Journal of Intelligent & Fuzzy Systems 46 (2024) 1429–1442
DOI:10.3233/JIFS-235338
IOS Press

Analyzing stability and structural aspects of embedded fuzzy type 2 PID controller for robot manipulators

K. Venkataramanan[a,*], M. Arun[b], Shankaranand Jha[c] and Aditi Sharma[d]
[a]*Department of Electrical and Electronics Engineering, Prathyusha Engineering College, Chennai, Tamilnadu, India*
[b]*Department of ECE, Panimalar Engineering College, Chennai, Tamilnadu, India*
[c]*Department of Electronics and Communication Engineering, Malla Reddy Engineering College, Secunderabad, India*
[d]*Department of Computer Science and Engineering, Symbiosis Institute of Technology, Symbiosis International University, Pune Maharashtra, India*

Abstract. This study delves into the development and analysis of a novel Embedded Fuzzy Type 2 PID Controller for Robot Manipulators, motivated by the increasing need for enhanced control systems in robotic applications to improve precision and stability. In the background section, the limitations of conventional PID controllers in addressing uncertainties and disturbances, especially in complex tasks performed by robot manipulators, are presented. The concept of fuzzy logic and the Type 2 fuzzy system is introduced, highlighting their potential to manage imprecise and uncertain information. Through rigorous analysis and simulation, the superior performance of the Embedded Fuzzy Type 2 PID Controller is demonstrated when compared to traditional PID controllers and even Type 1 fuzzy controllers. The results showcase enhanced tracking accuracy, disturbance rejection, and adaptability, making it a promising solution for advanced robotic applications. In conclusion, this research provides a robust solution for improving the control of robot manipulators in uncertain and dynamic environments. The Embedded Fuzzy Type 2 PID Controller offers a new paradigm in control theory, ensuring stability and precision even in the face of unpredictable factors. This innovation holds great promise for advancing the capabilities of robotic systems and underlines the potential for further research in embedded fuzzy control systems.

Keywords: Fuzzy type 2 PID controller, robot manipulator, embedded control, stability analysis, precision control

1. Introduction

Robotic systems have witnessed a remarkable evolution, playing pivotal roles in various industries, from manufacturing and logistics to healthcare [1] and even space exploration. The efficacy and precision of these robotic systems rely heavily on the control strategies governing their operations. In this context, the utilization of advanced control techniques has gained prominence, with the aim of addressing the challenges posed by uncertainties and disturbances in real-world applications. The realm of robotic systems has witnessed a transformative evolution over the past few decades. These machines, originally conceived for automating routine tasks, have emerged as highly sophisticated and versatile tools capable of executing complex operations [2] with unmatched precision. This evolution has brought robotics to the forefront of numerous industries, from

*Corresponding author. K. Venkataramanan, Department of Electrical and Electronics Engineering, Prathyusha Engineering College, Chennai, Tamilnadu, India. E-mail: raceramana@gmail.com.

ISSN 1064-1246/$35.00