Exploring and Mapping the Danube: Reading a Hydrographical Map of Buda and Pest (1833)

Zsolt Györö Török and Domonkos Hillier

Abstract The systematic survey of the waters in Hungary started as a late Enlightenment project in the early nineteenth century when hydrographic maps were produced by a new generation of civil engineers. László Vörös (1790–1860), who studied at the *Institutum Geometricum et Hydrotechnicum* (founded 1782), the world's first university-level civil engineering school in Pest-Buda, worked as surveyor, engineer, engraver and map maker for the Danube Mapping Project from 1828. The mapping of the river's section between Buda and Pest became a priority task because of the regular floods threatening the developing and expanding sister cities. Vörös was commissioned to construct a detailed and accurate map from the available topographic and hydrographic data. His large, detailed and elegant map was lithographed by the author and was published in 1833 with the support of the Bridge Builder's Union. Vörös' early thematic map is considered as a milestone in the history of Hungarian cartography and the *Széchenyi Chain Bridge* (1849), a symbol of the Hungarian capital, is the evidence for its contemporary importance. The interpretation of the map's rich data content is very difficult, especially for the modern reader, as it was produced by a specific, hydrographic mapping mode, which cannot be fully understood in the topographic paradigm. In this paper we suggest an historical approach to explore the map's thematic layer and interpret the entire work. By putting this remarkable map into contemporary technical, cultural and social contexts (discourses) its numeric data become meaningful. Modern cartographic visualizations facilitate the interactive exploration of this early map and make it intelligible for the novice or expert map reader. Visualizations of the spatio-temporal database are effective in a cognitively relevant context. In our opinion the successful realization of historical visualizations, beyond knowledge and skills of modern geoinformation technology, require the expertise of the historian of cartography.

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1 Hungarian Waters

On an early nineteenth century map of the Kingdom of Hungary the central part of country, the Great Hungarian Plain, was a huge flat area with abundant hydrography: apart from the two main rivers, the Danube and the Tisza, thousands of smaller rivers, creeks and waterflows, as well as lakes, swamps and marshes indicated the importance of water in the physical geography of the region. In the centuries of the devastating Turkish Wars, vast regions became deserted. After the reoccupation of the territory in the early eighteenth century by the returning Hungarians, other nationalities such as Slovak, German and Romanian settlers migrated here and created a multi-ethnic population with a characteristic settlement pattern of large villages and market towns in the plain. The increasing population and the extending agricultural production required more and more cultivated land. The work the generations of Hungarian civil engineers carried out since the Age of Reforms in the early nineteenth century can be better appreciated if one considers the earlier hydrographic conditions, i.e., the state before systematic water regulations started (Fig. 1).

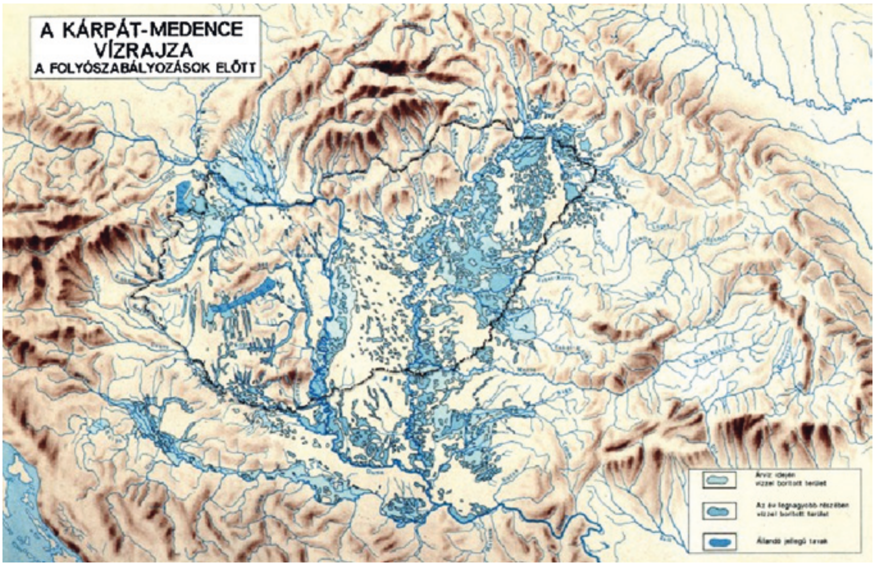

Fig. 1 The hydrography of the Carpathian Basin before water regulations (early nineteenth century) on the map published by the Hydrographic Institute, Budapest, 1938 (*Courtesy* of Department of Cartography and Geoinformatics, Eötvös Loránd University)

