

## First Person View Multi Copter (Quad Copter)

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**Abstract:** A Quad Copter is a flying robot that can achieve vertical flight in a stable manner and can be used to monitor various activities. Technological advances have reduced the cost and increased the performance of the low power microcontrollers so use of quad copters is growing. Building a quad copter that can obtain stable flight and carry out an aerial surveillance can help in solving security and defense related issues. A Frame, Motors, Electronic Speed Controllers, Battery, Flight Controller, Transmitter and Receiver are used for the building a quad copter however, synchronizing them together is challenging. A software named Openpilot is a tool to interface the components and calibrate them. The audio and video captured by the quad copter during flight is transmitted using a wireless transmitter module which is received by a wireless receiver module which then feeds it into a PC at the ground. Quad Copters being a multi-dimensional flying machine can be used for any purpose with little changes in its design thus can be called a highly flexible flying machine. A large payload capacity can make it more multi-dimensional and more flexible. This can increase the area of application of the quad copter built.

**Keywords:** Electronic speed controller, Flight controller, Openpilot, Quad copter.

### 1. Introduction

Many places on the earth are really difficult to infiltrate due to various reasons like natural barriers, security issues which includes terrorism, revolts etc. Along with that various hazardous places which are not safe for human health are also a big issue in current scenario. Active volcanoes, Nuclear Reactor breakdowns, Earthquake affected areas need continuous monitoring because the future scenarios are highly unpredictable in those areas. On the other hand, tight security on certain areas are really difficult for military personnel to maintain and military needs a clearcut view of what is happening in the area at which they are stationed. So, scientists and engineers together came up with a revolutionary idea of drone which is economical in comparison to the stealth technology as it comes in various sizes, physical appearances and possess a high degree of flexibility in terms of its application, range of working and many others.

A Drone is an unmanned aerial vehicle having large potential for performing tasks that are life threatening or tasks that may seem highly impossible for an unaided human being such as surveying the active volcanoes site, keeping an eye on terrorist controlled areas, inspection of high structures, search and rescue missions, inspections of jets as large as Airbus A330 and many others. Quad Copter, a type of drone is being more popular in recent days.

A quad copter is a type of drone having four rotors responsible for generating thrust for lift, anti-drag forces to overcome drag so as to achieve required pitch, roll and yaw motions. Quad copter has a high degree of freedom in terms of motion, in terms of application and in terms of its ability to understand its working environment. If quad copter is programmed in a way to collaborate with each other for same mission, then probability of getting the solution increases. A group of Quad Copters would be able to efficiently and autonomously search a missing person in a large area by sharing data between each other or the combined load capacity of a group of quad copters can be used to deliver medicine in remote areas. This increases the possibility of mission accomplishment. However, doing all this requires a common ability in the quad copter: aerial surveillance. By unlocking aerial surveillance ability, a clear interaction between quad copter and its surroundings can be developed. This ability can also be fruitful for some of the professional sectors like Aerial Photography, Geological Surveys and many more. As preliminary step towards the view of collaborating aerial robots, the best choice is to install this ability in a medium size quad copter which can fly indoors.

### 2. Literature survey

Leishman [1] documented, a helicopter and a quad copter have some common similarities in terms of flight principles, aerodynamic balancing, control systems and making all these systems to workout together to achieve proper propulsion. Understanding basic flight principles again leads to a very big scenario; how to fly? Hoffman et al [2] noted, the most basic way to understand flying is none other than by understanding how do birds fly and how easily they balance themselves in air withstanding wind forces, G- forces and many other

natural forces. As per them, more than easiness it's an art and in our artificial world this is possible by understanding how to increase the level of intelligence of the control systems so as to synchronize their abilities with physical hardware.

