A Semi-automatic Approach for Determining the Projection of Small Scale Maps Based on the Shape of Graticule Lines

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Extended Abstract

Knowing a map's projection is of essential importance. This is particularly true when using them as a source for creating derivative works, dealing with them in a GIS environment or when meta-data is assigned to these maps during the process of cataloguing in a library. However (especially on older maps), projection information is often absent or partially present. This problem is dealt with in a number of different ways in contemporary cartographic practice. The most common is to ignore the question of projections and use ground control points (with known geographic and image coordinates) to associate the image with its location in geographic space. This method is called georeferencing and is very broadly used. Georeferencing however, if used improperly, can introduce transformation errors that make these maps unsuitable for further use.

The related problem of determining the projection of maps, then using the resulting information for the purposes of georeferencing has not been studied in great depth historically. This is mainly due to the fact that such analysis would have required abundant computing resources that were unavaliable even a couple of decades ago. In the recent years however, several approaches were developed that allow us to make educated guesses about unknown cartographic projections. (Bernhard & Lorenz 2011), (Bayer 2014).

Our objective is to develop a semi-automated approach for determining the projection and projection parameters of a small-scale map. This both provides the meta-data needed for cataloguing and also serves as an aid for more precise georeferencing. Our method is based on the shape and secondary properties of a map's graticule lines. The method was first outlined in a study by György Érdi-Krausz (1958) then later refined by János Györffy (2012). Érdi-Krausz's study is concerned with the analysis of

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cartographic projections and describes a hierarchy for determining an unknown projection. The hierarchy is formulated as a decision tree with a set of questions. These can be answered by calculating different properties (primarily the shape) of graticule lines found on the map in question. While Érdi-Krausz provides methods for assessing these properties on printed maps using cartometric analysis (manual measurements), our approach automates these calculations using different algorithms and makes Érdi-Krausz's method work on maps that are given as digital raster images.

To this end, a web-based application is created. Its user interface is explicitly designed to be usable by a non-professional audience. Drawing tools are provided for manually tracing graticule lines and poles on raster maps uploaded by the user. Given the approximate traces of these lines, we run a three-stage analysis on them to determine the shape and secondary properties of graticule lines, then the exact parameters of the projection. In the first step, we employ a complex curve fitting algorithm to determine the primary shape of graticule lines. We are able to distinguish between a number of different curve types (non-degenerate conic sections circles, ellipses, parabolae and hyperbolae using the conic fitting algorithm by Wijewickrema et al. (2010) and straight lines). Recognition of the curve type allow us to ascertain the approximate category our projection fits into. However, to determine the exact type of the projection, we also need to compute other properties, such as the spacing between graticule lines, their angles and coordinates of intersections, their concentricity and parallelism. Having computed these properties, one can fit the projection into Érdi-Krausz's system. In a third step, further (projection-specific) computations allow us to ascertain the exact parameters of the projection, thus emitting georeferencing meta-data associated with the raster map in question. The algorithms we use are cheap in terms of computational resources and fast enough to allow semi-realtime processing.

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