OPEN SOURCE SYSTEM FOR SPATIAL AND TEMPORAL DATA MANAGEMENT, STUDY CASE OF THE BOTANICAL CENSUS OF THE ROYAL RACCONIGI PARK

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ABSTRACT:

The town of Racconigi is located in the north west of Italy, about thirty kilometers south of Turin. The Royal Park and Castle are part of the so-called system of "corone di delizie" (crowns of delights), a group of royal residences that surrounds Turin, the former capital city of the first Savoy Kingdom and later Italy. These residences have recently been included in the world heritage list by UNESCO (1997); in recent times the site has become a remarkable centre of cultural activities and events. The Park is rich in wildlife and lush vegetation, and, starting from the beginning of the twentieth century, it was left to run wild, because of high maintenance costs. Therefore, to face an overall decay, which became more significant after the Second World War, extensive recovery and restoration projects were required to bring the Park back to its original glory. The Architecture and Landscape Safeguard Office in Piedmont, which manages the site, started an important restoration project: the first phase consisted in the collection of reliable geometric knowledge, which was lacking, therefore the DITAG Geomatics research Group at the Politecnico di Torino was involved in creating a stable Reference Network and updated cartographic supports. The hydraulic system in the park has been completely replanned and restored over the last three years. Now attention is focused on the rich botanical property of the Royal Park, which is 170 hectares wide (about 430 acres), with an 18 hectare lake (about 45 acres) and about 25 Km of paths. A group of botanists carried out a complete census of the trees approximately twenty years ago, with the goal of preparing a botanical classification of the species and of examining their state of health. All the data was collected in a paper archive and their position mapped on a paper support; the survey output is now difficult to access or manage, and it needs to be updated. For a modern management of the site, all the data needs to be translated into a digital format. An appropriate information system is of primary importance. As the park is going to be opened to the public, it is so important to identify dangerous situations in order to guarantee the safety of the visitors. The system has to collect all available site data (historic plans, archive resources, specialists census, topographic surveys…), in order to have a complete overview of the situation; the system has to help in the ordinary maintenance operations of the trees (e.g. pruning, planting and the felling of the trees), and to keep the database updated, recording changes and variations. To guarantee these operations a support management system which is based on a web architecture in order to offer flexible usage, both in the data collection phase and in the system fruition has been created. An appropriate data structure was considered in a GIS environment, aimed at collecting the survey data, storing the historical information from previous sources and making the link to its position evident. The system is completely based on Open Source tools, in order to build a flexible and scalable architecture. This choice is also in tune with the policy of the Safeguard Office, which has the aim of developing a set of Open solutions that can be used to replicate in all the properties it manages. This database stores multi-temporal spatial data and its structure is described in the paper.

1. INTRODUCTION

1.1 Racconigi Royal Park

The Racconigi Royal Castle and Park is the subject of great interest for several reason: it occupies an important role in Garden Art History, its tree heritage is extraordinarily significant and it is the most significant and best preserved Park of the 19th century Romantic period in Piedmont.

The Royal Park of Racconigi extends for 170 hectares and it is surrounded by a 6 kilometre long wall. Inside the park, visitors can find an 18 hectare lake, venues and paths extending for about 25 kilometres, canals and various buildings.

The Castle was built in the 12th century as a fortress by the Marquis of Saluzzo and it was transformed into a royal residence by the Savoy family in the 17th century.

It reached the height of its splendour during the reign of Carlo Alberto, who chose it as his favourite residence in the first half of the 19th century.

Nowadays the Park still has the same layout as in the nineteenth-century, which was designed by the famous German landscapist Xavier Kurten according to the romantic taste of the age (19thcentury).

Kurten's work had some typical elements such as an extraordinary variety of trees, carefully selected and placed to make all the composition more suggestive and picturesque, curved and meandering lines, the perspective of arbored avenues, long lawns, a lake with irregular sides and a small island.

Thanks to Kurten's work, this park received a remarkable amount of vegetation, also of trees, including many specimens of plane, cedar, ash, maple, oak, horse-chestnut, elm, butternut, linden, birch, hornbeam and red-fir trees together with elms from the Caucasus, Judas trees, liriodendron, ailanthus, etc.

Starting from the beginning of the twentieth century, this park was left to run wild, because of high maintenance costs.

