GEODADIVAS
Geographic Information Systems for Blood Donation Management in Portugal

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Abstract: Blood donations are a significant part of good medicine nowadays. Needs in this area include geographic allocation off donors and its characteristics. Towards new applications in informatics systems and the implementation of ground theories in information systems (such as work and information flows), the changes in this area are promising. One kind of applications that enhances greatly this area are geographic information systems (GIS). They permit the allocation of raw data or processed information in a map, allowing contextualization of the information itself and the extrapolation of knowledge. Our goals focused on researching the state of the art off current status, data manipulation and processing relative of the donor's database, modeling and developing a program that could show a varied option of queries that can be done to the database. We used some statistic approach to the data as well as software implementation. After its completion, it was possible to calculate the distribution of blood donors and cross reference this with the places of collect. The distribution of the donors by group or area was made visible for interpretation purposes. Ultimately, the feasibility of such systems is proved and the changes in blood donation management can represent an important improvement towards good care.

1 INTRODUCTION

1.1 Transfusion Medicine

Transfusion Medicine practice has as fundamental purpose the attainment, availability and accessibility of blood and its components. They must attain a desired level of quality, safety and effectiveness.

Still actually, worldwide blood donation is insufficient to the existing needs (Nilsson Sojka, 2007). The medical investigation and the technological breakthrough in this sector had a big boom thus allowing an improvement in this area. In other hand, the development of a health care structure, and the differentiation and sophistication of medical techniques led to an increase on blood demands. Simultaneously, people are ageing and as a consequence there is a reduction of people elective to be donors (from 18 to 65 years) and an increase of number of people who actually needs blood components as they grow older.

1.2 Portuguese Blood Institute

During the last 50 years, a network capable of collecting blood in respect with the technological advances was created. It needs the adequate human, technical and material resources to function well however some aspects are still to overcome.

The National blood Service Mission was established, being assigned to the IPS (Instituto Português de Sangue, in portuguese) the normative and coordination competences and to the Regional Blood Centers of Porto, Coimbra and Lisboa the operational competences to collect process and distribute the blood components and the regional supervision.

The use of Geographical Information Systems (GIS) by the IPS, recurring to the referenced

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geographic information existing in its' databases, can constitute an important analysis and support tool to resources management.

Depending on the geo-positioning level actually available (or to exist in the future) in the Regional Blood Centers databases, a GIS can allow to visualize the resources and event distribution such as donors, the places of blood collect, blood types, gender, age, etc. and geographically contextualize blood donation frequencies or other situations making it easy to plan promotion actions towards blood collection accordingly to the existing needs.

One of the main difficulties nowadays in IPS, is the elevated costs of the mobile blood collection places that have a low rate of donations. These costs depend on human resources (physicians, technicians, nurses, drivers, etc.) to equipment, among others.

1.3 Geographic Information Systems

Geography takes a fundamental role in almost all decision we made. The choice of places, the appointing of market segments, the planning of distribution networks, response to emergencies scenarios, the redrawing of countries frontiers, all those problems address geographic issues. Geographic characteristics such as topography and geographic dispersion of population are fundamental factors in fair resources distribution (Leitner, 2002).

GIS crosses regular data and their geographic position with the purpose of building maps. This technology allows us to visualize data with different degrees of complexity in a map. This gives us a useful way of reveling spatial and temporal relations between data.

A GIS can integrate hardware, software, capture or recollection of data, management, analysis and the presentation of all types of information geographically.

Combining data and applying some analytical rules, it is possible to create a pattern in order to help answer the question previously made. The GIS primary goals in healthcare are (Maged, 2004):

- Inform and educate health professionals and population;
- Support decision making in many levels;
- Prevent results before making any compromises;
- Select priorities in lower resources environments;
- Change bad practices and routines;
- Monitor and watch continuously changes implementations.

Investigators, Public Health professionals, policy makers and others can use GIS to better understand geographic relation that affect health results, risks, disease transmission, health care access and other public health concerns. They're being used more and more often to deal with problems in a local, regional, national or international overlay (CDC, 2009).

GIS allow us to:

- Understand, question, interpret and visualize data in many forms revealing relations, patterns and tendencies under the form of maps, globes, reports or graphs:
- Answer questions and solve problems allowing looking at the data in a faster and easily shared way;
- Integration in almost any Information System within an organization;
- Solve more problems than the simple use of a mapping program or the adding of data to an online mapping tool.

Health related GIS have 2 main forms (Vanmeulebrouk, 2008):

- Epidemiology – focusing on the study and comprehension of incidences and prevalence of diseases and public health hazards, normally linked to environmental factors;
- Health care – allowing analyzing and characterizing the distribution and the access of institutions (hospitals, health centres, blood centres, etc.)

