

Fabrication of Quadcopter with Face Recognition for Surveillance

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Abstract

In the present scenario, drones are the ruling technology. But their usage has been limited because of their high cost. This work aims to fabricate a low-cost UAV Quadcopter system with face recognition for surveillance. The Quadcopter is controlled by a radio transmitter. The surveillance system used consists of an FPV camera, an FPV transmitter, and a receiver. Face recognition is done using OpenCV in python with the help of the Local Binary Pattern Histogram (LBPH) algorithm. The fabricated Quadcopter is capable of identifying a targeted person from a certain range.

Keywords

Quadcopter, UAV, Face recognition, LBPH and surveillance

1. Introduction

In the olden days, Surveillance is done by humans. Later on, CC Cameras came into the picture. As the technology is getting updated, Surveillance drones are slowly introduced into the market. The updated features like face recognition make drones capable of fulfilling many of the day-to-day applications like traffic density monitoring, Food delivery, etc. Sărăcin, et al (Sărăcin et al., 2017) proposed multiple ways of quickly recharging a drone to keep a surveillance drone running continuously in air. Pirotta, et al (Pirotta et al., 2022) discussed the applications of drones for monitor marine as well as wildlife.

A Quadcopter is a type of UAV (Unmanned Aerial Vehicle). The Quadcopter is the most stable type of drone and generally consists of four arms. Each arm has a propeller-driven by a motor. The principle behind the Quadcopter for lifting is Bernoulli's principle and Newton's third law of motion. The airfoil-shaped propeller pushes the air downwards, thus creating thrust against gravity. One pair of opposite propellers rotates in the clockwise direction and the other pair rotates in the anti-clockwise direction, hence torque will be canceled and the Quadcopter will become stable.

A Quadcopter has four different movements namely,

- Throttle
- Yaw
- Pitch
- Roll

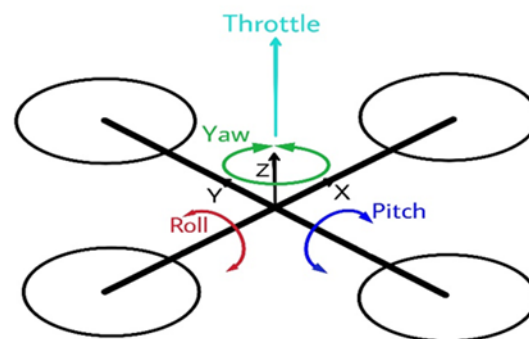


Figure 1. Quadcopter movements

The upward and downward movement of the Quadcopter is called throttle. Turning left or right about the vertical axis is called yaw. Tilting along the lateral axis is called pitch. This movement enables the Quadcopter to move forward or backward. The rotational speeds of the four motors decide the movement of the quadcopter.

1.1 Objectives

The main objective is to fabricate a low-cost face-recognition-based surveillance drone.

2. Literature Review

The design of drone plays crucial role in the development of drone. Many works were done on designing of drone and it is presented in (Nithyavathy et al., 2020; Tatale et al., 2019). G. Ononiwu et al. (Ononiwu et al., 2016) worked on the quadcopter drone for payload delivery. A proportional integral derivative controller is used in this drone and the simulation was done using MATLAB. Many drones were developed based on the Raspberry Pi microcontroller and used for rescue and surveillance applications (Benhadria et al., 2021; Brand et al., 2018; Chettri et al., 2021). Sevkuthan Kurak and Midgat Hodzic applied LQG and LQ methods to control the quadcopter system. LQ methods are not realistic because they do not produce accurate output. Due to which LQG methodology is introduced (Kurak and Hodzic, 2018). Adilet Tagay, et al, focused on the auto-balancing of the drone. The response time of the drone is high. But the performance of the drone made is good (Tagay et al., 2021). Raffay Rizwan, Muhammad Naeem Shehzad, et al., developed a health monitoring drone. The drone consists of the emergency medical kit and live streaming is done to the main control station so that the patient's condition can be directly known to the doctor and first aid can be easily done (Rizwan et al., 2019). Ashish Kumar and Sugjoon Yoon (Kumar and Yoon, 2020) developed a solution for the landing problems of the drone. They developed a Fuzzy logic to make a soft landing. This is achieved by using an ultrasonic sensor, the Raspberry pi. This logic also reduces the time for landing the drone. Neha Karna, et al (Karna et al., 2020) described a design and fabrication of a surveillance drone in which APM 2.8 flight controller is used for controlling the drone while Pi is used for the surveillance purpose.