2 Enlightenment Cartography in Hungary

The Habsburg government in Vienna realized the importance of water regulations in the modernization of Hungary. The existing maps of the country were unsuitable for planning purposes, so survey and mapping became a priority task already for the first civilian engineer of the Hungarian Chamber.

Samuel Mikoviny, after his studies at the University of Altdorf-Nuremberg and his engineering activity in the capital city of the Kingdom of Hungary Pozsony—Pressburg (Bratislava, Slovakia), was nominated as 'court geometer' in 1735. As the first professor of the mining school in Selmecbánya/Schemnitz (Banska Stiavnica), he was commissioned with the topographic survey and mapping of the counties of Hungary. His pioneer county maps, only partly published, were based on a geometrical and astronomical basis, using triangulation and astronomical observations.

In 1732 Mikoviny published a small booklet, *Epistola*, with the description of the principles of topographic mapping to introduce Enlightenment cartography in Central Europe (Török 2003). The novelty of his new mapping paradigm, how he explains it in his introduction to his maps in 1736, was that his maps were constructed on a measurement and geometrical basis. In the eighteenth century his former students followed in his footsteps, and the more accurate and detailed new maps made the old '*geographical dreams*' (Mikoviny 1735) gradually obsolete. Despite his versatility and continuous occupation with multiple tasks, the priority of water regulation in the period is best exemplified by his fate. In 1750 Mikoviny, at that time the sole civil engineer in the Kingdom of Hungary, worked on the regulation of the river Vág in Upper Hungary (Slovakia), caught a cold during this survey and died on his way home.

By the end of the eighteenth century, the former capital of the medieval Kingdom of Hungary became once again the centre of state administration. This was indicated by a royal decree in 1777 which ordered the Jesuit University founded in Nagyszombat (Trnava, Slovakia) in 1635, to move to Buda. At the relocated Royal University a special department was established in 1782. The *Institutum Geometricum et Hydrographicum* became the first institution in the world for the university level education of civil engineers. After the first years in Buda, the institution moved to a building near to the present University Library of the Eötvös Loránd University, in the city of Pest.

3 Pest-Buda and the Danube Mapping Project

In the early nineteenth century the two sister cities, Buda and Pest were situated on the opposite banks of the Danube, the largest river in Central Europe. Buda with its German population on the hilly side was very different to the Hungarian Pest at the edge of the Great Plain. The two cities were connected by ferries and a temporary boat bridge. Their capacity was, however, limited. With the accelerating development of Pest, where building sites were available, the idea of constructing a permanent bridge became more and more popular.

The rapid development in the first decades of the nineteenth century resulted in more than one thousand new houses, the majority built of wood and air-dried bricks without stable foundations. As the constructions were not water resistant, high water or floods were very dangerous in the densely populated city on the river's left bank. In the past the most devastating were the icy floods, for example the one of 1775, when the level of the water reached its measured maximum of 795 cm above the mean water level. Unfortunately, the raising of the embankment above this level and the blocking of the *Rákos* channel that endangered the suburbs could not solve the problem. From the 1820s onwards several hydrographic experts alerted the City Council that the flood was not only caused by high water. In winter time downstream from Pest-Buda, where the river bed suddenly became wide and shallow, the heavy pack-ice piled up. The ice 'plug' filled the whole river bed and blocked the stream. The river was frozen for 99 days in the winter of 1829–1830, but the water level rose only four metres, because the pack-ice started to move downstream earlier in the southern than in the northern section and, consequently, there was no ice barrier.

