Neural Computing at Sandia National Laboratories


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Neural Information Content

- Information theory provides entropy of a discrete random variable as a quantitative measure of information
  \[ H(X) = -\sum_{x} p(x) \log p(x) \]

Compressibility
- Use compressibility as a measure of the information content of a signal
- Once the spike signal is converted into a binary signal, where an action potential is encoded as a one and the absence of activity by a zero, the normalized complexity may then be computed as follows:
  \[ c_n(x) = \frac{C(x^n)}{n^2} \]

Adaptive Learning

- SVM Game/Algorithm Matched
- SVM Game/Algorithm Matched

Neuronal Decision Making

- Use neural algorithms that have been developed to understand the brain's ability to learn

Spiking Temporal Processing Unit (STPU)

- Neuronal architecture where each column is analogous to a multi-compartment leaky integrate & fire neuron

Neurons to Algorithms (N2A)

- N2A is a language and tool for coding neural algorithms. Like other simulation-independent languages, it saves effort by enabling the same model to compile on a range of platforms.
- Scalable object-oriented language
- Each part (or class in OO terminology) is a set of equations
- Currently supported backends include:
  - Xyce – a supercomputer version of the Spice circuit simulator
  - C++ – generated code that gets compiled
  - Internal – a reference simulator written in Java
  - STPU – a neuromorphic architecture, currently in prototype

Uncertainty Quantification & Sensitivity Analysis

- Information theory provides entropy of a discrete random variable as a quantitative measure of information
- Use complexity as a measure of compressibility in order to estimate entropy to quantitatively assess the information content of a signal
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Large Scale Modeling

Overview of model process

Design model to represent anatomy of neural systems

Neural network and connectivity

Full Model

Each node outside 2/3 radius of neurons

N2A and mapreduce SVM game

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Neural Inspired Machine Learning

Particle Image Velocimetry (PIV) estimates flow fields using dispersed particles

Two images are taken and subtracted into smaller windows

Maximum cross-correlation is used to estimate local flow

Neural Inspired Computer Architectures

Spiking Temporal Processing Unit (STPU)

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Edge Detection Example

- Internal state of integrate & fire neurons leads to edge detection process

Not activity across time

N2A and mapreduce SVM game

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