SOFT COMPUTING BASED MODELING OF DYNAMIC SYSTEMS

by

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ynamic Systems (mathematical programming)

Certificate

This is to certify that the thesis entitled *"Soft Computing Based Modeling of Dynamical Systems"* being submitted by **Mohammad Fazle Azeem** for the award of the degree of the **Doctor of Philosophy** to the Indian Institute of Technology, Delhi is a record of the bonafide research work he has carried out under our supervision. The results contained in this have not been submitted to any other University or Institute for the award of a degree or diploma.

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Abstract

The emergence of Soft Computing paradigm as a consortium of Fuzzy logic, Neural Computing and Genetic algorithms has paved the way for handling complex dynamic systems. The present thesis makes an attempt to tackle some problems such as input selection, structure determination and model learning, associated with modeling of complex dynamic systems from the imprecise and uncertain operating data consisting of input-output pairs. The issues arising from these problems form the basis of this thesis.

As part of input selection, new criteria have been proposed based on the fuzzy curve approach for evaluating the significance of inputs. Fuzzy curve is the output Approximate Fuzzy Data Model (AFDM) and the changes in the output of AFDM over the range of input yields the ratios, which form the basis for input selection.

The structure determination is concerned with the choice of the number of rules for a particular model. In order to widen the choice, a Generalized Fuzzy Model (GFM), which may be categorized into four classes, encompassing Takagi-Sugeno (TS) Model and Compositional Rule of Inference (CRI) Model as special cases has been proposed. In order to learn the parameters of GFM, a Generalized Radial Basis Function (GRBF) Network has been suggested. It is shown that for any solution using GRBF, the error surface generated is symmetric. Finally, the equivalence of GRBF with GFM has an important bearing on the learning ability of Generalized Adaptive Neuro-Fuzzy Inference Systems (GANFIS).

For determining the structure, we have used clustering by Fuzzy C-means, Modified Mountain techniques in addition to Fuzzy curve approach for partitioning the input-output hyperspace into a number of clusters, which correspond to the number of rules. To provide a trade off between the computational complexity and model performance a Structure Identification Criterion (*SIC*) has been proposed.

The parameters of GFM are learned through the Least Square Estimation (LSE) and gradient Descent (GD) learning. In case, the models fail to achieve the targeted performance, the local learning algorithm is combined separately with Simulated Annealing (SA) to give SA hybrid and with Genetic Algorithm (GA) to give GA hybrid.

The modeling methodology has been tested on the practical plant like Fluidized Catalytic Cracking Unit (FCCU).

CONTENTS