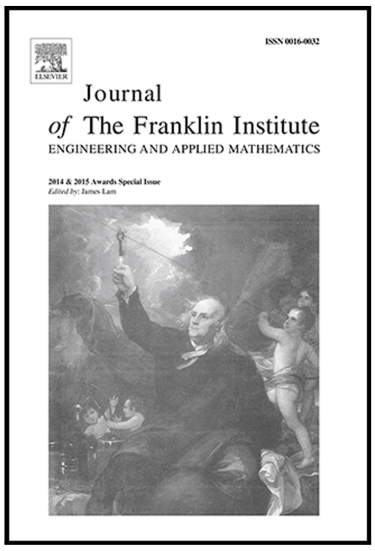

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PII: S0016-0032(18)30334-X
DOI: 10.1016/j.jfranklin.2018.05.022
Reference: FI 3456

To appear in: *Journal of the Franklin Institute*

Received date: 27 April 2017
Revised date: 25 April 2018
Accepted date: 7 May 2018

Please cite this article as: Mehran Mazandarani, Yi Zhao, Fuzzy Bang-Bang Control Problem Under Granular Differentiability, *Journal of the Franklin Institute* (2018), doi: 10.1016/j.jfranklin.2018.05.022

Fuzzy Bang-Bang Control Problem Under Granular Differentiability

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Abstract

In this paper, a class of fuzzy optimal control problem called fuzzy Bang-Bang (FBB) control problem is revisited. The FBB control problem aims at finding control inputs which transfer the states of an uncertain dynamical system to the origin in a minimum time. Since the conditions and/or parameters of the dynamical system are uncertain, the FBB control problem is a challenge task. To address the problem, we first introduce the concepts of the granular integral and derivative of fuzzy functions whose domain is uncertain. In addition, the notion of granular partial derivative of a multivariable fuzzy function whose variables are fuzzy functions with uncertain domains is presented. Then, we propose a theorem which is proved to be applicable to the FBB control problem. Moreover, taking the relative-distance-measure fuzzy interval arithmetic and horizontal membership functions into consideration, we further give complementary theorems to ensure that if the problem has a solution, then the controller assumes its boundary values. The simulated results confirm this theoretical conclusion. These findings may enrich our insight of the behavior of the uncertain dynamical system subjected to the FBB control problem, and guide to predict the uncertain trajectories.

Keywords: Horizontal Membership Functions, RDM Fuzzy Interval Arithmetic ,Granular Differentiability, Fuzzy Optimal Control Problem, Fuzzy differential equations

1 Introduction

Fuzzy differential equations (FDEs) have attracted more attentions since they appeared in 1978 [1]. The FDEs are differential equations in which conditions and/or parameters are considered as a class of possible sets called fuzzy numbers. The FDEs, as an effective tool, enable researchers to describe uncertain behaviors of a dynamical system with various degrees of possibility. So far, extensive research has been conducted on the FDEs, such as studying FDEs based on fractional calculus [2, 3, 4], presenting the existence and uniqueness of a solution to the fuzzy differential equations [5, 6, 7], and proposing various methods for solving FDEs [8, 9]. Along with mathematical progress on the FDEs, the FDEs have been widely considered in applications ranging from medicine [10], chemical engineering [11], economics [12], and control theory [13], etc. In many applications the behavior of dynamical systems is desired to be controlled, but meanwhile, the conditions and/or

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