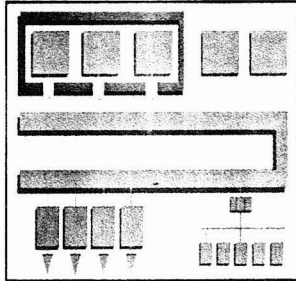Two Special Course Sequences From

THE ELECTRIC POWER PROGRAM SERIES
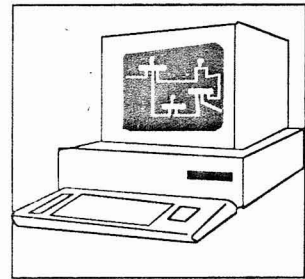
Advances in Design of Modern Power Utility Control Centers
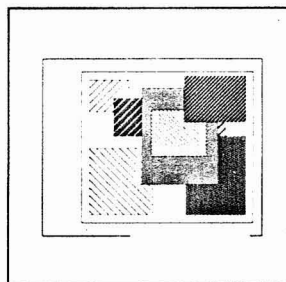September 7 - 9, 1992

Advanced Application Functions for Modern Power Utility Control Centers
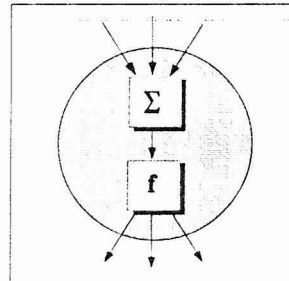September 9 - 11, 1992

MADRID, SPAIN • SEPTEMBER 7 -11, 1992

Expert System Applications to Power Systems
September 7 - 9, 1992

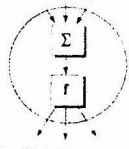## Artificial Neural Networks in Electric Power Systems
September 9 - 11, 1992

Presented By

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DECISION SYSTEMS
INTERNATIONAL
Atlanta, Georgia, USA

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Instituto de Investigacion
Technologica
Madrid, Spain

Artificial Neural Networks in Electric Power Systems

Course 618

September 9 - 11, 1992

SPEAKERS

Mohamed A. El-Sharkawi (Course Director), *University of Washington, USA*
Robert J. Marks II, *University of Washington, USA*

COURSE OBJECTIVES

- To provide an intelligible introduction to the theory, application, and implementation of artificial neural networks.
- To provide a working knowledge of artificial neural networks through software emulation.
- To present and evaluate several proven applications of artificial neural networks to power systems engineering.

WHO SHOULD PARTICIPATE

- Power utilities management and engineers involved in power system planning and operation interested in ANNs and other artificial intelligence techniques in critical applications.
- Consultants and/or software developers involved in applications software for power systems.
- University faculties and advanced students interested in research and/or the development of ANN.

DESCRIPTION

The purpose of this course is to provide an introduction of Artificial Neural Network technology to power systems engineers. The course is composed of two main sections. The first section deals with the analysis of Neural Network architectures, training algorithms and performance evaluation for several types of networks that are suitable for power system applications. The second section deals with specific applications to power system problems described as detection, classification, generalization, regression, and combinatorial optimization.

HANDS-ON

This course will emphasize hands-on experience. The engineers attending this course will have a chance to develop ANN structures and articulate training algorithms. Case studies will be developed and evaluated by the attendee.

COURSE CONTENTS

Introduction to NNs
History of Neural Networks
- The Early Days
- Biological Motivation
  - Hobb, McCullough Pitts
  - Mach and Lateral Inhibition
  - Rosenblatt, Widrow, Minsky Paper
- Since 1982

Neural Network Types
- Layered Perceptron
- Hopfield Networks
- Kohonen Nets
- Other
  - Bidirection Memories
  - Alternating Projection NNs

The Layered Perceptron
- Rosenblatt's Perceptrons
- Concept of Training
- Memorization vs. Learning (Architecture)
- Learning Algorithms
  - Steepest Descent and Least Squares Methods
  - Back Error Propagation
  - Conjugate Gradient Descent
  - Random Search
  - Adaptive Learning
  - Genetic Algorithms
- Problems with the Layered Perceptron
- Software Emulation

Hopfield NNs
- Combinatorial Search
  - Lateral Inhibition
  - The Queens Problem
  - The Traveling Salesman Problem

Features Extractions
- What is Features Extractions?
- Advantages of Features Extractions
- Mean-Distance Feature Extractions
- Karhonen Loe'v Extraction
- Comparative Study with and without Features Extractions

Neural Network Implementation
- Emulators
- Analog Electronic
- Digital
- Optronic

