Chapter 11
Environmental Monitoring, Data Mining, and Dynamic Analysis

Anneke Minke
University of Hildesheim, Germany

Helmut Lessing
University of Hildesheim, Germany

ABSTRACT

Online-monitoring systems as well as systems regarding environmental observation have evolved from classic analytic methods on the laboratory scale. Still, they are structured mainly medially and sectorally. At this point, the multi-sensorial array-technology opens up new possibilities. Today, the integration of these multi-sensorial chips into mobile units of the automotive domain or into cell phones and the transmission of empirical data to an integrated network are possible; there are no fundamental technological barriers. Nevertheless, the examination of this data collected by mobile sensors which are often in motion and the extraction of reliable, supra-regional information yield a new class of problems. In this chapter, an implementation concept will be described which will be evaluated within a pilot scheme.

INTRODUCTION

The dynamic observation of environmental changes – based on regions and countries – is a task that federal states as well as the federal German government and the other EU-members have to comply with, forced by EU-directives and their according laws at federal and state level. These legal requirements aim for an exact capture of changes in biotic and abiotic as well as in anthropogenic, urban, and technical systems – in general and in detail, too.

To achieve this goal, complex monitoring systems have been implemented in Europe over the past twenty years which continually monitor climate, oceans, lakes, rivers, ecosystems, soil and land use, and sealing and emissions in urban metropolises. By means of satellite and remote sensing, it is already possible to gather this kind of data cross-nationally and on a large scale (Landsat 30m*30m) (cf. Satpix, 2009). Using graphical data processing, the raw data is processed to a

DOI: 10.4018/978-1-61520-981-1.ch011

graphical representation which is intuitively comprehensible. This way, it is possible to precociously detect changes regarding the ozone shield or the glaciation of the polar caps which are relevant to the climate. Among the multitude of satellite systems available today, the ENVISAT carrier current system of transmission of the European Space Agency (ESA, 2009) has turned out to be particularly efficient.

Recently, in addition to remote sensing procedures, online-sensor systems have been able to prevail; they record different parameters at a certain position to a predefined point in time using specific sensors, and they transfer this data to a central unit. Particularly, the parameters in question are concerned with emissions in the lower atmospheric levels, such as the intensity of radiation, ozone formation, temperature, and precipitation. Thus, online-systems have been implemented in Germany which monitor all medial domains such as air quality, water, soil, or nuclear technological facilities; the German Federal Environmental Agency collects data of the different federal states and periodically reports the results (cf. Umweltbundesamt, 2008). Furthermore, the German Weather Service ("Deutscher Wetterdienst", DWD) possesses a comparatively close-meshed sensoring network of fixed measurement stations. Mathematical exploration and modelling methods enable the derivation of a laminar observation. Under these circumstances, accurate real-time information concerning local environmental parameters (temperature, ozone, radiation, humidity, and pollen count) only exists when a measurement station is available nearby. But investments for constructing and operating these monitoring systems are significant. Therefore, a sufficient "mesh network" of measurement stations is often lacking, with only a few stations being positioned at particularly representative or problematical locations.

This chapter focuses on the current state of environmental monitoring and innovative ideas in the area of monitoring systems as well as new, mainly theoretical aspects of sensor systems and how such a monitoring system can be implemented for collecting the data. In order to analyze the recorded data, different data mining techniques are essential. Hence, an overview of established data mining methods as well as research outcomes in the field of data mining and, in particular, fuzzy clustering will be given.

This chapter is organized as follows: In the next section, an overview of related work concerning the field of environmental monitoring will be given, followed by an overview of the sensor technology and the description of the general layout of the monitoring scenario. The mathematical considerations and algorithms used for analyzing the collected data will be introduced in the following section. The chapter concludes by giving an outlook to further research tasks.

BACKGROUND

Classic monitoring and environmental observation systems are structured sectorally and medially. This way, the "Luftmessnetz Niedersachsen" (LÜN; Niedersächsisches Ministerium für Umwelt und Klimaschutz, 2009) continuously measures different parameters concerning air quality such as carbon monoxide, particulate matter, ozone, nitrogen oxides, and sulfur dioxide as well as meteorological data like precipitation, wind direction and speed, air pressure, global radiation, temperature, and humidity at 29 selected positions employing technologically standardized containers. This data is immediately analyzed and aggregated to form an air quality-index. The index is shared with controlling institutions as well as the public over the internet. Furthermore, current measurements, temporal violations of limits concerning particulate matter, and measurement value progresses are provided.

On the one hand, these containers are positioned at places with critically high emission like, e.g., the intra-urban area of Hanover. On the other