Chapter 58

Old Maps and its Usage with Contemporary Map in Environment of Geographical Information System (GIS)

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Abstract

Old historical maps made in 19th century or earlier are saved (stored) in museums, libraries and other institutions should be easily accessable to wide users. Bibliographic data, mostly used ISBD(CM), are accessable through internet databases. The pictures of the old historical maps are rarely accessable at internet databases or at digital media (CD, DVD, blue ray), more rarely they are accessable in a certain coordinate system in order to compare them with other contemporary maps in geographical information system (GIS). The main topic of the paper are old historical maps in usable coordinate system as data for geographical information system (GIS). In the article are touched a calibrations of old historical maps and theirs transformation in GIS with some examples and data analysis.

Keywords: old maps, coordinate system, calibration, transformation, geographical information system (GIS).

58.1 Introduction

Principles of temporal GIS discussed Husak (1994) in his master of science thesis. He gave there basic guidelines and skeleton for building temporal GIS: The third

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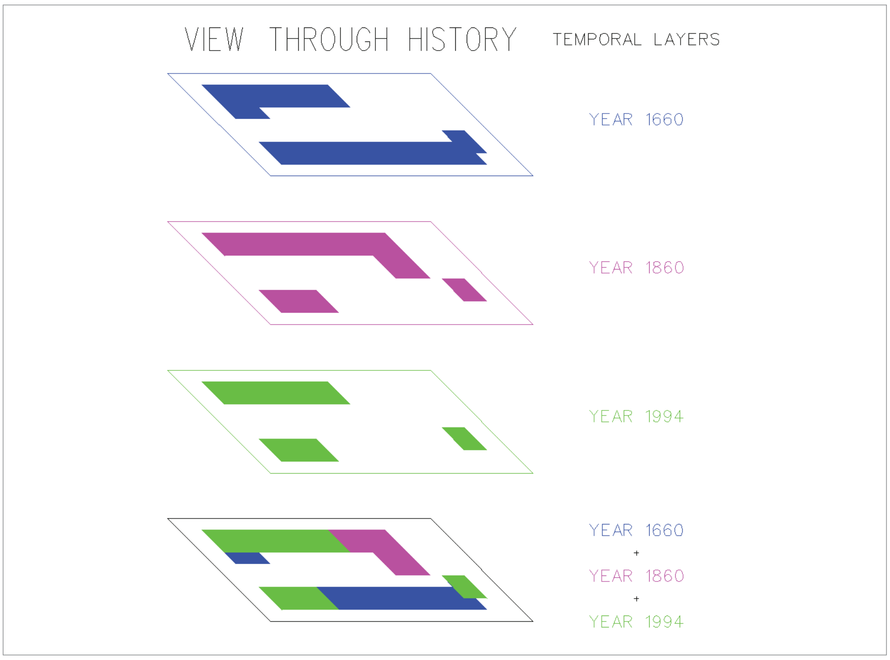

Fig. 58.1. Principle of temporal GIS (Husak 1994).

chapter Spatial and temporal concepts in GIS contains: spatio-temporal concepts in GIS, approach based on temporal layers and object approach and their comparison, map algebra with temporal layers (Figure 58.1), concept of time and temporal algebra, concepts of database modeling in temporal GIS. The principles of catching time and space are analyzed, types of time intervals including intervals with uncertain time limit. In the fourth chapter Technical solution describes hardware, software, lifeware, and orgware, the last uniting these four items (Figure 58.2).

The project area he researched is Varaždin centre (Figure 58.3). Rumsey & Williams (2002) gave very nice and instructive guidelines for building historical GIS.

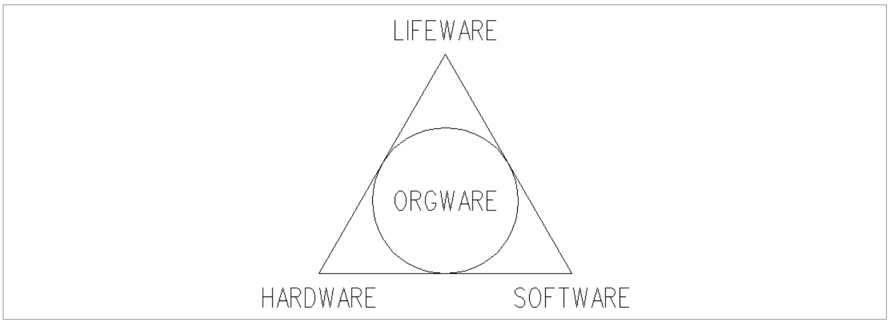

Fig. 58.2. Technical solution includes hardware, software, lifeware, and orgware.

