Cartographic Reconstruction of Historic Settlement Development by Means of Modern Geodata

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Abstract. This paper reports about the development of a workflow which allows for the creation of digital vector-based, GIS-compatible maps depicting the historical states of a specific area. The City of Nidau in Switzerland is chosen as a test site. Current vector data and scanned historic maps are available for this task. Core idea is a stepwise backward deletion of vector objects in order to "retro-map" the historic states. This is in order to avoid a complete re-digitisation.

Keywords: Map production, "retro-mapping", historic maps

1. Introduction

The use of historic maps as well as terrestrial and aerial images is an established method in order to document and analyse the development of landscape and settlements for scientific purposes, but also for landscape and spatial planning. It is quite common to directly depict the original, digitised historic maps in technical reports and other publications in the framework of such projects. Many historic maps are now already available in scanned form and even as time series: The Swiss Siegfried Map (1:25'000 and 1:50'000) for instance is available in versions between 1870 and 1945, followed by the National Map Series (<= 1:25'000) until today. However, as mentioned, the maps are only available as geo-referenced raster images which make them basically suitable for visual use and comparison. For current mapping and planning projects there is a high demand for GIS-suitable, topologically correct, and if possible cartographically edited vector data. In order to be compatible with the current data types and formats, and to ease combined comparison and analysis, historic data should ideally also meet those structural and technical demands.

2. Aim of the Project, Test Area

It would therefore be interesting to develop a workflow which allows for the creation of digital vector-based, GIS-compatible maps depicting the historical states of a specific area. For these purposes the small City of Nidau, Canton of Berne, Switzerland, was chosen. With 4500 inhabitants/km^2 Nidau represents one of the most densely populated areas in Switzerland. It can be compared to large cities such as Zurich. Since the late 1970ies, almost the entire area of Nidau is overbuilt, new building lots can only be opened by removing older buildings. On historic maps it can therefore be seen that the face of Nidau did not change much in the last 30 years, however, the changes in the 20th century were dramatic. It would be interesting to document this development with a series of graphically comparable maps depicting typical states in the history of Nidau. This project was carried out at ETH Zurich in the framework of a Master's project thesis by Christian Lorenz, under supervision of Lorenz Hurni and Lorenzo Oleggini.

The aims of the presented project are as follows:

1.) Derivation of a map series 1:25'000 depicting four situations of the development of the small City of Nidau, Canton of Berne, Switzerland;
2.) Use of ArcGIS for geodata preparation, structuring and management; use of OCAD Cartographic software for symbolisation of data;
3.) Use of the so-called Pagan-Map (1798), Siegfried-Map and the current Swiss National Map Series;
4.) The most innovative core of the project aims at using modern vector-based, generalised GIS data for deriving the historic states by deletion and modification of geo-objects in an efficient way.

3. Related Projects

A number of projects with a similar aim were carried out in the past by various authors. In the "Swiss World Atlas" (SWA 2010), the official Swiss school atlas, as well as in a so called "time series" (Rickenbacher 2011), a series of topographical large scale map extracts of specific areas were remapped. Rickenbacher puts these maps in the context of the Swiss Geoinformation law from 2008 which commits producers of geodata to publish them in useful form to provide access to the public. This encompasses not only the current National Map Series, but also the historic sheets and other precursor maps such as the 19th century Dufour Map and the Siegfried Map. Rickenbacher calls thes maps "Standardised maps" and the concept "retro-

mapping". However, the map examples in the Swiss World atlas and by Rickenbacher were created using conventional cartographic production technologies, i.e. the maps were manually digitised and symbolised using graphics software like Adobe Illustrator. They make use of symbolised vector data, but topology, fitness for GIS use and a semi-automated derivation are not ensured. Rickenbacher estimates the time needed to establish a 16-part nation-wide time series map to 400 person years, which is hardly fundable. Nevertheless, such a work could maybe speeded-up by applying (semi-)automatic computer-aided methods. Besides mapping Nidau, this was the other main reason to carry out this project.

4. Data and Methods

Due to the limited time available, a total of four states were selected for retro-mapping. For each state, specific map data as a basic source was selected.

