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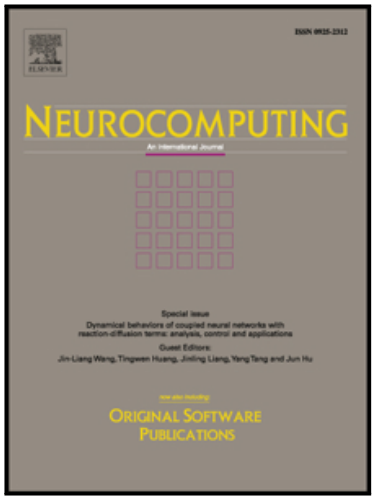

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GST-Memristor-Based Online Learning Neural Networks

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Abstract

At present, it is an urgent issue to effectively train artificial neural network (ANN), especially when the data is large. Online learning has been used to solve the problem, most of which is based on least mean square (LMS). However, it is inefficient to implement the LMS on conventional digital hardware, because of the physical separation between the memory arrays and arithmetic module. To solve this problem, CMOS has been utilized. However, it costs too many powers and areas while designing CMOS synapses in the very large scale integrated (VLSI) circuit. As a novel device, memristor is believed to overcome this shortcoming as memristors could be utilized to store the weights which could be changed by a voltage pulse. The filamentary bipolar memristive switching in $Ge_2Sb_2Te_5$ (GST) has been proved to be an ideal choice for memristive materials. And it has two states—amorphous and crystalline, which can be changed by DC sweep. In this paper, we consider an artificial synapse which includes a GST-memristor and two MOSFET transistors (p-type and n-type). A number of artificial synapses are employed to form a circuit which is expected to consume $2\% - 8\%$ of the area compared to CMOS-only circuit. And the accuracy is about 80%, which is good enough in realistic diagnosis and has good robustness with noise.

Keywords: Artificial neural network, online learning, CMOS, GST-memristor

1. Introduction

Human brain is organized by a large number of parallel nonlinear processing units, which can be self-organized and self-learning. Compared with the traditional computer, biological neural network is the most skillful and complex information processing system in real life because it has unparalleled information processing capabilities [1]. Therefore, the researchers hope to use artificial neural network to simulate the information processing mechanism of brain, which can be used in many fields such as pattern recognition and expert system. Moreover, if we could establish a neural network model with cognitive function, the artificial intelligence would be realized [2].

In 1943, W. McCulloch and W. Pitts [3] firstly proposed the mathematical model of neural by analyzing and summarizing the basic characteristics of neurons. Hebb [4] proposed artificial neural network (ANN) in 1949, which is a kind of model to simulate the structure and function of biological neural network. The research of artificial neural network has become a research hotspot in many fields [5-7], which is based on mathematics, physics and computer science. In recent, a large number of artificial neural networks and neural network models have been proposed, such as the linear threshold function neuron model [8], BP neural network model [9], Hopfield neural network model [10]. And some control strategies were proposed in [11-12] for neural networks. Adaptive coupling weights [13] is a good method to control complex dynamical networks. However, they all have to solve the problem: how to train the neural network effectively, especially when the data is large. Therefore, Zinkevich [14] proposed online learning and it costs

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