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Describing and exchanging models of neurons and neuronal networks with NeuroML

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The Neural Open Markup Language (NeuroML) project is an international, collaborative initiative to facilitate the exchange of complex neural models, allow for greater transparency and accessibility of models, enhance interoperability between simulators and other tools and support the development of new software and databases [1-3]. The increasing enthusiasm in the computational neuroscience community for standards that allow for greater simulator interoperability and model publication is driving current efforts, which focus on the key objects that need to be exchanged among existing applications and try to anticipate those needed by future applications. Examples of these objects include descriptions of neuronal morphology, ion channels, synaptic mechanisms, and network structure. The process of creating these common specifications encourages discussion among users of independently developed applications, which leads to succinct descriptions of the essential elements of models. NeuroML is an Open Source project based on XML, as it provides the transparency, portability and extensibility required in these efforts. The openness of the standards and the encouragement of feedback from the community are some of the guiding principles of the NeuroML initiative.

The declarative specifications for NeuroML are arranged into levels, with higher levels adding extra concepts at different spatial scales, an approach that ensures that the specification is provided in a modular way. Mappings exist between NeuroML elements and several commonly used simulators including NEURON [4], GENESIS [5] and PSICS [6], and a number of tools are available which allow a user to create and validate NeuroML documents and to generate code for model implementation by multiple simulators from these documents. In particular, the model development application neuroConstruct can import and write NeuroML documents as well as generate output for simulating neuron or neuronal network activity using either NEURON, GENESIS, PSICS or PyNN [7]. Currently, NEURON can import and export cells in NeuroML format, and import/export of NeuroML is in beta testing for PyNN, which is a Python package for simulator independent specification of neuronal network models [8]. The use of NeuroML with PyNN provides a connection between the NeuroML descriptions of large-scale neuronal network models and additional simulators.

Overall, NeuroML provides a valuable contribution towards simulator interoperability as well as model publication and exchange. The NeuroML standards will facilitate a broad range of research goals in computational neuroscience.

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