A detailed survey of various face recognition algorithms is presented in (Hasan et al., 2021; Kortli et al., 2020). Steenbeek and Nex (Steenbeek and Nex, 2022) used CNN for extracting data from UAV imagery for generation of terrain maps. Lal, M., Kumar, K., et al., Studied different face recognition techniques and approaches such as Eigen face, Artificial Neural Networks (ANN), Support Vector Machines (SVM), Principal Component Analysis (PCA), etc., and also tested face databases for results analysis (Lal et al., 2018). The use of Kalman filter for the controlling quadcopter is discussed in (Bauer et al., 2008). Park, et al (Park et al., 2022) used Random Forest method for analyzing 126 parameters to map using drones.

3. Methods

In the present work on the development of Quadcopter for surveillance, both hardware tools and software tools such as OpenCV, PC, Electronic components, etc., are used. The software tools increase the features for different applications. The technology regarding face recognition is also mentioned below.

3.1 Components Description

Electronic speed controller (ESC): It is an important constituent of the quadcopter drone. Because the speed of the motor should be controlled by the ESC. The signal received from the transmitter will be processed by the flight controller and according to that the rpm of specified motors will be controlled. ESC is compatible with a 3s Li-Po battery and it's a 30-amp ESC with a battery eliminator circuit that outputs 5 volts and 3Amps.

Motor: Brushless DC Motor, which is mostly used in drone applications because it doesn't have brushes and has permanent magnets. So, the motor has better efficiency and provides high speed and accurate control of rpm and torque. 1000 kV BLDC Motor is used for this drone. A2212 is the model of the drone and a compatible battery is a 3s Li-Po battery. The RPM was calculated as 1000 (RPM/V).

Propeller: 10 inches in length and 4.5 inches pitch propeller is used for this drone. The material of the propeller is plastic so, it has less weight, choosing thick propellers provides durability.

Frame: Q450 quadcopter frame is used for this drone. The frame material is Glass Fiber and Polyamide-Nylon. The base of the frame is a power distribution board, which distributes the voltage from the battery to all the components in the drone. It provides the necessary durability to this drone.

Flight Controller: The Flight Controller is the heart of the drone, which sends the signal to the electronic speed controller from the radio receiver to control the RPM of the motor. KK 2.1.5 Flight Controller is used in this drone which has 4 buttons used for accessing the flight controller options, it's coming with an inbuilt firmware. The flight controller has an ATMEGA 644PA 8-bit AVR RISC- based microcontroller having 64K of memory. The best advantage of this flight controller is calibration process is simple and it supports to gyroscope and accelerometer sensor, these two sensors will process the signal coming from the radio receiver and provides an output at ESC.

Radio Transceiver: Total control of the drone depends on the Radio Transceiver. The receiver will receive the signal from the transmitter and works consistently by processing that signal through the flight controller. FlySky CT6B 2.4Ghz 6 channel Transmitter and FS-R6B Receiver is used for this drone. Using this Radio Transceiver spectral bandwidth and out-of-band spectrum to meet adjacent channel power rejection requirements will reduce by using the Gaussian frequency-shift keying modulation.

