

## **Fuzzy rule based systems: applications, design issues, solutions, and open problems - where do we stand?**

*Nikhil R. Pal*

*Indian Statistical Institute, Kolkata*

*(presently at National Chiao Tung University, Taiwan)*

*e-mail : nrpal59@gmail.com*

Fuzzy rule based systems have been successfully used in numerous applications from washing machines to missile guidance. Two very distinct advantages of fuzzy rule based systems over other tools like neural networks are : they are readable and are less likely to produce poor generalization due to the reasoning architecture built into it. Yet, when it comes to solving application problems (pattern recognition type) by a practitioner, more often neural networks become the tool of choice. Why? An attempt to find the reasons behind this revealed the following answers/points : “fuzzy systems are difficult to design”, “no good tool box, like Matlab neural networks toolbox, is available”, “may not work for complex problems” .... So, where do we really stand and how relevant these points are?

We shall motivate our discussion with four representative applications where fuzzy rule based systems have done a great job. There four problems are: structure preserving dimensionality reduction, land-cover classification, detection of bounded weak echo region (relating to severe weather phenomena), and cloud-cover estimation. Then we shall identify and discuss various questions/issues that one needs to address for designing a useful fuzzy rule based system. Our discussion will be restricted to automatic methods based on exploratory data analysis. We shall discuss possible solutions to each issue and indicate how other choices can provide rich families of solutions. In spite of tremendous advancements in fuzzy rule based systems identification, there are a few problems that often make rule finding difficult and limit the applicability of fuzzy rule based systems. We shall discuss a few such problems and then present a new method to address two of the open problems in an integrated manner. Typically feature analysis is done separately from the rule extraction phase and the quality of each feature is assessed in isolation ignoring the problem being solved and the machine learning tool being used. The proposed method is unique in the sense that it can identify the necessary features along with extraction of the rules in an integrated manner and thereby can account for the subtle nonlinear interaction between features and fuzzy rules. This new method will be illustrated with applications in the bioinformatics area.