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# APPLICATION OF MECHATRONICS IN DESIGN AND CONTROL OF A QUAD- COPTER FLYING ROBOT FOR AERIAL SURVEILLANCE.

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## 1. INTRODUCTION:

Research and development of unmanned aerial vehicle (UAV) and micro aerial vehicle (MAV) are getting high encouragement nowadays, since the application of UAV and MAV can apply to variety of area such as rescue mission, military, film making, agriculture and others. In U.S. Coast Guard maritime search and rescue mission, UAV that attached with infrared cameras assist the mission to search the target [1]. Quad-copter or quad rotor aircraft is one of the UAV that are major focuses of active researches in recent years. Compare to terrestrial mobile robot that often possible to limit the model to kinematics, Quad-copter required dynamics in order to account for gravity effect and aerodynamic forces [2]. Quad-copter operated by thrust that produce by four motors that attached to it body. It has four input force and six output states (x, y, z, θ, ψ, ω) and it is an under1actuated system, since this enable quad-copter to carry more load [3].

Quad-copter has advantages over the conventional helicopter where the mechanical design is simpler. Besides that, Quad-copter changes direction by manipulating the individual propeller's speed and does not require cyclic and collective pitch control [4].

### 1.1 Problem statement

The main problem in quad-copter is the balancing and stability system. Most of quad-copter will be unbalance and lost stability in case there are disturbance direct on it such as wind. In this research, to solve above problem the full system of quad-copter is design and construct. Graphical user interface (GUI) is design in this research to make control task of quad-copter easier.

## 2. NEED & SIGNIFICANCE OF THE RESEARCH:

The quad-copter is proving to be a versatile tool that appears likely to support a number of markets and missions. Military missions, of course, are beyond the scope of our current project so we evaluated potential missions in the commercial and industrial sector that would be appropriate for the quad-copter that we are building. For example, we were thinking that the local police here on campus that have to spend many hours looking at parking permits on cars could send the helicopter out to fly down the car line and allow an operator to watch the onboard camera to see the permits. This would cut down on man hours as well as not wasting gas by driving around to inspect cars. Additionally, the quad-copter could be used during a campus incident to assess a dangerous situation without putting officers or first responders in harm's way.

### 2.1 Why to go for this research

A RC helicopter is a great toy and hobby to experience flight first hand, but when this helicopter technology is applied to a quad copter platform, there is potential for use beyond recreation. For example, Google Inc. has purchased several quad copters produced by Microdrones. Google plans to take advantage of the quad copter's exceptional stability which is a well-known characteristic of quad copters. These quad copters will be taking aerial photos for use in applications such as Google Earth. To achieve the desired level of high resolution photography and accurate imagery requires outstanding steady flight and hover conditions. Here this concept has very similar requirements to that of the Google mission.

## 3. SURVEY OF LITERATURE:

### 3.1 Quad-copter history

Etienne Oehmichen was the first scientist who experimented with rotorcraft designs in the 1920s. Among the six designs he tried, his second multicopter had four rotors and eight propellers, all driven by a single engine [5]. The Oehmichen used a steel-tube frame, with two-bladed rotors at the ends of the four arms. The angle of these blades could be varied by warping. Five of the propellers, spinning in the horizontal plane, stabilized the machine laterally. Another propeller was mounted at the nose for steering. The remaining pair of propellers was for forward propulsion. The aircraft exhibited a considerable degree of stability and controllability for its time, and made more than a thousand test flights during the middle 1920s. By 1923 it was able to remain airborne for several minutes at a time, and on April 14, 1924 it established the first-ever FAI distance record for helicopters of 360 m. Later, it completed the first 1 kilometer closed-circuit flight by a rotorcraft.

After Oehmichen, Dr. George de Bothezat and Ivan Jerome developed this aircraft, with six bladed rotors at the end of an X-shaped structure. Two small propellers with variable pitch were used for thrust and yaw control. The vehicle used collective pitch control. It made its first flight in October 1922. About 100 flights were made by the end of 1923. The highest it ever reached was about 5 m. Although demonstrating feasibility, it was, underpowered, unresponsive, mechanically complex and susceptible to reliability problems. Pilot workload was too high during hover to attempt lateral motion.

