Visual Cortex on a Chip
Large-scale, real-time functional models of mammalian visual cortex on a GPGPU

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Goal
Los Alamos National Laboratory’s PetaScale Synthetic Visual Cognition project is exploring full-scale, real-time functional models of human visual cortex using the Roadrunner supercomputer (1000 teraflop) supercomputer and future GPGPU-based exaflop (1000 petaflop) computers. The project’s goal is to understand how human vision achieves its accuracy, robustness, and speed. Commercial-off-the-shelf hardware for this modeling is rapidly improving, e.g., a teraflop GPGPU card for a workstation now costs ~$500 and is ~size of mouse cortex. We now present initial results demonstrating whole image classification using standard computer vision image data-sets, and object extraction from UAV video using a model of primary visual cortex running on a GPGPU (240-core NVIDIA GeForce GTX285).

As this technology continues to improve, cortical modeling on a GPGPU device has the potential to revolutionize computer vision.

Model
LANL’s PetaScale Artificial Neural Network (PANN) is a high-performance C++, C, and Python implementation of a feedforward-type hierarchical model of human visual cortex regions (primary visual cortex), V2, V4, and inferotemporal cortex (IT). The model uses the ventral pathway of visual processing (‘what’ pathway). PANN employs conventional classifiers of the form: $$G(x,w) = \frac{1}{1+e^{-w^T x}}$$, or hybrid models such as BNNs (Bayesian neural networks) and RBF functions. PANN has recently been shown to be very efficient for processing large image datasets with V1-like models using a single-CPU machine.

The key scientific question is how does visual cortex organize itself in response to large amounts of visual stimuli? PANN’s design is to process large amounts of still and video imagery in real-time with very low power/processing cost. Preliminary results on this imagery using a neural network learning algorithm to build a hierarchical representation of natural scenes, combined with a relatively small amount of supervised training, results in an ‘in-bread classifier’ (see below the network support vector machine (SVM)) [13]. The hierarchical representation of natural scenes is believed to be sparser, allowing for increased scalability of consumer hardware.

LANL’s Petascale Artificial Neural Network (PANN) is a high performance C++, C, and Python implementation of a Feedforward-type hierarchical model of human visual cortex regions (primary visual cortex), V2, V4, and inferotemporal cortex (IT). The model uses the ventral pathway of visual processing (‘what’ pathway). PANN employs conventional classifiers of the form: $$G(x,w) = \frac{1}{1+e^{-w^T x}}$$, or hybrid models such as BNNs (Bayesian neural networks) and RBF functions. PANN has recently been shown to be very efficient for processing large image datasets with V1-like models using a single-CPU machine.

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