw – Done by pushing the left stick to the left or to the right. Rotates the quadcopter left or right. Points the front of the copter different directions and helps with changing directions while flying.

Throttle – Engaged by pushing the left stick forwards. Disengaged by pulling the left stick backwards. This adjusts the altitude, or height, of the quadcopter.

Trim – Buttons on the remote control that help you adjust roll, pitch, yaw, and throttle if they are off balance.

The Rudder - It's the same as the left stick.However, it relates directly to controlling yaw (as opposed to the throttle).

Aileron– Same as the right stick. However, it relates directly to controlling roll (left and right movement).

The Elevator – Same as the right stick. However, it relates directly to controlling pitch (forwards and backwards movement).

Maneuvering:Bank turn – A consistent circular turn in either the clockwise or counterclockwise direction.

Hovering – Staying in the same position while airborne. Done by controlling the throttle.

Roll: Roll moves your quadcopter left or right. It's done by pushing the right stick on your transmitter to the left or to the right. It's called "roll" because it literally rolls the quadcopter. For example, as you push the right stick to the right, the quadcopter will angle diagonally downwards to the right.

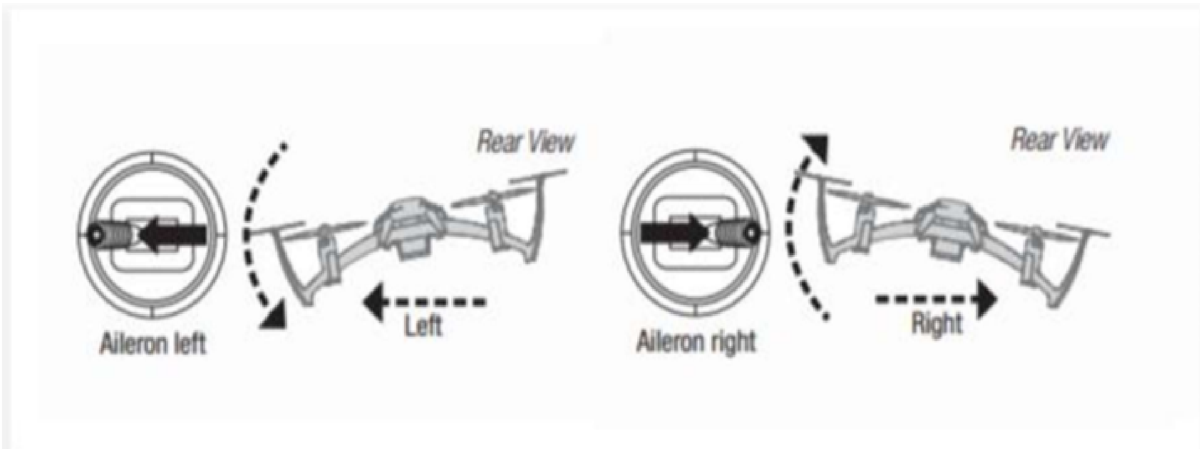

Figure 3.2: Example of a quadcopter rolling left and right

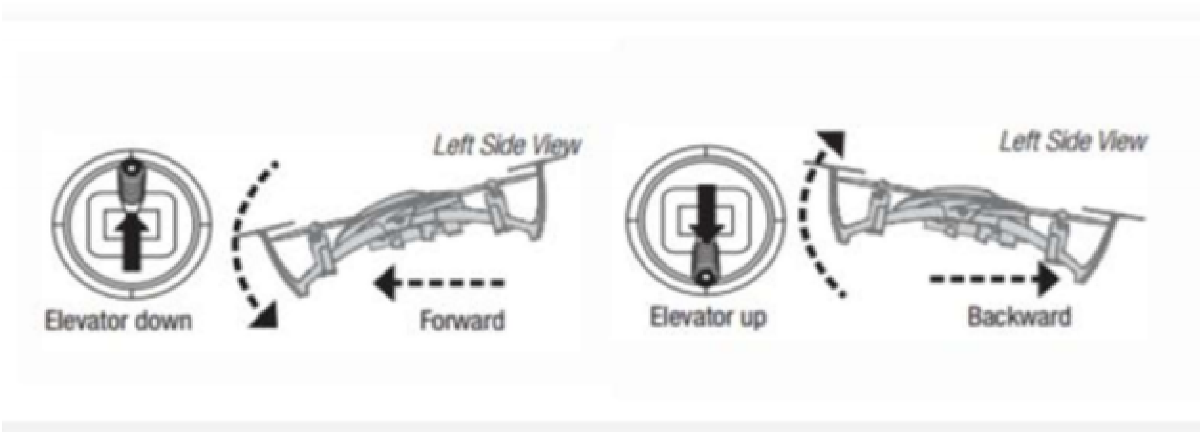

Figure 3.3: Example of a quadcopter pitching forwards and backwards

Yaw:This is done by pushing the left stick to left or to the right.

Throttle:Throttle gives the propellers on your quadcopter enough power to get airborne. When flying, it will have the throttle engaged constantly. To engage the throttle, push the left stick forwards. To disengage, pull it backwards.

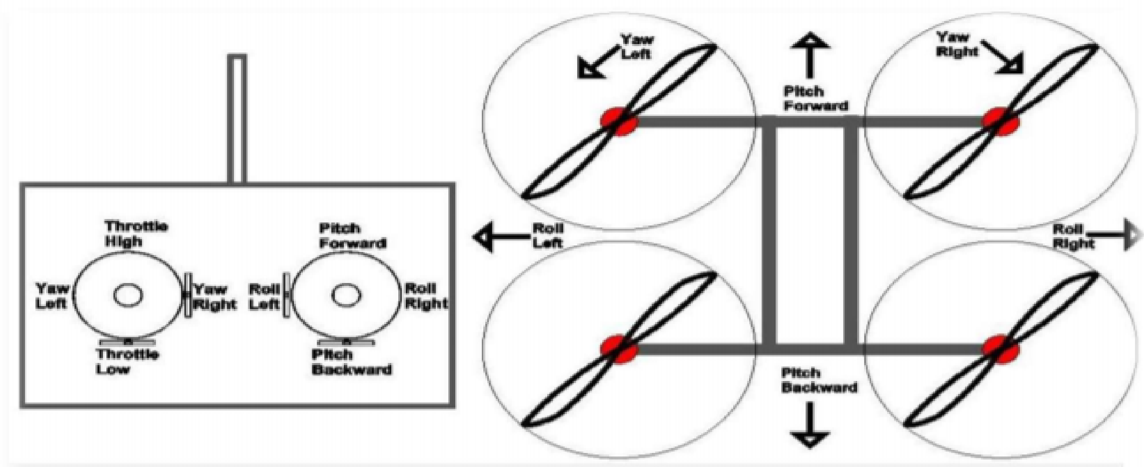

Figure 3.4: Simple sketch of roll,yaw,pitch and throttle on a transmitter

Chapter 4

Component Specifications

4.1 HJ450 frame

This is the glass fiber quadcopter frame which is very simple and easy to build frame. This Flame wheel is one of the most popular frames out there for a number of good reasons:

1. It's relatively inexpensive
2. It is famously durable
3. The centre plate doubles as a power distribution board which tidies things up quite a bit and allowed me to get rid of my ugly DIY wiring harness.
4. The design is really well thought out – it's a compact frame. Plenty of room for receiver, control board, ESCs, and battery, with mounting options and room to spare for a GoPro or other camera setup.
5. As one of the most popular quadcopter frames on the market, there is a wide

variety of spare parts and accessories to choose from such as landing gears, gimbals, etc

Every quadcopter or other multirotor aircraft needs a frame to house all the other components. Things to consider here are weight, size, and materials. They're strong, light, and have a sensible configuration including a built-in power distribution board (PDB) that allows for a clean and easy build. There are also a ton of spare parts and accessories available from many different websites. There are also a ton of clones out there, most of which include the same built-in PDB and durable construction as the original. Parts and accessories are 100compatible and interchangeable. Frames can also be built at home using aluminium or balsa sheet. But results will vary from manufactured frames, both aesthetically and in terms of flight attributes.

Figure 4.1: HJ450 frame

4.1.1 Type Of Frames

1. **Aerial Cinematograph**:Big enough to lift a specific camera with tall landing gear.

Figure 4.2: Aerial Quadcopter

2. **Sport**:Super light-weight and extremely stiff for crisp and responsive control.

Figure 4.3: Sport Quadcopter

3. **Sport FPV**:Lots of mounting surfaces for extra electronics and action cameras.

Figure 4.4: Sport FPV Quadcopter

4. **Mini**:Very small and virtually indestructible.

Figure 4.5: Mini Quadcopter

4.2 Electronic Speeed Controller

The electronic speed control, or ESC, is what tells the motors how fast to spin at any given time. We need four ESCs for a quadcopter, one connected to each motor. The ESCs are then connected directly to the battery through either a wiring harness or power distribution board. Many ESCs come with a built in battery eliminator circuit (BEC), which allows you to power things like the flight control board and radio receiver without connecting them directly to the battery. Because the motors on a quadcopter must all spin at precise speeds to achieve accurate flight, the ESC is very important. These days if you are building a quadcopter or other multirotor, it is pretty much standard to use ESCs that have the SimonK firmware on them. This firmware changes the refresh rate of the ESC so the motors get many more instructions per second from the ESC, thus have greater control over the quadcopter's behavior.

ESCs are normally rated according to maximum current. We are using 30 A.Generally the higher the rating, the larger and heavier the ESC tends to be which a factor when calculating mass is and balance in airplanes. Many modern ESCs support nickel metal hydride, lithium ion polymer and lithium iron phosphate batteries with a range of input and cut-off voltages. The type of battery and number of cells connected is an important consideration when choosing a Battery eliminator circuit (BEC), whether built into the controller or as a stand-alone unit. A higher number of cells connected will result in a reduced power rating and therefore a lower number of servos supported by an integrated BEC, if it uses a linear voltage regulator. A well designed BEC using a switching regulator should not have a similar limitation.

The ESC controls the speed of an AC motor with frequency, not voltage. If you plug an 11.1 volt battery into your power system, you have 11.1 volts going to the motor with the full amperage potential of the battery backing that voltage. The AC brushless motors we use are true 3-phase AC motors. The motors DO run on AC current. The ESC is a trapezoidal wave generator. It produces 3 separate waves (one for each wire to the motor). The speed of the motor has nothing to do with voltage or amps, but instead the timing of the current fed into it. By increasing and decreasing the wave length (frequency) of the trapezoidal wave on the 3 phases, the ESC causes the motor to spin faster and slower. The ESC switches the polarity of the phases to create the waves. This means that the voltage through any given winding flows 'Alternately' one direction then the other. This creates a push-pull effect in the magnetic field of each winding, making the motor more powerful for its size and weight. The motor and the load that is placed on it, is what determines the amp draw from the ESC and the battery.

In the below picture, we have 2 motors with 3 poles each. Their winding are labelled as poles"A", "B", and "C". The graph (under the 2 motors) shows the 3 separate waves that the ESC generates to drive a motor. The graph shows the signals time to voltage relationships. The black wave on the graph is the signal that is sent to winding "A". The red signal goes to winding "B", and the blue signal goes to winding "C". If you look at "AC Motor 1" and "AC Motor 2", and the signals shown on the graph that are sent to the windings; it is easy to see that when we swop any two motor connections, we change the order that the waves hit the windings, and that changes the direction of the motor.

