



# Breaking the virtual barrier: real-time interactions with spiking neural models

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## Abstract

The unrivaled complexity of the human brain has driven many researchers towards larger and more detailed models of neural processing. Often run on remote high-performance computing architectures, these simulations can be difficult to access at significant levels of detail. In general, after simulations are completed, the results are analyzed off-line. This paradigm can make development of large models exploring complex and time-consuming simulations, such as learning or persistent neural activity, very difficult. Presented here is a toolkit, dubbed NCSTools, used for real-time interactions with large-scale neural simulations run on the NeoCortical Simulator (NCS).

## NCSTools

- Mechanism for monitoring and dynamically modifying neural simulations.
- Bridge between Computational Neuroscientists and Engineers.
- Soft Real-Time network communication with NCS and Client programs.
- Modifiable at run-time through configuration format:
  - Definable communication "language"
  - GUI
  - User Inputs
  - Data Processing
- Constructed for the Linux OS with C++
- Component interfaces provide layered abstraction resulting in an extensible yet robust code base.

## NeoCortical Simulator

- High-performance MPI-based parallel architecture.
- Integrate-and-fire neurons with conductance based compartments and Hodgkin-Huxley formalism.
- Hebbian synapses with STD/STF, augmentation and STDP.
- Stimulus and reporting mechanisms supporting local and remote interactions.

