

Modifying Synaptic Connections On The Spiking Neural Network Architecture (SpiNNaker) In Real-Time

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Abstract—Artificial Neural Networks is a promising approach to study human brain computation. Recent computer architecture design of a low-power 72-core processor by the University of Manchester (SpiNNaker) has made it easier to study highly parallel networks. We designed an algorithm on the SpiNNaker chip to enable synaptic removal, addition, and randomization on a neural network topology during run-time. Additionally, we explored scalability issues and unintended pitfalls with this approach.

Keywords—Neural Networks, Synaptogenesis, SpiNNaker

I. INTRODUCTION

THE human brain is fast and low in energy. [TODO: Matt] blah blah blah. One property of the brain is it's plasticity (cite Lashley, or some Psyc studies). Our approach to neural networks is greatly influenced by this biological idea, and we want to enable networks to self-modify. With energy efficiency in mind, we enable this functionality on the Spiking Neural Network Architecture (SpiNNaker) provided by the University of Manchester.

A. SpiNNaker

[TODO: Matt] The SpiNNaker is cool. Here's why. (Energy efficient) It's so epic. And we have one. And we added a cool functionality to it.

B. Synaptogenesis

[TODO: Matt] Define Synaptogenesis and explain why it's cool. Here's why. Explain it's previous success from Levy's work.

[TODO: Matt] We're combining the two. And it's gonna be super useful.

II. IMPLEMENTATION DESIGN

NEURAL networks consist of biologically inspired relationships between individual nodes (neurons). Learning in such a network occurs by intelligently adjusting weights on the links between the nodes. We define the relationship between nodes into the following three categories:

- (a) **Static** - The network topology is fixed, and can only change by manually adjusting the relationship between nodes. Most neural networks fall into this category

because regardless of the number of nodes n , there is only one fixed relationship between them:

$$\text{NumberOfTopologies}(n) = 1$$

- (b) **Semi-Dynamic** - There is some freedom for nodes to rewire with other nodes in real time. The complexity grows polynomially. Each node has non-zero probability to be rewired with a constant c number of other nodes. Given n such nodes, the number of possible topologies can be up to

$$\text{NumberOfTopologies}(n) = n^c$$

- (c) **Dynamic** - Each node has non-zero probability to be wired with any other neuron in the entire network. In this case, the complexity grows exponentially. Given n nodes, the number of possible topologies becomes

$$\text{NumberOfTopologies}(n) = n^{n-1}$$

A biological neural network such as the human brain is not static. Connections between neurons are regularly formed and removed over time. Moreover, such a neural network is not fully dynamic either, since locality is a physical constraint. For example, a neuron on the far end of the left hemisphere of a brain may never directly connect with a neuron over on the right hemisphere.

We designed a programming framework on SpiNNaker's API to enable a semi-dynamic network topology. In our implementation, each neuron had the flexibility to rewire with none, all, or some of the fixed number of other neurons.

III. PITFALLS

SOME disadvantages are present when considering our approach for synaptogenesis on the SpiNNaker. [TODO: Matt] Blah blah.

IV. FURTHER STUDY

THIS paper reveals multiple questions that still need to be examined further.

V. CONCLUSION

The conclusion goes here.

APPENDIX A
SHANNON'S ENTROPY

Appendix one text goes here.

APPENDIX B
CALCULATION OF MUTUAL INFORMATION

Appendix one text goes here.

APPENDIX C
CALCULATION OF STATISTICAL DEPENDENCE

Appendix two text goes here.

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