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New features in MapAnalyst

Summary: MapAnalyst is a specialized application for the analysis of the geometric properties of old maps. It offers a user-friendly interface for the identification of reference points on an old and a new map. Various types of visualizations can be computed based on the reference points, including distortion grids or displacement vectors. This paper provides a short overview of the main functionalities of MapAnalyst, and focuses on new features. One important new feature is the integration of OpenStreetMap as reference map, which renders scanning and georeferencing paper maps unnecessary, and thus facilitates analyzing old maps.

Introduction: analysis and visualization of the geometric accuracy of old maps

Visualizations of space deformation are useful for analyzing the geometry of old maps. They can help map historians compare old maps with modern reference maps for examining various aspects concerning the creation of old maps. Visualizations of space deformation are also useful for assessing the geometrical reliability of the extracted information before using it for further studies. Map historians have developed various methods for analyzing and visualizing distortion in historical maps (for an overview see Forstner and Oehrli (1998), for a compiled list of literature see Jenny and Weber (2005)), but no comprehensive and easy-to use tool has been available until recently (Jenny, 2006).

Map historians can draw on a number of techniques when analysing and visualizing the planimetric accuracy of historical maps. The application of these techniques can be simplified and accelerated by using modern computers. However, map historians have been in an unfortunate situation, because existing software was generally not easily available, required a particular operating system, was partially based on expensive GIS, could not be easily extended, or did not provide an easy-to-use interface. The absence of ready-to-use computer software obliged map historians to either renounce on computer-supported analysis techniques, or to develop their own software. These shortcomings motivated the development of MapAnalyst, a user-friendly application that is freely available to the public at http://mapanalyst.cartography.ch/.

About MapAnalyst

MapAnalyst is a Java application that runs on all major computer platforms (Jenny, 2006; Jenny et al., 2007). It allows for the efficient identification and management of control points both in a historical map and in a corresponding reference map, and computes distortion grids, error vectors and isolines of scale and rotation. It offers a wide palette of parameters to fine-tune the generated graphics. MapAnalyst also computes the historical map's scale, rotation angle and statistical indicators, and offers interactive tools to explore local variations of displacements, scale and rotation.

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MapAnalyst is freely available for download, and its open-source code can be extended by anyone with Java programming skills. The software was designed with a special focus on a user-friendly interface that allows historians without a technical background to easily analyze the geometry of old maps.

New Features in MapAnalyst

MapAnalyst has been improved in several areas since its introduction in 2005. The most important new feature is the inclusion of OpenStreetMap as reference map, which is discussed in the next section. This section presents other relevant improvements, including options to amplify distortion grids; overlay distorted and undistorted grids; copy and paste control points among documents; and undo and redo actions affecting control points.

When analysing the geometric properties of a relatively accurate map, local distortions are difficult to detect visually, because distortion grids consist of almost straight lines, and displacement vectors are very short. The same problem also occurs when visualizing small movements or displacements originating from areas other than the history of cartography, for example the differences between two geodetic surveyings covering the same area. In MapAnalyst, an optional exaggeration factor can now be applied to amplify distortions. Figure 1 shows an example visualizing the difference between two geodetic reference systems for Switzerland. Local displacements in this data set are generally below a few metres, which would result in a visually perfectly regular distortion grid. A relatively large exaggeration factor applied to the distortion grid shows the local variations between the two reference systems more clearly.
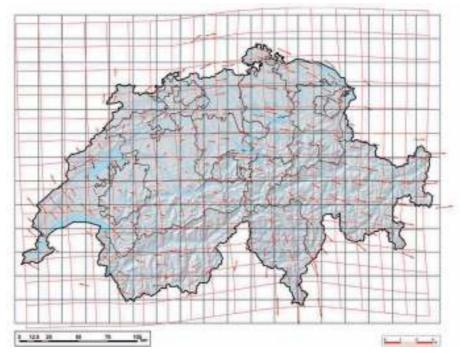

Figure 1: Exaggerated distortion grid illustrating the difference between two geodetic reference systems (Kistler et al., 2006).

An additional feature in MapAnalyst that helps visualize relatively small distortions is the overlay of an undistorted grid (Fig. 2). The undistorted grid has the same dimensions and cell size as the distorted grid, and is scaled and rotated to optimally align with the control points, but consists of perfectly straight lines. The undistorted grid is in fact an intermediate product when computing

the distorted grid. It is the grid of the reference map transformed to the old map using a Helmert or an affine transformation, but without local distortions applied.

MapAnalyst now also supports multiple documents. Control points can be selected, copied and pasted between documents. Hence, analysing a section of a map can be done very easily. For example, computing the rotation and scale factor for a local area is a matter of seconds. Furthermore, there are now commands to undo and redo all user actions affecting control points. This feature is useful when exploring the influence of individual points on distortion visualizations or on the computed scale and rotation factors.

