Implementation of a quadrotor UAV

Santiago Paternain
Faculty of Engineering
University of the Republic
Montevideo, Uruguay
spaternain@gmail.com

Rodrigo Rosa
Faculty of Engineering
University of the Republic
Montevideo, Uruguay
rodrigorosa.LG@gmail.com

Matías Tailanián
Faculty of Engineering
University of the Republic
Montevideo, Uruguay
matias@tailanian.com

Rafael Canetti
Faculty of Engineering
University of the Republic
Montevideo, Uruguay
canetti@anii.org.uy

***Abstract*—This paper describes the design and integration of a control system that allows the autonomous flight of a radio controlled commercial quadcopter. A mathematical model for the quadcopter is developed, its parameters determined from the characterization of the unit. An external intelligence is integrated to play the rol of the flight controller. An IMU is calibrated and added to the platform. Data from a 9 degrees of freedom IMU equiped with a barometer is combined with the information provided by a GPS within a Extended Kalman Filter to obtain a reliable estimation of the state variables. The control actions are obtained from a proportional-integral control system based on the LQR algorithm.**

I. Introduction

A quadrotor platform can be imagined performing countless tasks. Many applications are being developed based on such platforms, but how do they fly? The start point of developing an unmanned aerial vehicle (UAV) is that it in inherently unstable, staying still is not a simple task. The platform is based on a commercial quadcopter, the frame and the motor control system were preserved, but the IMU and intelligence were replaced by the flight controller that was developed. An ARM-Cortex-A8 processor running Linux performs the computations requiered to convert raw IMU data and combine it using an Extended Kalman Filter, overcoming the noise generated by the vibrations of the motors, and providing a reliable estimation of the state variables. Once the current state is known, the LQR algorithm is used to derive control actions required to bring the system to the desired setpoint.

This paper explains how to deal with an IMU, the mathematical model behind the system, the filtering techniques requiered to achieve a reliable state estimation based on noisy data, and the control system that will allow putting a quadrotor into flight.

II. Model of a quadrotor

The equations that govern the dynamics of a quadcopter are bla.

$$\boxed{\begin{aligned}
&\dot{x} = v_{q_x}\cos\varphi\cos\theta + v_{q_y}(\cos\theta\sin\varphi\sin\psi - \cos\varphi\sin\theta)\\
&\quad + v_{q_z}(\sin\psi\sin\theta + \cos\psi\cos\theta\sin\varphi)\\
&\dot{y} = v_{q_x}\cos\varphi\sin\theta + v_{q_y}(\cos\psi\cos\theta + \sin\theta\sin\varphi\sin\psi)\\
&\quad + v_{q_z}(\cos\psi\sin\theta\sin\varphi - \cos\theta\sin\psi)\\
&\dot{z} = -v_{q_x}\sin\varphi + v_{q_y}\cos\varphi\sin\psi + v_{q_z}\cos\varphi\cos\psi\\
&\dot{\psi} = \omega_{q_x} + \omega_{q_z}\tan\varphi\cos\psi + \omega_{q_y}\tan\varphi\sin\psi\\
&\dot{\varphi} = \omega_{q_y}\cos\psi - \omega_{q_z}\sin\psi\\
&\dot{\theta} = \omega_{q_z}\frac{\cos\psi}{\cos\varphi} + \omega_{q_y}\frac{\sin\psi}{\cos\varphi}\\
&\dot{v_{q_x}} = v_{q_y}\omega_{q_z} - v_{q_z}\omega_{q_y} + g\sin\varphi\\
&\dot{v_{q_y}} = v_{q_z}\omega_{q_x} - v_{q_x}\omega_{q_z} - g\cos\varphi\sin\psi\\
&\dot{v_{q_z}} = v_{q_x}\omega_{q_y} - v_{q_y}\omega_{q_x} - g\cos\varphi\cos\psi + \frac{1}{M}\sum_{i=1}^{4}T_i\\
&\dot{\omega_{q_x}} = \frac{1}{I_{xx}}\omega_{q_y}\omega_{q_z}(I_{yy} - I_{zz}) + \frac{1}{I_{xx}}\omega_{q_y}I_{zz_m}(\omega_1 - \omega_2 + \omega_3 - \omega_4)\\
&\quad - \frac{1}{I_{xx}}dMg\cos\varphi\sin\psi + \frac{1}{I_{xx}}L(T_2 - T_4)\\
&\dot{\omega_{q_y}} = \frac{\omega_{q_x}\omega_{q_z}(-I_{xx} + I_{zz})}{I_{yy}} + \frac{\omega_{q_x}I_{zz_m}(\omega_1 - \omega_2 + \omega_3 - \omega_4)}{I_{yy}}\\
&\quad - \frac{dMg\sin\varphi}{I_{yy}} + \frac{L(T_3 - T_1)}{I_{yy}}\\
&\dot{\omega_{q_z}} = \frac{-Q_1 + Q_2 - Q_3 + Q_4}{I_{zz}}
\end{aligned}} \tag{1}$$

III. Kalman Filter

IV. Control design

V. Software

VI. Flight tests

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VII. Conclusion

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Acknowledgment

The authors would like to thank...

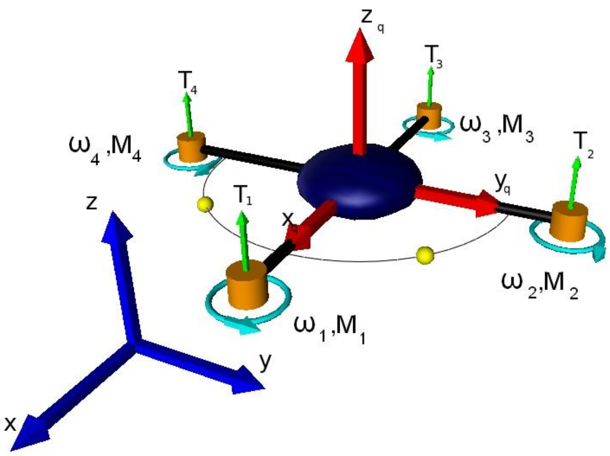

Fig. 1. Model of a quadcopter

References

[1] H. Kopka and P. W. Daly, *A Guide to LaTeX*, 3rd ed. Harlow, England: Addison-Wesley, 1999.