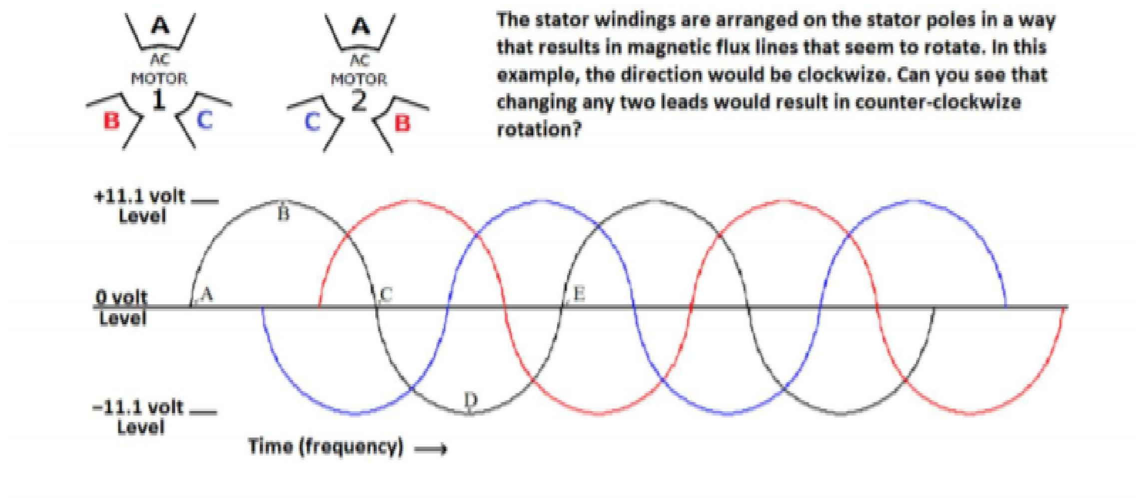

Figure 4.6: Frequency variation in motors

Figure 4.7: Electronic speed controller

Specifications

- Current Draw: 30A Continuous/35A Burst
- Voltage Range: 2-4s Li poly
- BEC: 5V3A Linear
- Weight: 35g

4.3 Brushless Dc motors

Brushless DC electric motor (BLDC motors, BL motors) also known as electronically commutated motors (ECMs, EC motors) are synchronous motors that are powered by a DC electric source via an integrated inverter/switching power supply, which produces an AC electric signal to drive the motor. In this context, AC, alternating current, does not imply a sinusoidal waveform, but rather a bi-directional current with no restriction on waveform. Additional sensors and electronics control the inverter output amplitude and waveform (and therefore percent of DC bus usage/efficiency) and frequency (i.e. rotor speed).The rotor part of a brushless motor is often a permanent magnet synchronous motor, but can also be a 12 switched reluctance motor, or induction motor. Brushless motors may be described as stepper motors; however, the term stepper motor tends to be used for motors that are designed specifically to be operated in a mode where they are frequently stopped with the rotor in a defined angular position. This page describes more general brushless motor principles, though there is overlap. Two key performance parameters of brushless DC motors are the motor constants KV and Km.

In a brushless DC motor (BLDC), you put the permanent magnets on the rotor and you move the electromagnets to the stator. Then you use a computer (connected to high-power transistors) to charge up the electromagnets as the shaft turns. This system has all sorts of advantages:

- Because a computer controls the motor instead of mechanical brushes, it's more precise. The computer can also factor the speed of the motor into the equation. This makes brushless motors more efficient.

- There is no sparking and much less electrical noise.
- There are no brushes to wear out.
- With the electromagnets on the stator, they are very easy to cool.
- You can have a lot of electromagnets on the stator for more precise control.

The only disadvantage of a brushless motor is its higher initial cost, but you can often recover that cost through the greater efficiency over the life of the motor. The poles on the stator of a two-phase BLDC motor used to power a computer cooling fan.

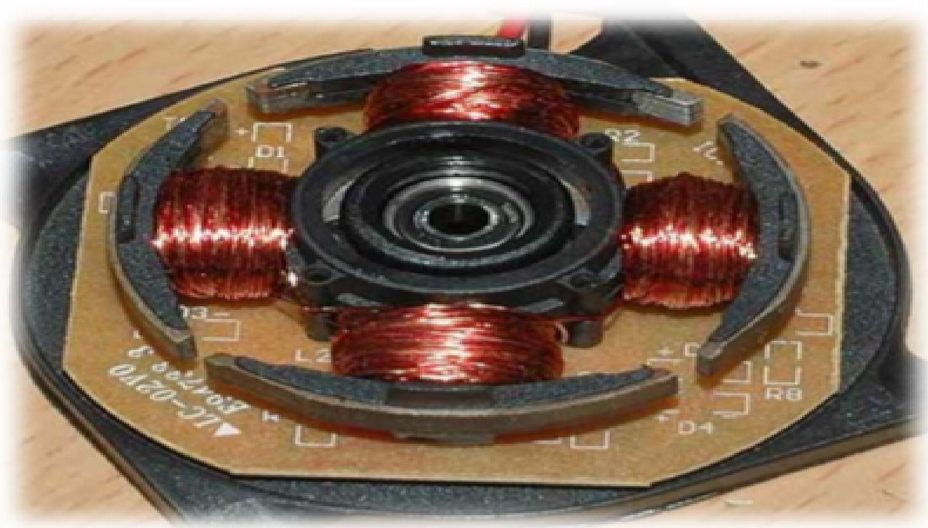

Figure 4.8: Brushless motor winding

Specifications:

- KV: 1300KV/1000KV/850KV/750KV
- Pull: 930g/890g/875g/866g
- Motor size(mm): 28*30
- Battery: 2-4s Li po

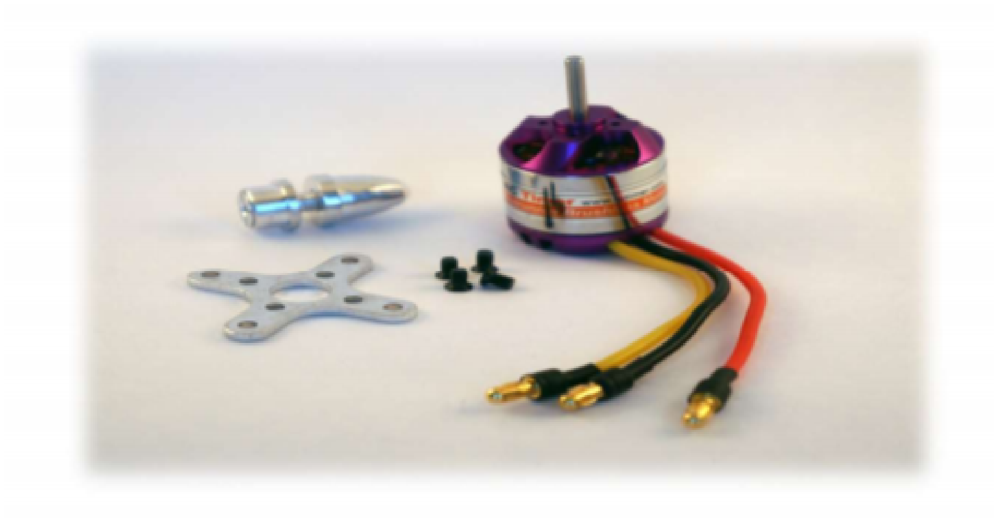

Figure 4.9: Brushless DC motor 1000kv

4.3.1 Types of motors

- **Brushed DC Motor**

  Since this type of motor is driven by a DC power supply, it is also called simply a DC motor. To distinguish it from a permanent magnet synchronous motor (brushless DC motor), here we will call it a brushed DC motor. Since it is comparatively economical and easy to drive, the brushed DC motor is used for a broad range of applications. A brushed DC motor generates torque by mechanically switching the direction of current in coordination with rotation using a commutator and brushes. Shortcomings of a brushed DC motor include the need for maintenance due to wear down of the brushes and the production of electrical and mechanical noise. The PWM duty ratio can by adjusted using a microcontroller, etc. to change the applied voltage, thus allowing the speed of rotation and position to be controlled.

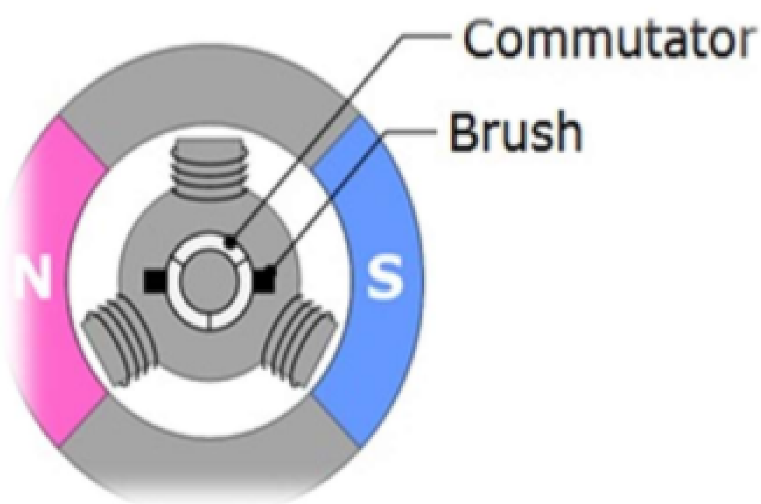

Figure 4.10: Brushed DC motor

- **Permanent Magnet Synchronous Motor (Brushless DC Motor)**
  Take away the commutator and brushes that are the shortcomings of the brushed DC motor and you have a permanent magnet synchronous motor (brushless DC motor). Due to the lack of brushes, a brushless DC motor has excellent device life and low-noise characteristics. Also, it can achieve great efficiency, so it is used in a broad range of applications including energysav-

ing home appliances and long-running industrial applications. There are two major types of structure, differing by how the magnet is equipped on the rotor.

Surface Permanent Magnet (SPM): This type has a permanent magnet affixed to the outside of the rotor, and magnetic permeability is constant through all positions.

Interior Permanent Magnet (IPM): This type has a permanent magnet embedded inside the rotor, and since the magnetic permeability varies with position, reluctance torque can be used. Since there is no structure for mechanically switching the direction of current, this needs to be performed electronically using an inverter circuit. By driving an inverter circuit using a microcontroller, etc., a three-phase alternating-current voltage is applied to the stator, generating a rotating magnetic field. Driving waveforms can be divided into the following two main types.

Trapezoidal wave drive: Drives by applying trapezoidal (rectangular) wave voltage.

Sinusoidal wave drive: Drives by applying sinusoidal wave voltage in order to suppress the vibration, noise, and torque ripple which are issues encountered with trapezoidal wave drive. In many cases, vector control (fields oriented control) is use to control torque and phase in a linearly independent manner. Since torque is proportional to drive current, high-speed and high-precision position and speed control is possible by adding position and speed sensors. In order to drive efficiently, it is necessary to detect the rotor (magnet) position. Hall sensors, encoders, and resolvers are used for detecting position. Due to temperature limitations of sensors and cost considerations, there are cases where rotor (magnet) position is estimated from three-phase current or induced voltage without using sensors (sensor less position estimation). In general, industrial systems mainly use a sensor method and home appliance systems use a sensor less position estimation method.

