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A Review on Design and Stability of Quadrotor to be used in the Precision Agriculture

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Abstract : Quadcopter otherwise know as the quadrotor is the next generation of aviation devices having greater dynamic stability than the helicopters, Quadrotors are underactuated robots.. They are predominantly used in different areas like civilian purposes such as agriculture, logistics, military exercises, fire sensing and other important areas dealing with complexities such a weight and space constraints. This paper is focused on the dynamic stability and the design of quadcopter. It addresses all the aspects of quadcopter ranging from mechanical design, aerodynamics, materials to be used, applications to the electronics used, The aim of this project is to optimize the quadrotor for Agriculture purposes.

Keywords: Quadrotor, Aerodynamics, Design, Stability, Finite Element Analysis, Frame etc.

I. INTRODUCTION

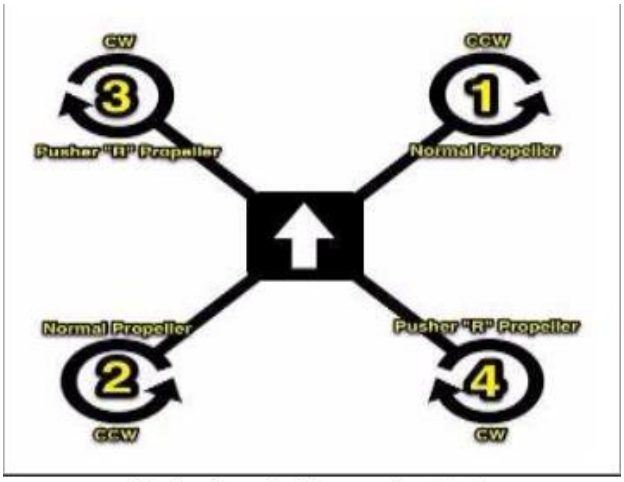

Fig.1. schematic diagram of quadcopter
(FigureSource:http://www.droneybee.com/quadcopter-blade-rotation-lift/)

I. PHYSICAL PRINCIPLES

Physical Principles. Quadcopter is lifted up high in the air with the help of propellers. These propellers convert rotational motion into thrust and this can be explained with the help of Bernoulli's principle and Newton's third law. Every action has equal and opposite reaction.

i. Bernoulli's Principle: Bernoulli's principle states that for an inviscid flow of no conducting fluid, and increase in the speed of fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy.

ii.Newtons Second Law: An air foil is the shape of the wing or blade as seen in the cross section, when moved through a fluid produces an aerodynamic force. Due to airfoil shape of the propeller, the air moves faster over the top than under the bottom which results in a greater pressure difference below the airfoil than above it. This pressure difference in turn produces the required thrust.

II. CONTENT

A. Objective:

1. To Study quadrotor Flight dynamics
2. To Study system interactions with the surroundings.
3. Electronic Components Used.
4. Possible Design Prototypes
5. Fabrication Process to utilize
6. Adopting the system as per Agricultural Requirements

B. Frame Selection: Here we are going to utilize the X4 type model for quadrotor as show in the figure 1. The X4 type configuration utilizes the 4 motor and propellers or 8motor and 8 propeller as per requirement providing slightly better control then X4.

C. Material Selection: The whole system is in dynamic motion and rotary arts are involved also landing of the

system can induce impact load on it. Therefore the material shall be so selected that it has high Strength to Weight ratio, this is the paramount property as the weight of aerospace system i.e our quadrotor has to be kept low to keep the power consumption low and to increase the flight time on the same power.

Table 1. Material Selection

Font Size	Material Selection Based on Properties Required		
	Component	**Material**	**Properties**
1	Frame/Plate	Carbon Fibre	Vibration Isolation and Absorption.
2	Propeller	Kevlar Epoxy Composite	High weight to Strength ratio.
3	Landing gear	Carbon Fibre	High Impact absorption.

