Energy Management of UAV (Quadcopter)

Vivek A, Ashutosh Kumar, Vishnu A Krishnan and Karthik Gopal R

Abstract :- A Quad-copter (Unmanned Aerial Vehicle) is basically a multi-rotor helicopter that is lifted and propelled by four rotors (two clockwise and two counter clockwise). The power distribution on four rotors in a quad-copter is independent. In this project a similar family of UAV is used and distribution of power on its four different rotors is minimised, so it takes less energy to traverse to its delivery points and back to initial point. Project mainly focusses on energy management of UAV's. In addition to energy management, we have also decided to add charging points in between the delivery points so that the UAV can be recharged in case of less charge.

Index Term:- A Quadcopter, Arduino Board, Medical Delivery Points, Charging Points.

I. INTRODUCTION

In recent years, the experiments on quad-copters with latest technology available has brought out many extra features and increased the manoeuvrability and hovering abilities. Nowadays, these quad-copters are widely used in the field of communication, Defence services like surveillance pf particular area, information gathering using high definition cameras. The charging of the quad-copters is also nowadays of less concern because of wireless charging spots. These quad-copters are also used in delivering medics and food items to areas where human help is not possible. The main application of these quad-copters can be in Military and Law Enforcements, Photography, Journalism, Humanitarian Operations, Art, Sport etc. In most of the cases, quad-copters are being used by peoples for photography and recording. In Defence sectors, it is used for surveillance and target tracking and locking. In this project we have planned to analyse the various situations in which mainly the main concentration has been on delivery of medicines in times of medical emergencies. We are mainly focusing on the energy management of the quad-copter by making it cover all the emergency points in an energy efficient way.

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This is achieved by calculating the distance of all points from a fixed initial point of the quad-copter in 2-D space and traversing the minimum distance path. The same procedure was followed after reaching the first delivery point. This continues till the next delivery point. The main logic behind this is that if the quad-copter travels the less distance each time it takes off, this makes less energy consumption for the whole journey. A number of situations are considered and path planning of the quadcopter is according to the distance from quadcopter to all the test points. Here, the quadcopter chooses the least distance point and then from that point to the next least distance point. This makes sure that there is proper energy management of the battery in quadcopter. We have developed an algorithm which is used for path selection. In addition to this, charging points are incorporated in between the delivery points. In recent years of research papers on quad-copter the cross and plus models of quad-copter's altitude linear control scheme has been performed in which a cascade PID controller is used and an algorithm is generated for control scheme. Two PI controllers were used in series for control strategy with consideration of external disturbances [1]. Use of different kinds of control strategies in quad-copter has always been the topic of innovation. One of the strategies used in [2] is Computer torque control for VTOL capabilities. This control strategy surpasses PID mechanism in many difficult and complex situations. "Mikrokopter" which is a open source quad-copter, yet another type distinguished by it's in build sensors and uses a different kind of control mechanism called as "Nested Loop Structure." The results from multi-rate velocity estimator and closed loop control mechanism are compared with ground truth from a motion capture system [3][4]. Later on experiments were conducted on comparing Dynamic models of two quad-copters including Translational dynamic using Euler-Lagrange method and rotational dynamic using the Newton-Euler method [5][11]. Later on more and more features were added in the quad-copters which enhanced the utility of the quad-copter for better and more versatile manner. New features installed in the quad-copters included Open-source RC transmitters and receivers, Open LRS transmitter, open LRS receiver, and OSRC transmitter. Autopilot feature was on the run. Many in build sensors were introduced for navigation and detection purposes [6][10]. During these times any quad-copter in the market was fully installed with all kinds of current additional features to attract viewers. This also marked the rise in

the price of quad-copters. There has also been some innovations in decreasing the cost of quad-copters using low cost microcontroller-based Hover control design in which flight control is made simpler by making the quad-copter fly at constant level height and also making manoeuvring easy [7][9]. A small-fixed wing aircraft's path planning modified using in build wind velocity sensors sensing wind speed. The path planning is majorly affected by aircraft's flight structure and kinematics and wind estimate [8][12].

II. SITUATION AND ITS REACTION

A. Explanation of the Situation

In the situation considered main emphasis is given to flight duration capability of a quad-copter by making it consume less power so as to cover all its destination points in accord with Energy Conservation principle. So to achieve that a medical operation scenario is designed. In that scenario four of delivery points are considered along with the initial position of the quad-copter. The quad-copter is made to respond to these delivery points as soon as the signal is received from them.