The import and export capabilities of MapAnalyst have been improved as well. More graphic formats are supported, and additional options exist to exchange control points with other software. For example, the user can select from a list of various spatial units when importing or exporting control points.
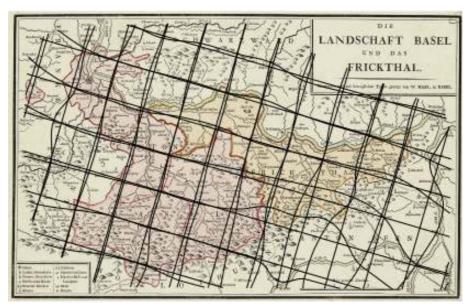

Figure 2: Distorted and undistorted grids overlaid (Map: W. Haas, Die Landschaft Basel und das Frickt[h]al, 1798).

OpenStreetMap in MapAnalyst

MapAnalyst 1.3 was the first version to include OpenStreetMap as a default reference map (Figure 3). The OpenStreetMap is a collaborative project to create a free editable map of the world at http://www.openstreetmap.org/. It covers large parts of Europe, North America and other areas of the world. The maps are created using volunteered geographic data (Goodchild, 2007) from portable GPS devices, aerial photography and other free sources (Haklay and Weber, 2008). OpenStreetMap is available for any scale, starting from a world overview, and ending at a large-scale detail map. The quality of the data is comparable to commercially produced maps, as shown for example by Haklay (2008). The integration of OpenStreetMap considerably facilitates the cartometric analyses of historical maps, as there is no longer the need to scan modern reference maps for areas covered by OpenStreetMap.

OpenStreetMap map tiles are loaded from www.openstreatmap.org and then assembled for rendering the map. MapAnalyst caches the streamed tiles locally to reduce the amount of Internet traffic. When MapAnalyst is closed, the cache is emptied automatically. This approach ensures

that the most recent version of OpenStreetMap is always used, which requires a modestly fast Internet connection.
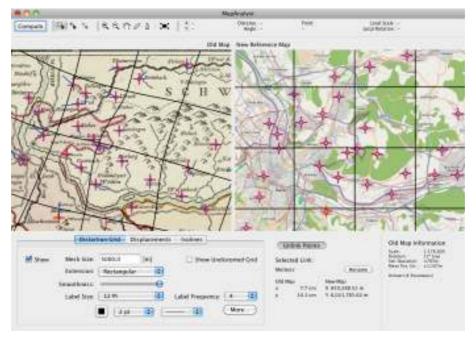

Figure 3: MapAnalyst's main window with an old map on the left and the OpenStreetMap on the right.

The map downloaded from OpenStreetMap uses the Mercator projection, which can be considered an unfortunate choice for the distortion analysis of old maps, because the Mercator projection adds considerable areal distortion at medium and higher latitudes. The Mercator projection is therefore not well suited for global maps, as areal distortion increases dramatically towards the poles. For example, the size of Greenland is more than ten times too large on a Mercator map. But also at latitudes closer to the equator, this additional source of distortion cannot be ignored when analysing distortion properties of a map.

To compensate for the distortions induced by the Mercator projection, MapAnalyst re-projects the control points before computing transformations, distortion grids, displacement vectors, and isolines. The following procedure is automatically applied by the current version 1.3.7 of MapAnalyst to remove the distortion introduced by the Mercator projection:

- The control points are projected from the Mercator projection used by OpenStreetMap to geographical coordinates on the WGS84 ellipsoid (using a so-called inverse projection).
- The points in geographical coordinates are projected to a Transverse Cylindrical Equal Area projection centred on the mean longitude of all control points.
- The points in the Transverse Cylindrical Equal Area projection are then used to compute a transformation between the old and the new map, including the global scale factor and the global rotation angle. The same points are used to compute the different visualizations.
- The visualizations for the new reference map (e.g. the distortion grid) are finally projected to the Mercator projection of OpenStreetMap and displayed.

The Transverse Cylindrical Equal Area projection is much better suited than the Mercator projection for most map analyses, as it introduces much smaller distortions. Yet, it does not perform well when analyzing old maps at small scales showing large countries, entire continents or even the complete globe. For such small-scale analyses, a reference map using a projection that approximates the projection of the old map must be used, as considerable distortions would be added

by the Transverse Cylindrical Equal Area projection. For maps at a large scale, however, the projection does not play an important role and the influence of the projection can often be ignored. This is also the case for maps at medium scales that are highly distorted.

Conclusion

MapAnalyst can be used to assess different questions related to the history of cartography, and is also useful for visualizing distortion or displacement phenomena not related to the history of cartography. MapAnalyst is under active development and will be further enhanced in the future. Features added since the initial release of MapAnalyst in 2005 include options to amplify distortion grids; overlay distorted and undistorted grids; copy and paste control points among documents; and undo and redo actions affecting control points.

The most important addition to MapAnalyst is OpenStreetMap, which considerably facilitates the analysis of the geometry of old maps, since the reference map is readily integrated in the application. OpenStreetMap already covers large parts of the Earth and continues to be improved by mapping enthusiasts. When OpenStreetMap is not of sufficient quality for analysing an area of interest, MapAnalyst can still read and display a scanned map.

Acknowlegments

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