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Quadcopter for Agricultural Surveillance

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Abstract

The aerial Quad copter used for agricultural surveillance is an unmanned vehicle used for proper and accurate surveying of the crops and leaves reducing the human effort. The agricultural farm is surveyed by an infrared camera which will show the colour image displaying the difference between infected or diseased crop and matured crop. The innovative foldable frame design developed will allow the Quad copter to be transported safely and with ease in a cylindrical shaped cushioned box packing.

Keywords: UAV, Quad-copter, Frame design, Infrared camera, image processing, Agricultural surveillance.

1. Introduction

A Quad-copter is a multi-rotor aerial and vertical take-off and landing vehicle. It is an aircraft that is lifted and propelled by four rotors. Quadcopter is classified as rotorcraft, as opposed to fixed-wing aircraft, because its lift is derived from four rotors. Quad-rotor crafts has a sophisticated control system in order to allow for balanced flight, so as to eliminate the inherent instability induced by minor differences in the thrusts and reaction torques exerted by the motors. In the quad-rotor, every rotor plays a role in direction and balance of the vehicle as well as lift, unlike the more traditional single rotor helicopter designs in which each rotor has a specific task - lift or directional control – but never both.

Each rotor produces both a thrust and torque about its centre of rotation, as well as a drag force opposite to the vehicle's direction of flight. Quadcopter achieves lift, yaw, roll and pitch simply via a manipulation of the thrusts of four motors relative to each other.This way, fixed rotor blades can be made to manoeuvre the quad rotor vehicle in all dimensions. Applications of quad copter are in, agricultural surveying, weather forecasting, traffic forecasting, scenic photography, weapon for war crisis, post natural disaster analysis, civil surveying, for chemical leaks and amusements.

2. Mechanical design

2.1 Design Methodology

- Design Of Quad Copter Arm (Static load consideration) :-

Material used Aluminium 6061-T6

- Density = 2712 kg/m^3
- Modulus of Elasticity = 68947.57 MPa
- Poisson's Ratio = 0.33
- Yield stress = 275.79 MPa
- Ultimate Stress = 310.264 MPa

- Considering Theory of Failure:[1]
  - Factor of safety (FOS) = Yield point stress/Design stress
  - Let FOS = 10Thus Design Stress = Yield point stress/FOS
  - Design Stress = 275.79/10 = 27.579 MPa

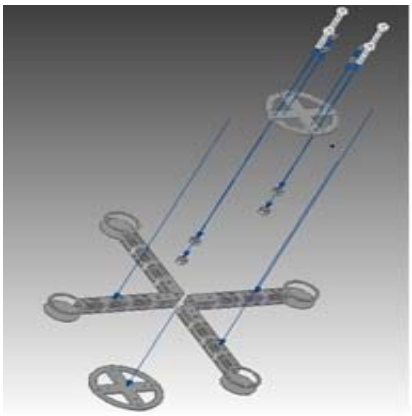
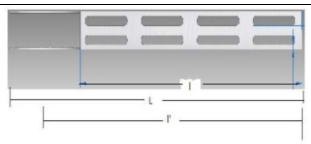
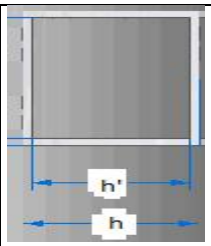
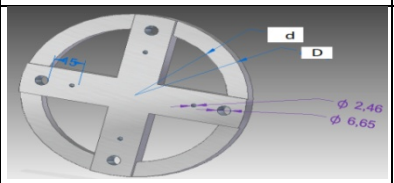


Fig. 1: Exploded view of design of quad-copter.

Table 1: Quadcopter frame design.