### 3.2 Recent Development

Recent quadrotors or quadropters which are being manufactured and used in aerospace industry are listed below:

1. Aermatica Spa's Anteos is the first rotary wing RPA (remotely piloted aircraft) to have obtained official permission to fly (Permit To Fly) issued in the civil airspace, by the Italian Civil Aviation Authority (ENAC), and will be the first able to work in non-segregated airspace [6].
2. Aero-Quad is an open-source hardware and software project which utilizes Arduino boards and freely provides hardware designs and software for the DIY construction of Quad-copters.
3. Ardu-Copter is an open-source multicopter UAV. Based on Arduino, it supports from four to eight motors, as well as traditional helicopters, and allows fully autonomous missions as well as RC control.
4. Open Pilot is a model aircraft open-source software project.

## 4. OBJECTIVES OF THE RESEARCH:

To achieve the goal of designing & implementation of this system we must

- Design and code a control system for the quad-Copter (move up, take-off, etc…)
- Design and code a sensor fusion algorithm for keeping the copter stable
- Design and build a power distribution system
- Design and build a chassis

**4.1 Specifications/Requirements of the system**

- Lift at least 500 gms of mass
- Must be able to hover at least 6 inches from the ground
- The Quad-Copter must communicate wirelessly at least 100m
- The Quad-Copter must be able flight for a minimum of 10 minutes (battery power)

**4.2 Research objectives**

The objectives of this project are:

(a) To design Quad-copter that can be controlled wirelessly based on computer OS or Android OS..
(b) To design graphical user interface to communicate and control quad-copter.
(c) To equip quad-copter with stereo camera to display video.
(d) To test the performance of designed quad-copter.

**4.3 Research scopes / constrains**

The scopes include the weather condition, distance and space:

(a) Quad-copter only can operate in sunny day or dry condition.
(b) Quad-copter operates distance not more than 100m in eye sight from the wireless receiver.
(c) Quad-copter is control by Arduino base microcontroller.
(d) Quad-copter is operated by brushless motor control by electronic speed controller.

**5. HYPOTHESIS, METHODOLOGY & TOOLS:**

Recent quad-rotors or quad-copters which are being manufactured and used in aerospace industry are mostly operated by using radio frequency remote controls only [7]. The proposed research is intended to design & built such a small radio controlled quad-copter with cameras attached to it to be controllable with OS or Android devices.

**5.1 Design concept**

The proposed design is as follows:

**Figure 1: Proposed designed concept**

**5.2 Approach**

The approach can be divided into two phases. The first phase is understanding the quad-copter structure and it basic mathematical modeling. The last phase is deals with design and construction of the Quad-copter. It will be built by splitting the design into different component whereby each component will be tested to ensure its working properly. This step is to minimize the risk of accidents which will lead to increasing number of component cost.

### 5.3 Quad-copter movement mechanism

Quad-copter can described as a small vehicle with four propellers attached to rotor located at the cross frame. This aim for fixed pitch rotors are use to control the vehicle motion. The speeds of these four rotors are independent [7]. By independent, pitch, roll and yaw attitude of the vehicle can be control easily. Pitch, roll and yaw attitude off quad-copter are shown in Figure 2.

The quad copter it’s a flying object, which flies with a help by four propellers, therefore is so called. Two opposite propellers rotates in one direction, for Take-off. First pair opposite propellers rotates in one direction for keeping balance in the Y-axis. Second pair opposite propellers rotates in opposite direction, for keeping balance In the X-axis. The main reason for opposite rotations of opposite pairs it's the elimination a rotation the quad copter in the Z axis.

