Robotics Studio 4: Quadrotor three – Proposal

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**I. Introduction**

The quadrotor is a 4-rotor Unmanned Aerial Vehicle (UAV), which contains the maneuvering ability of traditional helicopters with lower mechanical complexity [1]. Because of the maneuvering ability, the quadrotor becomes a tool helping users completing desired tasks in a dangerous or inaccessible environment. Furthermore, the quadrotor is usually used [1] in research of developing control laws. To have a better understanding of control laws and its application, our group decided to research this topic.

Regarding to the COVID-19 situation and limited time, we limit the scope of study as follows:

1. The action of a quadrotor is limited to hovering, which means translation in the x-y plane and orientation do not occur.
2. The input of the closed system is height.
3. The quadrotor’s behavior is controlled by torque in the x, y, and z-axis; and force in the z-axis.
4. The study is limited to the simulation process.
5. All physical parameters of the quadrotor are constant.
6. At least two sensor types are used: 6-axis IMU (3-axis accelerometer; and 3-axis gyroscope) and range sensor.
7. The simulation result is visualized as the movement in a 3D plane; graphs of position signal and rotation signal are plotted against time.

**III. Working of Individual System**

*2.1 Quadrotor Model and Control System*

The quadrotor is a vehicle having four propellers in a cross configuration. The two pairs of its propellers rotate in the opposite direction for the control purpose in figure 1[1]. The hovering action occurs when the propellers have the same speed. Otherwise, it will create rotation.

Diagram, shape, circle

Description automatically generated

Figure 2.1: results of adjusting each propeller’ speed [1]

The controlling system of the quadrotor composes of 3 subsystems: attitude control, altitude control, and lateral flight [3]. In this report, we will focus on attitude and altitude control for hovering action.

In hovering control, [1]H. Bolandi suggested that x, y, z, roll, pitch, and yaw can be controlled by independently varying four rotors’ speeds. This solution is possible because all variables are linearized (in a hovering situation, the derivative of variables is zero). However, this solution can’t be used in any further development—possible to hovering control only.

According to [2]T. Bresciani, controlling the quadrotor, 6-degree-of-freedom vehicle, with four rotors can reach a maximum of 4 DOF. He stated that in the body frame, the four best controllable variables are thrust (the movement along the z-axis), roll (the rotation about the x-axis), pitch (the rotation about the y-axis), and yaw (the rotation about the z-axis). Due to the complexity of frame reference, Bresciani’s solution is not suitable for this study. To simplify the difficulties in changing frame reference, we decided to control the torque and thrust in its body frame and modeled the system in a global reference frame.

To understand the physics of the quadrotor and its behavior, dynamics and kinematics knowledge are applied. The study of dynamics in FRA131 (Basic Mechanics for Robotics and Automation Engineering) supports the understanding of the behavior of the quadrotor and creates its state space. The kinematics study in FRA333 (Kinematics for Robotics System) helps us deal with variables in different frames (between global and body frame).

*2.3 Sensor Modeling*

ในทางปฏิบัติตัวแปรที่จะส่งผลต่อการทำงานของระบบควบคุมจะได้รับผ่านการส่งข้อมูลจาก sensor ซึ่งในโปรเจคนี้ sensor ที่จะทำการจำลองขึ้นมานั่นก็คือ Inertial Measurement Unit (IMU) โดยจะประกอบไปด้วย 3-axis gyroscope และ 3-axis accelerometer

*2.4 Sensor Estimation*

**IV. Testing case**

ในการทดสอบจะทำการทดสอบการเคลื่อนที่ขึ้นลงที่ระยะต่างๆตามที่ต้องการโดยจะทำการจำลองผ่าน Simulink และการ plot กราฟจาก MATLAB

# **References**

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| [1]  [2] | H. Bolandi, M. Rezaei, R. Mohsenipour, H. Nemati and S. Smailzadeh, "Attitude Control of a Quadrotor with Optimized PID Controller", *Intelligent Control and Automation*, vol. 04, no. 03, pp. 335-342, 2013. Available: 10.4236/ica.2013.43039.  T. Bresciani, "Modelling, Identification and Control of a Quadrotor Helicoptor", M.S. thesis, Automation Control, Lund Univ., Lund, Oct. 2008. Access on: Sep 1, 2021. [Online]. Available: https://lup.lub.lu.se/luur/download?func =downloadFile&recordOId=8847641&fileOId=8859343 |
| [3] | T. Choopojcharoen, "IMPLEMENTATION OF CONTROL & ESTIMATION OF QUADROTOR IN MATLAB", 2016. |

**Table 1:** planning and

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| --- | --- | --- | --- | --- | --- |
|  | **TASK** | **Description** | **RESPONSIBLE** | **START** | **FINISH** |
| 1 | Plannning and Listing all tasks |  | everyone | 24/Aug/21 | 30/Aug/21 |
| 2 | Modelling | | | | |
| Controller's Model | Altitude Control | Pakapak | 31/Aug/21 | 7/Sep/21 |
| Attitude Control |
| Lateral Control |
| Dynamic Model | Motion | 8/Sep/21 | 14/Sep/21 |
| Integrate Modelling |  | 15/Sep/21 | 21/Sep/21 |
| 3 | Estimation |  |  | | |
| Range Sensor | State Estimation | Tanach&Nattasit | 31/Aug/21 | 7/Sep/21 |
| IMU Sensor | State Estimation | 8/Sep/21 | 14/Sep/21 |
| Integral estimation of IMU and Range sensor |  | 15/Sep/21 | 21/Sep/21 |
| Kalman filter | Do kalman filter of state estimation of IMU and Range sensor | 25/Sep/21 |
| 4 | Simulation and Visualization | | | | |
| Do Plant |  | Tanach&Nattasit | 22/Sep/21 | 28/Sep/21 |
| Controller | PID Tuning |
| 3D-plot graph |  | 29/Sep/21 | 5/Oct/21 |
| 5 | Futher Develop | Visualization Develop | everyone | 6/Oct/21 | 19/Oct/21 |
| Adding sensor |
| 6 | Presentation | | | | |
| Rechecking |  | everyone | 20/Oct/21 | 26/Oct/21 |
| Wrting report and Do presentation |  | 27/Oct/21 | 24/Nov/21 |
| Proposal Presentation |  | 9/Sep/21 | 9/Sep/21 |
| Progress Presentation |  | 11/Oct/21 | 11/Oct/21 |
| Final Presentation |  | 25/Nov/21 | 25/Nov/21 |