Applications to Selected Power System Problems
- Classification
  - Dynamic Security Assessment
  - Static Security Assessment
  - Harmonic Prediction and Evaluation
  - Alarm Processing
- Regression
  - Electric Load Forecasting
  - Transient Stability
  - Adaptive Control
- Combinatorial Optimization
  - Capacitor Placement
  - Power Network Observability
  - Unit Commitment
- Challenges of Power System Implementations
  - Scale Problem
  - Learning vs. Memorization
  - Convergency

Case Studies
- Development of NN for Load Forecasting
- Development of NN for Security Assessment

Tomas E. Dy Liacco

Dr. Dy Liacco, is a foremost international consultant in power system control centers and has been involved in design specifications and evaluations of over 30 SCADA / EMS projects in many countries around the world. Starting in the mid-sixties he pioneered the development of concepts for system security, and in modern control center design. He has over 30 years expertise first as a utility engineer and manager, and later as a consultant to the industry. He is a life fellow of IEEE, and is active as a member of the IFAC Working group on Electric Power Systems.
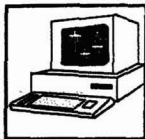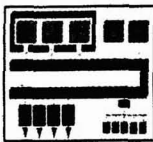
Atif S. Debs

Dr. Debs has been Professor of Electrical Engineering, since 1972, at the Georgia Institute of Technology (Georgia Tech), Atlanta, Georgia, USA. He played a key role in the establishment and development of Georgia Tech's renowned graduate and undergraduate electric power program. His career started in 1969 with the consulting industry where he specialized in control theory applications to power systems — developing an early state estimator for the first control center of a leading U.S. utility. He is currently involved in a variety of projects covering topics such as state estimation, OPF, and dynamic security assessment. Dr. Debs is the author of a 1988 book on control center applications entitled, **Modern Power Systems Control and Operation.** He will soon complete a second book on modern system planning.

Mohamed E. El-Hawary

Dr. El-Hawary is currently a Professor in the Department of Electrical Engineering at the Technical University of Nova Scotia. He has over 25 years of research and consulting experience in the area of Power System Optimization. He has written scores of articles and five books including, **Optimal Economic Operation of Electric Power Systems,** and **Electric Power System Design and Analysis.**
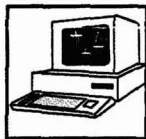
Mania Pavella

Professor Mania Pavella, University of Liege, Belgium, is heavily involved in control center applications, particularly in the visionary area of Non-conventional, Fast Stability Methods to power systems for on-line dynamic security assessment. These include Direct Stability and Artificial Intelligence methods which are currently under investigation for their implementation in real power systems. Her research efforts have extended heavily to other security-related functions — state estimation, bad data identification, voltage security and many others. Dr. Pavella is active in CIGRE, in particular within the task force dealing with the assessment of practical fast transient stability methods. Mania Pavella is co-author of the book entitled Large Scale System Stability (Springer).

Renato Lugtu

Dr. Lugtu is currently the Director of Applications Engineering at Empros Systems International, a major world-wide supplier of Energy Management Systems. Dr. Lugtu has also been Director of Research & Development and Manager of Advanced Systems at Empros. Prior to joining Empros, Dr. Lugtu was a Principal Engineer and EMS Product Manager at Harris Controls. Dr. Lugtu's areas of interest include Power System Applications, System Architecture, User Interfaces, and Real-time Control Systems.

Howard N. Wendland

Mr. Wendland is currently the Director of New Product Delivery and Customer Satisfaction/Services of Empros Systems International. Empros Systems International is a major supplier of SCADA, EMS and DMS software for electric utilities worldwide. Mr. Wendland was, most recently, Director of European Operations for Empros. Mr. Wendland's areas of interest are the Real-time Operating System, SCADA Software, Man-Machine Interface, and Inter-Utility Communications. He is a member of the IEEE Power Engineering Society, CIGRE, and of two working groups of the IEC Technical Committee 57 specializing in RTU and Inter-utility Communications.
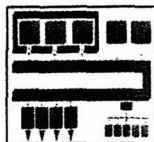
Artificial Neural Networks

Mohamed A. El-Sharkawi

Dr. El-Sharkawi is a pioneer in the area of applications of Artificial Neural Networks to Power Systems. Since 1980, he has been a Professor in the Department of Electrical Engineering at the University of Washington. Dr. El-Sharkawi is the Chairman of the IEEE Power Engineering Society task force on "Applications of Neural Networks to Power Systems." He organized and chaired several special sessions and panel discussions on the subject in various IEEE conferences. He was the organizer and general chairman of the first conference on "Applications of NN to Power Systems," held in Seattle in July 1991. Dr. El-Sharkawi is an Associate Editor of the IEEE Transactions on Neural Networks. He is a member of the Administrative Committee of the IEEE Council on Neural Networks. He is the chairman of the Video Tutorial committee of the IEEE Neural Networks Council. Professor El-Sharkawi has published numerous papers in the areas of neural networks applications to power systems, power system dynamics, power electronics and electric drives and high performance tracking and control.

