Determining Parameters in Jordan's (1986) Recurrent Network

Chi-Chih Chang (g9114@cs.nccu.edu.tw)
ElectroLab, Department of Psychology, National Chung Cheng University
Min-Hsiung, Chia-Yi, TAIWAN

Jon-Fan Hu (jon-fan.hu@psy.ox.ac.uk)
Department of Experimental Psychology, University of Oxford
Oxford, UK

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It is an important topic to investigate the mechanisms of sequential patterns of behaviors which are assumed to be related to variety of human cognitive function, including producing linguistic utterances or the automatic motor movement. They all reflect certain elaborate mental processes behind the scene in our mind.

Even though Jordan (1986) built up a generic recurrent connectionist model trying to simulate the serial order of behavior, there is evident that it lacks for detailed formulization regarding how to determine appropriate values of parameters in the network, such as the connection weights and bias for node activation.

Objective

This study aims on analyzing the original version of Jordan's (1986) network and tries to formularize explicitly the parameters for the computational processes in equations. Further attempts are to propose a proper determinist numeric system which can be used to simulate desired sequence of behavior.

Analysis and Formulization

Architecture of Jordan's (1986) Model

Figure 1(a) shows an example of Jordan's recurrent network with two linear input nodes, one binary hidden node, and two binary output nodes. There are one-to-one feedback connections between output and input layer. Each input node also has feedback connected to itself. For instance, in the case that a sequence of AAAB is to be produced by the network, a specific set of the initial connection weights and bias needed to be assigned in advance, given that A and B are represented as (1 1) and (0 0).

Simplified Version of the Recurrent Network

The original network was restructured by simplifying the connections and adjusting the corresponding weights and bias (indicated in Figure 1(b) and (c)).

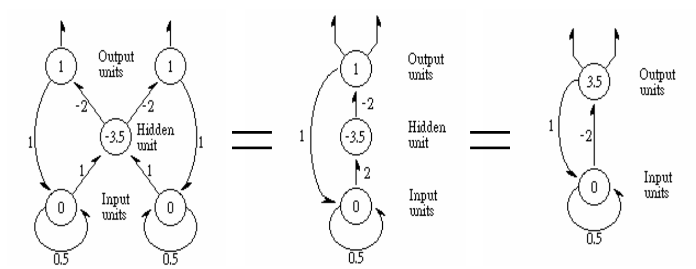
A Determinist Equation Derived

Essentially, based on the simplified version of the network, the activation of the output (O) can be determined by a general function of factors I (inputs), R (feedback weights to the input itself), W (weights between input and output layers), and B (bias):

$$O_n = O\left(B + W\left(\sum_{i=1}^{n-1} R^{n-i-1} O_i + R^{n-1} I_0\right)\right) \qquad \text{(Eq. 1)}$$

, where n is the n*th* element in the sequence and I_0 is the initial value of input.

Equation 1 is then used to derive defining *inequalities* for generating specific patterns of sequence (e.g. AAAB, ABAAA, et al.) Sets of values of parameter for producing particular outputs would also be determined accordingly.



(a) (b) (c)

Figure 1: An example of Jordan's (1986) recurrent network (a) and the simplified versions of the network (b and c).

Conclusion

Despite of the limitation of investigation reported in this study, it appears to provide a possible method to analyze the computational property of the network. Not only the determinist foundation underlying the information processes of the network is highlighted, but the proposed mathematical formulization pinpoints how the parameters in the network interact with each other. Implications from this study on understanding aspects of the behavior of serial order are also worth noting.

References

Jordan, M. I. (1986). Serial order: *A parallel distributed approach. ICS Report 8604*. San Diego, CA: University of California, Institute for Cognitive Science.