Usage of old maps in GIS

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Abstract

The contribution deals with the usage of old maps in GIS for urban re-development. As a model area the historical centre of Brno (Czech Republic) city including st. Peter-Paul’s cathedral and Špilberk castle were selected. On the basis of historical maps, plans and documents the main temporal points of urban development were established. The goal of this project was to attempt to establish urban re-development in these temporal points. The project analysis was made together with the cooperation of the experts of the middle age archeology branch. Final output is a GIS project in ARC/INFO created with the geo-database, which contains all temporary levels of map sheets, significant geographical objects with the attribute data and historical and current time photos of the interested objects. In ARC/INFO system also 3D model of Špilberk castle have been created.

Keywords: historical maps and plans, GIS, geo-referencing, data warehouse, 3D visualization.

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INTRODUCTION

Historic buildings or conservation area has undergone during its history many changes. They changed not only the appearance of the objects but also their style, layout or functionality. The aim of this project was to determine the method of reconstruction of historic buildings on the basis of contemporary materials (documents, reports, maps, photographs, etc.) and using GIS to determine their location or appearance at some stage of their development. In the region of interest were selected historical center of Brno and Špilberk castle. Brno is the second largest city in the Czech Republic with more than 400 000 inhabitants. It is the administrative center of South Moravia, and its historic district is a separate part of Brno - the city. The entire project was run in several major phases – see Fig. 1:

1. collection of historical materials relating to the area of interest,
2. assessment of the materials and consultation with experts in the field of history,
3. preparing and selecting the appropriate program; processing,
4. data processing and analysis of appropriate software, identifying the main stages in which there were significant changes in the region, creation of geo-database,
5. creation and presentation of outputs.

Each phase of solutions is described in subsequent chapters.

Figure 1 - Development of the project
HISTORICAL DATA COLLECTION AND EVALUATION

This phase was the most difficult of all. Although the center of Brno has a rich history, historical material has been preserved relatively little. The paradox is that most of the preserved historical documents were located outside the city of Brno, even outside the Czech Republic. In fact, some of the organizations visited as Museum of Brno city, Archive of Brno, Moravian provincial archive, National office for preservation of historical monuments in Brno, bishopric of Brno have some materials but the quality of its was in many cases insufficient. The most valuable items were found in the Military Archives in Vienna. It concerns the collection of 21 plans since 1658 – 1819, 5 profile sheets and 3 sheets of construction plans. All above mentioned materials were purchased by Institute of Geodesy, Faculty of Civil Engineering, Brno University of Technology for the needs of this project. Current map materials necessary for the reconstruction were provided by Facility management of Brno city and Czech Office for Surveying and Cadastre.

To the oldest and the most valuable exemplary belong de Rocheplein’s plan of Brno city of 1749 and the plan of 1754 - see Fig. 2. Overview of all collected historical materials is given in Table No 1. Collected data were evaluated with the help of experts from the field history and adapted for further processing.

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<th>Data source (company)</th>
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The collected materials collected occurred to be insufficient for processing. Above all it was necessary to look up and determine appropriate identical points for geo-referencing of old maps. Further it was necessary to verify current map material and compare them with a reality. For these reasons the collected data were completed with direct geodetic measurement in field. The actual selection of suitable materials for reconstruction was consulted with experts at Middle age archeology from Brno Museum. A basic document for a choice of appropriate elements and identical points for reconstruction was present cadastral map of a given locality. This map contained objects which can be divided into 2 categories:

1. Preserved parts of an object of late 18th century.
2. Objects with small construction works which cannot influence identification with old maps and plans (facades adaptations, building reconstruction on an original object etc.).

Above mentioned objects contained localities for placement of reference points for geo-referencing of old map documents. Other necessary identical points were obtained by geodetic surveying of south-west bastion of the castle Špilberk which was newly reconstructed in the year 2002 in the frame of archeological research. These points are the most accurate (both in history and topography). On the contrary the historical maps and plans have the lowest quality which is influenced by these factors:

- The ravages of time, causes fading of drawing which results in losing a part of a map.
- Precision of scanning in case, the map consists of several (in many cases damaged) parts.
- The exact dimension of map frame and field are unknown.
- Method of geodetic measurement and its accuracy are unknown.
- Disunited attribute style of drawing of maps and plans (various line styles and weights).
Therefore with transformation (geo-referencing) the accuracy was not determined and the whole process is only to a certain extent informative, but the only available one.

DATA PREPARATION AND PROCESSING

For the project was selected by ESRI ArcGIS software. Before entering into ArcGIS some files had to be adjusted. Raster data was preprocessed with Adobe Photoshop (cropping, downsizing, conversion, etc.), vector data has been adjusted in MicroStation V8. Upon entering into the system ArcGIS had to be some layers geo-referencing using identical points. In many cases, especially in historical maps, it was very difficult, because many elements of the past disappear. For the whole project was used S-JTSK system (Datum of Uniform Trigonometric Cadastral Network in the Czech Republic). All altitude dimensions were calculated into alitmetry system Bpv (Baltic Vertical Datum after Adjustment). There were successively inserted into the system or a newly created 172 layers, which were grouped into 23 categories.

