Quadcopter Technology

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Abstract---Quadcopter Drone is working principle on aviation, It means airborne, airplane, etc. A quadcopter or drone can be useful for certain scenarios such as search and rescue operations in remote areas, monitoring areas and boundaries, aerial photography. We can easily monitor one area by sitting at another place. This could be helpful in deploying preventive measures in case of trespassing by an uncouth entity. The simple advantage of drone photography is that you are able to get your camera higher in the sky for better perspectives. So many times, photographers wish, if there was a way to get a higher perspective to shoot a landscape. Higher perspectives make landscapes look longer and larger than they actually are. looking landscape photographs. This research focused on develops a remotely operated Quadcopter system. The Communication between GUI and Quadcopter is done by using wireless communication system. The Quadcopter balancing condition is sensed by KK2 microcontroller. For smooth landing, Quadcopter is equipped with ultrasonic sensor. All Signals from sensors are processed by KK2 Circuit board. The experiment shows that Quadcopter can hover with maintain it balancing and stability. Quadcopter can accept load disturbance up to 250g during it Hover condition. Maximum operated time of Quadcopter is six minutes using 3200mAh Lipo battery and operate time can be increase by using largest battery Capacity. These vehicles have almost boundless potential essentially because of their high mobility and small scale size, that permits their utilization in different applications. Among numerous kinds of UAVs, the multi-copter UAVs with 4 rotors (quadcopter) are being utilized and used regularly. Automatons are semi-self-governing airplanes that can be controlled and remotely. Economically accessible automatons are progressively being utilized in an assortment of uses. Quadcopter can accept load disturbance up to 250g during it hover condition.

Index Terms—Application, Drone, Dynamics, Structure, Unmanned aerial vehicle.

INTRODUCTION

A quadcopter is an aircraft heavier than air, capable of vertical take-off and landing (VTOL), which is propelled by four rotors, positioned in the same plane, parallel to the ground. Unlike standard helicopters, a quadcopter uses fixed-pitch blades in its rotors and its motion through the air is achieved by varying the relative speed of each propeller. The first quadcopter was the Omnichen 2, invented in 1920 by Etienne Omnichen. This craft made 1000 successful flights and flew a recorded distance of 360 meters. Then the convert a wings model a quadcopter designed by Dr.George E. Bothezat, appeared in 1956.[10] Nowadays there is an incredible evolution in 21st century in quadcopters. To introduce more robust controller and modeling, techniques, Universities, studentes and researchers are working continuosly, so that they can provide detailed and accurate representations of reallife quadrotors. Unmanned Aerial Vehicles (UAVs) like drones and quadcopters have revolutionised flight. They help humans to take to the air in new, profound ways. The military use of larger size UAVs has grown because of their ability to operate in dangerous locations while keeping their human operators at a safe distance. Here quadcopter as a small UAV is discussed. It is the unmanned air vehicles and playing a predominant role in different areas like surveillance, military operations, fire sensing, traffic control and commercial and industrial applications Their smaller blades are also advantageous because they possess less kinetic energy, reducing their ability to cause damage

STRUCTURE

The main part of the quadcopter is frame which has four arms. The frame should be light and rigid to host a LIPO battery, four brushless DC motors (BLDC), controller board, four propellers, a video camera and different types of sensors along with a light frame. The speed of BLDC motors is varied by Electronic Speed Controller (ESC). For higher stability i.e. to have lower C.G. the batteries are placed at lower half. The motors are placed equidistant from the centre on opposites ides. To avoid any aerodynamic interaction between propeller blades the distance between motors is roughly adjusted. All these parts are mounted on the main frame or chassis of the quadcopter as shown in, Fig.1. The detail quadcopter part list is given at the end of this article in section Appendix. Nowadays, main structure consists of a frame made of carbon composite materials to increase payload and decrease the weight.

