THE SUMMARY OF Ph. D. DISSERTATION

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Title

Motion Control of Cars Using Soft Computing Method

Abstract

Research and development of active motion control technology for cars have been actively performed because of strong requirement for safety driving. The control law of car motion control needs to be adaptable to the non-linearity of car dynamics due to the characteristics of tire-road force and uncertainty of drivers' behavior. The previous non-linear control theory and human performance analysis have not provided effective solution for such problems. The soft computing methodology such as neural network and genetic algorithm capable of treating non-linearity and uncertainty is regarded as a powerful means for such problems. In this study, this soft computing methodology is tried to be applied to real problems of car steering control.

This study aims at discussing the following issues concerning car motion control.

・To apply the neural network theory to the design of stabilizing controller that has been empirically performed with trial and error as an engineering optimizing method. Moreover, to extract a control rule from the control law of the neural network controller.

・To design a steering controller which steers similarly to drivers' operation by utilizing a leaning method with network and genetic algorithm. To discuss about the required information for driver on curved road.

・To design an intelligent controller of non-linear front steering by using neural networks.

Chapter 1 is the introduction and describes the research motivation and issues.

In Chapter 2, first, the dynamics of cars is explained, secondly the past studies on motion control of car are surveyed and a prospect trend of motion control technology of cars is commented.

In Chapter 3, the theoretical fundamentals of the neural network and the genetic algorithm are described. And the previous applications of soft computing method on car control technology are surveyed.

In Chapter 4, a trend of mechanical simulation software (MSS) is surveyed. And some techniques to avoid the problem of displacement input on the MSS are described.

In Chapter 5, a rule extraction from neural network controller for stabilizing control of car is presented. The neural network controller is designed through computer simulations of double-lane change with GA. By adding a forgetting genetic operator, the connections of neural network are reduced and simplified. As a result, a simple control law of direct yaw feedback is obtained, so that the control law utilizes the slip angle and its time derivative. This control law has good performance and corresponds to the conventional control of direct yaw.

In Chapter 6, a neural network steering controller that consists of three networks is applied to a non-linear steering operation problem. The neural network controller has a function similar to the operation of car drivers. Each neural network in the controller is learned by the genetic algorithm repeating numerical simulations for a case of passing through some simple curved roads. The effectiveness and the feasibility of this controller are verified by numerical simulation of a simple 4DOF car model.

In Chapter 7, an intelligent control of front wheel steering is presented. The controller consists of two neural network controllers and an integrator and in other words has an architecture of the Cubic Neural Network (CNN). The neural networks are learned by the error back propagation procedure. By using the CNN architecture, the controller can be adaptable to various values of road friction coefficient. The effectiveness and the feasibility of the present active steering method are demonstrated by numerical simulations of a simple 8DOF model and a DADS full vehicle model.

Chapter 8 is the conclusion of this paper.

By the above-mentioned results, an efficient and effective motion control method using the soft computing methodology was proposed in the field of automobiles.