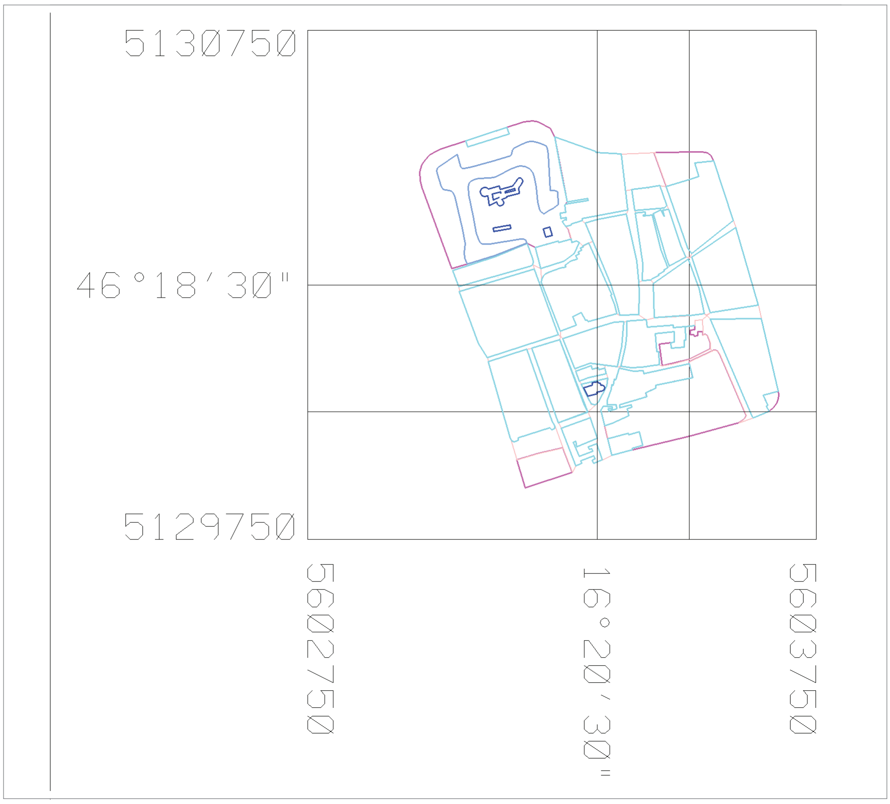

Fig. 58.3. The project area, Varaždin centre (Husak 1994).

58.2 Historical GIS

The paper is focused on using old maps in geographical information system (GIS) with contemporary map. For better understanding of the paper some definitions are alid down. The geographical information system (GIS) is a digital system that handles digital maps and attributes linked to them. A contemporary map is already digital map in state coordinate system (transformation is no needed). An old map in historical GIS should be digitized or scanned, then transformed using convenient transformation model that brings old map in state coordinate system supported by GIS (software). Map digitizing will be only shortly discussed in this paper because it is technical issue already known.

Husak (1994) used digitizing tablet for digitizing map photograph (Figure 58.4) in order to make vector drawing (Figure 58.5). These vector files were processed (sometimes two vector drawing were integrated into a whole) and then transformed.

