OpenBrain: Massively Asynchronous Neurocomputation

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Abstract

In this project we introduce a new framework and philosophy for recurrent neurocomputation. By requiring that all neurons act asynchrynously and independently, we introduce a new metric for evaluating the universal intelligence of continuous time agents. We are experimenting with a set of simple learning rules in the spirt of John Conway's game of life. Finally we evaluate this framework against different intelligent agent algorithms by implementing an approximate universal intelligence measure for agents embedded in turing computable environments in Minecraft, BF, and a variety of other reference machines.

Introduction

Most standard neuron network models depart from the biological neuron in a number of ways. Our asynchronous continuous-time model draws inspiration from physiological and biological principles for neuron dynamics. By modeling dynamics of the exponential decay of neuron voltage towards equilibrium, refractory periods, and numerous synaptogenesis phenomenons we aim to build a neural architecture that is both biologically inspired and computationally simple.

Open Brain Definitions

A **neuron** $n \in N$ is defined by:

- voltage $V_n(t)$
- decay time τ_n
- refractory period ρ_n
- voltaic threshold θ_n

A **connection** $c \in C$ is a tuple $(n_i, n_j, w_{ij}) \in N \times N \times \mathbb{R}$ where n_i is the **anterior neuron**, n_j is the **posterior neuron**, and w_ij is the standard synaptic weight.

Neuronal Dynamics

A neuron n is said to **fire** if it is not in its refractory period and $V_n(t_k) = V_n[k] > \theta_n$. Then for all $m \in P_n$,

$$V_m[k+1] \mathrel{+}= w_{nm}\sigma(V_n[k]);$$

that is, voltage is propagated to the posterior neurons. Immediately after neuron n fires, it enters a **refractory period** until time $t_k + \rho_n$, or iteration $k + \frac{\rho_n}{\Delta t}$. We say that a neuron n experiences **voltage decay** so that for all k,

$$V_n[k+1] \leftarrow V_n[k]e^{-\Delta t/\tau}. \tag{1}$$

so that unless it obtains voltage from anterior neurons' firing, its voltage will decay exponentially to 0.

Learning

Important Result

Theorem.

Universal Intelligence Measure in Continuous Time

A well established[] machine intelligence measure is the Universal Intelligence Measure proposed by Legg and Hutter [], whose work developed a consise definition of the intelligence of an *agent* in an *environment*: If π is an agent then we say that the **universal intelligence** of π is

$$\Upsilon(\pi) = \sum_{\mu \in E} 2^{-K(\mu)} V_\mu^\pi \tag{2}$$

where V_μ^π is the expected reward of the agent in μ,

$$V_\mu^\pi = \mathbb{E}\left(\sum_{i=1}^{\infty} r_i\right) \leq 1. \tag{3}$$

To make a continuous time intelligence measure which is compatible with agents who act instantaneously within an environment, we ??

Project Status

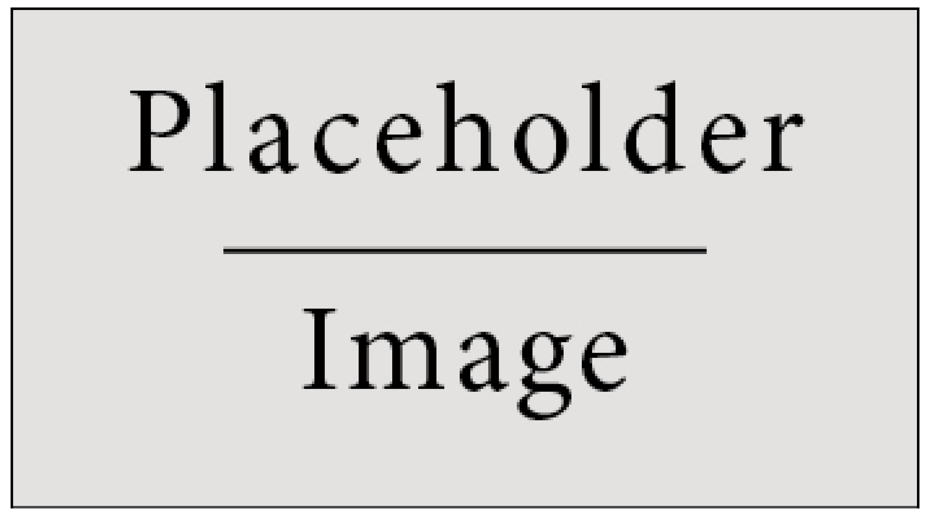

Figure 1: Figure caption

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Conclusion and Goals

Additional Information

References

[1] J. M. Smith and A. B. Jones.
Book Title.
Publisher, 7th edition, 2012.

[2] A. B. Jones and J. M. Smith.
Article Title.
Journal title, 13(52):123–456, March 2013.

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