

# Modeling Feedback in the Ventral Pathway

(AFRL Information Directorate)

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**Co-PI: James LaRue**

**AFOSR Joint Program Review:  
Cognition and Decision Program  
Human-System Interaction and Robust Decision Making Program  
Robust Computational Intelligence Program  
(Jan 23-27, 2012, Arlington, VA)**



# Modeling Ventral Pathway (Yuriy Luzanov, James LaRue)

## Objective:

Enhance current biologically inspired algorithms for object categorization and recognition in complex, cluttered stimulus images

## Technical Approach:

Incorporate feature-based attention into a general convolutional neural network using bidirectional associative memories

## DoD Benefit:

There is a need for accurate and reliable automated object recognition in EO and IR imagery and video to deal with ever increasing volumes of collected data

## Budget:

	FY11	FY12	FY13
Actual/ Planned \$K	120/ 120	50/ 120	120

Annual Progress Report Submitted?    N            N            N

**Project End Date: Sep 2013**

## List of Project Goals

- Produce an algorithm to *enhance current biologically inspired algorithms* for object categorization and recognition in complex, cluttered stimulus images.
- *Connect contiguous layers* of a feed-forward model and neural network classifier model *with bidirectional associative memories (BAMs)*.
- Maintain a tie to mathematical modeling in deference to empirical .
- Test and Evaluate the system loop.
- Submit paper for 2012 Society for Neuroscience conference in New Orleans.
- Hold workshop in Rome, NY - Spring 2012

## Progress Towards Goals (or New Goals)

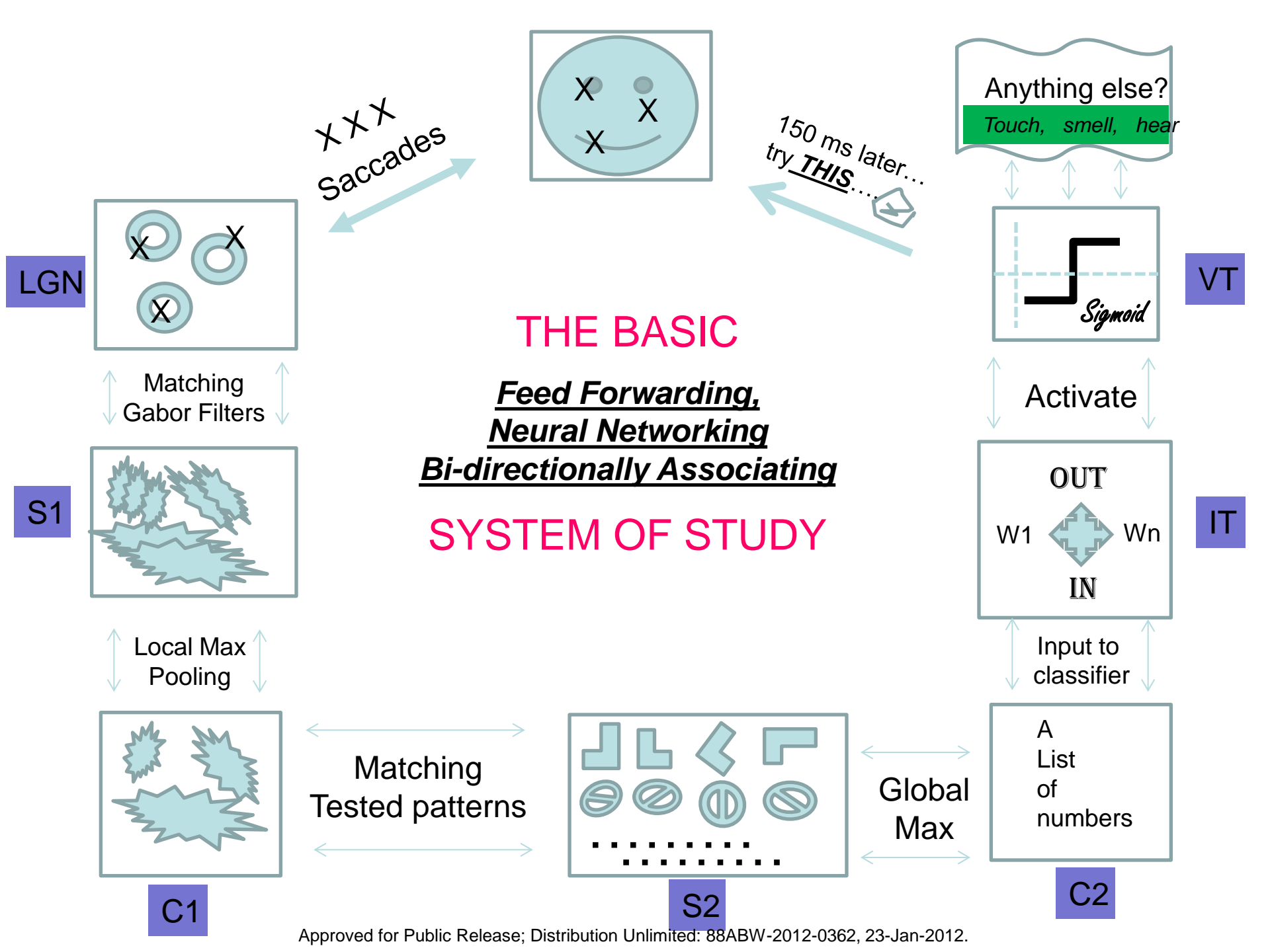
Converted c-mex code back into high level Matlab for agility

