Hexacopter Construction, Autopilot Installation and Flight Testing

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Abstract- Flight data are required to design a control system of a hexacopter. In this paper a hexacopter has been constructed, flight test has been done by using autopilot. Roll, pitch and yaw data are collected and has been plotted.

Indexed Terms- Hexacopter, Pixhawk Autoilot, and Flight Test data

I. INTRODUCTION

A hexacopter is amulticopter with six motors and propellers [1]. Comparing with other multirotor type such as quadcopter and octocopter, it has many advantages including good payload carrying ability with good flight time [1, 2,]. It is a good platform for aerial filming, photographing with DSLR camera produced by SONY, Canon or Nikon [3, 4, 5].A hexacopter is usually unstable flight platform. It is very difficult to fly without an assist of an autopilot or stabilizer. Many researches has been conducted with various approaches by many researchers. In ref. [1] the mathematical model is identified from experimental data and controller is designed. In [2] controller design is validated with experiment. Flight test data acquisition is discussed in [6]. There are many commercial autopilotsto control a hexacopter, such as ardupilot, pixhawk and Naza DJI controller but these autopilot are needed to tune or adjust according to each type of platform. In this paper, we propose a method to construct a hexacopter, to install an autopilot and conduct flight test for data acquisition.

II. PROBLEM STATEMENT

Flight test data are important and needed for system identification or todesign controller. To collect flight test data from real flight, it is needed to construct a hexacopter and to conduct flight test.

III. HEXACOPTER DYNAMICS

The dynamics of a hexacopter can be represented by statespace model as presented in ref. [3]. The equation [1] and [2] is state space form of hexacopter dynamics.

$$\dot{x} = Ax + Bu$$

$$y = Cx + Du \qquad \ldots\ldots (1)$$

$$\begin{bmatrix} \dot{u} \\ \dot{w} \\ \dot{v} \\ \dot{p} \\ \dot{q} \\ \dot{r} \\ \dot{\phi} \\ \dot{\theta} \\ \dot{\psi} \end{bmatrix} = \begin{bmatrix} x_u & 0 & 0 & 0 & x_q & 0 & 0 & x_\theta & 0 \\ 0 & y_v & 0 & y_p & 0 & 0 & y_\phi & 0 & 0 \\ 0 & 0 & z_w & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & l_v & 0 & l_p & 0 & 0 & l_\phi & 0 & 0 \\ m_u & 0 & 0 & 0 & m_q & 0 & 0 & m_\theta & 0 \\ 0 & 0 & 0 & 0 & 0 & n_r & 0 & 0 & 0 \\ 0 & 0 & 0 & \phi_p & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \phi_q & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \psi_r & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} u \\ v \\ w \\ p \\ q \\ r \\ \phi \\ \theta \\ \psi \end{bmatrix} +$$

$$\begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & z_{u_{vert}} \\ l_{u_{lat}} & 0 & 0 & 0 \\ 0 & m_{u_{lon}} & 0 & 0 \\ 0 & 0 & n_{u_{dir}} & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} l_{u_{lat}} \\ u_{lon} \\ u_{dir} \\ 0u_{vert} \end{bmatrix} \qquad \ldots\ldots. (1)$$

To identify the parameter of the hexacopter or the matrix**A,** input and output data are needed to collect from flight test.

IV. HEXACOPTER CONSTRUCTION

In this research a hexacopter is constructed from Tarot 680 hexacopter kit. This hexacopter has 680 mm from one opposite arm tip to another [13, 14].First we need to construct center hub for arm. After that, arms are assembled to the hub. Arm must be equippedwith motor mounts. 680 hexacopter is a foldable one not only for arm but also for landing skids. Steps by step construction are shown in Figure 1 to 4.

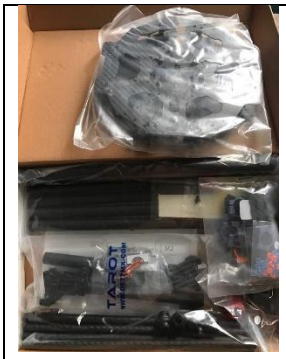

Fig. 1 Hexacopter Kit

Fig. 2 Center Hub construction

Fig. 3 Landind Skit Assembly

Fig. 4 Hexacopter Frame

V. POWER SYSTEM SETUP

The hexacopter is power with six Tarot 4108 380KV motors and 13 inches propellers. This motors are used with hobby wing 40A electronic speed control (ESC) and Tattu 6S battery. ESCs are connected to power distribution board and Pixhawk. Power distribution board is needed to solder the wire to connect with six ESCs. Power System and motors installation steps are shown in Fig. 5 to 9.

