

First Person View Camera Based Quadcopter with Raspberry Pi

C. R. Balamurugan, P. Vijayakumar, P. Kiruba, S. Arun Kanna, E. R. Hariprasath, C. Anu Priya

Abstract—This paper studies in details about the need of quadcopter in various fields especially in the place of remote area where the road transportation facility is very less. It is used to monitor and collect data in a specific region. The movement of this quadcopter is controlled by the Raspberry Pi. FPV camera is used for capturing the image and will transmit the image to the receiver which can be monitored using an android smart phone. This is mainly used for surveillance purpose and hidden activities can be captured.

Keywords—FPV camera, A2212 brushless direct current motor, Raspberry Pi, lithium polymer battery.

I. INTRODUCTION

A quadcopter uses four rotors for lifting, steering and stabilization. This aerial vehicle can achieve vertical flight in more stable manner. The quadcopter is not affected by torque as the helicopter experiences it by main rotor. Here Brushless DC motor is used to make the quadcopter fly and it has an advantage of quick acceleration and minimal friction. The movement of the quadcopter is controlled by Raspberry Pi. Its size is very compact and it is considered to be very good flight controller. FPV camera is used for capturing the aerial view of the object. The transmitter is connected to FPV camera which comprises of three cables, one is for image output and other two for voltage supply. Receiver is connected to android mobile through which the aerial image can be viewed. This technology can be widely used to save lives and prevent harm to others. Some of the applications of quadcopter in emergency management are to search and rescue which would require night vision and infrared optics. Quadcopter can be sent to read the placard instead of sending people. It can be used in code enforcement or inspection of building and bridge without placing a person (or) a ladder (or) in other potentially dangerous situation. We can assist the damage occurred due to disaster. Infrared can locate area of fire, thus quadcopter is efficient in view of fire incident. In agriculture it can be used to identify the affected crops using image processing. Quadcopter is mainly used for surveillance purpose which is done in military. Instead of using Arduino, here, raspberry pi is used which will provide a clear image of the object and the time taken for capturing the real time video

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is also reduced. Chen et al. [1] proposed a quadcopter based wireless charging platform for large-scale sensing applications. Boban et al. [2] developed a solar empowered quadcopter with smartphone control. Ko et al. [3] introduced an image based lane tracking in quadcopter. Borah [4] made a review on quadcopter surveillance and control. Javier et al. [5] discuss about the design, analysis and fabrication of quadcopter. Luo and Er [6] discussed about the intelligent control and navigation for an indoor quad-copter. Ononiwu and Okoye [7] proposed the design and implementation of a real time wireless quadcopter for rescue operations. Sandhu [8] developed ISR for Quadcopter. Siva and Kumar [9] developed mini unmanned aerial vehicle. Raj et al. [10] made design and fabrication of inclined arm miniature sized quadcopter unmanned aerial vehicle (UAV). Thiang et al. [11] discussed about vision-based object tracking algorithm with Augmented Reality (AR) Drone. Luxman and Liu [12] Implemented back-stepping integral controller for a gesture driven quadcopter with human detection and auto follow feature. Kumar and Kalaiyarasan [13] proposed a quadcopter based gas detection system. Kendall et al. [14] proposed on-board object tracking control of a quadcopter with monocular vision.

II. DATA COLLECTION AND IMPLEMENTATION

A. Motor Selection

The quadcopter consists of four A2212 Brushless DC motor of weighted 50 g. The motor can handle the current up to 30 A for 60 seconds. These small motors have the capacity of 2200 RPM/Volt and maximum efficiency of 75%. The maximum power of these motors is 220 W. Brushless DC motor is also known as electronically commutated motors (or) synchronous DC motors which is powered by DC electricity through an inverter. The advantages of brushless direct current motor (BLDC) motor over brushed motor are high power to weight ratio, high speed and electronic control. Brushless motors are used in places such as computer peripherals like disc drives, printers, hand held power tools and vehicles ranging from model aircraft to automobiles. The brushless DC motor uses electromagnetic windings which in turn produce magnetic field causing the rotor to rotate. A controller is used to determine the current rotor position and drive the rotor in proper direction. The rotor will rotate in opposite direction if the sequence is reversed.