D. Electronic Components used in the quadrotor system

1. Motors: Brushless DC motors also termed as BLDC motors are used in Quadcopters. These motors consist of a permanent magnet which rotates around a fixed armature. They offer several advantages over brushed DC motors which include more torque per weight, reduced noise, increased reliability, longer life time and increased efficiency.

Fig 2: Brushless DC Motor

Motor calculations: The motors should be selected in such a way that it follows following thrust to weight relationship.

Ratio=Thrust / weight =ma / mg

Thus, vertical takeoff and vertical landing (VTOL) is possible only when,(a / g) > 1 or in other words, The total thrust to total weight ratio should be greater than 1 so that the quadcopter can accelerate in the upward direction. In this case, we assumed that

Total Thrust = 2*(Total Weight of the Quadrotor)

Therefore,

Thrust Provided by Each Motors = Total Thrust/4

Electronic Speed Controller: Low voltage and current is provided by the microcontroller and this is not sufficient to drive motors. To drive the motors at specific speed, we require a motor driver to supply specific amount of voltage and current required by them and this work is done by Electronic speed controller.

Propeller: Propeller is a type of fan that converts rotational motion into thrust. Generally, propellers are classified on the basis of their diameter and pitch and are represented in terms of product of diameter and pitch. For e.g. 10 *4 449 × 255 7, 10*4.5, etc. The diameter of propeller indicates the virtual circle that the prop generates whereas the pitch indicates the amount of travel per single rotation of propeller. In order to counter motor torque, Quadcopter require two clockwise and two anticlockwise rotating propellers. All the propellers used in quadcopter should have same diameter and pitch. Many motors come with propeller specifications so as to have optimum power consumption. If propeller specifications are not mentioned on motor then we have to use trial and error method.

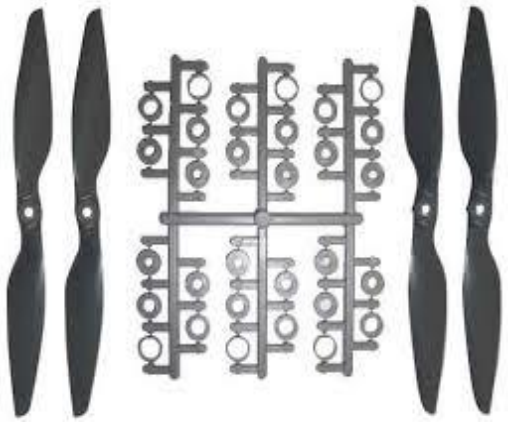

Fig 3: Propellers

Battery: Lithium Polymer (Li-Po) batteries are used in quadcopter. These batteries are rechargeable and also have low weight and high voltage capacity as compared to other type of batteries. Battery chargers are required for charging the battery

Battery calculations

Max. Current withdrawal by motors = no. of motors* maximum current withdrawal by single motor = 4*15 = 60 A

The discharge current of battery should be higher than the maximum current withdrawn by motors. Where, discharge current= Capacity in ampere * discharge rate. If we assume a constant current draw of 20A, then flight time for quadcopter is calculated as follows,

Flight time = (Capacity in amperes/Current draw) * 60

Flight Controller: To maintain balance, the quadcopter should continuously take measurements from the sensors and

make adjustment accordingly to the speed of the rotors to keep the body level. Flying capabilities and cost are the two main factors to be considered while selecting flight controller. Flying capabilities consists of following basic factors-

- Gyro stabilization: It is the ability to keep the copter stable and level under the pilot control.
- Self-leveling: It is the ability to automatically adjust itself during any orientation so that the copter stays level.
- Altitude hold: It is the ability to hover at a certain distance from ground without having to manually adjust the throttle.

