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Geographic and Management Information Systems Join Forces: Delivering More than the Sum of their Parts

Thomas Ganslandt[a], Stelios Gikas[a], Ronald Grolik[a], Katharina Diesch[a], Hans-Ulrich Prokosch[a]

[a] *Department of Medical Informatics, Friedrich-Alexander University Erlangen, Germany*

Abstract

Management and Geographic Information Systems have coexisted in the medical field with clearly defined boundaries. Recently, geovisualization toolkits like GoogleMaps™ have introduced freely-available high-resolution imagery and standardized APIs, lowering the barrier for a seamless integration of MIS data and GIS functionality. In this project, an existing MIS was extended by geovisualization functionality based on GoogleMaps. Sustainable usage scenarios were identified, including visualizations of patient origins, distributions of bacteria and drug-resistance patterns. It could be shown that geovisualization is suitable for location-based MIS queries.

Keywords:

Geographic Information Systems,
Management Information Systems, Data Warehouse,
visualization

Introduction

Management Information Systems (MIS) have been applied in the medical field since the early 1980s, providing consolidated data and analyses with an emphasis on administrative information needs, e.g. service performance and utilization or cost structures. Geographic Information Systems (GIS) have been increasingly mentioned in medical literature since 2000, with applications focusing primarily on the support of epidemiological studies at a regional or national level[1-4]. Early GIS development was hampered by a lack of freely available high-resolution map imagery as well as the necessity to implement proprietary application programming interfaces (APIs). With the advent of Google Earth™ and Google Maps™ in 2005, a simple-to-use API was made available together with high-quality digital satellite and map imagery under a license that permitted free non-commercial use. The simplicity of the API led to a rapid worldwide uptake, including the medical field[5;6]. As a virtue of this commoditization, GIS methods can now be leveraged to add a new dimension to MIS data analysis: visualizing service cost and utilization data geographically can further support management decisions on a regional or local level. Clinical users may also benefit by integrating workflow or infection surveillance data with a geographical representation. Erlangen University Hospital, Germany, has built an extensive MIS based on a data warehouse platform, integrating information from various administrative and clinical sources[7]. As the hospital is also distributed among several locations within the area, it would profit especially from a comprehensive geographic visualization of its MIS data. The goal of this project is to integrate the existing Erlangen MIS with GIS functionality and evaluate sustainable usage scenarios.

Materials and methods

The Erlangen MIS is based on the Cognos BI™ platform and imports data from all connected source systems on a nightly schedule. The reporting platform provides both standard relational and OLAP paradigms as well as the locally developed workflow visualization system *Pathifier*[8]. The geovisualization functionality was implemented as an extension of the *Pathifier* application. Geocoding of transactional data (e.g. patient addresses) occurred at run-time by means of freely available geocoding databases (OpenGeoDB, GNIS, GEONAMES), whereas coordinates for hospital locations were geocoded manually and permanently stored as additional attributes to the organizational dimension of the data warehouse. The geovisualization implementation was based on the GoogleMaps API, using a standard AJAX (Asynchronous Javascript and XML) pattern. Data warehouse-based measures (e.g. amount of cases selected, distribution of diagnostic tests ordered or antibiotic resistance) were dynamically rendered and overlaid on the maps. Detailed information on a specific icon was provided through pop-up windows. Icons were clustered dynamically depending on the chosen map zoom level.

Results

The GIS extension has been operational since mid 2006. Integration with the *Pathifier* application is seamless and delivers an intuitive graphical representation of fact data from the MIS. By clustering image elements on lower zoom levels, visual clutter is avoided. Geocoding worked reliably for full German address records including ZIP-codes. For records without ZIP-codes or international records it was necessary to rely on the less detailed GNIS and GEONAMES datasets which are susceptible to mis-

spellings as well as homonymous or synonymous location names.

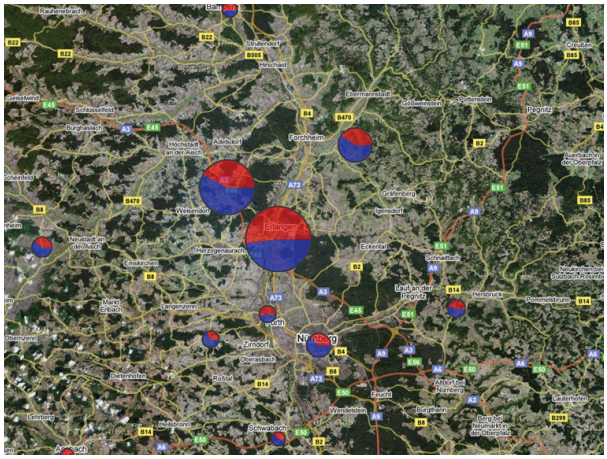

Figure 1 - Origin of Diabetes patients (2006) differentiated by sex (red=female, blue=male) on a regional level

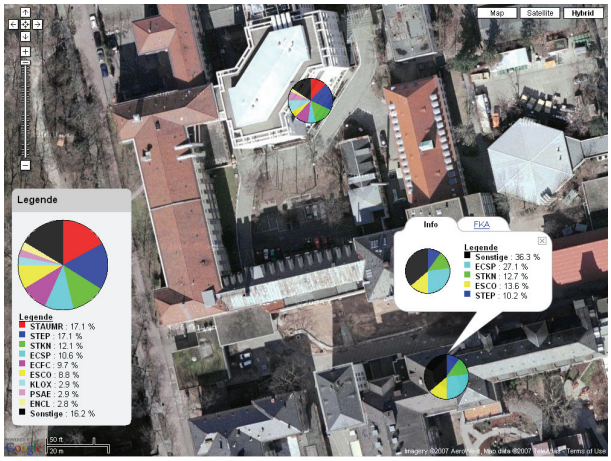

Figure 2 - Top 10 resistant bacteria strains at a standard care versus an intensive care unit

Discussion

In this project, we were able to achieve seamless integration of geovisualization functionality into an existing MIS by using freely available, standardized tools. Only limited effort was necessary to manually geocode hospital organizational units. Geocoding of address data was fully automated, but manual interventions might be necessary to disambiguate international or incomplete records with multiple or no matches in the respective geo-databases. Making use of the established GoogleMaps API and user interface provided users with a well-known navigational concept, making special training for the system unnecessary.

Preliminary feedback from users indicates that the new GIS functions are providing answers to common questions like "Which areas do my patients come from?", "At which wards are MRSA-infected cases?" or "What are the drug-resistance patterns throughout the hospital?". Data and corresponding tabular reports for all of these questions were available in the MIS previously, but the new visualization mode provides a faster overview and more intuitive. In comparison to epidemiological visualization projects published previously, using MIS data opens up a new field of view towards local developments occurring within organizational units, as well as providing detailed data updated on a daily basis. Data confidentiality is a concern, as an external service provider (Google) is taking part in the geovisualization process. However, geocoding takes place locally, and only aggregated iconic data is displayed within the map.

Conclusions and outlook

The synthesis of MIS data and GIS functionality is providing a valuable tool for both administrative and clinical users to visually explore location-based data in a way not possible previously. By being based on freely available standardized tools, the approach used in this project should be portable to other sites with a comparable infrastructure. Further development will include a formal evaluation of the system as well as further extensions of its visualization functionality. Areas of special interest will include infection surveillance and visualization of workflow patterns.

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Address for correspondence

Dr. Thomas Ganslandt
Department of Medical Informatics
Krankenhausstr. 12
DE-91054 Erlangen
Germany
thomas.ganslandt@imi.med.uni-erlangen.de