The Emergent Neural Network Modeling System

by Brad Aisa, Brian Mingus, & Randall C. O’Reilly 2007
University of Colorado Boulder
brad.aisa@colorado.edu brian.mingus@colorado.edu randy.oreilly@colorado.edu

Abstract
Emergent --- a major rewrite of PDP++ --- is a comprehensive simulation environment for creating complex, sophisticated models of the brain, cognition, and behavior using neural network models. It includes a rich, new GUI environment for constructing networks and the input/output patterns for the networks to process, along with many powerful analysis tools for understanding what the networks are actually doing. It has a new tabbed-browser style interface (in Qt4), with full 3D graphics (via OpenGL and Open Inventor/Coin3D), and an all new GUI programming system. Emergent supports all the same algorithms as PDP++: Backpropagation (feedforward and recurrent), Self-Organizing (e.g., Hebbian, Kohonen, Competitive Learning), Constraint Satisfaction (e.g., Boltzmann, Hopfield), and the Leabra algorithm that integrates elements of all of the above in one coherent, biologically-plausible framework.

Why Emergent?
Relative to MATLAB and other general-purpose tools for neural network simulation, Emergent offers many important advantages:
• Completely open source, free software.
• Highly optimized for execution speed (e.g., distributed memory computation) while supporting complex biologically-based neural architectures.
• Makes research simulations easily accessible to other users with minimal additional effort:
  - Built-in documentation system
  - Pervasive comment fields
  - Easy-to-use, transparent interface

Most importantly, Emergent is specifically focused upon the critical systems-level middle-ground --- between purely abstract, mathematical models on the one hand and single neuron simulations on the other --- precisely the level that is of greatest interest to psychologists, and to cognitive and behavioral neuroscientists. If you’re doing large scale, complex neural network models, Emergent offers many advantages.

Emergent vs. PDP++
In Emergent, everything has been boiled down to the most basic, general-purpose elements, which can now be combined in more powerful, "emergent" ways.
• All New Tabbed-Browser Interface
• GUI-Based Programming
• DataTable-Based Input/Output
• Virtual Environment Simulator

Data Table-Based Input/Output
The rendering of environments and the monitoring of output data --- along with the handling of all other forms of data have been consolidated into a single powerful DataTable object interface that supports many different kinds of operations (e.g., database-style Joins and Sorts, vector and matrix math, 3Dgraphing, statistics, etc).

Available Platforms
Emergent is available with native look and feel on Windows, Mac and Linux, under the standard GPL license.

Virtual Environment Simulator
In addition to a greater variety of network visualization tools --- including 3D --- brand new to Emergent is a built-in virtual environment simulator for doing robotics simulations with rigid body physics using the popular Open Dynamics Engine (ODE). As illustrated in the figure above, this allows networks to interact with a realistic simulated environment in order to explore embodied models and robotic functionality.

Why?...