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Review of HEXACOPTER Drone

[2]Ghazi. CH. Hameed ,B M Albakier,Alaa H. Muttar, Ali J.Askir [2,] Ammar A. Mhawish, Yasser W. Abdljalil,Mohamed G. Abbass, MA Alsaedi and mohammed H. Hafiz

Al-Iraqia University, Iraq

[2]Minisry of Oil, Iraq

Abstract: a hexacopter with a camera for maps construction is developed. The developed hexacopter is based on APM controller. An external GPS is connected to the controller to provide real-time position information in altitude, longitude, and latitude coordinate system. The apparatus consists of six controlled brushless DC motors, each have a propeller attached to it.

Index Terms— radiocontroller, hexacopter, drone

1 INTRODUCTION

Multirotor UAV (unmanned aerial vehicles), namely quadcopters and hexacopter, have become increasingly popular in recent years. Like the similar single rotor helicopters, they possess the ability to hover on the spot but have the added advantage that they are far more manoeuvrable; they can move in directions left and right just as well as forwards and backwards. The multirotor technology is becoming more popular and viable for industrial applications as the battery technology used to power the copters becomes lighter, lasts longer and becomes more cost effective. The large hobbyist following has also made the technology widely accessible to researchers. UAVs are currently being used in several industrial applications. In the mining industry they are used for aerial mapping, surveying and mining exploration. In the oil and gas industry they are used in both onshore and offshore settings for flare stack, pipeline and structural inspections. Similarly, they are also used in the power industry for transmission line inspection. Each of these applications takes advantage of the large areas of operation and the ability to remove workers from hazardous environments. However, multirotor technology has only recently become viable for industrial uses and there is still much room for research into the many possible applications for this technology.

1.1 Background

In the early 1900s, the Breguet Brothers built their first human carrying quadrotor helicopter called the BreguetRichet Gyroplane No. 1. The Breguet Brothers found that such machine exhibited poor stability characteristics. Although proving difficult to control, a quadrotor exhibits numerous advantages over other rotary wing UAVs such as helicopters. Control actuation consists of changing motor speeds rather than changing blade pitch. Thus, quadrotors compare favourably to traditional helicopter de- sign in the case of small, inexpensive electrically actuated UAVs where mechanical complexity is a disadvantage. Recent advances in technology, including sensors and microcontrollers, now allow small UAV's to be built relatively easily and cheaply. Practical applications of UAV quadrotors will require a high level of controllability and flying capabilities. Successful autonomous operation of quadrotors in windy conditions while carrying an unknown payload remains an open problem[1].

Although the first successful quadrotors flew in the 1920's, no practical quadrotor helicopters have been built until recently, largely due to the difficulty of controlling four motors simultaneously with sufficient bandwidth. The only manned quadrotor helicopter to leave ground effect was the Curtiss-Wright X-19A in 1963, though it lacked a stability augmentation system to reduce pilot work load, rendering stationary hover near impossible,6 and development stopped at the prototype stage. Recently, advances in microprocessor capabilities and in micro electro mechanical system (MEMS) inertial sensors have spawned a series of radio- controlled (RC) quadrotor toys, such as the Roswell flyer (HMX4),and Dragan flyer, which include stability augmentation systems to make flight more accessible for remote control (RC) pilots[1].
Many research groups are now working on quadrotors as UAVfor control algorithms for autonomous control and sensing, consistently selecting vehicle sizes in the range of 0.3 - 4.0 kg. Achieved control with external tethers and stabilizing devices. One such system, based on the HMX4, was flown, with the gyro augmentation system included with the vehicle active, and with XY motion constraints. Altitude and yaw control were demonstrated using feedback linearized attitude control. Back stepping control was applied for position, while state estimation was accomplished with an off board computer vision system. Another tethered used an extensive outward facing sensor suite of IR and ultrasonic rangers to perform collision avoidance. Control of the vehicle was achieved using a robust internal loop compensator, and computer vision was

used for positioning. A third project relied on a tether to use a POLYHEMUS magnetic positioning system. Tight position control at slow speeds was demonstrated using a nonlinear control technique based on nested saturation for lateral control with linearized equations of motion, and compensating in altitude control for the tilt of thrust vectors[1].