Have working feed-forward/classifier system loop

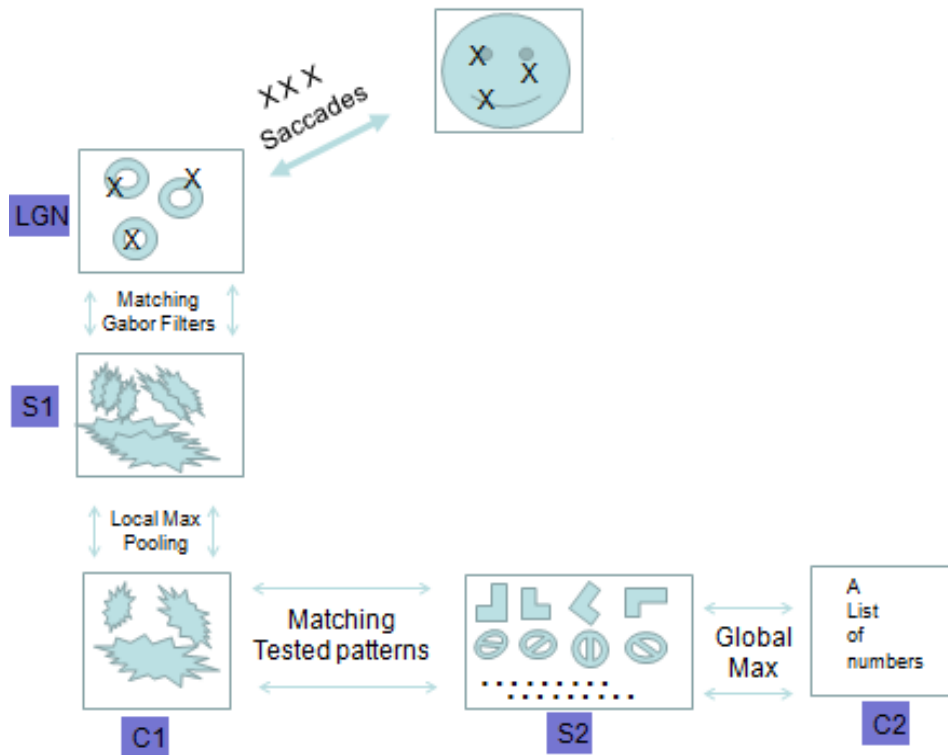
Have hooks placed at every stage for parallel monitoring

Have done appropriate research of state of the art

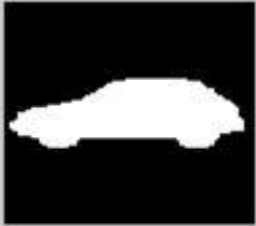
Have identified opportunities for BAM placement.



# From the feed-forward side



# Test car of interest and test templates



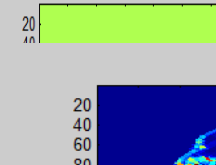
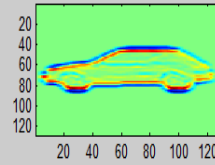
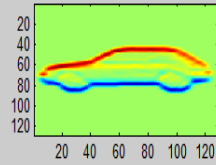
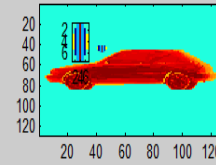
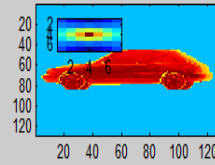
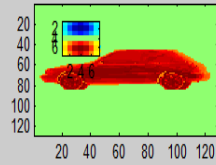
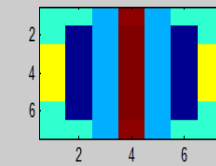
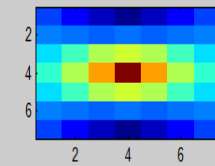
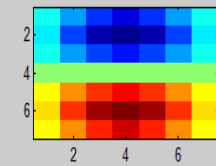
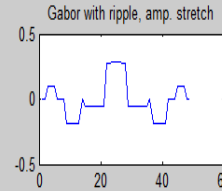
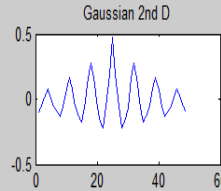
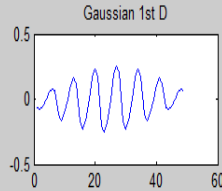
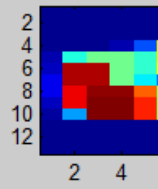
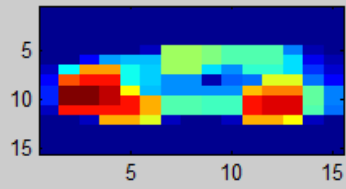
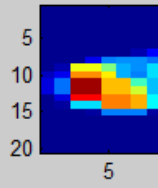
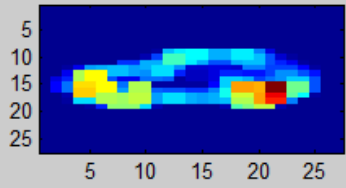
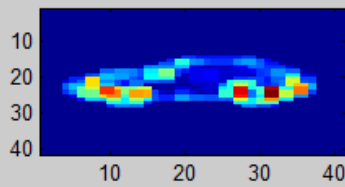
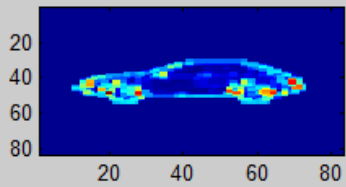
This is what we see, what we experience through senses





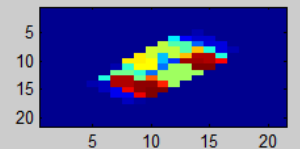
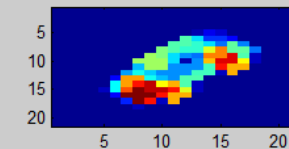
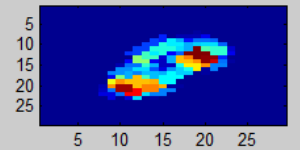
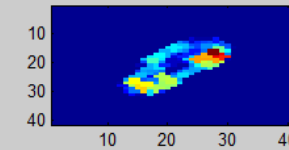
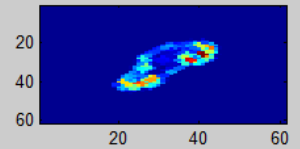
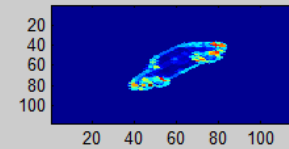
This is how a computer is fed sensory information





Currently correlations are done sequentially over the whole image

Procedural attempts at correlation based on ventral system understanding in terms of translation, rotation, dilation



