Generalized Asymmetrical Bidirectional Associative Memory for Human Skill Transfer

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Abstract

The essential requirements of neural network for human skill transfer are fast convergence , high storage capacity, and strong noise immunity. Bidirectional associative memory(BAM) suffering from low storage capacity and abundance of spurious memories is rarely used for skill transfer application though it has fast and wide association characteristics for visual data. This paper suggests generalization of classical BAM structure and new learning algorithm which uses supervised learning to guarantee perfect recall starting with correlation matrix. The generalization is validated to accelerate convergence speed, to increase storage capacity, to lessen spurious memories, to enhance noise immunity, and to enable multiple association using simulation work.

1 Introduction

Recently, neural network has found wide applications for modeling and transferring human skills to robot controls. Mainly service robot applications require this type of modeling which includes manipulative skills, locomotions, reaction and a man-machine interface suitable for applications which take place in human centered environment. In designing neural network for human skill transfer, three important aspects of the whole architecture should be considered. First, the stability of overall system should be guaranteed even when the neural network learned by successful human demonstrations fails to control the system due to modeling error. We previously designed a stabilizer which maintains boundness of system trajectory in Lypunov sense [16]. It is a switching scheme which activates robust controller when the system trajectory is trying to deviate over the prescribed threshold. The merit of this switching controller is any sort of neural network can be applied to model human skills. Design of neural network and system stability are divided into independent processes. Second, neural network should be learned fast for on-line applications. Third, neural network should be able to easily approximate arbitrary complex human behaviors by modifying network structure appropriately, *i.e.*, it should be an universal approximator. This paper is mainly devoted to solve the latter two problems by generalizing network sturcture of BAM.

In the early 1980's, Hopfield proposed an auto-associative memory model to store and recall information in much the same way as the human brain. In the late 1980's, Kosko extended the auto-associative memory model to a bidirectional one [1]. This two-level nonlinear memory model is based on earlier studies on associative memories [7]. The bidirectional associative memory (BAM) model is more general and powerful than the Hopfield auto-associative memory and includes the Hopfield memory as a special case. A BAM can associate an input pattern with a different stored output pattern of a stored pattern pair, thus allowing bidirectional association. Owing to their fast learning, good generalization, and noise immunity, BAM's are well suited for modeling human pattern recognition and control behavior.

A BAM consists of neurons arranged in two layers. The neurons in one layer are fully interconnected to the neurons in the other layer. There are no interconnections among neurons in the same layer. The neurons generate action trains which are dependent on the strength of the synaptic interconnections. The instantaneous state of the system is defined by the collective status of each individual neuron (firing or not firing). The memory storage capacity and recall reli-