A drone which only flies but does nothing more is just like a toy but if this toy is loaded with something that allows it to see and act upon what it sees or allows a human to see what it saw, then a dangerous and lethal security system could be developed. John Kaag and Sarah Kreps [3] have clearly mentioned this idea regarding defense, intruder alert system and counter reacting security breaches. Various technological upliftment led to a glorious and more visionary methods to work out against enemy's plots, surveil their motions, secure borders and even fulfill shoot command from the sky.

Understanding the prevailing technologies in current drones, the most suitable technology for defense is none other than vision technology which further unlocks various image processing technologies. However, the biggest problem is understanding how to live feed the video captured by the quad copter into the PC present at the ground station. To understand and overcome this problem, it is necessary to understand how wireless transmission of data is possible.

In today's world, nobody wants to go blind in an unknown area. Along with visual information for success of an any mission, it's a must to have a powerful analyzing system: a system that can say what it saw. The best type for this sort of analysis is none other than the facial recognition system. So, for an y defense related drones the facial recognition system can come handy. But facial recognition requires proper source for image and video feeding.

With the development of Google Deep Mind Artificial Intelligence Robots, the field of Image Processing is growing tremendously. So, in order to strive against the flow; it's a must to understand Image Processing Systems and also prevailing Image Processing Software. Gonzalez [4] noted, image processing is the heart of all vision related systems however image processing is not just a single dimensional disciplinary. Understanding it requires a high knowledge of integration by bits and bits.

Facial recognition is awell-known and well established technology in today's world however using it in a machine meant for defense and security related areas is a challenging task. Jinay S. et al [5] have clearly mentioned this concept in reference to 'UAV's for Border Security with GUI System'. In the journal, it's been clearly explained how a quad copter can be interfaced with the surveillance camera fitted in the quad copter so that an intelligent quad copter can be fabricated.

Generation of an idea requires sound and effective knowledge of problems or the upgrades to be brought to an existing model so as to improve the human life condition or to bring up and uplift a technology so that various social, technological, economic and cultural problems can be solved. In this technologically advancing world, the best idea to counter such problems could be by developing a much technologically advanced system called Drone having a surveillance camera fitted to it.

### **3. Objective and methodology**

#### **3.1 Objectives**

The objective of this work is to fabricate a aerodynamically unstable flying machine called a quad copter; install multi-disciplinary and highly flexible vision system into it so that it comes handy for defense related sectors. Along with that the work also focus on providing a revolutionary ability of facial recognition to the quad copter so that it can be highly effective for the work for which it has been set.

#### **3.2 Methodology**

During operation, when the operator, pushes the throttle stick, the radio waves coming out of the transmitter flows into the receiver in the flight controller; a mechatronics components. The Flight controller then analyzes the input signal and as per the intensity of input, it sends in the information at what RPM the motors should turn. The amount of current flowing into the motors is also regulated by the flight controller with the help of Electronic Speed Controller (ESC). When necessary amount of thrust to overcome the G-force is developed then the quad copter lifts off the ground.

Now, in the air the concept of proportional, integral and derivative (PID) controllability of the flight controller comes in picture. When the operator, uses the rudder stick to provide pitch and roll motion to the quad copter, the flight controller along with the collaborative action with the ESC, varies the speed of motors in the front or back for pitching and left and right for rolling.

When the operator tries to move forward the speed of the two motors at the back is increased however the set PID values control the level of stability to be maintained. Similarly, for backward motion the speed of the two motors at the front is increased. For the rolling action towards left, the speed of the motors at the right is

increased and vice-versa. For the yawing of the quad copter, the throttle stick is moved, for left yaw the throttle stick is moved towards the left and for right yaw, it is moved towards the right.

#### 4. Designing the quad copter

Designing a Quad Copter involves more calculative works rather than physical dummy modelling. Comparing various available models of the same parts prevailing in the market and turning them and using the as per own's necessities plays a vital role in designing of quad copters.

