On Evolution of stochastic dynamical neural networks

Fernando Niño *
University of Memphis and
Universidad Nacional de Colombia

German Hernandez†
University of Memphis and
Universidad Nacional de Colombia

Dipankar Dasgupta‡
University of Memphis
Memphis, TN 38152

Abstract

An evolutionary algorithm to train a new class of stochastic recurrent neural network is presented.

1 INTRODUCTION

We introduce a new class of neural networks that we call *stochastic dynamical neural networks* (SDNN's), which implement a particular class of random discrete dynamical systems, namely iterated random functions [2]. Such neural networks are able to approximate the dynamics of discrete dynamical systems with compact universal attracting set. By approximation we mean that there exists a SDNN whose dynamics emulates the dynamics of a system at any given precision.

A training procedure for SDNN's takes as input: a level of precision and an orbit (time series of the state) of the system which is dense in the universal attracting set; and produces as output a SDNN that approximates the dynamics of the system at the given level of precision. These orbits allow us to reconstruct approximately the attracting set of the system. Using the attracting set [1], we can search for an iterated random function (equivalently, a SDNN) that has approximately the same attracting set (similar dynamic asymptotic behavior), as the given system. The problem of training a SDNN can be formulated as an optimization problem, whose complexity makes suitable to use an evolutionary technique. We designed an Evolutionary Algorithm (EA) using special properties of the problem.

*e-mail: ninol@msci.memphis.edu
†e-mail: hernandg@msci.memphis.edu
‡e-mail: dasgupta@msci.memphis.edu

2 STOCHASTIC DYNAMIC NEURAL NETWORKS

A SDNN implements a random discrete dynamical system $\{X; W\}$ with state space X, a complete metric space, and dynamics W defined as $W(x) = w_i(x)$ with probability p_i for all $x \in X$, w_i is a contractive map, $p_i > 0$ for $i = 1, ...n$, and $\sum_{i=1}^{n} p_i = 1$. We introduce deterministic and stochastic neurons with input and output values in X. The neural network has a first layer of deterministic neurons, a second layer that consists of one stochastic neuron, whose output is fed back to the input of the first layer, i.e., the SDNN is recurent.

3 EVOLUTIONARY ALGORITHM

The evolutionary algorithm searches for the architecture of a SDNN that aproximates a dynamical system at a given level of precision. Using special properties of the problem, special genetic operators were designed. The fitness function included a factor used to penalize neural networks with large number of neurons. Experiments were performed on some well-known systems (e.g., Sierpinski's triangle), and the EA was able to evolve SDNN's that approximated well such systems.

Acknowledgments. This work was partially supported with a grant from COLCIENCIAS to F. Niño and G. Hernandez. The authors thank F. Botelho and A. Quas for their valuable comments.

References

[1] M. Barnsley. *Fractals Everywhere*. Academic Press, 1988.

[2] P. Diaconis and D. Freedman. Iterated random fucntions. *SIAM Review*, 41, 1999.