Fig. 1 shows the BLDC motor from a 3.5" floppy disk drive. The coils are arranged radially made of copper wire coated with blue insulation. The rotor has been removed and

grey ring located inside the rotor is the permanent magnet. In BLDC motors, an electronic servo system replaces the mechanical commutator contacts. The angle of the rotor can be detected by an electronic sensor and it controls the semiconductor switches which use transistors thereby current flow through the windings. The working life of the motor is limited by the life time of their bearings. Some limitations of brushed motors can be overcome by brushless motors which include higher efficiency and lower susceptibility to mechanical wear. A typical brushless motor has permanent magnet which rotates around a fixed armature, eliminating problems associated with connecting current to the moving armature. Brushless motor includes high torque to weight ratio, more torque per watt, increased reliability, reduced noise, longer life due to absence of brushes and commutator erosion, elimination of ionizing sparks from the commutator and overall reduction of electromagnetic interference. The A2212 BLDC motor is shown in Fig. 2.

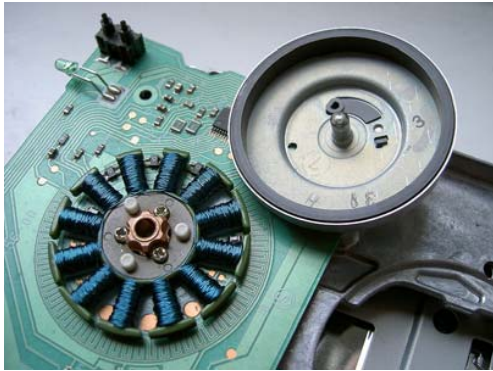


Fig. 1 Internal structure of BLDC motor



Fig. 2 A2212 BLDC Motor

B. Electronic Speed Controllers

An electronic speed control is an electronic circuit that controls and regulates the speed of the motor. It reverses the motor and also provides dynamic braking. In electrically powered radio controlled models, miniature electronic speed controls are used. The electronic speed controller is used to

control the DC motor speed and to provide the motor with three phase electric power from the DC battery source. The speed of the DC motor is controlled by the signals which are sent to the three phase brushless motor. The specification of this ESC is of maximum current 30A using 3S Li-po battery and mainly its weight is less. The direction of the rotation of the motor is also controlled by ESC. It works on 2S as well as 3S Li-po battery. Hence, it does not need a Battery Elimination Circuit. The ESC is shown in Fig. 3.

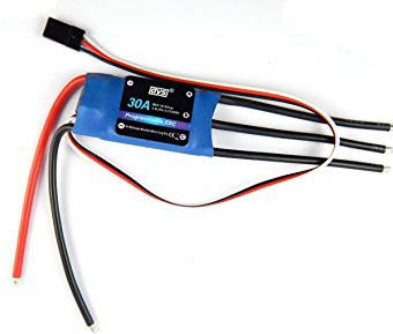


Fig. 3 Electronic Speed Controllers

Electronic Speed Controllers (ESC) are an essential component of modern quadcopters that offer high power, high frequency, high resolution 3-phase AC power to the motors in an extremely compact miniature package. The craft depends on the change in speed of motor which drives the propellers. This wide variation and fine RPM control in motor/propellers speed gives all of the control necessary for a quadcopter to fly.

C. Raspberry Pi

Raspberry pi was developed in United Kingdom by Raspberry pi foundation. It is a series of small single board computer. It does not include any peripherals such as keyboard, mouse etc. however some accessories have been included in several official and unofficial bundles.

Raspberry pi is compact in size and consumes less power compared to micro-controllers. It controls all the flight control without using an Arduino. As it has much computation power, the more complicated and better stabilized algorithm can be run on Raspberry Pi. Raspberry Pi 2 is shown in Fig. 4. The Raspberry Pi has a diverse range of input and output connectors allowing an array of sensors to be attached and processed by the 800 MHz internal processor. Computer advanced features can also be added in Raspberry Pi 2.