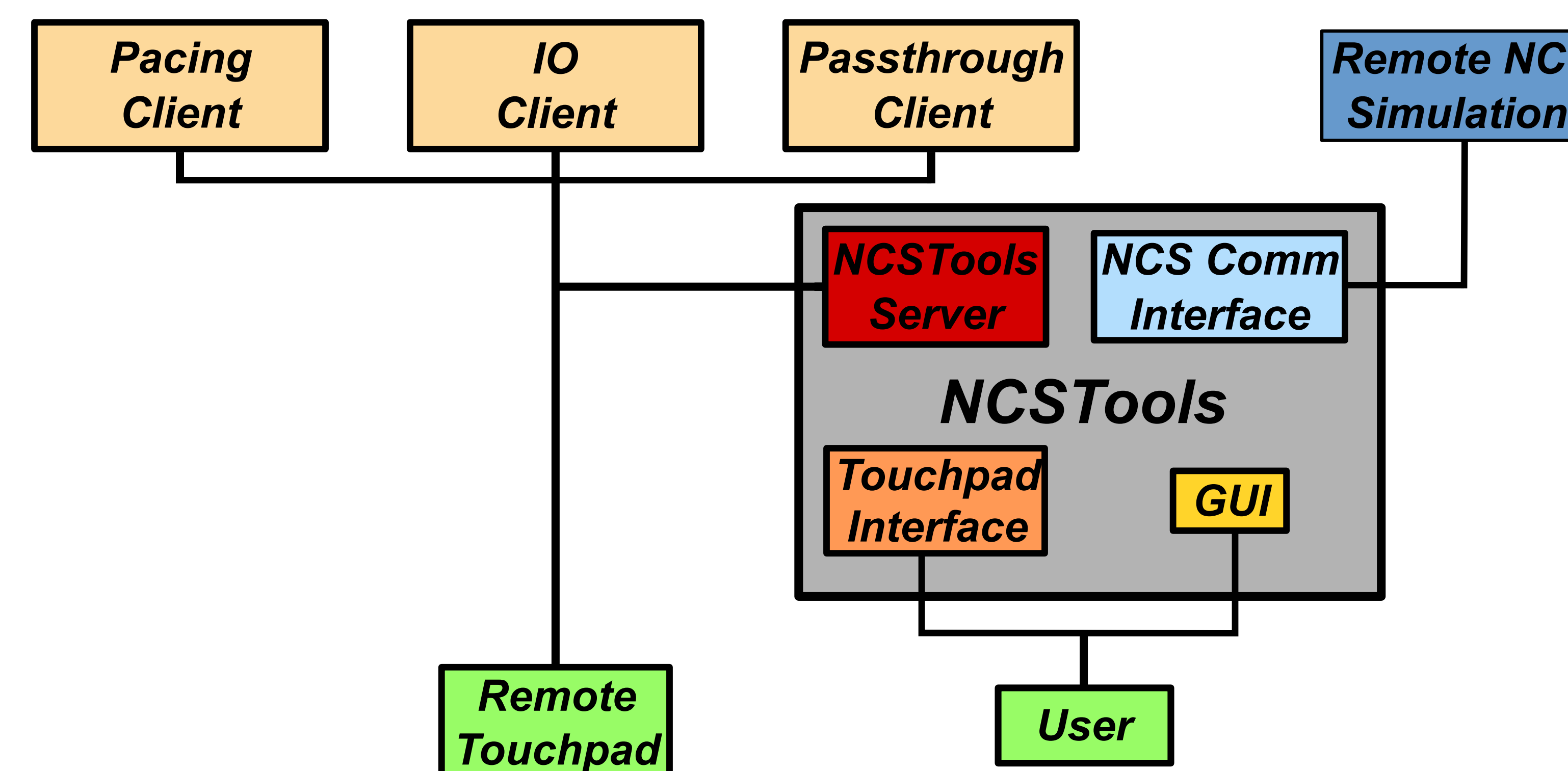
## Design

### Stimulus Options:

- Predefined values activated by clients
- Dynamic values from clients
- Configured touchpad stimulus.

### Control Interface:

- Saving of current brain state.
- Modification of synapses and Hebbian Learning.
- Append a new stimulus definition.
- Stop simulation.