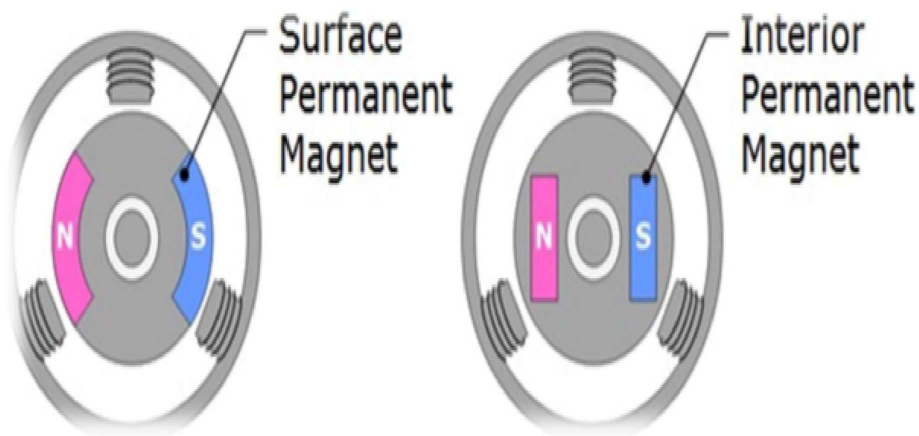

Figure 4.11: Brushless DC motor permanent magnet

- **Three-Phase Induction Motor**

  A three-phase induction motor is an induction motor driven on a three-phase alternatingcurrent power source. A rotating magnetic field is produced by passing a three-phase alternating current through a stator, and an induced current is generated in the rotor by electromagnetic induction. This rotating magnetic field and induced current generate an electromagnetic force, which causes the rotor to rotate. Since the magnetic field needs to move in respect to the rotor in order to generate an induced current, the speed of rotation of the rotor is always slower than the synchronous speed of the rotating magnetic field. The difference between the frequency of the rotating magnetic field and the frequency equivalent to the speed of rotation is called the slip frequency. The generated torque is proportional to the slip frequency. The structure of a three-phase induction motor is simple and sturdy. Because it is easy to use for large power motors and has relatively good efficiency, it is often used in industrial segments. However, due to the aforementioned slip frequency, it is unsuitable for position control. In many cases, the three-phase alternating-current used at factories and so on is input directly to drive the motor at a constant speed. For adjustable-speed energy-saving applications which value efficiency, the motor can be inverter driven to control torque.

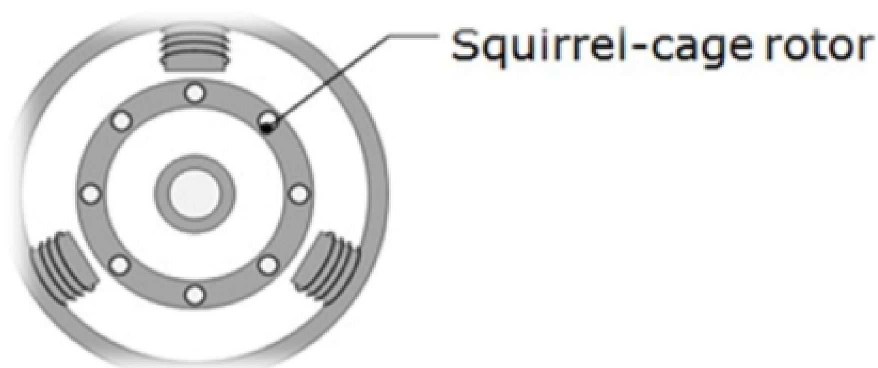

Figure 4.12: Three phase induction motor

Single-Phase Induction Motor (Universal Motor)

Single-phase induction motors are a type of induction motor which as the name implies operate on a single-phase alternating-current power source. Since self-starting is not possible with single-phase alternating current, the motor needs a way to start. Single-phase induction motors can be divided into the following three main types, depending on the way they start. Capacitor: A capacitor splits phases to produce a two-phase alternating current to obtain a starting torque. Split Phase: A starter coil with low inductance is used to obtain a starting torque. Shaded Pole: A shaded pole produces an induced current, which is used to obtain a starting torque. In many cases, the single-phase alternating-current used in homes and so on is input directly to drive the motor at a constant speed. The AC voltage phase can be controlled using a triac to control the speed of rotation.

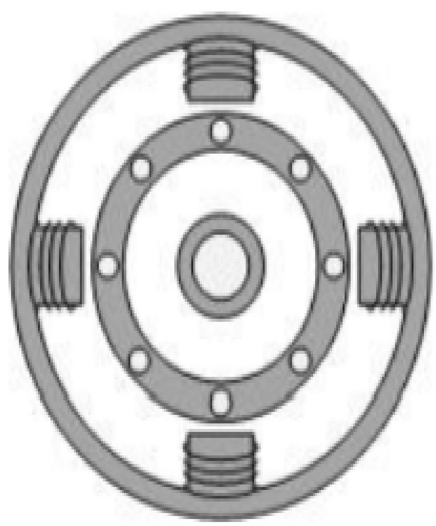

Figure 4.13: Single phase induction motor

4.4 Propellers

Here in this project quadcopter there arises the need of two types of propellers to need the purpose of flight. A pair of clockwise (CW) and anticlockwise (ACW) propellers are needed. The care should be taken in finalizing the dimensions of the propellers. A propeller is a type of fan that transmits power by converting rotational motion into thrust. A pressure difference is produced between the forward and rear surfaces of the air foil-shaped blade, and a fluid (such as air or water) is accelerated behind the blade. Propeller dynamics can be modelled by both Bernoulli's principle and Newton's third law. A marine propeller is sometimes colloquially known as pitch of the screw. Generally, increased propeller pitch and length will draw more current. Also the pitch can be defined as the travel distance of one single prop rotation. In a nutshell, higher pitch means slower rotation, but will increase your vehicle speed which also use more power.

When deciding on length and pitch, you need to find a good balance. Generally a prop with low pitch numbers can generate more torque. The motors don't need to work as hard so it pulls less current with this type of prop. If you want to do acrobatics, you will need torque propellers which provide more acceleration and it puts less pressure on the power system. Lower pitch propellers will also improve stability.

A higher pitch propeller moves greater amount of air, which could create turbulence and cause the aircraft to wobble during hovering. If you notice this with your quadcopter, try to choosing a lower pitched propeller.

When it comes to the length, propeller efficiency is closely related to the contact area of a prop with air, so a small increase in prop length will increase the propeller efficiency. (Pretty much like swimmers with larger hands and feet can swim faster, but also more tiring for them)

Figure 4.14: Propellers

4.5 Flight Controller Board

The KK2.1.5 is next big evolution of the first generation KK flight control boards. The KK2.1.5 was engineered from the ground up to bring multi-rotor flight to everyone, not just the experts. The LCD screen and built in software makes install and setup easier than ever. A host of multi-rotor craft types are pre-installed, simply select your craft type, check motor layout/propeller direction, and calibrate your ESCs and radio.

The original KK gyro system has been updated to an incredibly sensitive 6050 MPU system making this the most stable KK board ever and allowing for the addition of an auto-level function. At the heart of the KK2.1.5 is an Atmel Mega644PA 8-bit AVR RISC-based microcontroller with 64k of memory. An additional polarity protected header has been added for voltage detection, so no need for on-board soldering. A handy piezo buzzer is also included for audio warning when activating and deactivating the board.

The KK2.1.5 added polarity protection to the voltage sense header and a fuse protected buzzer outputs, in case something is accidentally plugged in incorrectly. The voltage sense line has been updated for better accuracy. The board is clearly labeled and the voltage sense line color has been changed to red for easy identification, making installation.

Its purpose is to stabilize the aircraft during flight. To do this it takes the signal from the 6050MPU gyro/acc (roll, pitch and yaw) then passes the signal to the Atmega644PA IC. The Atmega644PA IC unit then processes these signals according the users selected firmware and passes control signals to the installed Electronic Speed Controllers (ESCs). These signals instruct the ESCs to make fine adjustments to the motors rotational speed which in turn stabilizes your multi-rotor craft.

KK2.1.5 Multi-Rotor control board also uses signals from your radio systems receiver (Rx) and passes these signals to the Atmega644PA IC via the aileron, elevator, throttle and rudder inputs. Once this information has been processed the

IC will send varying signals to the ESCs which in turn adjust the rotational speed of each motor to induce controlled flight (up, down, backwards, forwards, left, right, yaw).

Specifications

- Size: 50.5mm x 50.5mm x 12mm
- Weight: 21 gram (Inc. Piezo buzzer)
- IC: Atmega644 PA
- Gyro/Acc: 6050MPU Inven Sense Inc.
- Auto-level: Yes
- Input Voltage: 4.8-6.0V
- AVR interface: standard 6 pin.

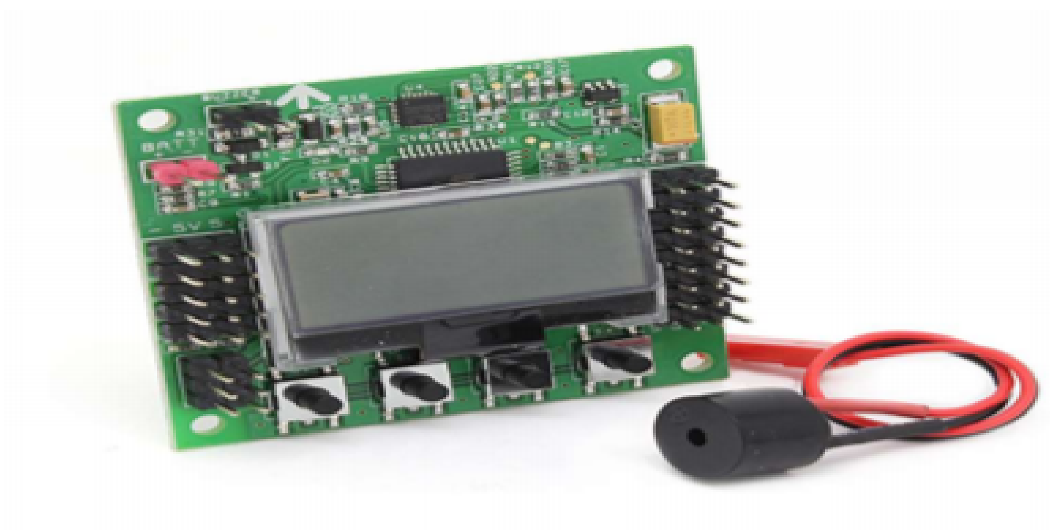

Figure 4.15: Flight control board

4.6 Flysky Transmitter and Receiver

Fly sky Transmitter and Receiver which we are using is CT6B which has 6 channels. It Requires a PC to change the channel variables, mixing and servo reversing. The radio transmitter and receiver allow you to control the quadcopter. There are many suitable models available, but you will need at least four channels for a basic quadcopter with the KK2.1.5 control board. In electronics and telecommunications a radio transmitter is an electronic device which, with the aid of an antenna, produces radio waves.

Transmitter

The transmitter itself generates a radio frequency alternating current, which is applied to the antenna. When excited by this alternating current, the antenna radiates radio waves. The term transmitter is usually limited to equipment that generates radio waves for communication purposes; or radiolocation, such as radar and navigational transmitters. A transmitter can be a separate piece of electronic equipment, or an electrical circuit within another electronic device. A transmitter and receiver combined in one unit is called a transceiver.

The purpose of most transmitters is radio communication of information over a distance. The information is provided to the transmitter in the form of an electronic signal, such as an audio (sound) signal from a microphone, a video (TV) signal from a TV camera, or in wireless networking devices a digital signal from a computer. The transmitter combines the information signal to be carried with the radio frequency signal which generates the radio waves, which is often called the carrier. This process is called modulation. A radio transmitter is an electronic circuit, which transforms electric power from a battery or electrical mains into a radio frequency alternating current, which reverses direction millions to billions of times per second. The energy in such a rapidly reversing current can radiate off a conductor (the antenna) as electromagnetic waves (radio waves).

