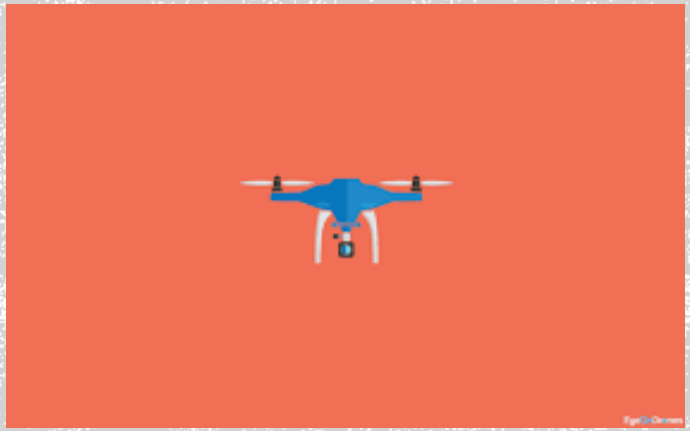
UAVS

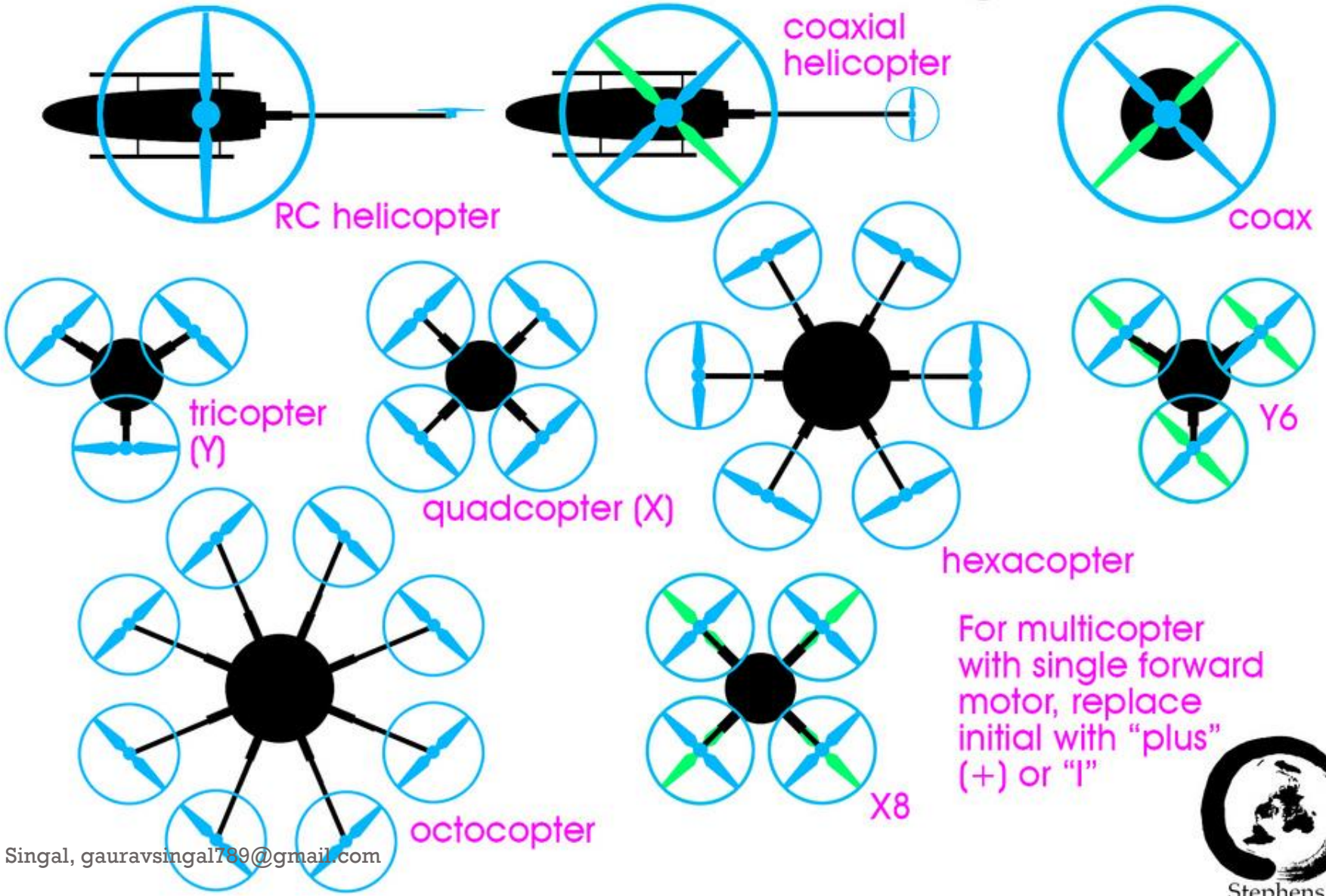


BENNETT UNIVERSITY
A TIMES GROUP INITIATIVE

INTRODUCTION TO DRONE

- A drone is an unmanned aircraft.
- Drones are more formally known as unmanned aerial vehicles (UAVs) or unmanned aircraft systems (UAS).
- A drone is a flying robot.
- The aircrafts may be remotely controlled or can fly autonomously through software-controlled flight plans in their embedded systems working in conjunction with onboard sensors and GPS.

Drone Typology



WHY HAVE WE CHOSEN QUADCOPTER???

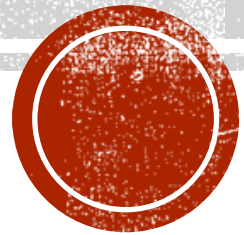
Mainly we choose quadcopter due to it's mechanical simplicity even though it has a few disadvantages like stability and efficiency.

5

The Tech Behind a Record-breaking Drone Show at PyeongChang 2018

By Intel

QUADCOPTER



INTRODUCTION TO QUADCOPTER

- The quadcopter is the **first and most popular drone** you can find in the market.
- This is an option that **uses 4 rotors** organized in a **square pattern**.
- The rotors are arranged onto **each individual corner** of the quadcopter's body.
- It allows for an even amount of support to get the drone **off the ground** and to make it **turn** in different directions.
- Quadcopter is an **aerial vehicle** which is operated to fly independently.
- It is a small representation of UAV. It is classified as **rotorcraft**.
- Quadcopters are **cheaper** and more **durable** than conventional helicopters.

ROTORQUIZ#1

Aircrafts have commonly been named after what???

INSECTS...

History

- Gipsy Moth, one of the most common aircrafts in UK in 1929
- 1935 - Put radio controls on a de Havilland Tiger Moth, a successor to the Gipsy Moth
- The Queen Bee (DH.82B) was one of the first returnable and reusable UAV - used as practice targets.

USES (PICTURES/VIDEO/GIF)

- Effective for Surveillance and Security.
- Research Purposes (robotics, flight control, etc.).
- Military, law enforcement and community agencies.

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Asking the Right Questions: Applications of Drone Technology

Mrinal Pai | TEDxSIBMBengaluru

- Commercial use and aerial photography
- Augmented reality games
- For delivering food and Medicine to affected places
- Geographical Calculations

TU DELFT – AMBULANCE DRONE

ROTORQUIZ#2

Which was the first country to build drones*???*

- A little hint:

ISRAEL...

- The first country to manufacture drones was Israel.
- Israel Aerospace Industries has production facilities about 24 countries around the world.

ROTORQUIZ#3

Which country are the highest users of drones *???*

AMERICA

- Over 181000 Americans have registered their drones with the Federal Aviation Administration of America.
- Stores report selling over 400000 drones.
- There are many unregistered American drones.
- Failing to register an American drone can lead to a fine of $27500.

APPLICATIONS

Search & rescue

Security

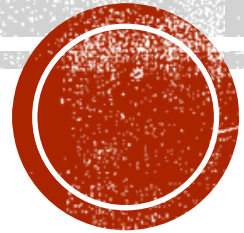
Inspection

Aerial Photography & Video

Surveying & Mapping

Science & Research

COMPONENTS OF QUADCOPTER



DRONE COMPONENTS

- Frame
- Motors
- Electronic speed Controller (ESC)
- Flight Controller
- Communication
- Propellers
- Battery

HOW TO CHOOSE A FRAME

4/11/2023

Purpose Decides the frame type.

TYPES OF DRONE

- Aerial
  - Used for cinematography.
  - High Definition Camera.
  - Strong and solid frame.
- Racing
  - Used for competing with others.
  - Light weight for high speed.
- Freestyle
  - It typically involves you are flying as hobby.
  - Light weight.

MATERIAL

- Carbon
- Aluminium
- Fiberglass

OTHER FACTORS

- Weight
- Size
- Layout
- Stiffness
- Price
- Review

HOW TO CHOOSE A MOTOR

4/11/2023

IMPORTANT POINTS

- Estimate the weight of the drone.
- Identify the frame.
- You will get an idea what motor and propeller to use.
- Most of them will suggest you while buying the frame.

