Soft Computing in Water Resources Engineering

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Soft Computing in Water Resources Engineering

Artifical Neural Networks, Fuzzy Logic and Genetic Algorithms

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To my children

Sümeyra Nur
Beyza Nur
Tarik Meliksah

About the author

Dr GökmenTayfur is a professor of Civil Engineering at Izmir Institute of Technology, Turkey. He graduated from the Department of Civil Engineering, Istanbul Technical University in 1985. He had continued his MSc degree program in the same department from 1985 to 1987. Upon rewarded a graduate studies in the USA by the Turkish Ministry of Education, he had completed his MSc and PhD degrees in the Department of Civil Engineering, University of California at Davis in 1990 and 1993, respectively. He had worked as a post doctoral researcher in the same department and in the department of LAWR in the same university from 1993 to 1995. Since 1995 he has been a faculty member in the Civil Engineering Department, Izmir Institute of Technology, Izmir, Turkey. He had spent 2004–2005 at Louisiana State University and 2007–2008 at the University of Mississippi as a visiting scholar. He has had published several book chapters, more than 50 national and international conference papers and over 40 scientific SCI journal papers. His research interest can be summarized as: Mathematical modeling, surface and subsurface flows, rainfall-runoff induced erosion, sediment transport, solute transport, chemical transport in surface and subsurface flows, application of artificial intelligence methods (ANN, Fuzzy Logic, GA) in water resources engineering problems, and river morphology.

Contents

Preface

Soft computing methods have relatively a recent history, starting in early 1940s with artificial neural networks (ANNs), 1960s with fuzzy logic (FL), and 1970s with genetic algorithms (GAs). The application of these methods in water resources engineering area is even more recent, starting in early 1990s. Many studies have proven their utility across disciplines, triggering many MSc and PhD research thesis projects. As a result, many students have looked for sources to have a grasp of these methods. This has, in turn, initiated the offerings of many soft computing courses across many departments all over the world. I, myself, got into a research in this area in 2001, offered the first graduate course on soft computing methods in 2003. Since then, many students from Engineering (Material, Environmental, Civil, Mechanical, Chemical, Food, Electronics) Departments, including the Departments of Physics, City Planning, and Architecture, have taken the course. In a short period of time, I believe, such courses would be offered at an undergraduate level as well.

Soft computing algorithms can be employed individually or in conjunction with other numerical, analytical, and empirical models to solve engineering problems. They can produce quick results, making them be more attractive to the practicing engineers and managers. ANNs and GAs are data driven optimization techniques that are not restricted to the constraints of mathematical functions. Fuzzy logic, on the other hand, employs verbal statements in solving problems, thus it is in more line with human thinking. The application problems that are demonstrated in the book compare artificial intelligence methods against numerical, regression-based, empirical, and stochastic methods. These comparative examples would enable readers to qualitatively see the performance and importance of the soft computing methods.

This book can be used as a textbook for engineering students and as well as for the students in other disciplines since the great deal of the book contains

the basics of the aforementioned soft computing methods with illustrative examples. Hydrologists and hydraulic engineers can further benefit from the book since the application problems involve the ones from the water resources engineering field, ranging from prediction of the seepage path in an earthfill dam body to longitudinal dispersion coefficient in natural rivers.

Water resources planning and management has always been an important issue since especially the second half of the 20th century. This period witnessed the theoretical concepts and methodologies development, along with the computational tools and numerical methods. The numerical methods are powerful and can be very effective when detailed data is available. They can provide detailed spatial analysis in three dimensions, including temporal variation. In some cases, however, hydrologists, and hydraulic engineers prefer simple, easy-applicable, user-friendly practical methods and this is exactly what the soft computing methods deliver.

This book is designed as having three basic parts:

1. Artificial neural networks (ANN)
2. Fuzzy logic (FL) algorithm
3. Genetic algorithms (GAs)

Part I consists of five chapters. The first four chapters give the basics of an artificial neural, artificial neural networks, network training and network testing. Chapter 5 contains ANN applications in solving water resources engineering problems of prediction, interpolation, extrapolation, classification, and forecasting.

Part II involves four chapters. Chapters 6, 7, and 8 give details and basics of fuzzy logic, fuzzy membership functions, fuzzy set operations and fuzzy relations, and the components (fuzzification, fuzzy rule base, inferencing, and defuzzification) of fuzzy model. Chapter 9 presents FL applications in solving several water resources engineering problems such as the predictions of total suspended sediment (TSS), sheet sediment, peak discharge, runoff hydrograph, and dispersion.

Part III consists of three chapters. Chapters 10 and 11 give basics of GA and its variants. Chapter 12 presents several applications of GAs in water resources engineering field.

I would like to deeply thank Prof. Dr Zekai Sen of the Department of Civil Engineering, Istanbul Technical University for introducing the soft computing methods to many of us in early 2000 and making his notes available to everybody. His contribution is very much appreciated. I thank

Prof. Alexander Cheng of Civil Engineering Department, University of Mississippi for encouraging me to write the book and Dr Sinem Bezircioglu of Izmir Institute of Technology to improve its reading. Finally, I would like to once again thank Prof. Zekai Sen for thoroughly reading, and editing the book.

Gökmen Tayfur

'Be Saint like water'
Turkish Saying

'In helping and generosity, be like a river'
Mevlana