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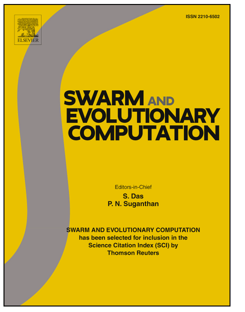

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An Aerial Robot for Rice Farm Quality Inspection With Type-2 Fuzzy Neural Networks Tuned by Particle Swarm Optimization-Sliding Mode Control Hybrid Algorithm

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Abstract

Agricultural robots, or agrobots, have been increasingly adopted in every aspect of farming from surveillance to fruit harvesting in order to improve the overall productivity over the last few decades. Motivated by compelling growth of agricultural robots in modern farms, in this work, an autonomous quality inspection over rice farms is proposed by employing quadcopters. Real-time control of these vehicles, however, is still challenging as they exhibit highly nonlinear behavior especially for agile maneuvers. What is more, these vehicles have to operate under uncertain working conditions such as wind and gust disturbances as well as positioning errors caused by inertial measurement units and global positioning system. To handle these difficulties, as a model-free and learning control algorithm, type-2 fuzzy neural networks (T2-FNNs) are designed for the control of quadcopter. The novel particle swarm optimization-sliding mode control (PSO-SMC) theory-based hybrid algorithm is proposed for the training of T2-FNNs. In particular, continuous version of PSO is adopted for the identification of the antecedent part of T2-FNNs while SMC-based update rules are utilized for online learning of the consequent part during control. In the virtual environment, the quadcopter is expected to perform an autonomous flight including agile maneuvers such as steep turning and sudden altitude changes over a rice terrace farm in Longsheng, China. The simulation results for T2-FNNs are compared with the outcome of conventional proportional-derivative (PD) controllers for different case studies. The results show that our method decreases trajectory tracking integral squared error by %26 over PD controllers in the ideal case, while this ratio goes up to %95 under uncertain working conditions.

Keywords: type-2 fuzzy neural networks, particle swarm optimization, sliding mode control, unmanned aerial vehicle, system identification, control

1. Introduction

Modern methods in agriculture have evolved tremendously over the last few decades with the advent of automation to increase crop yields in shorter time while utilizing less labour costs and resources. Motivated by compelling growth of agricultural robots in modern farms, unmanned aerial vehicles (UAVs) such as quadcopters are becoming increasingly popular to assist farmers for a possible increase in crop yields while decreasing crop damage [1]. There are already successful applications to perform essential functions such as conducting air quality check, monitoring the health of crops and soil through visual imaging, or spraying fertilizers in a timely and controlled manner [2]. Today, the greater role of quadcopters in agriculture presents itself as a challenging, yet interesting control problem.

Quadcopters are highly nonlinear, multi-input-multi-output, strongly coupled, open-loop unstable, and under-actuated systems. Therefore, their control is a fundamentally intricate problem. Moreover, in most cases, they are required to operate in subtle environ-

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