Maestría en Ingeniería en Automatización de Procesos Industriales

Title

Design and construction of a four-rotor drone for video surveillance application

Author

Alan Huchin Herrera

Contributor

Antonio Benítez Ruíz

Juan Antonio Arizaga

Luis Ignacio Olivos Pérez

September-December 2016

Desing and construction of a four-rotor drone for video surveilleance application

Alan Huchin Herrera, Antonio Benitez Ruiz, Juan Antonio Arizaga, Luis Ignacio Olivos Perez.

Maestría en Ingeniería en Automatización de Procesos industriales.

(alan.huchin, antonio.benitez, juan.arizaga, luis.olivos)@uppuebla.edu.mx

Tercer carril del Ejido "Serrano" S/N, San Mateo Cuanalá, Juan C. Bonilla, CP 72640, Puebla, México

1. Introduction

Unmanned aerial vehicles (UAVs) are robots that have the ability to fly and can be controlled by remote control , mobile devices, or even independently run flights.
Literature tells us that these vehicles were invented more than a century ago, for two applications: military and scientific use. Thanks to the technological progress UAV's has been gradually incorporated for civil use.
Currently, there are two well-define types of drones: the classic in the form of aircraft or those that are helicopter or quadrirotor. The best popular applications are for video surveillance or recognition.

2. Objectives

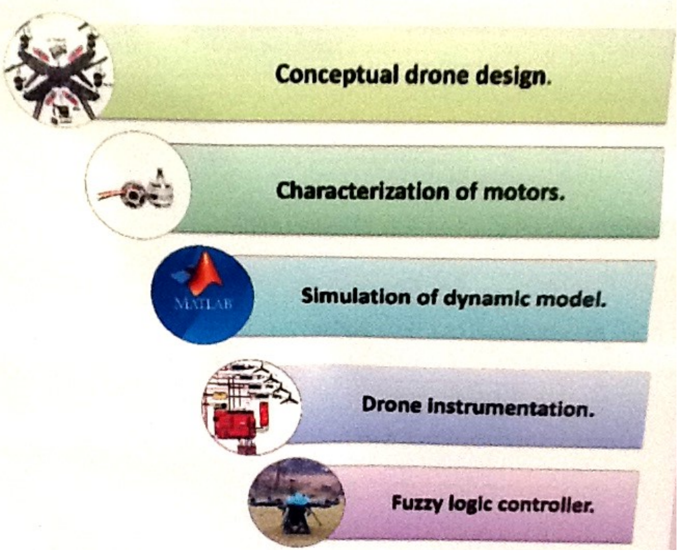
2.1. General objective

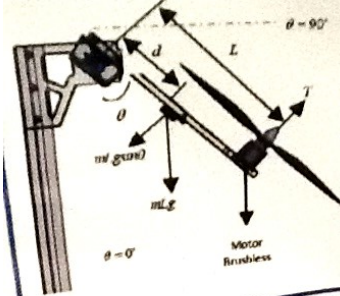
To design and to build a four rotor drone for video surveillance application.

2.2. Particular objectives

- To implement a fuzzy logic controller for drone height and position control.
- To determine the drone's mathematical model for video surveillance application.
- To implement an inertial system based on embedded systems for controller processing.

3. Method





Model:

$$T(t) = J\ddot{\theta}(t) + C\dot{\theta}(t) + mgdSen\theta(t)$$

Estimated transfer function:

$$\frac{\theta(s)}{V(s)} = \frac{5.13}{s^2 + 1.9754s + 18.5214}$$

Estimated transfer function ident:

$$\frac{\theta(s)}{V(s)} = \frac{11.3967}{s^2 + 1.0805s + 11.3967}$$

Figure 1. Modeling of the system based on a simple pendulum.

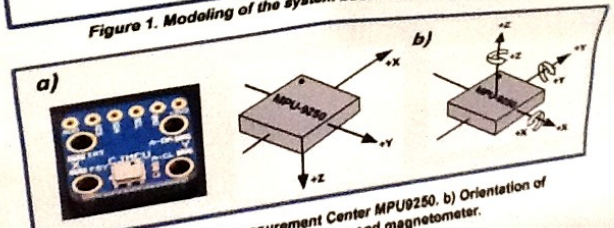


Figure 2. a) Inertial measurement Center MPU9250. b) Orientation of accelerometer, gyroscope and magnetometer.

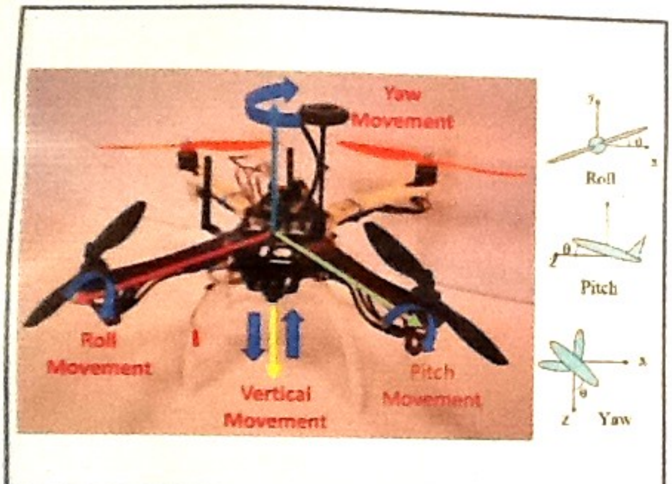


Figure 3. Mobility characteristics for drone.