##### 4.1 Designing the Frame

Fig. 1 shows the top view of the frame used for the build. The frame used is made up of Glass Fiber since Glass Fiber is cheap in comparison to Carbon Fiber and is much stiffer in comparison to wood and much lighter than Steel and Aluminum. The weight of the frame is around 200 gm.



Fig.1 top view of frame

##### 4.2 Brushless DC (BLDC) Motor

The motor is the source of thrust. Selection of suitable motor for the build requires the ability to assume the final weight of the quad copter after assembling all the parts. Along with the knowledge of weight, the payload capacity of the quad copter; desired speed during flight also plays a vital role for motor selection. The thrust generated by the motor during lift is given by:

$$W=mg(1)$$

Where,

'W' denotes the weight of the quad copter

'm' denotes the weight of the quad copter in N

'g' is the acceleration due to gravity i.e.  $9.8 \text{ ms}^{-2}$

Fig. 2 shows the BLDC motor along with its specifications.



Fig. 2 dji bldc motor

### 4.3 Propellers

The propellers are the important component of the quad copter as they help to produce thrustforce to lift the quad copter against the force of gravity and also helps to cut off the wind to work against the drag force. Fig.3 shows the Gemfan Propellers.



Fig. 3 gemfan propeller

Thrust absorbed byeach propeller from motor can be calculated using the formula:

$$\text{Thrust Absorbed by each propeller (F)} = 4.392399 \times 10^{-8} \text{ RPM} \frac{d^{3.5}}{\sqrt{\text{Pitch}}} (4.23333 \times 10^{-4} \times \text{RPM} \times \text{Pitch} - V_o) \text{ N(2)}$$

Where,

‘d’ is diameter of propeller in ‘m’

‘RPM’ is no. of rotations made by the propeller per minute

‘Pitch’ in inch

‘V<sub>o</sub>’ is the velocity of quad copter in m/s

### 4.4 Battery

The battery is the power house of the whole system and provides electric current to every components of the quad copter. The battery installed in the quad copter must be light in weight, should have suitable current rating and should have proper and steady charge and discharge rate and must have a higher capacity even though its size is compact. So, the only option is none other than LiPo battery which has Lithium electrodes dipped in plastic polymer. The suitable battery selection is a challenging task and involves heavy approximations. Carrying out all the possible random approximation a 3000 mAh battery is the most suitable battery for approximately 1.2 Kg quad copter. It can provide a current of 60 A at a discharge rate of 20 Coulombs when the motors are running ataverage condition. Even at this condition, the battery has 15% extra juice in it. Fig. 4 shows a LiPo battery.



Fig. 4 zippy flightmax battery

### 4.5 Power Distribution Board

The power distribution board as the name suggests is the power distribution center of the quad copter. The power that is fed into it from the battery is distributed among the 4 ESCs installed in the quad copter that

helps to generate bi-sinusoidal current that is fed into the motor and also the flight controller. The battery output terminal is soldered to one of the ends of the power distribution board and from the other terminals the ESCs withdraw the power for feeding it into the motors and the flight controller. Fig. 5 shows the Power Distribution Board.

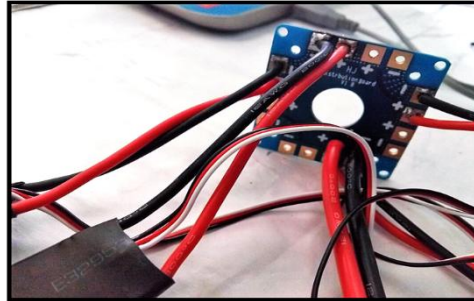


Fig. 5 power distribution board

#### 4.6 Electronic Speed Controller (ESC)

The Electronic Speed Controller is an intelligent unit of the quad copter and involves much in stable and intelligent power distribution by acting as an interface between the flight controller and the motors. As per the settings stored by the operator in the flight controller and also the input fed by the operator during real-time operation, the ESCs supply a regulated amount of current to the motors. Due to this regulated control over the bi-sinusoidal current fed into the motors, the ability to vary the speed of the motor became possible else the aerodynamic instability of the quad copter wouldn't have let the setup fly properly in the sky. The ESC used for the build is to be selected as per the motor specifications. Fig. 6 shows a 30 A ESC.