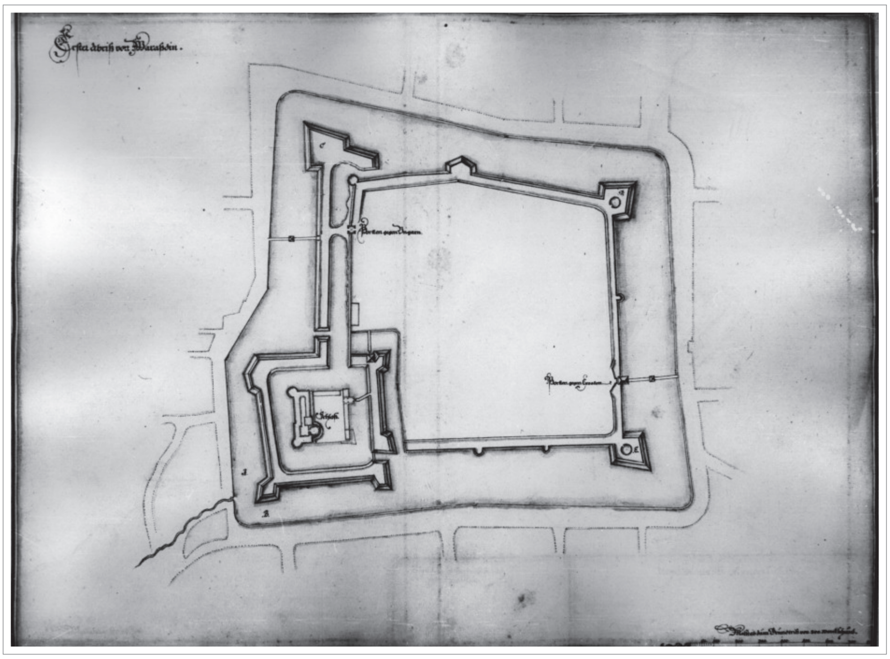

Fig. 58.4. Black and white photograph of map, later scanned.

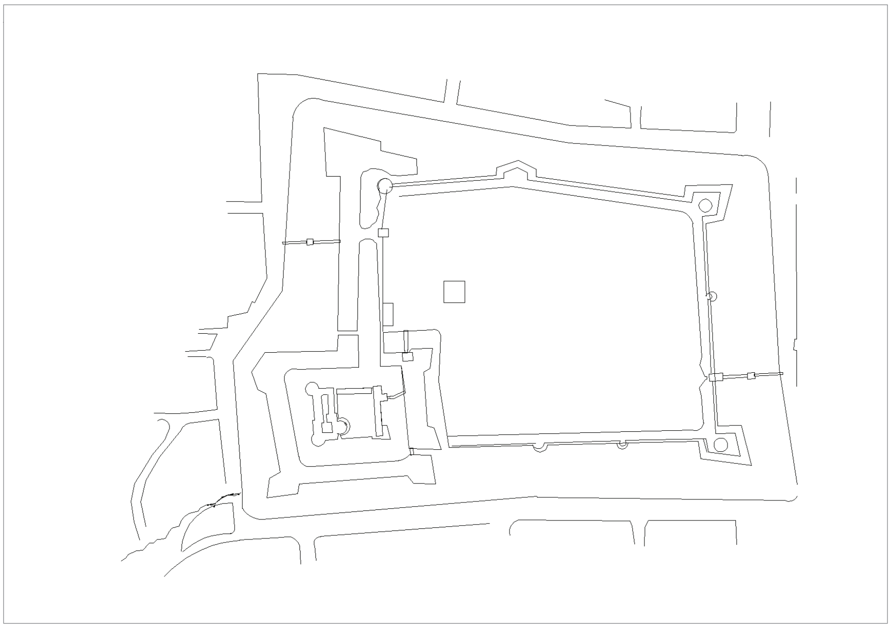

Fig. 58.5. Photograph of the map digitized on digitizing tablet resulting with vector drawing.

