A review on Quadcopter Surveillance and Control

Dhriti Raj Borah[1], Lidia Debnath[2], MrigankaGogoi[3]

[1]*borah.dhritiraj@gmail.com,* [2]*debnathlidia2@gmail.com,* [3]mriganka.gogoi@dbuniversity.ac.in

School of Technology, Technology, Assam Don Bosco University
Airport Road, Azara, Guwahati - 781017, Assam. INDIA.

Abstract: ***The aim is to design a low cost light UAV (Unmanned Aerial Vehicles) quadcopter system and make it comparable with others. The quadcopter will be controlled from a laptop or a pc from a certain distance wirelessly. There will be a simple avionics system and which include a camera and a GPS antenna for navigation and tracking the UAV. The quadcopter can also be used for measuring the height from the earth and is capable of measuring the temperature and humidity of the environment.***

Keywords: UAV, quadcopter, RF module, GPS.

1. Introduction

A quadcopter is a multi-rotor helicopter that is lifted and propelled by four rotors which is operated to fly independently. It is a type of a small representation of Unmanned Aerial Vehicle (UAV). Quadcopters are classified as rotorcraft, as opposed to fixed-wing aircraft, because their lift is generated by a set of rotors (vertically oriented propellers).

It has four rotating blades that collectively produce thrust to lift the whole thing up. Two rotate clockwise and two anticlockwise so it does not keep spinning. The interesting part is that all four of the rotors must be continuously controlled in speed for the system to stay stable in air. It is not the same as setting each at the same speed since the imbalance in weight will cause it to drift towards one side. Hence it is a control system with the input being its orientation-tilt, movement, acceleration and output being the speed of rotation of each motor.

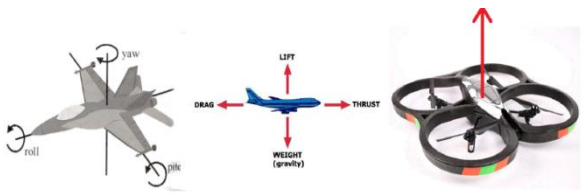


Figure1: A quadcopter [1]

2. Literature Review

2.1. Quadcopter

A quad-rotor helicopter (quadcopter) is a helicopter which has four equally spaced rotors, usually arranged at the corners of a square body [2]. The quadcopter is the advanced form of helicopter. A helicopter is a flying vehicle which push air downwards by using rapidly spinning two rotors. The quadcopter uses four rotors. As the quadcopter uses four rotors, it is found to be quite difficult to control these rotors without any electronic assistance.

Quadcopter consists of four narrow airfoils or lift generators located at the four ends of a perfect square shape. These lift generators are run by a very high speed motor and a precise balanced propellers, forcing the air flow down it generates the thrust to lift the Quadcopter above the surface [3]. The Quadcopter can be sized according to our own convenience. It can be designed as much small as we want by using the small sized components we need to make it.

2.2. Quadcopter flight dynamics

For controlling the altitude a particular type of controller is used. When the controller is moved up or down, the propeller speed is adjusted causing the quadcopter to gain or lose altitude and also a way to adjust thrust of the rotors via voltage supply to perform standard flight operations and to position the quadcopter into certain angular orientation depending on the circumstances of a particular flight routine. Thrust is one type of force. When a system accelerates mass in one direction, the accelerated mass will cause a force of equal magnitude but opposite direction on that system. The force applied on a surface in a direction perpendicular or normal to the surface is called thrust [4]. In quadcopter, two of the propellers are designed to rotate in the opposite of the other two propellers. First pair of the propellers rotates in one direction for keeping balancing in X axis and the other pair in another direction for keeping balancing in Y axis. The rotation in opposite direction is to eliminate rotation in the Z axis.

The movement of the aircraft is based on the rotational speed of each of the narrow airfoils; change of speed changes the position. The aircraft primarily is governed by control of the three major axes namely; pitch, roll and yaw [3]. There are numbers of forces in space which can disturbed the motion of quadcopter. So, it is very important to balance the forces acting on the quadcopter. To understand these forces we should know the three axes.