KK2.1.5

The KK2.1.5 flight controller serves as the central brain of the quadcopter, managing its stability, maneuverability, and overall flight performance. With its compact layout and intuitive interface, the KK2.1.5 board integrates essential components such as the accelerometer, gyroscope, and processor, allowing for precise control and real-time data feedback. During setup, users connect various peripherals like ESCs, motors, and receivers to the board, enabling seamless communication and coordination between these components. Calibration procedures ensure accurate sensor readings and smooth operation, while PID tuning fine-tunes flight characteristics based on user preferences and environmental conditions. The KK2.1.5 offers multiple flight modes, including Stability mode for beginners and Acro mode for advanced pilots, each affecting how the quadcopter responds to user inputs. The onboard LCD screen provides vital flight data and facilitates navigation through the controller's settings, making adjustments and configurations straightforward. Troubleshooting resources assist users in resolving common issues, ensuring the quadcopter operates reliably. Advanced features like GPS integration and telemetry options offer enhanced functionality for more sophisticated applications. Overall, the KK2.1.5 flight controller is a versatile and essential component that plays a crucial role in the success of any quadcopter project.

ESC (Electronic Speed Controller)

An electronic speed control or ESC is an electronic circuit with the purpose to vary an electric motor's speed, its direction and possibly also to act as a dynamic brake. ESCs are often used on electrically powered radio controlled models, with the variety most often used for brushless motors essentially providing an electronically generated three-phase electric power low voltage source of energy for the motor.

An ESC can be a stand-alone unit which plugs into the receiver's throttle control channel or incorporated into the receiver itself, as is the case in most toy-grade R/C vehicles. Some R/C manufacturers that install proprietary hobby-grade electronics in their entry-level vehicles, vessels or aircraft use on board electronics that combine the two on a single circuit board. A generic ESC module rated at 35 amperes with an integrated BEC. ESC systems for brushed motors are very different by design; as a result brushed ESC's are not compatible with brushless motors. Brushless ESC systems basically create a tri-phase AC power output of limited voltage from an on-board DC power input, to run brushless motors by sending a sequence of AC signals generated from the ESC's circuitry, employing a very low impedance for rotation. Brushless motors, otherwise called out runners or in runners depending on their physical configuration, have become very popular with "electroflight" radio-control aeromodeling hobbyists because of their efficiency, power, longevity and light weight in comparison to traditional brushed motors. However, brushless AC motor controllers are much more complicated than brushed motor controllers. Electronic speed controllers (ESCs) are used in many R/C applications. They translate signal to electrical supply. On a multi-rotor, every motor gets its own ESC, each of 25 which connects to the flight controller.

After computing the inputs, the controller directs each ESC to adjust its speed in order for the craft to perform them.

BATTERY

Multi-rotors draws a high current and can easily pull 40 A on a steep ascent. As a result, hefty batteries are a necessity for decent flight times. The industry standard is lithiumion polymer (LiPo) batteries. Relatively lightweight, compact, and offering high discharge rates, LiPos are well-suited for multi-rotors .Lithium Polymer –LIPO are a type of rechargeable battery that has taken the electric RC world by storm, especially for Quadcopters. They are the main reason electric flight is now a very viable option over fuel powered models. LiPo batteries are light in weight & hold huge power in a small package. They have high discharge rates to meet the need of powering quadcopters. Remember LiPo batteries are much expensive & have life time of only 300 to 400 charge cycles. The battery provides electrical power to the motors and all electronic components of the aircraft. Lithium Polymer (LiPo) batteries are used almost exclusively, because they have high specific energy. LiPo batteries have a capacity rating and discharge rating. The capacity rating, in milliamp-hours (mAh) indicates how much current the battery may output for one hour. Discharge rating, indicated by the letter "C", show how fast the battery may be safely discharged. To determine max allowed current, multiply the C value with the capacity. For this project, we selected 3300mAh 20C LiPo batteries. LiPo packs also have C ratings that indicate the maximum rate at which a pack can be discharged, with C standing for capacity. A 20C pack can be discharged at a rate 20 times its capacity. Capacity, therefore, is the third important factor. It's measured in milliamphours (mAh). Let's say our 20C pack has a capacity of 4000 mAh.

