# Applying Spiking Neural Network Simulation to Neuromodulatory Autonomous Robot Control

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# Applying Spiking Neural Network Simulation to Neuromodulatory Autonomous Robot Control

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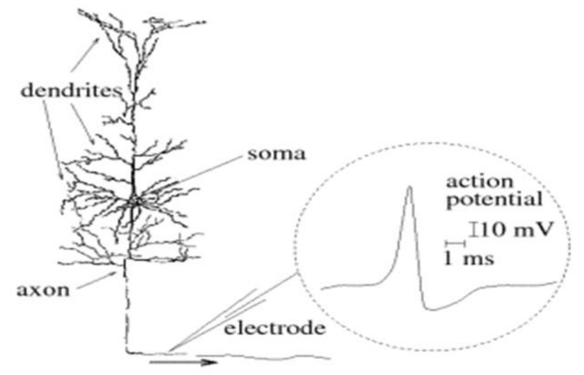
## Introduction

In this project, simulation of the brain based on an artificial spiking neuron model is used to create a self-learning algorithm based on the ROS platform. The spiking neuron simulation is used to demonstrate a neuromodulation program in which the reward seeking properties of dopamine, the risk-adverse effects of serotonin, and the attention-focusing effects of the cholinergic and noradrenergic systems are applied to multiple mobile robotic platforms as they move autonomously throughout an environment. External stimuli are recorded by the program as spiking "events" that result in corresponding amounts of dopamine and serotonin influenced spiking patterns. These spiking patterns affect how the robots adapt to their surroundings depending on what type of "mood" is set in the internal programming. Also, alternate hardware platforms are analyzed to see how the neural model can be expanded to include cloud computing as a method of control.

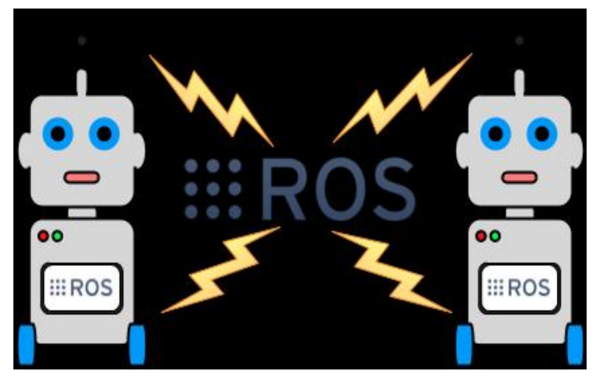
## Methods/Materials



Software

- Neural Network Code

The model consists of three groups of neurons - event neurons from sensory signals, neuromodulatory neurons and behavior state neurons. The first layer of neurons indicates the incidents happening in the real world environment for the robots. The neuromodulatory layer consists of ACh/NE neurons, one dopaminergic neuron (DA), and one serotonergic neuron (5-HT). The last layer of four neurons indicates the four different behavioral outputs as states. Finally the "mood" of the robot (risk-taking, risk-adverse or distracted) was set beforehand.



-ROS

The open-source Robot Operating System (ROS) is used as the software framework for the robots. ROS is a collection of publically available tools and libraries that allow for the creation of reusable general purpose robot code that can be ported over to many different platforms.

Hardware

-Turtlebot

The "Turtlebot" is a combination of off-the-shell products like the iClebo Kobuki robot base, ASUS laptop (on-board computation of parameters), Ubuntu Linux (ROS supported operating system), and the Microsoft Kinect (for motion sensing) to create a ROS-compatible robotic platform capable of running in many different applications.

## Future Plans

- Cloud Server

Using the ROS software platform, the neuromodulator code will reside on a single networked server, reducing the amount of on-board computation that needs to be done by the robot(s).

- SNN biological model

A more biological realistic model of artificial neuron called the Izhikevich neuron will be adapted into the neuromodulator code for the spiking neural network simulation.