Receiver

A radio receiver is an electronic circuit that receives its input from an antenna, uses electronic filters to separate a wanted radio signal from all other signals picked up by this antenna, amplifies it to a level suitable for further processing, and finally converts through demodulation and decoding the signal into a form usable for the consumer, such as sound, pictures, digital data, measurement values, navigational positions, etc. The receiver is the receiving end of a communication channel. It receives decoded messages/information from the sender, who first encoded them. Sometimes the receiver is modelled so as to include the decoder. Real-world receivers like radio receivers cannot be expected to receive as much information as predicted by the noisy channel coding theorem.

In the given figure below

Right Stick: The right stick controls roll and pitch. In other words, it moves your quadcopter left/right and backwards/forwards.

Left Stick : The left stick controls yaw and throttle. In other words, it rotates your quadcopter clockwise or counterclockwise, and it adjusts the height at which you are flying When you first push your throttle to get your quadcopter off the ground, you may notice that the UAV automatically tilts and flies to one direction (or multiple). This happens when the controls are unbalanced. To balance them out, certain controls need to be trimmed.

Figure 4.16: Flysky transmitter and reciever- CT6B

Specifications

- Channels: 6channels
- Model type: Heli, Airplane, Glider
- RF power: less than 20db
- Modulation: GFSK
- Code type: PCM
- Sensitivity: 1024
- Low voltage warning: LED warning
- DSC port: yes
- Charger port: yes
- Power: 12V DC(1.5AAA*8)

- Weight:680g
- ANT length:26mm

4.7 LIPO battery

A lithium polymer battery, or more correctly lithium-ion polymer battery (abbreviated variously as LiPo, LIP, Li-poly and others), is a rechargeable battery of lithium-ion technology in a pouch format. Unlike cylindrical and prismatic cells, LiPos come in a soft package or pouch, which makes them lighter but also less rigid.

Quadcopters typically use LiPo batteries which come in a variety of sizes and configurations. We typically use 3S1P batteries, which indicates 3 cells in parallel. Each cell is 3.7 volts, so this battery is rated at 11.1 volts. LiPo batteries also have a C rating and a power rating in mAh (which stands for milliamps per hour). The C rating describes the rate at which power can be drawn from the battery, and the power rating describes how much power the battery can supply. Larger batteries weigh more so there is always a tradeoff between flight duration and total weight. A general rule of thumb is that doubling the battery power will get you 50% more flight time, assuming your quadcopter can lift the additional weight.

Li Po batteries have three main things going for them that make them the perfect battery choice for RC planes and even more so for RC helicopters over conventional rechargeable battery types such as NiCad, or NiMH.

- Li Po batteries are light weight and can be made in almost any shape and size.
- Li Po batteries have high discharge rates to power the most demanding electric motors.
- Li Po batteries hold lots of power in a small package

Just as with other lithium-ion cells, LiPos work on the principle of intercalation and deintercalation of lithium ions from a positive electrode material and a negative electrode material, with the liquid electrolyte providing a conductive medium. To prevent the electrodes from touching each other directly, a microporous separator is in between which allows only the ions and not the electrode particles to migrate from one side to the other.

Unlike lithium-ion cylindrical and prismatic cells, which have a rigid metal case, LiPo cells have a flexible, foil-type (polymer laminate) case, so they are relatively unconstrained. By themselves the cells are over 20% lighter than equivalent cylindrical cells of the same capacity.

Being lightweight is an advantage when the application requires minimum weight, such as in the case of radio controlled models. However, it has been investigated that moderate pressure on the stack of layers that compose the cell results in increased capacity retention, because the contact between the components is maximized and delamination and deformation is prevented, which is associated with increase of cell impedance and degradation.

Figure 4.17: LIPO battery 2500 mAH 12v

4.8 Raspberry pi

Raspberry Pi is the name of a series of single-board computers made by the Raspberry Pi Foundation, a UK charity that aims to educate people in computing and create easier access to computing education.

The Raspberry Pi launched in 2012, and there have been several iterations and variations released since then. The original Pi had a single-core 700MHz CPU and just 256MB RAM, and the latest model has a quad-core 1.4GHz CPU with 1GB RAM. The main price point for Raspberry Pi has always been $35 and all models have been $35 or less, including the Pi Zero, which costs just $5.The Raspberry Pi is a very cheap computer that runs Linux, but it also provides a set of GPIO (general purpose input/output) pins that allow you to control electronic components for physical computing and explore the Internet of Things (IoT).he Raspberry Pi Foundation works to put the power of computing and digital making into the hands of people all over the world. It does this by providing low-cost, high-performance computers that people use to learn, solve problems, and have fun. It provides outreach and education to help more people access computing and digital making—it develops free resources to help people learn about computing and making things with computers and also trains educators who can guide other people to learn.

The Raspberry Pi operates in the open source ecosystem: it runs Linux (a variety of distributions), and its main supported operating system, Raspbian, is open source and runs a suite of open source software. The Raspberry Pi Foundation contributes to the Linux kernel and various other open source projects as well as releasing much of its own software as open source.

The Raspberry Pi's schematics are released, but the board itself is not open hardware. The Raspberry Pi Foundation relies on income from the sale of Raspberry Pis to do its charitable work.

Models

1. Pi 1 Model B (2012)
2. Pi 1 Model A (2013)
3. Pi 1 Model B+ (2014)
4. Pi 1 Model A+ (2014)
5. Pi 2 Model B (2015)
6. Pi Zero (2015)

7. Pi 3 Model B (2016)

8. Pi Zero W (2017)

9. Pi 3 Model B+ (2018)

10. Pi 3 Model A+ (2019)

In our project we are using raspberry pi model b+ which has many advanced features.

Features of Raspberry PI Model B

- 512 MB SDRAM memory
- Broadcom BCM2835 SoC full high definition multimedia processor
- Dual Core Video Core IV Multimedia coprocessor
- Single 2.0 USB connector
- HDMI (rev 1.3 and 1.4) Composite RCA (PAL NTSC) Video Out
- 3.5 MM Jack, HDMI Audio Out
- MMC, SD, SDIO Card slot on board storage
- Linux Operating system
- Dimensions are 8.6cm*5.4cm*1.7cm
- On board 10/100 Ethernet RJ45 jack

Figure 4.18: Raspberry pi model B

4.9 GPS Module

GPS module which we are using is NEO-6M which is a well-performing complete GPS receiver with a built-in 25 x 25 x 4mm ceramic antenna, which provides a strong satellite search capability. With the power and signal indicators, you can monitor the status of the module. There is data backup battery, the module can save the data when the main power is shut down accidentally. Its 3mm mounting holes can ensure easy assembly on your aircraft, which thus can fly steadily at a fixed position, return to Home automatically, and automatic waypoint flying, etc.

It can track up to 22 satellites on 50 channels and achieves the industry's highest level of sensitivity i.e. -161 dB tracking, while consuming only 45mA supply current.

Unlike other GPS modules, it can do up to 5 location updates a second with 2.5m Horizontal position accuracy. The u-blox 6 positioning engine also boasts a Time-To-First-Fix (TTFF) of under 1 second.

One of the best features the chip provides is Power Save Mode(PSM). It allows a reduction in system power consumption by selectively switching parts of the receiver ON and OFF. This dramatically reduces power consumption of the module to just 11mA making it suitable for power sensitive applications like GPS wristwatch.

The necessary data pins of NEO-6M GPS chip are broken out to a 0.1 pitch headers. This includes pins required for communication with a microcontroller over UART. The module supports baud rate from 4800bps to 230400bps with default baud of 9600.

Features

- A complete GPS module with an active antenna integrated, and a built-in EEPROM to save configuration parameter data.
- Built-in 25 x 25 x 4mm ceramic active antenna provides strong satellite search capability.
- Equipped with power and signal indicator lights and data backup battery.
- Power supply: 3-5V; Default baud rate: 9600bps.
- Interface: RS232 TTL

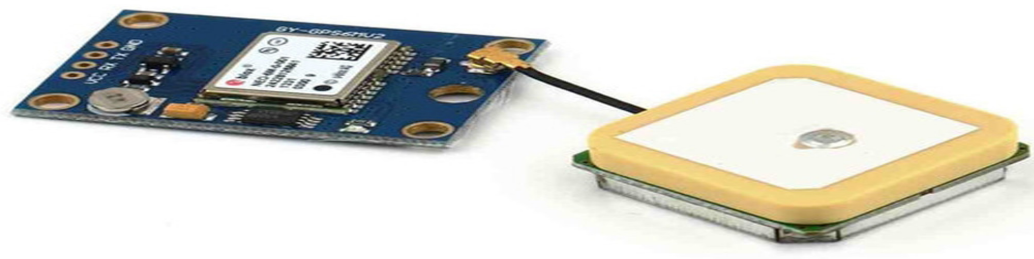

Figure 4.19: GPS module NEO-6M

4.10 DroNet:Learning to fly by driving

Our learning approach aims at reactively predicting a steering angle and a probability of collision from the drone on-board forward-looking camera. These are later converted into control flying commands which enable a UAV to safely navigate while avoiding obstacles.

To learn steering angles from images, we use one of the publicly available datasets from Udacity's project . This dataset contains over 70,000 images of car driving distributed over 6 experiments, 5 for training and 1 for testing. Every experiment stores time-stamped images from 3 cameras (left, central, right), IMU, GPS data, gear, brake, throttle, steering angles and speed. For our experiment, we only use images from the forward-looking camera and their associated steering angles.

There are no public datasets that associate images with collision probability according to the distance to the obstacles. Therefore, we collect our own collision data by mounting a GoPro camera on the handlebars of a bicycle. We drive along different areas of a city, trying to diversify the types of obstacles (vehicles, pedestrians, vegetation, under- construction sites) and the appearance of the environment . This way, the drone is able to generalize under different scenarios.

For the drone to navigate automatically in a feasible way without having any collision with objects it should have the property that detects the obstacles in front of it and should evade it. To accomplish this, we uses DroNet: a convolutional neural network that can safely drive a drone through the streets of a city. Designed as a fast 8-layers residual network, DroNet produces two outputs for each single input image: a steering angle to keep the drone navigating while avoiding obstacles, and a collision probability to let the UAV recognize dangerous situations and promptly react to them. The challenge is however to collect enough data in an unstructured outdoor environment such as a city.

DroNet is a convolutional neural network, whose purpose is to reliably drive an autonomous drone through the streets of a city. Trained with data collected by cars and bicycles, our system learns from them to follow basic traffic rules, e.g, do not go off the road, and to safely avoid other pedestrians or obstacles. The policy learned by DroNet is highly generalizable, and even allows to fly a drone in indoor corridors and parking lots.

The traditional approach wasto use a two step interleaved process consisting of (i) automatic localization in a given map (using GPS, visual and/or range sensors), and (ii) computation of control commands to allow the agent to avoid obstacles while achieving its goal. Even though advanced SLAM algorithms enable localization under a wide range of conditions, visual aliasing, dynamic scenes, and strong appearance changes can drive the perception system to unrecoverable errors. Moreover, keeping the perception and control blocks separated not only hinders any possibility of positive feedback between them, but also introduces the challenging problem of inferring control commands from 3D maps. The dronet rectifies all the disadvantages that a traditional method has.

