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Title: CONTROL BASED ON GLRT ALGORITHM FOR UNMANNED AERIAL VEHICLE

Authors: ZAVALA-CONTRERAS, Francisco Javier, ALAZKI, Hussain, CORTES-VEGA, David and GOLIKOV, Victor

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ECORFAN-México, S.C.
143 – 50 Itzopan Street
La Florida, Ecatepec Municipality
Mexico State, 55120 Zipcode
Phone: +52 1 55 6159 2296
Skype: ecorfan-mexico.s.c.
E-mail: contacto@ecorfan.org
Facebook: ECORFAN-México S. C.
Twitter: @EcorfanC

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Introduction

The Unmanned Aerial Vehicles (UAV) are versatile tools used to perform several tasks where a human pilot is not required.

Nowadays UAV are used like a support for the inspection and planning of building construction by giving a better view of the ground conditions (Freimuth et al. 2018), they are used for monitoring the development of a city's infrastructure and environmental management (Ezequiel et al. 2014), for 3D mapping and monitoring tasks for various ecosystems (Lucieer et al. 2014), even for optimize pesticides application over plantations (Faiçal et al. 2014) and the inspection of pipelines carrying gasoline and oil (Shukla et al. 2016).

Introduction

A certain type of algorithms use probability theory to improve the detection of targets, algorithms that use the Generalized Likelihood Ratio Test (GLRT) aims to detect an object floating in the sea without knowing a priori its size, shape, and position in a sequence of images using optical sensors, the quality of detection is not affected by low contrast or background noise, which makes it a very versatile detector.

Methodology

In this work it is proposed the study of a vision-based control scheme for an Unmanned Aerial Vehicle (UAV) for tracking objects floating on the sea surface, using the generalized likelihood ratio test (GLRT) algorithm.

For this purpose, it is necessary to implement a control PID to a mathematical model in order to test the performance of the system control.

Methodology

Mathematical model

The body of the quadrotor is constituted by 2 bars joined perpendicularly at the center of mass has 4 motors one for each end like in the figure 1.

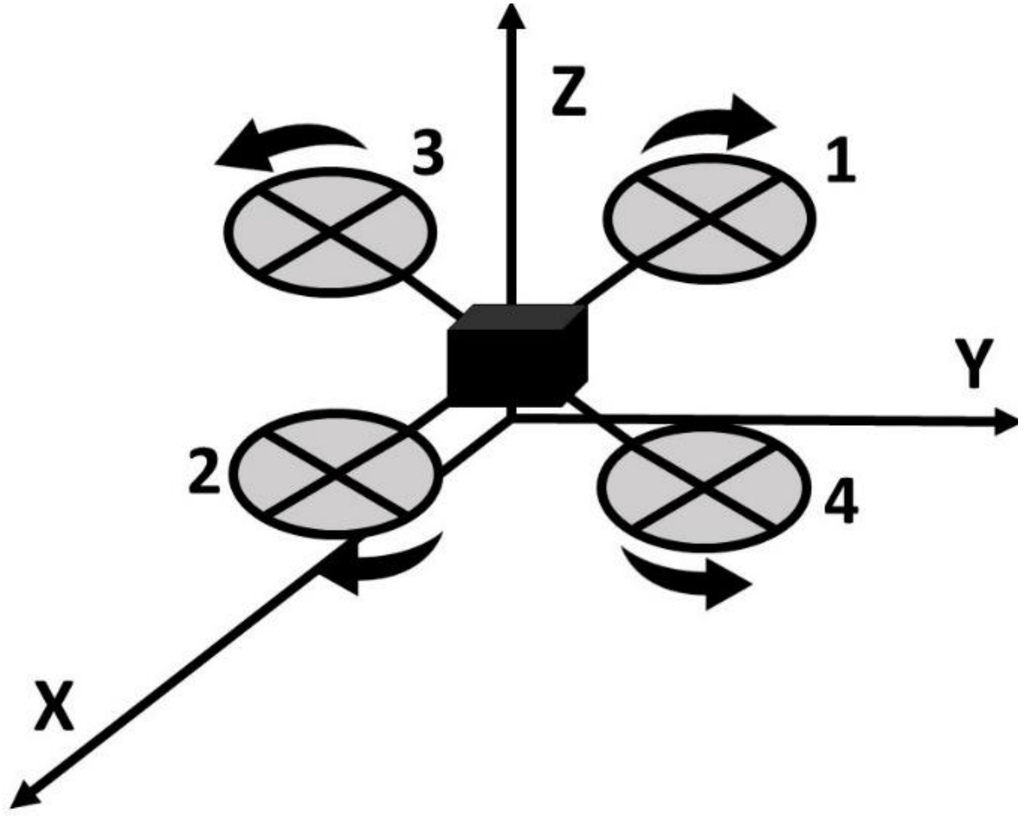

Figure 1 UAV motors alignment

Methodology

Mathematical model

The 3 equations describing the lineal movement of the UAV:

$$\ddot{x} = \frac{1}{m}(\cos\psi sin\theta cos\phi + \sin\psi\sin\phi)\frac{U_1}{m}$$

$$\ddot{y} = \frac{1}{m}(\sin\psi sin\theta cos\phi + \cos\psi\sin\phi)\frac{U_1}{m}$$

$$\ddot{z} = -g + \frac{1}{m}(cos\ \theta cos\phi)\frac{U_1}{m}$$

where U_1 is the principal control signal of the 4 motors.

Methodology

Mathematical model

The 3 equations describing rotational movement of UAV:

$$\ddot{\phi} = \frac{(I_{xx} + I_{yy} - I_{zz})}{I_{xx}} \dot{\psi}\dot{\theta} + \frac{\tau_{\phi}}{I_{xx}}$$

$$\ddot{\theta} = \frac{(-I_{xx} - I_{yy} + I_{zz})}{I_{yy}} \dot{\psi}\dot{\phi} + \frac{\tau_{\theta}}{I_{yy}}$$

$$\ddot{\psi} = \frac{(I_{xx} - I_{yy} + I_{zz})}{I_{zz}} \dot{\phi}\dot{\theta} + \frac{\tau_{\psi}}{I_{zz}}$$

Where I_{xx}, I_{yy} and I_{zz} are the moments of inertia in the x, y, and z axes.

Methodology

GLRT Algorithm

GLRT allows object detection even when the size, shape, and position are unknown using a sequence of images as input data. It is used like a universal detector for detection problems.

There are two options for this kind of detector; if the target is present, it will return the signal target plus the signal from the background clutter, otherwise it will return exclusively the background clutter.

Methodology

GLRT Algorithm

It is used video spatial-temporal patches, called bricks, to determine whether the observed brick contains the target in the presence of a random background.

A hypothesis test is made to distinguish a pixel with the signal of the target-plus noise (H_1) from the others who only contain the background clutter plus channel noise (H_0).

Methodology

Vision based control scheme

The proposed vision-based control scheme is illustrated in the block diagram in Figure 2

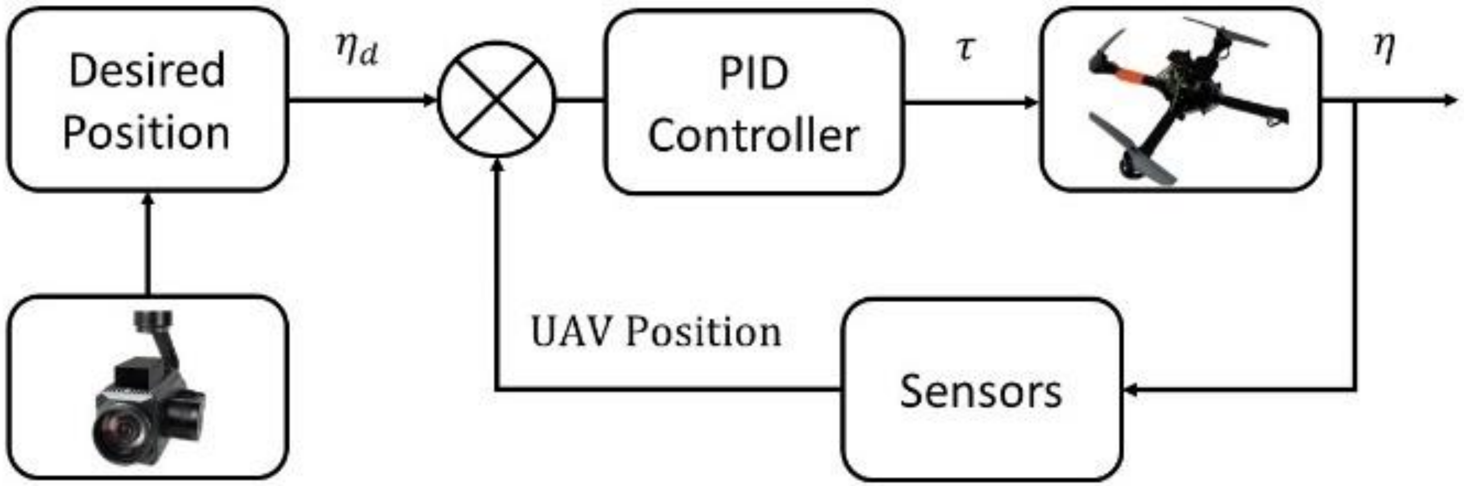

Figure 2 Block diagram of the proposed scheme.