6. Transmitter and receiver : The Transmitter (Tx) and Receiver (Rx) system allows the Quadcopter to be remotely controlled through a wireless signal. The aircraft controls would typically include throttle, pitch, roll, yaw, and mode settings.2.4GHz TX and RX system is used for its better performance, because it will not experience signal conflicts from other radio frequency (RF) controllers. Receiver used is having 6C 2.4 Ghz system which perfectly bonded with the 2.4Ghz transmitter.

E. Interaction with the surroundings.

The surrounding air in which the quadrotor operates is assumed to be a low Reynold no. flow i.e the flow is laminar in nature and the problem of low damping is imminent in the case of quadrotors as the friction provided by the air is almost negligible therefore the control has to

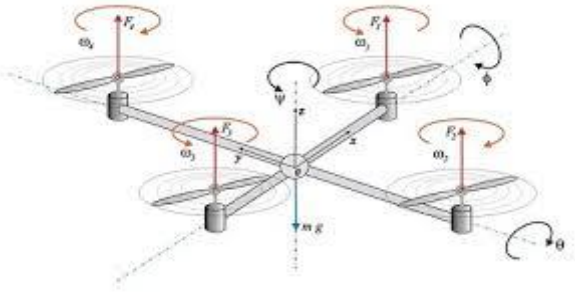

Fig 4: Degrees of Freedom of Quadrotor
(FigSource:http://www.azorobotics.com/Article.aspx?ArticleID=187)

E. Motions and their Manipulations

The quadrotor is an underactuated robot, ie the degree of free are more than the input sources, also it has move in frictionless undamped medium. therefore the to have exact motion tracing is a difficult task but can be achieved.

Vertical Take Off: The force required for this motion is known as lift force and generated by thrust produced by four propellers rotating at same speed.

Yaw Motion (ψ): This motion is attained by increasing speed of appropriate set of motors. By generating couple of force from two neighbour motors, yawing can be achieved.

Pitch Motion (ɵ): This motion can be attained by generating couple of forces from the set of motors in the direction of the movement (Front and rear motor).

Roll Motion (Φ): This motion can be attained by generating couple of forces from the set of motors in the direction other than the direction of motion (Left and Right side motor.

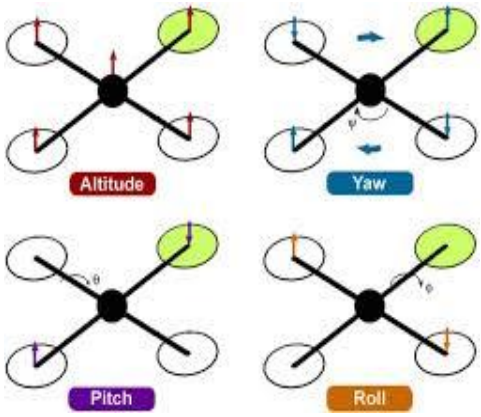

Fig 5: Motions of Quadrotor

(Figure Source: http://uav-society.blogspot.in/2014/06/quadcopter-mechanics.html)

F. Precision Agriculture

Goal of precision agriculture is to combine technology with agriculture to increase outcomes in agriculture, through database management of input variables and operation conditions, this data can be used for various reasons such as forecasting, inventory managements.

Fig 6: Smart Farming

(Figure Source:< https://www.smart-akis.com/index.php/network/what-is-smart-farming/>)

In precision Agriculture we optimize the bests of Economics, Environmental data, Management strategies and technological advancements.