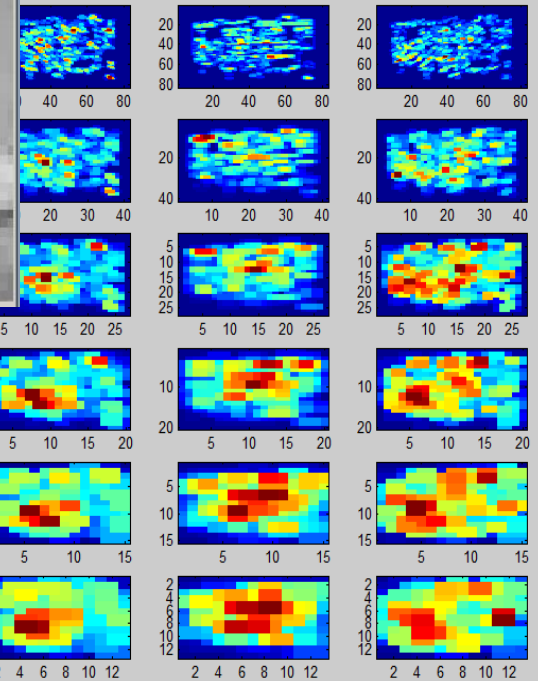
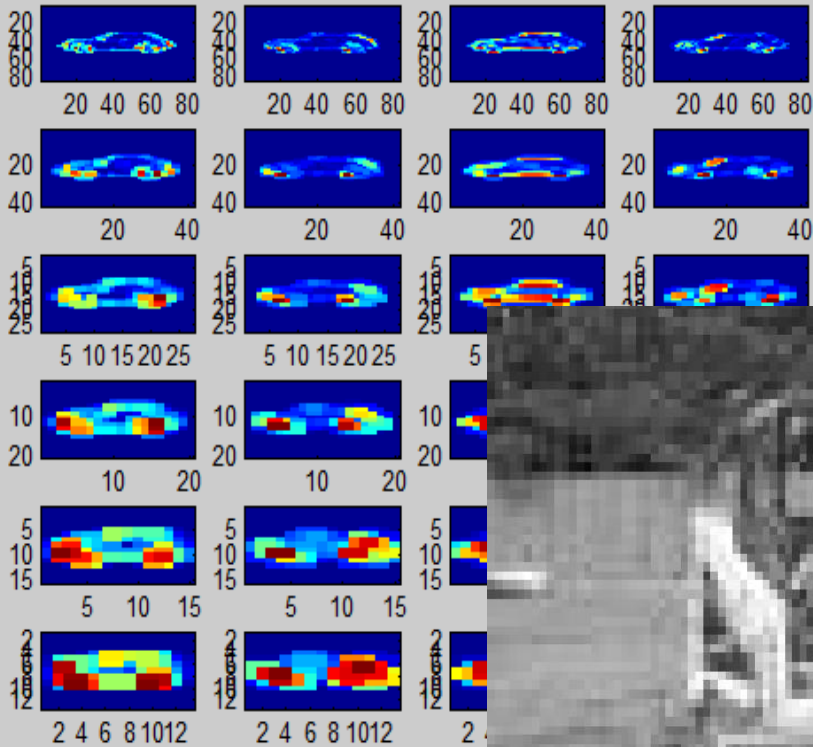


How about correlating  
at saccade locations?

**Saccades:** the eyes move around,  
locating interesting parts of the  
scene and building up a mental,  
three-dimensional 'map'  
corresponding to the scene