Other projects have relied on various nonlinear control techniques to perform indoor flights at low velocities without a tether. One such project, consisting of a modified Dragan flyer quadrotor helicopter, has demonstrated successful attitude and altitude control using a nonlinear control scheme. The OS4 quadrotor project features its own vehicle design and identifies dynamics of the vehicle beyond the basic nonlinear equations of motion, including gyroscopic torque, angular acceleration of blades, drag force on the vehicle, and rotor blade flapping as being potentially significant, although the effects of the forces are not quantified or analysed. A proportional derivative (PD) control law led to adequate hovering capability, although the derivative of the command rate was not included in the control law to manoeuvre the vehicle. A Lyapunov proof proved stability of the simplified system in hover, and successful attitude and altitude control flights were achieved. A third project achieved autonomous hover with IR range positioning to walls indoors, with a stability proof under the assumed dynamics. The system was modified to incorporate ultrasonic sensors, and later incorporated two cameras for state estimation as well[1].

Several vehicles saw success using Linear Quadratic Regulator (LQR) controllers on linearized dynamic models. The Cornell Autonomous Flying Vehicle (AFV) was a custom airframe with brushless motors controlled by custom circuitry to improve resolution. Position control was accomplished using dead reckoning estimation, with a human input to zero integration error. The MIT multivehicle quadrotor uses an off board Vison position system to achieve very accurate indoor flight of the Dragan flyer Viper, and demonstrated multiple vehicles flying simultaneously. The vehicles are capable of tracking slow trajectories throughout an enclosed area that is visible to the Vison system. It is possible to observe, the downwash from one vehicle disturbing another vehicle in flight, causing a small rocking motion, possibly due to blade flapping.

At Stanford, there has been prior work on quadrotor helicopters as well. First, the Mesicopter project developed a series of small quadrotors, ranging from a few centimetres from motor to motor up to tens of centimetres. This work focused on rotor design, and also studied first order aerodynamic effects. Next came a separate project, the Stanford of Autonomous Rotorcraft for Multi Agent Control (STARMAC). The first iteration was of two vehicles, STARMAC I aircraft that performed GPS waypoint tracking using an inertial measurement unit (IMU), an ultrasonic ranger for altitude, and an L1 receiver. Was derived from a Dragan flyer aircraft, and weighed 0.7 kg. In order to improve attitude control, this project found that frame stiffening greatly improved attitude estimation from the IMU, leading to cross braces between the cantilevered motors. Also, aerodynamic disturbances in altitude were observed, and modelled using flight data[2].

Quadrotor helicopters are an increasingly popular rotorcraft concept for unmanned aerial vehicle (UAV) platforms. These vehicles use two pairs of counter rotating, fixed pitch rotors located at the four corners of the aircraft. Their use as autonomous platforms has been envisaged in a variety of applications, both as individual vehicles and in multiple vehicle teams, including surveillance, search and rescue, and mobile sensor networks. Recent interest in the quadrotor design from numerous communities, including research, surveillance, construction and police use, can be linked to two main advantages over comparable vertical take-off and landing (VTOL) UAVs, such as helicopters. First, quadrotors can use fixed pitch rotors and direct control of motor speeds for vehicle control, simplifying design and maintenance by eliminating complex mechanical control linkages for rotor actuation. Second, the use of four rotors ensures that individual rotors are smaller than the equivalent main rotor on a helicopter for a given airframe size. The smaller rotors store less kinetic energy during flight and can be enclosed within a protective frame, permitting flights indoors and in obstacle dense environments with reduced risk of damage to the vehicles, their operators, or surroundings. These added safety benefits greatly accelerate the design and flight process by allowing to take place indoors or out, by inexperienced pilots, and with a short turnaround time for recovery from incidents [2].

As a result of these advantages, there have been a number of commercial Quadrotor platforms developed. However, there has been relatively little development of accurate dynamics models of quadrotors for operating at higher speeds and in outdoor environments. Such models and control techniques based upon the models are critical for precision control and trajectory tracking. The main contributions of this work are the presentation of aerodynamic models for quadrotors and the use of these models in the development of a quadrotor platform (the Stanford of Autonomous Rotorcraft for Multi Agent Control, or STARMAC) capable of achieving the sub-meter positioning precision necessary to fly multiple vehicles in a confined area with substantial motion[2].