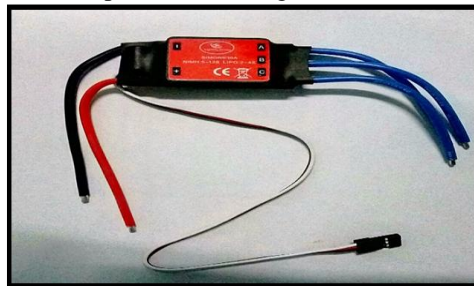


Fig. 6 electronic speed controller

#### 4.7 Flight controller

The Flight Controller (FC) is the brain of the quad copter. It is basically a circuit board that takes sensors data and user commands, and helps to control the motors in order to keep the quad copter in air. Flight Controller has basic sensors including Gyro (Gyroscopes) and Accelerometer, some more advanced Flight Controllers come with some highly advanced sensors such as Barometer, Magnetometer. Flight Controller also helps to interface some other peripherals such as GPS, LED etc. The Flight Controller must be tuned to a standard setup before getting the Flight Controller ready for the flight. As CC3D has the most commercialized name in the field of Flight Controller and since it's easy to tune and setup, it was installed into the quad copter for the build. Fig. 7 shows the CC3D Flight Controller.

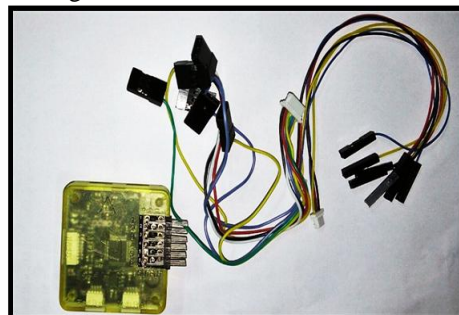


Fig. 7 CC3D flight controller

#### 4.8 Transmitter and receiver

The transmitter also known as the radio is like a remote controller that sends the input signal to the Flight Controller as commanded by the operator. The transmitter present at ground station converts the analog signal fed into it by the operator into radio waves that is captured by the receiver located at quad copter present in the air. The transmitter is more than just a remote controller. Using some of the common tuning software such as Openpilot, Cleanflight, it need to be suitably tuned to define and stabilize the amount of Yaw, Pitch or Roll. Fig. 8 shows the FS iA6 Transmitter and Receiver.



Fig. 8 FS iA6 transmitter and receiver

#### 4.9 Camera and Receiver

The camera is the source of video and audio information for the project. It records the images and through the in-built wireless transmission system it transmits or live feeds the video captured to the ground station having a receiver connected to a PC.

The camera used has following specifications:

- Range is 20-30 meters inside building.
- Range in open space is around 80-100 metres.
- 380 TV Lines Camera.

Similarly, the receiver used to receive the audio, video signal from the quad copter has following specifications.

- TV color system: NTSC or PAL.
- Operation frequency of 1.2Ghz.
- Horizontal Viewing Angle of 50 degrees.
- Power consumption around 1.2 W.
- Effective range of 300 ft. to 1000 ft.
- Valid Pixel: PAL to 628\*582, NTSC to 510\*492.

Fig. 9 and Fig. 10 shows a Camera and a Receiver wherein the camera sends the audio-video signal and the receiver receives the signal fed by the camera.



Fig. 9 wireless av camera



Fig. 10 wireless receiver

## 5. Working

Quad Copter is a device with intense mixture of Electronics, Mechanical and working for a common principle of Aviation. The Quad Copter has 4 motors whose speed of rotation and the direction of rotation changes according to the user's desire to move the device in a particular direction (i.e. Takeoff motion, Landing motion, Forward motion, Backward motion, Left motion, Right Motion). The rotation of Motors changes as per the transmitted signal send from the 6-Channel transmitter. The signal from microcontroller goes to ESC's which in turn control the speed of motor.

