Qualitative-Modeling-Based Design for Silicon Neuronal Networks

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Silicon neuronal network is a bottom-up approach to the neuro-mimetic systems, which are gaining prominence as a new approach to realize power-efficient, adaptive, and intelligent information processing systems with massively parallel architecture. It is a network of silicon neuron circuits which emulate the electrophysiological activities in neuronal cells in real time. A variety of neuronal cells with complex activities is observed in the nervous system. A class of neuron models that describes the dynamics of ionic particles near the cell membrane can precisely model these activities, but it is described by multivariable nonlinear differential equations. To realize power-efficient and simple silicon neuron circuits that reproduce the nonlinearity in these equations, we developed a new circuit design approach on the basis of nonlinear mathematical techniques that have been utilized in the qualitative neuronal modeling. This approach can also be applied to tune the dynamical properties of the neuronal activities after circuit fabrication and support a variety of neuronal activities.