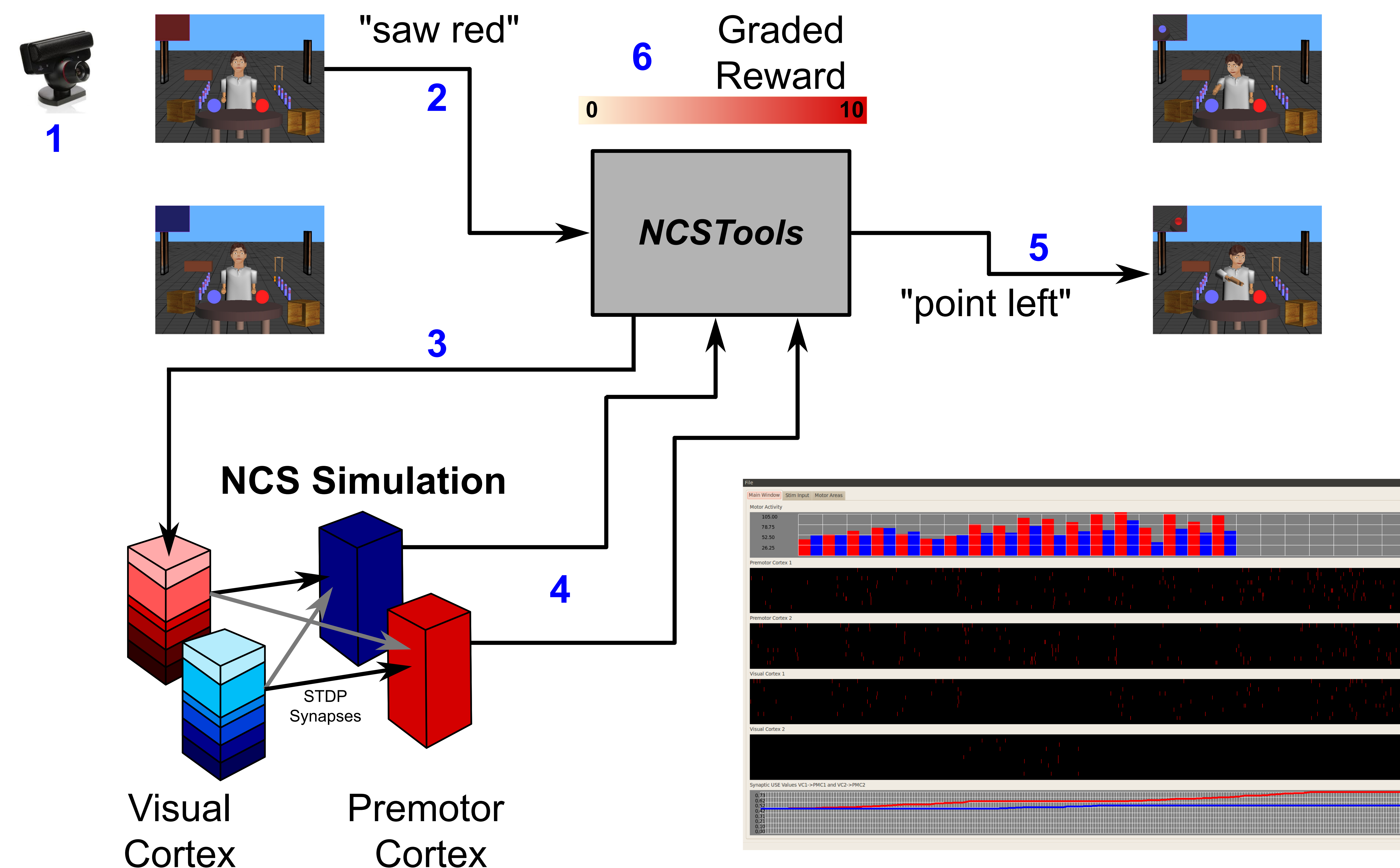


### Reports from NCS:

- Groups compared as Winner-Takes-All
  - Fixed-Time
  - Threshold with moving window
- Output to GUI
- Passed to connected clients

\*Interactions and visualizations are defined through a configuration language.