B. Analysis of the situation:

Basically to manage the power consumption quad-copter is made to move in 2-D space by calculating the distance using a Distance Formula.

[Eq. 1]

$$d = [(x2-x1)^2+(y2-y1)^2]^{1/2}$$

Quad-copter can be made to travel to any of the delivery points as per the least distance covering strategy. By making the quad-copter travel through delivery points in this strategy brings out the idea of consuming less energy to travel between delivery points.

SIMULATION RESULTS OF PATH PLANNING

Path Planning Of the quad-copter *For the path generation of quad-copter, a Matlab algorithm is generated and simulation results were obtained. Firstly, the distance from the initial point of quad-copter to the rest of the delivery points is calculated. Secondly, algorithm analyses the least distant point from the initial point and quad-copter maps the nearest point from its initial point. This is done again from the current point of the quad-copter only this time previous initial point of the quad-copter is not into consideration. This is repeated until all the delivery points are covered. This process makes it easy for the driver/autopilot to understand and assimilate whether quad-copter can travel the next delivery point depending on the charge in the battery of quad-copter.*

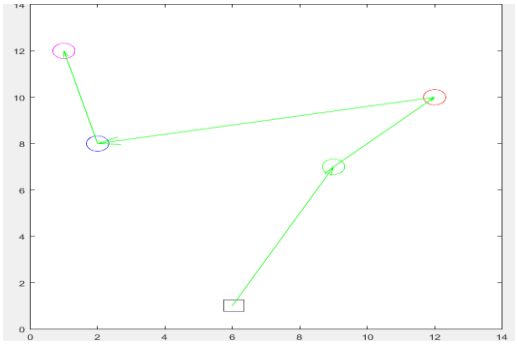

Fig.1a Quad-copter trajectory with distant delivery points.

C. Path Planning with Equidistant Delivery Points:-

When the delivery points are equidistant from initial position of the quad-copter and also from all the delivery points then it becomes difficult to apply the least distance strategy introduced. To overcome the given situation priorities were set to ensure the correct mapping of the delivery points. For that delivery points with Emergency will set a Flag to signal the quad-copter and it will try to map the same point delivery point first and after that it will go on with calculating least distance henceforth and map them.

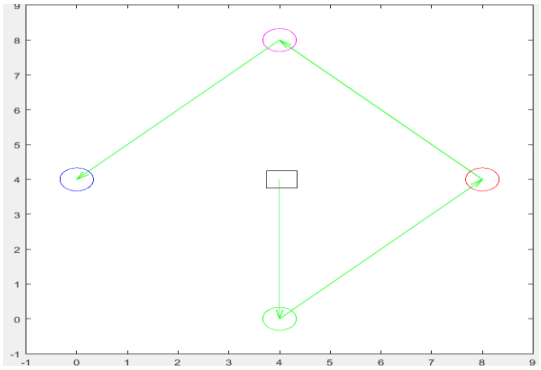

Fig. 2a.Zrajectory of quad-copter with equidistant delivery points with emergency at [4,0] [Eq. 1]

D. Path Planning of the quad-copter when there is two Emergency points:-

When there is two emergency points, one thing that can be done is setting different coloured flags at both different destinations and give priority to one of them. Here in one of the simulation results we are including two different coloured points as red and black. Here the priority is given to red point first and then to black. After responding to these two points other delivery points are covered.