### 5.1 Operating of Quad Copter

The Operation of a Quad Copter is illustrated in Fig.11,12&13 below:

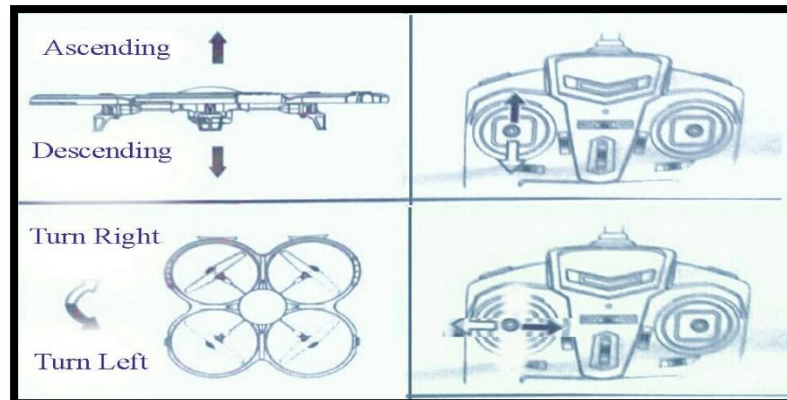


Fig.11 lifting the drone off the ground and yawing mechanism

The throttle stick is used to give the thrust for lift force as shown in Fig. 11. The thrust should be given initially beginning from zero. According to amount of thrust required, the throttle stick should be operated. If more speed in motor is needed the throttle stick should be pushed forward and vice versa. This thrust varies amount of lift produced during Take-off.

As the quad copter lifts off the ground, to provide the necessary yaw motions, the throttle can be pushed to the left or towards the right so as to produce right yaw or left yaw.

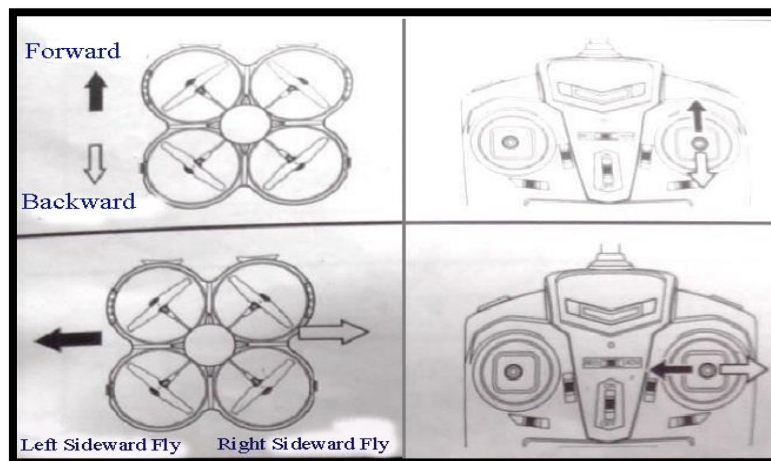


Fig.12pitch and roll mechanism

Fig. 12 shows the pitch and roll mechanism. When the right lever or the steering rudder is pushed forward then the quad copter produces the forward motion and pushing it backwards gives a backward motion. This motion is commonly known as pitch.

Similar to the pitch, turning the rudder stick to the left or right gives the roll motion. When the rudder stick is pushed towards the left, the quad copter changes it direction of flight towards left and pushing it towards the right makes it to change its direction of flight towards the right.