Systematic hydrographic surveys of the rivers in Hungary started in the southern part of the Great Plain. After the separate hydrographic maps, constructed by chartered civilian engineers of the counties. *Mátyás Huszár* started the survey of the river Körös in South-Eastern Hungary in 1818. This was a pilot work: Huszár devised methods of the meticulous survey and his reports included detailed practical instructions regarding the complex survey work. He also trained his staff including, among others, the young engineer *Pál Vásárhelyi*, who is the best known representative of nineteenth century Hungarian engineers. In 1822 Huszár was commissioned to direct the hydrographic survey and mapping of the Danube, the famous *Danube Mapping Project* (in German: Donau Mappierung, in Hungarian: Duna Mappáció) (Deák 2009).

4 Lászó Vörös, Carpenter and Cartographer

László Vörös was born in Hódmezővásárhely, Hungary in 1790 in an impoverished noble family with eight children. Due to the large family's financial difficulties he had to work for his living and for years he worked as his father's helper as a carpenter (Bendefy 1974) (Fig. 2).

Although he was a talented boy, he was already 24 years old when he could enrol in the famous College of the Reformed Church in Debrecen. Most probably he became interested in geography and cartography at this time. A decade earlier the students of the college, instructed by the Oxford-graduated professor, *Ézsaiás Budai*, collaborated on the publication of the first Hungarian school atlases, so Vörös could learn the elements of map construction and the technique of copperplate engraving here.

After working as a civil engineer for a short period, he was invited to join the survey staff of *Mátyás Huszár*, and from 1822 he worked as a surveyor on the Körös

Fig. 2 Aquarell portrait of László Vörös painted by György Dongó in 1958 (*Courtesy* Department of Cartography and Geoinformatics, Eötvös Loránd University, Budapest)

rivers. After 2 years of hard word, when Huszár became the director of the Danube Mapping, Vörös followed him. In Pest-Buda he had the opportunity to enrol in the *Institutum Geometricum*, attend the lectures and in the end obtain a degree. In the city he became acquainted with the well-knownt engraver and map publisher *Ferenc Karacs*, who helped and trained him and commissioned him with engraving work to enable him to earn some extra money. László Vörös graduated from the *Institutum* in 1828 and, as a young engineer, was immediately ordered to the Danube Mapping Project. This is the period when he started working on his important thematic map representing the section of the river at Pest and Buda (Török 2007).

After the dangerous floods of the 1820s, the *Governor's Council* realized the urgency of water regulation and flood control and commissioned Huszár and his staff of engineers with the survey. To compile his map Vörös could use earlier maps of the city engineers and he also had access to the survey documents of the Danube Mapping in which he was personally involved. Unfortunately, in 1829 the director of the project was removed and the authorities nominated a new director to the project. Huszár, whose anti-German, patriotic attitude was not tolerated, had to leave just as the great work started to bear fruits. This outcome led to great indignation among his colleagues and students and, to protest against this unfair treatment, Vörös also resigned from his position. The consequences of this noble decision were serious as he could no longer find a proper job where he could use his exceptional talents and his career suffered.

However, as a deputy county engineer he would continue his mapping project and, as an extraordinary case, he not only constructed but also engraved the stones for his large lithographic map. During this difficult period in his life news about the map in preparation reached the circles of the Hungarian Reformist movement in Pest-Buda. Count *István Széchenyi*, fascinated by the modernization of contemporary Britain, was the most prominent representative of this national movement aiming at the development of the country. Now he was already involved in the discussions on the permanent bridge across the Danube and, due to the relevance of the hydrographic map, the count and his circle became interested. In 1832 Vörös published two short reports on the advancement of the map in the journals of the reformists (Vörös 1833a, b).

The reason why his, now private, mapping project generated such huge interest was not just the initial task of flood control, but also the preparations for the construction of a permanent bridge connecting Pest and Buda. Vörös had been working on a map that was needed by the experts and for the public discussion of the possibilities. This explains why the Bridge Construction Society welcomed the Hungarian engineer who was seeking sponsorship. The society, actually a group of investors, became the publisher of László Vörös great work, '*The Topographic and Hydrographic Map of the free Royal Cities of Buda and Pest*', printed in 1833 (Fig. 3).