FPV Camera: First Person View Camera is used for the surveillance purpose of this drone. This camera-input voltage is 5v to 30v, 1/3" CMOS image sensor is used for this camera and it provides 1500 camera's horizontal resolution (Television lines)

FPV Video Transmitter: 40 channel Transmitter with an antenna is used for video transmission to the receiver. The live stream video from the FPV camera is transmitted to the receiver by using this video transmitter. The Frequency range of this video transmitter is 5.6 to 5.9 GHz. It's compatible and lightweight.

UVC OTG Receiver: FPV Receiver operating voltage is 5v and it receives the video stream coming from the transmitter placed on the drone. The receiver also has the same frequency range that which FPV transmitter has. This

receiver will search for the transmitter signal and shows the output when it reaches the accurate level of signal reception, Number of channels present in this receiver is 150.

3.2 Assembly of Quadcopter Drone for Surveillance

The female connector of the battery, FPV camera, transmitter terminal, and ESC terminals should be soldered to the base of the frame, which is the power distribution board (PDB) as shown in Figure 2. The voltage from the battery will be distributed to the components through this power distribution board. Attach the ESC to the arms of the quadcopter drone for proper placement and fix the arms to the base of the drone with help of screws. Now fix the motors on each edge of the arms of the quadcopter with the help of screws. Attach the top plate to the drone and place the flight controller on top of the top plate. Connect the ESC lead and receiver to the flight controller. Connect the ESC three-phase connection to the BLDC motors. Place the camera on edge of the base of the drone and the transmitter was connected to the camera ports. Place the battery in the middle of the drone. Now make the connection for the battery to its female connector, then the power will be distributed to all components of the quadcopter drone as shown in Figure 2 and Figure 3.