Fig. 5 Power Distribution Board

Fig. 6. Power Distribution Board (Lower Part)

Fig. 6. Power Distribution Board with Soldered Wire

Fig. 7. Power Line Installation

Fig.8. Motors Installation

Fig.9. Hexacopter after Hardware Installation

VI. AUTOPILOT INSTALLATION AND FARM WARE STETUP

Pixhawk Cube autopilot is chosen as flight controller for our hexacopter. Pixhawk Cube or Pixhawk 2.1 is a open source autopilot and one of the outputs of pixhawk project [11]. This version of autopilot includes cube section on the top of the autopilot for magnetic compass and inertial measurement unit (IMU) which include accelerometer and rate gyro [11]. This autopilot is added with Here GPS. For controlling hexacopter, hexacopter firmware is needed to install into pixhawk cube autopilot. After firmware installation remote control radio and

sensors like accelerometer and compass are needed to calibrate. After preparing and checking requirement, the hexacopter is rady for flight test. Firmware installation and other require steps are shown in Fig 10 to 17.

Fig.10. Pixhawk Cube Autopilot

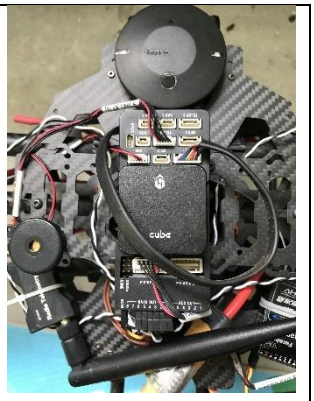

Fig.11. Pixhawk Cube Autopilot and Here GPS on the Hexacopter

Fig. 12. Firmware Installation by Using Mission planner

Fig. 13. Choosing Hexa Platform

Fig.14. Detecting Controller Board

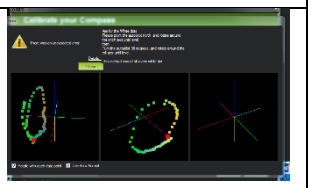

Fig. 15. Compass Calibration

Fig. 16. Radio Calibration

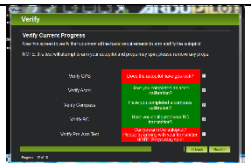

Fig. 17. Final Step of Firmware Installation

VII. FLIGHT TESING

After preparing and checking all requirements, the hexacopter is firstly conducted flight test by using Futaba Radio Control system. The pixhawk autopilot can fly stabilized flight mode with radio control (RC) system or with predefined waypoints following autopilot mode. Flight test pictures are shown in Fig. 18-23.

Fig. 18. Futaba Radio Controller

Fig. 19. Ground Check

Fig. 20. Take off Flight

Fig. 21. Stabilized Mode Flight

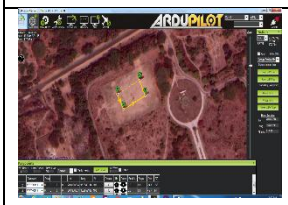

Fig. 22. Waypoints Mission Planning (Autopilot Mode)

Fig. 23. Waypoints Following Autopilot Mode Flight

VIII. FLIGHT DATA ACQUISITION

Pixhawk use double loops PID attitude controller.Pitch channel control structure is shown in Fig. 24. The same control structure is used for roll and yaw channel. Flight Data can be save and plot in mission planner. In the following figures roll, pitch and yaw data graph are shown.

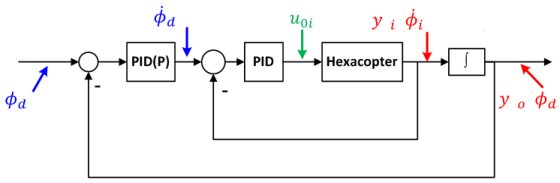

Fig 24. Pitch Channel PID controller.

Fig. 25. Roll Data Plot (Red Line is Desired Input and Green Line is Actual Output)

Fig. 26. Pitch Data Plot (Red Line is Desired Input and Green Line is Actual Output)

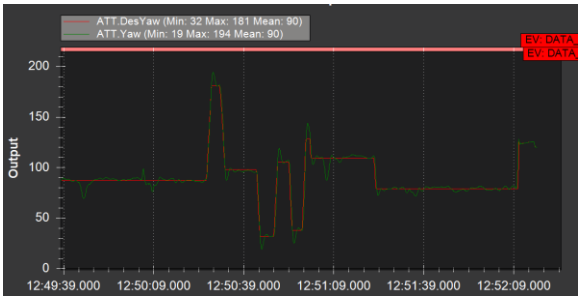

Fig. 27. Yaw Data Plot (Red Line is Desired Input and Green Line is Actual Output).

IX. CONCLUSION

The hexacopter has been constructed and an autopilot has been installed. The flight test has been successfully conducted and flight data are collected and plotted. It is still needed to check compatibility of data for system identification or controller design. More flight test may be needed.

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