MEDI COPTER

Dr. Akhilendra Yadav[1] , Abhishek Tiwari [2],Shubham Patanawar[3], Mahvish Khan[4], Satyam Khare[5],Saurabh Maurya[6]
Department of Electrical and Electronics Engineering
Shri Ram Murti Smarak College of Engineering and Technology, Bareilly, India akhilamu@gmail.com[1], att4478@gmail.com[2] ,shubhampatanawar@gmail.com[3], mahvish.khan2015@gmail.com[4], satyamkhare0404@gmail.com[5], saurabhmaury4@gmail[6]

Abstract—This paper presents methods for estimation and autonomous control of a hexacopter which is an unmanned aerial vehicle with six rotors. The hexacopter used is a ArduCopter 3DR Hexa B and the work follows a model-based approach using Dji Naza Lite GPS allocator installed in it and the work follows a model-based approach using GPS module after caliberation through DjI naza lite software . The main challenge will be to investigate how data from an Internal Measurement Unit can be used to aid an already implemented computer vision algorithm in a GPS-denied environment. First a physical representation is created by Newton-Euler formalism to be used as a base when developing algorithms for estimation and control.
The Dji GPS module provides remote controlling with accurate positioning co-ordinates enabling the use of dynamic home points and offering remote controller positioning information during active track.

The Dji flight controller is a tailor made for a multitude of bobbyist and industrial application**.**

I. INTRODUCTION

A medicopter is a type of aircraft similar to the traditional helicopter but with more than two rotors. The most common amount of rotors are 3 (tricopter), 4 (quadcopter), 6 (hexacopter) or 8 (octocopter), but any configuration is possible. More rotors give a higher maximum lifting capacity but are more expensive to build and need a higher current output from the batteries. If the multirotor is carrying expensive equipment 6 or especially 8 rotors can be recommended since a crash can be avoided even if one motor fails during flight. Multirotors have attracted a lot of attention for research in recent years due to their maneuverability, simple construction, flexibility and ability to take a payload. Today their main commercial use is related to send medicines, rescue operation ,surveillance and remote sensing [2]. With a few exceptions all multirotors belong to the families of vertical take-off and landing (VTOL) and unmanned aerial vehicles (UAV) and they can either be controlled manually with a radio controller or operate autonomously on their own. When flying autonomously outdoors the Global Positioning System (GPS) is usually the main source of information for position estimation, making navigation indoors a complex task since no GPS signal is available. To cope with this the most common approach is to use computer vision systems with cameras or laser scanners.

II. DESIGN OF HEAVY-LIFT HEXACOPTER

A. Hexacopter configuration

Hexacopter uses six motors that will rotate six propellers.This hexacopter lifting movement utilizes the thrust that is generated by the propeller combination of hexacopter frame.

The frame configuration is generally recognized as two type:

the Plus (+) and X configurations as in Fig. 1. The Hexacopter has 6 degrees of freedom (DOF), where the six degrees of freedom are affected by the rotational speed of each rotor, thusboth frames will have different motion dynamics models. In this research, the Plus (+) configuration frame is used. Fig.1 shows that each arm is connected to a brushless DC motor and has a propeller (fixed-pitch) so the rotor can force the air flow downward to generate the lift force. The direction of rotor rotation has two directions, i.e. three counterclockwise rotors (Counter Clock Wise; CCW) and three other rotors clockwise (Clock Wise; CW). So, it is clearly seen that the dynamic motion of hexacopter is simply influenced only by the speed of motor rotation.

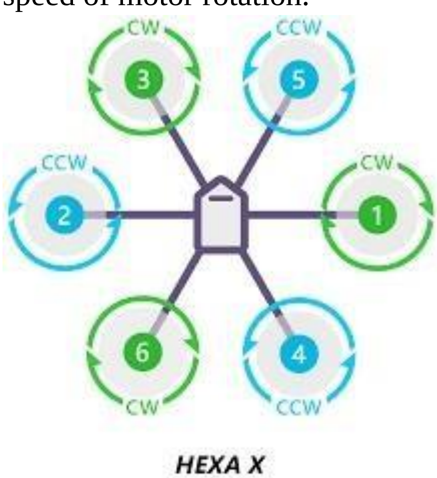
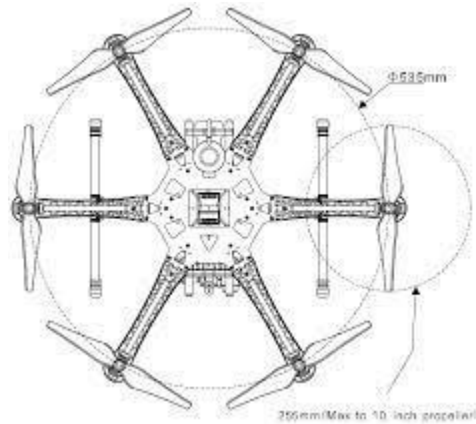


Fig. 1. Frame configuration

The frame should be constructed from the lightweight material but strong enough to



support its operational weight and structural load. Hence, it is necessary to analyze the flexibility and strength of the composing material of the frame. The design of this

Fig. 2. Heavy-lift hexacopter frame design

frame is hexagram with six equal long arms that attached to the center of a doubled hexagonal plate of as shown in Fig. 2.