THRUST TO WEIGHT RATIO

- It is important that your motors can produce around 50% more thrust than the total weight of your drone.
- Extra thrust will help you in wind and during aggressive flight maneuvers
- For example if your drone weighs around 600g then your motors need to produce 1.2 kg of thrust.

KV RATING

- kV rating tells us at what rpm a motor will spin at full throttle, at a certain voltage.

$$RPM = KV * voltage$$

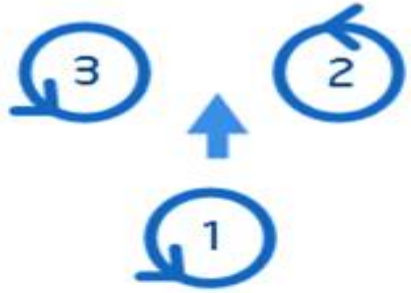
- If you need high performance drone then you need a high kV rating.
- If you need last longer and more stable then you need to power with least amount, so low rpm are ideal.

HOW TO CHOOSE PROPELLER

4/11/2023

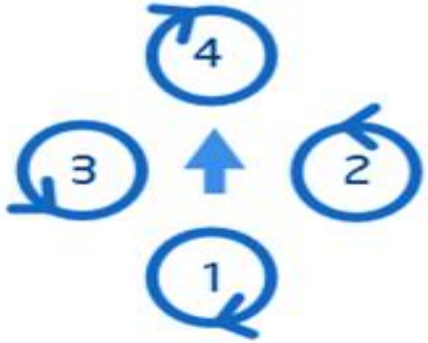
BASIC INFO

- Propellers are used to generate thrust and torque to keep your drone flying and maneuver.
- The faster they spin more thrust they produce.
- Torque is produced when they move up or down.
- To balance the torque all the propeller do not rotate in same direction.
- The length of propeller is measured from one tip to another tip.
- Pitch is the distance travelled by the propeller in a single rotation.
- Generally, the frame will give you an idea.

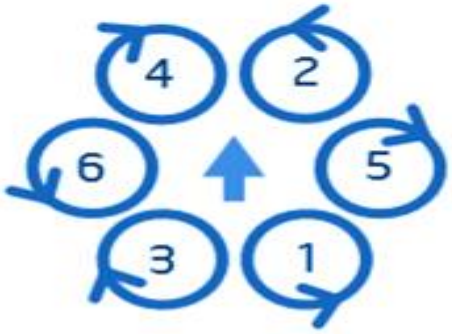


TriCopter

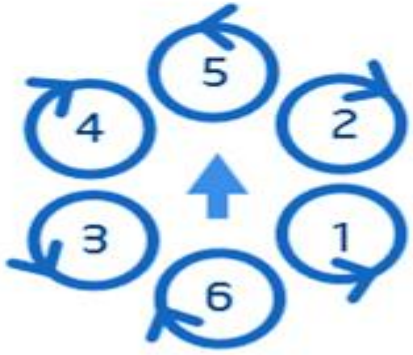
QuadCopter-X



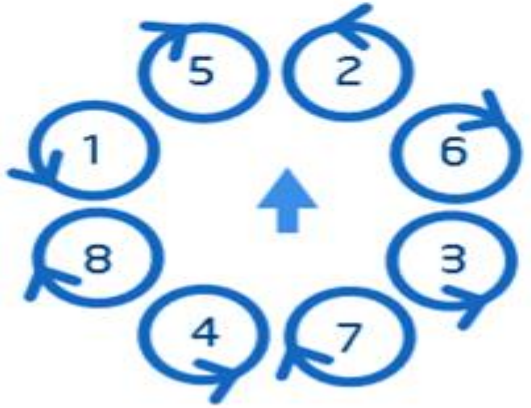
QuadCopter-Plus



Hexa-X



Hexa-Plus



Octo-X

IMPACT OF SIZE AND PITCH

- Propeller with smaller size will be easy to stop and speedup.
- Big size propeller will take time.
- Low pitch propeller will consume less power from the system and this will have positive impact on steadiness. But it will provide low speed.
- High pitch propeller will draw more power from the system and this can have negative impact on steadiness. But it will provide high speed.

MATERIAL

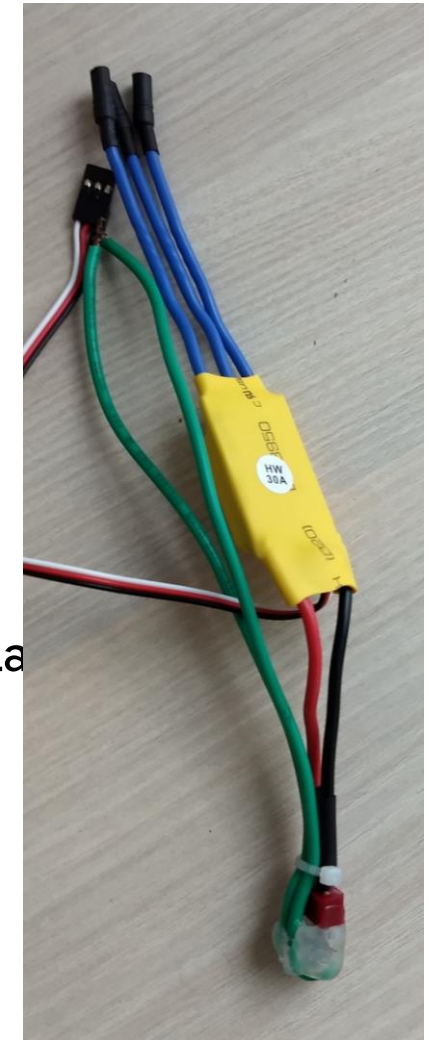
- It consist of materials like carbon, wood, plastic etc.
- Carbon and wood propeller are bit hard and provided smooth flight.
- Plastic propeller are more durable and reliable.

OTHER FACTORS

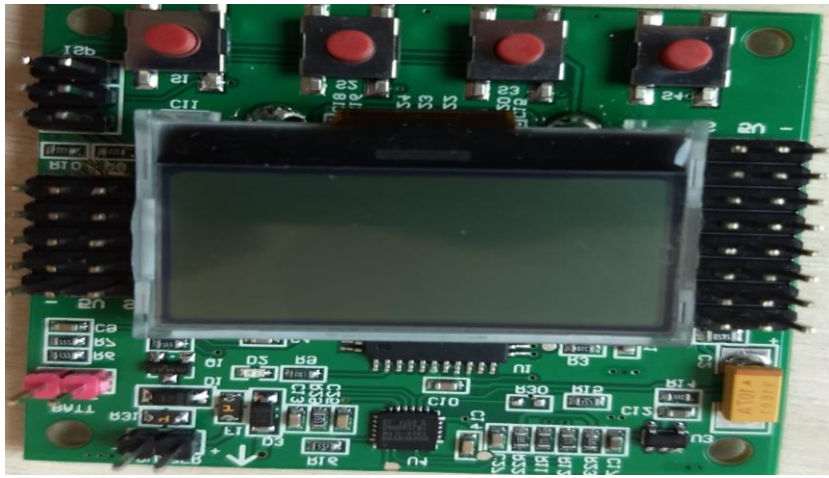
- Shape
  - it impacts on thrust.
- Number of blades
  - Generally dual blade propellers are used

ESC

- ESC stand for electronic speed control.
- They are used to control motor speed.
- ESC receives throttle signal from flight controller and drives the motor at tha speed.
- It tells us the amount of ampere it provide to the motor.
- ESC also tells us which battery it supports.



FLIGHT CONTROLLER



- Flight controller is a circuit board with sensors that detect the orientation change.
- It receives the user commands.
- You need to choose flight controller according to the purpose of your drone.
- Few sensors will be attached to flight controller and some of them you need to buy.

BATTERY

- LIPO battery is used for flying drone.
- Battery depends on size of drone and type of motors you use.
- Check the battery discharge rate
- Check the review of your battery.
- Buy the charger for your battery accordingly.
- Take great care of your battery as it is very sensitive and costly.

