IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 1 Issue 4, June 2014.
www.ijiset.com
ISSN 2348 - 7968

Self Stabilized Fire Fighting Quadcopter: A Conceptual Prototype

Amit Pandia

Department of Computer Science, Jodhpur Institute of Engineering and Technology
Jodhpur, Rajasthan

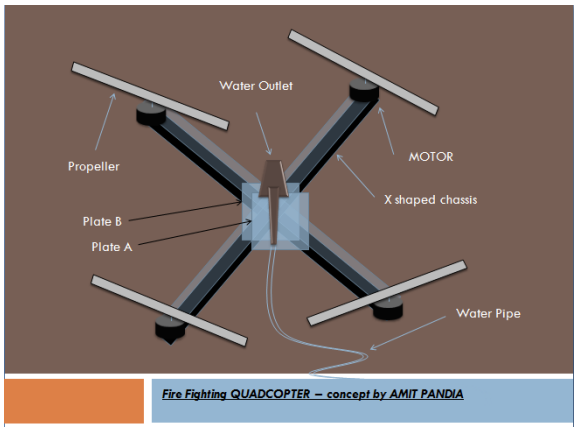
***Abstract*— Quad copters are small helicopters having four propellers. They are used as toys and are also used by army for inspecting a particular area. This paper explains the design, preparation, working and controlling algorithm of a fire fighting quadcopter prototype. The target of this paper is to explain this prototype briefly so that it could be used for fire fighting and can help our society. This paper also describes briefly about the components used in the design and their ratings. At many of the places notations are provided with the heading 'NOTE:' to explain the working and sources of error during the preparation and controlling algorithm. The paper also gives a brief algorithm for the self stability of this prototype and the balancing verification procedure for the prototype.**

***Keywords*— Quad (used for quadcopter).**

I. INTRODUCTION

This prototype is designed for fire fighting and reaching in unreachable areas during fire hazards. The key property of this prototype is that is remains stabilized in the air during its work. This is because of the algorithm used to control it. It is very easy to use this prototype. Even a 10 year old child can control it easily. Its strength lies in its controlling algorithm and the fact that using this quadcopter a person sitting on wheelchair can also work with equal strength as that of a completely fit fireman. This quadcopter can be easily mounted on the top of fire brigades and can act as a part of it also it has the ability to reach to higher storey of building in very less time as compared to the conventional method of taking a fireman to that storey using a crane.

II. PROTOTYPE DESIGN



III. LIST OF COMPONENTS AND DESCRIPTION

(i) Motors- These are dependent on the chassis size. For the prototype four 980 kv brushless dc motors were used, each weighing 30 grams. Each motor produce a thrust of 850g. Collectively all the motors were able to produce net thrust of (850x4=520 g) which was sufficient to lift quadcopter along with the pipe and hose.

(ii) Chassis- The chassis is in the shape of X as shown in the picture. Its length depends on the size of quadcopter. For the prototype design, the chassis had an angle of 75 degree between the two bars of chassis forming X shape. The length of each bar was 12 inches.

(iii) Propellers-10 inch carbon fiber propellers were used in the prototype to keep it light weight. During rotation propellers present on the same bar of chassis keep a minimum gap of 2 inches between each other.

(iv) Water pipe- A thin and light weight water pipe was used in the prototype so that the pressure of water could be more.

(v) Plate A and B- These are simple aluminum plates used for mounting camera, circuit and hose on the quadcopter.

(vi) Battery- A standard lithium polymer battery of 11.1 volts and 5000 mAh was used in the prototype, but AC to DC battery adapter can also be used.

(vii) Water pump- Any water pump can be used. The flow and pressure of water can be controlled using a tap which is connected in between of water pipe.

(viii) Camera- For the prototype a USB webcam was used because of light weight.

IV. HOW TO PREPARE

1. Arrange all the components and cross check them with the list.
2. The chassis should be made of aluminum (to make the quad light weight).
3. The chassis should make a pair of alternate opposite angles of 75 degree.(so that it will get its X shape).
4. Mount four motors on the corners of X shaped chassis.
5. Fix Plate B on the intersection of the bars of chassis.(Note: plate A and B both are of Aluminum)
6. Fix the circuit on plate B.
7. Now fix plate A on plate B in such a way that a minimum gap of 1 cm is left between the height of the circuit elements and plate A.
8. Make connections of the circuit with motors.
9. Fix all the propellers on the motors.
10. Mount The Camera to Plate A and connect it to the main circuit.
11. Fix the hose below plate B on the lower side of chassis and connect it with water pipe.
12. Connect the other end of pipe to the water pump.
13. Now connect a 12 volt DC battery with the circuit using 15 feet long wires.

NOTE: battery and water pump will remain at ground that is why the length of supply wire is kept long.

The preparation is done and quad is ready to work.

V. HOW IT WORKS

Quad copter is connected to hose and is made to fly to the fire zone. It is then used to target the fire by turning in the direction of fire. The camera mounted on the quadcopter gives the live view of the situation. Lens of the camera is marked with a vertical dash '|' which acts as an aiming mark for the hose. Water supply and pressure is controlled using the pumping motor kept on the ground. To make the quad independent of power supply the power is supplied through wires. The wires contain DC supply and run parallel to the hose. The remote control is wired, to reduce complexity in preparation. One more reason is that the whole prototype is wired so it is illogical to make remote wireless.

