ELE306 - Robotikk - Hand-in 1

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Gruppe 15 Haugesund - Challenge 5: Hexacopter

2

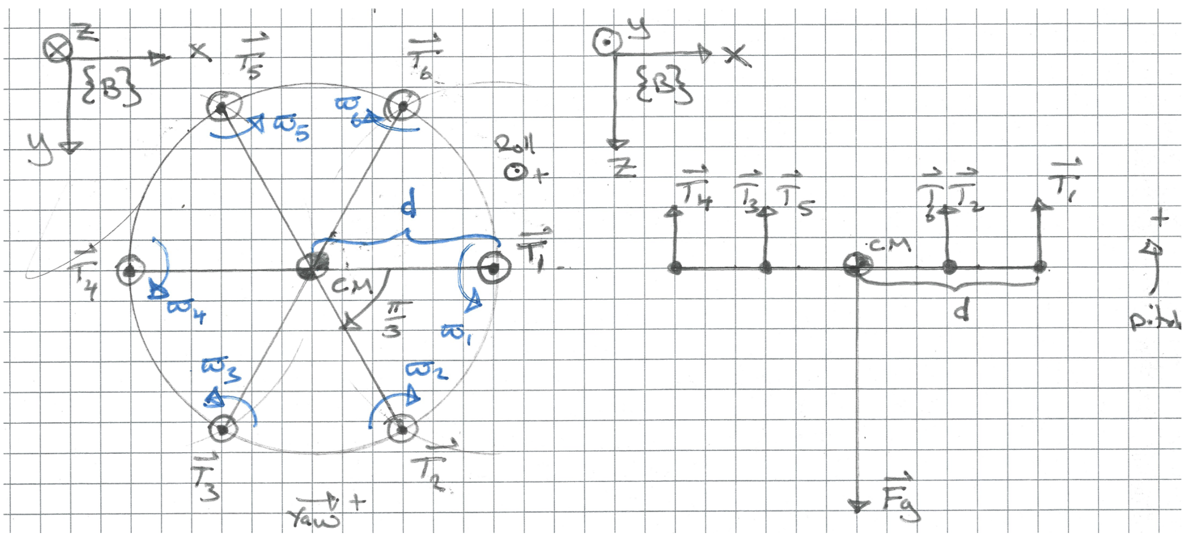

Figure 1: Schema with forces and torques working on the hexacopter

3

The thrusts generated by the rotors are given by:

$$T_i = b\varpi_i^2 \tag{1}$$

where $i = 1, 2, ..., 6$. Furthermore, the torques τ about the three axes depend on different combinations of thrusts, and are given by:

$$\tau_y = d(T_1 + T_2 + T_6) - d(T_3 + T_4 + T_5) = db(\varpi_1^2 + \varpi_2^2 + \varpi_6^2 - \varpi_3^2 - \varpi_4^2 - \varpi_5^2) \tag{2}$$

$$\tau_x = d(T_5 + T_6) - d(T_2 + T_3) = db(\varpi_5^2 + \varpi_6^2 - \varpi_2^2 - \varpi_3^2) \tag{3}$$

where torques about the y- and x-axes (τ_y and τ_x respectively) facilitate pitching and rolling. The torque τ_z about the z-axis, which facilitates yawing, is given by

$$Q_i = k\varpi_i^2 \tag{4}$$

and hence

$$\tau_z = Q_1 + Q_3 + Q_5 - Q_2 - Q_4 - Q_6 = k(\varpi_1^2 + \varpi_3^2 + \varpi_5^2 - \varpi_2^2 - \varpi_4^2 - \varpi_6^2) \tag{5}$$

Combining these equations gives us the following system of equations which relates the angular velocities of the rotors to the thrusts and torques of the hexacopter:

$$\begin{bmatrix} T \\ \tau_x \\ \tau_y \\ \tau_z \end{bmatrix} = \begin{bmatrix} -b & -b & -b & -b & -b & -b \\ 0 & -db & -db & 0 & db & db \\ db & db & -db & -db & -db & db \\ k & -k & k & -k & k & -k \end{bmatrix} \begin{bmatrix} \varpi_1^2 \\ \varpi_2^2 \\ \varpi_3^2 \\ \varpi_4^2 \\ \varpi_5^2 \\ \varpi_6^2 \end{bmatrix}$$

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A hexacopter configured as described in 2), where all rotors/actuators are parallel, is strictly speaking non-holonomic. This is because, even though it has the necessary amount of degrees of freedom, they are not independent. For example, if the drone is to translate forwards, it first needs to rotate (pitch forward/down).

5

Given the problem at hand, a hexacopter able to pick plums from the top of trees, we identify a minimum of 3 types of paths:

- from charger/plum storage to tree
- from tree to tree
- from tree to charger/plum storage

We also observe that the trees are stationary, which allows our navigational strategy to be based on a map. Because of these reasons, the D* algorithm seems to be a possible solution, since it allows us to change the start and goal positions, but, this strategy can be computationally costly.

6

In order to solve the problem of controlling the hexacopter, we choose to adopt the *Moving to a Pose* control strategy, since since this will place the drone in the same position and orientation relative to each individual tree, where it will use its camera (and other possible sensors) to identify and pick plums.

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Lastly, we choose the Extended Kalman Filter Simultaneous Localization And Mapping strategy, which is a strategy that both creates a map and localizes the drone at the same time. In a addition, this strategy allows for sensor fusion in order to reduce the error from any one sensor. A possible set of sensor for this project could be a combination of an accelerometer and a gryoscope, with the assistance of GPS.