Implementation on Nonlinear Systems on Stochastic Computing

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Abstract. Stochastic Computing is a form of approximate computing that may offer energy and are savings for mathematical operations. In this paper we analyze how to implement highly nonlinear differential equation systems using this approach. We focus on the Hindmarsh-Rose neuron model, showing how to implement it, as well as discussing the problems we face and the improvements it offers.

Introduction

Stochastic Computing is a flavor of approximate computing, first introduced by Von Neumann [1] around 1956. The basic idea of this kind of computation is replacing numbers by probabilities and operating on them. Since operations like addition and multiplication can be replaced by simple logical gates, the hardware implementation is fairly straightforward. The main drawback is that probabilities are implemented as estimations of probability based on the mean value of long chains of binary values, thus requiring long calculation times. It has been shown that this strategy is more energy-efficient up to 16-17 bit long numbers [2] or longer if additional strategies are used [3]. In this paper we will discuss how to implement nonlinear systems using Stochastic Computing, following our previous work [4][5].

Results and Discussion

Specifically, we will first discuss the general methodology of stochastic computing, followed by the procedure to adapt equation systems for this implementation. Further, we will present our results on the implementation of the Hindmarsh–Rose (HR) neuron model, analyzing the different trade-offs we needed to settle for. For instance, Fig. 1 shows the evolution of two of the variables, comparing the exact solution (using Matlab) with the results of using SC. We will also compare these results with the results of including noise in the exact solution, seeing that the results are very similar to SC.

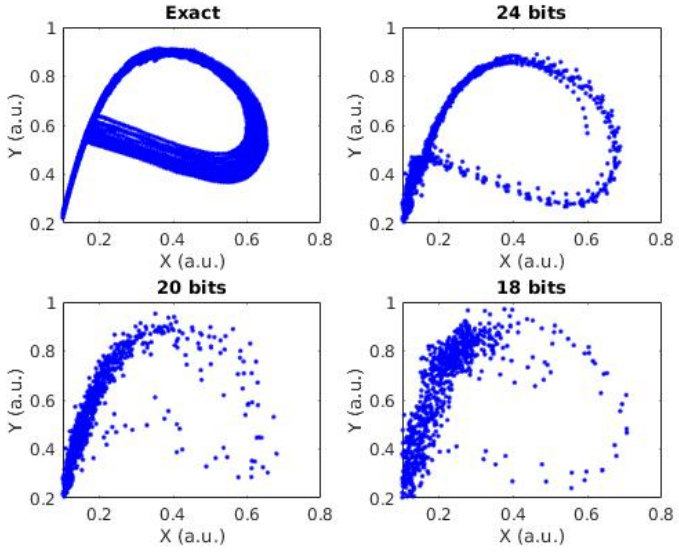

Figure 1: Comparison between the exact solution to the HR model and those calculated using different stochastic number lengths.

References

[1] Von Neumann J (1956) Probabilistic logics and the synthesis of reliable organisms from unreliable components. *Automata studies* 43–98.

[2] Moons B and Verhelst M (2014) Energy-Efficiency and Accuracy of Stochastic Computing Circuits in Emerging Technologies. *IEEE Journal on Emerging and Selected Topics in Circuits and Systems* **4**:475-486.

[3] Li S, Glova A. O, Hu X et al. (2018) SCOPE: A Stochastic Computing Engine for DRAM-Based In-Situ Accelerator. *MICRO* 696–709.

[4] Camps O, Stavrinides S. G and Picos R (2020) Efficient Implementation of Memristor Cellular Nonlinear Networks using Stochastic Computing *2020 European Conference on Circuit Theory and Design (ECCTD)* 1–4.

[5] Camps O, Stavrinides S. G and Picos R (2021) Stochastic computing implementation of chaotic systems. *Mathematics* **4**:375.