DIFFERENT TYPES OF SENSOR

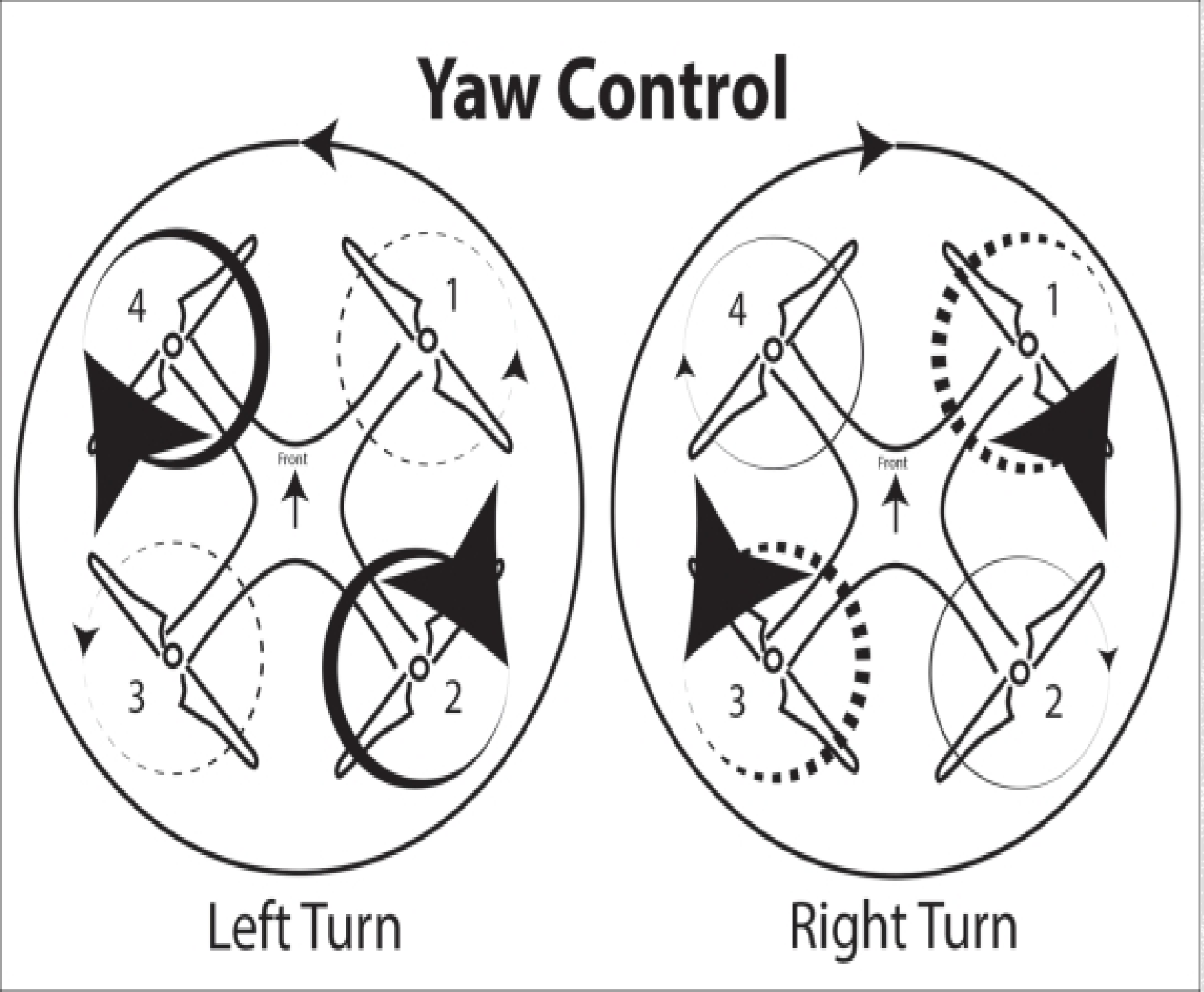
- Accelerometer
  - It is used for measuring the linear acceleration in three axes(X,Y,Z).it is very important as it tells us the direction up and down.
- Gyroscope
  - It is the most important sensor as it tells about the orientation of the drone, and hence the correction required to make it horizontal.
- Barometer
  - It is used to measure air pressure and also we can measure altitude.

DETECTION OF ORIENTATION OF DRONE

- Throttle
  - Controls the drone vertical and down motion.
- Yaw
  - It is left and right rotation of drone.
- Pitch
  - Forward and backward movement.
- Roll
  - It controls the side to side tilt.

THROTTLE

Controls the vertical motion.

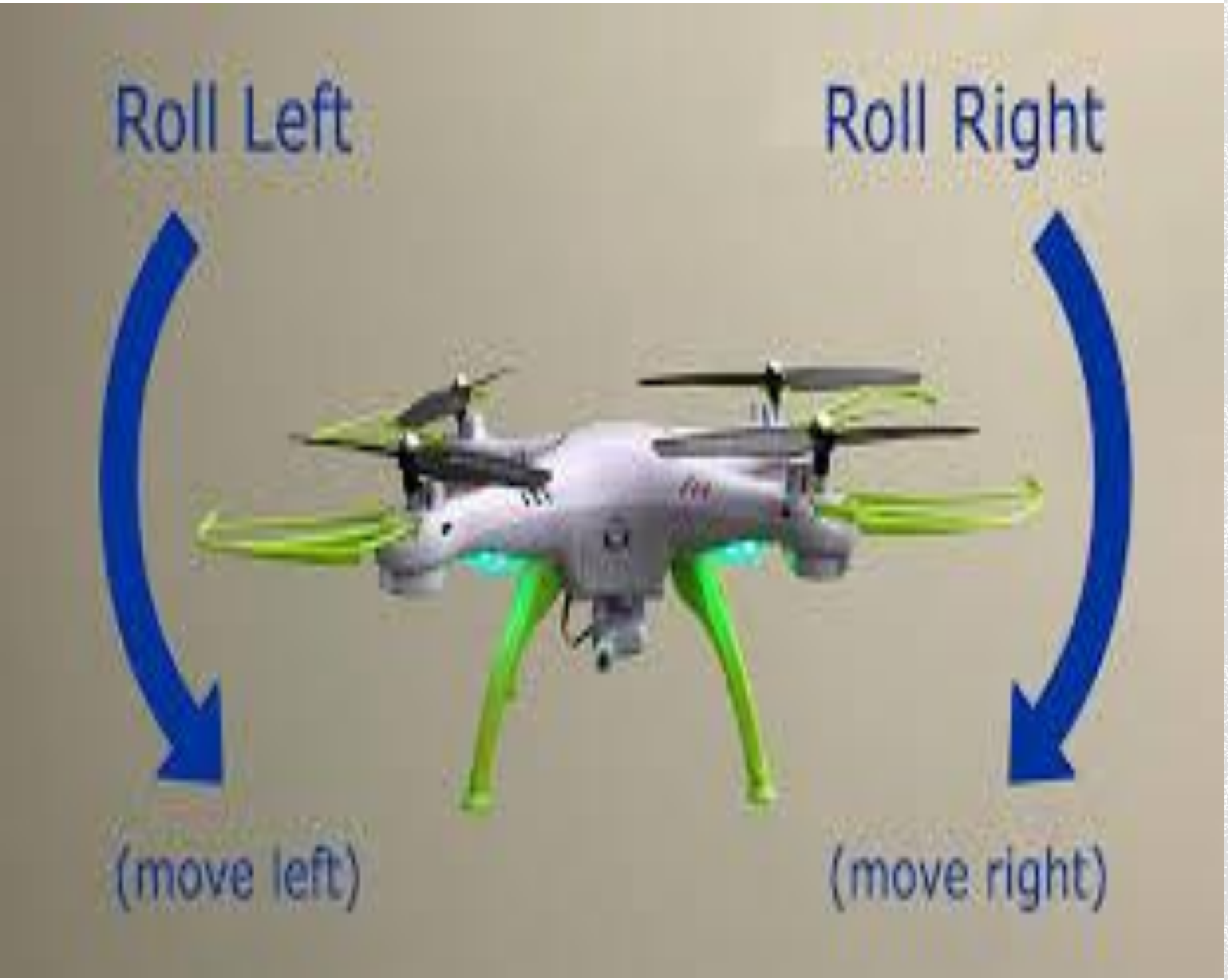


YAW

It controls left and right rotation.

PITCH

Forward and backward movement.



ROLL

it controls the side to side tilt.