B. Thrust and Motors

As the propulsion element for the hexacopter, the motor is the most important component. However, before determining the capacity of the motor applied in the design, it isnecessary to know the total weight that will be lifted and the thrust which is required to lift the heavy load of hexacopter. The

calculation to determine the thrust per motor as in the following equation:

Thrust= (total weight ×2)/(number of motors)——————(1)

Moreover, static thrust can be calculated by the following equation[19]:

$T^3=(\pi/2)\times D^2\times P^2\times\rho$————2

In this equation, T is thrust, D is the diameter of the propeller, ρ is the air density, and P is the motor power. This calculation will be combined with the following calculations were[19]:

Power = $K_p \times D^4\times Pitch\times\omega^3$.————3

Where Kp is the propeller constant, D is the diameter and RPM is the motor rotational-speed. The value of this RPM is calculated from the KV constant and the voltage that is used by the motor. As the main driving force in the Hexacopter system is used BLDC motor that has an advantage, where its structure does not use brush and commutator so that this type of motor will be more efficient than usual DC motor. BLDC motor can produce high RPM (Revolutions per minute). The main parameter of concern of BLDC motor is KV (rpm/volt), where this KV is a parameter that states the magnitude of rpm increase for each unit of voltage that is used.

C. Propeller Performance

The distance streamed by the fluid due to one rotation of propeller's blade is defined as the pitch parameter that is often noticed in the selection of propellers. Thus, if the pitch and diameter of the propeller are larger, so the motor rotation will be slower and the lifting force that is produced is large. So, if the hexacopter can lift the heavy load, it required large diameter propellers and large pitch. The thrust style equation of this propeller is [18]:

$F= \rho\ Ct\ n^2\ D^4$———————4

Where ɖ is the air density, n is the rotational speed of the propeller, Ct is the thrust propeller coefficient, and D in meters is the diameter of the propeller. For each speed, this Ct value varies with a small value so it can be ignored. While the power that is generated from the propeller can be calculated [18]: $Pp= \rho\ Cp\ n^3\ D^5$—————5

Cp is the power coefficient of the propeller that is obtained from the rotation. This Cp value changes with speed. For the torque on the propeller is generated based on the following equation:

$Tq=Pp/\omega$—————6

Where Ȧ is the propeller's angular speed.

D. Capacity of battery

Batteries are the power source to run all the components on the hexacopter. The battery also affects the flight time so that proper calculations are required to produce optimal results.

Therefore, to get the proper power and load combinations, the batteries that are used must have more current than motor currents. The parameter to be considered in the selection of the battery is the number of cells, discharge, and capacity. The number of cells determines the voltage of the battery in an empty state. Then the discharge shows how much current rating / current velocity can be released, and the capacity shows how long the battery can work on certain amperes.

PROBLEM FORMULATION AND OBJECTIVES

One of the most important tasks in was to attain a stable hover and this was partly accomplished. The medicopter could stay in position for some time but was subject to drift and was not very stable, mainly because of some of the weaknesses in the vision algorithm, unsatisfying altitude hold and Simulink lags. The vision algorithm is based on template matching where a small piece of an image frame, called template, is chosen and then by trying to fit this template into the next image frame a pixel displacement can be calculated.

- Use of nonlinear filtering for sensor fusion of computer vision and IMU data to improve position and velocity estimates.

- Improved altitude control of the medicopter. A more stable altitude hold will also give better results from the computer vision algorithm.
- Improved horizontal control.

The weight of each component is as follows:

No.	Items	Unit	Weight
1.	Battery	1	1250 g
2.	Motor	6	1200 g
3.	ESC	6	80 g
4.	Propellers	6	60 g
5.	Body	1	250 g
6.	GPS	1	100 g
7.	Radio Reciver	1	90 g
8.	Microcontrollers	1	150 g
	Total= 3180 g		

II. SYSTEM OVERVIEW

A. Overview of Hardware Circuit

Dji Naza M-lite V1.1 Controller

It contains inner damping, controllers, 3-axis gyroscope, 3-axis accelerometer and barometer in its light and small Main Controller. It can measure flying altitude, attitude and therefore can be used for autopilot/automatic control.
The advanced attitude stabilization algorithm not only inherits the outstanding flight stability of DJI products but also provides excellent maneuverability. It is more flexible and stable and gives the hobbyists a wonderful flight experience.