5 A General and a Thematic Map?

This map of the Danube was the first cartographic work in Hungary which had the newly coined Hungarian word, '*térkép*' (map), a neologism, in its title. In other words, this was actually the first 'map' to be made in this country. As the early nineteenth century is the formation period of modern cartography, the conceptual development the title of Vörös' map reflects, deserves special attention. The author included both '*ground plan*' and '*hydrographic*' as the subjects of his work, suggesting that he clearly realized his work is different from other urban plans or topographic maps of the city (Fig. 4).

At that time, in the first third of the nineteenth century, the modern concept of the thematic map did not yet exist. On the other hand, maps with thematic content and data based on scientific data collection had already appeared much earlier as a typical Enlightenment phenomenon (Török 2006).

Anyhow, in 1832 it was apparently acceptable to both the maker and the public to include rich *hydrographic* content in a *general* or reference map. It should be observed that in the case of this map of Pest-Buda, the additional, special content, the representation of the Danube, did not cause many graphic problems, because the thematic information appeared actually on the river, which was left almost blank on other contemporary maps. Vörös simply used this part of the graphic space to include the vast amount of hydrographic data he collected. The two content layers of his map were *spatially* separated and visual hierarchy was not a design problem.

As the additional thematic content was the result of a hydrographic survey, the *quantitative* data on the map was represented according to the methods of the engineers' plans, and was only meaningful for the professional. This is not surprising