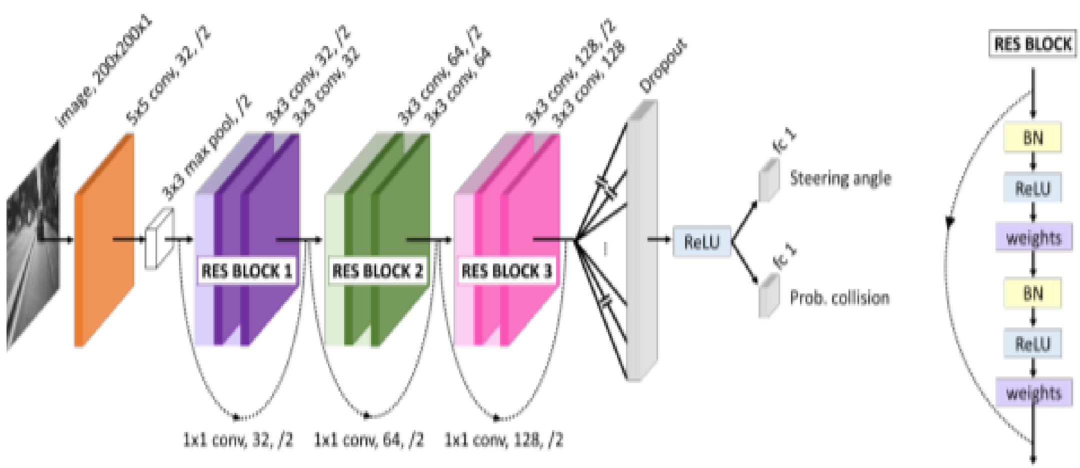

Figure 4.20: DroNet as a forked Convolutional Neural Network

4.10.1 Drone Control

The outputs of DroNet are used to command the UAV to move on a plane with forward velocity v_k and steering angle Θ_k. More specifically, we use the probability of collision p_t provided by the network to modulate the forward velocity: the vehicle is commanded to go at maximal speed V_{max} when the probability of collision is null, and to stop whenever it is close to 1. We use a low-pass filtered version of the modulated forward velocity v_k to provide the controller with smooth, continuous inputs ($0 \leq \alpha \leq 1$):

$$v_k = (1 - \alpha)v_{k-1} + \alpha(1 - p_t)v_{max} \tag{4.1}$$

Similarly, we map the predicted scaled steering s_k into a rotation around the body z-axis (yaw angle Θ), corresponding to the axis orthogonal to the propellers plane. Concretely, we convert s_k from a [1,1] range into a desired yaw angle θ_k in the range $[-\pi/2, \pi/2]$ and low-pass filter it:

$$\theta_k = (1 - \beta)\theta_{k-1} + \beta\pi/2s_k \tag{4.2}$$

4.11 Human Detection

Human Detection is a branch of Object Detection. Object Detection is the task of identifying the presence of predefined types of objects in an image. This task involves both identification of the presence of the objects and identification of the rectangular boundary surrounding each object (i.e. Object Localisation). An object detection system which can detect the class “Human” can work as a Human Detection System.

4.11.1 Early Approaches for Human Detection

Haar Cascades for Human Detection

Haar feature based approach for object detection is proposed by Paul Viola and Michael Jones in their paper “Rapid Object Detection using a Boosted Cascade of Simple Features” published in 2001. This approach is widely used for Face Detection.

Open CV

OpenCV includes inbuilt functionality to provide Haar cascade based object detection. Pre-trained models provided by OpenCV for “Full Body Detection”, “Upper Body Detection” and “Lower Body Detection” are available. OpenCV includes inbuilt functionality to provide HOG based detection. It also includes a pre-trained model for Human Detection.

Histograms of Oriented Gradients for Human Detection

HOG pedestrian detection approach is proposed by N. Dalal and B. Triggs in their paper “Histograms of oriented gradients for human detection” published in 2005.

4.11.2 Drawbacks of Early Approaches

Listed below are some common drawbacks that are noticed when using Haar cascades and HOG for Human Detection. These observations are based on pre-trained models available with Open CV.

Missed Detections

These two approaches are not very good in detecting humans in various poses unless multiple models are used to detect humans in each pose. Available pre-trained models with Open CV are trained to identify the standing pose of a person. They perform fairly well on detecting persons from front view and back view. However, detections from side views of persons are generally poor.

False Detections and Duplicate Detections

These early approaches are also susceptible for detecting non human objects as humans. A trade-off between Missed Detections and False Detections can be achieved by adjusting the threshold parameters. Certain false detections (such as the detections on the image below-left) can be avoided by defining thresholds on minimum detection box size. **Unreliable Detection Boundary**

The detection boundary provided by Haar cascade and HOG does not tightly fit the detected person. In fact, the margin of the boundary is not consistent between detections. This makes it difficult to derive positions of body parts of a person (say location of feet) using ratios calculated on the detection boundary.

Flickers in Detection

Quite often it is observed that a person detected in one frame is not detected in the following frame and vice versa. Thereby, detentions are susceptible to flickering.

4.11.3 Modern approaches for human detection

Modern approaches for human detection we consider here are characterized by following special features. They are **Deep Convolution Neural Networks**. Modern approaches for human detection are largely based on Deep Convolution Neural Networks. CNNs were widely adapted for various computer vision problems such as Image Classification (identifying what type of an object an image contains), Object Detection (detecting different types of objects in a image)and Object Localization (determining locations of detected objects). "Human Detection" is a special case of Object Detection and Object Localization. They are "Multi-class Object Detectors" Another key feature of modern CNN based Object Detection systems is that they are capable of detecting multiple classes of objects. Thus, modern state-of-the-art Human Detectors are not just Human Detectors, but accurate Object Detectors which can detect multiple types of objects including humans. "Tensorflow Object Detection API" and "Tensorflow Detection Model Zoo" are using this. Tensorflow Object Detection API is used in this project for human detection. Human Detection using Tensorflow Object Detection API TensorFlow™ is an open-source API from Google, which is widely used for solving machine learning tasks that involve Deep Neural Networks. Tensorflow Object Detection API is an open-source library made based on Tensorflow for supporting training and evaluation of Object Detection models. "Tensorflow Detection Model Zoo" is a collection of pre-trained models compatible with Tensorflow Object Detection API. Tensorflow Detection Model Zoo consists of 16 Object detection models pre-trained on COCO Dataset. Top 12 from this list of models provide "boxes" as output and they are compatible with the code linked to this article. These models are capable of detecting 80 types of objects including humans.

Chapter 5

Implementation Phase

5.1 Principle Of Operation

Frame principle: Frame is the structure that holds all the components together. The Frame should be rigid, and be able to minimize the vibrations coming from the motors. Quadcopter frame consists of two to three parts which don't necessarily have to be of the same material:

- The center plate where the electronics are mounted
- Four arms mounted to the center plate
- Four motor brackets connecting the motors to the end of the arms Most available materials for the frame are:
- Carbon Fiber
- Aluminum

- Wood, such as Plywood or MDF (Medium-density fiberboard)

Carbon fiber is most rigid and vibration absorbent out of the three materials but also the most expensive. Hollow aluminum square rails are the most popular for the Quadcopters' arms due to its relatively light weight, rigidness and affordability. However aluminum could suffer from motor vibrations, as the damping effect is not as good as carbon fiber. In cases of severe vibration problem, it could mess up sensor readings. Wood board such as MDF plates could be cut out for the arms as they are better at absorbing the vibrations than aluminum. Unfortunately the wood is not a very rigid material and can break easily in Quadcopter crashes. As for arm length, the term "motor-to-motor distance" is sometimes used, meaning the distance between the centers of one motor to that of another motor of the same arm in the Quadcopter terminology. The motor to motor distance usually depends on the diameter of the propellers. To make you have enough space between the propellers and they don't get caught by each other

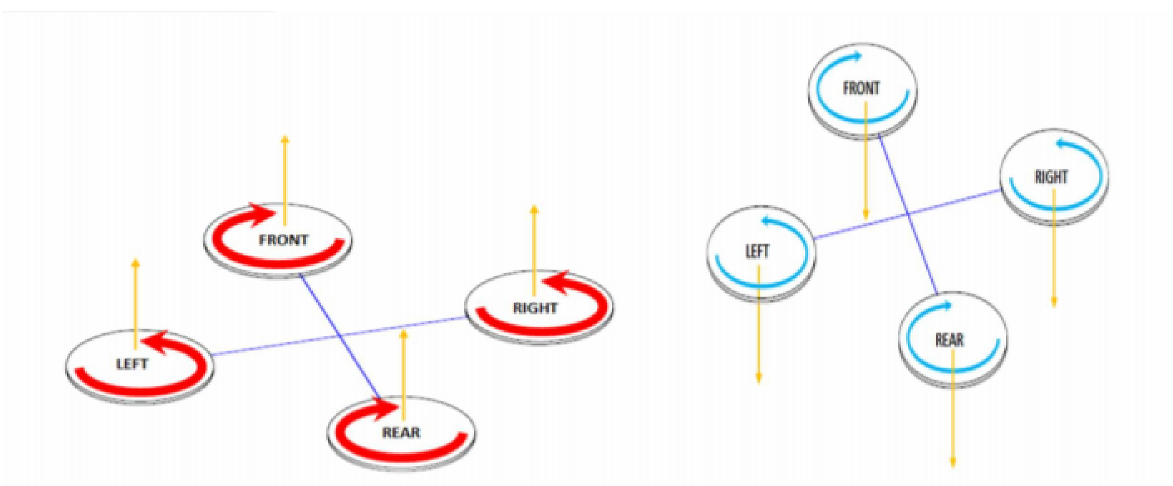

Figure 5.1: Takeoff and landing motion

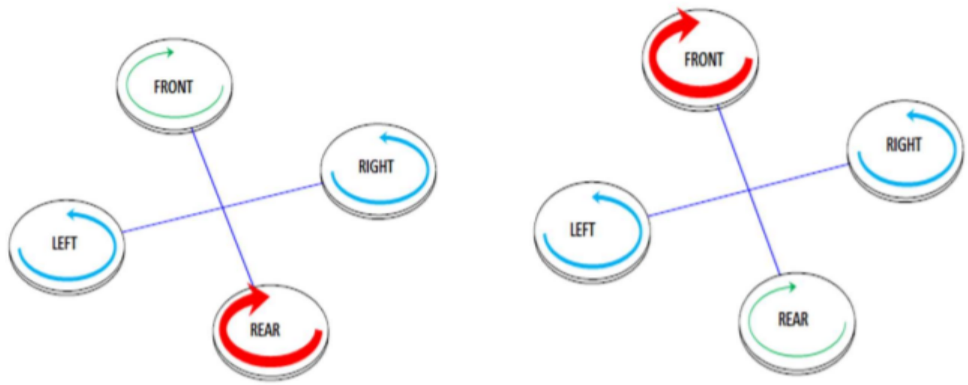

Figure 5.2: Forward and backward motion

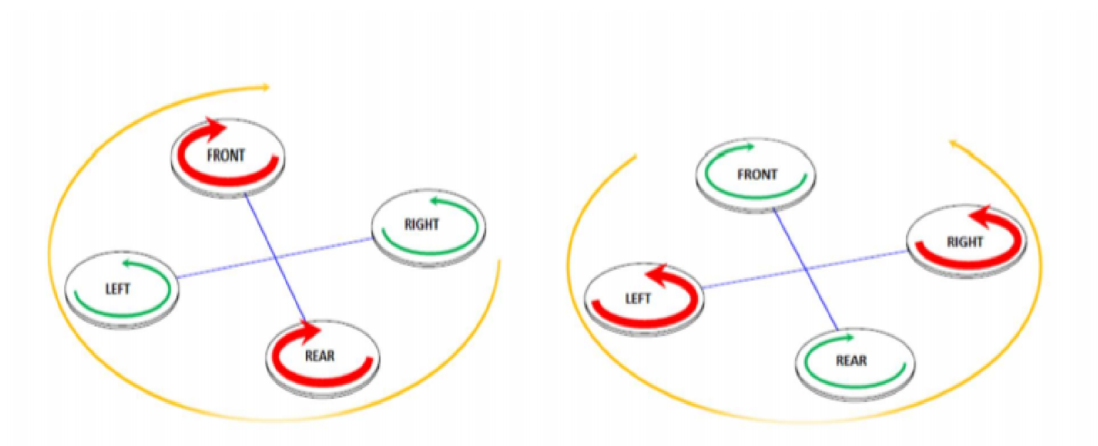

Figure 5.3: Right and left motion

5.1.1 Flying Principle

A propeller is a type of fan that transmits power by converting motion into thrust. Propeller dynamics can be modelled by both Bernoulli's principle and Newton's third law. The principle and working of a propeller is based on Bernoulli's Principle and Newton's Third Law Bernoulli's principle states that for an inviscid flow, an increase in the speed of the fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy. Newton's third law states that every action has an equal and opposite reaction.

