Lost technical landmarks and present hydrotechnical objects in the Vltava riverine landscape

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Abstract

The aim of the paper is to bring information about the present project dealing with the historical Vltava River valley and large amounts of hydrotechnic and other buildings on the river banks, namely old sluices, floodgates, mills, saw-mills, iron-mills with theirs mill-races, first hydropower plants, timber rafting outposts, granaries, pubs and restaurants, ferries and bridges and also modern dams and bridges. These objects are an important part of the technical heritage and thus the subject of the project. Because the project is mainly focused on the processing of old maps, these objects are searched on old maps and their database is created in the entire length of the monitored area from the source of the Vltava River to its confluence with the Berounka River. Furthermore extensive research of various public and institutional archives brings much wider insight to particular objects and reveals many others. State Regional Archives are prime sources of plans (technical and floor plans), graphical and textual documents dealing with industrial and hydrotechnic historical objects. Carefully selected map content is vectorized and the database of important objects with supplement attributes is being filled up and every feature has its location. Their documentation is supplemented by old photographs and postcards. The entire monitored area was modeled in 3D using contour lines from old maps. This offers space for the presentation of the entire valley, including all interesting objects. Old cadastral maps have been vectorized and can thus be used to model the texture of the created virtual landscape. Individual buildings can be modeled procedurally (especially uninteresting objects), others can be modeled in more detail (interesting mills, weirs, etc.). The landscape and modeled objects will be available to users in the form of a 3D map application, as well as in the form of virtual reality. Many beautiful technical structures ceased to exist but might be resurrected via modern digital methods.

Introduction

The Vltava River, the longest Czech river and, apparently, the most famous river, stretches over a territory where significant changes occurred in the river landscape in the XXth century due to the construction of the so-called Vltava Cascade. The Vltava Cascade is a series of 9 dams built in the upper and middle course of the river. The objective of the Ministry of Culture DG18P02OVV037 project “Vltava – transformation of historical landscape” is to present in a complex way the changes in the landscape occurring in the upper and middle course of the Vltava River (from about the mid-XXth century, when the first relevant map works were created, to the present day) in the context of various events. In the project, a whole range of spatial information concerning landscape transformations along the Vltava River is processed in an innovative way. As there are numerous diverse archival materials available thanks to which we can gain a lot of information about the original Vltava River stream, the project will produce a self-contained information system containing processed archival materials such as, above all, old maps, plans of

historic structures, photographs, historical documents, etc.[1] The Vltava River Landscape is one example of a territory in the Czech Republic that underwent an intense transformation in the XXth century, combined with the disappearance of local settlements, whether caused by increasing or reducing anthropogenic pressure on the landscape. On the old maps it is possible to identify the development in the vicinity of the river (mansion or solitude), water objects (mills, weirs, dams), communication infrastructure (bridges, wharves). Unfortunately, a number of objects no longer exist. Either they stopped serving their purpose and were demolished or they had to give way to the construction of a dam cascade on the Vltava. In the project, transformations of flooded areas, their form and functions are documented using three-dimensional models. When digitizing existing or defunct objects along the Vltava River, account is taken of their importance for example in understanding the problems of navigation (raft breaks), overcoming the flow (ferries, bridges), using hydropower (mills, sawmills) and flood issues.

Old maps as a basic source of information

Within the project, the most important sources of information were old maps. The Vltava River was an important source of water power and a trade connection for timber and salt. Since the time of Charles IV and beyond in the XVIth century, various navigational works have been carried out. Their intensity increased again from the XVIIth century. With the development of surveying and cartography, the first river maps were developed, primarily to improve the possibility of river transport and navigational management. Around the end of the XVIIth century, the sketches, maps and plans of the Vltava were taken without more precise measurements. The oldest undated cartoon map of the Vltava from Prague to Mělník dates from around 1600. After 1770, the last works to navigate the river (completed in 1777) began to produce a greater number of maps and plans, documenting in particular the river's surroundings, navigational obstacles, weirs and sluices, tow paths and other information. Five manuscript maps were found in archive funds, varying in content, processing and level of detail. Two maps were provided by the National Archives in Prague and another three copies of State Regional Archives in Třebon. Alongside river maps dedicated directly to the river Vltava, many other information can also be drawn from maps, documenting the entire territory of Czech countries. Military mapping was among these in the Austrian monarchy of the XVIIIth and XIXth centuries. Military mappings of the Habsburg empire (First, Second and Third) represent pivotal works enabling the study of the river and its surroundings in a wider context. From the first quarter of the XIXth century, fiscal needs were also mapped within the framework of the emerging so-called Stable Cadastre, which was accompanied by detailed maps. Of these, the most interesting at the moment are the so-called Imperial Obligatory Imprints, which were hand-held colored and archived in Vienna. River and topographical maps have been used in our project to locate hydrotechnical objects in medium-scale. In terms of documentation of technical monuments, the most important are maps of large scales, in our case the Stable Cadastre maps, where specific objects (structures, buildings) are captured in great precision. We also frequently used the State Map Derived in 1:5,000

[1] Cajthaml, Jiří, et Kratochvílová, Darina, et Janata, Tomáš, 2019, « 3D Model of Historical Vltava River Valley: Combination of Sources »*, Proceedings of the ICA*, vol 2, p.1-5, DOI: 10.5194/ica-proc-2-14-2019.

