

CS290 (models of spiking neurons) covers some mathematical models inspired by biological neurons. Some background from automata theory or formal language theory is helpful, since the neuron models are related to finite automata or other Chomsky formal grammars. Aspects of the computational power, e.g. vis-a-vis Chomsky hierarchy of languages, or computational complexity, e.g. asymptotic complexity, of the neuron models are tackled.

1 Background

CS290 is a special topic or seminar class created to support research, e.g. related literature, preliminary work, of graduate students. At least for computer science graduate students, CS290 can be used as a specialisation or elective class for accounting of classes prior to graduation.

The end of sem report in CS290 can be revised and extended after CS290 ends, and can become part of the thesis or dissertation or conference or journal paper of some graduate students. The class involves reading of some fundamental as well as up to date research on such models, in support of research interests of the students. Optional presentations may also be included. Finally, an end of sem report is required from each student.

2 Other resources

The following articles are some good starts or sources of further readings. Some of the following resources may be provided by the instructor or can be accessed for free, even remotely, using university resources, e.g. via the Engineering Library at <http://www.engl.lib.upd.edu.ph/>.

1. “Neural networks and formal models of language and computation” <https://www.dlsi.ua.es/~mlf/nnafmc/pbook/node7.html>
2. “The Computational Power of Neural Networks and Representations of Numbers in Non-Integer Bases” <https://mendel-journal.org/index.php/mendel/article/view/59>
With corresponding slides at <http://uivty.cs.cas.cz/~sima/mendel17.pdf>
3. “Spiking Neural P Systems. Recent Results, Research Topics” https://link.springer.com/chapter/10.1007/978-3-540-88869-7_15
4. “Relating logical neural network to conventional models of computation” <https://ieeexplore.ieee.org/document/155320>
5. “Calibrating Generative Models: The Probabilistic Chomsky-Schützenberger Hierarchy” <https://web.stanford.edu/~icard/pcsh.pdf>
6. “Formal language theory: refining the Chomsky hierarchy” <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3367686/>

Aside from the resources provided with this document, the following are some suggested and preliminary readings.

- [1] Samanwoy Ghosh-Dastidar and Hojjat Adeli. Third generation neural networks: Spiking neural networks. In *Advances in Computational Intelligence*, pages 167–178. Springer, 2009.

-
- 34 [2] Wolfgang Maass. Networks of spiking neurons: the third generation of neural network models. *Neural*
35 *networks*, 10(9):1659–1671, 1997.
- 36 [3] Wolfgang Maass. Computing with spikes. *Special Issue on Foundations of Information Processing of*
37 *TELEMATIK*, 8(1):32–36, 2002.
- 38 [4] Gheorghe Paun. Spiking neural p systems-a quick survey and some research topics. In *2014 16th*
39 *International Symposium on Symbolic and Numeric Algorithms for Scientific Computing*, pages 20–25.
40 IEEE, 2014.
- 41 [5] Haina Rong, Tingfang Wu, Linqiang Pan, and Gexiang Zhang. Spiking neural p systems: theoretical
42 results and applications. In *Enjoying Natural Computing*, pages 256–268. Springer, 2018.
- 43 [6] Simon Thorpe, Arnaud Delorme, and Rufin Van Rullen. Spike-based strategies for rapid processing.
44 *Neural networks*, 14(6-7):715–725, 2001.