Frame Part	Part view	Design consideration	Calculated safe values*
Arms	 Side view	-Failure in bending. Bending moment, M=P x l' Where, l'=(l+26.5 mm) P=Weight of motor x g	l= 147 mm L=180 mm

Arms	 Cross section	-Failure in shear. Stress at intersection of arm and motor mounting, $S=P/(h^2 - h'^2)$ $t=(h-h')/2$ Where, h=outer width of arm h'=inner width of arm t=thickness of arm	h=15 mm h'=12 mm t=1.5 mm
Central disc	 Top view	-Area necessary for mounting camera, microcontroller and battery. Where, D=diameter of disc t'=thickness of disc	D=50 mm t'=4 mm

*Practical considerations for dimension may change as project proceeds

2.2 Innovative Design Concept

The innovative quad copter design in which the any two arms of the quad copter arms can be folded either sides removing the propeller and the camera attachment. Hence this can transported with ease in a cushioned packed box and can again be assembled at the place of use. The entire design is made in Siemens Solid Edge software. It allows us to have a full 3D view of the system with motor mountings and circuit mountings. The physical properties of the material can also be known with the accurate volume and weight analysis.

3. Electronic System Design

3.1 Electronic Speed Controller

Regardless of the type used, the ESC interprets control information not a mechanical motion like servo motor but by varying the switching rate of network of FET's. It allows much smoother and more precise variation and more efficient manner. In broader sense, ESC are PWM controllers for motors. The ESC generally accepts nominal 50 Hz PWM servo input signal whose width varies from 1ms to 2ms. Depending on the size of pulse width, speed of the motor can be controlled. Using Ohm's law, we can determine the voltage loss. At 20A, this produces a 0.56V drop (V = I × R = 20A × 0.028 Ohms = 0.56V). We can use the second law to compute that the power loss would be 11.2W (P = I × V = 20A × 0.56V = 11.2W). The power loss can be reduced by using more MOSFETs in parallel, or using modern lower resistance MOSFETs. [2]

3.2 Infrared Camera

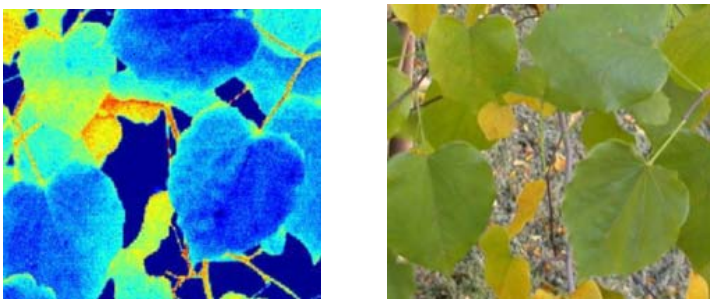


Fig. 2: Comparison between normal and infrared image of a plants.

The applications of remote temperature sensing of plants by infrared thermography and infrared thermometry depend on the sensitivity of leaf temperature to evaporation rate.

In most applications, such as in the early or pre-symptomatic detection of disease or water deficits, what is actually being studied is the effect of the disease on membrane permeability to water. [3] Hence the variation in temperature differs from plant to plant based on the size of pores on the leaves. Based on the image of the non-infected crop, all other crops' health is determined by comparing the infrared image of both the crops. The entire image processing program is operated in matlab software.

3.3 Motor Specifications

The motor used in quad copter is an out runner brushless DC motor. This motor is typically used in UAV's and consists in a stack of laminated magnetic material and a set of miniature coils. The out runner rotor is an assembly of powerful magnet. [4] These motors have coils fixed to the mounting. On outer side it contains number of magnets mounted to cylinder that is attached to shaft and hence there is no need of brush. Due to reduction in friction, power-to-weight ratio is favourable and can operate at higher speed than a conventional DC motor. The desired motion of copter can be achieved by varying speed of these motors at four arms.

3.4 Propellers

To achieve desired roll, pitch and yaw, selection criterion of propeller is crucial. Uncontrollable pitch propellers are used in quad-copter with opposite pairs of propellers revolving in same direction. More is the curvature of the propeller blade (pitch), makes it harder to drive it as it requires more power but will lift more weight as more grabbing ability the blade has to pull through the air. If we choose high speed motor than pitch should be smaller and vice versa. Diameter of the propeller is also inversely varied to the pitch. Large diameter calls for smaller pitch propellers. [5]

3.5 Power Supply

Lithium polymer batteries are used in quad-copter for their low weights and high capacities. LiPo batteries are available as 3.7V per cell. By series and parallel combination, desired power output can be achieved. These batteries are rated on their C-rating. C-rating specifies how fast a battery can discharge. A 2000mAh battery with 12C rating would be able to discharge 12 times its capacity i.e. 24000mAh for $1/12^{th}$ of an hour. Initially these batteries provide burst current and C-ratings are also specified as per burst currents.

