

Computational Tools for Neuroscience plus Project Ideas

- Instructor: Yoonsuck Choe; CPSC 644 Cortical Networks

1

Topographica

- <http://topographica.org/>
- Good for large-scale developmental/functional simulations.
- Example projects:
 - Implement motor apparatus and self-organizing motor map (Philipona et al. 2004; Graziano et al. 2002).
 - Implement sensory-invariance-driven action algorithm (Choe and Smith 2006).
 - Run texture-based self-organization (Park et al. 2009a,b).
 - See the future works chapter of the book <http://computationalmaps.org> (Miikkulainen et al. 2005).

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XPPAUT

- <http://www.math.pitt.edu/~bard/xpp/xpp.html>
- Good for small-scale simulation where model is describeable as ODEs.
- Example projects:
 - Systematic investigation of the influence of PSP time constant and/or conduction delay on synchronization (extend homework 1).
 - Extending Choe's thalamus model to have more realistic parameters (Choe 2004).

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Octave

- <http://www.octave.org>
- Generic numerical programming environment.
- Most linear algebra functions supported.
- Example projects:
 - Extend some existing code base: sida.m (SIDA), ga.m (simple neuroevolution), etc.
 - Other innovative uses.

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Motor-Based Grounding

- Choe's sida.m code (in Octave).
- Example projects:
 - RF learning with invariance criterion.
 - Extending sida.m to complex forms (spatiotemporal pattern invariance).

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References

- Choe, Y. (2004). The role of temporal parameters in a thalamocortical model of analogy. *IEEE Transactions on Neural Networks*, 15:1071–1082.
- Choe, Y., and Smith, N. H. (2006). Motion-based autonomous grounding: Inferring external world properties from internal sensory states alone. 936–941.
- Graziano, M. S. A., Taylor, C. S. R., and Moore, T. (2002). Complex movements evolved by microstimulation of precentral cortex. *Neuron*, 34:841–851.
- Miikkulainen, R., Bednar, J. A., Choe, Y., and Sirosh, J. (2005). *Computational Maps in the Visual Cortex*. Berlin: Springer. URL: <http://www.computationalmaps.org>.
- Park, C., Bai, Y. H., and Choe, Y. (2009a). Tactile or visual?: Stimulus characteristics determine receptive field type in a self-organizing map model of cortical development. In *Proceedings of the 2009 IEEE Symposium on Computational Intelligence for Multimedia Signal and Vision Processing*, 6–13. **Best Student Paper Award**.
- Park, C., Choi, H., and Choe, Y. (2009b). Self-organization of tactile receptive fields: Exploring their textural origin and their representational properties. In *Advances in Self-Organizing Maps: Proceedings of the 7th International Workshop, WSOM 2009*, 228–236. Heidelberg: Springer.

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Other

- NEURON:
<http://www.neuron.yale.edu/neuron/>
- GENESIS:
<http://www.genesis-sim.org/GENESIS/>
- Good for detailed morphological models and simulation.

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- Philipona, D., O'Regan, J. K., Nadal, J.-P., and Coenen, O. J.-M. D. (2004). Perception of the structure of the physical world using unknown multimodal sensors and effectors. In Thrun, S., Saul, L., and Schölkopf, B., editors, *Advances in Neural Information Processing Systems 16*, 945–952. Cambridge, MA: MIT Press.

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