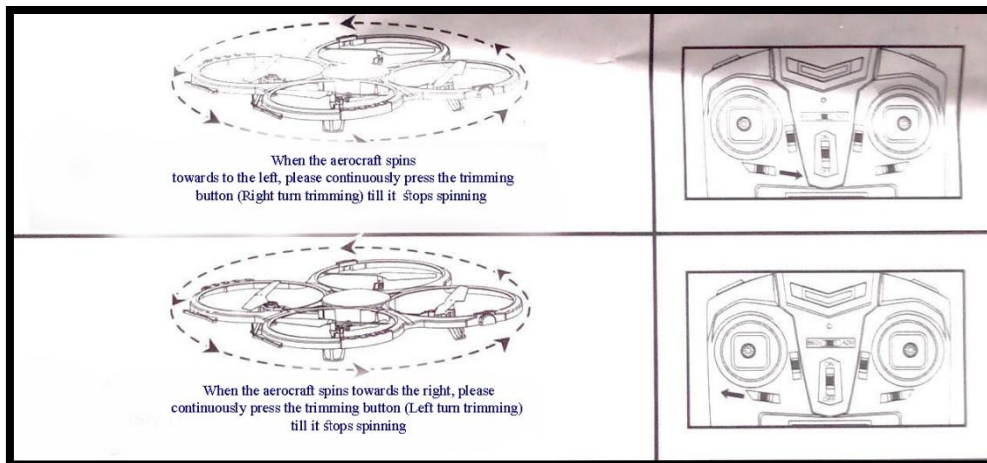


Fig.13operating a drone for 3d flip

While doing the 3D flip flying as shown in Fig.13, the pilot can perform some breathtaking operations. For performing this, initially the drone should attain a height of 3m. Secondly, clicking the flip key and pushing the right rudder to the end (in one direction) makes the drone to make a 3D flip.Fig.15 shows 3D Flips in forward, backward and left and right directions.

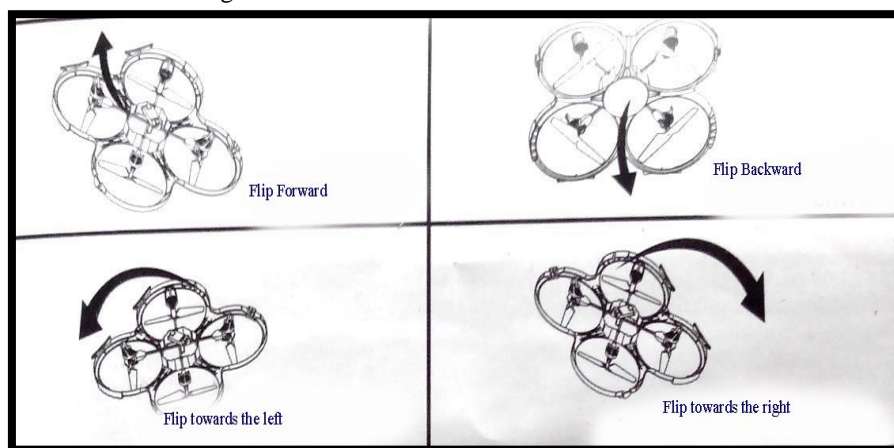


Fig.14operating a drone for 3d flips in various directions

### 5.2 Taking Off

Pressing the throttle starts the motor rotation and the drone will automatically position itself at an altitude of between 50 cm and 1 m. Sliding the joystick (bottom right) up / down to make the Drone climb / descendsit in increments of 10 cm.Pressing and holding the joystick in the up / down position to makes the Drone continuously climb / descend that is explained in Fig. 15.

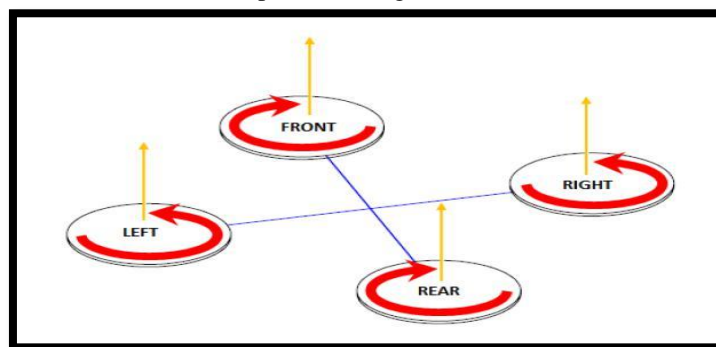


Fig.15taking off



### 5.3 Landing

Ensuring that the Drone is directly above a flat, dry and unobstructed surface and then press on the button. The process is shown in Fig.16.