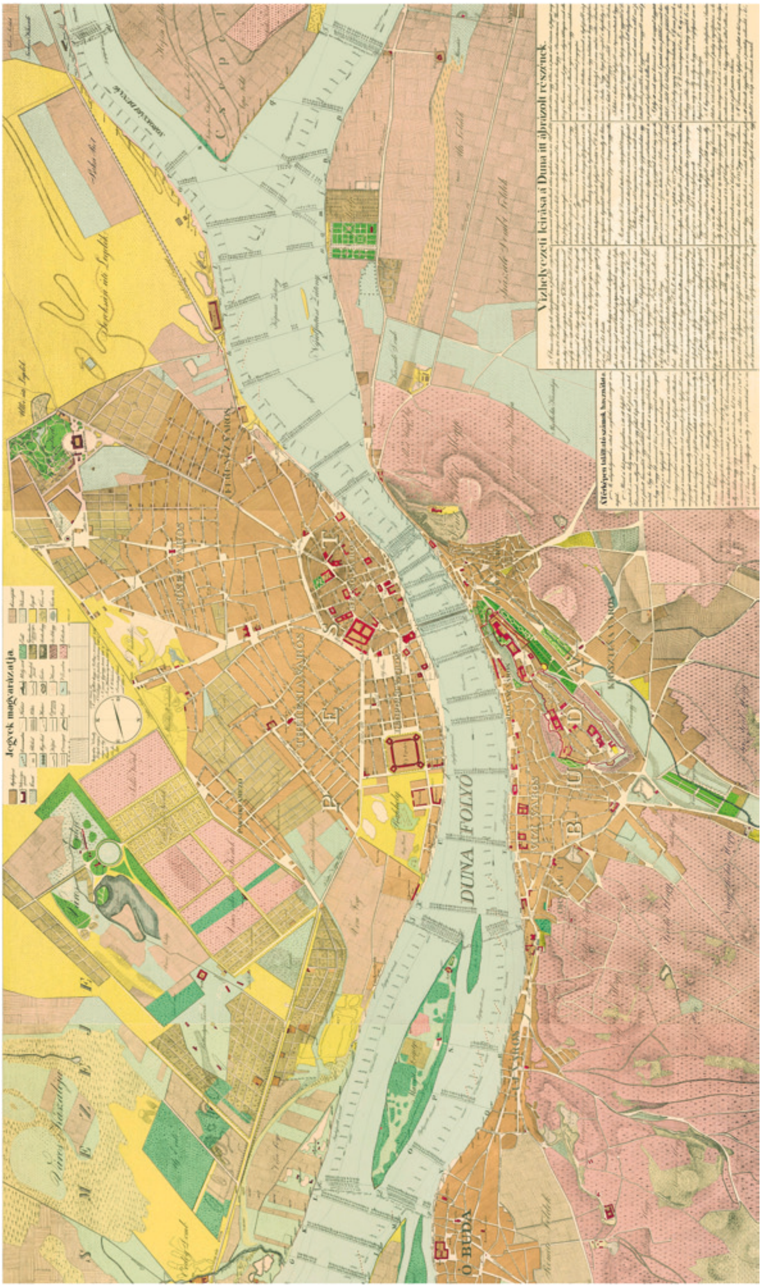

Fig. 3 Detail of László Vörös' map. Pest, 1833. Handcolored litograph. Size: 1745 × 855 mm (*Courtesy* Department of Cartography and Geoinformatics, Eötvös Loránd University, Budapest)

Fig. 4 A reference and thematic map: the descriptive title of the Danube map emphasized its duplicate subjects. Detail of Vörös' 1833 map

since initially Vörös constructed his map for planning purposes, originally for the regulation of the river. After 1829, when he left the Danube project, his task and target group changed and, as we can see above, the map was eventually published for the construction of a permanent bridge.

The usability issue, very rarely tackled in historical context, is neither ignored, but for practical reasons, nor emphasized by the map maker. In his 1833 journal article Vörös proudly refers to the appreciation of the British engineers, who found the earlier version of his map perfectly suitable for *planning* (Vörös 1833a: 373). On the other hand, for the *public*, the average contemporary Hungarian map reader, the data content of the map remained inaccessible. On the other hand, the additional information was highly appreciated and welcomed, as it created the image of professionalism and expertise. The contemporary advertisement of the map mentioned its overall *decorative* function, and the large and handcoloured copies were recommended 'to decorate the walls of palaces and libraries' (Kaján 1988: 54) (Fig. 5).

The fine lithography is still considered as a highly decorative item, and in 1986 its colour facsimile was published by Földmérési Intézet. Among the known copies of this rare work there is a remarkable example, today preserved in the collection of the *Danube Museum*, Esztergom. The information about its previous ownership by the Director of the former Hydrographic Office in Budapest in the first half of the twentieth century suggests that this was a special, presentation copy. The original letter in the archives of the Danube Museum, written by Vörös in late August 1832 to Count Széchenyi refers to a special copy of the map, sent to Széchenyi as gift immediately after publication. When we inspected the map in the museum we discovered the blind stamp of László Vörös in the bottom left corner, which is the evidence that this print was approved by the maker. It is not entirely speculative if we consider the possibility that the map which is now in the museum's collection

Fig. 5 Dr András Deák in front of the presentation copy of the 1833 map in the Danube Museum, Esztergom, Hungary. Photo by Zsolt G. Török

could once have been owned by Count Széchenyi. It is interesting to mention in this context that the same copy was used to decorate Count Széchenyi's study in the Hungarian film '*Bridgeman'* (2002), a biography of Count Széchenyi.

Vörös well understood the problems of his map's interpretation. In the bottom right corner of the map he placed a longer explanation, a detailed description of the map's content. Although written in Hungarian, the interpretation of the professional terms is rather difficult for even the modern Hungarian expert. Since the publication of the map we not only use the metric system, but, as the nineteenth century methods of survey and mapping are no longer in use, without the historical context it is really difficult to understand the conceptual framework. Although the map includes a vast amount of *quantitative* data, which make it especially suitable for modern geovisualization and analysis, without the knowledge of the historian of cartography these cannot be interpreted. The map calls for this kind of expertise which is necessary to establish the geodetic datum used by the author. Without knowing the reference system, the georeferencing of the map remains impossible. This explains why we used modern visualization methods to make both the base map and the thematic layer of this old map available for modern readers only after the study of the map and the contexts of its creation.