Figure 1. Racconigi Caste and Park

1.2 Botanical surveys in the 1980's

When, in 1980, the Architecture and Landscape Safeguard Office in Piedmont took over the Racconigi Royal Castle and Park, the park was next to collapse. The main problem was the lack of safety due to the great number of old trees whose life cycles were almost over. The first necessity, in that state of serious decay, was to have a detailed picture of the whole situation.

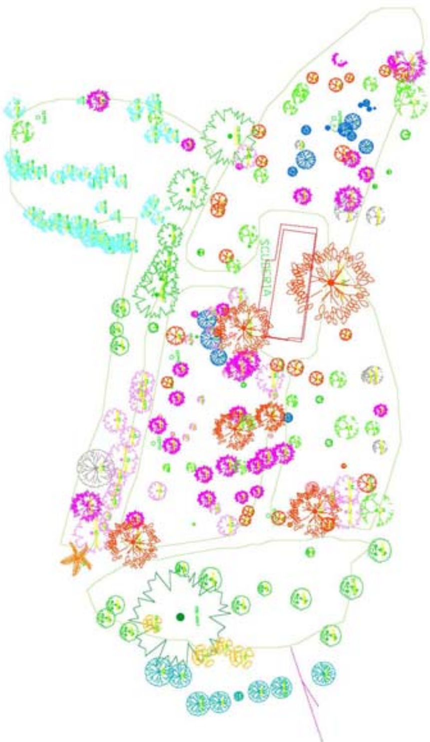

Figure 2. Detail of the botanic census representation in the 1980's

In the eighties, IPLA (*Istituto per le piante da legno e l'ambiente* – A regional institute for the safeguarding of trees and plants and environmental planning) conducted a survey campaign aimed at defining the state of think. The real goal of that campaign was a botanical classification of the species and to point out their state of health.

Over 20.000 trees were registered, ten percentage of which resulted to be higher than 30 meters.
During this first survey, all the trees and plants with a stem larger than 10cm were classified and labelled. The labelling was carried out assigning a unique identifying number to each plant. The numeration was carried out throughout the entire park in a progressive way, starting from 1 to 20000.
All the information about the features and classification was linked to this identification code.
All the data was collected in a paper archive and their position approximately mapped on a paper support.
In this work, the accuracy in the positioning of trees was not high, because of the fact there was no a topographic reference network to base the survey on.

1.3 Restoration works in the 2000's

In the nineties, the Architecture and Landscape Safeguard Office in Piedmont started an important restoration project in the park aimed at opening it to the public.
In this context, a cooperation with the Politecnico di Torino Geomatics research group was set up in order to provide an appropriate technical support. A reliable geometric base was created, and a permanent Reference Network, that would be maintained in time was planned. At the beginning of the project, there was a complete lack of reliable knowledge on the geometries of the Park, as there had never been a proper survey scheduling policy. The goal that was set was to develop a GIS that could help both the planning and documenting of the site changes.
The intervention works were aimed at recreating the park situation that was documented in an 1839 map.

Figure 2. The Racconigi site map of1839

A first step of that restoration was to plan the hydraulic system of the Park. The interventions were necessary to keep the system functioning: since it was first constructed, it had tended to fill with earth, and some canals had become completely obstructed.
The second step has now been started and it deals with the botanical aspect. A new botanical census has been carrying out in order to acquire detailed knowledge for an accurate planning of the restoration works. As in the 1980's survey a cartographic representation of the surveyed data is going to be created. In order to add metrical content to the representation and for a correct insertion of the data in the GIS database, GPS RTK tests were carried out. The tests where aimed to understand how the presence of leafs may influence data accuracy in order to define

a survey procedure. In the first survey, which took place during the winter season when trees are bare and without leaves the obtained mean precision was of 0,40 m, with a maximum error value of 1,20 m; in a spring test after foliation instead, the obtained mean precision was of 0,70 m, with a maximum error value of 1,90 m. The obtained precision during the winter test is considered suitable for the project requirements.

2. THE MANAGEMENT TOOL

To face the overall decay of the park and to manage the high maintenance costs, it is important to create a system that is able to compare and integrate all the available data (historic plans, archive resources, specialists census, topographic surveys…), including those from old surveys and those from on-going and future analysis. The common base for data determined from all these different studies is the stable Reference network and the updated cartographic supports created in the last few years by our research group. For example, the on-going botanical census is based onto the established reference system.
A complete vision of the Park can be achieved with a GIS tool, which offers the chance of overlaying different levels of information.