VI. CONTROLLING ALGORITHM

(i) FLY

1. Front left motor rotates in clockwise direction.
2. Front right motor rotates in anti clockwise direction.
3. Rear left motor rotates in anti clockwise direction.
4. Rear right motor rotates in clockwise direction.

Note: Voltage supplied to all the motors should be same so that the rpm of each motor becomes equal and thrust applied by each propeller on the ground is same.

(ii) HOVER

1. Check the voltage supplied to all the motors.
2. Reduce the voltage of all the motors the minimum value of voltage which was received by performing step 1.

Note: Thrust must be just equal to gravity or slightly greater than it to keep the quad stable in air. The voltage at which quadcopter hovers successfully is here called hovering voltage.

(iii) TILT

1. Reduce voltage of the motors of that side in which quad is to be tilted.
2. Increase the voltage of other three motors.

Note: The reduced voltage must not be less than hovering voltage. If the voltage becomes less than hovering voltage then the quad will flip in the direction in which we wanted to tilt it.

For Example: If quad is to be tilted in right side, so the voltage of front right and rear right motors is reduced and the voltage of front left and rear left motors is increased.

(iv) FORWORD MOTION

1. Decrease voltage of front left and front right motors.(voltage should not be less than hovering voltage).
2. Increase voltage of rear left and rear right motors.

(v) REVERSE MOTION

1. Decrease voltage of rear left and rear right motors.(voltage should not be less than hovering voltage).
2. Increase voltage of front left and front right motors.

(vi) MOTION IN RIGHT SIDE (WITHOUT TURNING)

1. Decrease voltage of front right and rear right motors.(voltage should not be less than hovering voltage).
2. Increase voltage of front left and rear left motors.

(vii) MOTION IN LEFT SIDE (WITHOUT TURNING)

1. Decrease voltage of front left and rear left motors.(voltage should not be less than hovering voltage).
2. Increase voltage of front right and rear right motors.

(viii) RIGHT TURN

1. Decrease voltage of front right and rear left motors.(voltage can be less than hovering voltage).
2. Increase voltage of front left and rear right motors.

(ix) LEFT TURN

1. Decrease voltage of front left and rear right motors.(voltage can be less than hovering voltage).
2. Increase voltage of front right and rear left motors.

(x) SELF STABILITY DURING HOVERING

1. Call hover function.
2. Save values of x, y and z coordinates in three different variables.
3. If x, y and z coordinates changes without input from the remote, then it means that the quad is displaced from its position without taking the input from the user and it needs to get to its earlier position.
4. If current value of x axis > stored value of x axis, fly down else fly up.
5. If current value of x axis = stored value of x axis go to step 6 else go to step 4.
6. If current value of y axis > stored value of y axis, fly left else fly right.
7. If current value of y axis = stored value of y axis go to step 8 else go to step 6.
8. If current value of z axis > stored value of z axis, fly backward else fly forward.
9. If current value of z axis = stored value of z axis, do nothing else go to step 8.
   (quad copter's position is restored).

(NOTE: Self stability during hovering is the most important part of the working of quad because it restores the change in position of the quadcopter caused due to any external source. This stability is

necessary for quad to splash water perfectly on its target. Also it balances the reverse force exerted by the water coming out of hose.)

VII. BALANCING VERIFICATION PROCEDURE

1. Tie one side of a rope to the center of the quadcopter and other side of the rope to a hook present at the ceiling of the roof so that the quad gets freely suspended in the air (same as that of a pendulum).
2. Check that all the propeller motors are at equal distance from the center of chassis.
3. Switch on all the motors.
4. If the quad flies vertically (i.e. making an angle of 90 degrees with floor), it means that it is perfectly balanced.
5. If the quad tilts towards the direction of any single motor, then the motor needs to be repositioned in outward direction from the center of chassis.
6. If the quad tilts in such a way that two motors are higher than the other two, then the motors which are lower needs to be shifted towards outward direction from the center of chassis.
7. Since quad has to carry water pipe and hose so it may tilt in such a way that its front motors raise higher than the rear motors. In such case reduce the voltage of the front motors to keep the quad in perfectly horizontal position.
8. To verify self stability, give a slight displacement to the freely suspended quadcopter. The quad shall be self stabilized in some seconds. If it does not get stable at all, check for the logical errors in the program for self stability.

VIII. CONCLUSIONS

- This quadcopter is an effective and an easy to use device.
- It can reach at those places where sometimes it becomes impossible for humans to reach.
- It can work for long hours without any problems.
- Even a person sitting on wheelchair can also contribute to help people who are stuck in the building.
- Children can also control it.
- There is no need of physical fitness of the controller.
- It can reach high in very less time as compared to the time taken by human beings.

IX. FUTURE DEVELOPMENTS

- It can be made completely autonomous using temperature sensors and image recognition techniques.
- Along with fire fighting it can be used to carry small first aid kit so that the injury can be treated at the primary level till the injured person is rescued from the building.
- It can be connected to a global positioning system so that the position of quad and people to be rescued can be easily traced.

X. REFRENCES-

[1] http://en.wikipedia.org/wiki/Quadcopter

[2]http://quadcopterproject.wordpress.com/static-thrust-calculation/

[3]http://wiki.openpilot.org/display/Doc/Basic+Quad Copter

[4] http://en.wikipedia.org/wiki/Pipe_flow