Spatial data management of cultural and environmental heritage: @tlante geo-portal for historic cartography in Lombardy

R. Brumana, B. Cuca, M. Scaioni
Politecnico di Milano, Italy
Building Environment Science & Technology Department (B.E.S.T.)

INSPIRE Conference, Krakow 22-25 June, 2010
The project Atl@nte

- Framework of this research: Italian project Atl@nte (2009-2011) funded by CARIPLO Fundation, Milano (Italy)
- Aim: to built up an SDI of historical cadastral and topographical maps of Lombardia, intergated to modern geoDBs
- Partners:
  - Politecnico di Milano, Dept. B.E.S.T. (project leader)
  - National Archive of Milano (ASMi)
  - Cadastral Administration (Agenzia del Territorio – AdT)
  - Centro Studi PIM
  - Regional Administration of Lombardia
  - Municipality of Gorgonzola (Lombardia)
  - CILEA inter-universitary consortium
Why the on-line publication of historical cadastral maps?

• Activation of the first release of geoportal Atl@nte (public presentation on 19 Jan 2010)
• Current available @ URL: www.atlantenoricolombardia.it
• Finalities:
  ▪ **Cultural**: to rise the “consciousness of the landscape” as a source of welfare, culture, historical memory and identity, to be transmitted to the future, by increasing the number of people who can access historical maps, now available only to a few technicians
  ▪ **Technical**: to introduce the use of historical information into the land planning process and as a tool to recognize the public property extension
Historical cadastral maps for land planning purpose

- Land planning, especially in urban areas, is currently based on analysis:
  - As-built situation (geoDBs)
  - Social and economical analyses
  - Integration to the surrounding region

- Added-value of using historical maps:
  - To respect the traditional character of a given area (agricultural, industrial, residential, touristic, religious…)
  - Recognize the presence of old settlements and possible archeological sites
  - Understanding the old water and canal networks (flooding vulnerability)
### Structure of the geo-portal

**MOSAICO GEOGRAFICO WEB E PERCORSI DI ACCESSO AI DATI**


La ricerca può essere effettuata seguendo percorsi differenziati e incrociati tra loro: accesso e ricerca geografica su carte georeferenziate, accesso al catalogo descrittivo, percorsi tematici.

**GEODBASE: BASI DATI CARTOGRAFFICHE PUBBLICATE (ASMI, a cura di M. Signori)**

<table>
<thead>
<tr>
<th>ACCESSO GEOGRAFICO E RICERCA SU CARTE GEOREFERENZIATE</th>
<th>CATALOGO DESCRITTIVO SERIE CATASTI STORICI</th>
<th>PERCORSI TEMATICI Navigazione su carte e mappe georeferenziate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CARTE TOPOGRAFICHE E CATASTI STORICI</strong></td>
<td><strong>CARTOGRAFIA DEI CATASTI STORICI CESSATI</strong></td>
<td><strong>RACCOLTA</strong></td>
</tr>
<tr>
<td>Aree storiche territoriali Ricerca per tipologia di mappa</td>
<td>Ricerca per toponimi</td>
<td>• Foto storiche</td>
</tr>
<tr>
<td>• Area regionale Aree provinciali</td>
<td>• 25.000 Mappe Catastali accessibili. Il servizio sarà attivato a breve.</td>
<td></td>
</tr>
<tr>
<td>• Aree urbane</td>
<td></td>
<td>• Corsi d’acqua</td>
</tr>
</tbody>
</table>

**Geographical access to georeferenced maps**

**Non-geographic catalogue of old cadastres**

**Thematic sections (in the 2° year)**
• Publication of small scale chorographic maps of old cadastres:
  - ‘Corografie delle Provincie del Regno Lombardo-Veneto’, from 1836 (at scale 1:115,000)
  - ‘Carta del Territorio del Milanese e del Mantovano’, 1788-1796 (at scale 1:86,400)
  - ‘Carta del Regno Lombardo-Veneto’, 1833 (at scale 1:86,400)
• Chorographic maps are the framework of (old and current) cadastral maps of municipalities (scale 1:2,000)
• Old large scale cadastral maps are undergoing a digitalization process to be published on-line
• Publication of chorographic maps can help to access to large scale cadastral maps in both cases of geographic and catalogue access
Georeferencing of chorographic maps

- Chorographic maps do not report any mapping grid, even though they derive from the generalization of large scale cadastral maps (these referred to a geodetic framework)
- Geographic publication needs georeferencing
- Use of current Italian mapping grids to allow comparison to up-to-date data:
  - Gauss-Boaga (datum “Roma 1940”)
  - UTM-WGS84 (datum “ETRF89”)
- Registration carried out by using vector layers of municipalities boundary from the regional geoDb (1:100,000)
- Boundaries and other physical features adopted as reference points for computing an affine transformation (6 parameters)
Example of result after georeferencing
Analysis of results

