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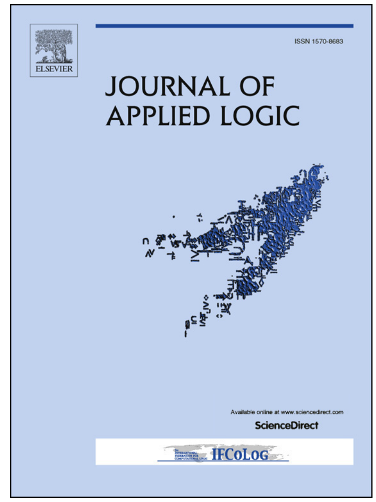

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Parameter selection based on fuzzy logic to improve UAV path-following algorithms

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Abstract

In order to steer an Unmanned Aerial Vehicle (UAV) and make it follow a desired trajectory, a high level controller is needed. Depending on the control algorithm, one or more parameters have to be tuned, having their values high impact on the performance. In most of the works, these parameters are taken as constant. In this paper, we apply fuzzy logic to select the parameters of the control law and compare this approach with the tuning by constant parameters and with another adjusting method based on the kinematic analysis of the equations of the UAV. After many simulations of the quadrotor following randomly generated paths, we have proved that the fuzzy tuning law is not only a good and feasible solution, but also more general as it can be applied to any trajectory.

Keywords: Fuzzy logic, Kinematic analysis, Path-following, Unmanned aerial vehicle (UAV), Quadrotor.

1 Introduction

One of the most basic mission that an Unmanned Aerial Vehicle (UAV) has to fulfill is to be able to accurately follow a given path. We can define the path-following task as following a given geometric trajectory independently of the variable time.

There exists many different methods and strategies to follow a path. Some of them were designed to be used for fix-winged UAVs, others for bidimensional movements. A good classification of methods and a comparison between them can be found in [22]. Among all the strategies, we can name carrot-chasing algorithms [23], non-linear guidance laws [19], pure pursuit [3], vector-field-based laws [12] and linear quadratic regulators [15].

In most of the UAVs two levels of control are used; on the one hand, a low level controller is in charge of stabilizing its dynamics [6]. On the other, a high level one steers it so that it follows a desired trajectory. Being that the case, a sufficient difference in the time response between them must be ensured. Typically the inner loop must be $\sim$2-4 times faster that the outer one [16]. This is the most common situation, the path-following algorithm controls the kinematics and generates the commands to the inner loop controller (usually a commercial autopilot).

Those high level control algorithms normally depend on different parameters, which are interrelated. Some of them have a physical meaning, others are just coefficients controlling the convergence of the system. Frequently, adapting continuously the parameters to the shape of the path, as the UAV travels along it, improves significantly its performance.

If the parameters have a low influence on the system response, which seldom occurs, they might be taken as constants with a value obtained based on the experience. In other cases, mostly when the constant has a clear physical meaning, one might be able to propose a natural value or function for it, sometimes implying the appearance of new parameters.

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