RADIO TRANSMITTER

We need a RC Transmitter (2.4 GHz RC radio transmitter) to direct the quadcopter direction and position. A 2.4 GHz RC radio receiver on the quadcopter receives commands from the RC transmitter on the ground. (One way link). You get a Receiver along with the corresponding Transmitter. The transmitter is the hand-held controller you use to remotely control your craft. The transmitters have two sticks, two trim buttons or a slider per stick, a number of switches, a display, and a power button. Transmitters and receivers need a frequency range to operate and the new frequency range is 2.4 GHz, with digital spectrum modulation.2.4GHZ is the ISM (Industrial, Scientific & Medical) Radio band which needs no license to operate. When you read the manual of a Transmitter, you come across the terms "set to Mode 1 Mode2, 3, etc. This refers to the Default Configuration of the Sticks on the Transmitter. Most widely used is the MODE 2 which means the Left stick controls THROTTLE & RUDDER & the Right stick controls ELEVATOR & AILERONS. A transmitter is described primarily by the number of channels it supports.

RECEIVER

On the other end of the control system is a receiver with a corresponding frequency. Of course, the number of receiver channels has to match the transmitter if you want to utilize all of the available functions. Each channel has a pinout that is connected using a servo cable to the appropriate component. The four stick outputs, at least, must be fed to the flight controller in order to control a multi-rotor. The radio receiver (Rx) receives radio signals from an RC transmitter and converts them into control signals for each control channel (throttle, yaw, roll & pitch).It has a built in 3 axis gyroscope and 3 axis acceleration sensor with self stabilising function which gives it a super stable flight performance. It supports all general receivers. Receiver type and multi-rotor type are very easily selected via the small DIP switches and calibration is also extremely easy with the set button. Once calibrated sensitivity is also a very simple affair with just one small adjuster on the front of the unit making this flight controller one of the easiest to set up ever.

BLDC MOTOR

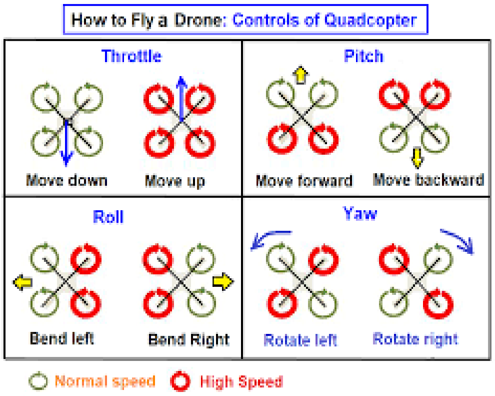
Motors used these days are almost exclusively of the “brushless” variety. That equates to minimal friction. A cylindrical shell of magnets rotates on precision bearings around a core of tightly and neatly coiled wire. The propeller is fastened atop. Many Tom's Hardware readers already know the composition of an electrical motor, but for enthusiasts dabbling in multi-rotors, the inner workings are unimportant. So long as reasonable care is taken and dirt kept clear of the bearings, brushless motors are famously reliable. Motors are assigned various notations, the most consequential being the Kv rating. Confusingly, Kv does not refer to kilovolts in this case. Rather, it's a motor velocity constant denoting the revolutions per minute (RPM) that a motor will turn when a 1 V 17 potential difference is applied with zero load. This number is important, as it defines a multi-rotor's flight characteristics based on specifications like battery voltage and takeoff weight. The other notation is the current rating which indicates the max current that the motor may safely draw. For our project, we selected 1400Kv, 30A max DYS brushless DC motors.

PROPELLER

Also vital are the propellers you choose. The variety of props is arguably greater than any other component we discuss; materials, dimensions, and price span a mindbogglingly wide range. Generally, cheaper props are less precisely manufactured and more prone to creating vibration. This applies especially to the relatively larger end of the prop spectrum, with differences becoming less perceptible for smaller craft. Again, some vibration can be acceptable, bolstering the case for less expensive propellers. But if you're flying a quadcopter with the intention of producing well-shot footage, expect to spend more money on propellers.