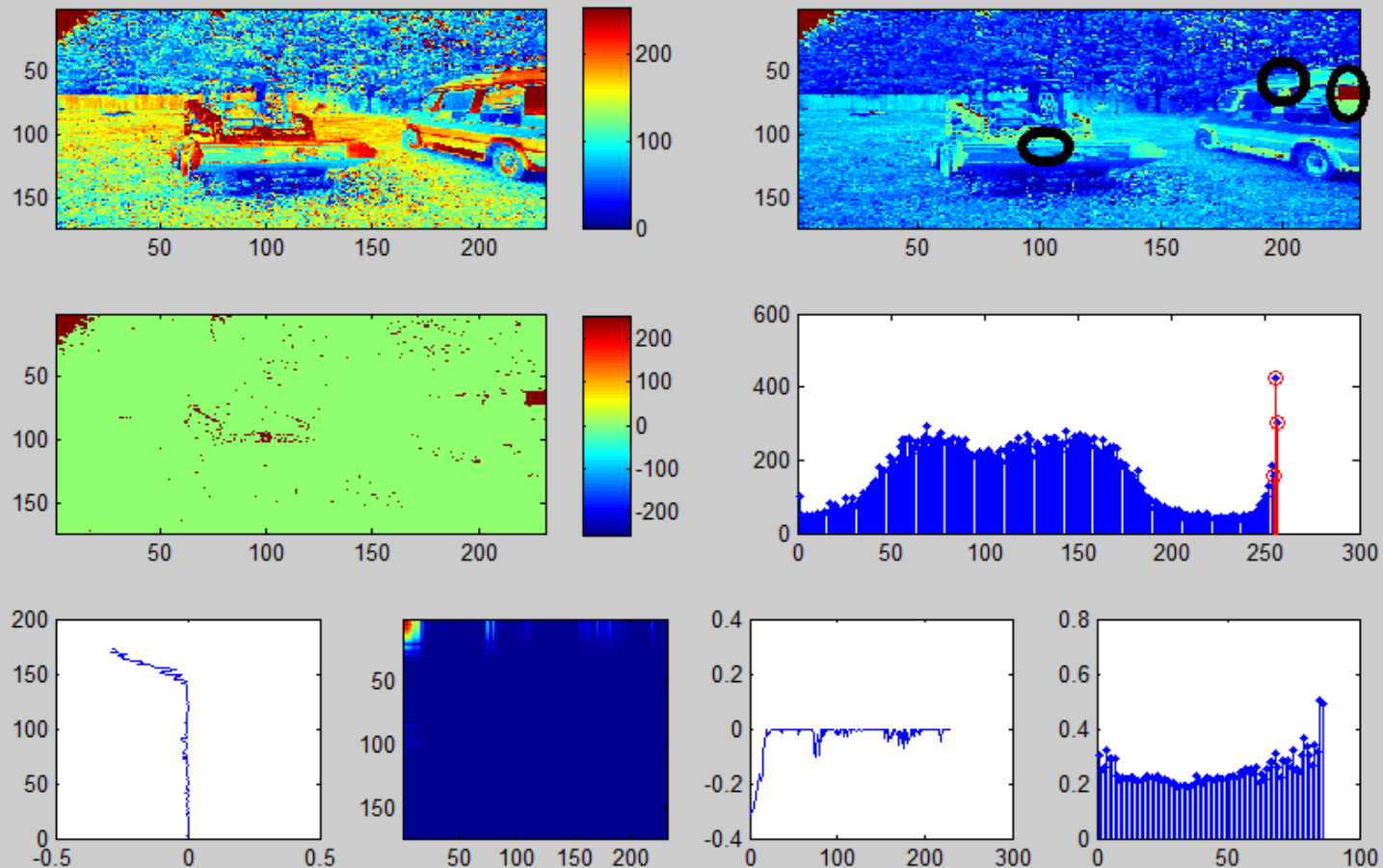


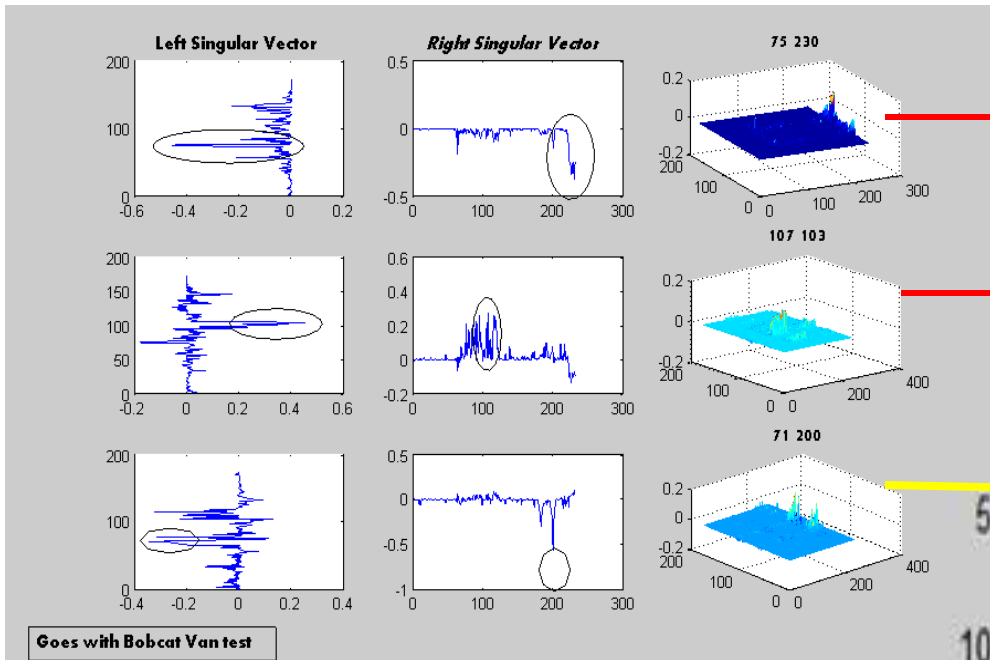
Principle is the same, in that we are actually taking subsamples from each set of correlations ready for a Radial Basis Function.



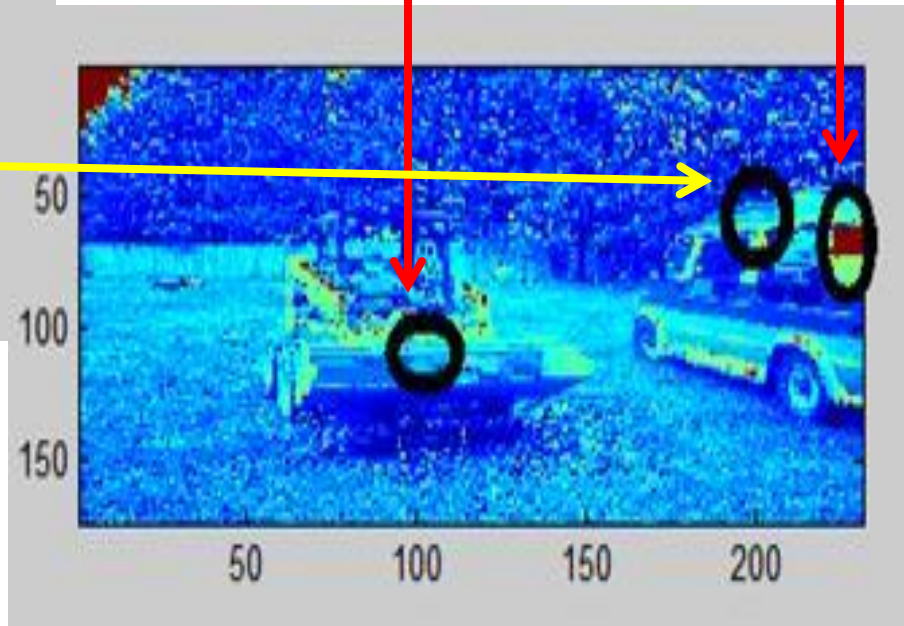
Correlation between test and template are fed into a **Radial Basis Function** as a least squares estimator, in the sense of a Gaussian distribution.

Experiment with 256 color levels taken 3 at a time, matrix of pixels are fed into the SVD where the top 'single' values are normalized and kept. From the  $256/3 = 86$  samples, we pick the top three numbers, and use the associated 'single' vectors at the color instance to determine where it should look.





Energy placement within 'single' vector  
Indicates matrix position.