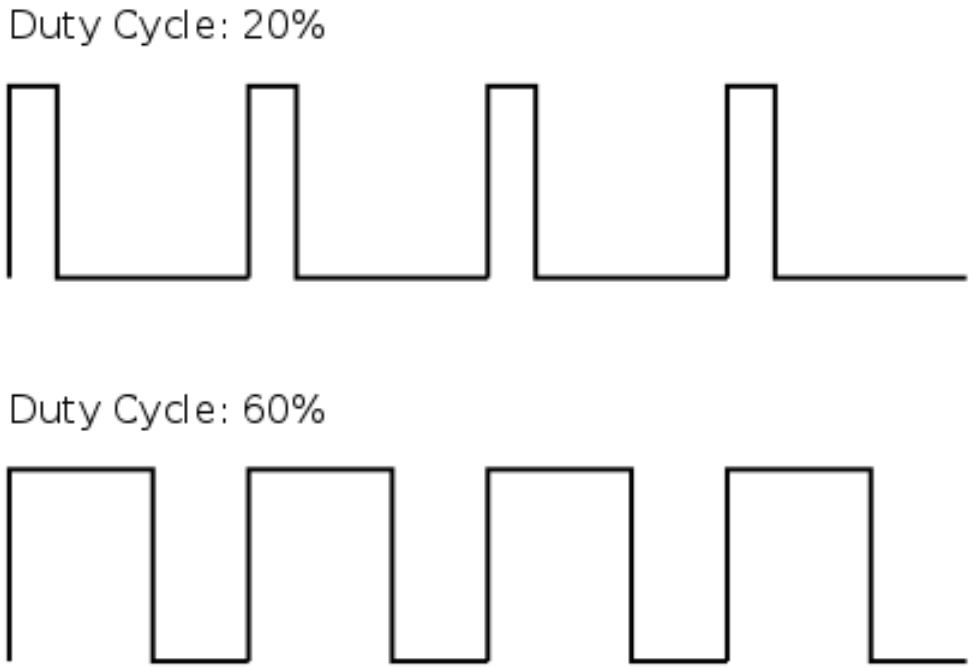
COMMUNICATION

DIFFERENT MODE OF COMMUNICATION

- Radio Control
  - It involves RC transmitter and receiver and need minimum four channels like pitch, roll, yaw and throttle.
- WiFi
  - It is being implemented through smartphone, computer or wifi router and range is limited.
- Infrared
  - This method is not suggested as there are lot of interference while flying and it is not reliable.
- Bluetooth
- Radio Frequency

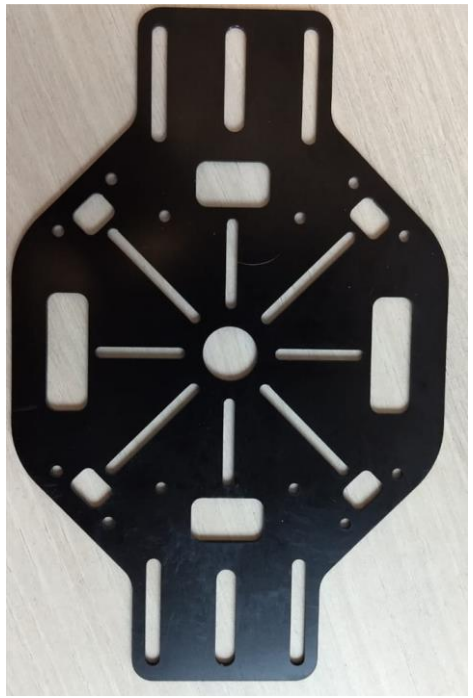
PWM SIGNALS

- PWM stands for Pulse Width Modulation
- A square wave is created by ON and OFF pattern by alternating between 0 and 5V.
- The duration of ON time is called pulse width.
- A call to analogWrite() is on a scale of 0-255, hence duty cycle of 100% is 255, 50% is 127 and so on.

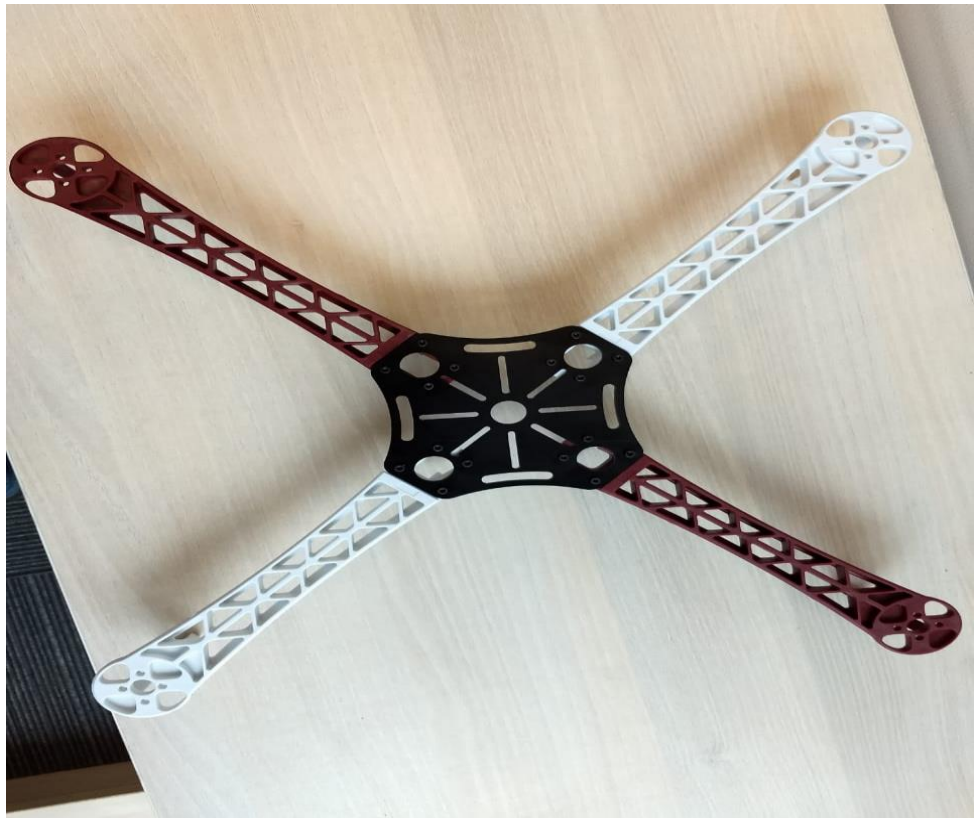


ASSEMBLING A DRONE!!

We start initially with these parts at hand..



Assembling the frame components and putting those pieces together we get..



After having the basic structure ready, we are ready to mount the esc and motor.

CAUTION

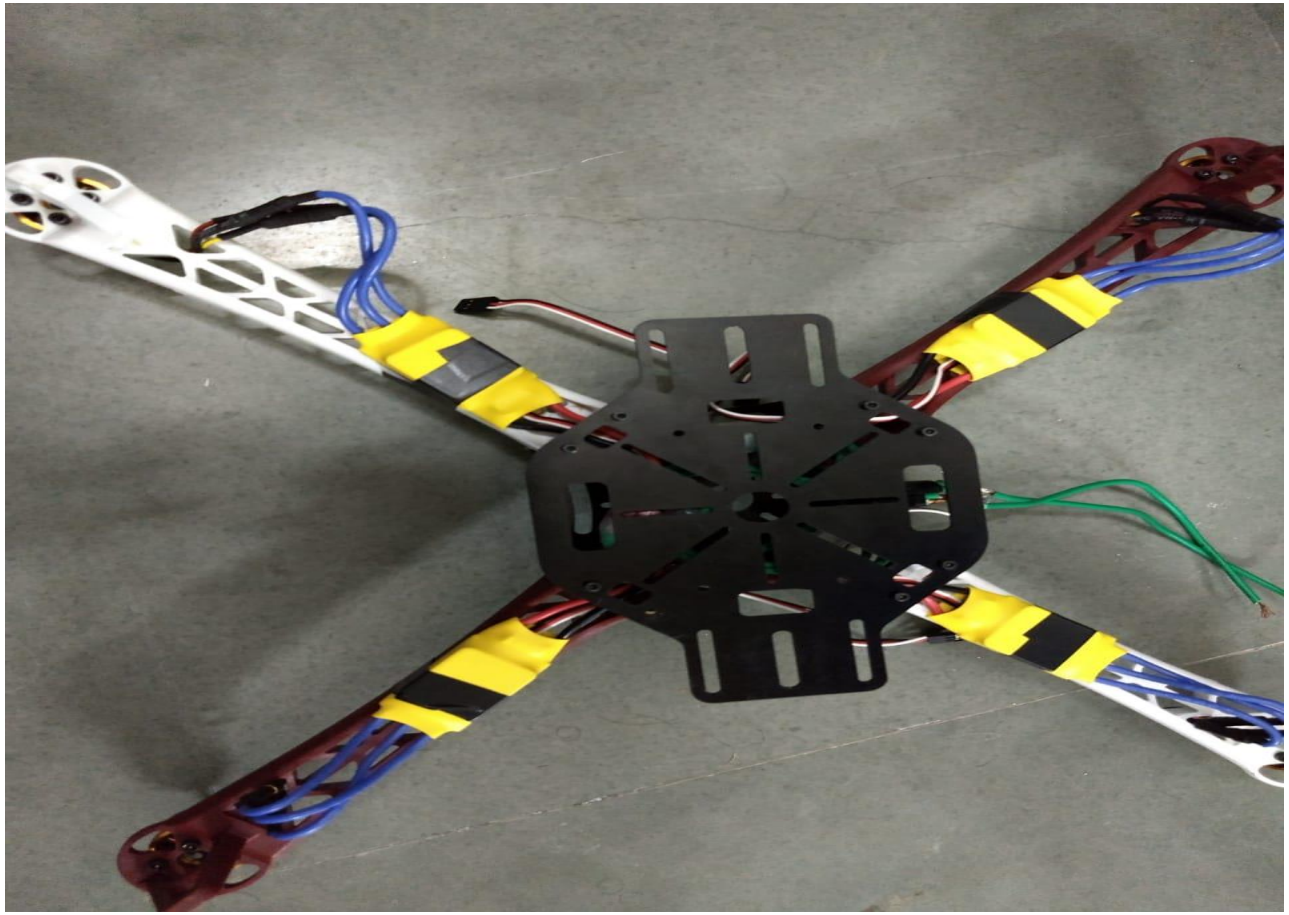
It must be ensured that all screws are tightened well. As spinning of motors along equipped with propellers might generate sufficient torque to separate the motor from the frame.