6 Historical Cartographic Visualization

The visualization of *historical data* is different from the generally known methods of cartographic visualization. In the case of early maps the problem is how to provide modern map readers with a historic view, as we want them to be able to interpret events or processes in the past. Compared to static cartographic displays based on a database, interactive or web visualization offer many more opportunities for the examination of historical data in a cognitively relevant context. Due to the users' interactive collaboration with the system, the possibilities are theoretically endless.

On the map of László Vörös the most important and immediately striking feature is its extraordinary rich data content. The large scale of the map, the origin of the data and the aim of the map all resulted in much quantitative information, which makes the work especially suitable for building a relational database and modern, computer based processing and display.

The most difficult problem was the, nowadays, unusual height representation. Vörös did not use our modern reference system, but a totally different representation of heights or depths (Bendefy 1958). He adopted an arbitrary level and from this level he would calculate his values. Moreover, the depth of the water is given in non-metric units (fathoms). Before designing cartographic visualizations, we had to georeference Vörös's map, which was not a simple task. The map has no information regarding its projection, only a scale is given. Starting from its numeric scale (1:7,200) we considered several possibilities. In the end we arrived at a known, and amongst nineteenth century hydrographers a rather popular projection, the Cassini-Soldner projection. Using its characteristics to georeference the map, we reached an accurate result with a mean positional error of c. 10–20 cm.

The GIS data processing and data clustering raised special problems, as we had to answer more difficult questions regarding the datum the map maker used, and solve technical problems regarding the handling of huge image files. The preparatory work summarized above was indispensable for the construction of the coherent database, and as a result we created the next four different visualizations which we introduce below.

7 Time Travel with a Nineteenth Century Map of Budapest

The visualization of the map with the use of the Google Earth webpage plug-in first of all emphasizes visual power and propaganda. This visualization actually compares Vörös' map with the urban conditions of today. On the known map and satellite image, after turning on the 3D buildings layer, the changes of the river (Danube) and the transformation of the built-in area in the last one and half centuries are well demonstrated.

When viewing the Southern Buda area (today Lágymányos) and the present location of the campus of the Eötvös Loránd University, a dramatic change visible. The causes of the transformation of the riverbed were river control and the embankment of the city. With this technology, with Vörös' map on a separate layer, we can show modern buildings and the present road network. The two points of temporal reference are 1833 and 2012. With this visualization the two dates can be shown simultaneously, and the river changes appear spectacularly, while the differences can be easily monitored. The interactivity of the visualization is made possible by the usual Google Earth navigation options, and also by the additional thematic layers, integrated into the webpage. With custom buttons on the webpage one can turn on and off layers, e.g., the terrain model, the road network or the three-dimensional visualization of the buildings. This application is prepared for the general public; the old map as a layer on the virtual globe provides a unique viewing experience for all those interested (Fig. 6).

8 Visual Analysis

Different considerations led to the creation of another, also Google-based visualization. The aim of this realization is that the previously interpreted and GIS software processed riverbed and other data are present in vector format in an easy-to-understand way. This visualization opportunity focused on detailed data display, for deeper understanding and exploration of the more detailed information. Perhaps it is less spectacular than the previous one, but it could seriously assist the specialist to interpret the contents of the map, and provides an effective tool for visual analysis.

On the original cartographic document there are heights, water depths and additional hydrographical data. These data classes were classified first and in this interpreted form displayed in the system. The vector data structure of point, line and surface objects are all related to attribute data. With the interpreted information the content of the display expanded. As a result of data clustering, their high accuracy, the different data types are marked with different graphic objects. The graphics are

