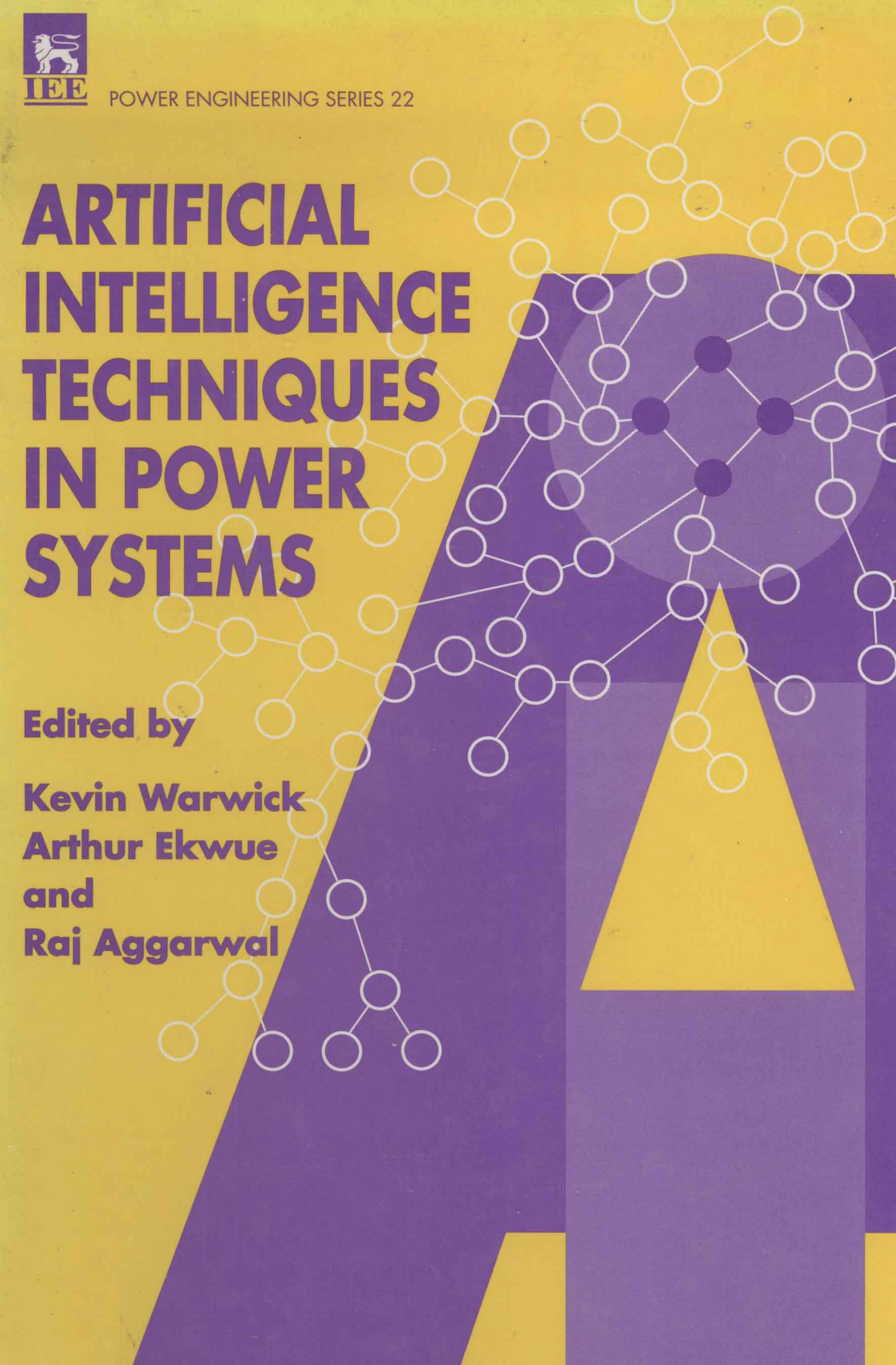
IEE
POWER ENGINEERING SERIES 22
ARTIFICIAL INTELLIGENCE TECHNIQUES IN POWER SYSTEMS
Edited by
Kevin Warwick
Arthur Ekwue
and
Raj Aggarwal

