Chapter 7
A Web–Based Intelligent Educational Laboratory System for Forecasting Chaotic Time Series

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ABSTRACT

In the context of Chaos Theory and its applications, forecasting time series of a chaotic system is an attractive work area for the current literature. Many different approaches and the related scientific studies have been introduced and done by researchers since the inception of this working area. Newer studies are also performed in order to provide more effective and efficient approaches and improve the related literature in this way. On the other hand, it is another important research point to ensure effective educational approaches for teaching Chaos Theory and chaotic systems within the associated courses. In this sense, this chapter introduces a Web-based, intelligent, educational laboratory system for forecasting chaotic time series. Briefly, the system aims to enable students to experience their own learning process over the Web by using a simple interface. The laboratory system employs an Artificial Intelligence-based approach including a Single Multiplicative Neuron System trained by Intelligent Water Drops Algorithm in order to forecast time series of chaotic systems. It is possible to adjust parameters of the related Artificial Intelligence techniques, so it may possible for students to have some knowledge about Artificial Intelligence and intelligent systems.

INTRODUCTION

Chaos Theory is an important research field in Mathematics employing many applications in different disciplines like Physics, Engineering, Economics, Biology…etc. Its scope is based on scientific studies associated with the search on behavior of nonlinear dynamical systems, which are highly sensitive to their initial conditions (chaotic systems). In time several kinds of sub-working fields have also been introduced within the context of research studies on the Chaos Theory.

Control of Chaos, Chaos Synchronization and Chaotification (Anti-control of Chaos) are some sub-working fields that can be examined within the mentioned content. Additionally, there are also some other research orientations supporting these fields. At this point, forecasting (prediction – estimation of) time series of a chaotic system is an attractive work area for the current literature.

In time, many different approaches have been introduced to provide effective solutions for the related problem on forecasting time series of chaotic systems. Actually, this problem on forecasting time series of chaotic systems comes from the failure of forecasting methods, which are mainly used on stationary time series before (Gromov & Shulga, 2012). In this sense, the related methods were unable to provide effective solutions to forecast time series of chaotic systems and so, a remarkable effort on searching for a solution for this problem has been provided by researchers. Regards to the introduced approaches – methods, Artificial Intelligence based approaches, methods and techniques have an important role on providing solutions for the 'forecasting problem'.

On the other hand, it is also another important research point to ensure effective educational approaches for teaching Chaos Theory, chaotic systems within the associated courses given at universities or private institutes. Especially teaching the related sub-working fields (which were expressed in the first paragraph) of the Chaos Theory may direct anyone, who is interested in the related scientific field, to improve his / her knowledge for performing research works in the context of the associated literature. In time, technological developments have given a rise to employing more effective and efficient approaches to improve educational view and make something more possible to reach to the desired objectives of the "science". At this point, the latest improvements in educational technologies enable researchers to perform more effective works for improving individuals' experiences during teaching – learning processes. For example, designing and developing software systems to be used along computer-based educational processes is one of the most popular works in the literature.

This chapter introduces a Web-based, intelligent, educational laboratory system for forecasting chaotic time series. Briefly, the system aims to enable students to experience their own learning process over the Web; by using a simple interface. The laboratory system employs an Artificial Intelligence-based approach including a Single Multiplicative Neuron System trained by Intelligent Water Drops Algorithm in order to forecast time series of chaotic systems. Here, it has been aimed to provide an intelligent, effective enough approach to perform better forecasting operations while studying on the related subject over the Web-based system. It is possible to adjust parameters of the employed Artificial Intelligence techniques; so it may possible for students to have some knowledge about also Artificial Intelligence and intelligent systems. In this work, the effectiveness of the laboratory system was tested on time series provided by Lorenz System, Rössler System, Chen System, and an EEG time series.

The rest of the paper is structured as follows: The next section provides a brief literature review indicating the related "Background" on forecasting problem. Next, the Section 3 and 4 are devoted to the Artificial Intelligence approach employed in the Web-based laboratory system and in these sections, basics of the Single Multiplicative Neuron System, and the "training approach": Intelligent Water Drops Algorithm are explained briefly. Following that, the Section 5 is devoted to the brief explanation of the forecasting approach that was achieved by using the related Artificial Intelligence techniques. After that, the Section 6 introduces the Web-Based Intelligent Educational Laboratory System briefly and the Section 7 focuses on the evaluation process performed for evaluating effectiveness of the laboratory system. Finally, Section 8 outlines the conclusions that have been reached with this study and explains some future works.

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