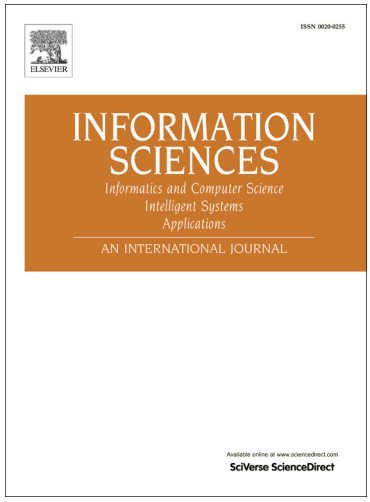
# Accepted Manuscript




Big Bang-Big crunch optimization based interval type-2 fuzzy pid cascade controller design strategy

Tufan Kumbasar, Hani Hagras

PII: S0020-0255(14)00623-9
DOI: http://dx.doi.org/10.1016/j.ins.2014.06.005
Reference: INS 10929

To appear in: *Information Sciences*

Received Date: 23 November 2013
Revised Date: 26 March 2014
Accepted Date: 1 June 2014

Please cite this article as: T. Kumbasar, H. Hagras, Big Bang-Big crunch optimization based interval type-2 fuzzy pid cascade controller design strategy, *Information Sciences* (2014), doi: http://dx.doi.org/10.1016/j.ins.2014.06.005

# BIG BANG-BIG CRUNCH OPTIMIZATION BASED INTERVAL TYPE-2 FUZZY PID CASCADE CONTROLLER DESIGN STRATEGY

Tufan Kumbasar[*1] and Hani Hagras[2]

[1] *The Control and Automation Engineering Department, Faculty of Electrical and Electronics Engineering, Istanbul Technical University, Maslak, TR-34469, Istanbul, Turkey*

[2] *The Computational Intelligence Centre, School of Computer Science and Electronic Engineering, University of Essex, Colchester CO4 3SQ, United Kingdom/King Abdulaziz University, Jeddah, Saudi Arabia*

***Abstract***

Fuzzy logic control is a recognized approach for handling the faced uncertainties within control applications. However, type-1 fuzzy controllers using crisp type-1 fuzzy sets might not be able to fully handle the high levels of uncertainties and nonlinear dynamics associated with real world control applications. On the other hand, interval type-2 fuzzy controllers using Interval Type-2 Fuzzy Sets (IT2-FSs) might be able to handle such uncertainties to produce a better control performance. However, the systematic design of interval type-2 fuzzy controllers is still a challenging problem due to the difficulty in determining the parameters of the IT2-FSs. In this paper, we will present the novel application of Big Bang-Big Crunch optimization (BB-BC) approach to optimize the antecedent membership parameters of Interval Type-2 Fuzzy PID (IT2-FPID) controllers in a cascade control structure. Since the IT2-FPID control structure involves more design parameters compared to its type-1 counterpart, it is beneficial to employ the BB-BC method which has a low computational cost and a high convergence speed. The presented BB-BC based optimized IT2-FPID cascade structure will be compared with its Type-1 Fuzzy PID (T1-FPID) and conventional PID controller counterparts which were also optimized with the BB-BC optimization. In addition, the proposed IT2-FPID structure will be compared with a self-tuning T1-FPID control structure. We will then present the novel application of the cascade control architecture to solve the path tracking control problem of mobile robots which inherits large amounts of uncertainties caused by the internal dynamics and/or feedback sensors of the controlled system. Several experiments were performed in simulation and in real world using the PIONEER 3-DX mobile robot which will act as a platform to evaluate the proposed control systems in this paper. The results illustrated that the IT2-FPID structure enhanced significantly the control performance even in the presence of uncertainties and disturbances when compared to the PID, T1-FPID and self-tuning T1-FPID structures. Moreover, it has been shown that the reason for the superior control performance of the IT2-FPID under high levels of uncertainty and noise is not merely for its use of extra parameters, but rather its different way of dealing with the uncertainties and noise present in real world environments by comparing with a self-tuning T1-FPID structure.

*Keywords:* Interval Type-2 Fuzzy Logic Systems, Interval Type-2 Fuzzy Sets, Interval Type-2 Fuzzy PID Controllers.

*Corresponding Author. Tel +90-212-2856664, Fax: +90-212-2852920

*E-mail address:* kumbasart@itu.edu.tr (T. Kumbasar)