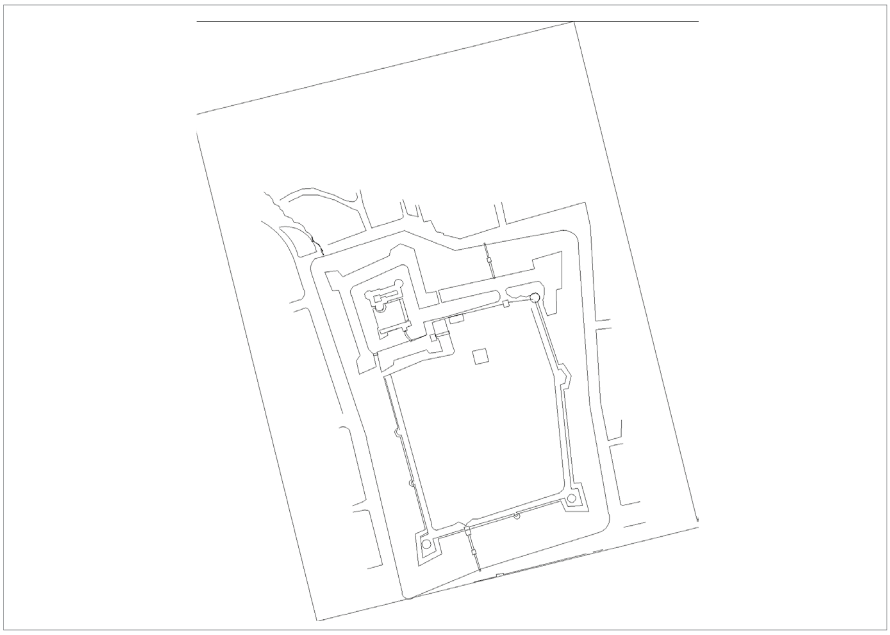

Fig. 58.6. Geo-referenced vector map: translated, rotated and scaled map.

Transformation model isn't used for old scanned maps. They were accesseble for on-screen viewing (as they are scanned, no transformation is performed, Figure 58.11) in suitable resolution like pictures (not in the state or any other coordinate system) and printing them at printer device.

Transformation models paid my attention, at the first sight the model looks simple. He noticed through practical research the following:

1. Simple models used on entire map (translation, scaling, and rotation) can be performed usually (Figure 58.6). Results are usable for global research. The most CAD editors support such simple transformation model.
2. For detailed comparison mentioned transformation model is not convenient.

Husak (1994) tried to bring an old map in state coordinate system in order to compare it with contemporary map (Figure 58.7, Figure 58.8, Figure 58.9, and Figure 58.10).

Models that are more complex should be performed by programming language (Autolisp, Autodesk, MDL applications, Bentley systems, etc.). Mentioned programs handle drawing.

Suggesting another way for transforming historic map into state coordinate system is converting drawing into drawing code file that saves semantics and stores coordinates. By choosing control points known at old map and at contemporary map (conditions), transformation should be performed on drawing code file of historical map. Actually, the coordinates of historic maps are processed, and then

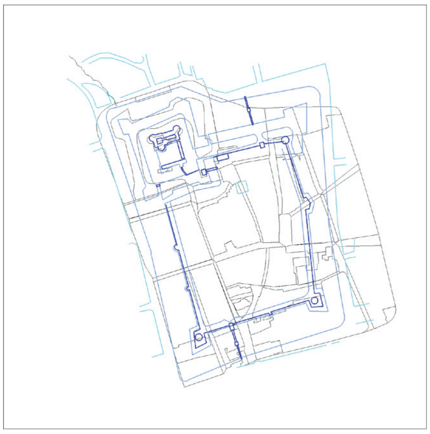

Fig. 58.7. Map overlaying.

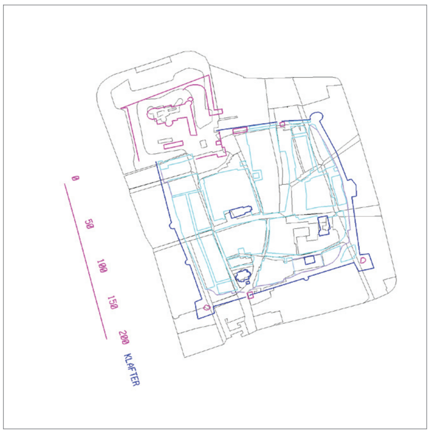

Fig. 58.8. Map overlaying.

Fig. 58.9. Map overlaying.