ARTIFICIAL INTELLIGENCE TECHNIQUES IN POWER SYSTEMS

Edited by

Kevin Warwick
Arthur Ekwue and
Raj Aggarwal

The Institution of Electrical Engineers

Published by: The Institution of Electrical Engineers, London,
United Kingdom

British Library Cataloguing in Publication Data

A CIP catalogue record for this book
is available from the British Library

ISBN 0 85296 897 3

Printed in England by Bookcraft, Bath

IEE POWER ENGINEERING SERIES 22

Series Editors: Professor A. T. Johns
J. R. Platts

ARTIFICIAL INTELLIGENCE TECHNIQUES IN POWER SYSTEMS

Other volumes in this series:

Volume 1 **Power circuits breaker theory and design** C. H. Flurscheim (Editor)
Volume 2 **Electric fuses** A. Wright and P. G. Newbery
Volume 3 **Z-transform electromagnetic transient analysis in high-voltage networks** W. Derek Humpage
Volume 4 **Industrial microwave heating** A. C. Metaxas and R. J. Meredith
Volume 5 **Power system economics** T. W. Berrie
Volume 6 **High voltage direct current transmission** J. Arrillaga
Volume 7 **Insulators for high voltages** J. S. T. Looms
Volume 8 **Variable frequency AC motor drive systems** D. Finney
Volume 9 **Electricity distribution network design** E. Lakervi and E. J. Holmes
Volume 10 **SF_6 switchgear** H. M. Ryan and G. R. Jones
Volume 11 **Conduction and induction heating** E. J. Davies
Volume 12 **Overvoltage protection of low-voltage systems** P. Hasse
Volume 13 **Statistical techniques for high-voltage engineering** W. Hauschild and W. Mosch
Volume 14 **Uninterruptible power supplies** J. D. St. Aubyn and J. Platts (Editors)
Volume 15 **Principles of digital protection** A. T. Johns and S. K. Salman
Volume 16 **Electricity economics and planning** T. W. Berrie
Volume 17 **High voltage engineering and testing** H. M. Ryan (Editor)
Volume 18 **Vacuum switchgear** A. Greenwood
Volume 19 **Electrical safety: a guide to the causes and prevention of electrical hazards** J. Maxwell Adams
Volume 20 **Electric fuses, 2nd Edn.** A. Wright and P. G. Newbery
Volume 21 **Electricity distribution network design, 2nd Edn.** E. Lakervi and E. J. Holmes

Preface

In the field of power systems one of the most exciting and potentially profitable recent developments is the increasing use of artificial intelligence techniques in monitoring, control and assessment. As a result of this, it was felt timely for a series of related articles to be put together to form a comprehensive guide which can serve as a reference text in the area. This book certainly serves as such a text, however it also provided the supporting material for a two-day workshop on the subject held at the University of Reading in January 1997.

The intention of the book is to give an introduction to, and an overview of, the field of artificial intelligence techniques in power systems, with a look at various application studies. The book should therefore be useful to a range of readers; including practising power systems engineers, researchers in the field and those studying the use of artificial intelligence.

In chapter 1 the subject of the book is introduced, in particular with methods such as knowledge-based systems, fuzzy logic, neural networks, genetic algorithms all being looked at for the first time. This chapter also contains a useful survey of developments in the area over the period 1990-1996. Chapter 2 takes a closer look at the use of knowledge-based systems through a relation checking algorithm developed at the University of Washington. This chapter describes work carried out for the Puget Sound Power and Light Company and concentrates on maintaining consistency in the rule base.

Chapter 3 introduces work on the use of object oriented software implementation for AI techniques. The use of a good Graphical User Interface (GUI) is stressed and it is explained how, by means of such a software approach, a range of complex applications can simply be 'bolted-on'. In Chapter 4 the use of fuzzy logic and fuzzy expert systems is investigated. Interestingly it is shown how hybrid systems can also be constructed in which fuzzy systems are mixed with either neural networks or genetic algorithms.

In Chapter 5 the particular application area of alarm analysis and fault diagnosis is described and it is shown how both expert systems and genetic algorithms can be successfully implemented. Chapter 6 meanwhile looks at voltage control, again showing how AI techniques can be made use of, particularly in trying to achieve fast and reliable real-time reactive power control. The use of AI for protection systems is then discussed in Chapter 7 and it is indicated that the integration of different AI branches can be extremely beneficial.

