Computational Neuroscience

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Organisation

Name of the organisation Ghent University (UGent)

Department Information Technology

Country Belgium

Geographical Area Flemish Region

SCOPE OF THE METHOD

The Method relates to	Human health
The Method is situated in	Basic Research, Translational - Applied Research
Type of method	In silico
Specify the type of cells/tissues/organs	Animal and Human Neurons

DESCRIPTION

Method keywords

computational models

in silico

Data analysis

prediction models

Neurons

Scientific area keywords

computational modelling

neuroscience

bioengineering

Biomedical Engineering

Method description

Computational neuroscience aims to study the nervous system by mathematical and computer simulations. Computational models can be built on multilevel scales. With the bottom-up approach, the model is built from the same building blocks as observed in human or animal tissue. As such, the functioning of a neuron depends on the behavior of its ion channels. Subsequently, these neurons are connected via synapses to obtain the network response. Ion channels and synapses are mathematically represented by a set of differential equations, modeled after the Hodgkin-and-Huxley formalism. The models enable simple and systematic parameter manipulation of often experimentally inaccessible aspects. They can therefore be used to test hypotheses concerning underlying mechanisms of neurological diseases on multilevel scale. New hypotheses can be formulated as well. The obtained results can be used to design more delineated *in-vivo* I *in-vitro* experiments, reducing the amount of experiments needed. Finally, they are an ideal tool to gain more insights in the effect of treatment strategies and provide improved treatment protocols.

Lab equipment

- High performance cluster
- NEURON simulation software (open source)

Method status

Still in development

Published in peer reviewed journal

PROS, CONS & FUTURE POTENTIAL

Advantages

- Systematic research
- Cost reduction
- Reduction *in-vivo* and *in-vitro* experiments
- Improved understanding of underlying mechanisms

- Generalization of sparse data *Treatment optimization

Challenges

- Validation of model assumptions / predictions / results
- Animal's *in-silico* model to human outcome translation
- Computational complexity / cost
- Simplified
- Intersubject variations

Modifications

Increased computational power and better experimental methods will result in more accurate models.

Future & Other applications

- Optimization of treatments for neurological diseases,
- Improved understanding of pathologies of nervous system diseases.

REFERENCES, ASSOCIATED DOCUMENTS AND OTHER INFORMATION

References

- Carnevale, N. T., & Hines, M. L. (2006). The NEURON book. Cambridge University Press. - Fan, X., & Markram, H. (2019). A brief history of simulation neuroscience. Frontiers in neuroinformatics, 13, 32.
- Tarnaud, T., Joseph, W., Schoeters, R., Martens, L., & Tanghe, E. (2021). Improved alpha-beta power reduction via combined electrical and ultrasonic stimulation in a parkinsonian cortex-basal ganglia-thalamus computational model. Journal of Neural Engineering, 18(6), 066043.

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