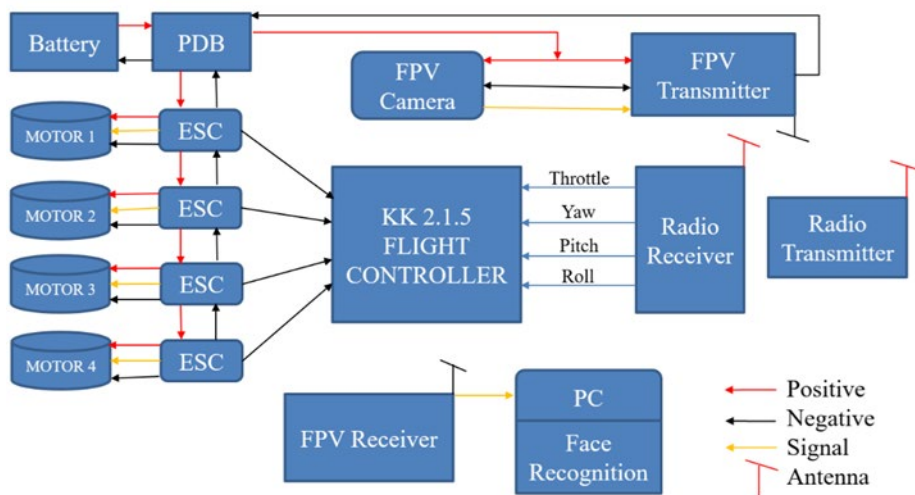


Figure 2. Block diagram of Quadcopter

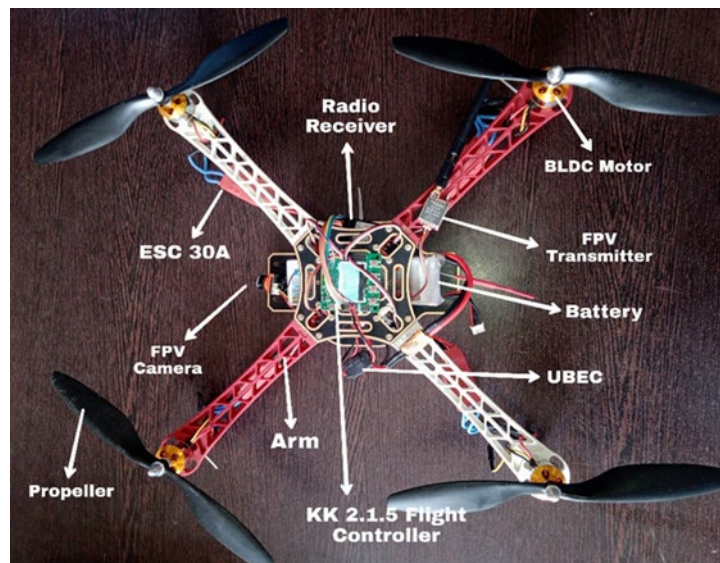


Figure 3. Assembled model of Quadcopter

3.3 Quadcopter Drone Working

Quadcopter has 4 motors; clock wisely noted as 1 to 4. 1 and 3 motors will rotate in the clockwise direction and the remaining two will rotate in the anticlockwise direction. The procedure of controlling the quadcopter is detailed in Figure 4. The controls of the drone will be Throttle, Pitch, Roll, and Yaw. The Throttle is used for moving up and down movement, the Pitch is used to move the drone forward and backward, Roll is used for bending right and left, and Yaw is used for Rotating right and left. Before the setup process, make sure to reset the flight controller. Now, select the quadcopter X-mode and observe the motor numbering and its moment of direction. After that, the calibration process should be done followed by a receiver test. Switch on the Transmitter and give full throttle, disconnect the battery, hold buttons 1 and 4 of the flight controller, connect the battery, and slowly decrease the throttle to its minimum position. At last, the flight controller will be armed, if the throttle is held at the right side for 5 sec and it's ready to fly (Figure 4).

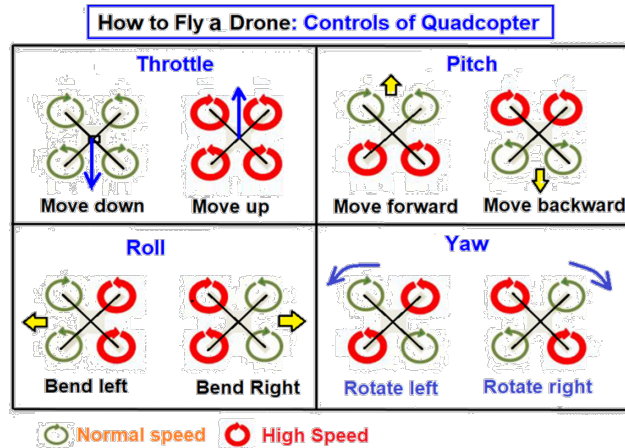


Figure 4. Control procedure of quadcopter

3.4 Surveillance

The application of this drone is for surveillance, which performs the face recognition of the targeted people in a certain range. The camera will share the live stream from the FPV transmitter to the FPV receiver, which is connected to a laptop to perform the face recognition of the live stream. Face recognition is possible by following the procedure:

- Creating a dataset of user
- Training the dataset
- Face recognition

Creating a dataset will be done using a webcam or manually prepared data stored in the directory. To create yml file for face recognition, the prepared data set (Images) needs to be trained by performing a Python trainer file, face recognition code will take the created yml file for the recognition process. It compares the features of the stored one with the live stream and mentions the name on the screen if the person matches the dataset. This process of face recognition and the algorithm used in this face recognition process is called Local Binary Pattern Histogram, which is a widely used algorithm and also it can recognize persons in almost all light conditions with good accuracy. Figure 5 shows the outputs of the face recognition system used in the drone (Figure 5).