Methodology

Vision based control scheme

The PID-based control scheme uses 4 references to control the 6 degrees of freedom this type of control is named “underactuated” 6 equations were developed to describes those movements.

The mathematical model is inserted in Simulink allowing the simulation of the system the references are, the linear displacement in the z-axis and the control of the angular rotations in the 3 axes of the body coordinate system, through these rotations that indirectly the body can move along the x and y axes linearly.

Results

Figure 3 Objective in one frame of the video

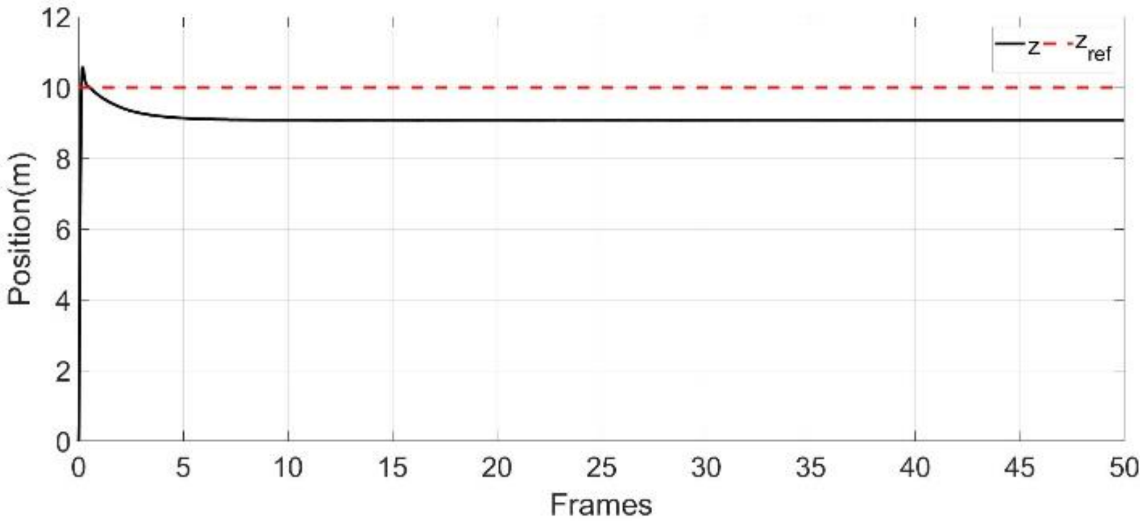

Figure 4 Desired and actual trajectories in z-axis

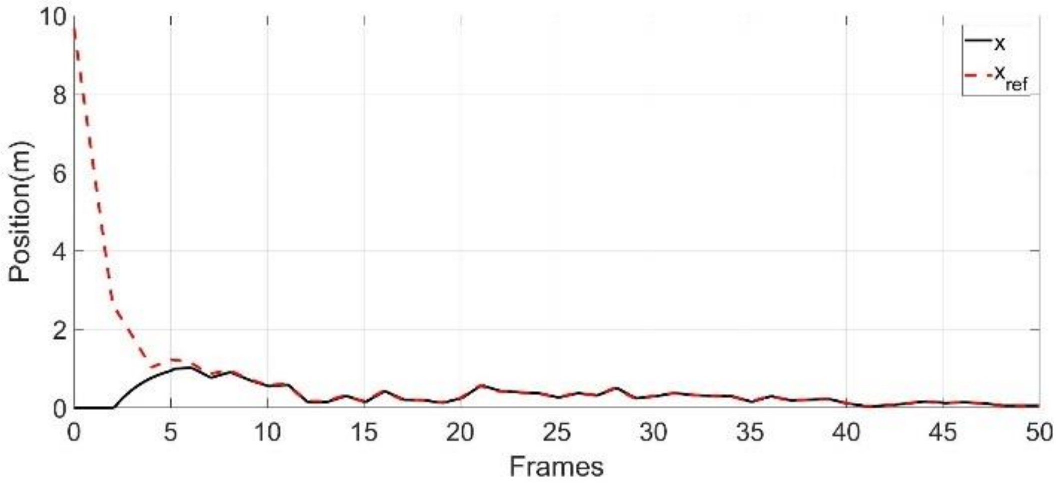

Figure 5 Desired and actual trajectories in x-axis

Results