(published since 1950). It is a state map work, the planimetry of which was derived from cadastral maps and the altitude component from topographical maps.

Figure 1. Example of old manuscript map of the Vltava River, source: National Archives in Prague

To work in geographical information systems, old maps had to be digitized. In addition to using scanned rasters, we vectorized selected map elements. The resulting vector model contains geometric objects (points, lines, polygons), their interlinkages and properties, and serves not only to visualize the territory at the time corresponding to the origin of the original map, but especially for spatial and space-time analyses (it becomes one of the layers of the resulting multitemporal GIS). A combination of automatic and manual vectorization processed 334 scanned first edition maps of the SMO-5, replicating the upper and middle part of the Vltava. Overall, over 26,000 km of contours and over 3,700 altitude elevation spots have been vectorized. The vector elevation was the default data source for the subsequent creation of a 3D model of the historic Vltava valley. Due to the size of the territory and the large amount of data involved, a combination of automatic and manual vectorization of contour lines was chosen. ArcGIS's ArcScan was used to automatically convert contour lines from individual georeferenced map sheets of SMO-5 into vector form. The research also covered changes and developments in the land use around the Orlík, Lipno and Slapy reservoirs. Changes and developments in the land-use were monitored between three time horizons from the first half of the XIXth century to the present. Using spatial analyses, vector data from three time periods have been compared to each other and outputs have been produced in the form of tables, graphs and thematic maps, which provide information on the change and development of individual areas.
Using vectorized data, we reconstructed the 300 km long pre-dam valley of the Vltava flooded by a system of water reservoirs. For the purpose of reconstructing

the extinct geo-relief, methods based on archival aerial images and old maps have been tested in detail. The reconstruction of such a large area is exceptional as the total area under reconstruction is 1670 km². DTM (Digital Terrain Model) based on vectorized contours from the SMO-5 maps serves as a base for both 3D printing and visualization.

Other sources of information

In addition to the old maps, there are a number of other sources that can help to document the defunct hydrotechnic monuments. Historical photographs are an important source of information. They enable to view the objects in their historical form, usually in black and white. In our project, we have localized all historical photographs to places where they were probably taken with information about the angle of the shot. Another important source are the plans of the objects, especially the building plans. Some historical mills, power plants, weirs, etc. have documentation that accurately describes their shape, dimensions and materials used. We have digitized these plans within the project and they will be used for 3D modeling of selected objects. If we were to search for an already existing database of technical objects on the Vltava, it is possible to find the website www.vodnimlyny.cz, which contains a complete list of mills (even historical ones) on the territory of the Czech Republic. We used this database and within the web map application it is referenced for all relevant objects. At the turn of 2019 and 2020, the public had an unusual opportunity to at least partially look under the Vltava in the area of the current Orlík reservoir. From October 2019 to March 2020 the level of the reservoir was lowered considerably. The reason was the planned reconstruction and extension of the ship's lift in the area of the dam. The level of the reservoir was lowered by an average of about 14 m. We took advantage of this situation and carried out a drone photography. The processing of these images produced a very accurate orthophoto, which documents objects normally hidden below the surface (e.g. former mills, weirs, bridges). Compared to the standard orthophoto (current and historical), which we also use, here we obtain unique data that cannot be otherwise obtained. The last of a number of interesting data sources is underwater measurement using sonar. We took advantage of this at the Lipno water reservoir, where the sonar was aimed not only at several interesting natural formations (e.g. the original meander “Heart of the Vltava”), but also at a number of technical monuments. For example, this is the original railway line Lipno nad Vltavou - Nová Pec, whose remains are clearly visible at the bottom of the dam.

Database of technical objects and web map application

Based on various archival materials, current data and field research, a database of extinct and current objects connected with the river has been created. For each object, basic data are recorded - name, type of object, description, dating and spatial location is determined. Moreover, additional available information, image material, historical photographs, site and building plans are collected, including information on their archival storage, availability and other resources, which facilitates further research and research of specific objects.