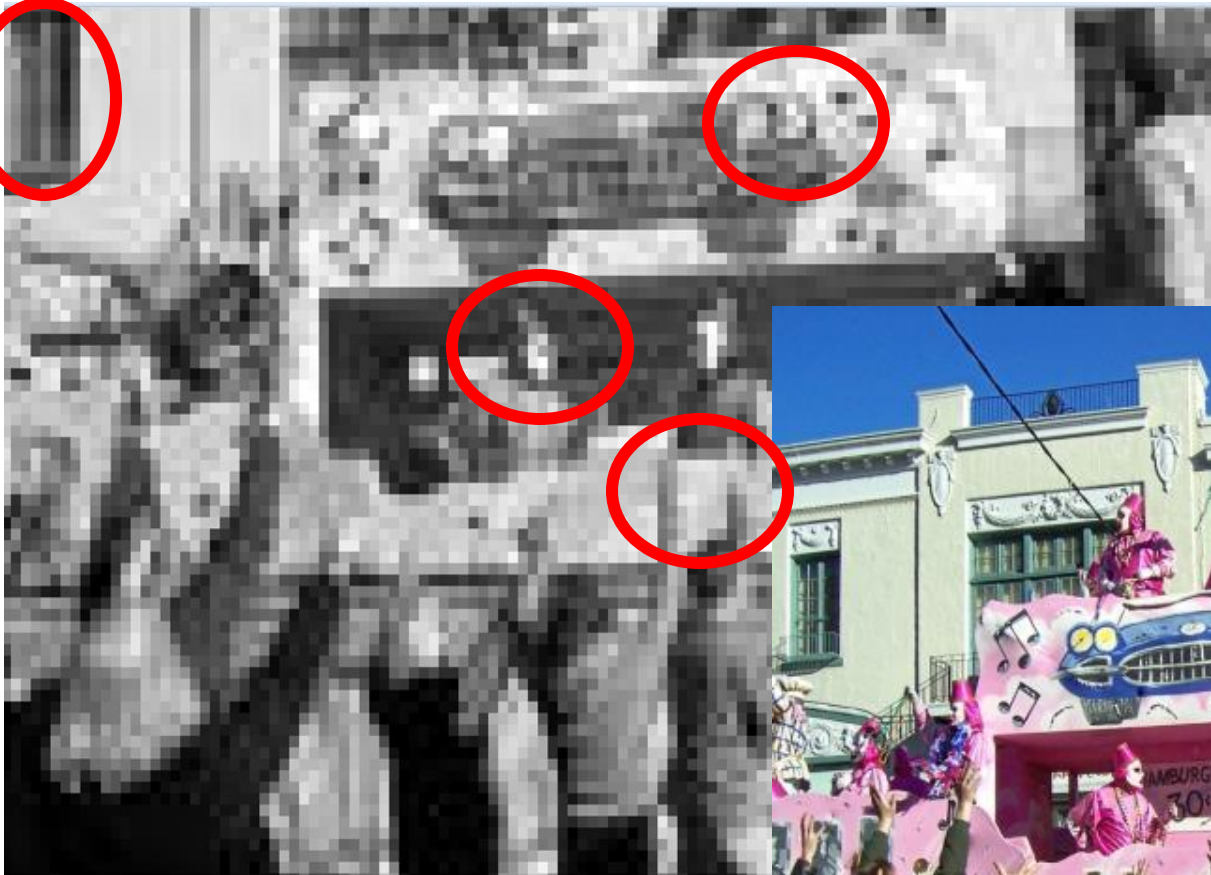


'Find a starting point, and start predicting'....Jeff Hawkins

Where

are

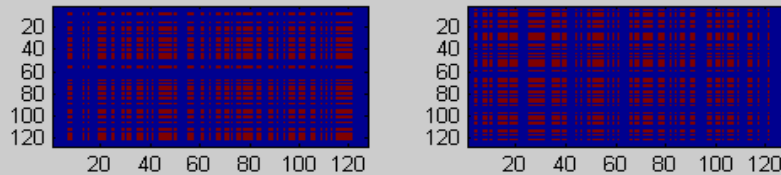
YOUR



SACCADES  
?

# Two paths to travel

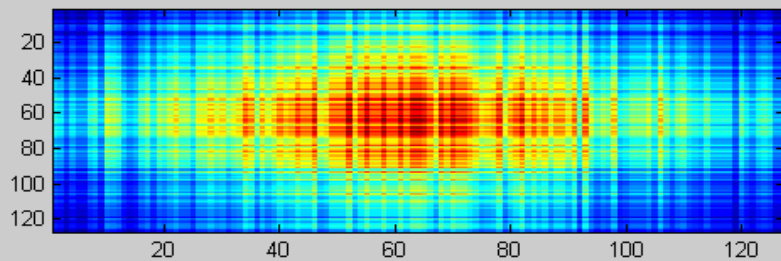
Where probably traveled before



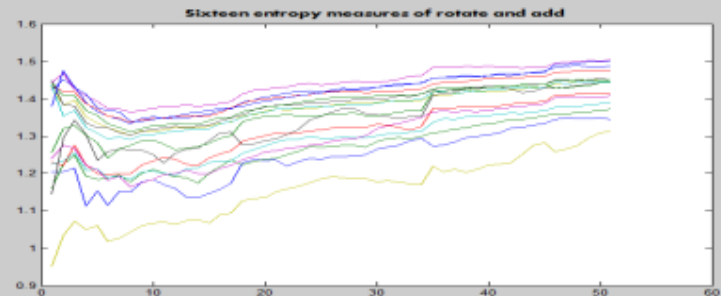
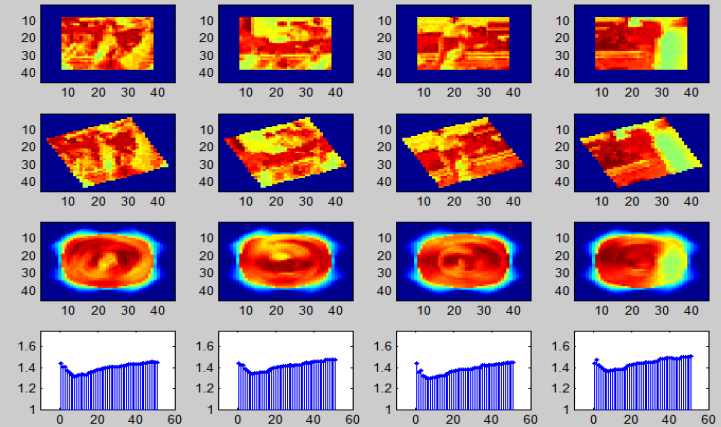
LEFT

