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Original Article

Mathematical Model Based on Stability of the Raspidrone

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***Abstract* – *Therefore, there was the need for researching the drone's stability and balancing for the purpose of detection systems. Within this framework of studying the drone's dynamic stability, the mentioned algorithm has been developed and further improved according to specific theoretical and practical data. First, we will identify the following four dimensions in 3D space: "thrust", "pitch", "yaw", and "roll". Each of the measurements is expressed in the XYZ axis, where their movement direction is recorded as θ, ψ, φ, and identified by the angle change. To do this, we based on the stabilization theory. Also, the named theoretical equation was used and improved in this system.*

Keywords **-** *Theory of the Newton-Euler's and Euler's, theory of the Aerodynamic, Euler's angle, Coordinate system, acceleration angle, Matlab module, Programming platform of the Raspberry.*

I. INTRODUCTION

However, a drone flight can be directly impacted by external and internal environment and weather conditions. This is one of the disadvantages of a drone. Another disadvantage is the relatively short time period of its flights. Moreover, weather condition like the wind is an overpowering factor. Depending on the speed of the wind, the timing of the drone operation varies.

The PID management system is very effective in maintaining the drone's flight stability and in using various algorithms in detection systems, human face identification and vehicle license plate number detection. Therefore, we have developed some technical specifications and mathematical models or algorithms to improve the above. The external environment makes a flight relatively unstable. So, we have to reconsider the improvement. By way of experimenting and analyzing all unsatisfactory test results, we developed an additional algorithm for a wind speedometer and anti-wind power. In case a drone is caught up by wind or flies in the wrong direction due to wind power, this algorithm allows to launch of another algorithm (PID) which ensures the drone's better stability. The movement equation is determined under the Newton and Euler theory. Also, the motion equation was calculated based on the 3-dimensional space with direction, trajectory and vector, which is a so-called cylindrical coordinate system. The drone's tilt and angle change due to wind power and other similar external factors were determined by a certain mathematical methodology. However, motion data have been processed by the PID system, and the results of some mathematical models expressed in the cylindrical coordinates system have been described in graphic representation. The data were processed under the maximum accuracy method pertaining to the control system, and the results of such processing were prepared.

II. DYNAMIC MODEL OF THE DRONE

For determining the drone's movement, the speed of rotation of four propellers is increased or reduced, leading to the desired steering. And for designing a dynamic motion model, it is essential to analyze the impact of air resistance and other external forces. Thus, the motion model has been developed correlating to several values in the three-dimensional cylindrical coordinate system. For accomplishing this, the Newton law and Newton-Euler law were studied, and certain improvements were made. [1-2]

When the drone's motion is calculated in the counting system, the change of points and angles of each of x, y, z axes are defined by the orthogonal matrix method.

The rotation matrix size is 3x3. [3-4] In other words, the rotation matrix is expressed in three-dimensional metrics: Rot (x, φ), Rot (y, θ), Rot (z, ψ) (image 1).

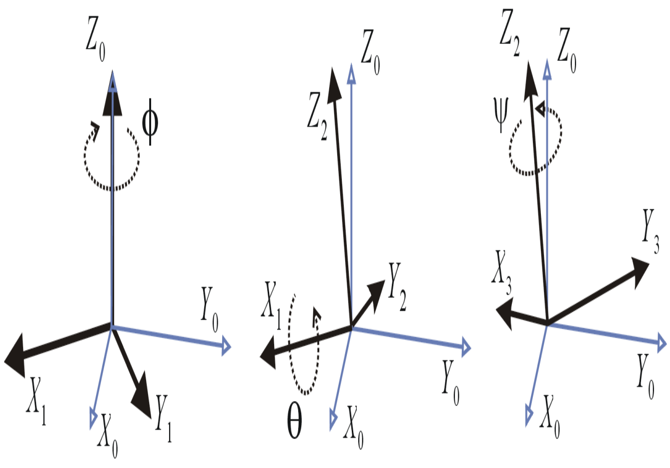

Fig. 1 The position of the rotation coordination system

Diversion of coordinate points in the 2nd coordinate system is projected over the points in the 1st coordinate system, and the changes of coordinate points are recorded (image 2).