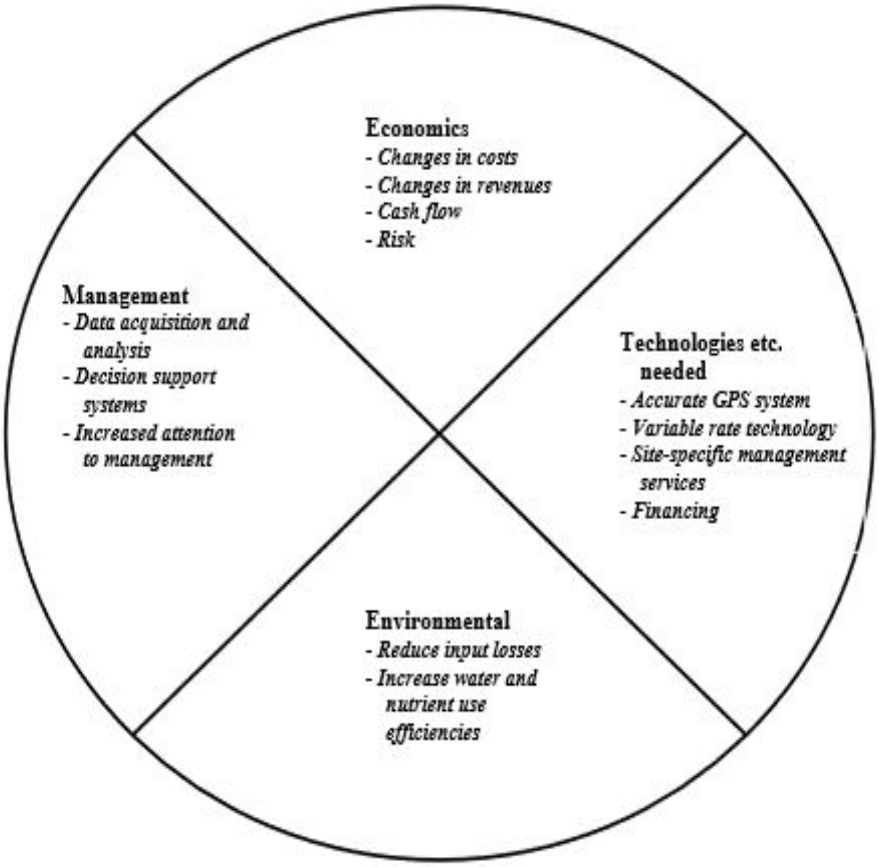

Fig 7: Input and Impact of Precision Agriculture.

G. Literature Review

A.V. Javir (2015) [1] In this paper safety of the quadrotor is discussed, safe design of the quadrotor is done by designing a quadrotor model on a CAD software and doing its analysis on Ansys 15.0 Workbench, the thrust generated by the propellers to lift the system and its effect on the surrounding and the effect of vibration generated on the system itself.

Ahmad Khushairy Makhtar (2012) [2] This paper discusses the various different configurations of the quadcopter and provides a basis to chose a quadrotor model over other various model such as fixed wing type model. The pros mentioned in the paper are greater flight stability and VTOL feature. Addition to that its ability to hover closer to specified targets. Sometime however hovering is unstable, making the navigation difficult and use for precision usage. The purpose of this research was to fix this hover stability issue and fix the control system, but fully customisable to suit its users' needs. The results of the hardware implementation show that the quadcopter has a stable hover with an error of ±2 cm for a total flight time of 5 minutes with a total implementation cost of USD 24.

Hardik Modh (2014) [4] This paper takes the quadrotor from the engineering perspective and the problems associated with them in whole and also the the weight reduction of the complete system is the target. Our main goal is to design and fabricate a Quadrotor which can be used for various application in market, defense, commercial and infrastructure applications like Traffic obverse and control, disaster management operation, weather and height estimation, concourse management, Locating forest fire or frost conditions in farmlands, Weather forecasting, post natural disaster, Object identification and Reconnaissance. With the help of our project guides, we have the resources and technical knowledge to successfully complete this project. We chose the UAV Quadrotor for project because of its flexibility, high learning opportunity and potential of future research. The project tries to beyond the conventional ways of how we use quadrotors today, how we can incorporate it with daily usage, making it more robust, reliable and user friendly. This project will be definitely useful to implement new function of high weight lifting in the account of UAVs.

