NeuronPlot: A Dynamical Systems View of a Neuron

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Understanding neuronal dynamics often requires advanced mathematical tools that are not easily accessible to students or researchers without specific mathematical training. This project aimed to develop an interactive software platform, NeuronPlot, to visualize and analyze neuronal behavior from a dynamical systems perspective using the two-dimensional Morris–Lecar model. The simulator was implemented in Python using numerical integration methods to solve systems of differential equations governing membrane potential and gating variables. A graphical user interface was designed to allow real-time interaction with model parameters and initial conditions. The program computes and displays phase portraits, nullclines, equilibrium points, and trajectories, along with bifurcation indicators such as saddle-node and Hopf transitions. Additional tools include automatic detection of stable limit cycles and a mathematical inspector that evaluates local stability through Jacobian analysis and eigenvalues. Testing was performed using established neuron parameter regimes to verify that the simulator reproduces known dynamical behaviors. NeuronPlot reproduced monostable and bistable states, resonator and integrator dynamics, stable limit cycles, and transitions associated with saddle-node and Hopf bifurcations. This study demonstrates that NeuronPlot provides an accessible and rigorous framework for exploring neuronal dynamics through geometric visualization. The platform may serve as an educational and research tool for understanding excitability and bifurcation phenomena in neuroscience, lowering the barrier to applying dynamical systems theory in biological contexts.

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