Many of those systems possess simple functions such as measuring the distance between resources and the population. So, questions like: at what distance can we find the nearest hospital, or where's the closest institution where I can donate blood, can be easily answered avoiding many constraints.

Despite the evident benefits of GIS use, its dissemination and utilization it's not yet a generalized reality. Some possible explanation for this to happen can be (Rob, 2003):

- The lack of consideration towards user needs;
- Elevated cost of existing applications;
- The need to learn the way they function and operate.

At requirement level, we verify an almost total need of community involvement since the very beginning. Meaning, users and developers must work directly together in the project. Only in this way can projects be realistic, reasonable and sustainable (Weiner, 2002).

1.4 Google API and Google Maps

Google Maps API (Application Programming

Interface) is a survey and map visualization free service utilizing satellite images. Besides maps and satellite images, it provides routes between pre-determinate spots, zoom, dragging the map, among others (Davis, 2006). It's also possible to create a KML (Keyhole Markup Language) archive with coordinates and geometric forms in order to visualize in the map presented by Google Maps server (Davis, 2006).

The simplicity and open source methodology are its biggest assets. The grabbing and dragging possibility, increase or decrease zoom without big delays in the web page are a few of the simple tasks that favor it.

1.5 Motivation

The main motivation arises from the need of IPS to improve the planning and management of mobile blood collect places utilizing donors' geographic analysis without increasing costs. The authors embraced this project, and implemented it during the classes of the discipline Health Information Systems I of the Master in Medical Informatics of the University of Porto (SBIM, 2005).

2 OBJECTIVES

2.1 General Objective

To create an open source Geographic Information System that would allow the graphic representation of the information concerning blood donations, using the IPS database and Google API.

2.2 Specific Objectives

- To facilitate the analysis, in a geographic context, of the blood campaign coordination process;
- To support the professionals in planning and distributing resources for mobile collect posts;
- To help the professionals define places and dates of mobile collect posts, according to the need to refill blood components stoking by blood type;
- To explore and deepen the existing knowledge about GIS and its applications;
- To describe the systems creation process, exploring the motivation, difficulties and potentialities founded.

3 METHODS

This work can be classified as an applied and technological (Jung, 2009) research, because its goal is the development of an application allowing the graphic representation of blood donations in Portugal.

Although this work has a statistical approach, it incorporates qualitative standards. The two methodologies are used to help carrying the whole process.

The statistical analysis is present in the first data approach and posterior interpretation. Deductive processes are always associated with this type of approach.

At the same time, a qualitative analysis of data meaning and process is used thus enriching the obtaining of results.

This work followed the following methodology:

- Research of Google Maps API functionalities and resources;
- Initial data analysis, treatment and statistical analysis of the data given by the IPS;
- Survey of the geographic divisions of Portugal;
- Building a prototype, design and create the database, design and implement the prototype;
- Evaluation meetings with the project team in order to improve the system;

3.1 Arquitecture

3.1.1 Requirements

Taking in account the overall characteristic of this proposal, the requisites where analyzed and defined by a multidisciplinary team composed of; a clinical analysis technician, a nurse and a computing engineer. For the application, the following requisites where defined:

- To show the blood donation in the map;
- Allow that donation to be filtered by: Date, District, Council, Lab results, Collect places, Blood group, Rh factor, Gender, Age.
- Show the collect posts and IPS, allow posts to be filtered;
- Develop the application using open source technology.

3.1.2 Languages and Development Tools

The following guidelines where established to fulfill the requisites:

- The data server will be MySql;
- The main developing language will be PHP

5.0, however JavaScript and HTML functions will also be used;

- Google Maps API 2.0 will be used;
- In order to fulfil a good usability CSS and JavaScript JQuery v.1.3.2 framework styles will also be used.

All the tools and resources used in this development are Open Source thus being in conformity with one of the project goals.

3.1.3 Diagrams

When open the software is carried out a query to the database, to fill the respective fields of the filters.

The consultation of blood donations, according to the selected filter is displayed in the software by following iterations showed in figure 1.

