

Building a Multipurpose Quad Copter with a Thermal Sensing Device

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Abstract: Quad copter is also termed as quad rotor due to its four equidistance rotors that are used for propelling in air is the next form of helicopter having more dynamic stability than a helicopter. They are playing a predominant role in different areas like surveillance, multimedia, agriculture, military operations, fire sensing and some important areas having many complexities. To which we get with an idea to combine our quad copter with a system that will enable it to use in different application field and make it as a multipurpose quad copter.

This paper addresses the theoretical part of a quad copter, along with this finite element analysis is done on the frame so as to sustain the loads generated in the vehicle and conclude that small deformation occurred on the center plates are safe and within the limit.

The main focuses of this paper is to know how well a quad copter can be used with a thermal detector which can bring it to search and rescue operations. Along with that, to know how well a thermal sensing camera can be attached with a quad copter for making it a multipurpose aerial vehicle.

Keywords - Quad copter, thermal sensing camera, gear box, propeller, motor, battery, electrical control unit (ECU), radio transmitter and controller.

I. INTRODUCTION

A quad copter is an unmanned aerial vehicle, which works quite like helicopter but has a different way of functioning as it is lifted and propelled by four rotors. Quad copters are included in the classification rotorcraft because their lift is generated by a set of rotors (vertically oriented propeller). Two pairs of identical fixed propellers are used in a quad copter and out of them two rotate clockwise (CW) and two rotate counterclockwise (CCW). It is possible to generate a desired total thrust, total desire torque or turning force and locate for the center of thrust by changing the speed of each rotor specifically. Speed is controlled by the independent rotation of each propeller. Quad copters differ from conventional helicopters, which use rotors that are able to vary the pitch of their blades dynamically as they move around the rotor hub. Diagram showing how a quad rotor is been regulating it individual rotor speed for different maneuver.



Fig 1: A quad rotor applying equal thrust in all the four rotors to lift in air or to maintain an altitude.



Fig 2: A quad rotor applying more thrust to rotors rotating in one direction for moving about a vertical axis.



Fig 3: A quad rotor applying more thrust to one rotor and less thrust to its diametrically opposite rotor for adjusting its pitch.

Quad copter flight dynamics

A Quad copter operates within two frames of reference. The first one is its own frame of reference which is termed as “Body frame” whereas the second one is measured relative to world frame of reference which is termed as “inertial frame”.

In case of body frame, the rotor axes are pointing in positive z direction with the arms pointing in x and y directions while in case of inertial frame, the gravity pointing in the negative z direction.

As we already know that a Quad copter lifts up in air with the help of propellers. These propellers convert rotational motion into thrust.

This mechanism can be well illustrated with some known principles and these are the Bernoulli's principle and Newton's third law.

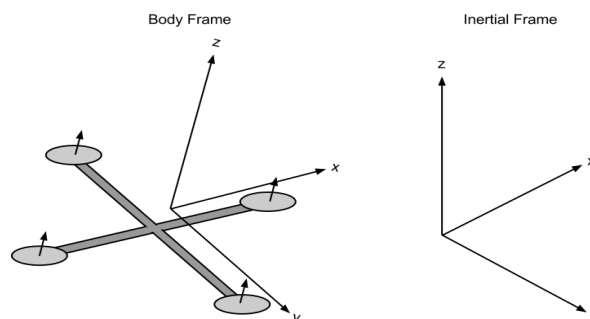


Fig 4: A quad copter's body frame.

Bernoulli's principle helps in explaining that how our propeller can achieve lift because of the shape of its wings. They are shaped so that, that air flows faster at top wings of the propeller and slower at the bottom. Fast moving air equals low air pressure while slow moving air equals high air pressure.

And Newton's third law helps in explaining that how an equal and opposite amount of force helps in pushing the quad copter upward due to an opposite reaction of air in downward direction.