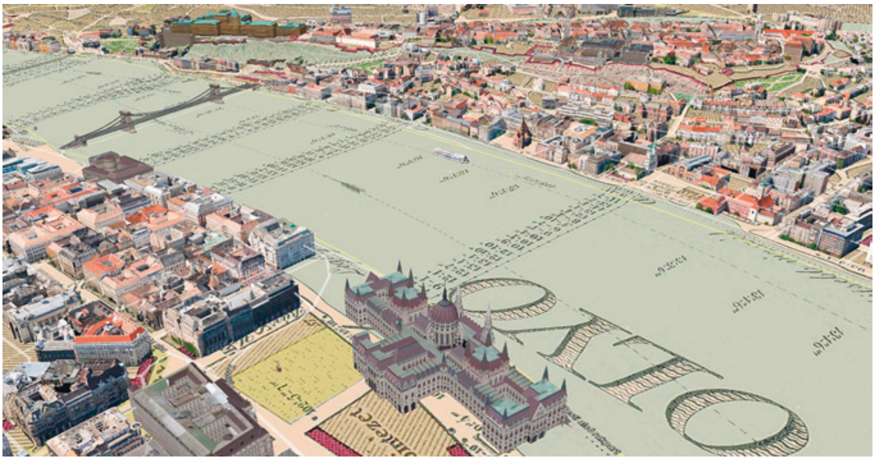

Fig. 6 The House of the Hungarian Parliament in the 1833 riverbed. Visualization of the 1833 map in Google Earth with the 3D layer of modern buildings

simple and clean, so the detailed old map's content is much easier to overview, and it can be used for spatial analysis purposes. Overall, this display option enhanced the early map's decision support functions, so that it can be used for similar current purposes.

9 Comparison of the Former and Present States

The integrated study of an old map and a present satellite image of the same area enhances the potential for visualization. The third method for visual exploration of László Vörös's Danube map is a Flash-based, interactive visualization. This is different from the former two network solutions as it operates independent from the Internet and uses only internal programmed and generated files. The essence of this animated display is that the former and present state of the same geographical point can be easily compared, and so the changes can be clearly followed. In the visualization we took the original map and a modern satellite image and put them on precisely matching layers. The comparison is facilitated along a horizontal line separating the two images. The position of the line can be changed interactively so the two images can be compared. This display is good for illustrating or monitoring the changes and the detection of a casual relationship. This technique is suitable for any representation of spatially well-defined historical topics. The spectacular visual application's possibilities are wide-ranging (Fig. 7).

Fig. 7 Spatio-temporal comparison of the 1833 map and the 2012 satellite image. The detail with the city of Budapest demonstrates changes as well as the accuracy of the georeferencing

10 Virtual Terrain Model

From the visualization described above the opportunities offered here are significantly different. Compared to the previous display, the creation and application of Vörös's map's 3D terrain model-based display was a much more complex and complicated task. The map contains three-dimensional data for the 1833 Danube river bed. We created a display to demonstrate the former state of the Danube in the section covered by the map with the help of a terrain model. After the lengthy data-processing of the linear elements delimiting the riverbed, a TIN model was made from the point-cloud representing the Danube. Next a DEM model was created for improved visualization.

This model depicts the state of the riverbed of the Danube in 1833 on the basis of the cross-sections and other points measured. Information is limited to the riverbed because we had no contemporary relief information about the cities, so in the 3D model we used current data (ASTER). The texture placed on this model was taken from the raster image of the original early map. After the necessary vertical exaggeration, from the complete three dimensional data an interactive model was made for the general public. The data has been converted into a VRML model and with the help of a plug-in this can be viewed in a web-browser. Using the viewer's function, the model can be enlarged and rotated as best suited to the user. Perspective views can be created interactively with the tools of modern cartography. By getting the user involved in this process he/she can study a map or 3D model made by himself/herself.

11 Conclusions

László Vörös's printed, large scale thematic map of 1833 is a detailed and accurate depiction of the topography of the contemporary cities, Buda and Pest, but it also a summary of the hydrographic-hydrologic survey of the river. Although the importance of the map has long been recognized, the analysis and the interpretation of its content only became possible through the adoption of the historical approach suggested in this paper. The map is interpreted in the technical and historical contexts of its creation, especially in the frame of the *discourse* on the construction of a permanent bridge connecting Buda and Pest. To visualize the database a series of different historical visualizations were created, each of them facilitating an interactive visual exploration of the maps' information and data content in a *cognitively relevant* spatio-temporal context. The applied visualization methodology, rarely used in conjunction with historical cartography, provides new possibilities for the interpretation of historical maps for both specialists and novice users.

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