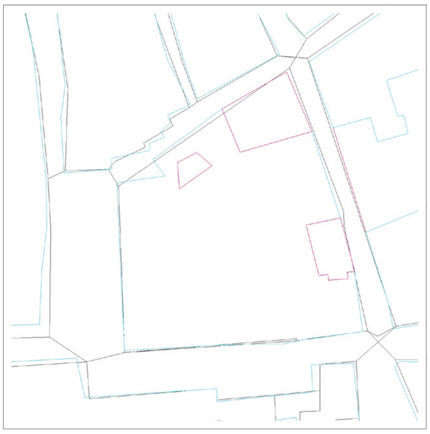

Fig. 58.10. Map overlaying: detail, city block.

the file should be converted back in drawing file format using the same semantics but new transformed coordinates. The result is new drawing file of historic map that matches at contemporary map used in the advance chosen conditions.

Integrating historical maps (Figure 58.4) in GIS to analyze the spatial information they contain, or layer them with other data, requires that the maps be geo-referenced (Figure 58.6). That is, selected control points on a scan of the original map must be aligned with their actual location, either by assigning geographical coordinates to each point, or by linking each point to its modern, accurate digital map. Once the control points are in place, one applies mathematical algorithms to warp the original map image to fit the chosen map projection as nearly as possible. Further adjustments can be done manually to try to find the best fit for all parts of the original map.

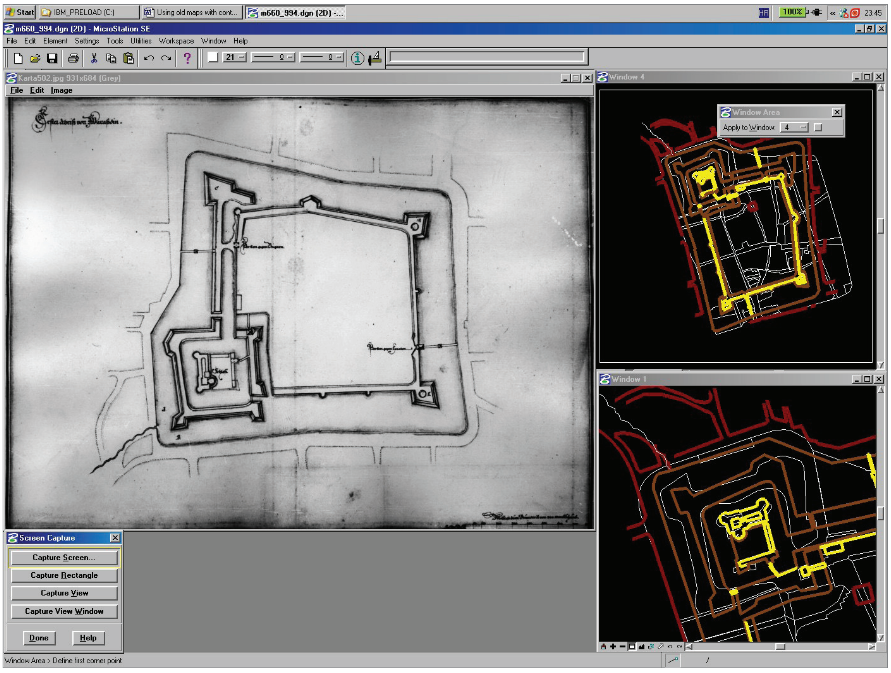

Fig. 58.11. Geo-referenced map in GIS environment with image of the original map in a GIS project.

The process is sometimes called rubber sheeting because it stretches and shrinks the map image like a thin sheet of rubber being pulled to fit a particular form.

It is almost impossible to perfectly align an old map to modern coordinate systems because mapping methods before the age of aerial photography often only very imprecisely represent scale, angle, distance, and direction. For most GIS projects, the value of the historical information on paper maps more than compensates for the residual error in their geo-referenced versions. What one should keep in mind is that geo-referencing does not necessarily improve a historical map or make it more accurate. In the course of changing the original map to make it amenable to digital integration, geo-referencing changes lines and shapes, the distance between objects, the map's aesthetics, and its value as a cultural artifact. One gains knowledge of the original while processing it for inclusion in GIS, but one also loses something if the original map is not represented for comparison with its actual size, proportions, and qualities. Ideally, researchers should include both the warped map and the scanned image of the original map in a GIS project or publication (Figure 58.11).

The impossibility of aligning historical maps perfectly with modern maps can itself yield historical information.