- Larger swarms of robots of different models

Tests so far have been done with only two robots at the most in one environment. Recording the neural activity of three or more robots in a single space would be a long-term goal. Also, the only robot type used in the lab so far has been of the "Turtlebot" type. The vast majority of the neuromodulated code base can be ported onto other ROS compatible robots to create heterogeneous swarms of various sizes

## References

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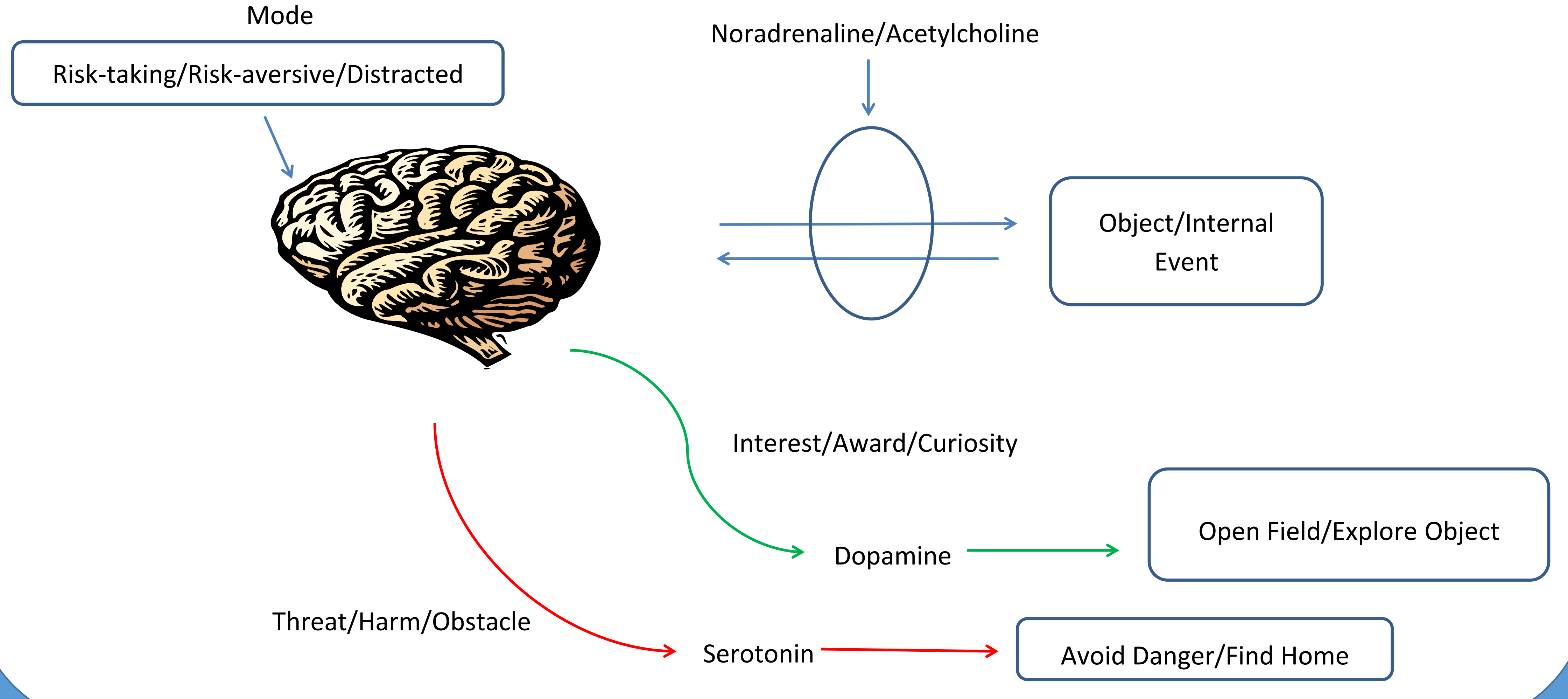
## Graphical Overview of Neural Model