Most Raspberry Pi chips can be over locked to 800 MHz, and some to 1000 MHz. The Raspberry Pi 2 can be similarly over locked to 1500 MHz discarding all safety features and overvoltage limitations. The chip can be protected from overheating by an appropriately sized heat sink.

The BCM2835 SOC used in the first generation of Raspberry pi. It is equivalent to smart phones where its CPU is an older architecture. It has a level one cache of 16 KB and level two cache of 128 KB. The level 2 cache is used by graphics processing unit. The Raspberry pi 2 uses a Broadcom

BCM2836 SOC with a 900 MHz, 32 bit quad-core and 256 KB level 2 cache and also it was upgraded to a Broadcom BCM2837 SOC with 1.2 GHz, 64 bit quad-core. The same SOC is used in Raspberry pi 3. Raspberry pi 2 version 1.1 included a quad-core cortex –A7 CPU running at 900 MHz in 1 GB RAM. This is more power full than its predecessor of about 4-6 times.



Fig. 4 Raspberry Pi 2

Raspberry pi 2 version 1.1 is 14 times faster than Raspberry pi 1 model B+. It may be operated with USB computer keyboard, mouse and also used with USB storage, USB to MIDI converters and virtually any other device with USB capability. On the surface of the Raspberry pi, other peripherals can be attached through various pins and connectors. Raspberry pi models do not have a real time clock, so they are unable to keep track of the time of day by itself. It has been used in a wide variety of tasks and also perfect for projects where a computer is necessary but does not require much processing power. It also saves space and keeps the cost low. Using a Raspberry pi it is possible to implement some real life applications such as barcode detection, motion detection and tracking, hand gesture detection and Chroma key with green screen in the live video.

D. FPV Camera

FPV is a type of remote control which involves mounting a small video camera and an analogue video transmitter to the quadcopter and flying by means of live video downlink commonly displayed on portable monitor. First Person View (FPV) also known as Remote Person View (RPV) or video piloting is the method used to control a radio controlled vehicle from the view point and most commonly used in the radio controlled aircrafts. The camera which is placed on the drone acts as a transmitter which transmits the image to the receiver. The receiver sends the image to the display device i.e., android mobile. The two important things required for selecting the camera is Field Of View and the lens focal length. The camera used is 2.8 mm lens which provides 120 degree FOV. FPV camera is shown in Fig. 5.

The weight of the camera is about 30 g and there is also availability of micro FPV camera which weights 1-5 g. The electrical connections of this camera usually consist of three

cables. The red wire is the positive voltage power, black wire is the ground, yellow is the video signal and the white wire is for audio. Any remote control vehicle capable of carrying a small camera and video transmitter can be operated by FPV. It can be commonly used for remote control cars and other ground based models. It is frequently used for aerial photography.



Fig. 5 FPV Camera

E. Battery

Lithium polymer battery is a rechargeable battery which has low weight and height voltage capacity compared to other batteries. Hence Li-Po battery is used for quad-copter. There are three types of rechargeable batteries; nickel-cadmium, nickel-metal hydride and lithium polymer batteries. Nickel-cadmium battery has a low internal resistance that allows for high power output, can operate a large temperature range but suffers from losing the amount of capacity that the battery can store after each discharge. The overall capacity of the NiCad battery will decrease over time. NiMH batteries are similar to NiCad batteries except they can hold 30% more capacity but suffer from a large discharge [15]. Li-Po battery can hold 30% more capacity and are much lighter than the NiMH battery. Li-Po also suffers from a lower discharge compared to NiMH battery. The disadvantage of NiMh battery is including a high self-discharge (around 50% greater than NiCd) and a degradation of performance if stored at elevated temperatures. Due to this reason Li-Po battery is been chosen and it is shown in Fig. 6.



Fig. 6 Li-Po battery

Li-Po battery works on the principle of intercalation and de-intercalation of lithium ions from positive and negative electrodes, with a liquid electrolyte providing a conductive medium. A micro porous separator is in between which allows only the ions and not the electrode particles to move from one place to other. It varies from 2.7 V-3 V to about 4.2 V. A

specialized charger is used to monitor the charge on per cell so that all the cells are brought to the same state. Li-Po battery is used in mobiles phones, power banks, portable media players' electric vehicles, very thin laptops.

