

Workshop on the Application of Artificial Intelligence to Environmental and Geospatial Sciences

Friday-Saturday January 12-13, 2007, Conrad Blucher Institute, Corpus Christi, Texas

Organized by the American Meteorological Society's Committee on Artificial Intelligence Applications to Environmental Science, the Conrad Blucher Institute and the Local Offices of the National Weather Service

Abstracts of the Main Workshop Presentations

Friday January 12, 9:00-10:00 AM

V. Lakshmanan, National Severe Storms Laboratory, NOAA Norman, OK

Introduction to AI Techniques and their Application to Environmental Science

This introductory talk will discuss the evolution of AI research and briefly compare and contrast the common AI techniques that individual speakers will talk about in more detail during the following presentations. This introductory will also describe the underlying assumptions behind each of the techniques and the considerations that can therefore be used to choose amongst different AI techniques.

Friday January 12, 10:30-12:15 AM

Sue Ellen Haupt, Computational Mechanics Division, Applied Research Laboratory, The Pennsylvania State University

Applications of Genetic Algorithms in the Environmental Sciences

A genetic algorithm (GA) is an optimization technique inspired by the biological processes of genetics and evolution. This talk introduces the elements of GAs in the context of environmental problems and demonstrates their application. The GA operators of mating and mutation work to both explore and exploit the most likely regions of the parameter space by combining parts of the best solutions as well as extending the search through mutations, thus making GAs more robust than traditional optimization methods. The trade-offs involved in selecting population size, mutation rate, and mate selection algorithm are discussed. Examples are given of both binary and real valued GA problem solutions using low dimensional environmental examples, demonstrating convergence. We discuss strengths, weaknesses, and tricks for using GAs. Various examples demonstrate the types of applications that can be found in the environmental sciences.

Friday January 12, 2:15-4:00 PM

S. Lakshmivaran, School of Computer Science, University of Oklahoma, Norman, Oklahoma,

Data Mining: An Overview

In this talk we will provide a broad overview of our recent work in this area covering the following topics:

- 1) Two forms in which data set often occurs – time series and data matrix form.
- 2) The type of operations one can perform depend critically on the scales – nominal, ordinal, interval and ratio type, of the variables.
- 3) There is often a need for data transformation and data reduction.
- 4) We then provide an overview of the basic multi-variate methodology of clustering.
- 5) Optimal clustering is computationally infeasible
- 6) We then provide an overview some of the basic methods in this area.
- 7) We will then close with examples of applications of this class of methods to
- 8) multi-model ensemble analysis and classification of rainfall systems.
- 9) Time permitting; provide an overview of the volatility modeling in time series.

Saturday January 13, 8:30 - 10:00 AM

Antonello Pasini, CNR – Institute of Atmospheric Pollution, Rome, Italy

Neural network modeling in climate change studies

Climate is a complex system. In this framework, AI methods are able to help researchers in capturing and understanding its behavior. In this talk, starting from the basis of neural network (NN) modeling, different strategies for the application of this kind of modeling to climate change studies are explored and some case studies are analyzed. First of all, due to some drawbacks of global climate models (GCMs) and their dynamical reconstructions of the climate system by coupled systems of equations and parameterizations, an alternative strategy is explored in the problem of attribution of past climate change. In particular, the fundamental forcings to the climate system are considered and their influence on the global temperature during the last 150 years is analyzed by NNs. Then, the Lorenz system is considered as a toy model for investigating changes of predictability in past and future climate scenarios and it is shown that a NN model is able to correctly forecast these changes. Finally, NN modeling is analyzed as a complementary strategy to GCMs, in the framework of a well-founded activity of NN downscaling of GCMs for obtaining reliable reconstructions in the past and accurate climate scenarios for future times at a regional scale.

Saturday January 13, 10:30-12:00 PM

John Williams, National Center for Atmospheric Research, Boulder, CO

Fuzzy Logic

Fuzzy logic provides a framework for creating expert systems that encode human knowledge and are relative straightforward to design and implement. A central concept is that of fuzzy sets, which may be used to represent unsharp concepts like those commonly used in human communication and reasoning. A mathematical definition of fuzzy sets, accompanied by rules for manipulating them in analogy to classical sets, is presented. A discussion of how fuzzy membership functions may be formed and combined via logical operations is followed by descriptions of fuzzy numbers, Mamdani and Takagi-Sugeno fuzzy inference, consensus methods, adaptive fuzzy systems, and fuzzy clustering. Although the development of fuzzy logic systems does not require data, training data can be used for algorithm tuning if they are available. Fuzzy logic provides a natural way to incorporate data quality control into decision support algorithms and to integrate ambiguous information efficiently. The power of fuzzy logic is illustrated using several applications developed at the National Center for Atmospheric Research for assessing data quality, diagnosing weather-related hazards, and forecasting various weather phenomena.

Saturday January 13, 1:15-3:00 PM

V. Lakshmanan, National Severe Storms Laboratory, NOAA Norman, OK

Machine Learning Techniques on Spatial Grids

Environmental data are often spatial in nature. In this talk, we will examine image processing techniques which play a key role in artificial applications operating on spatial data. These AI applications often seek to extract information from the spatial data and use that information to aid decision makers. Topics covered include: gridding of point observations, convolution filters, matched filters, filter banks, objective analysis, texture, morphology, segmentation, hysteresis, segmentation, processing image sequences, tracking and estimating movement.