Stability Analysis of a Class of Artificial Neural Network Systems

S N Sivanandam\textsuperscript{a}, S N Deepa\textsuperscript{a}

\textsuperscript{a}Department of CSE, PSG College of technology, Peelamedu, Coimbatore - 641 004, TN, India

In this paper, certain algebraic procedures are suggested to analyze the stability nature of the artificial neural network system represented by their system matrices. Using these matrices, the unstable situation is inferred and the asymptotic stability as well as aperiodic stability is analyzed for the represented neural network system. The stability analysis is carried out employing Marden’s table and Fuller’s table using the characteristic equation in discrete domain of the given neural network system. The presented procedures are easily applicable without having any computational overheads.

1. INTRODUCTION

Stability is the most important property of all kinds of systems. Numerous algebraic and graphical schemes are available to study the characteristics of stability of linear discrete systems. The characteristics of stability in discrete systems are, asymptotic stability having oscillations, aperiodic stability (dead beat response) and unstable with growing oscillations as well as aperiodically unstable having increase in magnitude. These types of observations are possible to occur in certain class of artificial neural networks [1–15].

Tanaka [15] analyzed the stability of a certain class of neural network control systems, adopting Nyguen and Widrow model; where Lyapunov criterion is used to identify the stability conditions. The present paper proposes Marden’s Table [16] and Fuller’s Table [4] for inferring unstable situations and analyzing the asymptotic as well as aperiodic stability employing the characteristic equation of neural network control systems.

2. STABILITY CONDITIONS OF A CLASS OF NON-LINEAR SYSTEMS

Consider the following class of non-linear system,

\[ x(k + 1) = A(z(k))x(k) \]  

(1)

\[ A(z(k)) = \sum_{i=1}^{r} h_i(z(k)) A_i \]  

(2)

where, \( r \) is a positive integer, \( z(k) \) is a vector, \( x(k) = [x_1(k), x_2(k), ..., x_n(k)]^T \) and it is assumed that,

\[ h_i(z(k)) \geq 0, \text{ with } \sum_{i=1}^{r} h_i(z(k)) = 1 \]  

(3)

The non-linear system described in Equation (1) can be regarded as a kind of linear differential inclusions [15]. The stability condition for ensuring stability of Equation (1) is given as follows: The equilibrium of linear differential inclusions described by Equation (1) is asymptotically stable in large; if there exists a common positive definite matrix \( P \) such that,

\[ A_i^T P A_i - P < 0, \text{ for } i = 1, 2, 3, ..., r \]  

(4)

If the above result holds good then \( A_i \) is a stable matrix. For the neural network described in [15], the following condition also holds good for stability. The product matrices \( A_i A_j \) should be stable for \( i, j = 1, 2, 3, ..., r \).
k=1,2,...35 using Back Propagation Network algorithm as shown in Figure 3.

Illustrations clearly indicate the simplified stability aspect of neural networks and easy application of the procedures without computational overheads.

7. CONCLUSION

The paper proposed a simple algebraic procedure for analyzing asymptotic stability of the given neural network system represented by their system matrices. In this, the stability condition is also tested easily by inspecting the first row elements of the system matrices. The approach also identifies the instability nature of the considered neural network architectures. Thus, it is observed that the stability conditions discussed are simple to apply without having computational overheads.

8. ACKNOWLEDGMENT

The author’s wishes to thank All India Council of Technical Education (AICTE) for providing the grant to carry out this research work.

REFERENCES


S N Sivanandam received the PhD degree in Electrical Engineering from Madras University, Chennai in 1982. He is currently Professor and Head, Department of Computer Science and Engineering, PSG College of Technology, Coimbatore. He has a total teaching experience (UG and PG) of 41 years. He has published 12 books. He has delivered around 150 special lectures of different specialization in Summer / Winter school and also in various Engineering colleges. He has guided and coguided 30 Ph.D research works and at present 9 Ph.D research scholars are working under him. The total number of technical publications in International / National journals / Conferences is around 700. He has chaired 7 International conferences and 30 National conferences. His research areas include Modeling and Simulation, Neural networks, Fuzzy Systems and Genetic Algorithm, Pattern Recognition, Multi dimensional system analysis, Linear and Non linear control systems.

S N Deepa has completed her M.E (Control systems) from PSG College of Technology in 2004 and currently a Full time PhD Research Scholar in Department of Computer Science and Engineering, PSG College of Technology, Coimbatore. She has published 7 books and 16 papers in International and National Journals/ Conferences. Her research areas include Neural Network, Fuzzy Logic, Genetic Algorithm, Optimization Techniques, Digital Control, Adaptive and Non-linear Control.