An aero foil of a propeller is shaped so that air flows faster over the top than under the bottom. There is, therefore, a greater pressure below the aero foil than above it. This difference in pressure produces the lift. Lift coefficient is a dimensionless coefficient that relates the lift generated by an aerodynamic body such as a wing or complete aircraft, the dynamic pressure of the fluid flow around the body, and a reference area associated with the body. **Hovering or static position**:

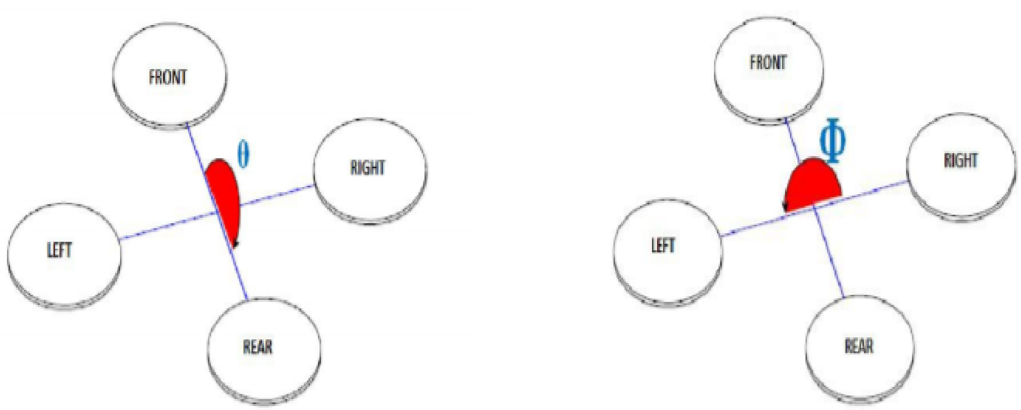

Figure 5.4: Pitch and roll direction

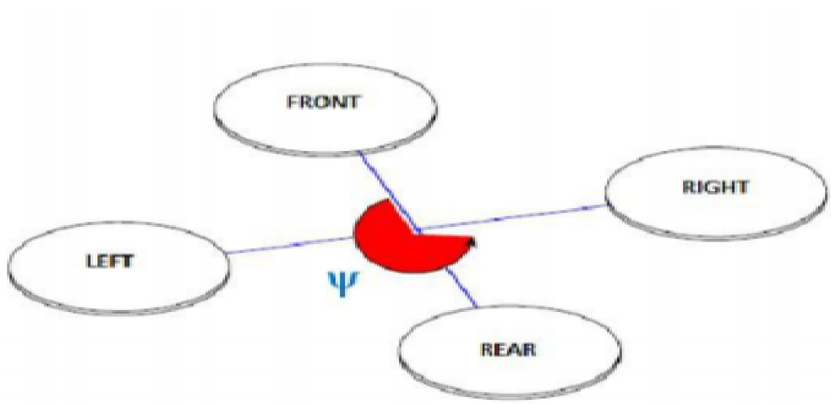

Figure 5.5: Yaw direction

The hovering or static position of the Quadcopter is done by two pairs of rotors, by rotating in clockwise or counter-clockwise respectively with the same speed. By two rotors rotating in clockwise and counter-clockwise position, the total sum of reaction torque is zero and this allows the Quadcopter to be in a hovering position.

Forward and backward motion: Forward (backward) motion is controlled by increasing (decreasing) speed of rear (front) rotor. Decreasing (increasing) rear (front) rotor's speed simultaneously will affect the pitch angle of the Quadcopter.

Left and right motion: For left and right motion, it can be controlled by changing the yaw angle of the Quadcopter. Yaw angle can be controlled by increasing (decreasing) counter-clockwise rotors speed while decreasing (increasing) clockwise rotor speed.

5.1.2 Processing of receiving signal

Pulse Width Modulation: Modulation Technique in Quadcopter: Pulse Width Modulation Pulse width modulation is a way of simulating an analog output by varying HIGH and LOW signals at intervals proportional to the value. Width of each pulse varies according to the amplitude of the analog signal.

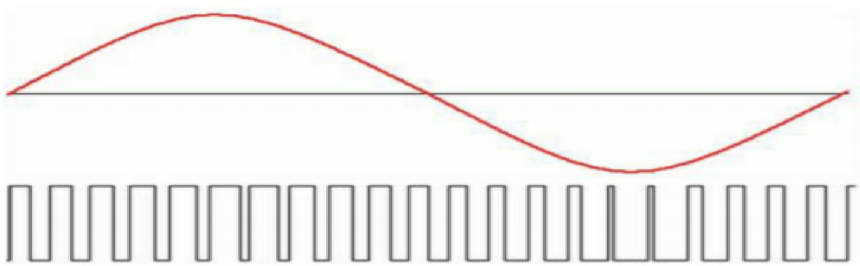

Figure 5.6: Pulse width modulation

Pulse position modulation: Pulse-position modulation is a form of signal modulation in which M message bits are encoded by transmitting a single pulse in one of 2M possible time-shifts. This is repeated every T seconds, such that the transmitted bit rate is M/T bits per second.

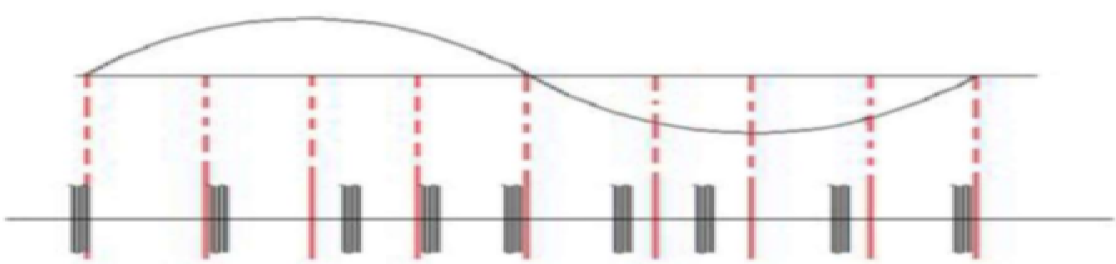

Figure 5.7: Pulse position modulation

PWM to PPM conversion: Pulse position modulation (PPM) is a pulse modulation technique that uses pulses that are of uniform height and width but displaced in time from some base position according to the amplitude of the signal at the instant of sampling. PWM refers to a pulse width modulation signal, where the width of each pulse changes according to the amplitude of an analog signal. PPM on the other hand refers to a pulse position modulation signal, where the width of each pulse remains the same, but each pulse is displaced by a certain position based on the analog signal amplitude. The basic need for conversion of a PWM signal received from a transmitter into a PPM signal arises due to the fact that the main controller board used (ArduIMU) on a Quadcopter can't process a PWM signal and hence a converter is required to convert a PWM signal to a PPM signal.

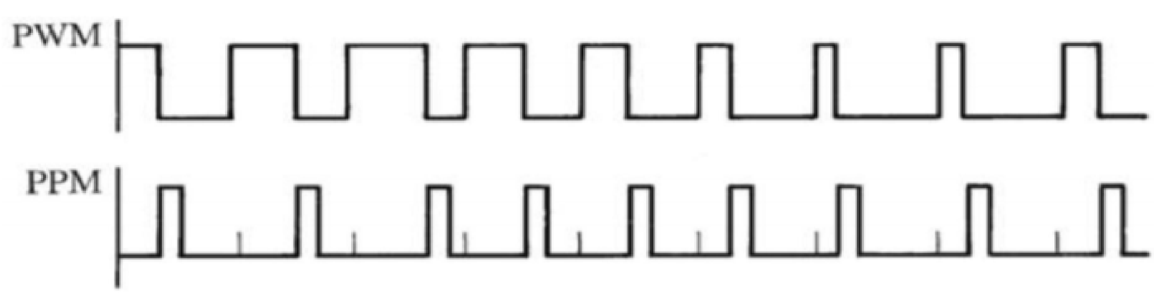

Figure 5.8: PWM to PPM conversion

5.2 Steps for Making the Drone

1. Assembling of Frame
2. Soldering for Chassis
3. Connection of ESC'S
4. Fixing of Brushless motors
5. Propellers fixing
6. Attachment of Flight controller KK2.1.5
7. Synchronization of Transmitter and Receiver
8. Checking receiver test and calibration
9. Testing the Quadcopter
10. Rasberry pi with pi cam and gps module

5.2.1 Frame

Quadcopter frame can be called as the chassis of the quadcopter. The frame can be achieved in different configurations such as +, X, H, etc... the selection of the frame is totally a user defined choice based on his own purposes. We used HJ 450 Frame. FlameWheel450 (F450) is a multi-rotor designed for all pilots for fun. It can achieve hovering, cruising, even rolling and other flight elements. It can be applied for entertainment, aerial photography, FPV and other aero-modeling activities. When flying, the fast rotating propellers of FlameWheel450 will cause serious damage.

Safety precautions to be taken are:

1. Keep flying multi-rotor away from objects, such as obstacles, human beings.
2. Do not get close to or even touch the working motors and propellers, which will cause Serious injury.
3. Do not over load the multi-rotor.
4. Check that the propellers and the motors are installed correctly and firmly before flight.
5. Make sure the rotation direction of each propeller is correct
6. Check whether all parts of multi-rotor are in good condition before flight. Do not fly with old or broken parts.

5.2.2 Soldering

Chassis which is inbuilt with HJ-450 frame has to be soldered for connecting ESC'S. Chassis works as a PCB printed Board for power supply. We have used Insulating material for soldering. While soldering we must make sure that there is no open or close circuit.

Figure 5.9: Chasis

5.2.3 Connection of ESC's

After Soldering is done 4 ESC'S has to be connected to Chassis of HJ-450 frame. Proper Care should be taken so as not to get short circuit.