Mode

Risk-taking/Risk-aversive/Distracted

Noradrenaline/Acetylcholine

Object/Internal Event

Interest/Award/Curiosity

Dopamine

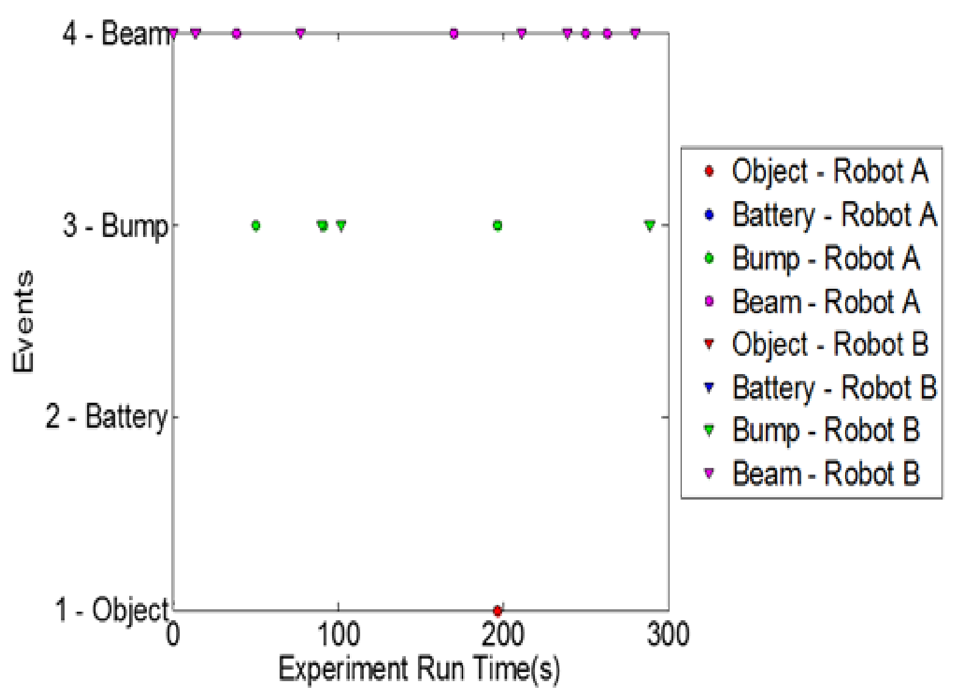
Open Field/Explore Object

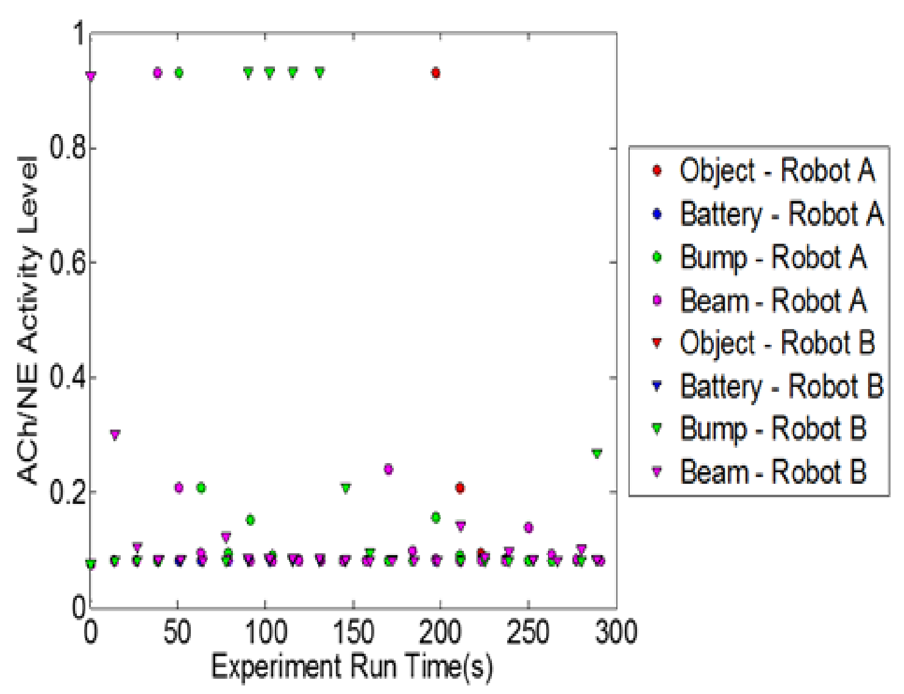