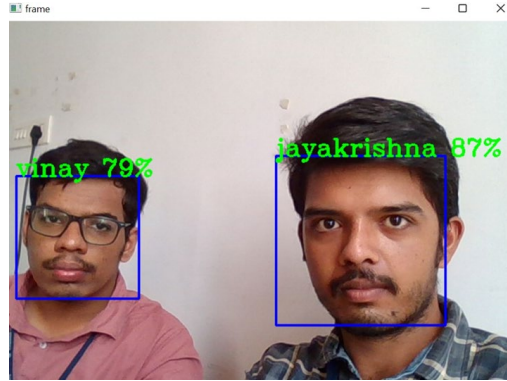


Figure 5. Face Recognition System output

4. Analysis of Quadcopter

The Analysis of Quadcopter is required to select the motors and to simulate the drone arm for perfect hovering and control.

The mass of the drone is approximated to 1kg. Therefore,

Weight of a drone is,

$$W = m * g = 1 \text{ kg} * 9.81 \text{ m/s}^2 = 9.81 \text{ N}$$

To hover the drone comfortably, the lift force must be greater than the 9.81 N (Weight of drone).

Lift required for each arm is,

$$L = 9.81 \text{ N} / 4 = 2.4525 \text{ N}$$

If thrust is equal to weight, the drone just hovers and lands. Therefore, the thrust must be twice of the drone weight.

Minimum Thrust Required to hover = 2 * mass = 2 * 1 = 2 kg or 2000 g

Based on the thrust required, A2212 1000 KV Brushless DC Motor is selected, as each motor can lift up to 800 g of weight.

5. Simulation of Drone Arm

The drone arm is simulated to make sure that the design and material selected for arm is sustainable for hovering.

Maximum lift generated by each motor = 800 g * 9.81 m/s² = 7.85 N (Upwards)

Weight taken by each arm = 250 g * 9.81 m/s² = 2.45 N (Downwards)

Based on the above calculations, the drone arm is simulated (Figure 6 and Figure 7).

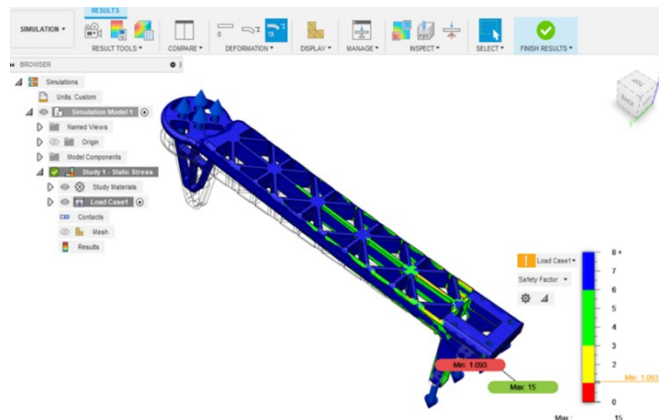


Figure 6. Factor of safety

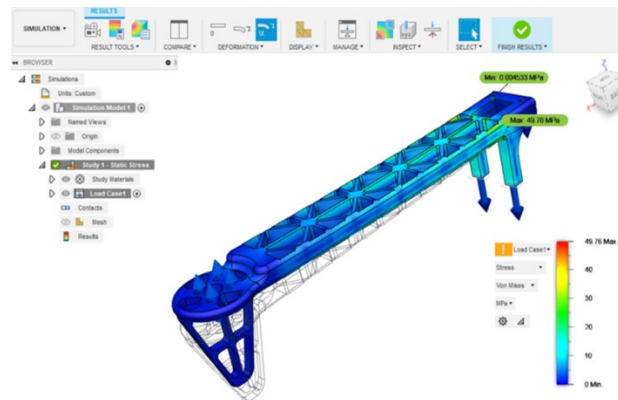


Figure 7. Stress distribution

6. Conclusion

The Quadcopter for surveillance with face recognition is helpful in the identification of targeted people in situations like search and rescue operations, remote areas, military purposes, etc., and it can also increase the security at remote locations. The main outcome of the study is to fabricate a cost-effective quadcopter drone with face recognition as additional functionality. The Local Binary Pattern Histogram Algorithm offers a greater accuracy level with lower complexity and the level of detection of the face is fast.

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