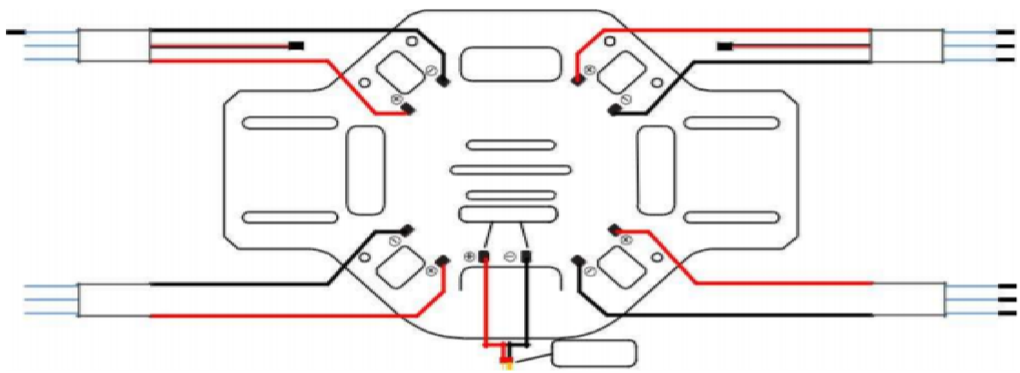

Figure 5.10: ESC wiring

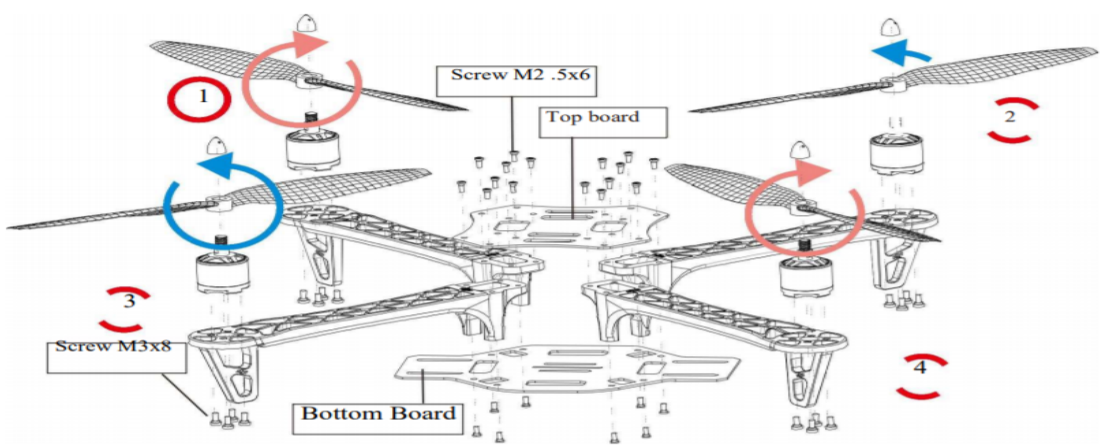

Figure 5.11: Overview of HJ450

5.2.4 Fixing of brushless DC motors

After fixing of ESC'S we need to attach 4 brushless motors of 1000 kv each.Attachment of Brushless motor to ESC'S is to be done carefully so as not to get burst of winding.The three bullets which are attached to brushless motore is to be connected with ESC'S.

Figure 5.12: Brushless DC motor

5.2.5 Fixing of propellers

After attaching brushless DC motors we need to 4 propellers.Two of them in clockwise and two of them in counter clock wise direction.

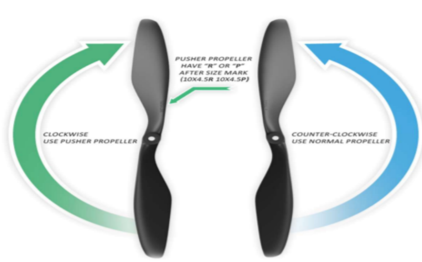

Figure 5.13: Propellers

5.2.6 Flight controller KK2.1.5

Firstly we need to “LOAD MOTOR LAYOUT”,checking for the directions of 4 motors of clock wise and counter clock wise direction.

Secondly we need to set PI controller settings as:

Roll/Pitch Axis:

Pgain = 50

Plimit = 100

Igain = 25

Ilimit = 20

Yaw Axis:

Pgain = 50

Plimit = 20

Igain = 25

Ilimit = 10

Default gains are set to 50/50/50 (roll/pitch/yaw) P-term, and 25, 25, 50 I-term. Limits are used to set the maximum value of the available motor power to be used for correction, so for example 100 is 100%. The I limit value is also known as anti wind-up in PID theory. The use of Limits is most important on the yaw axis and to prevent a large yaw correction from saturating the motors causing no control of the roll/pitch axis. The default values permit 30(P Limit 20 + I limit 10) of the motor power to be used to make a yaw correction, making 70% available for the roll/pitch axis, the most important ones. You can increase Yaw P Limit for faster Yaw response. Note that Yaw response is also limited by the craft dynamics itself.

Accessing the Self-Levelling Mode

1. Can access the self-levelling mode either from the settings of STICK or AUX channel.
2. When set to AUX Mode you must connect a spare channel usually CH5 or Ch6 and changing the Transmitter switch position will enable/disable Self-Levelling mode.
3. When set to STICK Mode to go into Self-Levelling Mode, you must set the Throttle to Minimum and set maximum Left Rudder whilst at the same time, setting maximum Left Aileron to disable SL or maximum Right Aileron to enable SL.

Flight Controller Sounds

1. One Beep (short beep, 2 sec delay) is emitted when the board is armed and the throttle is closed, this is for safety reasons so you know it's armed.
2. One Long Beep is emitted when the board is either Armed or Disarmed. Status Screen
3. Displays the message "SAFE" and the KK2.1.5 will not arm unless it says "OK"

Thirdly caliberation of flight controller has to be done from Ground Level according to surface area. The Flight Controller Board must always have a source of +5v from an ESC, either one of the motors ESC or from a separate unit feeding the Receiver. If each ESC has a BEC (normal unless OPTO types) then it may be necessary to remove the power feed from the other ESC, usually by cutting the power line (RED) Cable on the other ESC.

STEP-1 Mount the FC on the frame with the LCD facing front and the buttons facing back. Use the supplied anti-static foam container as a form of protective case for the Flight Controller on the craft.

STEP-2 Connect the receiver outputs to the corresponding left-hand side of the controller board.

STEP-3 Connect the ESC's to the right side of the Flight Controller Board. M1 is towards the front of the board and M8 is nearest to the push buttons. The negative (black or brown) lead towards the edge of the FC. The negative (black or brown) lead is connected to the edge of the Flight Controller.

The Flight Controller Board must always have a source of +5v from an ESC, either one of the motors ESC or from a separate unit feeding the Receiver. If each ESC has a BEC (normal unless OPTO types) then it may be necessary to remove the power feed from the other ESC, usually by cutting the power line (RED) Cable on the other ESC.

5.2.7 Synchronization of transmitter and receiver

Receiver which is connected to Flight controller has to be synchronized with transmitter fly sky-CT6B. Receiver has Six channels and BAT.Each has three pins as:

1. Signal
2. Ground
3. Supply

Dummy Wire has to be connected to BAT Of Signal and Supply.After connecting it has to be synchronized with transmitter by pressing the BEEP button present.Along with it any one of the four ESC'S has to be connected to any of the channel present in the receiver.

5.2.8 Receiver test

Once it is synchronized,in the flight control board the receiver parameters will start changing according to adjustment in the fly sky transmitter-CT6B.

- Aileron
- Elevator
- Throttle
- Rudder
- AUX

5.2.9 Testing

After all the operations are performed,transmitter should be On and then moving the throttle up and down for about 3 times and then moving left to right,will make the flight controller to change to ARMED state and hence quadcopter hover the skies.

Chapter 6

Results

After configuring all the parts, assembling as required, configuring Software, finally we obtained our quadcopter which is shown below. We need to test the Acceleration Calibration every time when we change the ground surface area.

Figure 6.1: Quadcopter

The CNN DroNet was succesful in providing the optimum output when it was fed a sample video. The dataset consisted of different urban trails including straight paths and sharp curves,it even showed high efficency and good results for an indoor dataset. Based on this output we can derive the individual motor control signal.The commands like fly,stop,left and right is used to determine the direction of rotation of the propellers. The speed of the propellers can be controlled by PWM signals which are derived from the output percentage output. In our project we hope to use DroNet for obstacle detection and avoidance, while geolocalisation is done from the GPS input obtained from the user.

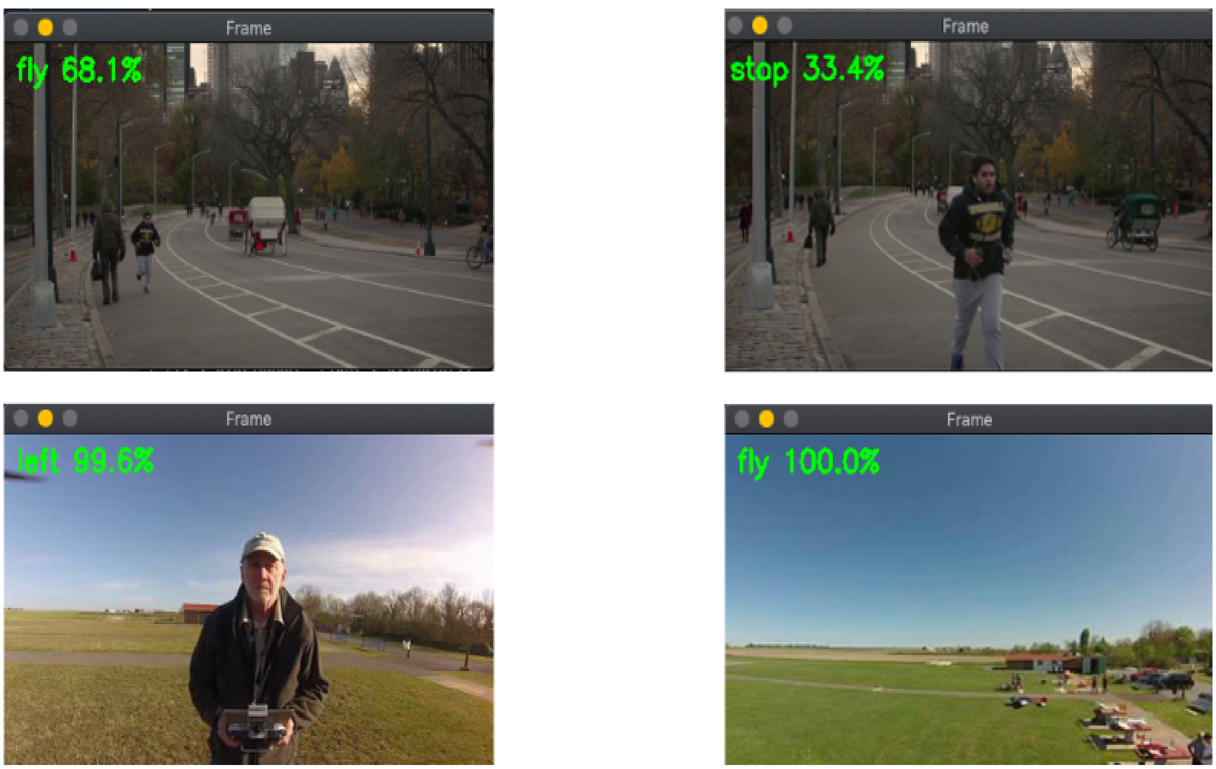

Figure 6.2: Dronet Output

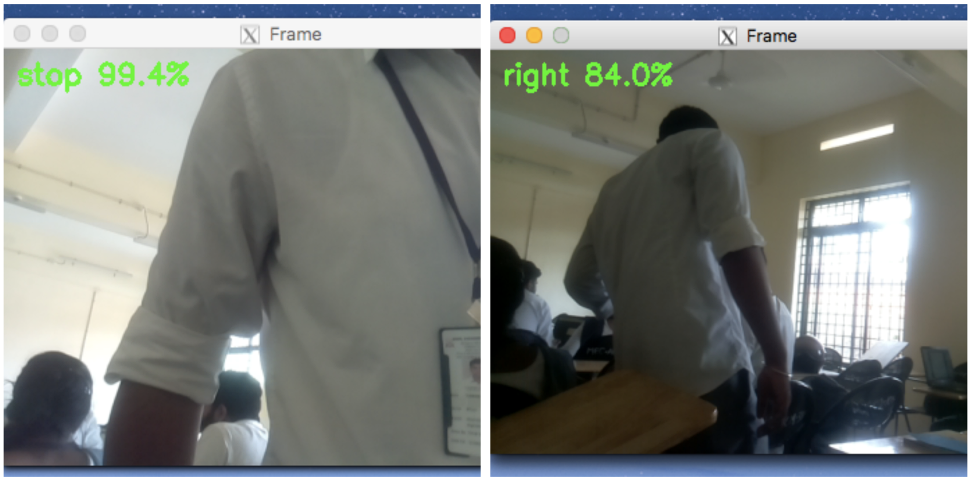

Figure 6.3: Real Time Dronet Output

Human detection were also implemented in the drone with the help of raspberry pi and was tested for both non real time and real time scenarios.