The thermal cameras are also called heat vision camera, temperature sensing camera, heat sensing camera and much more as thermal sensing camera are used to collect pictures or videos from not visible light having some electromagnetic spectrum. The wavelength of such spectrum ranges from $1.3\mu\text{m}$ to $15\mu\text{m}$. Other than detecting heat, a thermal camera also detect the tiny differences in heat and it could be as small as 0.01° Celsius. This information is displayed in various colors in the thermal software or apps for analysis. All matter discharge heat energy in the form of electromagnetic radiation. A term Emissivity that is taking into account, as it is the efficiency in which an object emits infrared radiation. It's highly dependent on properties of the material or object. This will allow us to know how much radiation a object emitting while capturing images as it measures the efficiency of a surface that emit thermal energy relative to a perfectly black body source. Another term that comes into account is reflectivity and it is a measure of the ability of a surface to reflect the radiation. These are the term that will help us to know the exact information while we are analyzing the captured images.

We are using thermal sensing camera over the night vision cameras or the infrared cameras because thermal sensing does not require any source light as it can even detect temperature in fog or smoky environment and that why its beneficial for our detection purpose.

II. LITERATURE RIEVIEW

Berni, José A. J. Zarco-Tejada, Pablo J. Suárez Barranco, María Dolores (2009) in their research demonstrated the ability to generate quantitative remote sensing products by means of a helicopter-based UAV equipped with inexpensive thermal and narrowband multispectral imaging sensors. There paper demonstrated that results obtained with a low-cost UAV system for agricultural applications yielded comparable estimations than those obtained by traditional manned airborne sensors.^[1]

Michael Teutsh, Thomas Mullar, Marco Huber, Jurger Beyerer (2014) in their research study found that with a long wave infrared (LWIR) camera which provide them a better fundamental of person detection by masking background texture or lack of illumination and it is done especially for outdoor scenarios. By this process they were able to recognize the moving and stationary person in real- time in low resolution by using two steps, first is to detect person hotspot they use maximally stable external regions MESR and in that they normalized the scale to 16×32 pixels, second is that they distinguish between person and the clutter using the technique discrete cosine transform (DCT) and the classifier random naïve bayes (RNB) which provide them better classification.^{[2],[3],[4],[5]}

Abdul Nishar, Steve Richards, Dan Breen, John Robertson, Barbara Breen (2015) in their research study got with a demonstration that how to convert the thermal infrared videos into still images by using the PIX 4D software. They attempted to capture thermal infrared images of geothermal system with unmanned aerial vehicle. The orthomosaic of the thermal infrared imagery is displayed and described. They also have to make it minimize the cost as well as to minimize the weight so as to compete with other UAV. And for doing all these they have to study some advance technique in sampling, processing, and analyzing UAV images and also identify some research challenges and limitations in the use of UAV platforms and sensors.^{[11],[12],[13]}

Mathew Thomas, Albin A T, Christin Joseph, Amal Kurian Mathew Jerin Cyriac (2016) in their research study they wrote how they used carbon fiber in building their quad copter and did the structural analysis. The conclusion they found was that the vibration got reduced when compared to the plastic UAV further there was no effect to the rotors propellers and other electrical components by using this carbon fiber and even the strength and resistance capacity was increased from the standard values.^[15]

Stefano Focardi, Anna M. De Marixis, Maurizio Rizzotto and Alessandra Pucci (2016) in their research study they took images of lots of animals in the wildlife and then compare them by thermal infrared imaging (TI) and by spotlight (SL) and then compared them both with the suitable formula provided and checking which is better suitable for wildlife survey. For SL survey they again use two methods first observer in motor vehicle (5km/hr) equipped with an 8,00,000 candle power spotlight, second they use binoculars for animal identification. For TI survey they use a Galileo unit for fauna observation (GUFO) uses a 2 lens with magnification of 5x and 30x for measuring temperature difference range -5 °C to 100 °C. They get to know that thermal infrared (TI) imaging was more efficient (SL). But we observe more animals by SI than TI.^{[6], [7], [8]}

Evans H Nguyen, Mathew J Mergener, Wade Bruch (2017 US patent) in their research study they got with a thermal detection device which include a visual camera, a controller, a thermal detector, a display, a user interface and a removable and rechargeable battery pack. It included additional software and hardware to perform all the operation. First both the output of visual and thermal camera are controlled by the software and then displayed into the screen. And this done by thermal imaging device in following manner. A visual camera configured to generate a first signal related to a visual image. An infrared sensor configured to display the visual image based on the first signal and the thermal image based on the first signal and the thermal image based on the second signal and a controller electrically control all the signal and display it on the screen.^{[9], [10]}