FIXING THE ESCS

- Three bullet connectors from the motor are to be connected to the other three bullet connectors on ESC.
- It must be noted that to conserve angular momentum in drones two propellers spin clockwise and other two spin anti-clockwise.
- Opposite propellers always have the same spin.

- Hence while connecting ESCs we have to make sure that the positive terminal of the motor is connected to the positive terminal of ESC, and the negative to the negative, for a clockwise configuration.
- The positive and negative wires of motor are swapped in case of anti-clockwise configuration.
- The middle wire from the ESCs always connects to the middle wire of the motor, in both clockwise and anti-clockwise configuration.

NOW WE HAVE THIS..



PROCESSING UNIT OF OUR QUADCOPTER!!

Flight controller processes all the data received from the sensor and keeps the drone horizontal by providing error-correction mechanism.

KNOW YOUR FLIGHT CONTROLLER!

- We have used a KK2.1.5 flight controller board.
- This board comes with an LCD screen that enable us to configure settings such as PID and calibration without connecting to a computer.
- The board also has self-level mode which can be helpful for beginners to fly the quadcopter.

OTHER FLIGHT CONTROLLERS

- KK2 is a simple flight controller board with minimal features.
- Other flight controller such as ardupilot APM comes with GPS, telemetry options, etc.
- KK2 is simple to use and gives a stable flight.

SETTING UP THE CIRCUIT

- Circuit building is a crucial part for implementing a quadcopter.
- The right side of the flight controller board has to be connected the ESCs. Notice the thin (black, red, white) wires from the ESCs.
- The white write is the signal pin and has to be connected in the line marked with ‘s’ on the flight controller board. The second and third pin are to be connected with red and black respectively. Innermost pin is the signal pin.
- ESCs are connected in order. Therefore ESC of motor 1(clockwise spinning) goes in the first set of three pins. The second ESC of motor 2(spinning anti-clockwise) goes to second set of pins and so on.

RECEIVER

- Receiver receives the values of aileron, elevator, throttle, rudder from the transmitter and passes it on to flight controller.
- Connect the first set of three pins on the receiver to the first three pin set on the left side of flight controller, keeping in mind the signal pin.
- Do the same for all the four channels on the receiver.

CONNECTING THE BATTERY!

- We use a 11.1V battery capable of dissipating current at high rates.
- All the red wires of the ESCs are connected and grouped and similarly all the black wires of the ESCs are connected and grouped.
- These grouped wires are then connected to a T-connector.
- This T connector will go to the battery when Quadcopter is to be switched on.
- Make sure the positive terminal connects to the positive of the battery and negative to the negative.

CALIBRATING THE MOTORS

- When running the ESCs for the first time we need to specify at what input signal it should run at highest speed and at what input signal at the lowest speed. This process is called calibration.
- Our flight controller board has an inbuilt calibration mode, for calibrating all the ESCs together.

CONT..

- To calibrate the motors switch on the transmitter and put the throttle stick at extreme upper end.
- Now hold the first and last buttons (red) on the flight controller which you connect the battery.
- The ESC should beep.
- When the beeps stop bring the throttle stick down, and the ESC should beep again.
- Once this is done our ESCs are calibrated.
- Bring the throttle stick up to see the motors running.

CAUTION!!

Always remove the propellers before calibrating.

ACCELEROMETER CALIBRATION

- Our quadcopter needs to be told what is the horizontal level that it should maintain, this information should sync with the gyroscope sensor.
- To calibrate just put the drone on levelled surface and switch it on.
- Now Go to Menu-> ACC calibration.
- It will ask for confirmation and then you can proceed.
- It will be calibrated automatically.

PUTTING ON PROPELLERS

- There are two types of propellers in the set, one is for clockwise and one is for anti-clockwise spinning motor.
- A clockwise spinning propeller has a bulge on its top right side.
- Put similar propellers on the diagonally opposite side.

FLYING QUADCOPTER

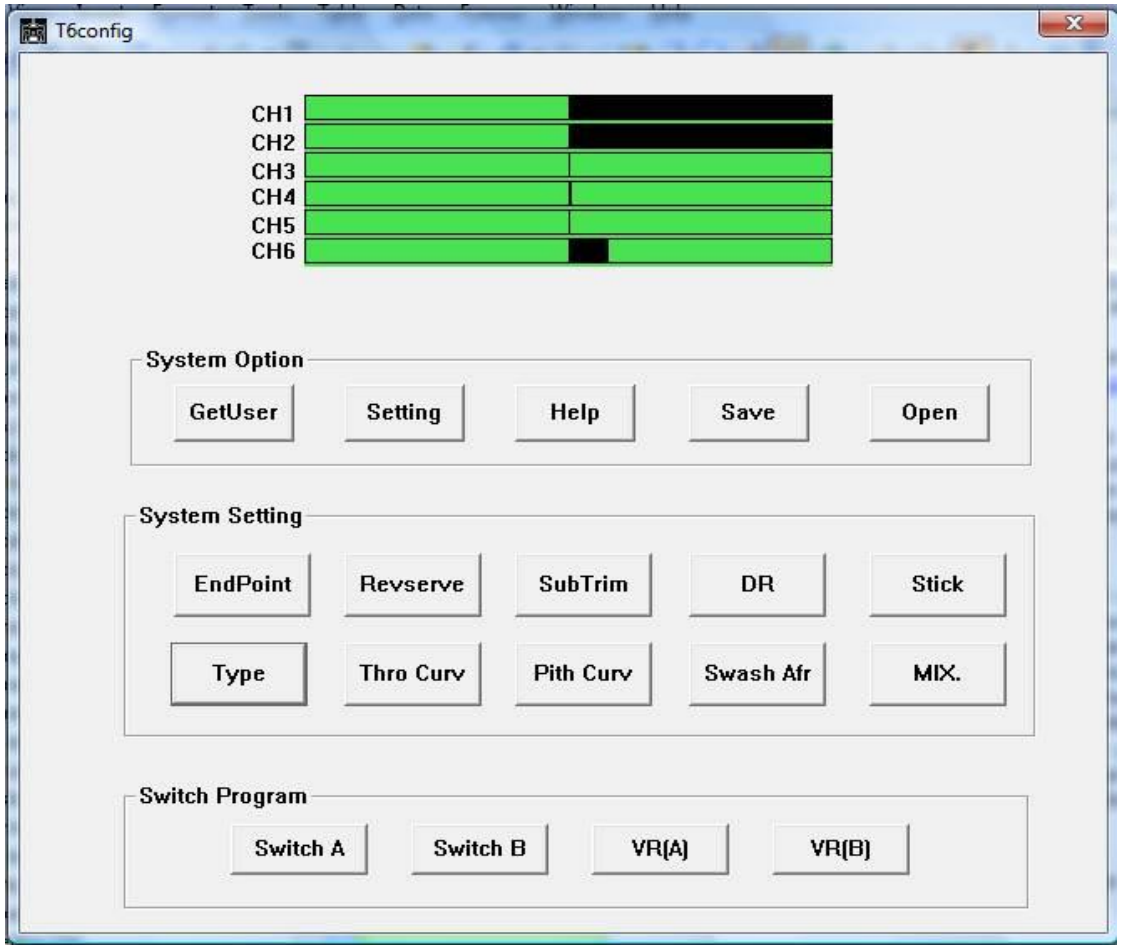
- Always fly your quadcopter outdoors.
- The propellers attached are dangerous.
- Always check if the quadcopter is configured properly.

ARMING THE QUADCOPTER!

- Arming is the procedure which enables the motors to spin, and indicates that the user is ready to fly.
- Always arm the quadcopter once you are on a safe distance from it.
- To arm the quadcopter pull the first stick of the transmitter to the extreme low and to the extreme left.
- A red light on the flight controller board indicated that the quadcopter is armed.
- The flight controller board also has ARMED written on center of its screen.

TRANSMITTER CONFIGURATION

- The FS-CT6B transmitter comes with a CD carrying the configuration program and driver.
- Install the drivers.
- The configuration program (T6Config) can be used to adjust the transmitter values and reverse channels.
- The modes (or) layout of transmitter channels can also be changed.
- It is useful at times to reverse the pitch to get better intuitive control.



