SUMMARY OF Ph.D. DISSERTATION

School	Student Identification Number	SURNAME, First name
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Title

A Study on the Fuzzy Modeling of Nonlinear Systems Using Kernel Machines

Abstract

This thesis presents new approaches to fuzzy inference system for modeling nonlinear systems based on input and output data using kernel machines. It is important issue how to select the best structure and parameters of the fuzzy model from given input-output data. To solve this problem, the state-of-the-art kernel machine is used as the fuzzy inference engine. In the proposed fuzzy system, the number of fuzzy rules and the parameter values of membership functions are automatically generated using extended kernel machines such as an extended Support Vector Machine (SVM), an extended Feature Vector Selection (FVS) and an extended Relevance Vector Machine (RVM). As the basic structure of the proposed fuzzy inference system, the Takagi-Sugeno (TS) fuzzy model is used. In addition, the number of fuzzy rules can be reduced by adjusting the linear transformation matrix or the parameter values of a kernel function using the gradient descent method.

Chapter 1 describes the motivation, background, contribution and the outline of this work.

Chapter 2 describes the preliminaries of the fuzzy system, statistical learning theory and kernel-induced feature space. In particular, the fuzzy set and logic, fuzzy reasoning and TS fuzzy model in fuzzy system are introduced. In statistical learning theory, generalization error, empirical risk minimization and structure risk minimization principle are presented. In kernel-induced feature space, learning in feature space and kernel function are described.

Chapter 3 describes the fuzzy inference system using an extended SVM. The extended SVM is proposed as fuzzy inference engine. The structure and learning algorithm of the FIS using an extended SVM are presented. The proposed FIS is tested in three numerical examples.

Chapter 4 describes the fuzzy inference system using an extended FVS. The extended FVS is also proposed as fuzzy inference engine. The learning algorithm of the extended FVS is faster than the extended SVM. The extended FVS consists of the linear transformation part of input variables and the kernel mapping part. The linear transformation of input variables is used to solve problem selecting the best shape of the Gaussian kernel function. The proposed FIS is evaluated in the examples of two nonlinear functions.

Chapter 5 describes the fuzzy inference system using an extended RVM. The extended RVM is also proposed as fuzzy inference engine. The extended RVM generates the smaller number of fuzzy rules than the extended SVM. The extended RVM does not need the linear transformation of input variables because the basis function of the extended RVM is not restricted within the limitation of the kernel function. The structure and learning algorithm of the FIS using an extended RVM are presented. The proposed FIS is evaluated in the examples of nonlinear dynamic systems and robot arm data.

Chapter 6 concludes this thesis.