Georeferencing of the Third Military Survey of Austrian Monarchy

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A typical III. Military Survey map sheet
Outline

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• Proposed georeferencing procedure
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Motivation

Importance of maps of the Third Military Survey

• cover most of central and southern Europe
• long period of usability – almost 80 years
• many emissions and revisions up to 1959
• most requested old maps in the Czech Republic
• frequently used by historians, environmentalists, urbanists, ...
Objectives

Availability of the old military maps on Internet

- comparison with contemporary maps
- precise georeferencing
- access through Web Map Services
- usability in client GIS
Overlap of the III. Military Survey map with a contemporary map
State of the art

Significant positional differences have encountered.

- usual result: 90 – 130 m discrepancy (4 - 5 mm in a map sheet)
- best result until now: 40 m discrepancy (2 mm in a map sheet)
- impossible visual comparison
- impossible usage by WMS
- unknown causer of the big discrepancy
- worse than in the II. Military Survey
Positional errors on trigonometric points in the Third Military Survey
State of the art – technical details

• Even with huge number of ground control points (> 4200) → significant biases 108 m ± 28 m (max 206 m)

• 56% of the points belong to interval 90 - 130 m

• certain global trend is apparent
Main principles of the new georeferencing

• maximal number of ground control points
• statistical testing of validity of the coordinates
• map sheet shrinkage elimination
• consideration of the original cartographic projection
• special elastic transformation to correct local inhomogenities
• reasonable transformation parameters – fine tuning
Proposed georeferencing procedure

1. map sheet shrinkage elimination
2. map sheet projection onto Bessel ellipsoid
3. cartographic projection from Bessel ellipsoid to plane
4. elastic transformation in plane of contemporary coordinate system
1. Map sheet shrinkage elimination

Affine transformation

\[ x = QX + r \]

\( x \) … measured corner of a map sheet

Least-squares estimation of \( Q, r \)

\[ X = \hat{Q}^{-1}(x - \hat{r}) \]
2. Map sheet projection onto Bessel ellipsoid

**Inverse Sanson-Flamsteed projection**

- 30’ x 15’ on the ellipsoid -> map sheet 1 : 75 000
- A quarter of the map sheet 1 : 75 000 is the required map sheet 1 : 25 000.
4. Elastic transformation in plane

- least-squares collocation
- complex arithmetics
- accuracy estimation of an arbitrary point
Resulting composed transformation

- digital image in contemporary coordinate system (S-JTSK)
- seamless mosaic covering the region of interest (Czechia)
Data capture - scanning

- several sources of map sheets 1:25,000
- scanning by calibrated large-format scanner
- 234 color map sheets, 133 grayscale, 9 missing
Data capture – coordinate measurement

- Ground control points (GCPs): trigonometric points
  - church towers
- Manual measurement of points
  - 4526 ground control points
  - 1400 corner points
- Statistical testing
- 4,246 ground control points selected
Results

- two computational transformation procedures:
  - forward
  - backward

- forward transformation – accuracy estimation

- backward transformation – pixel color determination (nearest neighbour method)

- No resampling is needed for partial transformation.

- web application
  http://www.chartae-antiquae.cz/maps/military3
Coincidence of 4 mapsheets
Overlap with a contemporary map - after solution
Overlap with a contemporary map – before solution
Accuracy assessment of the georeferencing

- Resulting positional errors on GCPs - few meters (< 4m)
- Set of 958 testing points – statistical analysis
- Resulting positional error: 9.1 m
  (0.36 mm in the map sheet 1:25 000)
Positional errors on test points
Summary of advantages

- significant accuracy improvement (110 m → 9 m)
- rigorous respect of cartographic principles
- most prospering effect: elastic transformation
- sensitive matching of mapsheets
- corrections of local inaccuracies of map content
Conclusions

- Accuracy of georeferencing was significantly improved (9.1 m).

- Resulting raster images are available on server of the Research Institute of Geodesy, Topography and Cartography.

- Overlays of regions of interest are possible.

- Strong tool for countryside development studies (1880 - 1950) is available on-line.
Thank you for your attention

www.chartae-antiquae.cz/maps/military3

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