An Exploration of Spiking Neural Networks and their use on Reinforcement Learning Tasks

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under the supervision of Dr. William Raffe and Dr. Jaime Garcia

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Certificate of Original Authorship

I, Andrew William Rafe declare that this thesis, is submitted in fulfilment of the requirements for the award of MSc (Res) in Computing Sciences, in the School of Computer Science at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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Production Note:
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This thesis is dedicated to my mum who, in the opening weeks of this research, lost her long battle with breast cancer. You always taught me to pursue my interests in life and your immense commitment to your children has given me the opportunities to do just that.

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Publications

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Abstract

Artificial neural networks have recently been the prominent architecture for reinforcement learning tasks. However, there is emerging evidence that spiking neural networks can perform just as well and can retain this performance across similar environments. Spiking neural networks are experiencing a surge in popularity due to their potential for large efficiency gains when compared to their traditional artificial neural network counterparts. Though, when attempting to replicate the successes of artificial neural networks, challenges are faced due to their vastly different architectures and therefore differing methods for training and optimisation. As spiking neural networks are considered more biologically plausible, methods of training inspired by natural learning have been proposed. These methods have been minimally applied to complex reinforcement learning domains, instead typically focusing on supervised learning problems. This thesis aims to explore the use of spiking neural networks in reinforcement learning domains. Methods of evolutionary and spike timing based training will be explored. Additionally, an in-depth analysis of different encoding and decoding methods is conducted. This research also addresses the trends in the effect of the time period that a state is exposed to a spiking neural network on the performance of the networks.