Right

*Binocular*



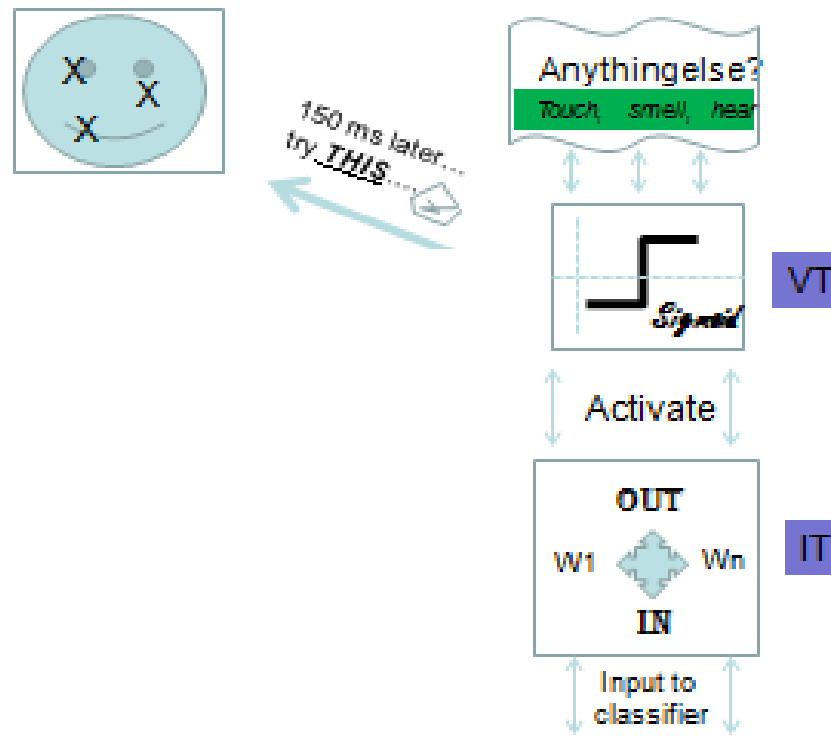
Mixture of Fourier and Special Sequences possible design improvement over Cat and Slit experiment. Process will track movements of reverse, rotate, translate, and dilate...and is well defined. Inspired by paper on hierarchical peripheral vision.



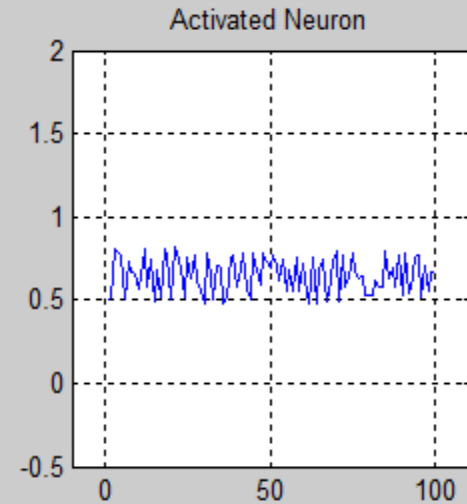
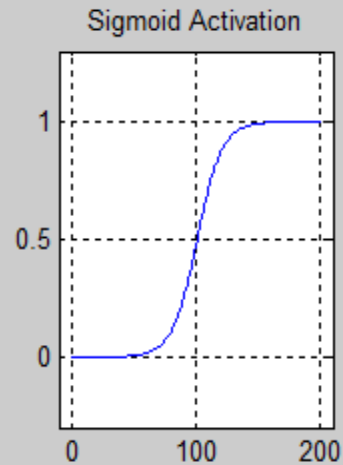
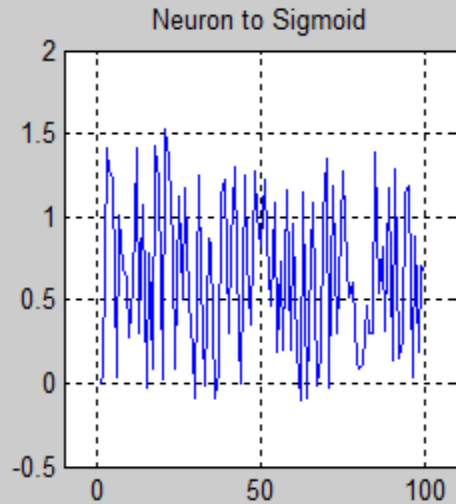
Mixture of rotation and Shannon entropy to detect changes in structure



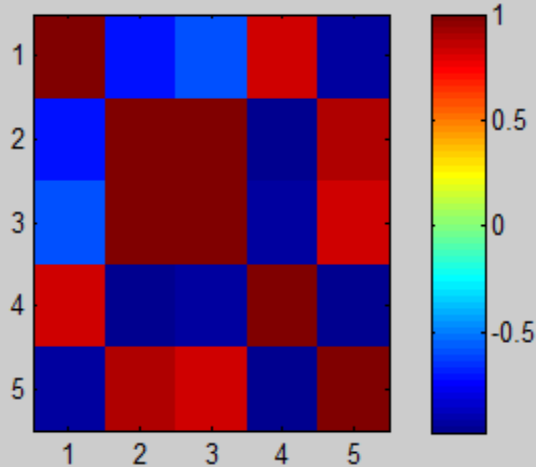
# From the neural-network side



# Sigmoids, Afferents, Resonance, Mathematics



XCORR Five Pre-Activated Neurons

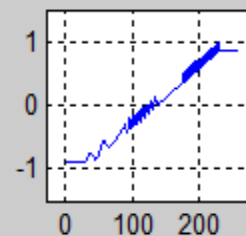


SigMod concept intro:

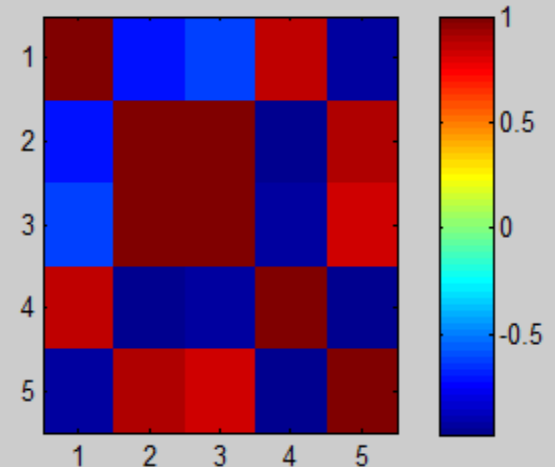
Tread - Striatal Beat Frequency

Riser- Max LRS of varying degree BEBR TST

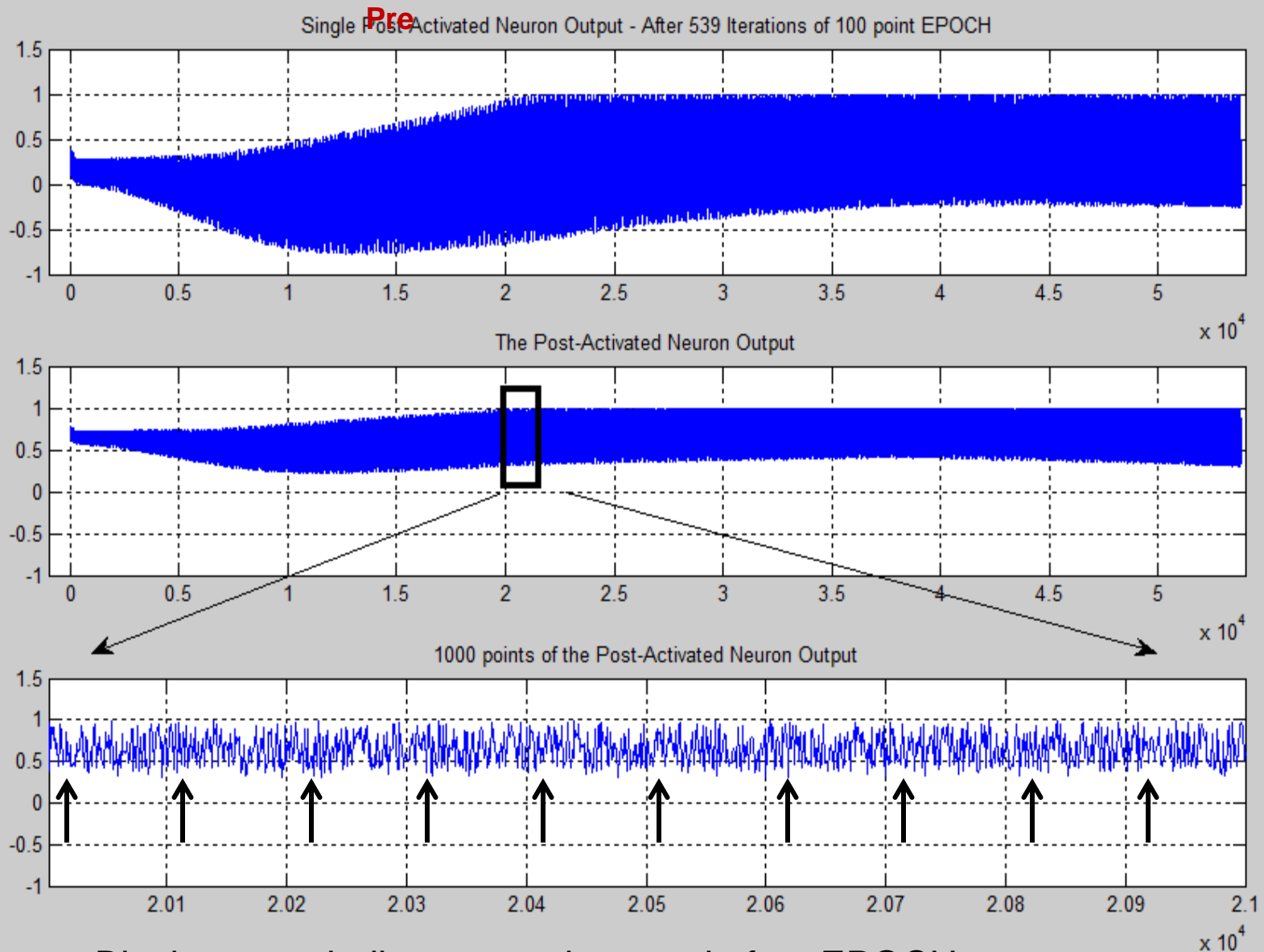
Tread-Riser Activate Candidate



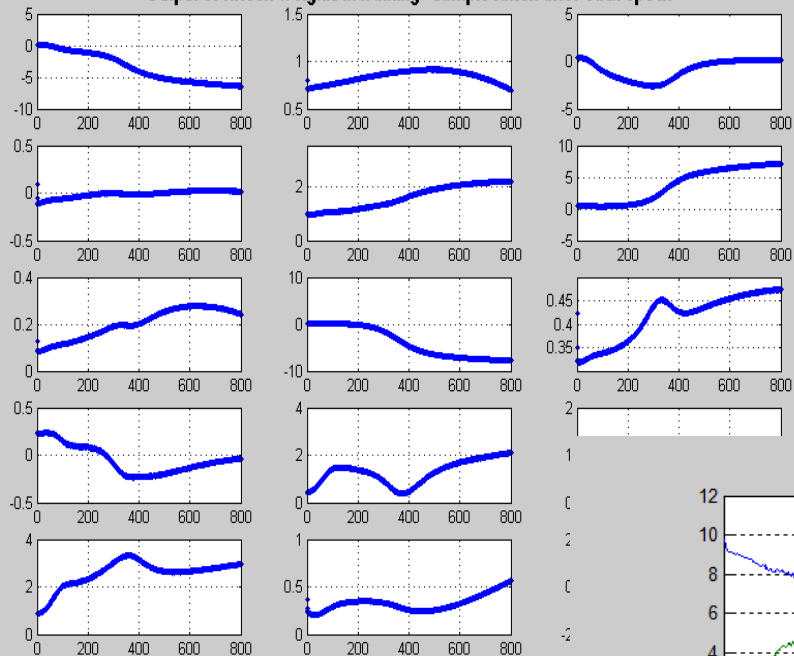
XCORR Five Activated Neurons



# Neuron output continuously adjusted by sigmoid



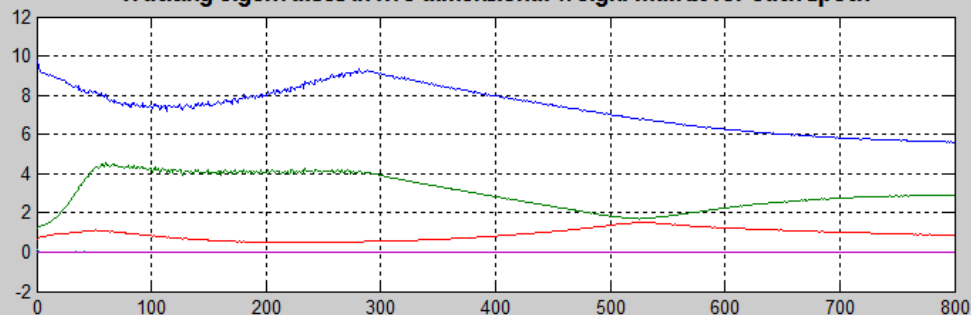
Output of fifteen weights in training - sample taken after each epoch



