Neurino
User's Guide

Introduction

Neuromorphic processors :

Since the late 1950's when scientists elucidated the basic mechanisms[1] governing their functions, brain cells, or neurons, have inspired many successful robotics and AI projects. Most of the time, artificial neural networks are simulated numerically on conventional computers, which are convenient but very inefficient to simulate massively parallel systems like neural networks. For a few years now, efforts are being made in the industry and academia to develop neuromorphic processors, the very structure of which is optimized to simulate neural networks.

Analog simulations :

Some neuromorphic processors use analog electronics instead of conventional processors to simulate neural networks. In such systems, the different physical entities allowing the functioning of biological neurons are replaced by other physical entities that together work in an analogous way (see table below)

Physical entity in biological neurons	**Analogous entity in electronic neurons**
Ions	Electrons
E_{Na+} (Na^+ electrochemical gradient)	Positive power supply V+
E_{K+} (K^+ electrochemical gradient)	Negative power supply V-
Membrane	Capacitor
Leak channels	Resistors
Na and K voltage gated Ion channels	Transistors
Voltage sensing domain of Ion Channels	Reference voltage and Comparator

There are many advantages to using analog circuits to simulate neural networks.

-*Speed :* Contrarily to numerical simulations where the run time increases quadratically with the size of the network, networks of analog neurons run in real-time, irrespectively of their sizes.

-*Power consumption*: electronic analog neurons can be set to work at extremely low power. Think that the 86 billions neurons of the human brain consume less power than a light bulb[2] while the super computers of the human brain project running state-of-the-art brain simulations, require the same amount of power as that of a small city [2].

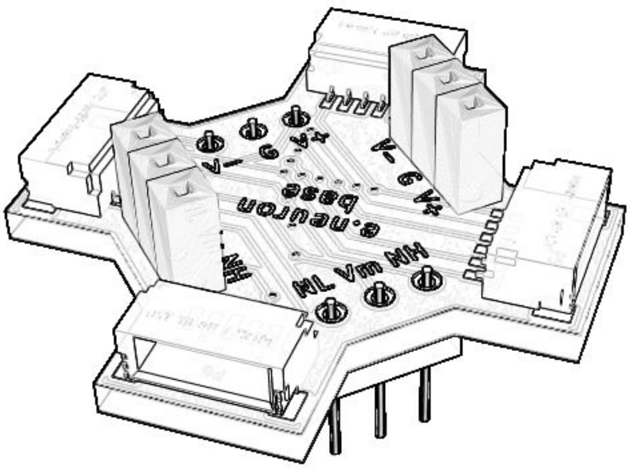
-*Robustness :* Because the processing power is spread all over the network, its functions can be maintained upon failure of a few neurons if redundant connections are present. Oppositely, a single corrupted byte in a binary code sent to a conventional processor can prevent it from running at all. Analog electronics are also more robust to environmental stress (heat, radiations, magnetic fields, etc...).

These assets make analog neuromorphics particularly suited for the field of robotics. However, contrary to the case of standard computers, the hardware and software of analog computers are intertwined, meaning that in order to change the parameters of analog computers, material changes have to be done. Numerical simulations on conventional computers can be modified easily by changing a few lines of code, therefore making them a very useful complementary tool to test and optimize networks before starting physical implementations.

e-Neurons :

e-Neurons are open-source analog electronic circuits that operate similarly to biological neurons, that is by generating and transmitting electrical impulses called action potentials, or spikes.

In combination with e-synapses, e-neurons can be assembled into networks covering a wide range of applications, from biomimetic robots to artificial intelligence.



Ratings :

References :

[1] For more information on how neurons work, you can see https://www.khanacademy.org/science/biology/human-biology/neuron-nervous-system/v/anatomy-of-a-neuron

[2] http://www.scientificamerican.com/article/thinking-hard-calories/

[3] https://www.humanbrainproject.eu/faq/computing/