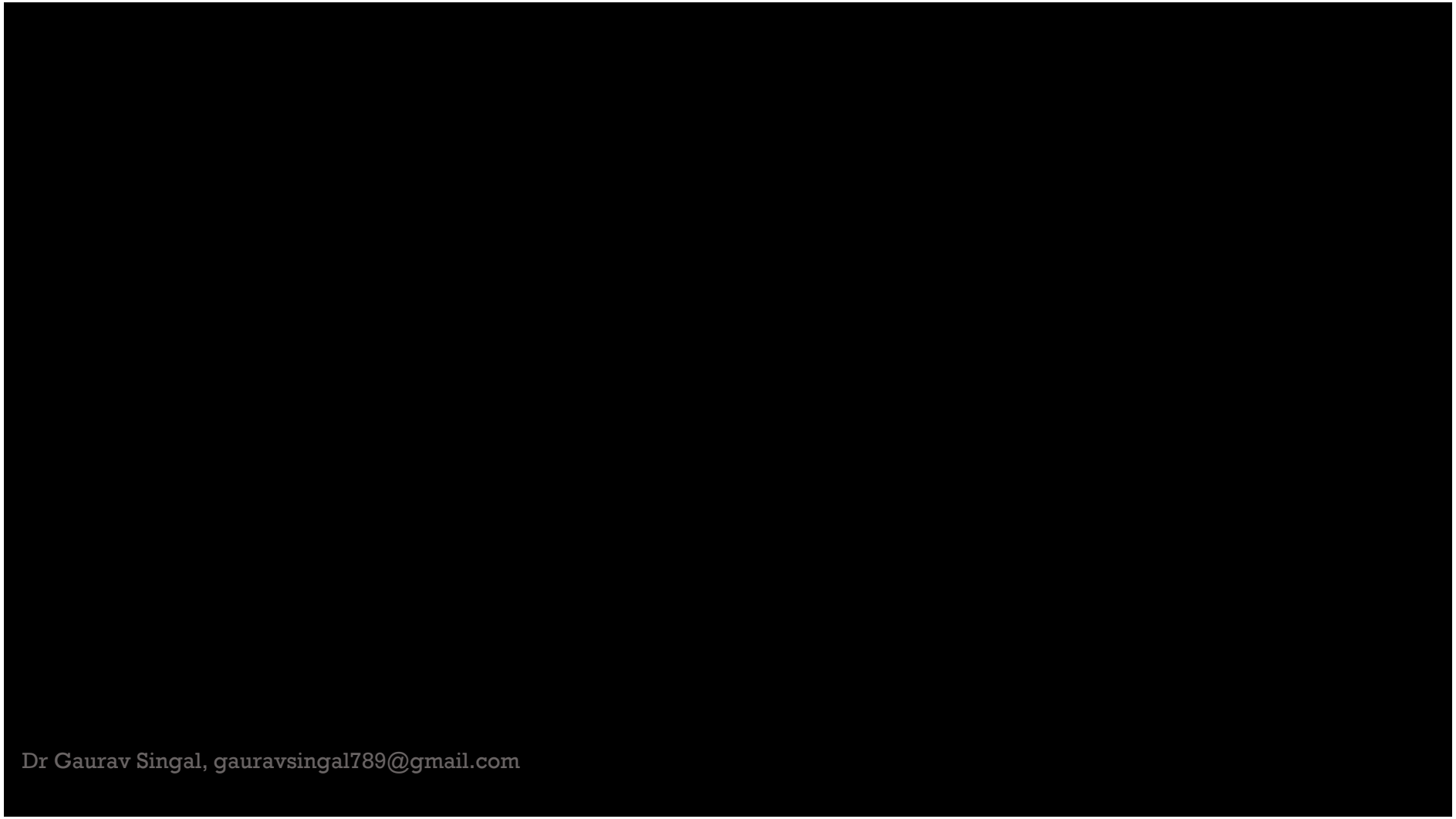
PID TUNING

- P is Proportion, I is Integral and D is Derivative.
- PID tuning is very important as it determines how responsive the drone is to the controls.
- Responsiveness decides the experience of the flight.
- The need for responsiveness also depends on the purpose of flight.
- A drone racer (person) would need more responsiveness while a photographer would need less responsiveness.

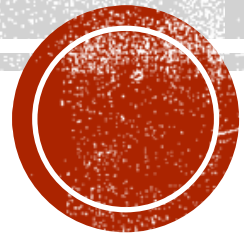
PID TUNING

- Increase p gain if the response to command is too slow, but if on changing the command, the Quadcopter oscillates with respect to that command then decrease p gain.
- For example in case of yaw, if the Quadcopter oscillates around the axis decrease p gain, else if the response in moving only about the axis slow, decrease it.
- While PID tuning consider moving the Quadcopter only in the movement of command being tuned.

PID TUNING



APPLICATIONS



AERIAL IMAGING

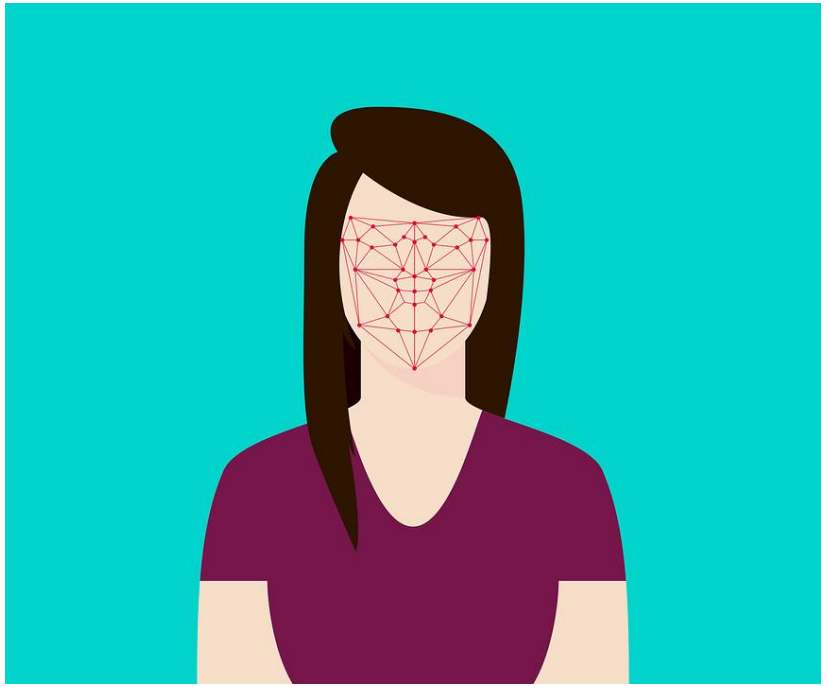
- UAVs are capable of capturing images and video at thrilling angles, creating effects that are appealing to people.
- Images and videos captured by drones are post-processed.
- Post-processing includes stitching of images so as to make them look as if they were taken from uniform altitude, pitch, roll, and yaw.
- Videos captured with drones are usually noisy, due to the vibration. However post-processing makes them better.

SURVEILLANCE

- Recently, drones have become quite popular in surveillance.
- Drones can often survey subjects that are not accessible to otherwise and can offer FPV(First-Person View).
- First-Person View is the ability to view from different visual perspectives.
- Drones combined with computer vision, object recognition and face recognition can essentially bring surveillance to another level.

WHY FACIAL RECOGNITION WITH DRONE?

- Facial recognition with drones can help in identifying subjects on whom the surveillance is being done.
- It can help in identifying photos of people carrying out robberies, by matching the frames in video to photos in crime records.
- It enables us to identify the person so that he can be tracked by the drone.

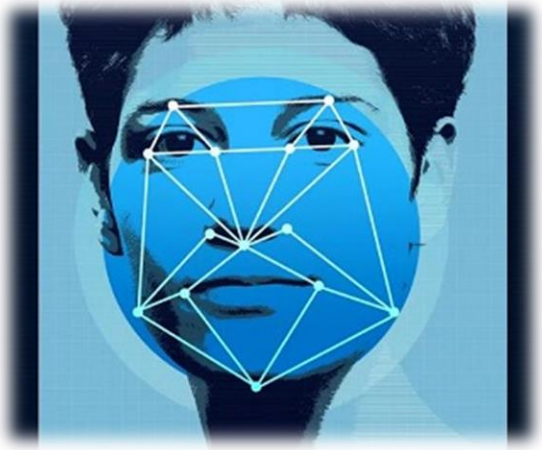


ABOUT FACIAL RECOGNITION

- Facial recognition can be divided into face detection and identification.
- Face identification can be done in several ways such as using non deep learning algorithms like eigenfaces and LBPH.
- However, deep learning based methods give extremely higher accuracy and even comparable to human vision on several datasets.

METHOD

- Our network architecture for face recognition is based on ResNet-34 from the *Deep Residual Learning for Image Recognition* paper by He et al., but with fewer layers and the number of filters reduced by half.
- We use dlib library of python.
- The frame is processed to detect face.
- The face is then pre-processed and fed into the trained model which generates a 128-d embedding.
- If Euclidean distance between these embedding of two different faces is below a threshold then we say it is a match.
- The threshold values in our model is 0.4.

