Available online at www.sciencedirect.com
SCIENCE DIRECT®
Atmospheric Environment 40 (2006) 532–541
ATMOSPHERIC ENVIRONMENT
www.elsevier.com/locate/atmosenv

A competitive neural network approach for meteorological situation clustering

Ignacio J. Turias[a,*], Francisco J. González[b], M[a] Luz Martín[c], Pedro L. Galindo[a]

[a]*Computational Intelligent Systems Research Group—TIC 145, Computer Science Department, Polytechnic Engineering School of Algeciras, University of Cádiz, Avenida Ramón Puyol s/n, 11202 Algeciras, Spain*

[b]*Applied Physics Department, Research Group—TEP 221, Polytechnic Engineering School of Algeciras. University of Cádiz, Avenida Ramón Puyol s/n, 11202 Algeciras, Spain*

[c]*Chemical Engineering and Environmental Technologies Department, Polytechnic Engineering School of Algeciras. University of Cádiz, Avenida Ramón Puyol s/n, 11202 Algeciras, Spain*

Received 20 June 2005; received in revised form 16 September 2005; accepted 28 September 2005

Abstract

A complete competitive scheme is proposed in this work in order to perform a classification analysis of meteorological data in the 'Campo de Gibraltar' region (in the South of Spain) from 1999 to 2002. The main objectives of the study presented here have been the characterization of the meteorological conditions in the area, using a competitive neural network based on Kohonen learning rule. Standard Principal Component Analysis (PCA) and VARIMAX rotation have allowed interpreting the physical meaning of the classes obtained from the competitive scheme. Quantitative (using three quality indices) and qualitative (from the analysis of the data projection) criteria based on Fisher Discriminant Analysis were introduced to verify the results of the clustering. A randomized procedure is developed to assure the best performance of the models and to select the best model in the experiments. The different experiments developed extracted five classes, which were related to typical meteorological conditions in the area.
© 2005 Elsevier Ltd. All rights reserved.

Keywords: Artificial intelligence; Cluster analysis; Automated meteorological classification; Artificial neural network; Multivariate techniques

1. Introduction

It is extremely important to consider the effect of meteorological conditions on atmospheric pollution, since they clearly influence dispersion capability of the atmosphere. Severe pollution episodes in the urban environment are not usually attributed to sudden increases in the emission of pollutants, but to certain meteorological conditions which diminish the ability of the atmosphere to disperse pollutants (Ziomas et al., 1995; Cheng and Lam, 2000). The study of meteorological conditions could be done by analyzing meteorological variables individually. However, this analysis suffers from at least one shortcoming because air pollution is known to respond to the complete meteorological data which comprises an air mass, rather than to certain selected meteorological variables (Kalkstein, 1991).

*Corresponding author. Fax: +34 956 028014.
E-mail address: ignacio.turias@uca.es (I.J. Turias).

1352-2310/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.atmosenv.2005.09.065

In the last years the use of cluster analysis to better elucidate the dependency of air quality on meteorology has proliferated. It has been used successfully in numerous studies which relate air quality and meteorological situations. Thus, Eder et al. (1994) and Zelenka (1997) used clustering results to develop "unique" or "separate" regression models for ozone and acid aerosols, respectively. In the work of Ludwig et al. (1995) cluster analysis is used to categorize meteorological data and determine the combination of conditions associated to daily ozone maxima.

Davis et al. (1998) used similar techniques to those used by Eder et al. (1994), where principal component analysis (PCA) and *k*-means clustering procedure were used with the objective of determining synoptic meteorological scenarios. Similar approaches have been used in Berman et al. (1995), Lam and Cheng (1998), and Triantafyllou (2001). More recently, Kim Oanh et al. (2005) have also developed an automated scheme to classify the synoptic meteorological conditions governing over Northern Thailand. Because a quantitative approach utilizes a variety of meteorological variables for the classification of synoptic patterns, it involves intensive statistical data treatment, normally accomplished in the literature by a combination of the PCA and clustering techniques.

In Avila and Alarcón (1999) a clustering analysis of meteorological variables was applied as a classification tool, while PCA was performed to help interpret the groupings. The meteorological classification was compared to an independent grouping based on PCA.

Up to date, no meteorological classification approach has been applied to the assessment of the relationships between climate and air pollution in the 'Campo de Gibraltar' region (in the south of Spain). The main objectives of this work were firstly to analyse the capability of a competitive network (Kohonen, 1987) with unsupervised learning to find different classes from the meteorological data available, and secondly, a quantitative analysis (through four quality indices (QI) based on Fisher Discrimination Analysis) and a qualitative analysis (with the aid of the visualization capabilities of the Fisher projection) of the data clustered. PCA (Jollife, 1986) with a VARIMAX rotation (Kaiser, 1958) has been applied to make class interpretation easier, while Fisher transformation (Fisher, 1976) has been used to verify and control the quality of the procedure. These networks require no priori assumptions about the model in terms of mathematical relationships or data distribution. Our interest is to classify meteorological situations for the later purpose of determining whether the meteorological situations can be used for air pollution forecasting and for developing future control or warning strategies. In general, the modelling of "separate" models (one for each cluster) will give better performance results, rather than the modelling of a unique model for the whole data (Zelenka, 1997). This approach will allow formulating better effective mitigation strategies and better predictions to help or warn elderly and sick people.

The paper is organized in several sections. Section 2 presents the study area and the data collected. In Section 3 the basic concepts of clustering and Kohonen competitive learning approach are briefly described as well as how PCA and Fisher analyses are used to identify, visualize and compare the clustering results. Section 4 reports the results obtained. Finally, the conclusions and future researches are shown in Section 5.

2. The study area and the data

The 'Campo de Gibraltar' is the southern-most region of the Iberian Peninsula. It is 584 km^2, and is surrounded by western mountains (a Natural Park called 'Los Alcornocales') that rise up to 700 m, and the Rock of Gibraltar in the South–East, with a maximum altitude of 420 m. Its climate is Mediterranean and winds are predominantly easterly and westerly. About 300,000 inhabitants live in the different towns spread in the region (Algeciras, 120,000; La Linea, 65,000). It is a very complex scenario, where many stationary sources are present (Fig. 1): an oil-refinery and some petrochemical factories close to it, a coal-fired and several fuel-oil power plants, a large steel factory and a paper factory.

The port of Algeciras, one of the most important ship-trading ports in Europe, and the airport of Gibraltar are other possible sources of particulate and gaseous air pollution in the area. Due to the economic development of the region, many construction activities, which are important particle emission sources, have been carried out lately. In addition, the region is one of the paths that African air masses from Sahara and Sahel deserts take, increasing significantly particulate air concentration in different areas of Spain and Europe (Rodriguez

Download English Version:

https://daneshyari.com/en/article/4443699

Download Persian Version:

https://daneshyari.com/article/4443699

Daneshyari.com