The raw vector data obtained from terrestrial and photogrammetric surveys were edited (area reconstruction) and linked to the available information, for example, the sketches of the network vertices. The GIS environment was also supplied with products that are able to integrate the Park and its historical evolution description: the orthophoto, and the DEM.

This GIS was also important to weigh the benefits offered by a GIS in the management of the entire site. GIS technologies offer the opportunity of coordinating different activities: to create an environment on which to overlay the historical studies on the current situation of the park, to check the evolution of the works in the park, to monitor the danger situations, and the every day management.
The restoration project carried out has two main requirements: First, it is important to identify dangerous situations in order to guarantee the safety of visitors; a tool to record and manage the maintenance operations of the trees (e.g. pruning, planting and the felling of trees) is then needed. An appropriate information system was therefore considered to be of primary importance. It has to collect all the data, both the "old" and the "new", and to keep the database updated, registering changes and variations. This up to-date database makes it possible to carry out a day by day analysis of the property in order to point out the critical situations, focusing the monitoring operations.
The information system has been planned to fulfil these requirements.

3. DATA STRUCTURE AND ARCHITECTURE

An appropriate data structure in a GIS environment was considered with the aim of collecting the survey data, storing the historical information from previous sources and to making the link to its position evident.
First of all, a simple structure of the database was designed in order to collect the information from the survey performed 20 years ago, together with the information from on-going surveys. The structure is based on a double core: Plant table, which collects data matched from the two surveys about each tree; and a Diagnostic table, in which all information about the diagnostic and maintenance actions are registered. The Diagnostic table is linked to the Plants table, and it records the multi-temporal action carried out on each tree.
The Plant table and an Area table has information about their spatial components. The plants are represented as points, while areas as polygons.

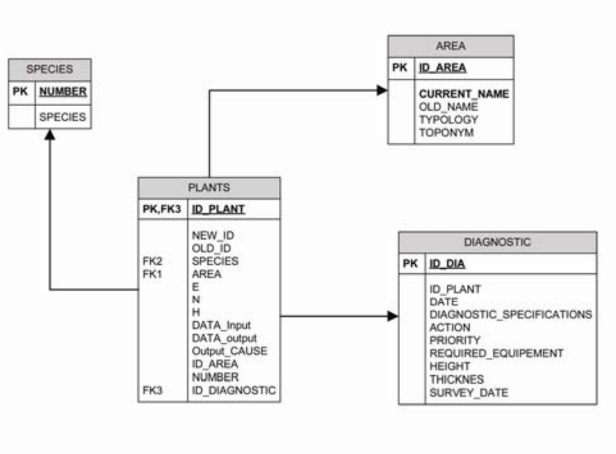

Figure 1. DB structure of the multi-temporal botanic surveys

In order to offer the possibility of flexible usage, both in the data collection phase, and in the system fruition, the system was based on a web architecture.
The first and undeniable advantages of using Internet technology to publish GIS data consists in the simplicity and economy of the implementation.