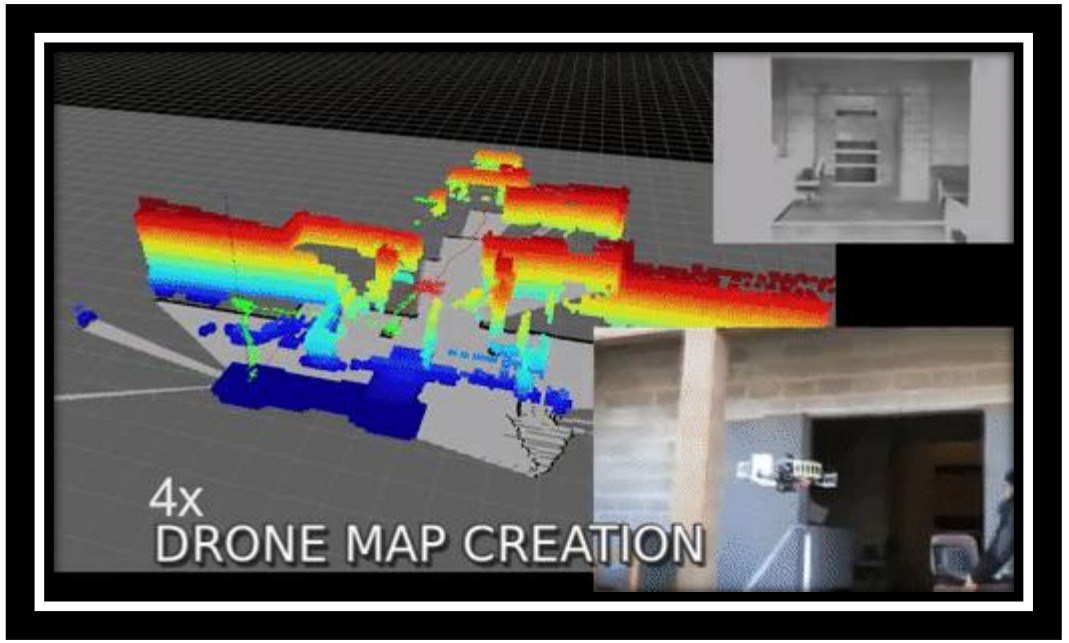


FARMING

- Drones can prove very useful in farming, specially in India where farming is an essential activity.
- Spraying of pesticides and other harmful chemicals by farmers can affect their health seriously.
- Determining crop health using computer vision techniques.
- Determining crop variations, etc.

SLAM

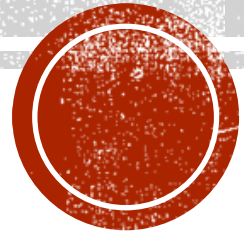
- We are currently working on implementation of SLAM at our university.
- SLAM stands for Simultaneous Localization and Mapping.
- Simultaneous localization is the computational problem of updating the map of a place while keeping the current location of drone.
- SLAM can map the entire location, using camera or sensors like LIDAR(Light Detection and Ranging).



OTHER APPLICATIONS

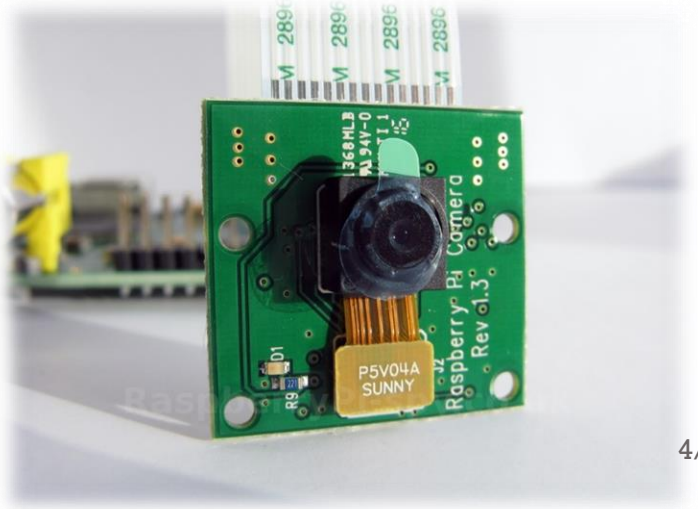
- Condition survey, detecting leaks.
- Rescue missions on tough terrains.
- Logistics(Amazon delivery drone).
- Managing security threats in battle grounds.
- Eliminating terrorism.

IMPLEMENTING APPLICATIONS



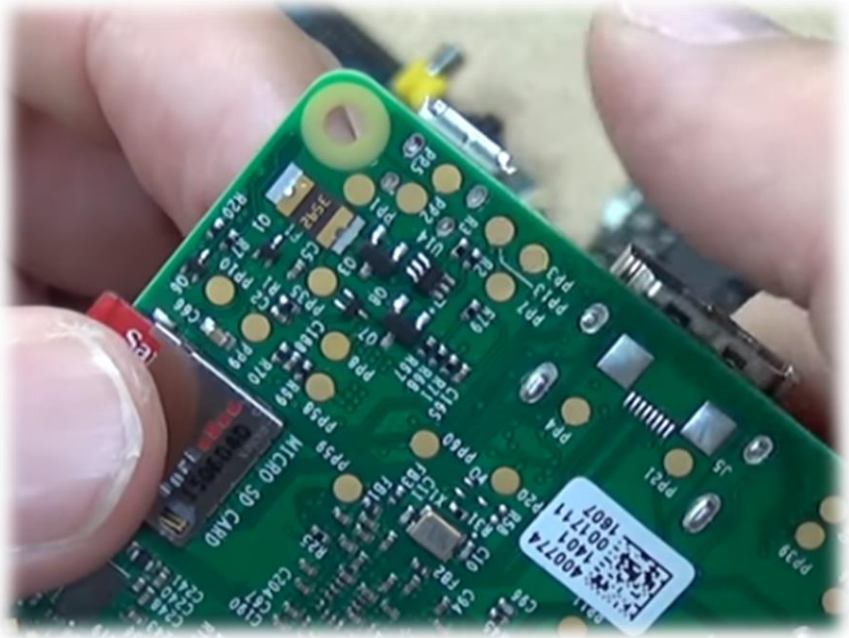
REQUIREMENTS

- Raspberry Pi.
- Pi Camera.
- DC-DC voltage buck converter.
- Other sensors specific to application.



POWERING RASPBERRY PI

- Raspberry pi can be powered in different ways:
  - Through USB cable
  - Through GPIO pins
  - Supplying 5V directly through pads below USB input.



THROUGH GPIO PINS

- To power raspberry pi from GPIO pins, the positive and negative terminals from Li-Po go to IN+ and IN- terminals respectively marked on buck converter.
- Fix voltmeter on OUT+ and OUT- and rotate the screw until you get 5V on voltmeter.
- Remove the voltmeter and connect OUT+ to pin 2 and OUT – to pin 6 of raspberry pi.

Raspberry Pi 3 GPIO Header

Pin#	NAME		NAME	Pin#
01	3.3v DC Power		DC Power 5v	02
03	GPIO02 (SDA1 , I²C)		DC Power 5v	04
05	GPIO03 (SCL1 , I²C)		Ground	06
07	GPIO04 (GPIO_GCLK)		(TXD0) GPIO14	08
09	Ground		(RXD0) GPIO15	10
11	GPIO17 (GPIO_GEN0)		(GPIO_GEN1) GPIO18	12
13	GPIO27 (GPIO_GEN2)		Ground	14
15	GPIO22 (GPIO_GEN3)		(GPIO_GEN4) GPIO23	16
17	3.3v DC Power		(GPIO_GEN5) GPIO24	18
19	GPIO10 (SPI_MOSI)		Ground	20
21	GPIO09 (SPI_MISO)		(GPIO_GEN6) GPIO25	22
23	GPIO11 (SPI_CLK)		(SPI_CE0_N) GPIO08	24
25	Ground		(SPI_CE1_N) GPIO07	26
27	ID_SD (I²C ID EEPROM)		(I²C ID EEPROM) ID_SC	28
29	GPIO05		Ground	30
31	GPIO06		GPIO12	32
33	GPIO13		Ground	34
35	GPIO19		GPIO16	36
37	GPIO26		GPIO20	38
39	Ground		GPIO21	40

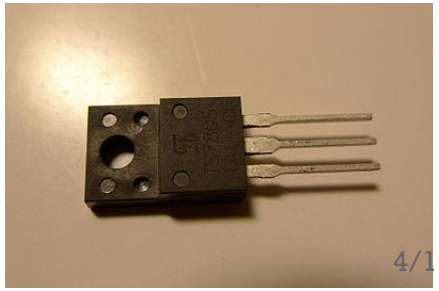
Rev. 2
www.element14.com/RaspberryPi

BUCK CONVERTER

- It is used to step down the voltage, and get constant voltage output which is required for stable functioning of raspberry pi.
- We have used LM2596, which gives a current output of 3A.
- The Li-Po battery used provides an input of 11.1V which is brought down to 5V.

