MODELING AND CONTROL OF NON-LINEAR SYSTEMS USING INTELLIGENT TOOLS

by

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Submitted

in fulfillment of the requirements of the degree of Doctor of Philosophy

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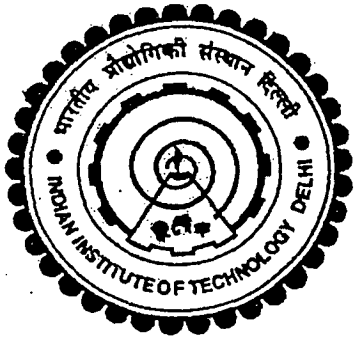

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- nonlinear mechanics
- nonlinear control
- physiological

Certificate

This is to certify that the thesis entitled ***"Modeling and Control of Non-Linear Systems using Intelligent Tools"*** being submitted by **Smriti Srivastava** for the award of the degree of the **Doctor of Philosophy** to Indian Institute of Technology, Delhi is a record of the bonafide research work she 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 thesis presents several studies aimed at enhancing the capabilities of fuzzy models by taking in to account the specific characteristics of the given input-output data and by bringing to the fore the hidden dynamically varying relationship. The characteristics of the input-output signals though explored in the signal processing area by the wavelets are not utilized in the fuzzy domain. In this thesis, we have made use of two properties of wavelets, viz., compression and multiresolution in the framework of Takagi-Sugeno model to design two architectures of Fuzzy Wavelet Neural Networks (FWNN). These architectures are then used for identification and control. The control is achieved through Fuzzy PI and neural network controller.

In the next study, we have bent upon devising an efficient controller that consists of linear and nonlinear parts. Several candidates have been used for these two parts and finally the combination of FTF serving as linear part and α-LMS and gradient descent learning serving as the nonlinear part in the neural learning came out with flying colors.

Our attention is then turned on to the treatment of non-additive fuzzy systems. The Takagi-Sugeno model combines the information from independent input sources. In many realistic applications, the assumption of independence doesn't hold good. In this thesis, we have addressed this problem at length and proposed Choquet fuzzy integral based identification and control. The modification here is the replacement of consequent parts of fuzzy rules of TS model by Choquet integral. In this integral, the information from any two sets is combined non-additively with the inclusion of λ-parameter. As there are problems with its solution we have used a q-measure which is a generalization of λ-measure and it involves splitting a fuzzy set into two. Next, to improve the convergence of the λ-parameter, we have proposed four-measure by which we split up a fuzzy set into four. This four measure is then

extended to n-measure and complexity of different fuzzy measures vs. performance is also studied.

We have also made an extensive use of Choquet integral in the reformulation of learning law and the fuzzy curve approach intended for structure determination of non-additive fuzzy systems.

Finally, the dynamics of the input-output behavior is realized through the fuzzy model by modifying the consequent part of the fuzzy rule of TS model. In this formulation, the inputs and outputs are expressed in terms of state space type equations. The approaches presented in the thesis have been validated by applying them on benchmark problems.

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