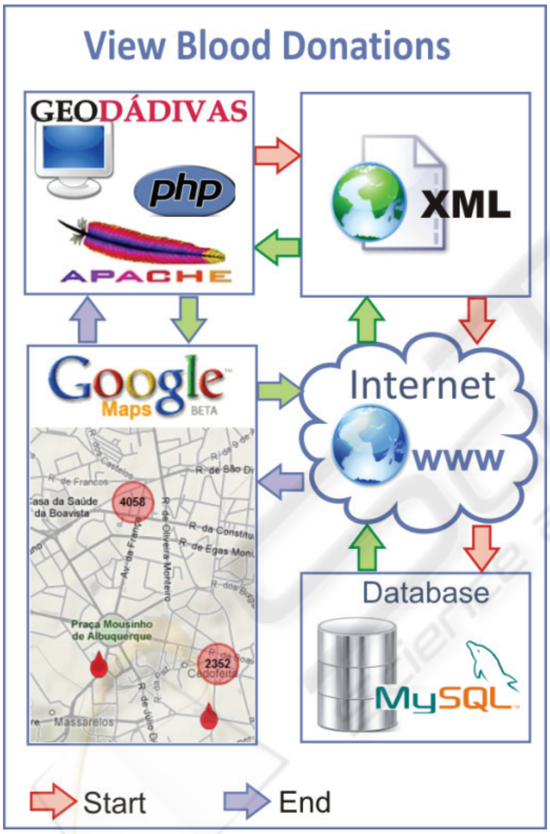

Figure 1: Diagram: View Blood Donations.

The main activities diagram was elaborated grouping activities by actors, as showed in figure 2.

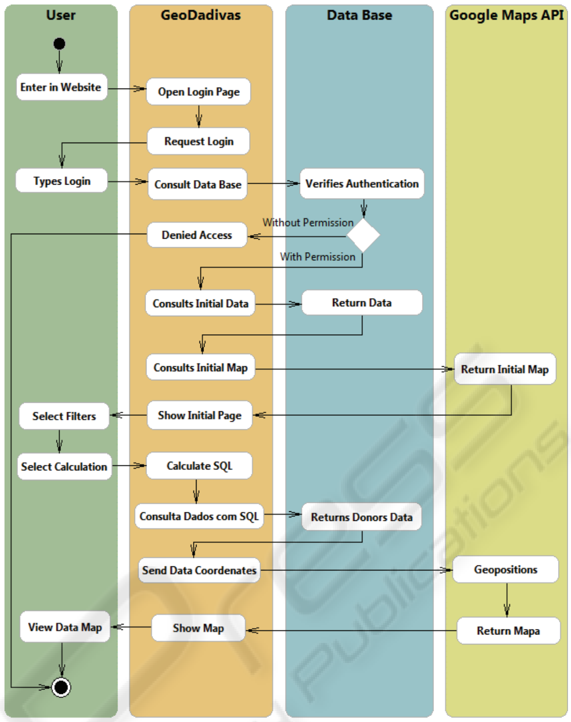

Figure 2: Activities diagram.

3.2 Application Interface

The primary interface of the application has three distinct parts, a header in the top of the page and two columns, one of filters on the left and another of results on the right as we can see in figure 3.

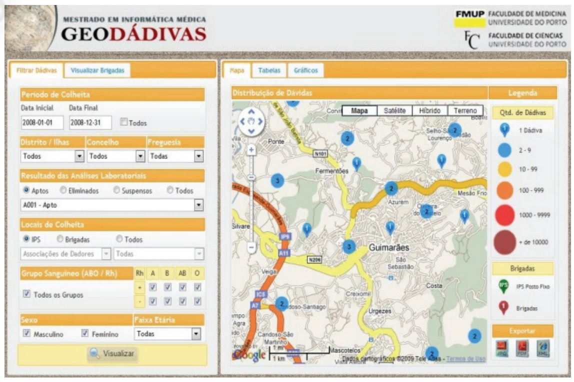

Figure 3: Main Application Window.

4 RESULTS

4.1 Data Analysis

The database used for the prototypes refers the blood donations occurred in the northern region of

Portugal between the years 2000-2008 (IPS, 2009).

The initial analysis revealed that the database possessed approximately 634 000 entries with the following variables: date, donor, place, year, number, gender, birth date, marital status, profession, zip code, place, total of donations, total of donation in IPS, inscription hour, triage hour, weight, height, max blood pressure, min blood pressure, hemoglobin, blood type, Rh factor, triage results, collect results and lab results.

It was possible to detect a certain degree of error in some fields. There were more than 80% of missing data in some fields (profession, weight, height, max blood pressure, min blood pressure, hemoglobin). Others presented serious typing errors (place, inscription hour, triage hour). And some presented mathematical inconsistency (total of donations and total of donation in IPS). These fields were not taken in consideration.

Some records from the triage collect and lab results were missing. That didn't represent a missing value because a donor can make the registration and, for some reason, leave without performing the collect or refused to give. For that reason, the queries that involve these fields just take in consideration the non missing values.