6.

[1] M.
[2] K. C
[3] M. C
didáctic
2010.
[4] S. Ki
Kocaeli

4 Motors
4 Forces ω_i^2
4 Torques ω_i^2

Control :

Roll (Around the x-axis) :
$$\tau_\phi = l(F_{iz} - F_d)$$
Pitch (Around the y-axis) :
$$\tau_\theta = l(F_{ad} - F_{at})$$
Yaw (Around the z-axis):
$$\tau_\psi = k(F_{ad} + F_{at} - F_{iz} - F_d)$$

Total thrust:
$$\tau = b \sum_{i=1}^{4} \omega_i^2$$

(Roll, Pitch, Yall)= $(\emptyset, \theta, \Psi)$

Figure 4. Orientation.

4. Results

- Implementation for a test bench for the characterization of brushless motors.
- Conditioning C-libraries for inertial measurement sensor (IMU).
- Obtaining the mathematical model of the pendulum for the characterization of the motors.
- Controller design using fuzzy logic.
- MATLAB simulation for dynamics system using a PID control vs. Fuzzy logic control.
- Design of a library for the C-fuzzy logic controller for ARM-Mbed microcontrollers.
- PCB design for integration of drone instrumentation with microcontroller.
- Calculation of the power stage for the drone depending on the weight and time of flight (dynamic model).
- Selection of components.
- Drone implementation and instrumentation (95%).

Pzas.	Component	Total weight (g)	Capacity	Total (A)
1	Frame	282		
4	Motor	212	60%	33.2
4	ESC	100	100%	1.0
1	Battery	399		
1	Micro	20	100%	1.0
1	GPS	10	100%	0.023
1	Telemetry FPV	6.8	100%	0.5
1	Telemetry 915Mhz	6.8	100%	0.1
1	Camera HD	74	100%	0.16
	TOTAL	1008.6		34.985

Motor thrust:
$$T_{thrust} = \frac{(1008.6g)(2)}{4} = \frac{2017.6}{4} = 504.4g$$
Flight time based on drone weight:
$$t = \frac{(8A)(60min)}{34.985A} = 13.72min$$

Figure 5. Calculation the drone weight to estimate the flight time.

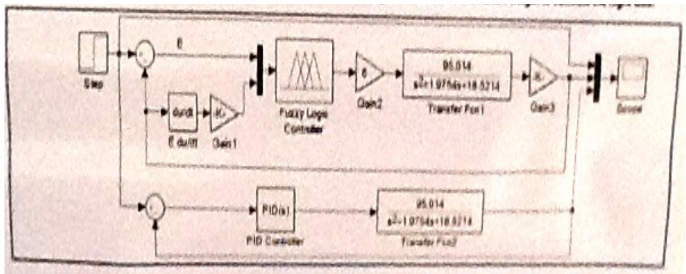


Figure 6. Fuzzy control Blocks' diagram.

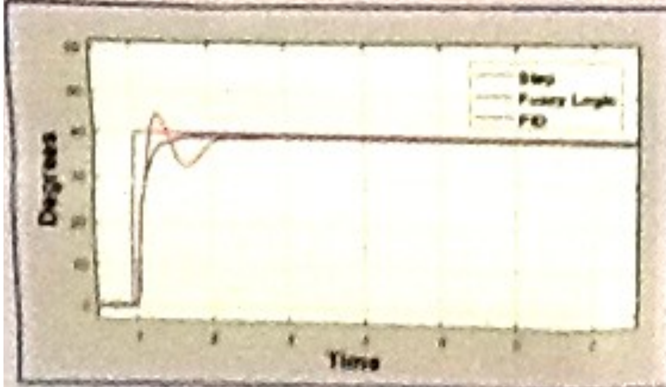


Figure 7. Response to step to PID control vs. fuzzy logic control.

5. Conclusions

According to the preliminary results we can conclude that:

75% of the project has been complete.

6. References

[1] M. A. Laborie Iglesisas, «La Era de los Drones,» *Aceno*, nº 41, pp. 56-59.
[2] K. Ogata, Ingeniría de Control Moderna, España: Prentice Hall, 2008.
[3] M. G. Francisco E., B. V. José A., A. G. Yulianny E. y A. R. F., «Desarrollo de un módulo didáctico para el control angular de un péndulo suspendido,» *ISSN*, nº 2, pp. 48-54, 2010.
[4] S. Kizir, Z. Bingul y C. Oysu, «Fuzzy Control of Real Time Inverted Pendulum System,» *Kocaeli University*, pp. 1-8.

Acknowledgements

To CONACYT, National Council of Science and Technology for Master of Engineering in Industrial Process Automation of the Universidad Politecnica de Puebla, awarded to Ing. Alan Huchin Herrera with No 737720.

2016