

- Study of the stability criteria of fuzzy controllers.

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Research activities related to fuzzy sets and fuzzy logic at the Machine Intelligence Unit of the Indian Statistical Institute, Calcutta, India

Though the *Machine Intelligence Unit* is at its infancy, the members of this unit – especially those who are working on fuzzy sets and fuzzy logic – are actively engaged in this field for quite a long time and have earned national and international recognition. Recently, the group is mainly concentrating on the following major topics.

Soft computing: Research is in progress to realize the basic goal of soft-computing, viz., tractability, robustness and low cost. Various hybridizations like neuro-fuzzy, neuro-genetic, fuzzy-rough, neuro-fuzzy-genetic are being carried out in this regard.

Image processing using fuzzy sets: Various types of image segmentation, image enhancement and image skeletonization techniques are developed by some of the members of the group. Further research is in progress mainly to develop neuro-fuzzy techniques for image processing by incorporating the merits of fuzzy set theory and neural networks.

Multivalued pattern classification systems using fuzzy logic: A multivalued pattern classification system which assigns multiple class labels with certainty factors to an input pattern is developed. Its applicability is demonstrated widely on remotely sensed images. An efficient way of decomposing the feature space is under investigation.

Neuro-fuzzy systems for pattern classification and rule generation: Members working on this topic have already developed some algorithms and models for pattern classification and rule generation by designing various modified versions of different neural network architectures so as to handle fuzzy input, provide fuzzy output label for patterns and to use fuzzy operators. The system has the ability to query users for any additional information it needs. Demonstrations of the utility of these techniques on finger prints and EEG are in progress.

Fuzzy logic controller: A new concept of context sensitive reasoning has been proposed and used to develop reinforcement type learning algorithms for designing adaptive fuzzy controllers. Relative importance of rules

has also been incorporated into fuzzy models for design of robust and efficient controllers. The fuzzy control paradigm has been used in conjunction with human psycho-visual facts for edge detection.

Uncertainty measures: A new measure of total uncertainty in the Dempster Shafer framework has been suggested. A unique measure of information quantifying the conflict aspect of total uncertainty associated with a body of evidence has been derived. Besides these, various entropy measures were developed by this group.

Very recently the unit has completed a project sponsored by the Defence Electronics Applications Laboratory, Government of India on analyzing remotely sensed data using fuzzy set theoretic techniques. (Unsupervised) segmentation of remotely sensed images, classification of various land cover types and detection of various important objects were the prime outcome of the project. Another project of national importance titled “*A Neuro-fuzzy Image Recognition System: Methodology Development for Forensic Applications*” (sponsored by CSIR) will be completed successfully next year.

Members of the unit do collaborative work on fuzzy technology with University of West Florida, USA; NASA, USA; Duke University, Durham, USA; Colorado State University, Fort Collins, USA; Georgia Southern University, USA; University of Houston, USA; Institute für Wirtschaftswissenschaften, Germany; Hannan University, Japan; Ryukoku University, Japan; and Osaka Prefecture University, Japan.

This year one of the members (Sushmita Mitra) of the group got her Ph.D. degree for her contribution on developing neuro-fuzzy pattern classification and rule generation techniques. Title of her thesis: *Neuro-fuzzy Models for Pattern Classification and Rule Generation*. Another member (Jayanta Basak) got his Ph.D. degree for his contribution on designing neural network architectures for object recognition. Thesis title: *Connectionist Models for Certain Tasks Related to Object Recognition*. The group publishes intensively in International Journals and Conferences. An edited volume on *Genetic Algorithms for Pattern Recognition*, CRC Press, Boca Raton, has been brought out by Prof. S.K. Pal, co-edited with Prof. P.P. Wang of Duke University. Besides, some of the members of the group are highly engaged with editorial activity of many international journals like IEEE TNN, IEEE TFS, IETE, Neuro-Computing, Pattern Recognition Letters, Applied Intelligence, Information Sciences, Int. Journal of Approximate Reasoning, and Resonance.

Dr. Ashish Ghosh and Dr. (Ms.) Mohua Banerjee of the group got the *Young Scientist* award from the Indian National Science Academy in 1995; and Dr. Jayanta Basak in 1996. This award is considered to be one of the coveted and prestigious awards for Indian scientists below the age of 32. Prof. Shankar K. Pal worked for the last two years with the prestigious Jawaharlal Nehru Fellowship for developing neuro-fuzzy expert systems. He is a fellow of the IEEE. He is the recipient of S.S. Bhatnagar prize (high-

est and most coveted scientific award in India), Vikram Sarabhai Research Award, NASA Tech Brief Award.

At present Dr. Ashish Ghosh is visiting the Department of Industrial Engineering, Osaka Prefecture University with the Japanese Government (MONBUSHO) Fellowship to work on projects related to fuzzy sets and genetic algorithms. Prof. Sankar K. Pal will visit some of the Japanese Universities during this year under INSA-JSPS collaborative programs. Dr. C.A. Murthy will be visiting Pennsylvania State University, PA, from July 1996 for one year.

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Fuzzy Research at Department of Control Engineering, Kyushu Institute of Technology, Japan

In our department, research in control engineering and applied dynamics is carried out by ten professors. The subjects studied are, e.g., analysis and control of mechanical vibration, man-machine interface, robot dynamics and control, control system theory, computer control, vision technology, nonlinear control dynamics and digital control systems. Fuzzy research, mainly stability analysis of fuzzy control systems, has been carried out in our department by Prof. T. Yamashita, myself and our co-researchers as one of our main studies since 1990. We are now interested in development of more effective stability analysis methods and practical applications of fuzzy set theory to control system. Prof. Y. Araki and his research group had successfully used fuzzy control method for wave pattern control of pulsation in air-pulsated coal preparation jig.

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Fuzzy Research at the Institute of Systems Engineering, Dalian University of Technology, China

A few research groups work on fuzzy sets at the Institute of Systems Engineering, Dalian University of Technology. One of the groups including Prof. Qu Xiaofei and myself has done fuzzy research since 1991. The research was once involved with a project 'A Theoretical Study for Multiperson Multiobjective Decision-making with Incomplete Information Based on a Bargaining Game' supported by the National Natural Science Foundation of China. Now the project has been finished, but our research work for fuzzy set theory and application is just in the initial stage.

Currently, our group is mainly interested in fuzzy decision-making, fuzzy mathematical programming and the application of fuzzy set theory in economics and computer science. We would like to get in touch with other researchers who are interested in these areas.

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