Fortunately, from the beginning of the project, a suitable data set was available: VECTOR25 (swisstopo 2013) was produced by the Swiss Federal Office of Topography swisstopo by vectorizing the National Map Series 1:25'000. This latest dataset represents the state of 2005.

The two Swiss National Map Series 1:25'000 sheets "Chasseral" (1956) and "Büren an der Aare" (1957) (swisstopo 2013a) depict the situation during the rapid construction phase after World War II.

The two Siegfried Map sheets "Orvin" (1872) and "Biel" (1876) (swisstopo 2013b) document the situation after the so-called Jura Water Correction which led to a lowering of the level of the nearby lake Biel and the establishment of a number of stream bypasses in the region.

Finally, for the first state, the map of Nidau of 1794 by Samuel Pagan was chosen. It depicts however only the municipal territory of Nidau without the surroundings.

VECTOR25 consists of all thematic layers of the National Map Series 1:25'000 (point, linear and area elements). Based on these vector elements and on the scanned historic maps, the historic situations could now be re-established by a stepwise backward deletion of objects. This is the core idea of this project in order to avoid a complete re-digitization. In some cases, however, amendments to buildings needed to be digitized in a more demanding manual editing and also no longer existing objects were re-digitized manually. This work was carried out in ArcGIS. *Figure 1* shows an overlay of edited VECTOR25 data (already in the state of 1956/57) and the Siegfried map of 1872/76. All objects in VECTOR25 which are not present

in the preceding state were deleted. No longer existing objects needed to be re-digitised, as said. Some specific editorial work was done for extensions of buildings. This procedure was repeated for every state and a file copy of every year covered was kept.

