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Monostable multivibrators as novel artificial neurons

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Abstract

Retriggerable and non-retriggerable monostable multivibrators are simple timers with a single characteristic, their period. Motivated by the fact that monostable multivibrators are implementable in large quantities as counters in digital programmable hardware, we set out to investigate their applicability as building blocks of artificial neural networks. We derive the nonlinear input-output firing rate relations for single multivibrator neurons as well as the equilibrium firing rate of large recurrent networks. We show that in rate-encoded monostable multivibrators networks the synaptic weights are tunable as the period ratio of connected units, and thus reconfigurable at run time in a counter-based digital implementation. This is illustrated with the task of handwritten digit recognition. Furthermore, we show in a task-independent manner that networks of monostable multivibrators are capable of nonlinear separation, when operating directly on pulse streams. Our research implies that pulse-coupled neural networks with excitable neurons showing a delayed response can perform computations even when working solely with suprathreshold pulses.

Keywords: neuron model, ANN, network dynamics, pulse coupled, PCNN

PACS: 87.19.ll, 87.85.Wc, 87.18.Sn

1. Introduction

Historically, artificial neural networks (ANN) have employed many different neuron models. Some, such as the Hodgkin-Huxley [Hodgkin and Huxley \(1952\)](#) model, are firmly grounded in physiological principles, aiming to capture biological reality. The FitzHugh-Nagumo (FHN) model [FitzHugh \(1961\)](#); [Nagumo et al. \(1962\)](#), is a mathematical simplification of the Hodgkin-Huxley model, that is still able to explain many of the dynamical phenomena. Other neuron

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