Robert J. Marks II

Dr. Marks is a foremost international authority on Artificial Neural Networks. He is currently a Professor in the Department of Electrical Engineering at the University of Washington, Seattle. He was the Chair of IEEE Neural Networks Committee and was the co-founder and first Chair of the IEEE Circuits & Systems Society Technical Committee on Neural Systems & Applications. Professor Marks was also elected the first President of the IEEE Council on Neural Networks. He is a Fellow of the Optical Society of America and a Senior Member of IEEE. He is co-founder and current President of Multidimensional Systems Corporation. Professor Marks is the Editor-in-Chief of the IEEE Transactions on Neural Networks. He is a former topical editor for Optical Signal Processing and Image Science for the Journal of the Optical Society on America-A. He is also a former member of the Editorial Board for The International Journal of Neurocomputing. He has published over one hundred journal and proceeding papers in the areas of signal analysis, detection theory, signal recovery, optical computing, signal processing, and artificial neural processing. Dr. Marks has two U.S. patents in the field of artificial neural networks.

Expert Systems

Ignacio J. Pérez-Arriaga

Dr. Pérez-Arriaga is Professor of Electrical Engineering and Director of the Instituto de Investigacion Tecnologica (IIT) in the Universidad Pontificia Comillas, Spain. His areas of interest include reliability, control, optimization and applications of knowledge engineering in electric power systems. He is the author or co-author of more than 30 international publications. During the past six years, he has been principal investigator in several research projects concerning expert systems for the diagnosis of incipient faults, and on-line security support of power plants and systems.

Luis M. F. Barruncho

Mr. Barruncho, with the Instituto Superior Técnico (Technical University of Lisbon), received his MSc from IST (1986) and will conclude (Summer 1992) his Ph.D. in Electrical Engineering and Computer Science. Since 1982, he has been involved in joint projects with university/industry/research agencies, namely: "Digital Automation of Distribution Substations" as a researcher (1982/86) and "Optimization Techniques and Expert Systems in Electric Power Systems: Reactive Management, Voltage Monitoring and Control" as main researcher and technical manager (1987/91). He is now leader of the project "Advanced Architectures in EMS/DMS" for distributed problem-solving environments in transmission and distribution control centers.

Monika Pfau-Wagenbauer

Ms. Pfau-Wagenbauer received the M.S. degree in Computer Science in 1988 from the Technical University of Vienna. Since 1987, she has been working with Siemens Austria and is responsible, as a team leader, for the development and implementation of a real-time diagnostic expert system for power network applications. Mrs. Pfau-Wagenbauer is a member of the CIGRE Working Group 38-06.

Harald Schwarzjirg

Mr. Schwarzjirg received the M.S. degree in Physics in 1974 from the Technical University of Vienna. Since 1975, he has been working with Siemens Austria and is responsible for the development of expert systems for power networks. Mr. Schwarzjirg has been responsible for the implementation of various international SCADA/EMS projects.

Juan J. Alba

Mr. Alba, from the IIT research staff, has been working in knowledge engineering applications in industry for seven years. He is currently responsible for the knowledge engineering group at IIT. He has been the leader or a participant in projects including applications of knowledge engineering in switching sequences planning in power systems, power systems security analysis, nuclear power plants operation, electronic circuits troubleshooting, space systems design, office buildings risk management, etc. His areas of interest and activity also include machine learning, neural networks, qualitative reasoning and computer communications and networking.

Arnaud Hertz

Dr. Hertz (Member, IEEE) received a civil engineer degree from the Ecole Nationale des Ponts et Chaussées (computer science option), and a Ph.D. degree in Artificial Intelligence from the University of Paris VI, in 1975. He joined the R&D division of ELECTRICITE DE FRANCE as a research engineer in 1976. He has developed operational-research software for the planning of electrical networks. Since 1987, he has directed a team of twelve engineers and researchers dealing with the application of Artificial Intelligence techniques and new algorithmic methods to power systems. His team is also involved in "software engineering for power systems. He has published various papers on the above subjects. Dr. Hertz is a member of the AFCET scientific association and a member of the CIGRE Group 38-08.

Miguel-Angel Sanz-Bobi

Mr. Sanz-Bobi, from the IIT research staff, has been working in knowledge engineering applications in power plants for six years. He was the project leader in the development of SEQA (Water Chemistry Expert System) among the first expert systems to be fully operational in a power plant, in 1989. He is also involved in the development of expert systems for incipient failure detection of power transformers, machine tools and other subsystems in power plants, for operation of nuclear power plants, etc. His areas of past and current activity also include artificial neural networks applications, reliability of power plants, databases and fiber optics.