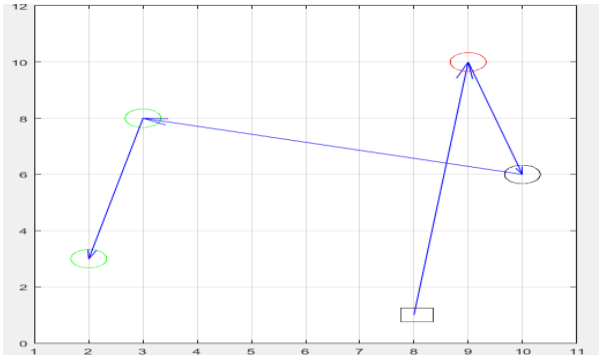

Fig. 2c. Trajectory of quad-copter with two Emergency points

III. INTRODUCTION AND MAPPING OF CHARGING POINTS:-

The path planning of the quad-copter is indeed based on the least distance strategy introduced above but the charge has to wear off sometime, so to complete the entire path planning of the quad-copter installation and mapping of charging points is an important factor to be considered. So to continue with that some charging points were introduced near the delivery points for the quad-copter to charge itself when there is a deficiency of charge in them. To make it possible in the simulation of the quad-copter path design, Firstly, speed of the quad-copter was constant and no variation in the speed is considered. Secondly, distance travelled by the quad-copter got calculated at every instant. Thirdly, using that distance, Time is calculated instantaneously. For calculation of all the above parameters a table of battery discharging rate Vs. Time of the battery used was taken into account. We referred and selected a time where the charge of the battery was going below the minimum level. So once the quad-copter has travelled for that period of time it required a charging point to get charged and was made to go to nearest charging point after reaching the deadline. In Fig.3a orange, blue and red colour points are charging points introduced and after the second point it went to charging point C3 (orange) and back to P3 and P4.

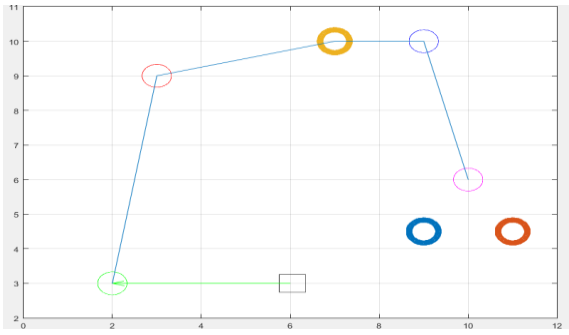

Fig.3a. Introduction of charging points in the quad-copter path planning

IV. CONCLUSION

In this paper we discussed how energy management can be done using on the quad-copter by path planning of the quad-copter. Using distance formula as an equation to calculate the distance and choosing the efficient energy path for the quad-copter to map. Different scenarios were considered which depicted the various situations in which the quad-copter has to travel to destination points. Later charging points were introduced and mapped for the quad-copter to get charged while travelling to delivery points. In practical sense of this paper, while there is two emergency points or more than that then a signal can be generated by the on field quad-copter to the master station and more quad-copters can be sent to the locations of emergency. This can be applied to the major rescue operation situations or maybe to more surveillance destinations. As far as charging of the quad-copter is considered wifi-charging of these quad-copters can be done on the spot for better field performance.

REFERENCES

[1] PengCheng Wang,Zhihong Man,zhenwei Cao,Jinchuan Zhing,Yong Chao.”Dynamics modelling and linear Control of quadcopter”,2016 International Conference on Advanced Mechatronics systems(ICSmechS),30 nov-3 dec,2016.
[2] . E Balasubramanian,R Vasanthraj,”Dynamic modelling and control of Quadrotor”,vol .5,pp 63-69,feb 2013
[3] I. Sa,P.Corke,”System Identification estimation and control for a cost effective open-source quadcopter”,Robotics and Automation (ICRA) IEEE International Conference ,pp.2202-2209.2012
[4] Y.R.Tang,Y.Li,”Dynamic modelling for high performance controller design of a UAV quadroter” Information and Automation 2015 IEEE International Conference,pp.3112-3117,2015.
[5] J.d.J.Rubio,P.Cruiz, Z. Zamudio A. Salina “Compaison of two quadcopter dynamics IEEE Latin America Transactions,vol.12,(531-537,2014)
[6] H.Lim, J.Park,D.Lee,H.J.kim,”Build your own Quadrotor: Open source projects on Unmanned areal vehicles”,IEEE Robotics &Automation magazine,vol.19,pp.33-45,2012
[7] Bernard Tat, Meng Leong, Sew Ming Low, Melaine Po-Leen Ooi,”Low-cost Microcontroller(IRIS 2012).
[8] Sebastian Bendess Andreas Wenz,Tor Anne Johannson,”Adaptive path planning for unmanned aircraft using Inflight wind velocity estimation”,2018 International conference on unmanned Aircraft systems(ICUAS),Pallas,Texas,USA.
[9] Vivek A, Nandagopal J L Purushothaman A, ”Compound Optimal Docking of Multiple Spacecraft’s with Formation Reconfiguration”, ICCAR
[10] Jayasree K R, Jayasree P R Vivek A,” Implementation of SRRT in Four Wheeled Mobile Robot”,ICSCS 2018
[11] Sini S, Nandagopal J L, Vivek A,”DEVELOPMENT AND CONTROL OF LABORATORY HELICOPTER”, TAP ENERGY.
12. Jayasree K R, Jayasree P R Vivek A, ”Smoothed RRT Techniques for Trajectory Planning”, TAP ENERGY.

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