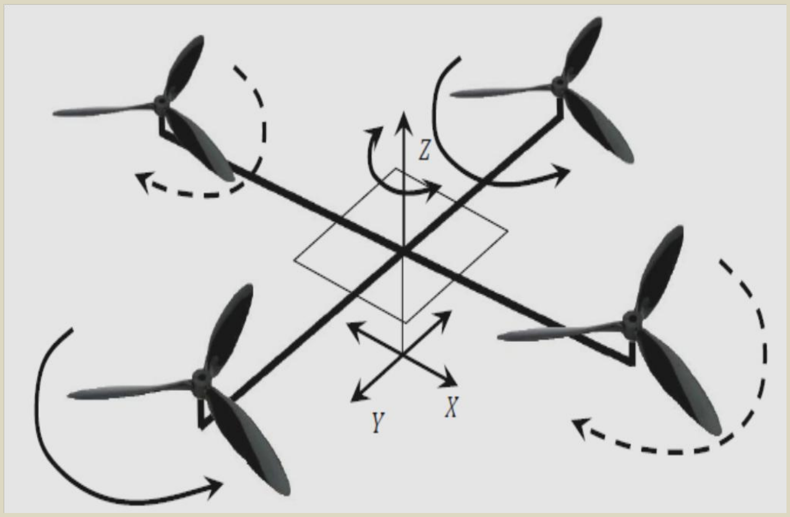


**Figure 2 Quad copter concept**

### 5.4 Flow chart & Quad-copter components:

Designs of quad-copter are divided into two stages that is part design in first stage and full interface at second stage. Flow chart of Quad-copter design is described in Figure below:

***Quad-copter components:***

1- Frame.
2- Microcontroller
3- Motors
4- Electronic Speed Controller (ESC).
5- Lithium Polymer Battery.
6- Propeller.
7- Inertial Measurement Unit (IMU Digital Combo Board).
8- RF receiver.