BUCK CONVERTER V/S LINEAR VOLTAGE REGULATOR

- Linear voltage regulators can be used in place of buck converter.
- Linear voltage regulators are simple to use, and cheaper.
- However, they lose a lot of energy in form of heat.
- Hence it is suggested to use buck converters.

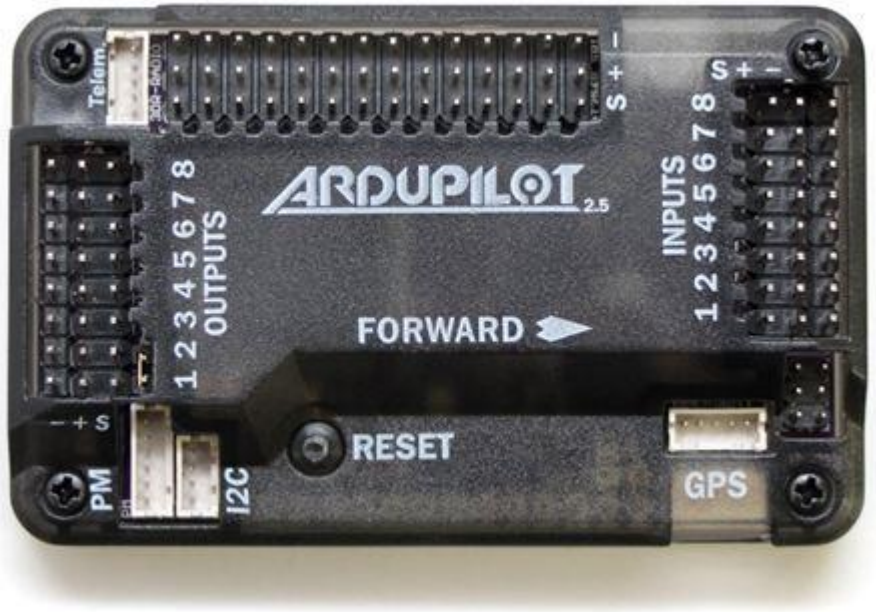


COMMUNICATING WITH RASPBERRY PI

- VNC server can be used for accessing raspberry pi.
- To use VNC server create a hotspot and connect raspberry pi to it.
- To send data to raspberry pi socket programming can be used.
- As programming can be done in python, sending data using socket programming becomes easier.

COMMUNICATING WITH FLIGHT CONTROLLER

- Generally flight controller gets input from radio receiver.
- For automating drone the input such as throttle, yaw, pitch, roll can be calculated using a computer vision algorithm and then sent drone via raspberry pi.
- Flight controllers like ardupilot APM support serial input.



COMMUNICATING WITH FLIGHT CONTROLLER

- For Flight controllers such as KK2 which do not have a serial input, the pi output must be converted to PWM signals.
- As raspberry pi does not have 4 hardware PWM pins, we cannot get stable PWM signals.
- This problem can be solved using an intermediate Arduino which converts the serial input from pi to PWM signals and gives stable input to KK2 board.

ADDITIONS TO DRONE

- GPS:
  - Global Positioning System module can be used with flight controller to get GPS co-ordinates of drone. This enables us to move the drone autonomously, or to plan the flights rather than using a transmitter.
- Ultrasonic sensor:
  - Ultrasonic sensors detect distance from respective object by sending a sound wave of specific frequency.
  - Ultrasonic sensors are very useful in avoiding collisions of drone in cases of autonomous flights. They detect obstacles and provide information to move accordingly.

FINAL STEP

- The last step is to write code specific to the application.
- Raspberry pi can be programmed in python, and PiCamera and GPIO libraries help in accessing camera stream and writing GPIO outputs.

TIPS AND TRICKS

- Always keep a voltmeter handy, it is useful in several ways:
  - It can be used to check if proper voltage is being applied at specific places.
  - It can be used to check connectivity in connections, helpful in detecting broken wires and faulty jumpers.
- Have an Arduino programmed which can give PWM reading.
- Calibrate your drone at regular intervals, motor and level calibrations determine flight experience.
- Try not draining Li-Po battery completely, dispose them if you see a swelling.
- Do not leave the connections loose, as they can come out easily while a drone is flying.

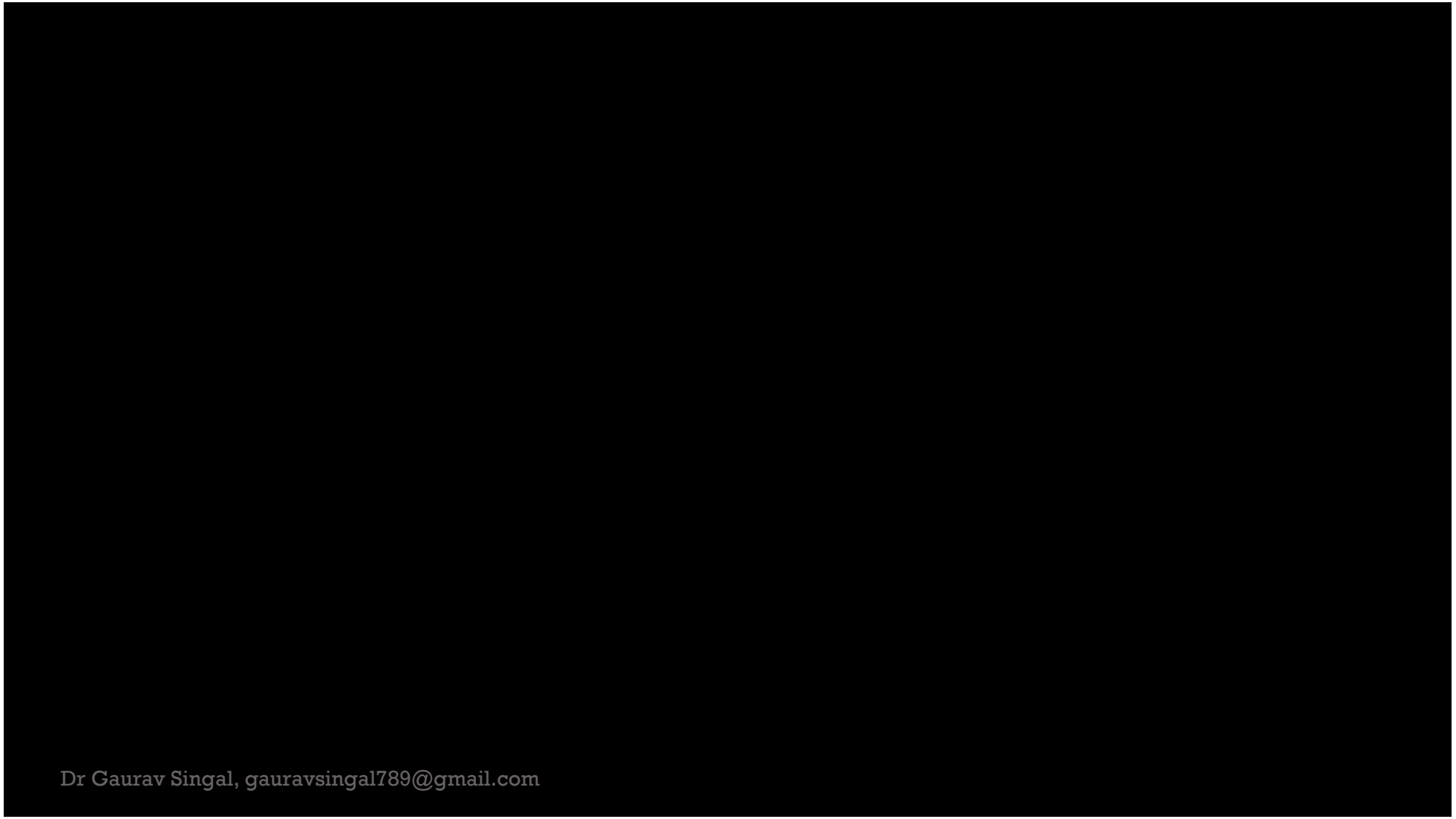
DGCA RULES AND REGULATIONS

- DGCA stands for Directorate General of Civil Aviation.
- New policy is to come in effect from 1st December 2018.
- *The DGCA has segregated drones into five different categories*
  - Nano : Less than or equal to 250 grams.
  - Micro : From 250 grams to 2kg.
  - Small : From 2kg to 25kg.
  - Medium : From 25kg to 150kg.
  - Large : Greater than 150kg.

DGCA RULES AND REGULATIONS

- Seven day prior permission is required to hold a drone flying event.
- Exceptions:
  - Drones of size nano and micro do not need seven days prior information.
  - Height should not reach more than 60 m for micro drones.

DGCA RULES AND REGULATIONS



Thank You!!