2.2.1. Yaw

It is the vertical axis that passes through the geometric centre of the quadcopter. Rotational force vector of all the four motors acts at the centre and cancels out each other at the exact geometric centre, in conditions when it does not cancel and the resultant vector has net positive or negative magnitude the quadcopter rotates about this axis clockwise or anti clockwise respectively.

2.2.2. Pitch

It is the axis that passes horizontally parallel to the plane of quadcopter extending towards the front and back end of the quadcopter. Rotational force vector of all the four motors acts at the centre and cancels out each other at the exact geometric centre, in conditions when the resultant of the rotational force vector is not zero but either positive or negative the quadcopter moves in the forward or backward direction respectively.

2.2.3. Roll

It is the axis that passes horizontally parallel to the plane of quadcopter extending from left to right. Rotational force vector of all the four motors acts at the centre and cancels out each other at the exact geometric centre, in conditions when the resultant rotational force vector is not zero but either positive or negative the quadcopter moves in the right or left direction respectively [3].

2.3. Motors and rotate regulators

The quadcopter needs relatively a high thrust of a motor. For this purpose are good AC brushless motors. The thrust is possible continuously control with PWM pulses. Generated PWM pulses for motors are form output ports of a kit whit the MCU brought on an ESC (Electronics Speed Control) of each motors [5]. The ESC needs to know the position of the rotor of motor. The AC motors are 30-50% lighter against the DC motors with same performance. Use of these AC motors construct lighter models which can fly longer. While selecting the motors it is necessary to check the performance of the ESC. The selection must be a good one because the take off and the concrete weight depends on the performance and properties of the motors.

2.4. Controller of Quadcopter

The quadcopter is designed using simple GUI. The quadcopter model is designed using two layer shape aluminum plate. Weight of the Quadcopter is proportional with it hover ability. Less weight will increase hover ability of it with minimum power consumption [6]. Motor calculation software provided by Motrofly is used to calculate the weight and thrust of each motor. The only simple communicating tools between the human and as operator and quadcopter movement is Graphical User Interference (GUI).

A proportional–integral–derivative (PID) controller is a generic control loop feedback mechanism. The PID controller calculates with error value as the difference between a measured process variable (PV) and a desired set point. With this error value is counted each actions of controller. The controller attempts to minimize the error by adjusting the process control inputs [5]. The altitude motion of the quadcopter is mainly controlled by PID controller developed and embedded in Arduino Uno.

Estimation and control of the horizontal translational motion of an open-source and cost effective quadcopter-the MikroKopter. The simplicity of the quadcopter makes it easy and cheap to build and there are a number of low-cost radio-controlled toy quadcopters. It comprises of four brushless-DC motors each with its own speed controller. These communicate via I2C bus to the central flight controller board. The flight control board version 2.1 is based on an Atmega 1284 processor running at 20MHz which implements the state estimator, control loops, decodes the pulse stream from the radio control receiver, and also receives commands over a serial data port and transmits status information. The great advantage of the MikroKopter is that the flight control software is open source-nearly 7000 lines of C [7]. Here, the PID controller mostly come into picture as the Mikrokopter uses PD controller at 50 Hz.

2.5. Quadcopter using Raspberry Pi

The quadcopter is controlled by raspberry pi and how to build all together physically, electronically and in software. Firstly it said about the propeller blades. Next there are sensors attached to the breadboard on the raspberry pi, these provide information to the raspberry pi about rocking and rolling in 3D plus information about acceleration forward, backward, up, down, left and right. The sensor connected to the raspberry pi [8]. The raspberry pi board on the quadcopter has lots of advantages it controls the motor along with it camera interfacing is also possible. The battery used here is the LiPobattery which provides 11.1V up to a peak current of 100A, with the full-charge of 3300 mAh thus supplying 3.3A for an hour or 100A for two minutes or anywhere in between.

The primary limitation to the performance of the image detection and tracking programs was the relatively low computational power of the on-board Raspberry Pi computer used for data and image processing, as necessitated by the payload restrictions of the MUAV. Due to the computational limitations, the final object detection and tracking program operated at an average frame rate of 2.85 frames persecond for a captured image resolution of 1920 by 1080 pixels. The developed programs were thoroughly field tested to evaluate their performance in real world conditions [9].