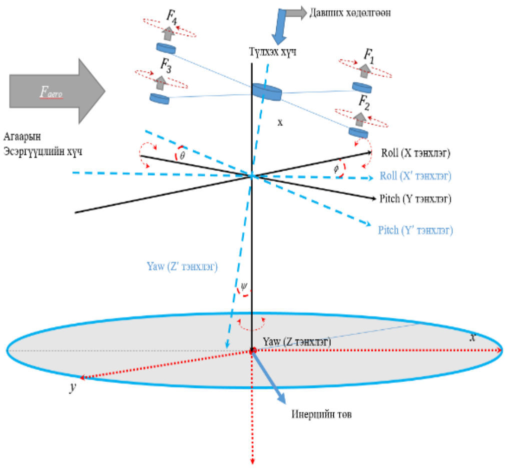

Fig. 2 The coordinate system on parameters on drone stabilization

Then, the angle changes are analyzed, taking into consideration changes in coordinate points on the 1st and 2nd coordinate systems. The following five conditions will be considered when calculating the motion model. These parameters are S_1, S_2, S_3, S_4 the angular speed equation (5-6).

$$I_x\ddot{\varphi} = \dot{\theta}\dot{\psi}\left(I_y - I_z\right) - j_r\theta\omega + lS_2$$

$$I_y\ddot{\theta} = \dot{\varphi}\dot{\psi}\left(I_z - I_x\right) - j_r\varphi\omega + lS_3$$

$$I_x\ddot{\psi} = \dot{\theta}\varphi\left(I_x - I_y\right) - j_r\psi\omega + lS_4$$

$$S_1 = F_{PRF}, S_2 = \tau_\varphi, S_3 = \tau_\theta, S_4 = \tau_\psi$$

These four identified variables indicate that the drone's displacement and angular changes occur at the coordinates defined at the drone's relocation.

At now, calculate the same equations. The defined basic equation for the drone rotation dynamic control system.

$$m\ddot{x} = \left[(\cos\phi\sin\theta\cos\psi + \sin\phi\sin\psi)\sum_{i=1}^{4} F_i - \sum_{i=1}^{4} D_{xi} - \frac{1}{2}pAC\left(U^B\right)^2\right]$$

$$m\ddot{y} = \left[(\cos\phi\sin\theta\sin\psi - \sin\phi\sin\psi)\sum_{i=1}^{4} F_i - \sum_{i=1}^{4} D_{yi} - \frac{1}{2}pAC\left(U^B\right)^2\right]$$

$$\ddot{z}m = -mg + (\cos\phi\cos\theta)\sum_{i=1}^{4} F_i - \sum_{i=1}^{4} D_{yi} - \frac{1}{2}pAC\left(U^B\right)^2] \qquad (14)$$

This equation allows the coordinate system to calculate the orientation and direction of the drone.

III. EXPERIMENT RESULT

A mathematical model of a dynamic management system has been developed, and some calculations have been performed at a certain level. The data processing and analysis of the above equation have been performed based on the Matlab software, where some outcomes have been reported. The simulation was performed where the coordinate's axis point was considered to be switching in certain t time intervals, and the following results have been obtained.

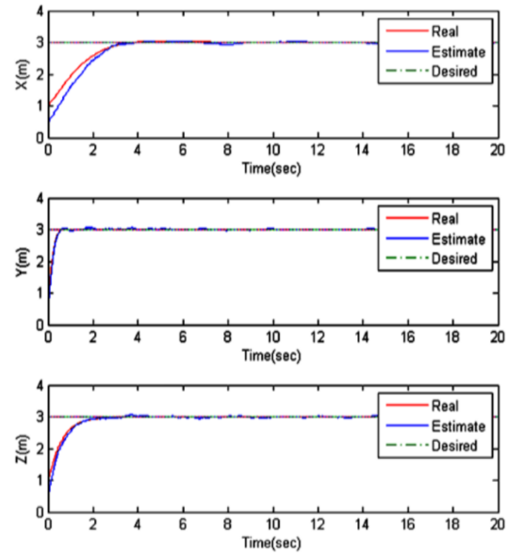

Fig. 3 Result of the drone's stabilization

IV. CONCLUSION

The results of our experiments show that there have been a number of errors relative to our interpretation of the correlation between the computations and data analysis. There were slight delays in certain units during data processing. In contrast to some similar research and development works, our experiments showed more advantages over the time of balance position recovery.

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