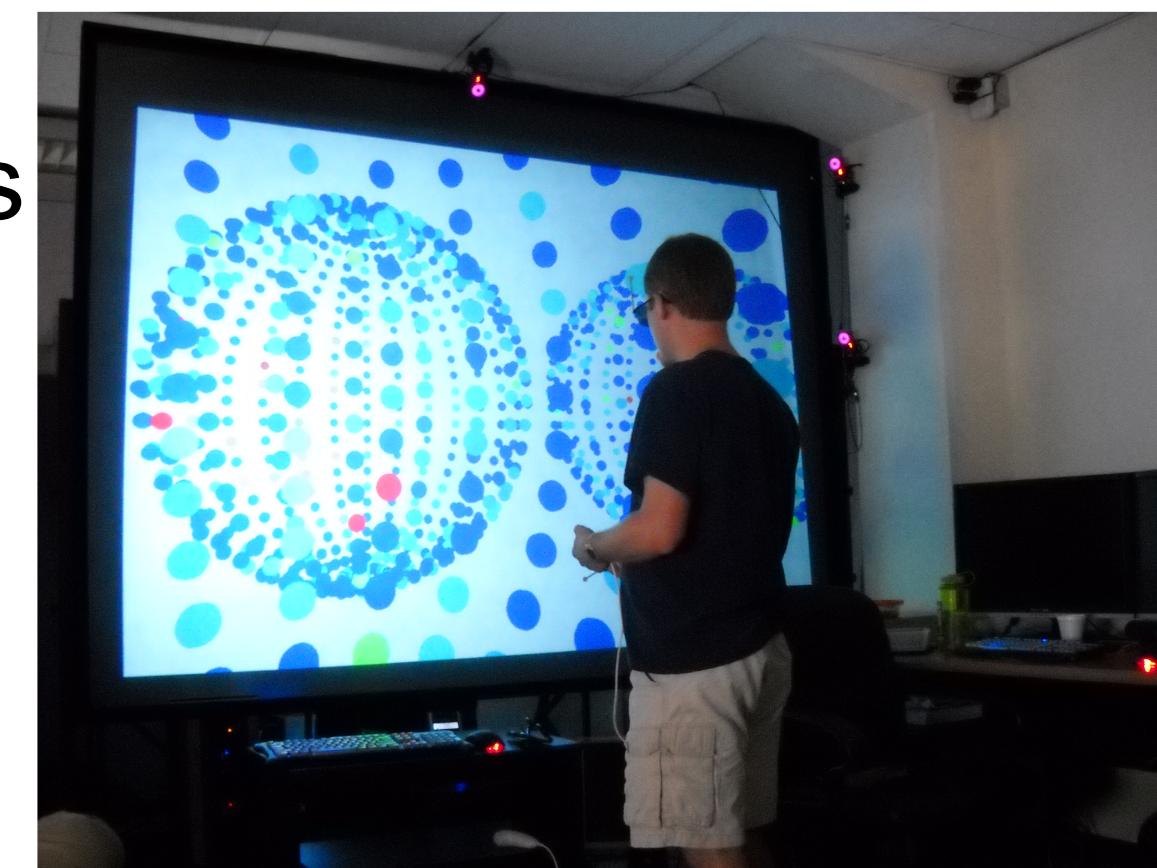
## Example VNR Scenario



## Current Applications

### Virtual Reality:

- Supports X3D Models
- Visualizes running NCS simulations.
- Tested successfully on 3D wall and 6 sided CAVE.



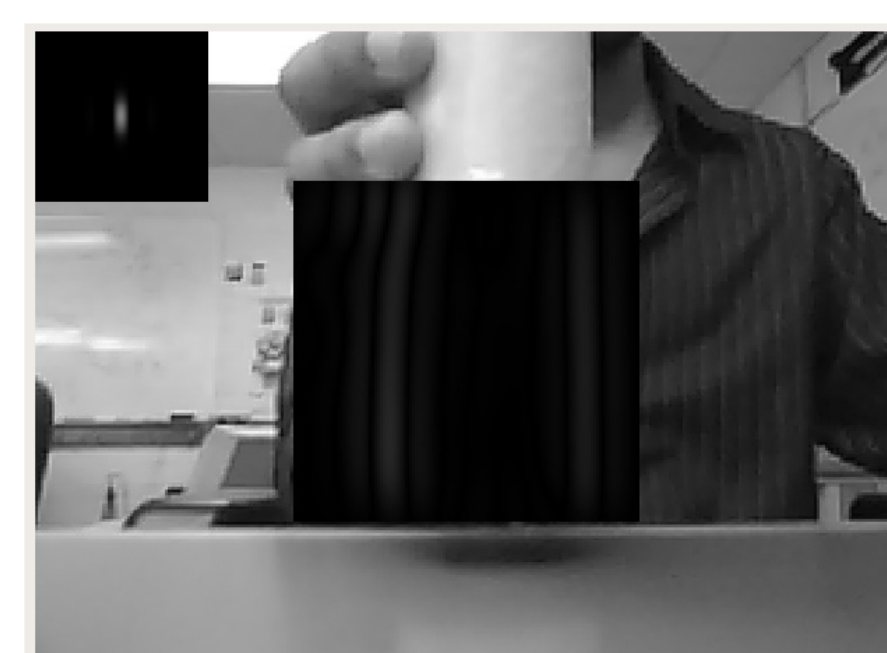
### Audio Processing:

- Extraction of emotional content has been completed.
- Currently working on hardware models of cochlear processing.



### Video Input:

- GPU based gabor filtering.
- Images are processed and values sent to simulated visual pathways.



## Future Directions

- Structural and connective modifications of neural models during simulation.
- Cluster-aware version.
- Additional input processing mechanisms.
- Hard real-time version for interactions with experiments and time sensitive applications.
- Dynamic server configuration. Provide clients the mechanism for defining interactions on the fly.

## Acknowledgements

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