Small-scale historical maps are prone to greater error than large-scale maps. A large area of the earth's surface is harder to depict on a flat surface than a small area

Fig. 58.12. Map over a digital elevation model (Rumsey, Williams 2002).

such as a town (Figure 58.3). Large-scale maps are often more easily and accurately converted for use in GIS because they tend to have less egregious geographical errors. Maps drawn at a large scale may also have more unique local data to contribute, such as information on land ownership, the location of buildings, paths, and streams, and so forth.

Large-scale city maps can be wonderful sources for urban history, and adding one to a GIS can greatly increase its utility. Overlaying geo-referenced historical maps allows one to combine maps of greatly differing sizes and scales, such as did Husak (1994), in the same coordinate space.

Visual overlay of this type (vector over geo-referenced scanned map) is very useful in research and teaching. However, to query or measure spatial relationships between features, they must be lifted off historical maps and made into vector GIS layers. This is done by digitizing map features as points, lines and areas. Because few archives provide access to a digitizing tablet, scholars often choose to have historical maps scanned. They can then digitize the maps directly on the screen. Digitizing is far more time-consuming than geo-referencing, but it adds tremendously to the amount of data available for use in GIS.

By creating vector polygon features from the city blocks and building location on the example of Varaždin, we could join attribute data such as owner, land use category, date of construction, structure type, and architectural style for each building. All lots could be then queried for ownership and classified as either private or public. Different colors could then be used to signify public and private lots. Performing the same steps on a later map of the city and comparing the two sets of data would enable us to identify the changing patterns of public and private ownership and architectural style. The dynamics of urban change could be displayed through an animation of cartographic snapshots, that did Husak (1994) for Varaždin's built environment (project area Figure 58.3 and map overlaying pictures as a slide show).

On a number of the historical maps we have discussed, shading or hachures (fine black lines) suggested elevation. Using GIS, one can simulate topography more dramatically and vividly by using digital elevation models, which are raster surfaces composed of longitude (x), latitude (y), and elevation (z) coordinates. We already saw how draping the Wheelers survey's Yosemite map over a digital elevation model enhanced the historical map's depiction of the landscape (Figure 58.12). Verisimilitude can be powerful teaching tool when it helps students to understand the physical character of a past place.

One can also use digital models to explore the terrain that lies beneath the oceans.

To include historical maps in GIS for teaching and research, scholars will need access to high quality scanners or prepared digital images. We envisage a time in the near future when thousands of historical map images, some already geo-referenced and digitized as vector layers, will be available through shared networks and public access Web sites. Recent improvements in GIS software are resolving the problems of storing ever-larger spatial data sets by enabling users to access remotely stored data. The Library of Congress Geography (URL 1) and Map Division and a few other leading map collections in the United States and some other countries, for example Croatia (URL 2) have launched digital dissemination projects. From the Library of Congress Memory Web site, anyone can download map images and then zoom in to study their details on-screen as if with a powerful magnifying glass. National and university library in Zagreb, Croatia give us possibility to preview all available maps, but without downloading them.

Since the process of converting historical maps into GIS-compatible formats is time-consuming, resource intensive and expensive, it is doubly important that the burden be shared and the resulting resources aggregated. Each digitized map will require excellent, standard metadata to describe it and make it easy to retrieve.

58.3 Conclusion

The most maps in libraries are described using international bibliographic standard for cartographic material ISBD(CM) that contains basic information of a (historic) map. It is good starting point to find and collect maps for different libraries. There are many libraries in the world they have ISBD(CM) standard in use, but only two of them that I researched in detail have usable internet interface for vieng and downloading maps: Library of congress in Washington, USA (URL 1) and National and university library in Zagreb, Croatia (URL 2).

Transformation models are great opportunity for researchers that include use of GIS and application of mathematics. Here were displayed only tiny segment researched by Rumsey and Williams (2002) and Husak (1994).

Historical maps have great deal to offer GIS, and GIS brings new techniques to the analysis and display of historical maps. As historical maps becomes more sophisticated, it is certain that scholars will combine the two in creative ways yet to be imagined. Cartographers of days past would have been pleased to know that centuries later a new mapping technology is stimulating new interest in their work.

References

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URL 2: http://www.nsk.hr/Heritage.aspx?id=25, 22.11.2008.;13:58