Chapter 8 contains an in-depth look at the use of neural networks for static security assessment. Various neural network topologies and methods are considered and it is shown how different end objectives can indicate that one approach is better than another. The need to pre-process data is however stressed. In Chapter 9 condition monitoring is the subject in question. Here issues of maximum financial benefit within constraints, such as technical and regulatory, are paramount. A particular point of interest looked at is the problem of integrating diverse reasoning systems.

Maintenance scheduling of transmission networks, by means of a genetic programming approach is considered in Chapter 10 and it is shown how relatively low cost schedules can be produced for a region within an overall network, also taking into account the need for network robustness. Meanwhile in Chapter 11 the use of a hybrid neural network/expert system approach is discussed in terms of a number of power systems application areas in particular alarm analysis, which was considered initially in Chapter 5. Again, the need to pre-process data is stressed.

The final two chapters both look directly at applications. Chapter 12 looks at the use of intelligent systems for demand forecasting, where, the need is to accurately predict the future load on the network, in the presence of daily and seasonal variations. Then Chapter 13, describes a practical application of the use of a neural network for autoreclose, in response to transmission line faults.

In its entirety the book gives an up-to-date, broad coverage of the possible uses of artificial intelligence in a power systems environment, as well as an indication of recent research progress. The book could easily be used as a comprehensive text giving a fair coverage of different aspects of the field or rather in terms of the individual chapters, each of which deals with a specific topic in depth. The intention is that the book is of use as much to those from a power systems background who wish to find out about how artificial intelligence techniques could be of use, as it is to those from an artificial intelligence background who would like to find out more about the specific power systems application area.

The Editors wish to thank each of the authors for their promptness in completing their chapter and, where relevant, for their help in modifying their work in putting together the finalised text. We would also like to thank Joanne Jones at the IEE for her assistance in putting on the Workshop at Reading University on which this book was originally based. Our gratitude also goes to Robin Mellors-Bourne at the IEE for his help in the production of the book. The major workload in putting the complete publication and overcoming incompatible word processing formats was however undertaken by Michelle Breadmore and Rachel McCrindle at Reading and without their input the book would not have come together — thank you.

Kevin Warwick, Reading University
Arthur Ekwue, National Grid
Raj Aggarwal, Bath University.

January 1997

Contributors

M A Laughton
Dept of Electronic Engineering
Queen Mary and Westfield College
University of London
Mile End Road
London, E1 4NS, UK

C -C Liu
Dept of Electrical Engineering
University of Washington
Seattle, WA 98195, USA

H Marathe
Utility Information Systems
New Jersey, USA

T -K Ma
National Sun Yat-Sen University
Kaohsiung, Taiwan

G Rosenwald
ABB
110 Corning Road
Cary, NC 39207, USA

N B P Phillips, J O Gann, Y H Song and M R Irving
Dept of Electrical Engineering and Electronics
Brunel University
Uxbridge, Middlesex, UB8 3PH, UK

R Dunn, R Aggarwal and A Johns
School of Electronic and Electrical Engineering
University of Bath
Bath, BA2 7AY, UK

K Warwick, L Kiernan and J Hannan
Department of Cybernetics
University of Reading
Whiteknights
PO Box 225,
Reading
RG6 6AY, UK

D Niebur and R Fischl
Department of Electrical and Computer Engineering
Drexel University
Philadelphia
PA 19104, USA

D G Esp, A O Ekwue, J Macqueen and D T Y Cheng
Technology and Science Laboratories
National Grid Company plc
Kelvin Avenue
Leatherhead
KT22 7ST, UK

J R McDonald, G M Burt and A Moyes
Dept of Electronic & Electrical Engineering
University of Strathclyde
50 George Street
Glasgow, G1 1QE, UK

W B Landon and P C Treleaven
Dept of Computer Science
University of London
Gower Street
London, WC1E 6BT, UK

R Khosla and T Dillon
School of Computer Science and Computer Engineering
La Trobe University
Melbourne Vic
Australia 3083

S Majithia
DEAF Group
National Grid Plc
St Catherine's Lodge
Wokingham,
RG41 5BN, UK

I P Gardiner
Reyrolle Protection
PO Box 8
Hebburn
Tyne & Wear,
NE31 1TZ, UK

Contents