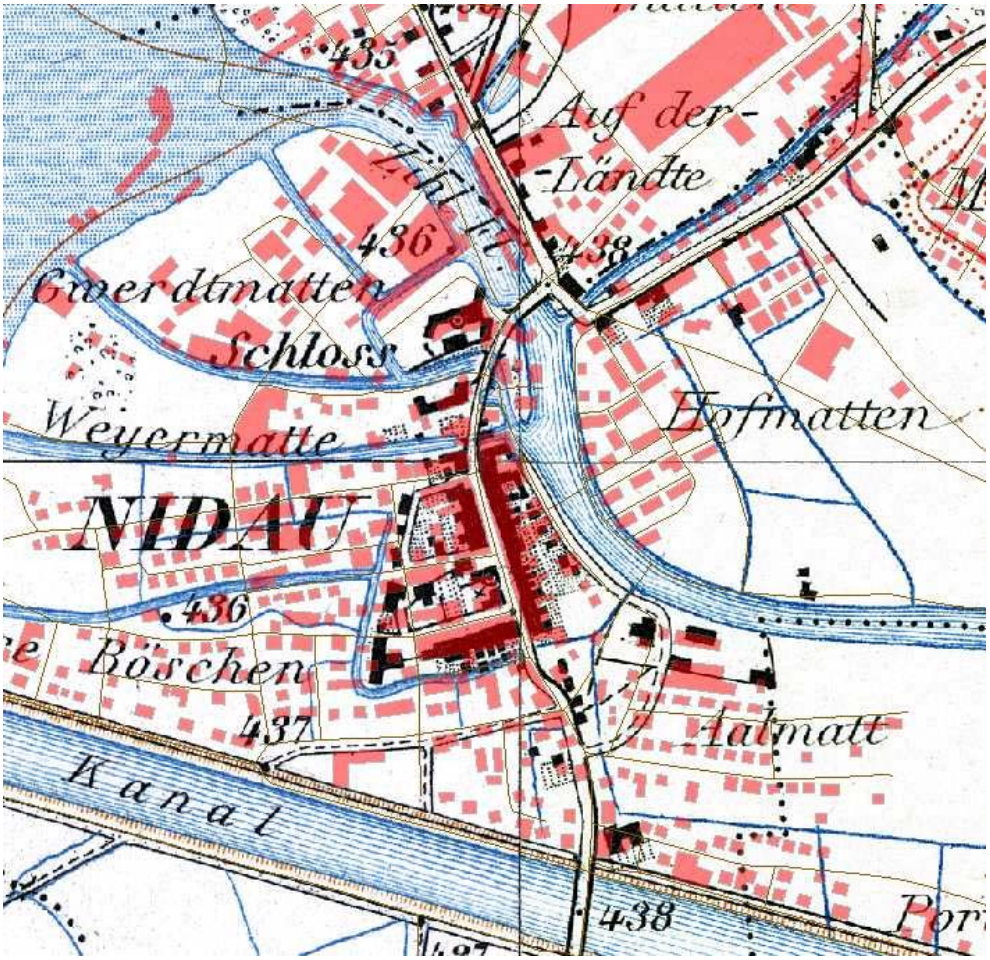

Figure 1. Overlay of edited VECTOR25 data (light red; already in the state of 1956/57) and the Siegfried map of 1872/76.

During the development of the workflow and the setting up of the various map files, the following major technological and methodological challenges were encountered: Despite the use of the WYSIWYG-based software OCAD, some graphical design problems such as special road forks were symbolised improperly; however the problems could be solved by altering the original GIS-file in ARCGIS without losing topological correctness. Another challenge was the occurrence of local deformations in the historic maps which could be solved by local adaptation/transformation.

Currently we are aiming at further improving and automatizing the workflow, e.g. by applying pattern recognition algorithms for detecting historic objects and matching them with todays (vector-based) objects.

The four files were then imported in the software OCAD (OCAD 2013). For each object type, its graphical representation (colour, line weight, filling, etc.) was defined. OCAD is a Swiss software which was originally developed for the production of orienteering maps. In the later versions, the software was extended by capabilities to produce maps with any user-defined symbols. For the time series map of Nidau, the slightly modified symbols of the Swiss National Maps are used, since VECTOR25 is based on this map. It is intended that most graphical problems are already solved in the GIS data set in order to maintain the correct topology. However, it appears that some special cases like road forks or the border between the lake and the river can only be solved in OCAD after visual inspection and manual editing.

5. Results

As a result of this work, a series of four maps 1:25'000 with identical symbolisation showing Nidau between 1794 and 2005 is now available. Data was also converted into Adobe Illustrator format, by maintaining the ArcGIS and OCAD layers. *Figures 2–5* show the maps of the four states.

6. Discussion, Outlook

The developed workflow has led to a series of uniformly symbolised maps 1:25'000 of the City of Nidau which allows for detailed analysis and comparison of its historic developments. Especially the changes due to a regulation of the nearby Lake of Biel can be impressively visualised (*Figure 6*).

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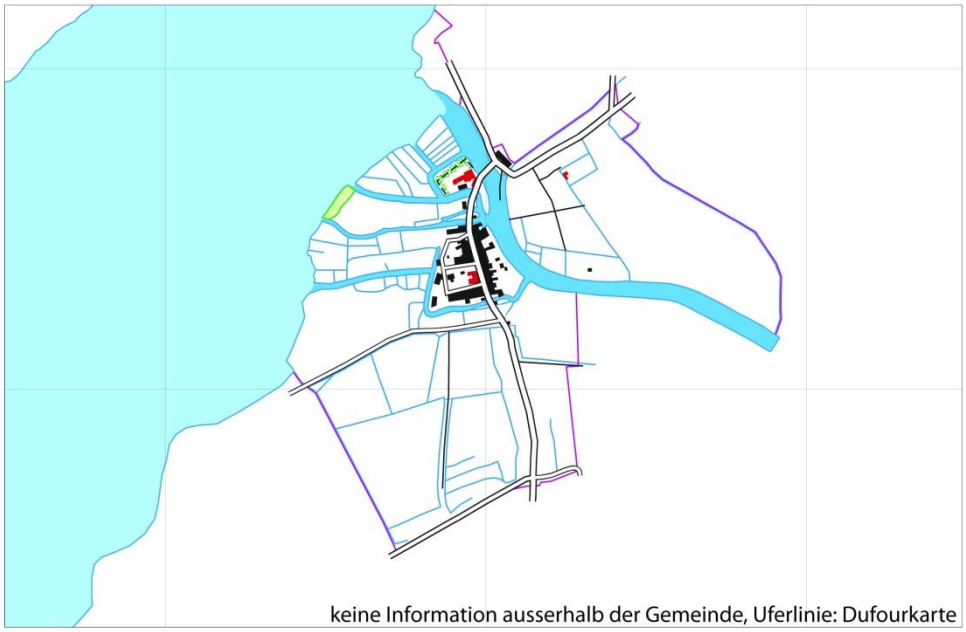