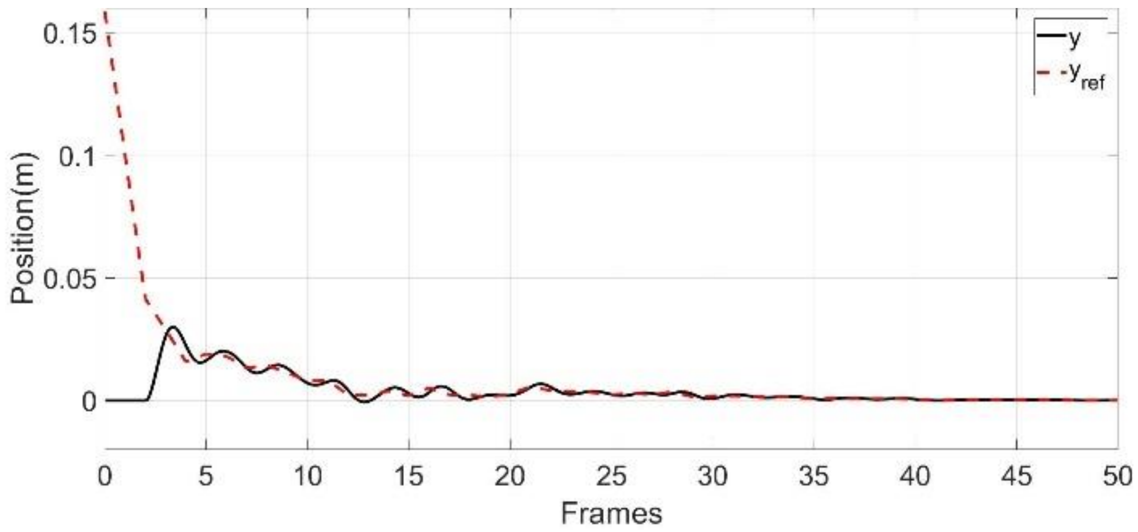

Figure 6 Desired and actual trajectories in y-axis

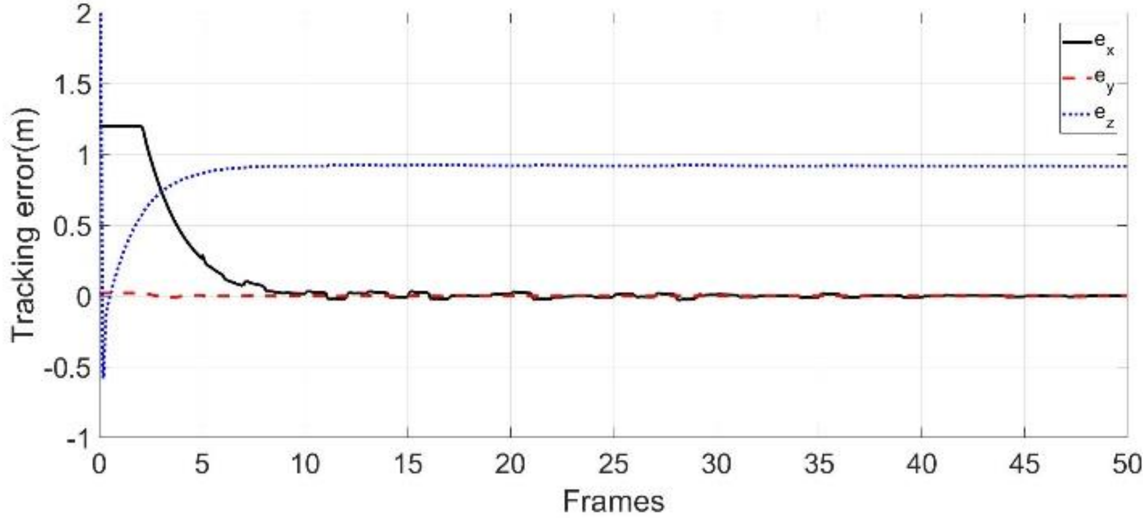

Figure 7 Tracking error (*x*-*y*-*z*-axes)

Conclusions

This work presented a vision-based control scheme for tracking objectives with a quadrotor with a video camera. The results obtained show a good behavior of the detector, despite the constant oscillation generated by the sea waves, it managed to capture with sufficient accuracy the target within the image allowing the generation of the objective trajectory. The PID control was able to maintain an appropriated tracking of the given coordinates both in the x and y axis, however, the desired height was not reached remaining at 9 meters when the reference is 10.

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