• Apart a few modification of some boundaries, results show a paradox:
  ▪ Somewhere a perfect correspondence after the computed transformation
  ▪ Somewhere else significant shifts of large portions of a boundary, without any evident systematic error on the whole original sheet

• Possible source of errors:
  ▪ Construction process of the chorographic maps (generalization of large scale cadastral maps at 1:2,000 scale)
  ▪ Deformation over the time of hard-maps
  ▪ Digitalization process (under investigation)
  ▪ Errors due to the georeferencing procedure
    • Uncorrect modelling
    • Uncorrect reference points identification
Quality assessment of primary data

- In-depth analysis of maps of Gorgonzola:
  1. Georeferencing of chorographic map including Gorgonzola town
  2. Georeferencing of all 16 large scale (1:2,000) cadastral sheets: results coherent with the expected map tolerance
  3. Comparison of municipality's borders obtained from (2) with respect to the ones from (1): presence of significant discrepancies
  4. Conclusion: the process for the generation of chorographies from large scale maps was not rigorous
Issues concerning quality of georeferencing

- Use of affine transformation motivated by its easy implementation in GIS platform (TWF files)
- A preliminary test was performed to check how many reference points have to be used in order to:
  - reduce the man work
  - keep a good geometric quality
- Reference points selected among features which are expected to be persistent along time
- Homogeneous and regular distribution of points on each sheet
- Reference quality for chorographic maps: tolerance of modern maps at the same scale (1:100,000): t~50 m
Results of the test

<table>
<thead>
<tr>
<th>Sheet</th>
<th># reference points</th>
<th>total RMS error</th>
<th>Residual error min.</th>
<th>Residual error max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milano</td>
<td>6</td>
<td>22 m</td>
<td>2 m</td>
<td>34 m</td>
</tr>
<tr>
<td>Milano</td>
<td>9</td>
<td>35 m</td>
<td>14 m</td>
<td>56 m</td>
</tr>
<tr>
<td>Milano</td>
<td>30</td>
<td>169 m</td>
<td>57 m</td>
<td>255 m</td>
</tr>
<tr>
<td>Milano</td>
<td>35</td>
<td>196 m</td>
<td>48 m</td>
<td>367 m</td>
</tr>
<tr>
<td>Milano</td>
<td>52</td>
<td>307 m</td>
<td>33 m</td>
<td>546 m</td>
</tr>
<tr>
<td>Milano</td>
<td>203</td>
<td>178 m</td>
<td>27 m</td>
<td>297 m</td>
</tr>
<tr>
<td>Milano</td>
<td>232</td>
<td>210 m</td>
<td>41 m</td>
<td>440 m</td>
</tr>
</tbody>
</table>

- By increasing the number of points, errors become larger accordingly (no direct dependency)
- Solutions with many points adopted to privilege a less precise but most accurate georeferencing
- The same strategy was adopted for other sheets, with largely different results between different sheets
Implementation of the geoportal

- The geo-portal was conceived in open-source WEB-GIS technology and to provide Web Map Services (WMS)
- Developed using Geoserver, an Open Geospatial Consortium (OGC) application, in order to ensure interoperability requisite (by CILEA)
- Needs of the end-users:
  - **Discovery**: finding data of particular interest over a specific region through metadata catalogues
  - **Viewer**: consultation and evaluation of sample data and detailed reports to help the user determine if the data is of their interest;
  - **Access**: order, package and delivery data (off-line or on-line)
  - **Exploitation**: data use by the consumer for their own purpose
Methodology for publication of Cultural Heritage geodata (1)

**Documentation:**
- Documentation of historical buildings
- Cataloguing: Digital Databases
- Virtual Reconstruction of lost scenery

**Representation:**
- Digital memory
- Monitoring for research: updatable databases
- Production of copies or relevant parts

**Conservation/Preventive maintenance:**
- Documentation of restoration done
- Planning of future actions
- Digital simulation of different possibilities

**Dissemination / valorization:**
- Multimedia applications
- Visualization and Discovery: Interactive actions
- Virtualized heritage

**Spatial Data Infrastructures Platform for Cultural heritage**

**DATA LAYER:**
- Photogrammetry + laser scanner data + Topography data

**SERVICE LAYER:**
- Discovery
- Visualizer
- Meta data editor

**USER INTERFACE LAYER:**
- Virtual Museums, web geo-portals etc.
Methodology for publication of Cultural Heritage geodata (2)

Bodies/institutes involved in CH protection and documentation

Architects/Planners involved in conservation projects; local authorities

Regional authorities; Public administration.

