L-Measure: Morphometric Analysis of Neuronal Trees

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The study of dendritic morphology is a key to correlate cellular structure, activity, and function in the nervous system. The increasingly common employment of computer-interfaced motorized microscopes has resulted in the widespread adoption of digital formats to represent, store, manage, analyze, visualize, and exchange neuromorphological data. Several hundreds of complete 3D neuronal reconstructions are now publicly available in digital format. Since dendritic reconstruction is time-consuming and extremely sensitive to specific experimental conditions, the neuroscience community greatly benefits from the sharing of this data.

To unleash the potential of these electronically available data collections, we created a powerful software tool called 'L-Measure'. This freeware application measures from digitized morphological files almost any possible parameter that describes the anatomical structure of dendrites and axons. L-Measure allows the analysis of single neurons or groups of neurons by using 40 different geometrical functions (e.g. lengths, diameters, angles), which can be invoked alone (e.g., to measure the total membrane surface area), or in combinations or distributions (e.g., to return the surface area vs. distance from the soma). In addition, geometrical functions can be used to select a portion of the tree thus enhancing the specificity of the analysis (e.g. surface area of branches with diameter smaller than 1 micron vs. distance from the soma). L-Measure outputs morphological data as statistical summaries (average, standard deviation, range, sum), histogram distributions, or raw numbers for further processing by external software.

The L-Measure program has two main components. The Graphical User Interface allows the user to open and convert morphological files, and to select, specify, run, and save anatomical analysis. The GUI is entirely implemented in java swings (light weight components). The L-Measure engine, in contrast, is the backend computational server that processes the data. The engine, implemented in C++, is controlled by the GUI and is transparent to the user. This dual object oriented architecture results in a cross-platform executable, which runs both stand-alone and as java applet in common Internet browsers. The program is fully documented and constantly updated.

L-Measure has been used to successfully carry out exhaustive quantitative analyses of neurons as diverse as hippocampal pyramidal cells, cerebellar Purkinje cells, spinal motoneurons, and cultured cortical cells, from a variety of experimental preparations, computational simulations, and digital formats. These applications constitute powerful examples of how the computational approach and modern software technology can help resolve the intriguing challenge of characterizing complex neuroanatomical structures.

L-Measure is freely available at http://www.krasnow.gmu.edu/L-Neuron (case sensitive).

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