STARMAC has been developed to take advantage of the benefits of Quadrotors, with the aim of being an easy to use and reconfigurable proving ground for novel algorithms formultiagent applications. It is currently comprises six STARMAC II quadrotors. These vehicles have been used to demonstrate a variety of algorithms, including experiments for collision avoidance, information theoretic control for cooperative search, dynamically feasible trajectory generation, and verification of provably safe aerobatic manoeuvres. In each case, the flexibility and convenience of the quadrotor design in general and the precision flight capabilities of STARMAC in particular have enabled rapid evaluation of new technologies[3].

Last decade the interest on the study and development of unmanned aerial vehicles has rapidly increased, due to their proved application in a wide range of areas such as aerial photography, power line inspection, sampling and analysis of atmosphere for forecasting, reconnaissance, surveillance, etc. In the academic community, unmanned aerial vehicles constitute suitable platforms to develop and a new generation of sensors and materials and to implement control strategies. A very successful design for UAV helicopter is the one that has four horizontal rotors, since this configuration simplifies the design, maintenance and control of the vehicle. However, the increase on the size and mass of the payloads, and the reliability of the aircraft has leaded the research community to explore new ideas so as to develop multirotor helicopters that could be competitive in practical industrial applications. For example, a large quadrotor has been designed and setup, from the design of the quadrotor frame to the design and manufacturing of efficient blades capable of carrying heavier loads[4].

2 LITERATURE SURVEY

Many efforts and work were already achieved and available in the literature. The previous available efforts can be summarized as in the following subsections.

1.3.1 Helicopter

Adding payload mass to a helicopter changes the dynamic response of the system. The aircraft's flight control system must continue to maintain stability with altered attitude dynamics and must also reject any bias torque induced by a shifted centre of mass. If the controller does not maintain stability with changed mass parameters, or cannot reject the step disturbances due to added torque bias from unbalanced loading, the system will be destabilized whenever an object is grasped. This is especially important where a linear commercial off the half system is used, which may not be adaptable to a changing plant mid-flight. Adding mass to the vehicle slows the natural frequency of the attitude dynamics this has the advantage of filtering out high- frequency disturbances, but makes it harder to affect fast course corrections[5]–[9].

WHILE SEVERAL AUTONOMOUS HELICOPTERS HAVE FLOWN WITH TETHERED LOADS, THE SLUNG CONFIGURATION IS SPECIFICALLY DESIGNED TO DECOUPLE THE MOTION OF THE LOAD FROM THE HELICOPTER, AND SEPARATE THE TIMESCALES OF THE ATTITUDE AND TETHER PENDULUM DYNAMICS. IN THE CASE OF GRASPED AND RIGIDLY AFFIXED LOADS, THE PAYLOAD IS DIRECTLY COUPLED TO VEHICLE PITCH AND LATERAL MOTIONS THE CLOSED LOOP SYSTEM MUST BE SHOWN TO REMAIN STABLE IN THE EXPECTED RANGE OF SYSTEM MASS AND INERTIA.

-Bi Copter

A twin rotor-type UAV is a type of helicopter which is propelled by two rotors. The blades rotate in opposite directions and a tail rotor is not required in order to counter act the angular momentum of the propellers. As a coupled dynamical system, by altering the motor speed, the position is also changed. The system is under actuated and very dynamically unstable. In many situations it is desirable that the system is to be as small as possible to achieve large movements, being able to move both vertically and horizontally. Specific characteristics, such as vertical flight ability and flying at low speeds, allow the model to perform tasks which are difficult to implement through other mechanisms and structures. With demand of applications for this kind of aerial vehicle rapidly increasing, also increases the interest in research, both in industry and academics. Several studies are being conducted on the dynamics and describing methods to regulate their flight by adding automatic stability control through a diversity of hardware and software control schemes[1], [10].

The objective of this work is to describe the design and the construction of the structure of the twin rotor device that can carry extra payloads. It is controlled by a remote transmitter that sends commands via radio to a microcontroller present on the twin rotor. This microcontroller is responsible for sending values of the speed for each rotor[1], [10].