Threat/Harm/Obstacle

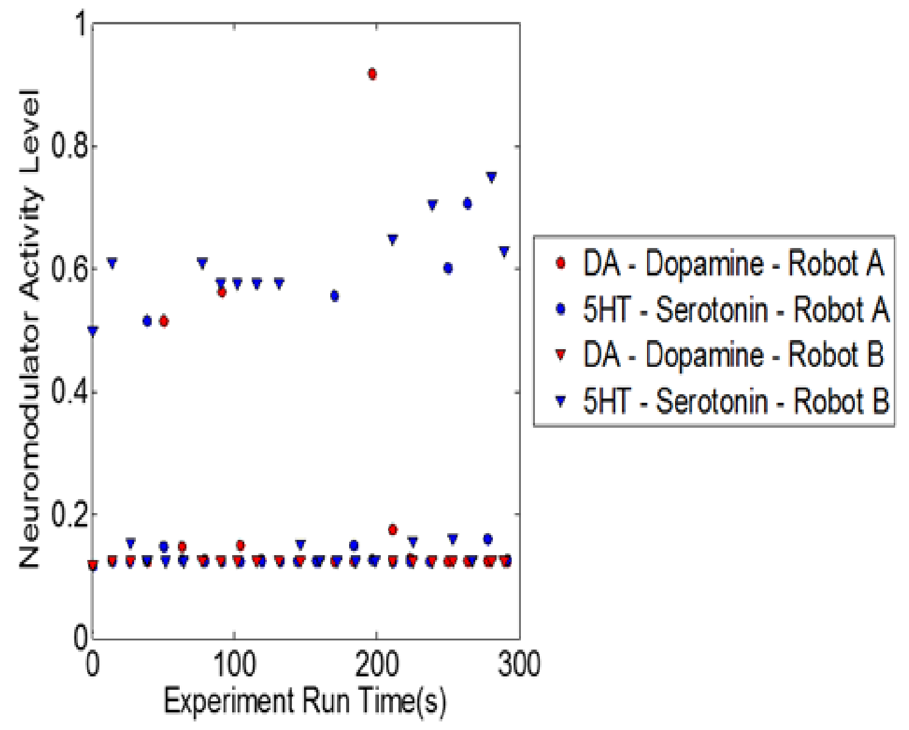
Serotonin

Avoid Danger/Find Home

## Results – Robot A (risk-taking), Robot B (risk-aversive)

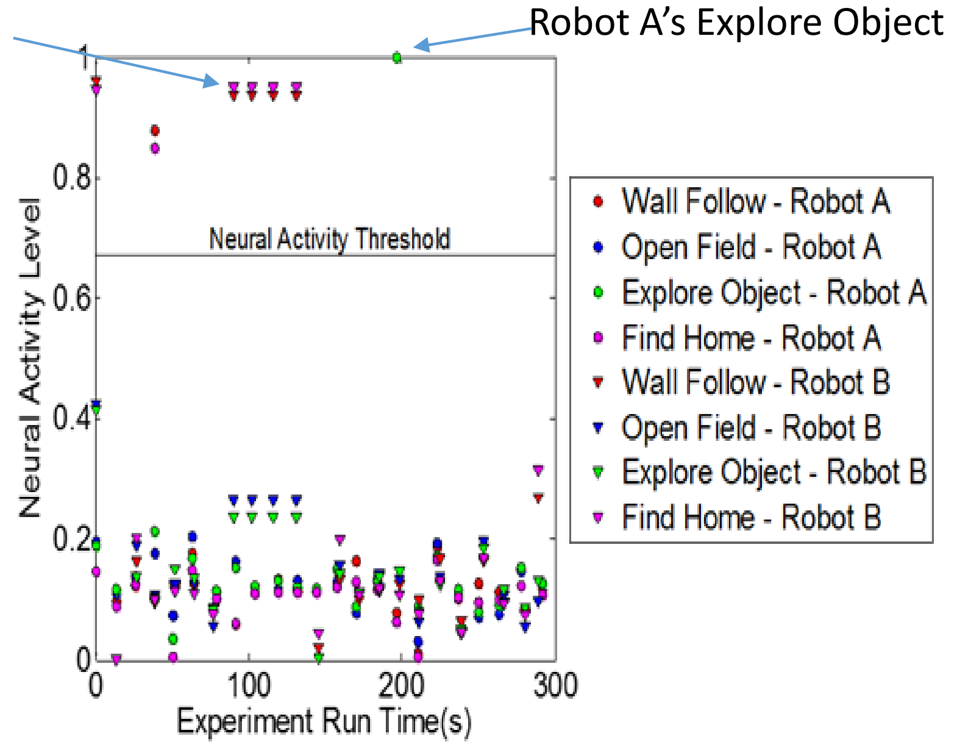


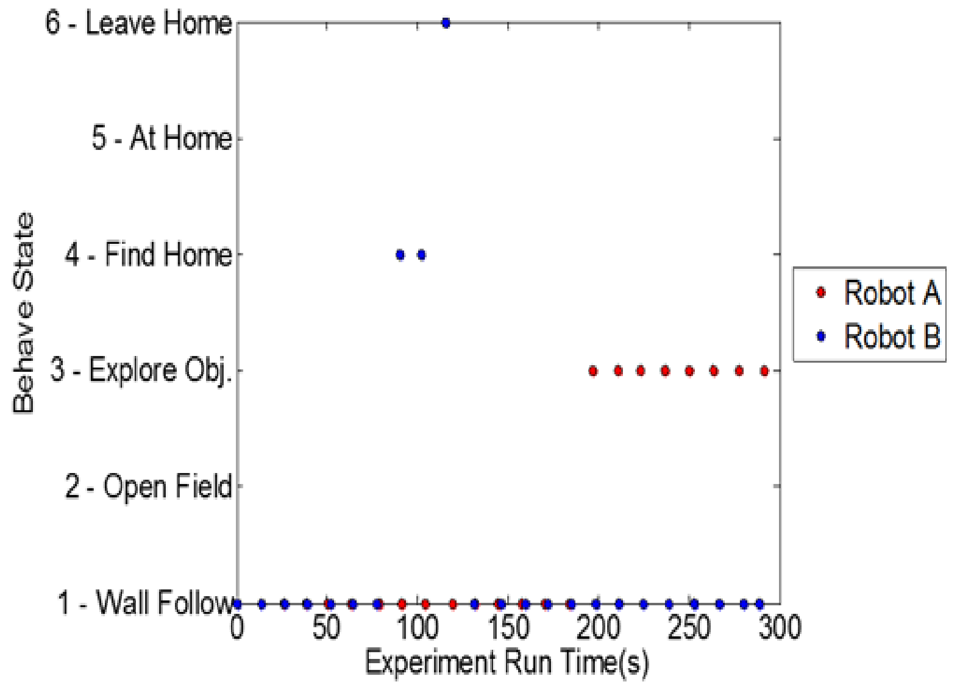




Robot B's Find Home and Wall Follow neurons fire

Robot A's Explore Object neuron fires





In this case, while Robot B sticks to walls and tries to find home, Robot A eventually spots Robot B and follows it till the end of the simulation.