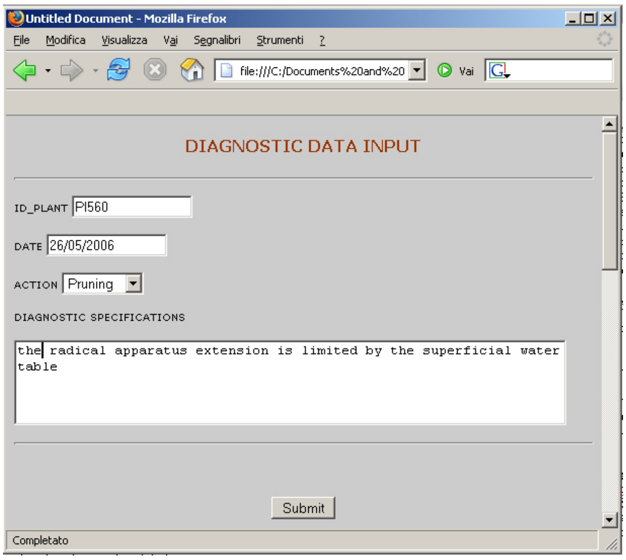

Figure 2. HTML page for data input

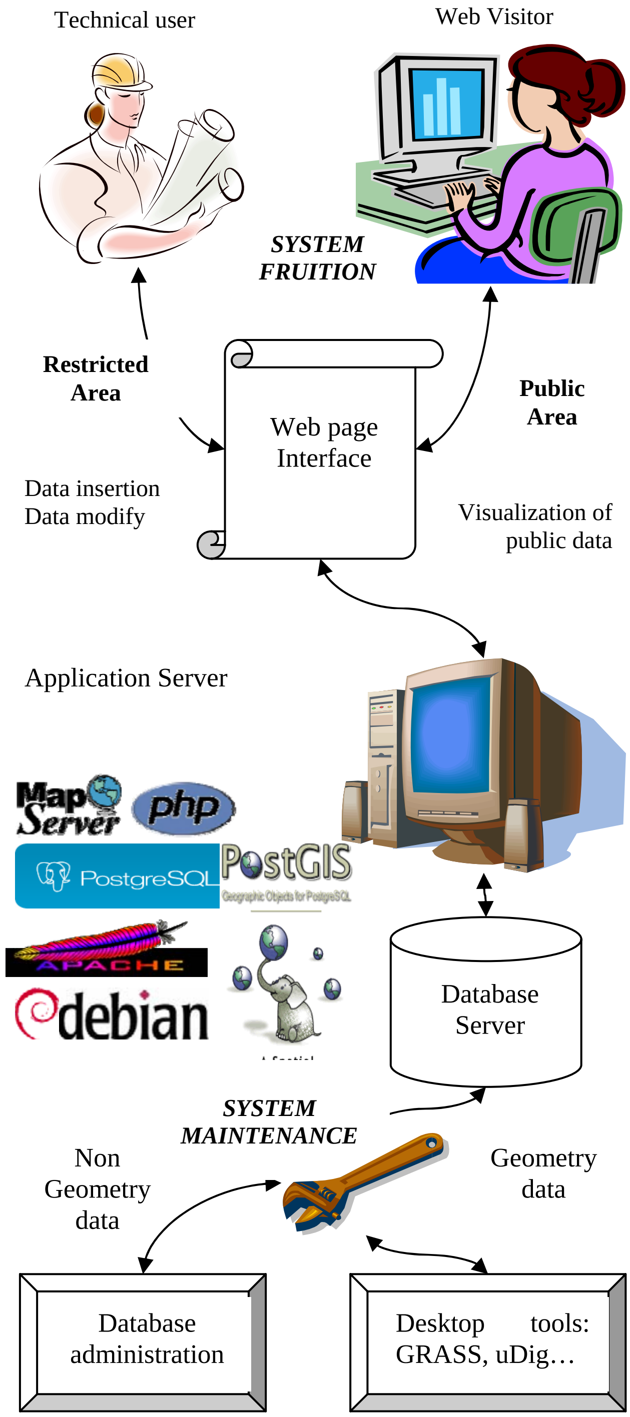

Figure 3. System Architecture

Users who access GIS resources, shared using a Web server and published on a specific Web site, no longer need particular hardware configurations or software knowledge: it is sufficient to connect to the WWW, and use a traditional Web browser. Furthermore, the database is continuously up to date and unique, thus avoiding problems of data replication and data consistency.
This database stores multi-temporal spatial data and the system architecture has the classical structure of a dynamic system, where public access for users, Web page navigation and protected access to allow administrators and operators to manage the data contained in the system are integrated. Specialists from different disciplines are allowed, with different kinds of access, to input and edit information and data in the system. This access is also protected by a password and each specialist has his personal password in order to monitor the activities and to associate data to whom has input it to system, protecting their property as well.
In order to limit the experimentation costs, it has decided to base the system on an Open Source architecture. This choice makes it possible to work with different tools to find the solution that best fits the projects needs. This solution makes it possible to set up a very flexible, scalable and easy to be maintained architecture.
The choice of this kind of architecture is in tune with Italian guidelines on software adoption for Public administrations and the Safeguard Office of Piedmont’s policy.
The basis of the system architecture is the database, where most of the information is stored. The chosen instrument is PostgreSQL, which is used in conjunction with its spatial extension, PostGIS, a tool that adds the opportunity of storing geometric information.
This structure proves to be very flexible: the maintenance of the geometric base can be carried on by means of desktop GIS tools, such as GRASS or uDig, while it is possible to have a view of them through the web application. This application also provides the chance of editing the database via web: specific forms are available for authorised users for inserting data from survey campaigns about the tree properties of the Park and to keep the database up to date. It is possible, for instance to enter the information of the planting of new trees, or of the removal of one, or to store some maintenance intervention information.