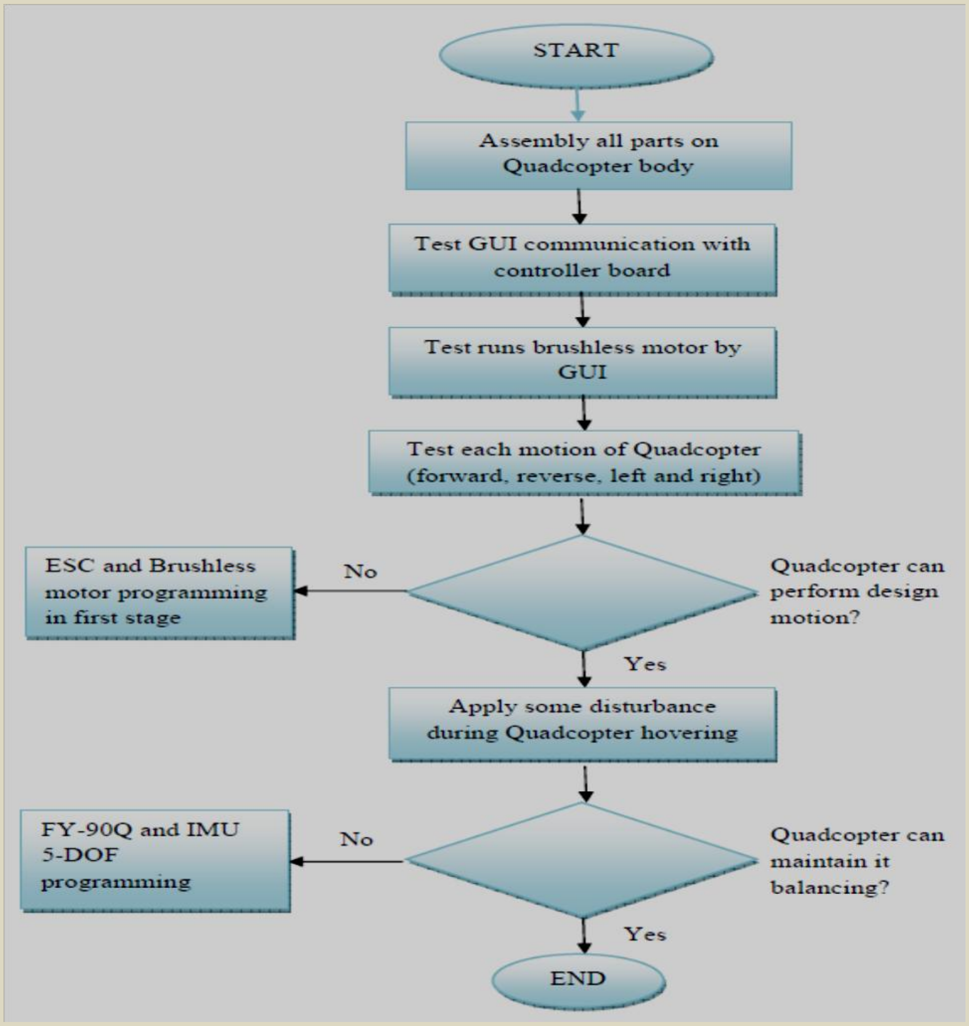


**Figure 3: Flow chart of quad-copter design**

## 5.5 Hardware & Component requirement

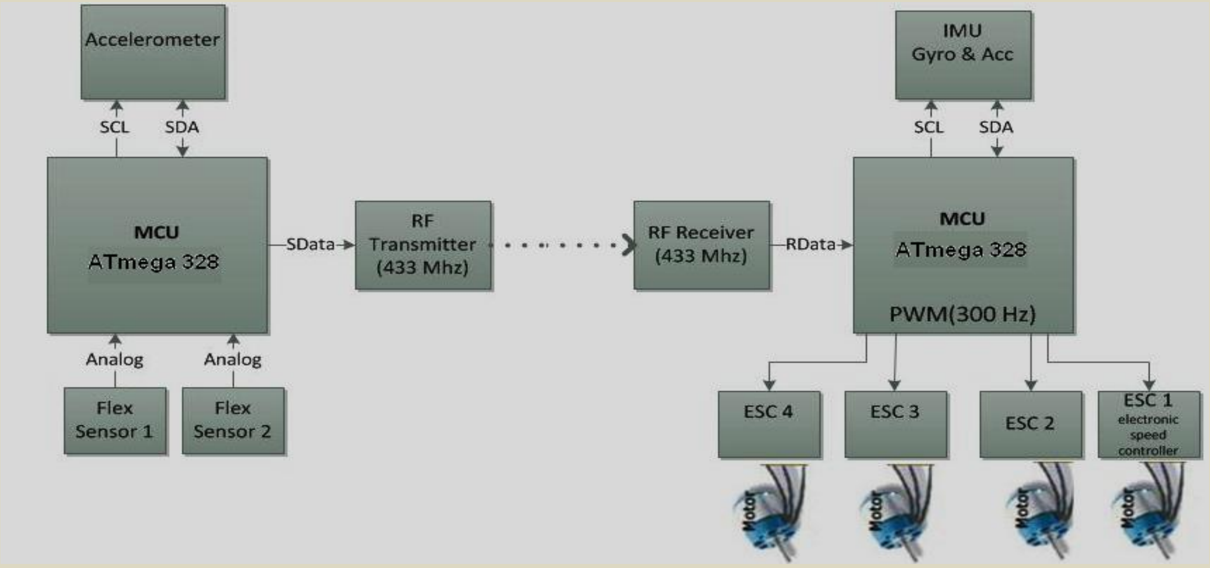

**Figure 4 Hardware Implementation**

## 6. CONCLUSION:

Several issues encountered in this research and we continue to work on outstanding issues. Although a lot of work remains, optimistically we will continue the research. When the basic flight control systems are complete, the quad-copter will be ready for experimental missions. At that point the project could go in a variety of directions since the platform seems to be as flexible as we initially intended. Occasionally small corrections are still needed to keep the quad-copter in one spot. Better settings of controller, for example with using another method for finding the controller actions or use a better control method it may help for a better stabilization. Also it is possible to refine the positioning in space by adding more sophisticated filters. On flight of the quad-copter acts also the wind effect, therefore it is needed to include this effect into the overall stabilization. The remote control over a mobile application works very well. Now is implemented a basic control of the quad-copter with possibility turn on/off controllers. Into the future can be added some advanced control functions for special maneuvers. One of the many advantages of the quad-copter is ability to fly on places, which are for human complicated to reach or so quickly as he and with the help of a camera is possible explore inaccessible locations. With added devices we can to determinate a flight path or track some objects.

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