Neo Cortical Microcircuit

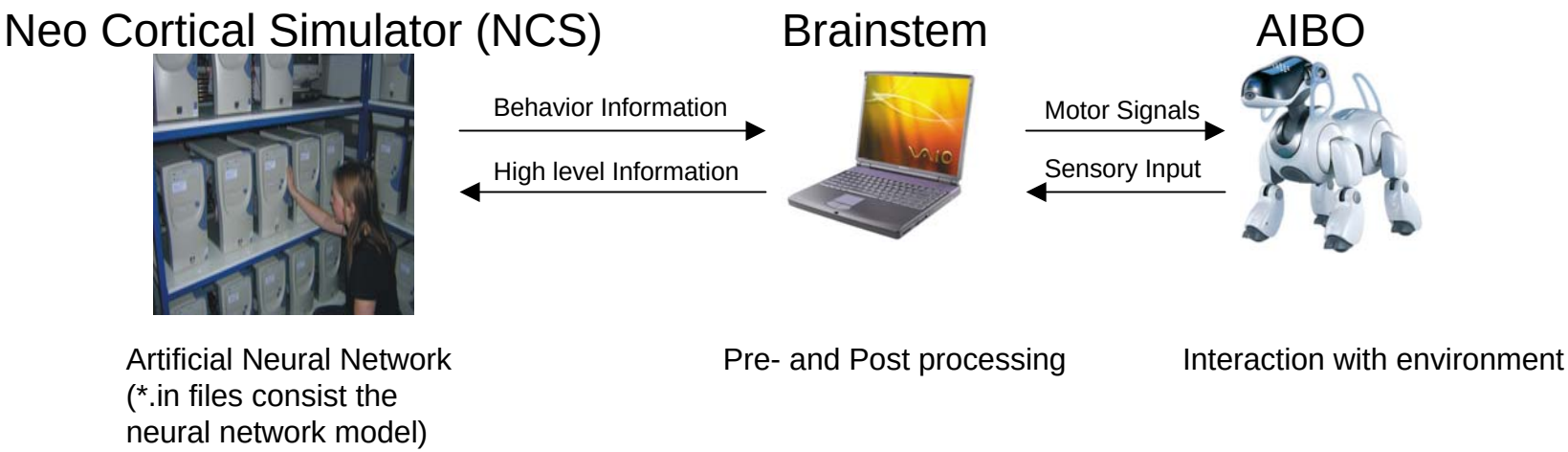
By Milind Zirpe
Project Guides: Dr. Rene Doursat, Dr. Philip Goodman
University of Nevada, Reno
CS 790R, 2/27/2006

Overview

- Introduction
- The Problem
- Complex System Model
- Exploring the Model
- Implementation

Introduction

- The overall system:



The Problem

- Modeling Neocortical Locks:
  - Modeling of Neocortical Locks from the Lock and Key model.
  - Lock is the network of neurons, consisting of excitatory and inhibitory cells.
  - Key is the external stimulus, ideally consisting of random audio or video stimulus from the environment.
  - Objective is to find a lock which resonates quite perfectly with a given key (i.e. has same phase as key, when the key is applied).
  - Later on, let the network learn based on reward and punishment scheme.

Complex System Model

- Elements of the complex system:
  - Network of neurons and external stimulus (like Poisson train of pulses).
- Behavior rules:
  - Spiking if membrane potential is above threshold (Excitatory neurons) or De-spiking if same as above (Inhibitory neurons).
- Local interactions:
  - Flow of charge (chemicals) between neurons through axon and synapse.

Complex System Model

- Network interactions:
  - Axons and Dendrites.
- Hierarchy of levels:
  - Brain, 3D Network of neurons, Neuron, Soma (body of neuron).

Exploring the Model

- Model a network of neurons which will have some inherent behavior (Lock).
- Introduce a signal as an external stimulus to the post-synaptic cells (Key).
- Idea is to adjust the strength of the synaptic conductance from pre-synaptic cells to the post-synaptic cell to get the lock to resonate with the key.