Abishini A H, Priyanka Das, Raque Bertilla A (2018) in their research study for advance under water redesigned undersea quad copter got with a conclusion that ABS plastic are lighter in weight, stronger in structure and are good for undersea flight as it proved to be corrosion resistant under sea.^{[16],[17]}

III. RESEARCH GAP

After reading some of the research paper we get to know that a quad copter has various structural and material demands along with that there are various field in which a quad copter can hold its caliber to perform to make work easier. We also got to know that it can also be used under water by using different material fabrications.

Further we get to know thermal sensing camera has a futuristic approach if we use this camera as a auxiliary equipment with the quad copter.

IV. METHORDOLOGY

After studying all the related paper reviews we have came up with an idea that to built a quad copter that will be multitasking not only in the required field but also could make it capable in different application uses. Thermal sensor infrared camera will help in detecting the amount of heat energy or even coldness that is generated by an object or system that further help in sense or detect any physical change to that temperature producing either by an analogue or digital output.

First of all we will be designing a quad copter that will enable the estimated weight of a camera to carry and fly for a longer duration of time. We will increase the time duration of flying with the same power battery available in market by introducing the gear system for rotating the rotors. The motor gears and rotor gear will be in the ratio 1:10 so that the power consumption for 3000mAh battery will be reduced to 300mAh for individual motor. It will provide larger rpm by consuming 1/10 of battery power and eventually increase the time duration of flight. Then we will place the camera in a suitable direction so that the degree of freedom for the camera to rotate in all the direction will be possible. We will be attaching some of the know sensors like the accelerometer, barometer, and the gyroscope along with that a electrical controlling unit board that will be connect with the radio transmitting device for controlling the quad copter.

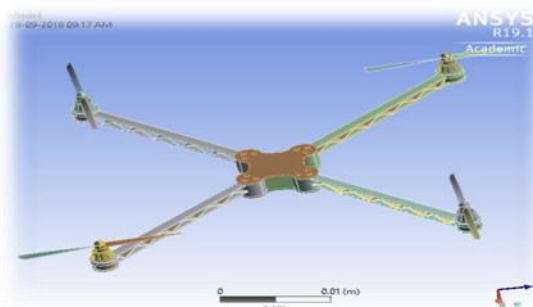


Fig 5: Proposed design of a quad copter using ANSYS 19.1

Material that we will use for building our quad copter will be carbon fiber that is composed of carbon atom bonded together to form a long chain. These fibers are strong and light and are used in many processes to create other building materials too. There are some properties of a carbon fiber material which makes it to our building material and these are; Carbon fiber has high strength to weight ratio, It is fire resistance and thus are non flammable, It has good fatigue resistance, It has Low coefficient of thermal expansion. We could have also use hard plastic as our material but carbon fiber is a small diameter fiber (or filament) made mostly of carbon atoms. So it's like carbon fiber is stiff, strong and light, as well as resistant to chemicals where as in hard plastic such things are not possible.

V. CONCLUSION

Our research concluded that by using thermo sensing camera, it is possible to determine and localize defects to pipeline insulation and leaks of the transferred media. (Gas or liquid Pipeline inspection with thermal diagnostics). And even in security purpose, as security is an expression that has become very common now a day, most frequent source of fear is the risk of entry by undesirable people (or animals) into buildings and onto land. Searching of these is not usually problematic in a day time but fog may appear, or the area may be intentionally smoked out then thermal sensing camera can play a good role in finding out these things. (Security applications using thermal imaging systems). Further it is also can be used in wildlife centuries where inspection for each and every creatures and animals is a difficult task, but with the use of a thermal sensing along with a quad copter it will be easy to count the number of species of same variety of animals and even to check the body temperature of animals which could help in detecting the infected animal from the rest (Wild life animal's body thermal checkup).

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