Professional in the field

Visitor/Student/Virtual tourist

Use Case Model as illustrated within INSPIRE data specification document on Protected Sites (September 2009)
The rising need for SDI distributed services calls for standards and indications definition.

Objectives:
- provide **identification** of the information resource for which metadata is created i.e. give the **classification** and **identification** of: **geographic location** and **temporal reference**, **quality & validity**, **conformity** with implementing rules on the interoperability, **constraints** related to access and use, and organisation **responsible** for the resource.
- provide **homogeneous** metadata scenarios;
- promote **data sharing** at international level via web.

Metadata on metadata record itself needed to **monitor, up date** and ensure the **maintenance** of the metadata.

**INSPIRE** Instruments: **Metadata Editor** and **Metadata Validator** in form of prototype

Spatial dataset | Spatial dataset series | Spatial data service

National legislation and indications fundamental for further implementation!
Cultural and environmental heritage find their place among the theme of protected sites. The field of heritage protection and conservation is strongly subjected to case-by-case analysis → need for some special attention from geospatial data community.

Example of xml metadata file

→ still some complex but precious work to be done!
Geo-portal as a single access point to distributed geospatial sources.

GeoServer allows publishing of geospatial data with OGC compliant communication standards

**Portal Services**

a single access point to resources and services available; administration functions and management of the portal.

**Access to services:**

- **Visualization client** - the visualization and navigation interface of available resources
- **Research client** - the instruments for queries and localization of resources based on characters defined by the user
- **Publication Client** - administrator or another authorized user to publish resources
- **Gazetteer client** - allows geographical queries based on toponyms

**Catalogue Services**

the catalogue services provide instruments to classify, register, query, manage and use metadata and geospatial services; metadata can be obtained and queried via catalogue service in order to evaluate (within more advanced systems), invoke and obtain the resource described by metadata themselves.

**Presentation service**

are services dedicated to visualisation and navigation of geospatial data

**Data Services**

services that provide access to geographical data found in repository o data banks
Publication of chorographies on the geoportal

- After georeferencing, each map in TIFF+TWF format was exposed through Geoserver as WMS
The integration of old maps to features of the current geoDB allows to directly access large scale sheets in the same region (also the ones not yet georeferenced).
• Different thematic sections are under development
• Thematic section: “Water & Territory”
Cross-correlation between themes
example of “Water” topic
Annex I
Addresses
Cadastral parcels
Hydrography
Protected sites
Annex II
Land cover – Orthoimagery
Annex III
Buildings
Agricultural and aquacultural facilities
INSPIRE DIRECTIVE - Annex Themes

- Geoimagery
- Cadastral parcels
- Administrative units
- Land cover
- Artificial infrastructures
- Hydrography
- Buildings
- Addresses
- Geographical names
- Elevation - costlines
- Protected sites
- INSPIRE Conference, Krakow 22-25 June, 2010
The Martesana canal
Some details on 17th century maps

Giovanni Paolo Bignati, *Navigazione dal lago di Como, attraverso l'Adda e il naviglio della Martesana, lungo un percorso impervio e ambizioso, costruito ad arte per oltrepassare anche corsi d'acqua quali il Lambro e il Seveso, e confluire nella cerchia dei Navigli urbani nei pressi dei Tombone di San Marco a Milano.*
Other old maps in Milano

- To evaluate the path of Martesana canal inside and outside the city of Milano in past centuries, other maps were georeferenced.
- In Milano the following ones are used:
  - Teresian Cadastre (6 sheets used at scale 1:2,000);
  - Map of the Astronomers from Brera (39 sheets at scale 1:1,000)
Suggestions: possible uses of historical maps in comparison to the current ones

- After georeferencing, old maps can be overlapped to the up-to-date ones
- Several analysis are possible
  1. Change of river over time (and properties directly facing the river)
  2. Change of road paths
Conclusions and future work

• On-line publication of historical metric maps in Atl@nte can provide a synthetic and continuous vision of the territory, at different historical levels

• Comparison between landscape of yesterday, today and tomorrow (land planning) becomes easier for both cultural and technical purposes

• Several technical aspects are related and still open:
  - Automation of georeferencing (looking for reference points in automatic way)
  - Analysis of errors and improvements of the adopted geometric models
  - Quality control (map scanning, georeferencing)
  - Accessibility to on-line very large map archives through WMS
  - Metadata Implementation, as requested by INSPIRE directive
  - Study of different INSPIRE themes related

• Development of planned activities of the Atl@nte project:
  - Thematic sessions
  - Integration of terrestrial data (UAV-based, laser scanning)
  - Publication of 3D data (metadata, up-dated geoDb, PEM, DTM, …)
THANK YOU FOR YOUR ATTENTION!

www.atlantestoricolombardia.it