Alexander Gegov

Fuzzy Networks for Complex Systems

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Prof. Janusz Kacprzyk
Systems Research Institute
Polish Academy of Sciences
ul. Newelska 6
01-447 Warsaw
Poland
E-mail: kacprzyk@ibspan.waw.pl

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Fuzzy Networks for Complex Systems

A Modular Rule Base Approach

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Author

Alexander Gegov
University of Portsmouth
School of Computing
Buckingham Building
Portsmouth PO1 3HE
United Kingdom
E-mail: alexander.gegov@port.ac.uk

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To the architects of United Europe

Preface

There is only one limit to fundamental research – the sky.

This book introduces the novel concept of a fuzzy network. In particular, it describes further developments of some results from its predecessor book on Complexity Management in Fuzzy Systems, published in 2007 in the Springer Series in Studies in Fuzziness and Soft Computing.

The book contents build on a number of special presentations made by the author at international scientific events in the recent years. These presentations include an invited lecture at the EPSRC International Summer School in Complexity Science in 2007, tutorials at the IEEE International Conferences on Fuzzy Systems in 2007 and 2010, tutorials at the IEEE International Conferences on Intelligent Systems in 2008 and 2010, a tutorial at the IFSA World Congress in 2009 as well as plenary lectures at the WSEAS International Conferences on Fuzzy Systems in 2008 and Artificial Intelligence in 2009.

The notion of complexity has recently become a serious challenge to scientific research in a multi-disciplinary context. For example, it is quite common to find complex systems in biology, cosmology, engineering, computing, finance and other areas. However, the understanding of complex systems is often a difficult task.

There are two main aspects of complexity – quantitative and qualitative. The quantitative aspect is usually associated with a large scale of an entity or a large number of elements within this entity. The qualitative aspect is often characterised by uncertainty about data, information or knowledge that relates to an entity.

A natural way of coping with quantitative complexity is to use the concept of a general network. The latter consists of nodes and connections whereby the nodes represent the elements of an entity and the connections reflect the interactions among these elements. In this case, the scale of the entity is reflected by the overall size of the network whereas the number of elements is given by the number of nodes.

An obvious way of dealing with qualitative complexity is to use the concept of a fuzzy network. The latter consists of nodes and connections whereby the nodes are fuzzy systems and the connections reflect the interactions among these fuzzy systems. In this case, the uncertainty about data, information or knowledge related to an entity are reflected by the rule bases of the corresponding fuzzy systems and the underlying fuzzy logic.

In the context of the considerations made above, a fuzzy network represents a natural counterpart of a neural network. Both neural networks and fuzzy networks are computational intelligence based networks with nodes and connections.

However, the nodes in a neural network are represented by neurons whereas the nodes in a fuzzy network are represented by rule bases.

The author would like to thank Mathworks for including this book in their Book Programme and for providing a free individual licence of Matlab and the Fuzzy Logic Toolbox. These software products have been used for validating some of the theoretical results on fuzzy networks.

The author would also like to thank the Springer Series Editor Prof Janusz Kacprzyk for the useful comments on the draft contents of the book. His feedback has been very helpful for the subsequent improvements made to the final version.

The author is very indebted to the Springer Editorial Assistant Heather King for the cooperation on the editorial aspects of the book. Her kind help from the very start of the writing process until the final submission is gratefully acknowledged.

The author is very thankful to Annette Wilson, Head of School of Computing at the University of Portsmouth, for her managerial support with regard to the book. Her cooperation in keeping the teaching and administration duties of the author within reasonable bounds has helped for the timely publication of the book.

The author is also very thankful to the PhD students Nedyalko Petrov and Emil Gegov from the University of Portsmouth and the University of Brunel for validating some of the theoretical results from this book in the Matlab software environment. Without their help the book would have only a theoretical focus.

The author would like to acknowledge the visiting research fellowships granted to him in the past by the Alexander von Humboldt Foundation and the European Commission. The associated research visits to the Universities of Duisburg and Wuppertal in Germany as well as the Delft University of Technology in the Netherlands have laid down the early foundations for some of the ideas presented in the book.

The author would like to thank his wife, parents and sister for their spiritual support during his work on this book. Without their support the writing process would have been more difficult and more time consuming.

Finally, the author would like to thank his friend Diana Koleva for her help during the proofreading process, his colleagues from the University of Portsmouth rock band Discovery for the musical-turned-scientific inspiration over the years as well as his favorite bands and music channels for the entertainment during the typing process.

June 2010, Portsmouth, UK Alexander Gegov

Contents

Abbreviations

AGG – aggregation
AI – accuracy index
APP – application
CFS – chained fuzzy system
DEF – deffuzification
EI – efficiency index
FI – feasibility index
FID – fuzzification inference defuzzification
FN – fuzzy network
FNN – fuzzy neural network
FUZ – fuzzification
HFS – hierarchical fuzzy system
IMP – implication
NFS – networked fuzzy system
SFS – standard fuzzy system
TI – transparency index