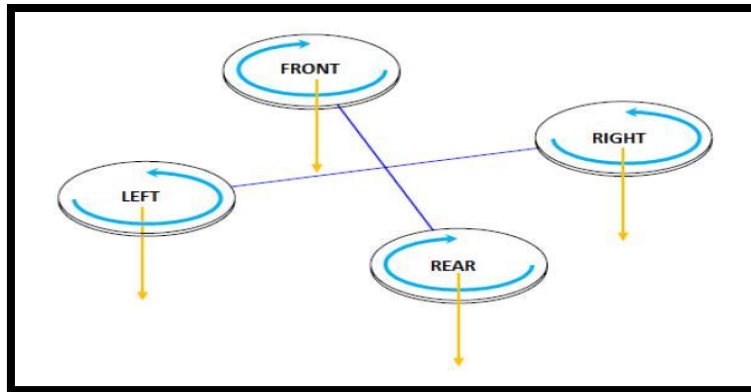


Fig.16 landing motion

## 6. Face Detection

Image Processing is a fast-growing technology having high future scope in various sectors of technological enhancements like Artificial Intelligence, Defense and Security sectors, Guided Vehicle Launch, Survey and many others. Keeping same concept the ability of the quad copter to see and recognize the faces of people that it records is overviewed.

For the detection of face, the first and foremost thing that the system must be capable of is that it must have good ability to see things and the next thing is; it must have good ability to analyze and say what it saw. For this, a software developed for image processing called OpenCV should be clubbed with a programming language Python. Python gives the platform to type the codes and OpenCV acted as the means to analyze these codes and implement them to recognize the faces.

### 6.1 Steps for Face Detection

For Face Detection purpose the most important thing is the clarity of captured faces. The image of the faces captured must be of high quality for accurate recognition. The basic steps for image recognition are discussed in further topics.

#### 6.1.1 Dataset Creation

For a system to work and analyze anything it must have some connection with a library. In dataset creation, library of different faces to be recognized is created. In this step, initially a recognizer is created which stores the faces captured into the dataset. The ability to differentiate face from other parts of the body is given by a haarcascade file present in OpenCV library.

#### 6.1.2 Training the Dataset

The dataset is just a raw folder with just a collection of array of various faces captured. So, for further processing and analyzing it is a must to make it possible to calculate the position of key point in face such as position of eyes, nose, ear, mouth and others if any facial expression present. So, it's a must to create an interface between OpenCV and the codes written in Python.

#### 6.1.3 Detecting the Faces

After the trainer collects all the information regarding the images present in the database, the detector uses these information; to compare and detect whose face is that or who is that person. For proper detection, a high-resolution camera must be onboard in the quad copter. When the quad copter flies and sees some recognizable face i.e. is already present in the database then it queries the information present in the trainer and through the trainer if the face matches, it feeds in the information into the detector where it is checked who is that person and if the detector has any information regarding the person; it is displayed in the monitor.

Thus, it is clearly viewed how the facial recognition system works and in what basis and also for what purposes it can be implemented to achieve a higher level of security and an ability to easily identify the intruders, if any.

## **7. Advantages and disadvantages of quadcopter**

Quadcopter or any multirotor configuration are implemented only in small or micro unmanned aircrafts. As already mentioned: in such sizes, masses and volumes a helicopter configuration is too complex and too difficult to implement. Unlike a helicopter with a single giant rotor that is unsafe to use by a civilian user, a multirotor can be made to be much safer, easier to use and can be set up to accommodate strong or uneven wind and loading conditions.