OPERATION OF QUADCOPTER

To make the multirotor hover, which means the multirotor stays at a constant altitude without rotating in any direction, a balance of forces is needed. The flight controller will need to counteract the force of gravity with the lift produced by the rotors. Throwing a bit of math into the picture now, the force of gravity acting on the multirotor is equal to the mass of the multirotor times gravitational acceleration (which, as far as we are concerned, is a constant as long as we are staying on Earth). The lift produced by the multirotor is equal to the sum of the lift produced by each of the rotors. Therefore, if the force of gravity equals the force of the lift produced by the motors, the multirotor will maintain a constant altitude.To ascend or descend, therefore, the flight controller disrupts this balance. If the lift produced by the multirotor is greater than the force of gravity, the craft will gain altitude. If the opposite is true, that is, if the lift produced by the multirotor is less than the force of gravity acting on the multirotor, then the multirotor will fall.



FLIGHT DYNAMICS

1.Physics of Quadcopter Flight

Before we embark upon a project as complex as this one, it is useful to have an understanding of the theoretical underpinnings involved. I think it is valuable to have atleast a basic understanding of the physics of Quadcopter flight. While it is certainly possible to simply follow a set of directions for building and flying a multirotor, it will be much clearer, and more meaningful, if you can explain to yourself the rationale behind each step. There is a huge amount of physics involved in multirotor flight, and we are only going to skim the surface in this report. Here we are going to focus on the physics involved in manoeuvring the multirotor which involves adjusting the balance of forces acting on the craft. We are going to avoid talking about the physics of how the props generate lift, the physics involved in the multirotor's power system, the physics of how brushless motors work, et cetera.

2.Steering

While flying your multirotor, it is very important to understand how the multirotor moves and how we control it. At the root of all the multirotor's movements is the rotational speed of the motors. By adjusting the relative speeds of the motors in just the right ways, keeping in mind that the rotational speed of the motors determines how much lift each prop produces, the flight controller is able to cause the multirotor to rotate around any of the directional axes (roll, pitch, and yaw), or make the multirotor gain or lose altitude.

3.Roll And Pitch

To make the multirotor rotate about the roll or pitch axes, the flight controller makes the motors on one side of the multirotor spin faster than the motors on the other side. This means that one side of the multirotor will have more lift than the other side, causing the multirotor to tilt. So, for example, to make a Quadcopter roll right (or rotate about the roll axis clockwise), the flight controller will make the two motors on the left side of the multirotor spin faster than the two motors on the right side. The left side of the craft will then have more lift than the right side, which causes the multirotor to tilt.

4.Yaw

Controlling the multirotor's rotation about the yaw axis is a bit more complex than controlling its rotation about the roll or pitch axes. First, let's discuss how we37 prevent rotation about the yaw axis. When assembling and programming multirotors, we set up the motors so that each motor spins in the opposite direction than its neighbours. In other words, using a Quadcopter as an example again, starting from the front-left motor and moving around the multirotor clockwise, the motors' rotational directions alternate, CW, CCW, CW, CCW. We use this rotational configuration to neutralize, or cancel out, each motor's tendency to make the multirotor rotate. In order to stabilize the Quadcopter, it is first crucial to determine the aircraft orientation (also called attitude) relative to the fixed inertial frame of the earth. This inertial frame is shown in Figure 10, and consists of 3 orthogonal axes (North, East, & Down) and the rotations about these axes (Roll, Pitch, and Yaw). In order to attain stable flight, the roll and pitch axes must first be stabilized. If these axes are not properly controlled, the Quadcopter will immediately tip over and be unable to fly. The roll and pitch attitudes of the aircraft are determined using the attitude sensor. In the case of our project, this was done using the gyroscope and accelerometer in conjunction, in a manner which will be discussed in more detail in subsection. He yaw axis must also be relatively stable for the Quadcopter to be controllable , but is less critical. Slight drift in the yaw axis is easily counteracted using the radio controller, and usually will not result in a loss of control. Using only an accelerometer and gyroscope (as was done in this project), the absolute yaw orientation is in fact not measurable. Only the change in yaw orientation is measurable by using the gyroscope, but this proved to be sufficient to enable control of the Quadcopter.

