BMC Neuroscience

Poster presentation

Open Access

Axon guidance simulation: a multi-agent approach

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from Seventeenth Annual Computational Neuroscience Meeting: CNS*2008
Portland, OR, USA. 19–24 July 2008

Published: 11 July 2008

BMC Neuroscience 2008, **9**(Suppl 1):P95 doi:10.1186/1471-2202-9-S1-P95

This abstract is available from: http://www.biomedcentral.com/1471-2202/9/S1/P95

Introduction

One of the greatest problems lacking resolution in neuroscience is to know how axons travel from one source neuron to its target neuron (axon guidance problem). It is known that there are thousands of actors (e.g. Axons, Neurons, Glia cells, Guide Posts, tissues, etc.) in this environment and that these actors interact with each other using molecules (guidance cues), constituting a very complex system in which interesting behaviors can be found (e.g. Cooperation, Fasciculation and Competition). Neuroscientists encounter several difficulties when trying to study this subject, such as the time and preparation of in vivo/vitro experiments, ethical aspects and mistakes in interpretations caused by non-controlled side effects [1].

The answer to this problem is of high importance because it could lead to new insights in neuronal regeneration and so improve the quality of life of millions of people over the world. As suggested by [1] combined computational-experimental collaborations can potentially make inroads that neither one could achieve alone.

The Multi-Agent Systems (MAS) paradigm [2] is an appropriate approach for modeling complex systems such as axon guidance [3]. We propose a Multi-Agent simulation system to be used by neuroscientists in order to test theories and gain deeper knowledge about axon guidance, that contrary to studies already made can bring in a single platform all of the important elements easily (see [1], for an extensive list of answers that can be achieved with the help of simulation).

Simulating axon guidance

In the simulation there are several agents and many others can be added, but for now the total number of agents can go from 5 (Environment, Guidance Cue, Source Neuron,

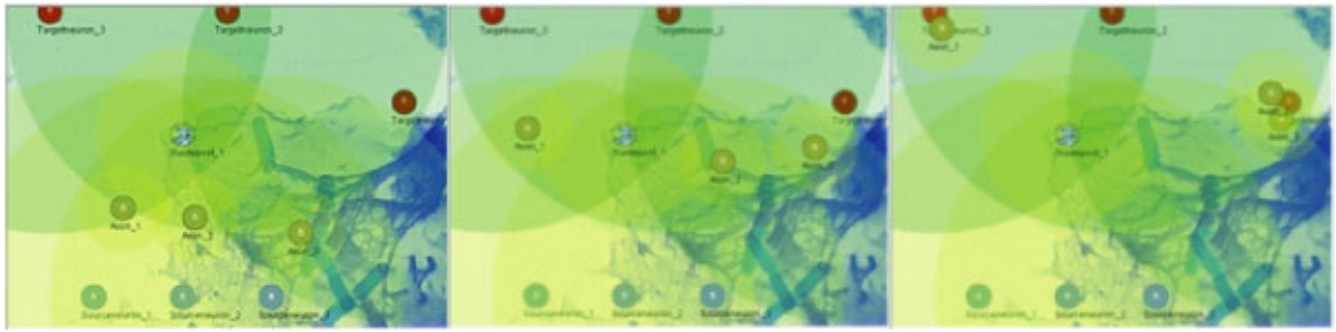

Figure 1
AGSim Sequence (Prototype). 3 Target Neurons – 3 Source Neurons – 3 Axons – 1 Guidepost.

Target Neuron and Axon) to 8 (Environment, Guidance Cue, Source Neuron, Target Neuron, Axon, Guide post, Glia Cell, Tissue). All of the simulation is dynamic and almost any parameter can be changed during runtime.

Conclusion

In this phase simple simulations were made concerning mainly the attractive/repulsive interaction. Figure 1 shows a prototype simulation sequence where it is already possible to figure out what the final application will look like. The size of the simulation in terms of the number of agents will certainly be between very few (5–8) and hundreds of agents, depending on the experiments made. The system that we propose can be used to test theories and so it might help to uncover the logic beyond axon guidance.

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