

A Review of Several Fuzzy Function Structures

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I. INTRODUCTION

Within the last decade or so, there have been several proposals to develop fuzzy system models via functional representation in place of rule base representation. We review at least three of these approaches:

1) "Fuzzy Functions" originally proposed by Turksen I and later further developed by Celikyilmaz and Turksen I-I in a variety of versions. "Fuzzy Functions" are developed essentially with original input variables and membership values and their various transformations as required for a particular system representation. For this purpose membership values are obtained from FCM, Fuzzy C-Means I, or IFCM, Improved FCM, I algorithm. Thus, this approach requires the availability of an input-output data base for analysis by FCM or IFCM algorithm for the extraction of membership values. There is a "Fuzzy Function" for each cluster. Thus, "Fuzzy Functions" are an improved alternate system models to "Fuzzy Rule Bases".

2) The objective of "Fuzzy C-Regression Model", (FCRM), clustering algorithm I, as in all clustering algorithms, is to classify objects into similar groups. FCRM clustering algorithm yields simultaneous estimates of parameters of "C-Regression Models", while fuzzy partitioning a given dataset. A prominent feature of this clustering algorithm that separates it from other point-wise clustering algorithms, e.g. FCM, is that, cluster prototypes are functions instead of geometrical objects.

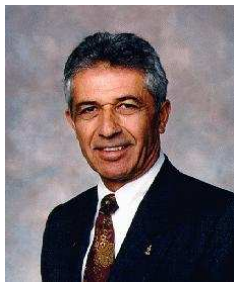
3) Höppner and Klawonn I combine FCM I, and FCRM I algorithms in one clustering schema, to build a combined clustering structure. Their main goal was to update FCM fuzzy clustering algorithm so that they can prevent the effect of harmonics by modifying the objective function. They not only deal with point-wise clustering algorithms such as "Fuzzy C-Means" (FCM) clustering algorithm I, they also deal with "Fuzzy C-Regression Model" clustering algorithm (FCRM) I. It is also well-known that Hathaway and Bezdek, 1993, proposed to build linear regression models. Whereas one can build non-linear regression models with Höppner and Klawonn, 2003, approach.

A critical review will be demonstrated with examples.

REFERENCES

- [1] J.C. Bezdek, S.K. Pal, *Fuzzy models for pattern recognition*. IEEE Press, Piscataway, N.J., 1992.
- [2] A. Celikyilmaz & I. B. Turksen, "Modeling Uncertainty with Fuzzy Logic: With Recent Theory and Applications", Springer Book Series 2009, foreword by Prof. Lotfi A. Zadeh.
- [3] A. Celikyilmaz & I. B. Turksen, Increasing Accuracy of Two Class Pattern Recognition with Improved Fuzzy Functions, *Expert Systems with Applications*, 36, pp. 1337-1354, 2009 .
- [4] A. Celikyilmaz & I. B. Turksen, Fuzzy Decision Making Under Uncertainty, Invited Paper, *International Journal of Approximate Reasoning*, accepted, 2009.

- [5] A. Celikyilmaz & I. B. Turksen, Uncertainty modeling with evolutionary improved fuzzy functions approach, *IEEE Systems, Man, and Cybernetics- Part B*, vol. 38, no. 4, August 2008.
- [6] A. Celikyilmaz & I. B. Turksen, Enhanced Fuzzy System Models with Improved Fuzzy Clustering Algorithm, *IEEE Trans. on Fuzzy Systems*, volume 16 (3), pp. 779-794, June 2008.
- [7] A. Celikyilmaz & I. B. Turksen, Validation Criteria for Enhanced Fuzzy Clustering, *Pattern Recognition Letters*, volume 29, pp. 97-108, 2008.
- [8] A. Celikyilmaz & I. B. Turksen, Fuzzy Functions with Support Vector Machines, *Information Sciences*, volume 177, pp. 5163-5177, 2007.
- [9] R. Hathaway and J. Bezdek, "Switching regression models and fuzzy clustering," *IEEE Trans. Fuzzy Syst.* vol. 1,3, 1993, pp. 195-204.
- [10] F. Höppner, F. Klawonn, "Improved fuzzy partitions for fuzzy regression models," *Int. Jml. of Approximate Reasoning*, vol. 32, pp. 85-102, 2003.
- [11] I. B. Turksen, Fuzzy Functions with LSE, *Applied Soft Computing*, vol. 8, issue 3, 2008.



I.B. Türksen, received the B.S. and M.S. degrees in Industrial Engineering and the Ph.D. degree in Systems Management and Operations Research all from the University of Pittsburgh, PA. He joined the Faculty of Applied Science and Engineering at the University of Toronto and became Full Professor in 1983. In 1984-1985 academic year, he was a

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His current research interests centre on the foundations of fuzzy sets and logics, measurement of membership functions with experts, extraction of membership functions with fuzzy clustering and fuzzy system modeling. He proposed "Fuzzy Functions" as an alternate to "Fuzzy Rulebases". His contributions include, in particular, Type 2 fuzzy knowledge representation and reasoning, fuzzy truth tables, fuzzy normal forms, T-formalism which is a modified and restricted Dempster's multi-valued mapping, and system modeling applications for intelligent manufacturing and processes, as well as for management decision support and intelligent control.

He has published near 300 papers in scientific journals and conference proceedings.

His book entitled "*An Ontological and Epistemological Perspective of Fuzzy Theory*" was published by Elsevier, The Netherlands, in January, 2006. (ISBN-10: 0-444-51891-6, ISBN-13: 978-0-444-51891-0)

His second book, co-authored by A. Celikyilmaz, entitled "Modeling Uncertainty with Fuzzy Logic: With Recent Theory and Applications , Springer Berlin / Heidelberg, ISSN:1434-9922 (Print) 1860-0808 (Online), ISBN: 978-3-540-89923-5, April 01, 2009.