BMC Neuroscience

BioMed Central

Poster presentation

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Artificial grammar recognition using spiking neural networks

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from Eighteenth Annual Computational Neuroscience Meeting: CNS*2009
Berlin, Germany. 18–23 July 2009

Published: 13 July 2009

BMC Neuroscience 2009, **10**(Suppl 1):P352 doi:10.1186/1471-2202-10-S1-P352

This abstract is available from: http://www.biomedcentral.com/1471-2202/10/S1/P352

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Introduction

A biologically inspired neocortical model consisting of spiking neurons is designed to perform artificial grammar processing. Building on work in [1], the model is designed to categorize symbol strings as belonging to a Reber grammar [2]. Columnar organization of the cortex is used as the general inspiration of the network [3,4].

The model consists of an input layer and a recognition layer. Input layer has six DC generator nodes designed to represent the presence of a specific symbol of input. The symbols are all those that the Reber grammar can produce (Figure 1). When a symbol is presented to the input layer, the corresponding node generates a direct current that is fed into the recognition layer. The recognition layer consists of 20 nodes connected in a way designed to sustain activity at around 50 Hz, called the recognition level, when the correct sequence of symbols occurs. Each node is a minicolumn model consisting of 100 neurons, of which 80 are excitatory and 20 inhibitory. Excitatory connections inside the node sustain activity, indicating when input is received. Indication of longer sequences is achieved by combining inputs from nodes representing symbols which can appear after another in the grammar, thus the recognition layer consists of the following 20 nodes: {#, M, T, R, V, X, MT, MV, RM, VT, VX, XT, XV, XR, XM, VXT, VXV, VXR, VXM, OUT}. Three levels are used in which the first layer receives input directly from DC gen-

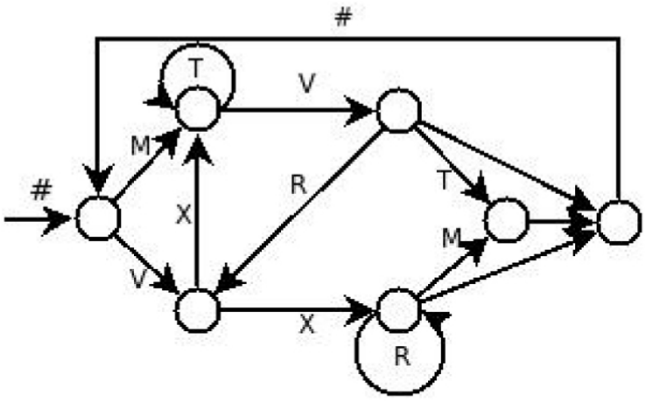

Figure 1
Finite State Machine (FSM) defining Reber grammar. Minicolumn model activity.

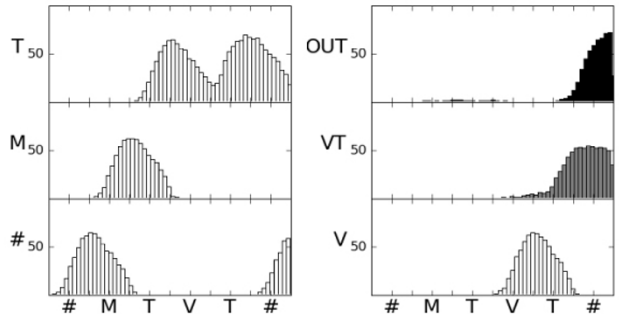

Figure 2
Grammar string is recognized by the network.

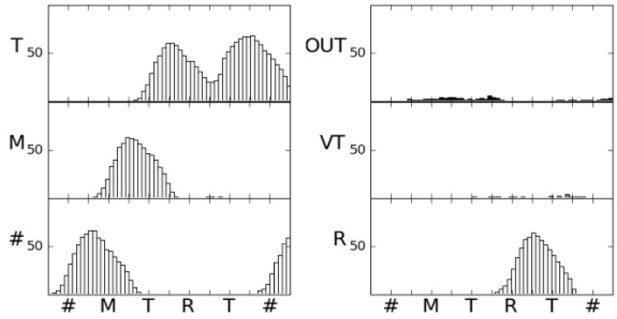

Figure 3
A random string does not excite the OUT node above the recognition level.

erators, effectively recognizing single character input. The next layer is activated by two-symbol substrings in the grammar. A third layer is activated by subsequent three-symbol substrings. When the activity of the OUT node exceeds 50 Hz, it is said to recognize the string. Each symbol is presented for 500 ms; the next symbol is presented immediately afterwards. The nodes are designed to sustain the activity for 1000 ms after the node received an input. After that time, local inhibition overcomes excitatory activity silences the node.

Discussion

The results from two strings are presented here. One belonging to the grammar '#MTVT#' and one string not belonging to the grammar '#MTRT#'. The OUT node passes the recognition level of 50 Hz, recognizing the grammar string (Figure 2). The other string, is recognized as not being in the grammar (Figure 3). Strings with between 4 and 15 symbols, representing all paths through the grammar FSM produce promising results. Further work will explore different network paradigms and their ability to recognize strings from the grammar.

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