-TriCopter

The tricopter that has been used in this thesis is a small model rotorcraft with three arms that has a brushless electrical motor attached to each one of them. These arms are attached to a plate and the arms are shaped as the letter Y, where the angle between any two arms is 120◦ and the length of the arms is 0.50 m. One of the motors is attached to a servo that can tilt the motor. The control loop consists of an inner and an outer loop. The controller in this thesis uses only the inner loop to stabilize the rotational rates of the tricopter. That is because the microcontroller did not have enough computational resource to handle both the inner and outer loop. On each of the motors a rotor is attached. These rotor blades have fixed angles[11]–[15].

Quadcopter

After deciding to create the Quadcopter, we had to decide what electronics to use and which sensors we would incorporate into it. After a lot of research on the web, we found a couple forums that discussed open source electronic and software components suitable for making a Quadcopter. Also, very basic but highly customizable Quadcopter bodies were available that were suitable for us to use to create our baseline system. The DIY drone's forum provided good information on what was being done in the amateur drone community and provided important information on what would be possible for us to use for our project. Motivated by the UAV forge challenge, we believed that the Quadcopter would be a good design starting point since it could lift off vertically, travel some distance to a specific location, record video of an object, hover if necessary, and return home upon completion. This scenario led us to the conclusion that we would need sensors including gyroscope, accelerometer, compass, GPS, and a battery monitor. We would also need payload components including a camera and a telemetry system to send imagery back to the lift off site. Furthermore, we would need a control mechanism that would allow flight beyond the line of sight since that was also a requirement. We thought of two approaches for control beyond the line of sight. One was 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. Second, a more ambitious approach would be to use on board GPS and guidance and a waypoint system to send commands to the Quadcopter via the telemetry link which the Quadcopter would execute autonomously. We decided to attempt the second goal as a stretch goal for our project. At this point in the design process, we believed that it would be possible to perform most of the manoeuvres and tasks required by the UAV forge challenge but we had no idea if the components we would be able to assemble would meet the performance requirements. We also had to realistically scope our project given a very small budget, a small team, and a limited amount of time to complete. We therefore decided to leverage as many commercial components as possible, get a baseline system working as quickly as possible and then focus on problems we encountered in the areas of payload design, body design, system integration, and mission evaluation[2]–[4], [16]–[35]

HexaCopter

Multirotor UAVs are a keen platform for many autonomous aerial robotics research projects. Of the literature surveyed, research divides into either indoor applications, mainly employing a vision based navigation system, or outdoor applications using GPS based navigation. Common across the literature are the 5 parts of an autonomous aerial robotic system:

1) Sensors and hardware
2) System modelling
3) Pose estimation and sensor fusion
4) Control loops
5) Goal setting.

3 CONCLUSION

This work involves the development and integration of hexacopter using APM microcontroller to control the whole UAV movements. It also involves the integration and use of a UAV's camera to automatically construct a local map based on the images acquired from the UAV while flying through a dedicated area of interest. The results show a successful control for a hexacopter to fly using a ground pilot with RC flight control.

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In this chapter we have simulation of simulink model have single phase with 220 v , supply voltage was supplied to R C snabber to convert the power from ac to dc . the load voltage and un controlled rectifier load current supplied to single phase locked loop after that to logical circuit after that to ideal switch then to active filter to reduce the 5th and 7th harmonic in secondary winding.

This project presented the analysis of the HVDC transmission system of the 2000-MW capacity. It is found that although the filters installed in the primary side of the converter transformer eliminate the harmonics in the source end, the secondary windings are very much affected by the harmonics and the voltage spikes caused by commutation overlap. Three solutions have been proposed by the authors to reduce the, intensity of problems caused by voltage transients. From the simulation results obtained, it is found that a combination of passive filters of the fifth and seventh order installed in the secondary side of the transformer along with an R-C snubber in the dc link yields maximum reduction in the current harmonics and commutation overlap voltage spikes. It is envisaged that the installation of filters on the secondary side will also simplify the design of secondary windings of the converter transformer and the requirement of filters on the source side will be reduced. RC snubbers with a suitable design on the secondary of the converter transformer can provide relief to insulation stresses across the winding

Out of these three solutions, a combination of the dc-link capacitor and passive filters seems to be yielding the best results. However, due to the limitations of the Simulink/Matlab software, transient modeling of the transformer winding could not be performed accurately. To obtain accurate results on the stress reduction with the introduction of secondary side filters and R-C snubbers, an accurate transient modeling of the transformer winding is very much essential.

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