Figure 2. Nidau 1794 (based on Pagan's map).

Figure 3. Nidau 1872/76 (based on Siegfried map).

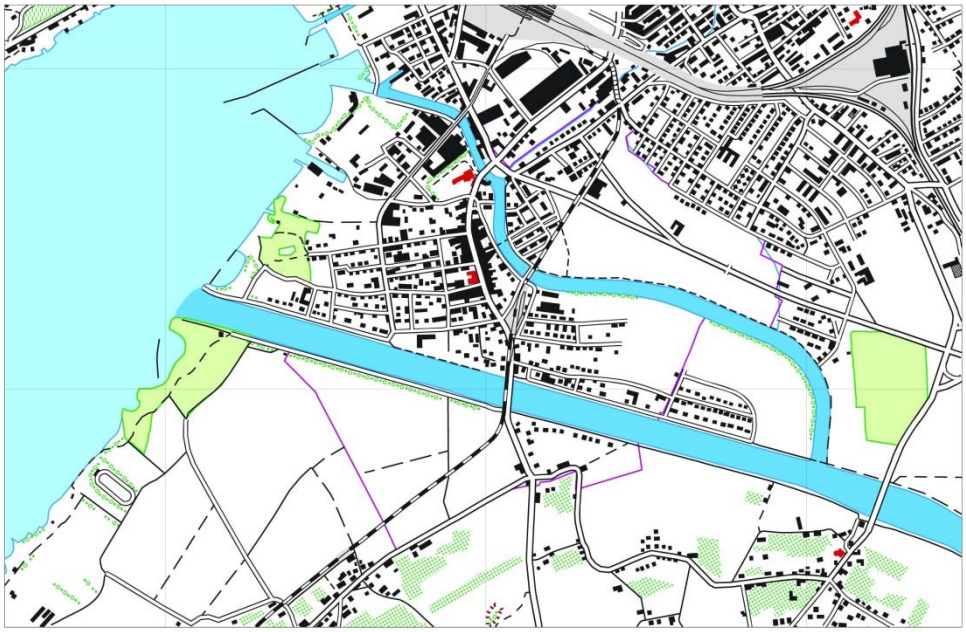

Figure 4. Nidau 1956/57 (based Swiss National Map Series 1:25'000).