3.6 Microcontroller

Arduino is a single-board microcontroller with a simple open source hardware board designed around an 8-bit Atmel AVR microcontroller. The software consists of a standard programming language compiler and a boot loader that executes on the microcontroller. Some shields communicate with the Arduino board directly over various pins, but many shields are individually addressable via an I²C serial bus, allowing many shields to be stacked and used in parallel. Arduino programs are written in C or C++ with RS232 as serial communication.There is an inertial measurement unit, or IMU, interfaced with controller. IMU is an electronic device that measures andreports on a craft's velocity, orientation, and gravitational forces, using a combinationof accelerometers and gyroscopes, sometimes also magnetometers. IMUs are typicallyused to maneuver quad copter.

4. Image Processing

Infrared (IR) light is electromagnetic radiation with longer wavelengths than those of visible light, extending from the nominal red edge of the visible spectrum at 700 nm to 1 mm. Infrared image has proved its presence across wide range of thermal sensing applications. As different wavelengths represent different shade of light, image processing is done on based on pixel value of the image. The captured infrared image of a crop is then analysed withMatlab programming. This infrared image indicates the different temperatures of the crop by different colours specifying the health of the crop.[6] Red colour in infrared image indicates higher temperature while blue colour indicates lower temperature.

This infrared image under examination is converted to binary image by Matlab program. The pixels indicating temperature higher than our decided threshold are converted into white pixel and those having values less then threshold are converted into black pixels. With due studies related to the some crops, each crop has different values for threshold.As these white pixels in the binary image indicate higher temperature,it represents infected or unhealthy regions in the crop. The program then calculates the number of white pixels. If the number of white pixels (i.e. infected region) is greater than our decided number of pixels depending upon the type of crop then the program gives output ‘The crop is UNHEALTHY’ else the program gives output ‘The crop is HEALTY’. By using such a Matlab program, total healthy yield of

crops in the farm can be evaluated and tentative position of unhealthy crop can be estimated.

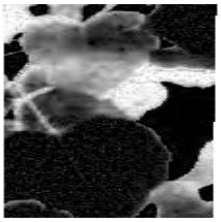


Fig. 3: Processed Image of bad crop

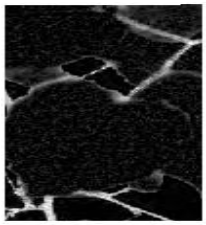


Fig. 4: Processed image of good crop

5. Conclusion

The core intention of this project is to make a robust design of a Quadcopter which can be used in the market for agricultural surveillance use. We chose the Quadcopter for our UAV design since it has interesting design elements with stability and potential for marketable gains. At this point the primefocuses of the project is to reduce human efforts in agricultural surveillance by appropriate use of image processing. At the end, this project will able to specify total healthy yield of crop in the farm by amalgamation of aerodynamics, machine vision and microcontrollers. Thisproject being flexible, allows changing the functions it performs and also allows integration of any technology that would prove to be useful. This project will clearly demonstrated the goals of proving that small scale UAVs are useful across a broad range of applications.

References

[1] R. S. Khurmi “Machine Design”, for designing of frame structure based on Theory of failure.
[2] http://www.stefanv.com/electronics/escprimer.html
[3] Hamlyn G. Jones “A advanced Botanical Research” Volume 41, 2004
[4] Weh H., Hoffman H., Landrath J.: "New permanent magnet excited synchronous machine with high efficiency at low speeds", 1988.
[5] Stumpf J., Gurdan D.: “Design of a flexible high performance Quadcopter platform breaking the MAV endurance record”, 2011
[6] Hamlyn G. Jones, RachidSerraj, Brian R. Loveys, LizhongXiong, Ashley Wheaton and Adam H. Price“Thermal infrared imaging of crop canopies for the remote diagnosis and quantification of plant responses to water stress in the field”