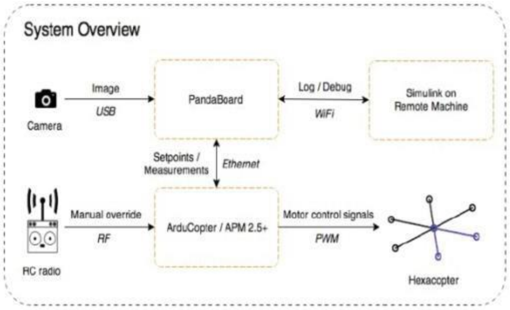
It offers three types of control modes:

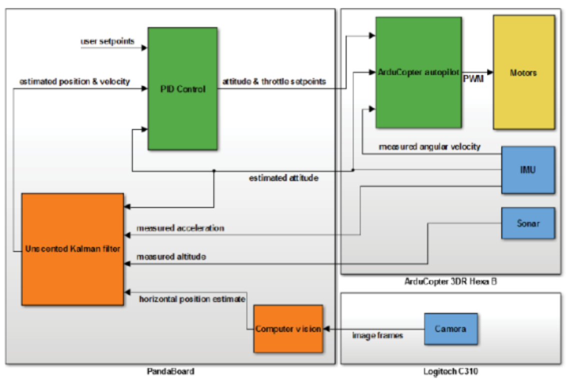
- GPS Atti. Mode (with GPS module)
- Atti. Mode
- Manual Mode.

The pilot can switch between the three modes to achieve different flight characteristics. It also can adjust automatically to the flight environment and intelligently switch between GPS Atti. Mode and Atti. Mode to make sure the flight is safe and secure.

The plug and play GPS module will greatly enhance the performance of Aerial Photography with accurate Position Hold, Return-To-Home and Intelligent Orientation Control functionalities. With the GPS Module, the multi-rotor will have position and altitude locked accurately even in windy conditions. Hovering accuracy is approximately 2.5m horizontal and 0.8m vertical.

OPERATION





IV. SYSTEM IDENTIFICATION

A. ANGULAR ROTATIONS

The ArduCopter 3DR Hexa B comes with an autopilot capable of controlling roll, pitch and yaw in a stable manner and thus no low level control of the attitude has to be developed. However, attitude set points are sent from the position controller on the Pandboard to the ArduCopter autopilot which creates a need for a model describing the relation between attitude setpoints and actual attitude. This model was developed by system identification in the previous thesis work using the attitude reference as an input and the measured attitude as output, thus including both the physics and the controller.

B. THRUST

Instead of trying to model the electronic speed controllers (ESC) and the motors of the hexacopter a more heuristic approach was taken to determine the thrust for a given pulse width modulation (PWM) signal. The hexacopter was attached to a ABB robot with a pressure sensor in the robotics lab at LTH,

. **RESULTS**

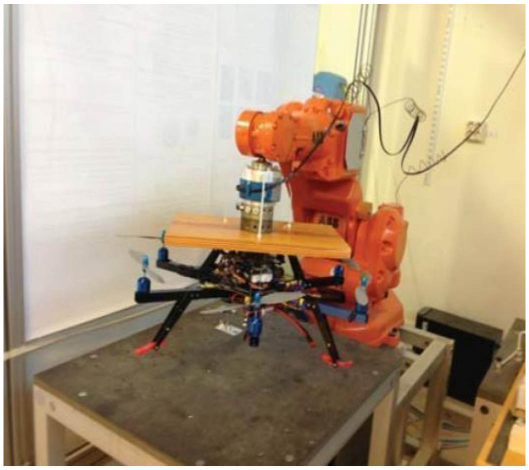
With a total weight of 3180g is known then thrust of each motor can be determined as

Thrust= (total weight ×2)/Number of motors

Thrust = (3180×2)/6

Thrust = 1060 Grms.

Thus, for the ability to fly and hover, the heavy-lift hexacopter must overcome the gravity force. Based on the above calculation, each motor must produce a thrust alr 1060 grams with the assumption that all motors have equal thrust. To ensure the thrust of the rotor that is used is capable of lifting and moving the hexacopter, it is necessary to measure the thrust of the rotor. Measurements are conducted in the rotation speed of BLDC motor and thrust force that is produced. BLDC motor speed measurement uses a digital tachometer where the output is already RPM



CONCLUSION

Medi copter is an autonomous copter which minimizes the man-labour and labour cost.
It helps rescue operations and sends medical nessscities during any other natural calamity.It can also help in navigation purposes etc.
This research has been able to design, analysis and constructs heavy-lift hexacopter that is capable of flying and lifting the payload. In testing the heavy-lift hexacopter is also capable of moving maneuver to a height of 26 meters and flight time is 15 minutes. Heavy-lift Hexacopter is also able to fly by lifting the payload. Future research that is done in the future is to control the heavy-lift hexacopter is autonomous.

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