NeuroUnit: Validation Tests for Neuroscience Models

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Rigorous validation of a scientific model's explanatory power requires comparing the model's predictions against all available and relevant experimental data. Model validation is an ongoing process -- models must not simply be compared to data available when the model is initially reviewed for publication, but also to data gathered after it has been published. We argue, by drawing an analogy between scientific model validation and software testing, that *precise* validation criteria that allow model validation to be partially *automated* are essential for answering many important questions in science. While modern journal articles tell us clearly ***how*** a model works, they provide only incomplete and quickly dated outlines concerning ***which*** observations they aim to explain and ***how well*** they achieves these explanations. To overcome this problem, we have proposed *formalizing* the model validation process by creating collections of software tools dedicated to scientific model validation.

In software engineering, a *unit test* is a function that validates a single component of a computer program against a single correctness criterion. We have proposed the analogous concept of a *validation test* -- an executable function that validates a provided model implementation against a single empirical observation to produce a *score* that indicates agreement between the model and a single piece of data. We have previously described a core framework written in Python, ***SciUnit***[1], that begins to fulfill this vision, and here we describe ***NeuroUnit***, a library of SciUnit tests and associated standards specifically for the neurosciences. Suites of these tests are described here and will be elaborated via a distributed cyberinfrastructure that enables collaborative construction and curation of tests by members of the neuroscience community. Visual summaries of the aggregate results will provide neuroscientists with an up-to-date, centrally-collected report of progress in their research area. The merits and deficiencies of competing models will be clearly visible, benefiting both ongoing modeling efforts and informing new theoretical and experimental directions.

Our examples consist primarily of validation tests and supporting workflow applicable to a range of single neuron models from *in vitro* neurophysiology. A principal source of empirical data guiding these example tests is Neuroelectro[2], which provides a convenient API for extraction of data from published articles. Combined with the NeuroUnit test library and utilities, test construction is fully automated, and can be applied to published models or, by analogy to software development, to models in-progress to guide and constrain their development. We demonstrate the complete pythonic testing workflow using several example models available at Open Source Brain[3]. We also describe how other sources of data could be used for test initialization, and how tests for other domains of neuroscience could be generated.

1) RC Gerkin, C Omar (2012) SciUnit: A collaborative framework for formal validation of scientific models.
http://goo.gl/HBrxX http://github.com/rgerkin/sciunit

2) SJ Tripathy, J Savitskaya, RC Gerkin, NN Urban (2012) NeuroElectro: A database describing the electrophysiology properties of different neuron types, Neuroinformatics, Munich, Germany.
http://www.neuroelectro.org

3) P Gleeson, E Piasini, SM Crook, R Cannon, V Steuber, D Jaeger, S Solinas, E D'Angelo, RA Silver (2012) The Open Source Brain Initiative: enabling collaborative modelling in computational neuroscience. BMC Neurosci 13:O7.
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