2.6. Applications of Quadcopter

Quadcopter in military ground mainly used at border to detect intruders, land mines, enemy troops etc. keeping our soldier at safe distance. The only problem in military ground is that we should take care about the size of the quadcopter during construction [10]. Now-a-days, quadcopter in military ground helps to safe many of our soldiers life in terrorist attack also helps to have the information of the opposition party without any risk.

3. Proposed Model

The purpose of the work is to control a quadcopter from a distance by using a pc. The quadcopter movement and control will be carried out by the raspberry pi. The model consist of two blocks which is mentioned below. The quadcopter is command through the raspberry pi from the computer side block. The command signal will be transmitted wirelessly from the trans-receiver of computer side block to the trans-receiver of the quadcopter side and the quadcopter will move accordingly. The quadcopter also includes some features like height measurements, camera, navigation, etc. All these features are also controlled by the raspberry pi.

13.1. Block diagram (Computer side)

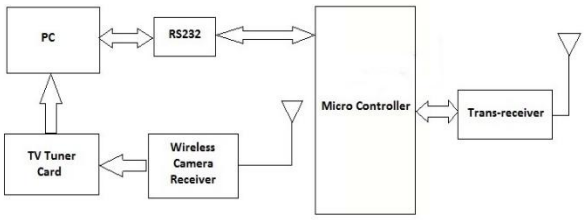


Figure 2: Block diagram (Computer Side)

23.1. Block diagram (Quadcopter side)

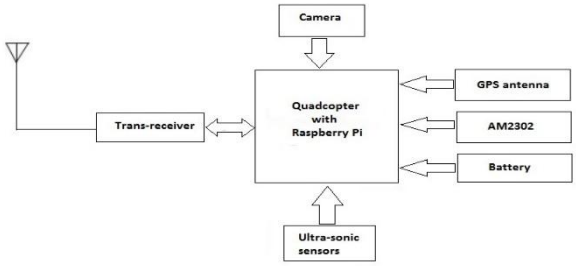


Figure 3: Block diagram (Quadcopter Side)

33.1. The Model consist of following parts:

The model of a quadcopter consist of a frame where we mount everything, wood or carbon fiber, a control board the brain here we use raspberry pi, motors and propellers for the movement of the quadcopter, speed controllers or ESC to control the motors, camera for sensing the environment, ultra-sonic sensors for the height measurement, GPS antenna for tracking the quadcopter, AM2302 for measuring the temperature and humidity and battery for the power [11].

3.3.1. Frame

Every quadcopter or other multi-rotor aircraft needs a frame to house all the other components. Things to consider here are weight, size, and materials.

A rule of thumb is required

$$\text{Thrust per motor} = (\text{weight} \times 2) \div 4 \quad (1)$$

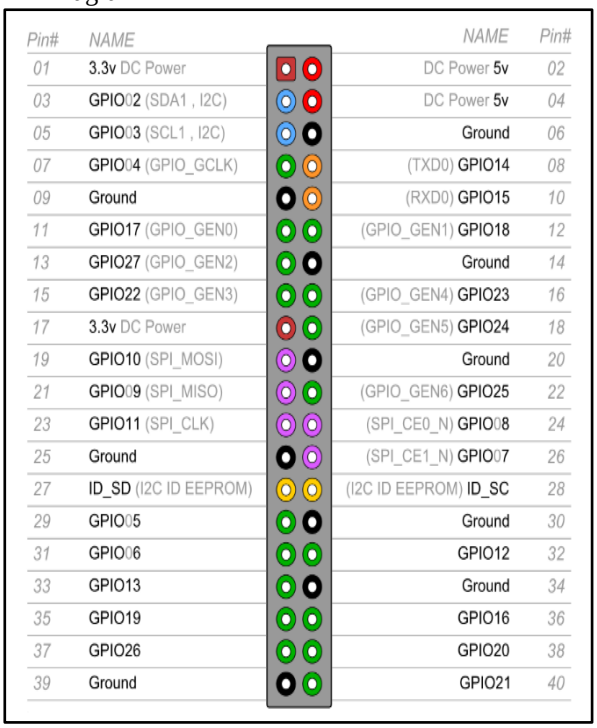
3.3.2. Control board (raspberry pi model B+)

It is the heart of system. All the controlling functions, data transmitting functions are done by this unit.