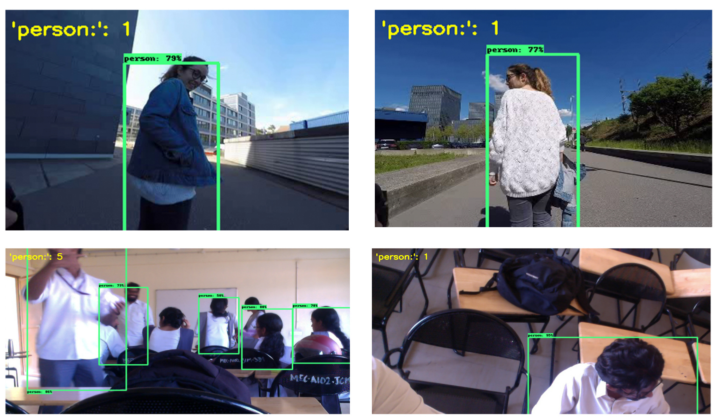

Figure 6.4: Human detection

Geoloacalisation is done with the help of gps module which sends the latitude and longitude of the drone. We will get the gps coordinates in an app that was developed by us. In this way the geolocalisation is done.

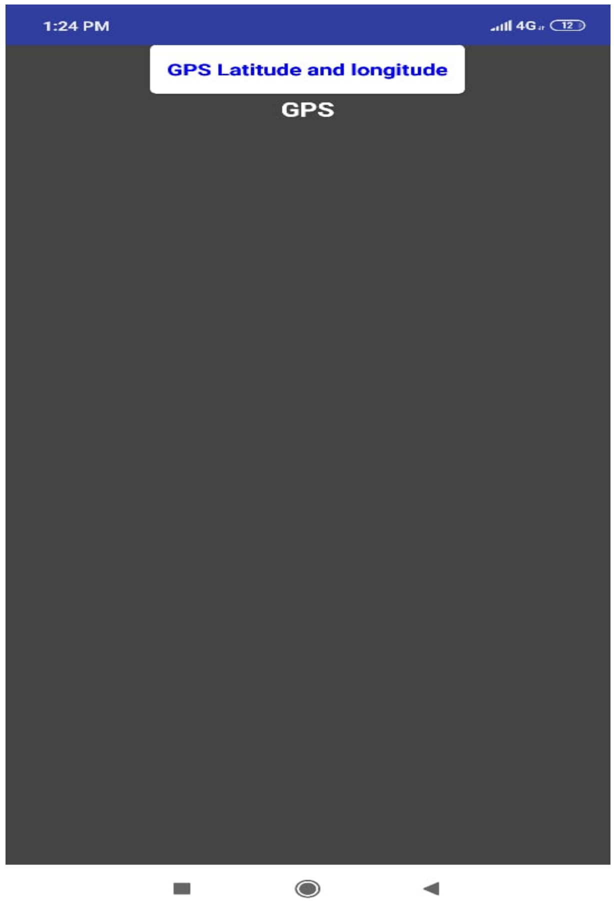

Figure 6.5: App interface

Chapter 7

Conclusion And Future Scopes

As per the design specifications, the quad copter self stabilizes using the array of sensors integrated on it. It attains an appropriate lift and provides surveillance of the terrain through the camera mounted on it. It acts appropriately to the user specified commands given via a remote controller .Its purpose is to provide real time audio/video transmission from areas which are physically in-accessible by humans. Thus, its functionality is monitored under human supervision, henceforth being beneficial towards military applications. It is easy to manoeuvre, thereby providing flexibility in its movement. It can be used to provide surveillance at night through the usage of infrared cameras. The system can further be enhanced for future prospects. The GPS data logger on the quadcopter stores its current latitude, longitude, and altitude in a comma separated value file format and can be used for mapping purposes. This project required members not only to interface and program the components of the quadcopter, but also exposed them to mechanical components and reality of project management to accomplish the project objectives.

We developed a DroNet: a convolutional neural network that can safely drive a drone in the streets of a city. Since collecting data with a UAV in such an uncontrolled environment is a laborious and dangerous task, our model learns to navigate by imitating cars and bicycles, which already follow the traffic rules. Designed to trade off performance for processing time, DroNet simultaneously predicts the collision probability and the desired steering angle, enabling a UAV to promptly react to unforeseen events and obstacles. We showed through extensive evaluations that a drone can learn to fly in cities by imitating manned vehicles. Indeed, it could be complementary to traditional "map-localize-plan" approaches in navigation-related tasks, e.g. search and rescue, and aerial delivery. Another one is we mounted a pi camera on the drone for human detection. The drone is then capable of detecting humans and counting it. So it helps to find people who got trapped in a place where humans cant go.

The drone that we have developed will have obvious limitations and the modifications that can be done is so many. We can be able to make the drone automatic using the dronet algorithm so that it can fly easily through the streets without having any collision. Also the human detection is done by tensorflow api and more effective form of human detection can be done by using thermal sensors, the advantage of using this thermal sensors are we can detect the presence of humans inside the buildings without having a direct vision of human. This helps when people gets trapped inside a building or when a forest fire or flood occurs.

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Appendices

Appendix A

Human Detection Code

import tensorflow as tf

from utils import backbone

from api import object$_{c}ounting_{a}pi$

$input_{v}ideo = ''sample1.avi''$

$detection_{g}raph, category_{i}ndex = backbone.set_{m}odel('ssd_{m}obile$

$net_{v}1_{c}oco_{2}017_{1}1_{1}7')targeted_{o}bjects = ''person''$

$fps = 80$

$width = 400$

$height = 200$

$is_{c}olor_{r}ecognition_{e}nabled = 0$

object$_{c}ounting_{a}pi.targeted_{o}bject_{c}ounting(input_{v}ideo,$

$detection_{g}raph, category_{i}ndex, is_{c}olor_{r}ecognition_{e}nabled,' person', //50, width, height)//def targeted_{o}$

$category_{i}ndex, is_{c}olor_{r}ecognition_{e}nabled, targeted_{o}bject, fps, width, //height):$

$withopen('object_counting_report.csv','w')asf:$

$writer = csv.writer(f)$

$csv_line = "ObjectType, ObjectColor, ObjectMovementDirection, ObjectSpeed(km/h)" \ writer.writerow$

fourcc = cv2.VideoWriter$_fourcc(*'XVID')$

$output_movie = cv2.VideoWriter('output.avi',$

$fourcc, fps, (width, height))$

$cap = cv2.VideoCapture(input_video)$

$total_passed_vehicle = 0$

$speed = "waiting..."$

$direction = "waiting..."$

$size = "waiting..."$

$color = "waiting..."$

$the_result = "..."$

$width_heigh_taken = True$

$height = 0$

$width = 0$

$withdetection_graph.as_default():$

$withtf.Session(graph = detection_graph)assess:$

$image_tensor = detection_graph.get_tensor_by_name('image_tensor:0')$

$detection_boxes = detection_graph.get_tensor_by_name('detection_boxes:0')$

$detection_scores = detection_graph.get_tensor_by_name('detection_scores:0')$

$detection_classes = detection_graph.get_tensor_by_name('detection_classes:0')$

$num_detections = detection_graph.get_tensor_by_name('num_detections:0')$

while(cap.isOpened()):

ret, frame = cap.read()

if not ret:

print("end of the video file...")

break

input$_{f}rame = frame$

image$_{n}p_{e}xpanded = np.expand_{d}ims(input_{f}rame, axis = 0)$

(boxes, scores, classes, num) = sess.run(font = cv2.FONT$_{H}ERSHEY_{S}IMPLEX$
detection$_{b}oxes, detection_{s}cores, detection_{c}lasses, num_{d}etections$

,

$feed_{d}ict = image_{t}ensor : image_{n}p_{e}xpanded)$

counter, csv$_{l}ine, the_{r}esult = vis_{u}til.visualize_{b}oxes_{a}nd_{l}abels_{o}n_{i}mage_{a}rray(cap.get(1),$

$input_{f}rame,$

1,

$is_{c}olor_{r}ecognition_{e}nabled,$

$np.squeeze(boxes),$

$np.squeeze(classes).astype(np.int32),$

$np.squeeze(scores),$

$category_index,$

$targeted_objects = targeted_object,$

$use_normalized_coordinates = True,$

$line_thickness = 4)$

$if(len(the_result) == 0):$

$cv2.putText(input_frame, ''...'', (10, 35), font, 0.8, (0, 255, 255), 2, cv2.FONT_HERSHEY_SIMPLEX)$

$else:$

$cv2.putText(input_frame, the_result, (10, 35), font, 0.8, (0, 255, 255), 2, cv2.FONT_HERSHEY_SIMPLEX$

cv2.imshow('object counting',input$_frame)$

output$_movie.write(input_frame)$

$print(''writingframe'')$

if cv2.waitKey(1) 0xFF == ord('q'):

break

if(csv$_line! = ''not_available''):$

$withopen('traffic_measurement.csv', 'a')asf:$

$writer = csv.writer(f)$

$size, direction = csv_line.split(',')$

$writer.writerows([csv_line.split(',')])$

cap.release()

```
cv2.destroyAllWindows()
```

Appendix B

Dronet code

```
from keras.preprocessing import image
from keras.preprocessing.image import img_to_array
from keras.models import load_model
import imutils
import argparse
import numpy as np
import time
import cv2
import tensorflow as tf
from operator import itemgetter
import picamera
from picamera import PiCamera
from picamera.array import PiRGBArray
```

```
ap = argparse.ArgumentParser()
args = vars(ap.parse_args())

print("[INFO]␣start␣video...")
camera = PiCamera()
camera.resolution = (640, 480)
camera.framerate = 32
rawCapture = PiRGBArray(camera, size=(640, 480))

# allow the camera to warmup
time.sleep(0.1)
out = cv2.VideoWriter('outpy.avi',cv2.cv.CV_FOURCC(*'XVID'), 25, (400,30
print("[INFO]␣loading␣network...")
model = load_model("./avcnet_best_5.hdf5",custom_objects={"tf": tf.cast})

alfa=.1
dist=300
dist_old=300
# capture frames from the camera
for frame in camera.capture_continuous(rawCapture, format="bgr", use_vid
        # grab the raw NumPy array representing the image, then initializ
        # and occupied/unoccupied text
        image = frame.array
        orig = image.copy()
```

```
image = cv2.resize(image, (64,64))
image = image.astype("float")/255.0
image = img_to_array(image)
image = np.expand_dims(image, axis=0)
(stop, left,right,fly) = model.predict(image)[0]
my_dict = {'stop':stop, 'left':left, 'right':right,'fly':fly}
print (my_dict)
maxPair = max(my_dict.iteritems(), key=itemgetter(1))
label=maxPair[0]
proba=maxPair[1]
label = "{} {:.1f}%".format(label, proba * 100)

output = imutils.resize(orig, width=400)
cv2.putText(output, label, (10, 25), cv2.FONT_HERSHEY_SIMPLEX,
    0.7, (0, 255, 0), 2)

cv2.imshow("Frame", output)
key = cv2.waitKey(10) & 0xFF

out.write(output)
rawCapture.truncate(0)

if key == ord("q"):
        break
```

```
cv2.destroyAllWindows()
```