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A systematic analysis of Non-Singleton Fuzzy Logic Systems: Control with Noisy Inputs

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ABSTRACT:- *A major asset of fuzzy logic systems is dealing with uncertainties arising in their various applications, thus it is important to make them achieve this task as effectively and comprehensively as possible. While singleton fuzzy logic systems provide some capacity to deal with such uncertainty aspects, non-singleton fuzzy logic systems (NSFLSs) have further enhanced this capacity, particularly in handling input uncertainties. This work broadly aims at removing the black boxed ness of Fuzzy Logic (Non-Singleton type) systems by plotting Fuzzy Basis Functions (FBF's) under different settings of membership functions of inputs, membership functions of antecedents and inference variants.*

In the initial part of the work, preliminaries define & clarify several issues & concepts connected with Non-Singleton FLS's and the reasons are bought out clearly as to why NSFLS's shall be superior to SFL's in case the Input is noisy. Several differences between SFL's & NSFL's are demonstrated through simulations under different inference schemes, a variety of membership functions of the input variables and the membership functions of antecedents.

KEYWORDS*: SFL, NSFL.*

INTRODUCTION

Fuzzy logic is an extension of Boolean logic by Lotfi Zadeh in 1965 based on the mathematical theory of fuzzy sets, which is a generalization of the classical set theory. By introducing the notion of degree in the verification of a condition, thus enabling a condition to be in a state other than true or false, fuzzy logic provides a very valuable flexibility for reasoning, which makes it possible to take into account inaccuracies and uncertainties. It provides a technique to deal with imprecision and information granularity. The fuzzy theory provides a mechanism for representing linguistic constructs.

Since we are all limited in our ability to perceive the world and to profoundly reason, we find ourselves everywhere confronted by uncertainty which is a result of lack of information (lexical impression, incompleteness), in particular, inaccuracy of measurements. The other limiting factor in our desire for precision is a natural language used for describing or sharing knowledge, communication, etc. We understand core meanings of word and are able to communicate accurately to an acceptable degree, but generally we cannot precisely agree among ourselves on the single word or terms of common sense meaning. In short, natural languages are vague.

It is important to observe that there is an intimate connection between Fuzziness and Complexity. As the complexity of a task (problem), or of a system for performing that task, exceeds a certain threshold, the system must necessarily become fuzzy in nature. Real world problems (situations) are too complex, and the complexity involves the degree of uncertainty – as uncertainty increases, so does the complexity of the problem. Traditional system modeling and analysis techniques are too precise for such problems (systems), and in order to make complexity less daunting we introduce appropriate simplifications, assumptions, etc. (i.e., degree of uncertainty or Fuzziness) to achieve a satisfactory compromise between the information we have and the amount of uncertainty we are willing to accept.

Based on both intuitive and expert knowledge, system parameters can be modeled as linguistic variables and their corresponding membership functions can be designed. Thus, nonlinear system with great complexity and uncertainty can be effectively controlled based on fuzzy rules without dealing with complex, uncertain, and error-prone mathematical models.

The variables in fuzzy logic system may have any value in between 0 and 1 and hence this type of logic system is able to address the values of the variables (called linguistic variables) those lie between completely truths and completely false. Each linguistic variable is described by a membership function which has a certain degree of membership at a particular instance. The human knowledge is incorporated in fuzzy rules. The fuzzy inference system formulates suitable rules and based on these rules the decisions are made. This whole process of decision making is mainly the combination of concepts of fuzzy set theory, fuzzy IF-THEN rules and fuzzy reasoning. The fuzzy inference system makes use of the IF-THEN statements and with the help of connectors present (such as OR and AND), necessary decision rules are constructed. The fuzzy rule base is the part responsible for storing all the rules of the system and hence it can also be called as the knowledge base of the fuzzy system. Fuzzy inference system is responsible for necessary decision making for producing a required output. The fuzzy control systems are rule-based systems in which a set of fuzzy rules represent a control decision mechanism for adjusting the effects of certain system stimuli. The rule base reflects the human expert knowledge, expressed as linguistic variables, while the membership functions represent expert interpretation of those variables.