A. Features

1. Chip: Broadcom BCM2835 SoC
2. Core architecture: ARM11
3. CPU: 700 MHz Low Power ARM1176JZFS
4. Memory: 512 MB SDRAM
5. Operating System: Boots from Micro SD card (NOOBS)
6. Dimensions: Micro USB socket 5V, 2A
7. Ethernet: 10/100 Base T Ethernet socket
8. Video Output: HDM (PAL and NTSC)
9. Audio Output: 3.5mm jack, HDMI
10. USB: 4x USB 2.0 Connector
11. GPIO Connector: 40-pin
12. Camera Connector: MIPI Camera Serial Interface
13. Display Connector: Display Serial Interface
14. Memory Card Slot: SDIO [12].

B. Pin Diagram



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

Figure 4: Pin diagram of Raspberry Pi Model B+ [13]

3.3.3. Motors and propellers

The motors have an obvious purpose to spin the propellers. Motors are rated by kilovolts, and the higher the kV rating, the faster the motor spins at a constant voltage. A quadcopter has four propellers, two 'normal' propellers that spin counter-clockwise, and two 'pusher' propellers that spin clockwise.

3.3.4. Speed controllers

The electronic speed control or ESC tells the motors how fast to spin at any given time.

3.3.5. Camera

The Raspberry Pi camera module is used to take high-definition video, as well as still photographs. It is easy to integrate the camera module to the Raspberry Pi.

3.3.6. Ultra-sonic sensor

Ultrasonic sensors convert ultrasound waves to electrical signals or vice versa. It is used for the measurement of height of the quadcopter from the ground.

3.3.7. GPS antenna

Global Positioning System is a space based navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth. This antenna is magnetic so it will stick to the top of any structure.

3.3.8. AM2302

AM2302 is a wired version in a plastic body. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and splits out a digital signal on the data pin.

3.3.9. Battery

LiPo batteries are used which come in a variety of sizes and configurations. These are small in size and light in weight but provides maximum power which has power rating in mAh (milliamps per hour).

4. Conclusion

A surveillance system with the help of a quadcopter can increase the security strength especially in the area where human interference is strictly prohibited. In all civilized countries surveillance of the terrestrial areas is very important. The core intension is to study the complete designing process of quadcopter from the engineering prospective and improving their balancing and stability system.A quadcopter that is wirelessly controlled by a computer is a challenging task. It will also help in analyzing various parameters like height, temperature, humidity etc. It can also be used for performing live video streaming with the help of a camera. Furthermore using some sensors like LIDAR collisions can be avoided, GPS can be attached for automotive navigation system.

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Authors Profile

Dhriti Raj Borah, (B.Tech in ECE), Heis currentlypursuing B.Techdegree in the Department of Electronic and Communication EngineeringatAssam Don Bosco University, Azara, India. He had completed his 10th from KendriyaVidyalayaNagaon, Assam, India in 2010 and 10+2 in Science from VikasVidyaniketan, Visakhapatanam, India in 2012.

Lidia Debnath, (B.Tech in ECE), She is currently pursuing B.Tech degree in the Department of Electronic and Communication Engineering at Assam Don Bosco University, Azara, India. She had completed her 10th from St. Vivekananda English Academy, Assam, India in 2010 and 10+2 in Science from Netaji Vidyapith Railway H.S. School, Assam, India in 2012.

Mriganka Gogoi,He has received M.Tech degree from North East Regional Institute of Science and Technology (NERIST) in 2011. He worked as guest lecturer in NERIST for a period of six months. In 2012 he joined Assam Don Bosco University as Assistant professor in the department of Electronics and Communication Engineering. He has published 6 papers in national/international journal/conference. His research interest includes signal processing, watermarking and VLSI.