Figure 2. Examples of collected materials of Nový Mlýn hydroelectric power plant (historical photograph, old site plan, ground and drone photographs)

All collected data are integrated into a unified information system presented via web-based map application[2]. For online visualization, prepared old and current maps and their vector models form the main base layers that represent the topography of landscape in different time periods. In addition to these continuous layers, they are supplemented by partial situation plans of smaller locations. Objects recorded in the database are presented by a point layer, each type of object presents a point map symbol. Further information about the object can be obtained in the popup window after clicking on the point. The popup displayed provides basic information and also makes available the object card, where detailed information and other pictorial and textual material can be viewed. An important layer that shows both the landscape and objects is a layer of localized photographs, which appropriately complements maps, plans and textual materials.

[2] Krejčí, Jiří, et Cajthaml, Jiří, 2022, « Historical Vltava River Valley–Various Historical Sources within Web Mapping Environment », *ISPRS International Journal of Geo-Information*, vol. 11(1), ISSN 2220-9964. DOI 10.3390/ijgi11010035.

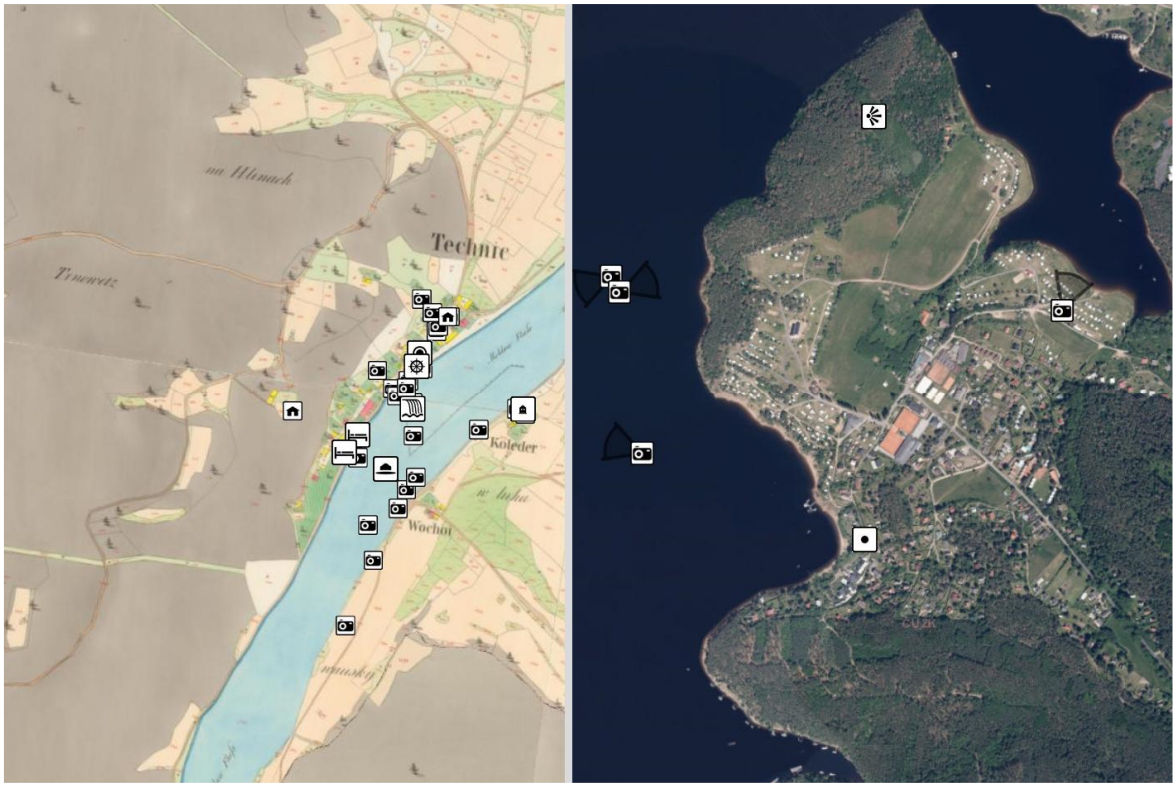

Figure 3. Depiction of web map application with swipe of two layers

Selected significant defunct landmarks have been virtually reconstructed in CAD software. A detailed 3D model has been created. The model can be viewed separately or as an object set in a complex online 3D scene. The area of interest covers a large area from the sources of the Vltava to Prague and the whole area is presented in a 2D map application, but also in a 3D scene reconstructing the original landscape and buildings. 2D and 3D applications can be viewed separately or simultaneously in a split synchronized window.
Esri technologies (ArcGIS Pro, ArcGIS Server, ArcGIS API for JavaScript 4.x, CityEngine) and CAD software were used for map processing, their publication, web map application and 3D visualization.

Conclusion

In this paper, we present the results of our project focused on reconstruction of the historical Vltava valley, especially in the form of a web-based map information system. Our approaches are unique in the breadth of used materials. We use old maps, plans, photographs, existing databases, our own measurements using drones or sonar as well as field research. The basic idea is to process all data in space, i.e. to link non-spatial data to certain map elements. It turns out that such a complex information system is very interesting for the work of researchers as well as for the general public.

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