After statistical analysis, we can verify that the frequencies distribution is similar to the Portuguese study of blood types (Duran, 2007) in which 46.6% of the population has type A, 3.4% AB, 7.7% B and 42.3% O. In terms of Rh distribution, this also happens. The distribution was 16.54% for Rh- and 83.45% for Rh+.

4.2 View Blood Donations

We can observe in figures 4 and 5 the evolution in blood donations between the years 2000 and 2008. The colored circles represent the number of donors in that area and change according to the proportion (from blue to dark red).

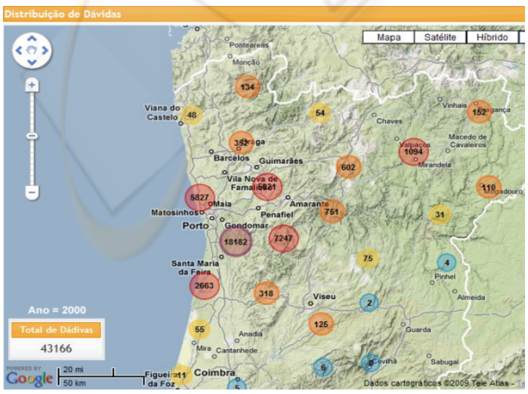

Figure 4: Blood donation in the year 2000.

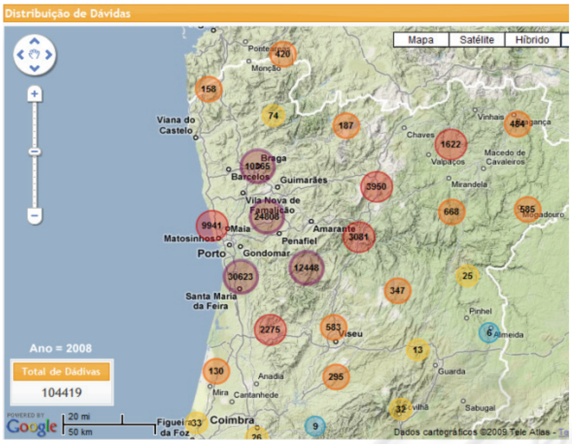

Figure 5: Blood donation in the year 2008.

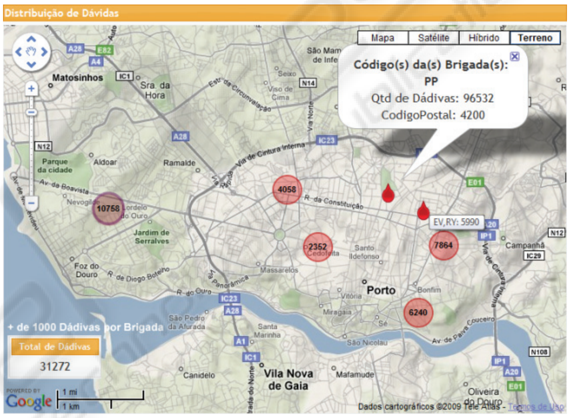

Figure 6: Blood collect places in Porto city and donors distribution.

The blood collection places can also be visualized as seen in figure 6. They're marked by a tear drop sign.

5 DISCUSSION

After the completion of this work we can realize that the GIS development is a complex system that needs much research.

The fact that it was developed by a multi-disciplinary team was essential towards its realization. The view of (a) the professional that is integrated in the entity where the system will be implemented (Clinical analysis technician), combined with (b) the scientific analysis view from other health care area and (c) the technologic knowledge of the Informatics professional, constituted an important point in its execution.

As the treatment and data manipulation revealed itself a difficult task, the software development became more complex.

We can conclude that all the initial project of data treatment (analysis, integrity verification, validation, and comparison with other scientific studies already done), although having consumed the majority of time spent, was crucial to final work quality.

The frequencies of the variables in our system are consistent with national published studies. This gives us an additional prove of data integrity quality.

Initial tests revealed that a GIS Open Source system is feasible in this context. Also we could realize that (a) Google Maps API can support big volume of data in each query, and that Web 2.0 technologies and JQuery UI Framework were a good choice in this experimental project phase, especially in relation with the user-system interaction.

The cluster method partially solved the graphic visualization problem, reducing the markers' quantity relatively close between themselves. However, after system conclusion, we could verify that clusters could easily create an optic illusion of blood donation, when less zoom was utilized.

For future work we suggest that other functions can be added and existing ones can be improved, namelly:

- possible use of colorized polygons that delimitate cities can be used in replacement of the cluster solution because they can facilitate the visual interpretation;
- more complex functions to establish relations between different variables such as calculation the distance between donor's houses and blood collection places;
- determine with higher precision the location of blood collect places with lowest frequencies that represent high resources consumption;
- relate the population density with blood donations in certain areas.

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