Chapter 13
Bayesian Ontologies in Spatial Integrating Medical Information Systems

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ABSTRACT

Geographical Information Systems (GIS) play a major role in all areas of health research, especially for the understanding of spatial variations concerning disease monitoring. The information produced by the spatial analysis can be modelled and displayed using maps. Spatial analysis (as an alternative statistical technique) may be used in order to suggest health patterns for describing the spreading of various diseases. Areas where GIS can be of benefit include the point mapping of patients and aggregated analyses within different geographical areas. The incorporation of GIS sections in Healthcare Information Systems aims towards the efficient and automated follow-up of prevalence of various diseases in diverse geographic regions. A very important feature of the current system is the integration of queries for the extraction of specific information regarding the above parameters. The queries have been developed through the ontologies of the system. Each ontology refers to each of the correlations that are being explored. The appropriate ontology design techniques have been used to assure the validity of the query output. This work describes the methodological approach for the development of a real time electronic health record, for the statistical analysis of geographic information and graphical representation for disease monitoring. Uncertainty of the ontology system may be achieved by proposing Bayesian type statistical techniques like Bayesian network and Markov logic. Implementation of the proposed techniques will be illustrated considering real accident data.

INTRODUCTION

Geography plays an important role with regard to the understanding of various causes in health dynamics. The trinity of public health that is constituted by the individual, means and the environment underlines the importance of geography (environment where we live) as far as health and illnesses are concerned. The main application in the territorial database systems is GIS. Geographic Information systems (GIS) are constituted by hardware, software data and people, aiming to

DOI: 10.4018/978-1-61350-120-7.ch013

collect, store, analyze and handle information that refer to particular geographic regions (Harris, 1989); Harris and Batty, 1993).

GIS technology and its applications is a powerful tool for community health for many reasons. Among these, the possibility of incorporating data from different sources, in order to gain new information, is included. This is made possible by making use of the possibilities given by presenting these elements (mapping), which can lead to the efficient analysis of health problems and support decision-making, for the improvement of healthcare provision. GIS provides the possibility of finding regions with an increased frequency of diseases and inverse health conditions and it examines the territorial relation between the prevalence of diseases and information that is shown through the territorial GIS systems. Geographic Information Systems (GIS) can be used for territorial analysis, quantified representation and the analysis of territorial elements (Klosterman, 1997). By selecting the appropriate populations needed for the analysis, it uses the attributes of these individuals in order to acquire the population size, the composition and the characteristics as well as their geographic spread patterns (Klosterman, 1993). The data allow the classifications in table according to the data attributes and the demographic analysis that uses statistical techniques (Chou, 1997; DeMers, 2000). There have been developed many clinical GIS systems worldwide. (Odero et. al., 2007) describes an electronic system of monitoring accidents. Also, the study of (Williams et. al., 2003) should be mentioned, in which Geographic Information Systems were used in order to analyze and describe the geographic distribution of incidents of burns in children aged between 0-14 years. The follow-up of accident rates, as well as of mapping and territorial statistical analysis allows primarily for the monitoring of accidents and for the identification of small geographic regions with high frequency of accidents. Finally, Brownstein et al (2005) examined issues of personal data protection and secrecy of information for GIS systems (Wu et. al., 2006).

In our country, the adoption of Electronic Health Record is yet to be incorporated in the healthcare system, and the same is valid for monitoring and data analysis tools. The development and utilization of effective and real time efficient electronic health records combined with spatial databases can be used for the improvement of the health status and the follow-up of related health parameters. The incorporation of GIS sections in Healthcare Information Systems aims towards the efficient and automated follow-up of prevalence of various diseases in diverse geographic regions (Zimeras et. al., 2009a; 2009b).

A very important feature of the current system is the integration of queries for the extraction of specific information regarding the above parameters. The "correlation" queries are the basis for the creation of a spatial statistical analysis of selected parameters so that the user of the system can draw conclusions regarding the correlation between the selected factors that want to be analysed. The queries have been developed through the ontologies of the system. Each ontology refers to each of the correlations that are being explored. The appropriate ontology design techniques have been used to assure the validity of the query output. Ontology is an explicit, formal representation of the entities and relationships that can exist in a domain of application. Ontologies are formal representations of knowledge about a given domain, typically expressed in a manner that can be processed by machines. Specifically, an ontology explicitly represents the types of entities that can exist in the domain, the properties these entities can have, the relationships they can have to one another, the roles they can play with respect to one another, how they are decomposed into parts, and the events and processes in which entities can participate.

A major shortcoming of ontologies is their uncertainty to represent incomplete data. Under this condition, implementation of probability ontologies is in big demand. Some tasks like learning and mapping ontologies already automatically produce uncertain ontologies. In most of the cases,