Amir Abbas Bakhtiari (2013) [5] Precision farming is a data-based management and a way of agricultural production, which takes into account the in-field variability. Precision agricultural technologies, such as Global Positioning Systems,Geographic Information Systems, remote sensing, yield monitors, mapping, and guidance systems for variable rate application, made it possible to manage within-field variation on large scales. The objectives of this perusal are to collect information about precision farming technology and

its opportunities, challenge and difficulty. It can be concluded by results of the study that there numerous opportunities and problems in adopting the precision farming across the world specially in south-asia which is mainly agriculture dependent and yield when compared to western world is low. Different mode of precisions can be used in the different parts of the world depending on the creativity of users.

NITI Ayog, Government of India [6] This paper aims on discussing important set of policy issues and challenges faced by Indian Agriculture and to come up with total solutions to bring about second Green Revolution and this time not concentrated to just some part of the name but rather to be pan India and maintain that levels of growth, maitaing the growth is also challenge. Five key issues are determined: measures necessary to raise productivity, policies ensuring remunerative prices for farmers, reforms necessary in the area of land leasing and titles, a mechanism to bring quick relief to farmers hit by natural disasters, and initiatives necessary to spread Green Revolution to eastern states. While measures that have been outlined are essential for rejuvenation of agriculture as well as ensuring a decent life for farmers, we must not lose sight of the fact that relief to farmers will remain incomplete without the creation of job opportunities for them in non-agricultural sectors. With industry and services able to grow much faster than agriculture—the fastest that agriculture has grown over a continuous ten-year period in the post independence era is 4.7% during the 1980s—the share of agriculture in the GDP will continue to decline. Already, this share is down to approximately 15% while it supports 49% of the workforce. In order that today's farmer families can share in the faster growth occurring in industry and services, it is essential that some of them be able to find good jobs in these sectors. As some of the farm families move out of agriculture, the opportunities for consolidating and enlarging land holdings will open up as well. In turn, this will allow greater use of modern machinery and farm techniques allowing productivity and wages to rise rapidly in agriculture as well. The following offers a summary of policy recommendation.

ALEX McBRATNEY (2015) [7] We have to be careful that we do not get stuck in a limited paradigm, such as zone management. Different kind of aim should be there for different kind of countries, developing or developed or based on there requirements, there should be no hard and fast rule for making a quadrotor . Challenges or conflicts in designing as per the requirements should be noted and resolved .Concerted and co-ordinated research effort is needed in the following six areas.

(1) Appropriate criteria for the economic assessment of PA.
(2) Recognition and quantification of temporal variation.
(3) Whole-farm focus.
(4) Crop quality assessment method
(5) Product tracking and quality assurance.
(6) Environmental auditing.

Amy T. Winstead and Shannon H. Norwood [8]

Evidence from the 2009 Alabama Precision Ag and Field Crops Conference indicated that sequential adoption of precision agriculture technologies exist, especially regarding yield monitors and GPS guidance. It was clear that precision agriculture technologies have been more readily adopted by farms with larger acreage rather than small-acre farms. It was also clear that users of precision agriculture technologies rely upon the university/Extension system for information.The perception of land value as a function of variable or uniform application indicates one incentive to adopt precision agriculture

CONCLUSIONS

The core intention of our project is to study the complete designing process of quadrotor from the engineering perspective and to fabricate a working model of UAV-Quadrotor with improvement in its weight carrying capacity. Our main goal is to fabricate a Quadrotor which can be used for multipurpose application in market, military, commercial and industrial applications like Traffic monitoring and management, Search and rescue operation, Temperature and altitude estimation, Crowd management, Locating forest fire or frost conditions in farmlands, Weather forecasting, post natural disaster, Object identification and Reconnaissance. With the help of our project guides, we have the resources and technical knowledge to successfully complete this project. We chose the UAV Quadrotor for project because of its flexibility, high learning opportunity and potential of future research. This project can go further in variety of research work to integrate various technologies with UAVs to get various useful outputs. This project will be definitely useful to implement new function of high weight lifting in the account of UAVs.

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