Data Models of the Oldest Czech Maps

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It has been published earlier, that old maps are huge source of valuable information about our history. At the Department of mapping and cartography we are working on the research project focused on the early maps of Bohemia, Moravia and Silesia. These maps were created within the years 1518-1720. Almost every map from this era was created only by one cartographer. Among many maps, there are some important pieces which are objects of our research. Information from these maps can help us understand some historical processes (human or natural).

Every old map contains historical information about landscape (rivers, mountains) and about man-made changes in the environment (settlements, trade routes). Traditionally, these map elements were studied only by visual comparison. If we want to compare map elements on the old maps more precisely, we have to georeference these maps. The georeferencing means spatial localization in some common coordinate reference system. Because of huge distortion of the oldest maps, there is no exact method how to do that. If we want to find the best method, we have to create the database of identical points from as many maps as possible. After studying many old maps, we find out, that the best way for later maps comparison is to create digital data model of every map in GIS software. When having these data models in many different coordinate systems, we can start georeference them with respect to current position of identical points.

The data model of an old map consists of basic map elements. On the old maps from the area of Bohemia, Moravia and Silesia, we can find settlements (cities, towns, villages, castles and chateaus), rivers and streams, trade routes, hills and mountains. These elements are usually represented by point or line cartographic symbols. Before creation of a geodatabase of these objects, there is necessary to decide, which attributes of elements should be stored. For example, if we are creating database of cities on the map, there is advisable to store the old name of the city, current name of the city, population category and some other attributes depending on the map symbols. For every map element on the map should be created one feature class with appropriate attributes. Attribute domains should be well described in the data model documentation. Once we have created the data model (feature classes, attributes and attribute domains) we can start with filling up the database. The image of old map (usually scanned) is opened in desktop GIS software. There is necessary to transform the original image into well defined coordinate system that could be used if it is needed in the future. This transformation may not change the spatial relationships of map elements. Therefore, the similarity transformation must be used. For doing that, it is important to find very well significant point as coordinate origin. The direction of coordinate axes should be defined by other significant point (defining one of the axes). We found out, that the best solution is to choose two symbols for cities and use them as written above. After the transformation, the image of the old map is prepared to digitizing.

Map symbols are digitized as point or line feature classes. Their attributes are stored together with the spatial information into the geodatabase. The final product is the database of all map elements of the old map in defined coordinate system. This database can be used for next research. We started with the oldest map of the Bohemia, Klaudyan's map. This map is very valuable, till today survived only one original printed copy. Klaudyan's map has untypical south-orientation. The map was created by Mikulas Klaudyan in 1518. The map image contains 280 point symbols of settlements. These are distinguished according to the king's towns or other towns and towns with a catholic or protestant church, with map symbols. Besides towns and castles, some rivers are displayed also on the map. Trade routes are symbolized by miles-dots.

After creation the data model of this map in ArcGIS software we transformed the map into defined coordinate system. As the origin the town "Kladsko" was chosen. The direction of the "x" axis is defined by the town "Frydlant". In this coordinate system, all map symbols were digitized and stored into the geodatabase. Now we have the digital model of the map in vector form that can be used for the georeferencing.

In the first phase the global transformation models to the contemporary system S-JTSK were tested. All digitized towns (except one that was not found) were used as identical points. Testing many types of transformation gave us interesting results. The affine transformation (the first-order polynomial) gave the RMS error 14.3 km, the second-order polynomial transformation gave the RMS error 12.7 km, and the third-order polynomial transformation gave the RMS error 10.5 km. The image of the map was badly distorted using second- and third-order polynomial transformation. After omitting 33 identical points (with high residuals) the affine transformation gave the RMS about 10.0 km. This global transformation was chosen as the best, because of better preserving spatial relationships.

The local transformation models are being tested now. IDW (inverse distance weighted) and TPS (thin plate spline) transformations are probably the best solution. Other old maps are being digitized also and will be transformed as well. The aim of our project is to transform these maps into contemporary coordinate system S-JTSK. After that, we will be able to say, which map elements keep their position, and which are moving (e.g. rivers). We will be able to recognize how the newer maps were influenced by older ones by comparison of map images. Georeferenced data can be also used for finding some disbanded castles or towns. The output of our project will be also the table with spatial characteristic of maps (in fact their spatial precision).

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