### **7.1 Advantages**

- Quad-Copters have frame that enclose the rotors permitting flights through more challenging environment with lower risk of damaging the vehicle.
- Small scale Quad-Copters makes the vehicle safer for close interactions.
- They use four rotors allowing each individual to have smaller diameter allowing them to possess less kinetic energy.
- They are easier to build for small blades compared to large one.
- They save lives. They greatly reduce putting military power in combat or in harm.
- The unmanned aerial vehicles are preferred for the missions which are too dangerous or dull for the humans, they provide the attack capability for high-risk missions and they originated mostly in the military applications.
- The unmanned aerial vehicles can be used in other applications such as policing and the surveillance, the data collection, the aerial photography, the agriculture and the drone racing, they can be used in the commercial, the scientific and the recreational.
- The drones have many different names. They are referred to as the killer drones and the attack drones. They are called the spy drones or the surveillance drones. They can be both remote controlled by the pilot or controlled by the computer and they are used to carry out certain actions without direct human piloting .
- The drones can have more pinpoint accuracy from greater distances thus reducing the collateral damage to the civilians and the infrastructures, the drones are as lethal to the enemy combats as regular airplanes
- The drones can be used in spying, years before the drones were used in combat, the drones have proven to increase the surveillance, reconnaissance, and general military intelligence, the drones are easier and faster to deploy than most alternatives.

### **7.2 Disadvantages**

- It is very costly since it is complex in design and fabrication is tedious.
- It can be misused and thus is highly risky if in wrong hands.
- The drones or the fleet of drones can take and controlled by the enemy.

The drones cause the collateral damage such as killing the civilians and damaging the civilian property, some cultures believe that the use of drones is not brave and cold hearted, they are too easy, by making the drone warfare very similar to video games, the drone warfare makes combat too easy by diminishing ethical decisions.

## **8. Results and discussions**

Verification and testing of each hardware and software component is a must to ensure stable flight.

### **8.1 System Verification and Testing**

This section of the document discusses the methods used to test each component of quadcopter, the problems faced, and the remedies.

- Testing and Configuring on Open Pilot CGS

To modify the flight software, the user configuration header file had to be changed. Certain variables needed to be defined according what components the quadcopter had and what functions were to be installed in the quadcopter. This should be done by both commenting and un-commenting the necessary definition statements in the user configuration header file. If the software uploads successfully, then no mistakes are present in the user configuration header file. The configuring software used is Open Pilot CGS.

## **9. Conclusions**

Based on the experimental work carried with the quad copter the following conclusions were made

- The equations of motion for a quadcopter, starting with the voltage-torque relation for the brushless motors and working through the quadcopter kinematics and dynamics gives the information regarding the required motor and capacity of battery.
- Air friction as a linear drag force in all directions has to be considered, though aero dynamical effects such as blade-flapping and non-zero free stream velocity can be ignored.
- Testing of the PID controller (with minor modifications to prevent integral wind-up) and it is found to be better at preventing steady-state error than the PD controller when presented with the same disturbances and using the same proportional and derivative gains but the tuning of PID controller can be difficult, and would lead to an unstable system for unknown reasons.
- The Python gave us a platform to type the codes and Open CV acted as the means to analyze these codes and implement them to recognize the faces for image processing.
- Various areas of image processing like Face Detection, Smile Detection, object Detection, Full Body Detection were studied and understood using Open CV.
- The trainer collects all the information regarding the images present in the database, the detector uses this information to compare and detect whose face is that or who is that person.
- When the quad copter flies and sees some recognizable face that is already present in the database then it queries the information present in the trainer and through the trainer if the face matches, it feeds in the information into the detector where it is checked who is that person and if the detector has any information regarding the person, it is displayed in the monitor.

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