APPLICATIONS

Quadcopters are a useful tool for university researchers to test and evaluate new ideas in a number of different fields, including flight control theory, navigation, real time systems, and robotics. In recent years many universities have shown quadcopters performing increasingly complex aerial manoeuvres. Swarms of quadcopters can hover in mid-air, fly in formations, and autonomously perform complex flying routines such as flips, darting through hula hoops and organising themselves to fly through windows as a group. There are numerous advantages to using quadcopters as versatile test platforms. They are relatively cheap, available in a variety of sizes and their simple mechanical design means that they can be built and maintained by amateurs. Due to the multi-disciplinary nature of operating a quadcopter, academics from a number of fields need to work together in order to make significant improvements to the way quadcopters perform. Quadcopter projects are typically collaborations between computer science, electrical engineering and mechanical engineering specialists. Quadcopter unmanned aerial vehicles are used for surveillance and reconnaissance by military and law enforcement agencies, as well as search and rescue missions in urban environments. One such example is the Aeron Scout, created by Canadian company Aeron Labs, which is a small UAV that can quietly hover in place and use a camera to observe people and objects on the ground. The company claims that the machine played a key role in a drug bust in Central America by providing visual surveillance of a drug trafficker's compound deep in the jungle (Aeron won't reveal the country's name and other specifics).

After a recreational quadcopter (or "drone") crashed on the White House lawn early in the morning of January 26, 2015, the Secret Service began a series of test flights of such equipment in order to fashion a security protocol against hostile quadcopters. During the Battle of Mosul it was reported that commercially available quadcopters and drones were being used by Islamic State of Iraq and the Levant (ISIL) as surveillance and weapons delivery platforms using improvised cradles to drop grenades and other explosives.

RESULTS

The goal of this project is to develop and test an operational helicopter with four propellers that is semi-autonomous that would be able to correct itself if tilted too far in one direction or another, or dropped from any altitude. Autonomous control would be provided with data received from an Accelerometer and a Gyroscope, where nonautonomous control would be processed with a joystick. We thought of two approaches for control beyond the line of sight. One is to use the camera and video to allow us to view the flight path from the Quadcopter point of view while guiding it with an RC controller. Quadcopter via the telemetry link which the Quadcopter would execute autonomously. In this section of the document we will be discussing the verification and testing of each hardware and software component. All problems will be described in detail and the solutions we made to solve these problems. In this section we will also discuss our overall results of the project and what we could have done to improve upon our project. Future work for this project will also be mentioned in this section of the document.

DISCUSSION

This article present mechanical structure and describe all parts of quadcopter which gives good solution for a quadrotor design when its dimension and cost are the main constraints. The quadcopter configuration has a greater stability as compared to the other configurations and it is able to hover close to its target, unlike its other counter parts. This type of project plays a major role in civilized countries for surveillance of the terrestrial areas, film industries, managing traffics and city planning. The core intention of this work is to study complete designing and manufacturing process of quadcopter from the engineering prospective and improving their balance and stability system. As per future aspects, there is advancement in technology of quadcopters dramatically. In recent days, a companies like Boeing, Airbus, DJ Innovations, Parrot, Walkera, Blade and Heli-Max are working on some projects like Bell Boeing Quad TiltRotor, AeroQuad and ArduCopter, Parrot AR. Drone, Nixie, Zano (drone), Lily Camera drone, etc

CONCLUSIONS

The project is successfully completed in the given time period and we have completed several tethered test flights. We have resolved several issues encountered in this project to date, and we continue to work on outstanding issues. The Quadcopter will be ready for experimental missions. At this point the project can go in a variety of directions since the platform seems to be as flexible as we initially intended. As a team, we can completely change what function it performs and we are able to integrate any technology that would prove to be useful. This project will clearly demonstrate the goals of proving that small scale UAVs are useful across a broad range of applications.

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