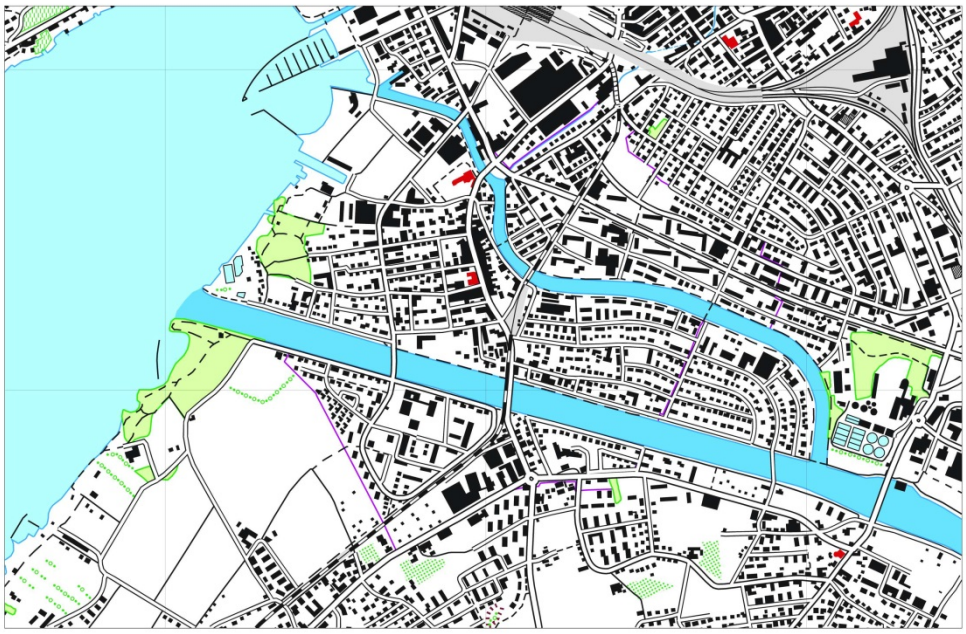

Figure 5. Nidau 2005 (based on VECTOR25).

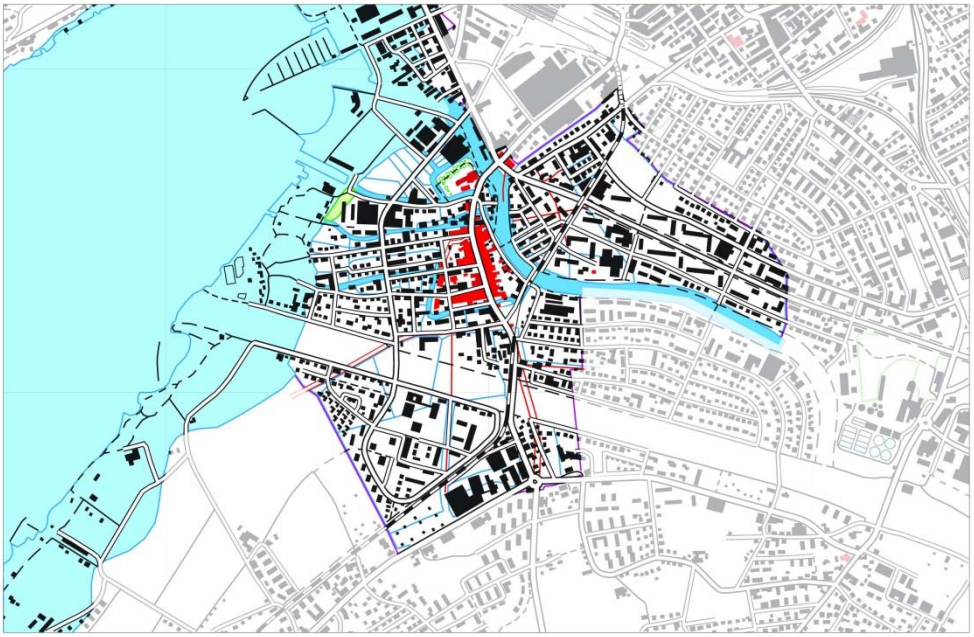

Figure 6. Overlay of Hydrography (lake, rivers, canals) of 1794 with the situation (buildings, roads, lake shore) of 2005. Historic buildings are in red.

References

OCAD (2013) Website. http://www.ocad.com. Accessed 15 April 2013.

Rickenbacher M (2011) Zeitreihen – eine neue Herausforderung für das Bundesamt für Landestopografie. Cartographica Helvetica 44: 35–41

SWA (2011): Schweizer Weltatlas. Konferenz der Kantonalen Erziehungsdirektoren.

Swisstopo (2013) VECTOR25 project documentation on swisstopo website. http://www.swisstopo.admin.ch/internet/swisstopo/en/home/products/landscape/vector25.html. Accessed 15 April 2013.

Swisstopo (2013a) Swiss National Map Series documentation on swisstopo site. http://www.swisstopo.admin.ch/internet/swisstopo/en/home/products/maps/national/25.html. Accessed 15 April 2013.

Swisstopo (2013b) Siegfried map documentation on swisstopo website. http://www.swisstopo.admin.ch/internet/swisstopo/en/home/products/maps/hist/siegfried.html

The maps depicted are based on the data set VECTOR25. They are reproduced by permission of swisstopo (JA100120).