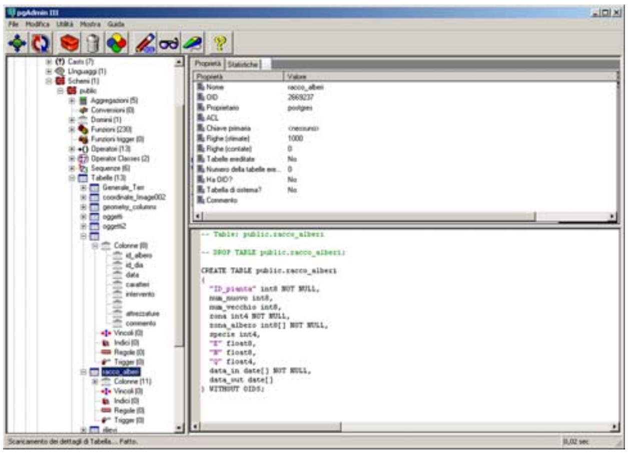

Figure 4. Tree table in a PostgreSQL client tool

The web-Application uses the University of Minnesota MapServer as a visualization tool, whereas the connection of the web pages and the database is made possible by PHP scripting.
The park is going to be covered by a wireless network and it will thus be possible for operators to load and consult data in real time thanks to the created web GIS interface.
The possibility of a web connection makes it available pocket PC usage for on-site access to the system: this feature is important both in the technical management of the park and in a tourist fruition of it.
A botanist, for example, could obtain all the available information about a tree he is surveying and directly upload new information. In the same way, a maintenance man could access technical information about the past and planned intervention. A specific interface is planned for park tourists to

access historical and natural information about park heritage to make them enjoy their visit.

The wireless network makes it possible to extend an on-going test carried out by the Electronic Department of the Politecnico di Torino.
There are many secular trees, higher than 30 meters IN the park; their radical apparatus extension is limited by the superficial water table. This can cause the trees to fall suddenly and creates dangerous situation for the visitors.
The test deals with the use of verticality sensors to monitor tree stability. The position of the sensor is known and stored in the database. By selecting the feature on the map, it is possible to access the sensor recorded data. A future development of this project is the use and interpretation of the data to create a safety procedure. At the moment it is still subject to investigation.

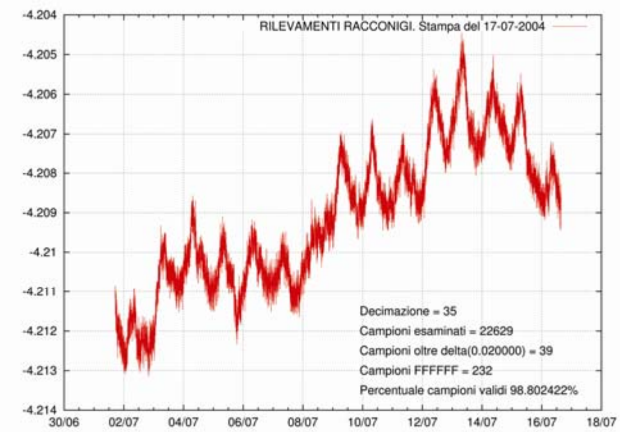

Figure 5. An example of the verticality sensor output: variations are also connected to atmospheric factors; the data interpretation is the subject of study

4. CONCLUSIONS

When dealing with the problem of preserving and managing the heritage of a historic Park, such as the Royal Park of Racconigi, it is very important to collect a great variety of information. In this case the acquired data had to be organized in a database and shared, by implementing an Information System.
GIS technologies allowed a complete and correct integration of all the acquired data during the different survey campaigns. GIS functionalities can be used by the persons in charge of the maintenance and managements of the site to support the decisions they have to make and to give a proper direction to their policies.
Web GIS solutions are the best way providing an easy access to the data, using an easy to use map interface. The planned system is a useful instrument to keep the data updated, as the creation of knowledge is a continuously ongoing process: the system is capable of managing multi-temporal data and tracking the evolution of the data botanic property.
The system is completely based on Open Source tools; this choice is in tune with Italian directives for the adoptions of software applications in Public Administration and safeguard office criteria aimed at encouraging Open Source solutions to support software reutilization in its own managing system. This solution also made it possible for us to connect different software components to find the solutions that best fit the project requirements.

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