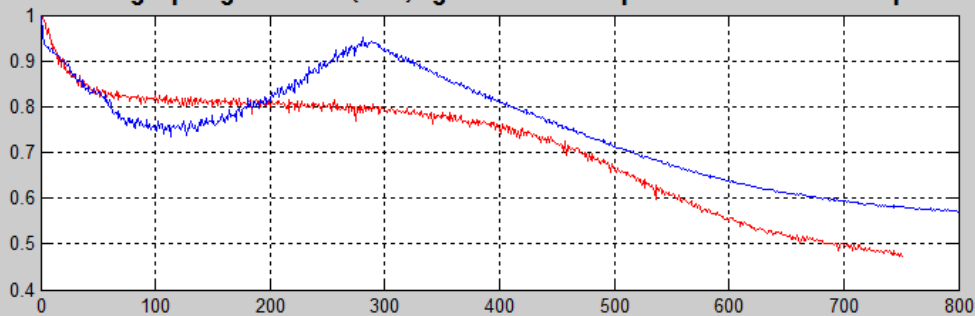
800 EPOCH points from each of 15 weights where an EPOCH is sampled at the end of a forward/backward iteration.

Tracking eigenvalues of a weight matrix and tracking the Error curve to monitor changes made to the system templates.

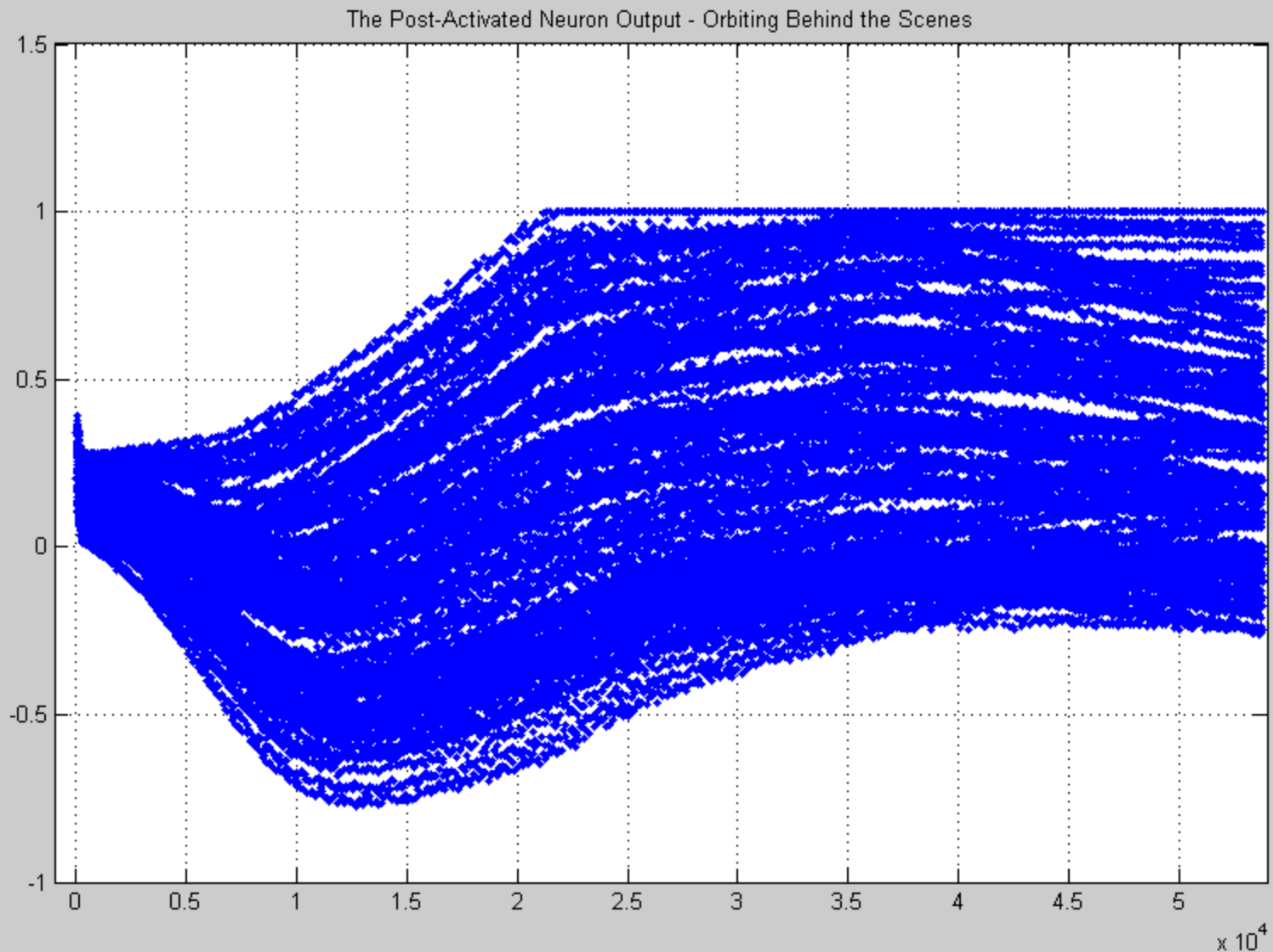
Tracking eigenvalues in five dimensional weight matrix for each Epoch



Tracking top singular value (blue) against desired output error curve for each Epoch



# Monitoring the streaming orbits by concatenating all points in each EPOCH



Remainder of research will be directed towards

**BAMs**

## Interaction with Other Groups and Organizations

- Attended Society for Neuroscience 2011 in Washington, DC.
- Neuroscience department of the Medical University of South Carolina (MUSC) and Physics Department of the College of Charleston – Buhusi and Oprisan...Striatal Beat-Frequency concept of Meck.
- Image Processing Department and Information Science Department in the Applied Research Laboratory at Penn State – Richard Tutwiler ... Learn from scratch, not from match.
- Physics Department at the University of New Orleans – George loup – Old timer in signal processing.
- Would like to utilize the Griffiss Institute in Rome, NY to transfer technology from AFRL to SPAWAR/RDECOM/USSOCOM.

# List of Publications Attributed to the Grant

- None yet



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Director, Strategic Development  
AFRL Information Directorate  
Rome, NY

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Haykin, Kosko, Nelson, Rusjan, Bojanczyk, Pugh, Chapman, and  
Bill Copeland.