Exploring the Model

- Other parameters to adjust are:
  - Number of neurons in the network.
  - The inherent behavior of the neurons.
  - Synaptic connections between the two types of neurons.
  - “Threshold” of the “Compartment”.
  - Spike shape, if needed.
  - “Absolute use” of the synapse in case of learning.
  - Type of learning, duration, FSV (Frequency of Sampling Value), and various other parameters.

Exploring the Model

- Results:
  - Expected result is to obtain reproducible unique response from the lock given a particular key.
  - Further part of project is to develop a network of neurons which learns as it experiences external stimulus.

Implementation

- Implementation modules:
  - The neural network model (*.in files) generating the behavior of the lock.
  - Programs in Matlab for analyzing the report files from NCS and for interpreting the results.

Implementation

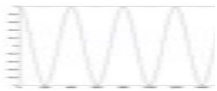
- Software and Languages:
  - Neo Cortical Simulator developed in GBCL. It accepts the *.in files as an input.
  - Matlab 7.0, mostly for analyzing the results.
  - Probably, pre-developed Python scripts for automating the generation of *.in file.
- Environment:
  - Windows XP and Linux (NCS clusters).

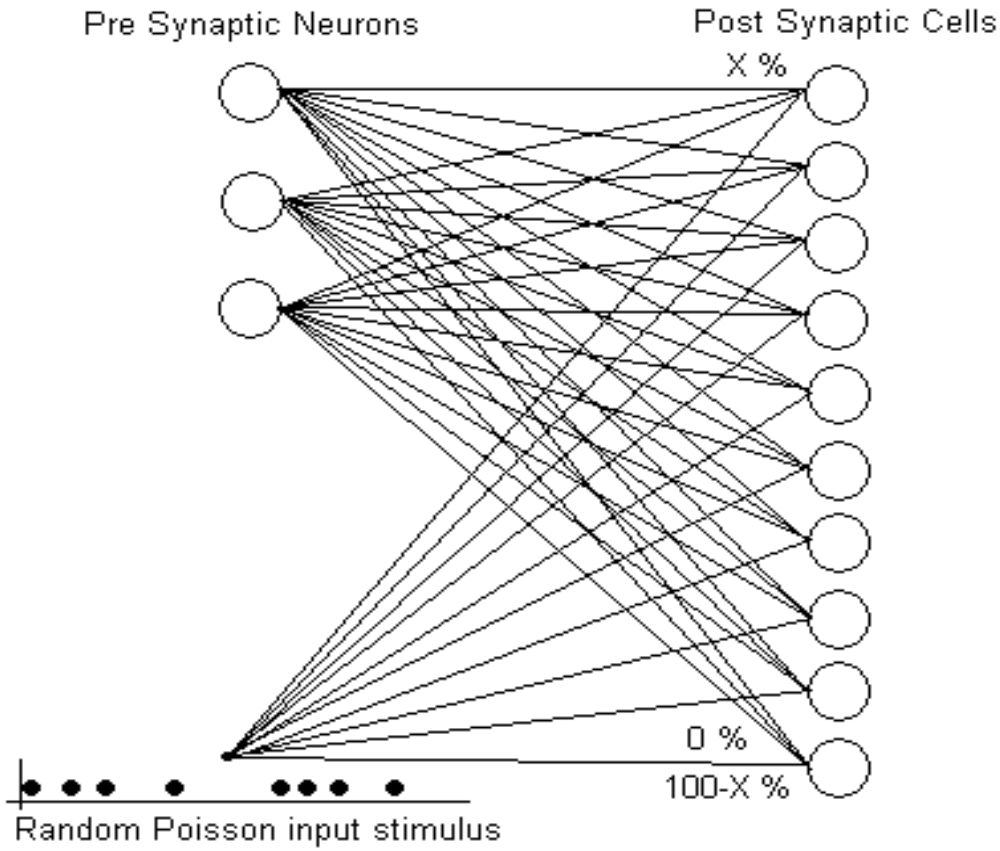
4 Cell Simple Neural Network

Internal behavior

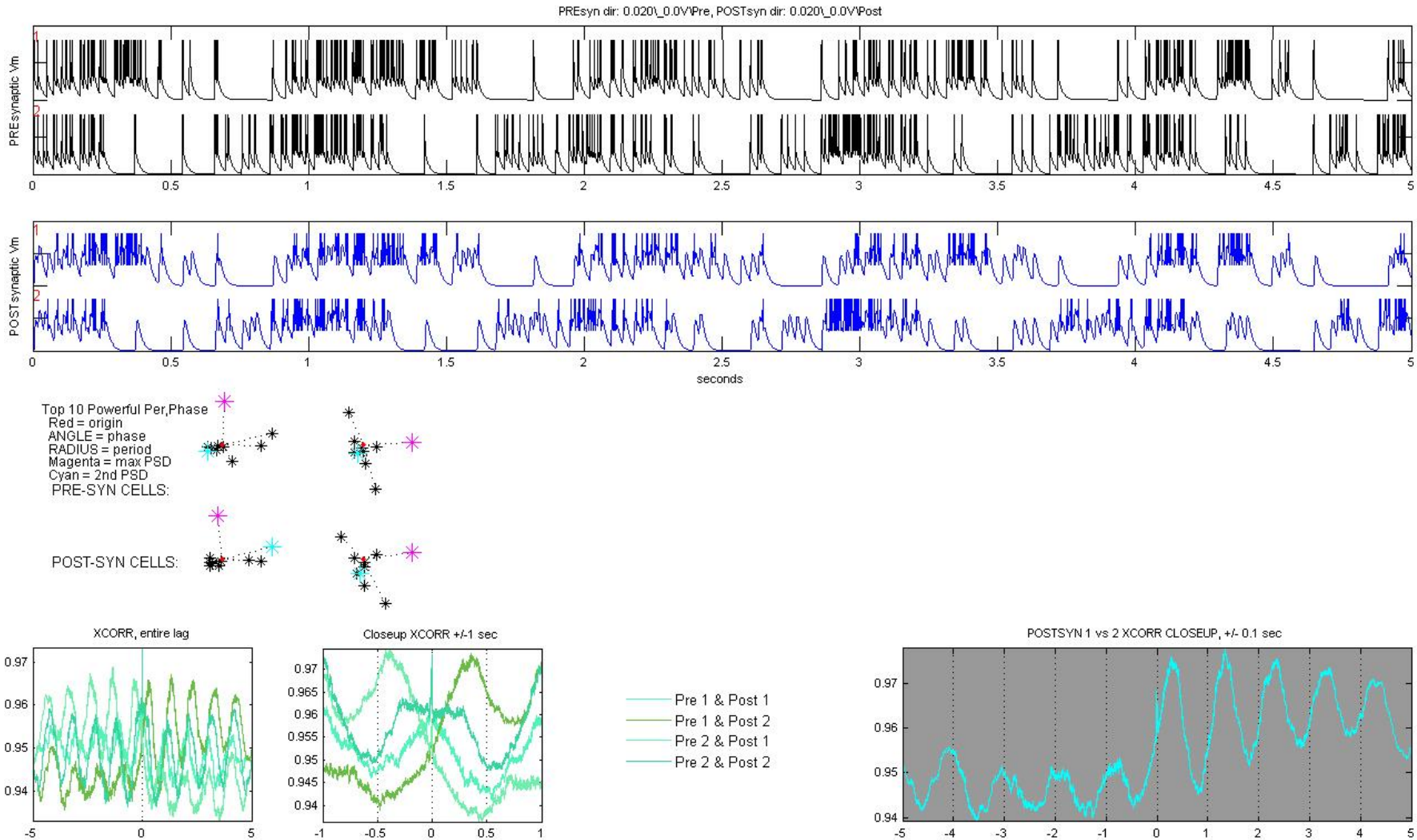
Sine

Sine 90^0 out of phase



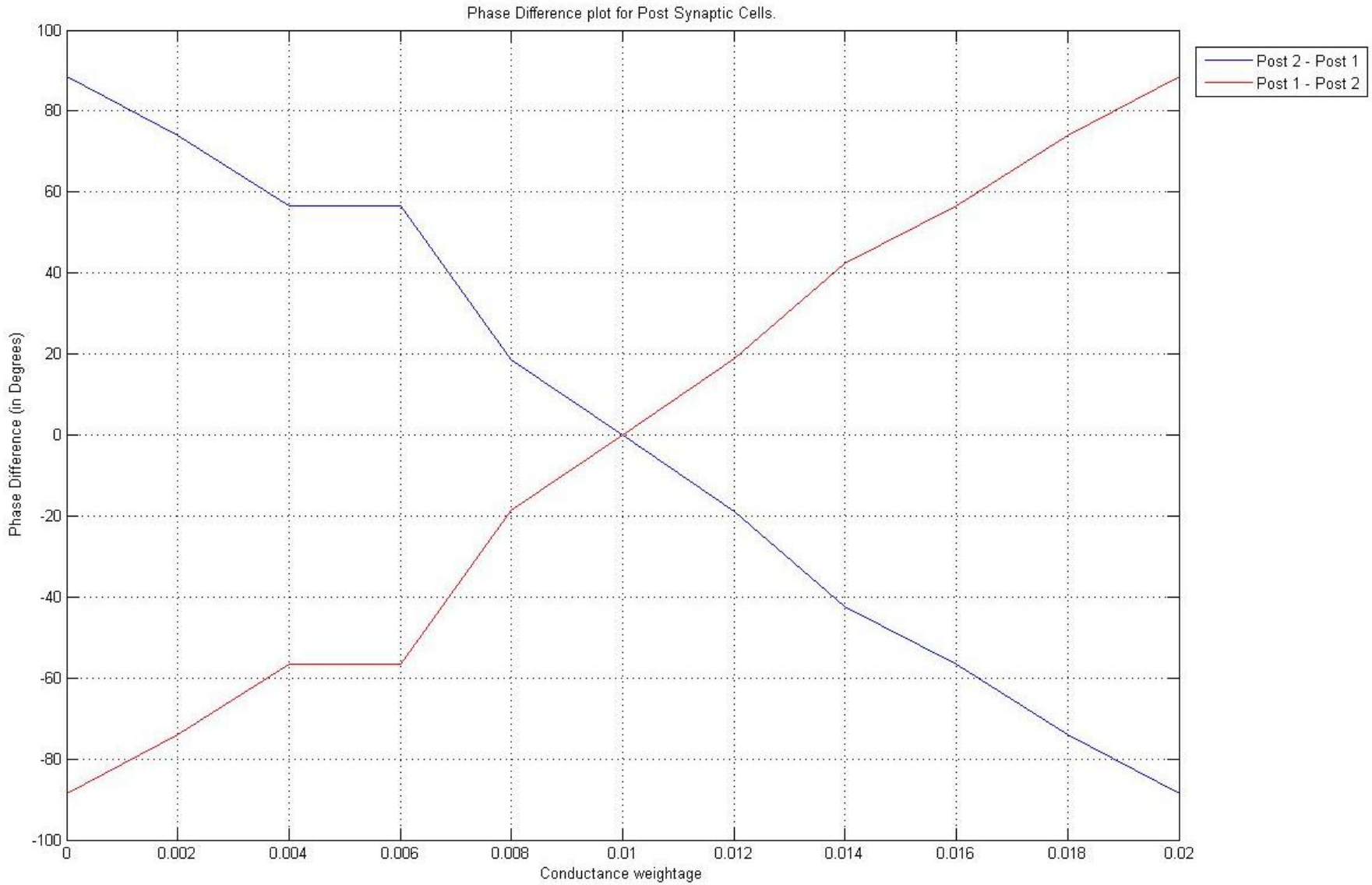


Result



Result of the previous slide spiking network for 100% strength of Pre-Syn1 and 0% strength of Pre-Syn2 applied to Post-Syn1 and vice versa for Post-Syn2.

Result



Phase difference plot for Post-Syn1 and 2 cells over a range of 0-100% strength, with step size of 10% (0.002V).

Thank You