III. DESCRIPTION

There are four propeller blades. Two of the four are designed to rotate clock-wise; the other two anti-clockwise. Blades which are designed to move the same way are placed diagonally opposite on the frame. Organising the blades like this helps stop the quadcopter spinning in the air. When the supply is given, the propeller lifts the end corners. Each propeller has its own DC brushless motor. These motors can be wired to rotate clockwise or anti-clockwise to match the propeller connected to them. The motor has coils in three groups around the body (called the stator) and groups of magnets attached to the propeller shaft (called the rotor). To move the blades, power is applied to one group of the coils and the rotor magnets are attracted to that coil, moving round. If that coil is turned off and the next one is powered up, the rotor moves around to the next coil. Repeating this around the three coils in sequence results in the motor rotating. The faster you swap between the three powered coils the faster the motor rotates. This makes the motor suitable for 'digital' control. The direction and speed of movement of the propeller blade exactly matches the sequence and the rate of power pulses are applied to the coils. The working process and block diagram of quadcopter is shown in Fig. 7.

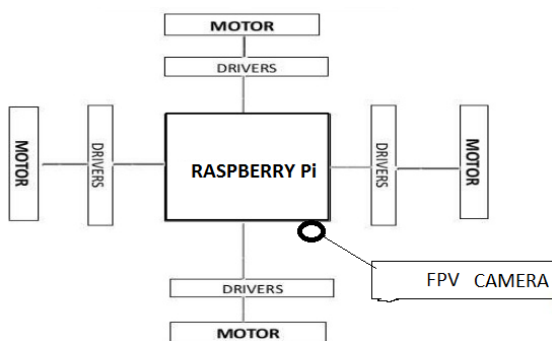


Fig. 7 Block diagram of quadcopter

The motors take a lot of power to spin the propeller blades fast enough to force enough air down to make the quadcopter take-off. Existing system takes more power than a Raspberry Pi. It translates a Pulse Width Modulation (PWM) control signal from the Raspberry Pi and converts it to three high-current signals, one for each coil of the motors. The power comes from a single lithium polymer (Li-Po) battery which provides 11.1 V, up to a peak current of 100 A, with the full-charge of 3300 mAh thus supplying 3.3 A for an hour or 100 A for two minutes (or) anywhere in between. This is powerful and dangerous, yet it only weighs 250 grams.

FPV camera is small, lightweight and cheap mounted on to the quadcopter to send the real time image back down to a transmitter. This is fairly common for most aerial

photography. It is used to record (or) take the photo. FPV transmitter is a device that is connected to the camera and it transmits the image from the copter to the mobile over the airways in the real time. The frequency of the FPV transmitter runs on 5.8 GHz, depending on the location we can also use 900 MHz, 1.3 GHz or 2.4 GHz to transmit the FPV signal. The down size of using the camera for FPV is that they all have latency issues. Although their latency typically around 100-200 ms is hardly noticeable with general flying, this speed is slow for FPV racing drones when it flies at 50 mph with a 100 ms delay which can mean that the drone will travel about 1.7 m before we receive the image which could mean the difference in missing an obstacle. Raspberry Pi connected to the quadcopter controls its movement using python code. FPV camera captures the real time image and transmits the image to the receiver and will be displayed in android mobile.

IV. CONCLUSIONS

Quadcopter can be used for risky security tasks and by using smart phone based control system makes it more convenient to use. It could also be used as a surveillance system to increase the security strength especially in the area where human interference is strictly prohibited. It could also be used for performing live video streaming. Quadcopters offer advantages for many applications when comparing with their manned counter parts. They save human pilots from flying in dangerous conditions that can be encountered not only in military applications but also in other scenarios involving operation in bad weather conditions, or near to buildings, trees, civil infrastructures and other obstacles. Future expansion and innovative ideas can be implemented later.

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