From institutions or private entities have taken these layers:

- Historical maps,
- Ortho-photo maps,
- Geological map,
- ZABAGED (Fundamental Base of Geographic Data) – contour lines and topography,
- State map of Brno city in the scale 1:5000,
- Utilities map of Brno city
- Zoning plan of Brno city
- Current cadastral maps of Brno municipality

Figure 2 - Plan of Brno city from 1754 year
Based on an analysis of existing layers were determined four periods in which were the most important urban changes, namely:

- 1750 – 1815
- 1816 – 1880
- 1881 – 1945
- 1946 – 2010

These new layers have been created further categories or layers:

- Municipality fortification,
- Situation in 1890,
- Housing development in four above mentioned periods,
- Historical sightseeing tour in 1750 and 1890 – see fig. 4,
- Digital terrain model with layers: TIN, aspect, slope, hillshade, view, TIN-grid – see fig. 8,

Further were created followed special layers:

- Layer for WMS (Web Map Services)
- Layers of significant historical objects: st. Peter’s and Pauls’ cathedral, st. James church and German house,
- Graph of selected profiles of Špilberk hill,
- Group layers of reconstruction of Špilberk castle.

For all newly created layers geo-database has been designed. Part of geo-database for registration of religious objects is in Figure 3.

As a special part of the project was create a topography and altimetry reconstruction of the castle Špilberk. Based on historical and current maps was created 3D model of Špilberk castle during the Baroque period - see Figure 9.

**RESULTS AND OUTPUTS**

The main results of the project are:

- Collection of historical and contemporary material (map, documents, photographs and reports) of the selected location,
- Classification of the material, determine the main stages of construction work - see Figure 6,
- Create new layers that show major changes in selected buildings,
- Creation of a common geo-database of historic buildings,
- Connection to the WMS services, where each user can work on-line with the selected map data,
- A special coating on the important historical places of Brno (st. Peter’s and Pauls’ cathedral, st. James church and German house),

![Figure 3 – Part of geo-database: database of religion features](image-url)
- Creation of GIS analysis in the locality - 3D Model, profiles,
- Complex process of reconstruction of the castle Špilberk in both 2D and 3D model.

Housing development and historical sightseeing tour in Brno of 1750 year

All major results are presented in Figure 4 to 9. Figure 4 shows the main phase of structural changes in the center of Brno. There is marked historical guided tour in 1750 with outstanding stops. In Figure 5 you can see important milestones in the development of the St. Peter’s and Paul’s cathedral, based on old maps. Fig. 6 shows the historical center of Brno in 1750 and Fig. 7 the same site in 1890. On both figures it is clear what significant changes have taken place during the 140 years. Relatively stable are church buildings and squares, big changes can be observed in transport infrastructure (rail, tram). Another figure 8 presents a 3D model of representative sites created in the 3D Analyst module in ArcGIS. Elevations of the legend are given in altimetry system Bpv (Baltic Vertical Datum after Adjustment). The last figure represents the result of reconstruction of the castle Špilberk. This reconstruction in 3D has 2 phases:

1. The creation of digital terrain model (DTM) of Špilberk hill – see previous fig. 8.
2. 3D model of historical reconstruction of Špilberk castle and its fortification – see fig. 9.

For making DMT these materials have been used:
- A plan of Špilberk castle of 1984 borrowed from Brno Museum in the scale 1:1000. The plan contained contour lines with the interval 1 – 0,5 m which have been digitalized.
- Altimetry of Špilberk in ZABAGED system (Fundamental Base of Geographic Data) – see table no. 1.

For 3D model of historical reconstruction of Špilberk castle and its fortification these materials have been used:
- Plan of 1749 by Pierre Philippe do Beichade de Rochepine containing 15 dimensioned sections.
- Plan of 1759 with 2 sections missing in the previous plan.
- Plan of 1809 showing the fortress damaged in the period of Napoleonic wars.
- 4 map sheets of 1917 containing detailed drawing of building adaptation in the years 1840 – 1880 including altimetry spots dimensioned heights of terrain and fortification.
- Contour lines ZABAGED (Fundamental Base of Geographic Data) in the locality.
- Geo-database of topography map created in a previous phase of the project.
- Current digital cadastral map of Brno centre.
Figure 5 – Significant re-building stages of st. Peter’s – Paul’s cathedral

Figure 6 – Historical centre of Brno city in 1750
Figure 7 – Historical centre of Brno city in 1890

Figure 8 – TIN model of historical centre of Brno city
CONCLUSIONS

The goal of the project was documenting the historical development and changes in core of the housing city, creation of a functioning system of historical database, serving a special interest group of users. This process was done on the basis of maps imported into the ArcGIS program. Furthermore, it was also working with information obtained from literature. Some materials (especially historical maps) did not meet the required accuracy, therefore, had to be supplemented by direct measurement in field. Created project allows comparison the development of urban historical core of Brno in various stages of the Middle Ages to the present. Layers contain the most important of all elements ranked classified according to purpose, style and time. Further was created the fly over the terrain by module ArcScene. The entire project was exported into a format PMF (Publish Map Format), which can be viewed by AcrReader. This application enables users work with all layers without license (free ware). The project was completed WMS capabilities, which allows the sharing of geographic information in the form of raster maps on the Internet. Allows you to connect to the workflow software (GIS, CAD) geographical data (maps, satellite images, ortho-photo, etc.) stored on other servers, in different formats (*.jpg, *.tif, *.png). Showing thematic geographic information (layer), or composite map (overlay multiple layers). This data is already related to a given coordinate system, which allows us to their correct interpretation.

Another contribution of this project is a creation of 3D model today non-existing baroque fortification of Špilberk castle. It will be historically the first 3D digital model of the citadel taking original shape the one the second half of 18th century. I believe the results of historical reconstruction of Špilberk castle and its surroundings will become a valuable contribution not only for institutes and people working in the field of medieval archeology, but it will also draw attention of general public.

The project is not completely closed, maps are prepared and depends only on the ideas of more effective treatment and complete, because each area, the building has a special history, characteristics that can be further described.
References


Biography of the author and photo

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