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NUMERICAL PROCESS OF STRAIGHTENING THE EDGES OF GRAPHICALLY-BASED CADASTRAL MAPS

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Abstract

This article describes a solution for a problem we face combining maps of graphically-based cadastral maps. Convex or concave borders are aligned through a special transformation which changes the parcel geometry. Minimal geometric distortion is achieved through the use of carefully selected curves.
Keywords: *digital land cadastre, edges straightening, graphic survey, maps*

1 STARTING POINTS

In the process of setting up the digital land cadastre (DLC) one uses two main sources of data that define the links between the topology and the geometry of individual parts of parcels in the land cadastre. These are numerically- and graphically-based cadastral maps. The basic units of management in the DLC are cadastral communes, so the sheets (into which the cadastral commune is currently divided in the current documentation will have to be joined together). We start with the fact that both numerically and graphically-based sheets were rectangular in their basic form. Somewhere in the process of transformation from the analogue to the digital form, this condition therefore needs to be fulfilled, the geometrical structure must not be altered, i.e. the relative relationships in the DLC must be preserved in the present documentation (the basic starting point for the DLC). After the transformation of sheets, their present contents must correspond to their original contents (there should be no transfer of parcels from one sheet to another).

2 PROBLEM

This transformation does not require any additional work nor does it present a problem in the case of numerically-based maps, since their maintenance has become coordinate, whereby the edges of the sheets had a status of immovable lines (they were a component of the cadastre, so to speak). In graphically-based maps this is different. Through maintenance procedures of the graphically-based sheets, their edges acquired a convex/concave form (the rule of absolute untouchability of the sheet edges was not taken into account for historical reasons) and the sheets are no longer rectangular (Figure 1).

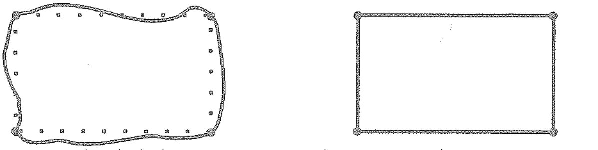


Figure 1: Actual state and theoretical forms of sheets from cadastral maps

Due to this new form of sheets overlapping, holes can occur when joining sheets (Figure 2) and individual parts of parcels and the parcels themselves can be lost. Sometimes it is impossible to join the same parcels and their topological connection is thus lost.

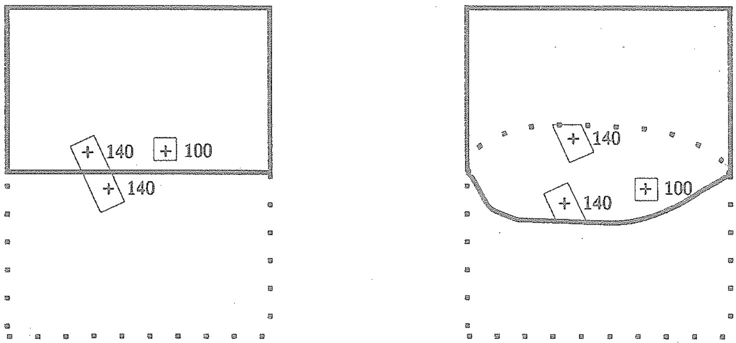


Figure 2: Theoretically combining sheets and the case of a problematic connection of actual sheets

The problem of concave or convex forms unfortunately is not solved by any of the known general plane linear transformations (Helmert, afine, bilinear). All authors who have dealt with the transformation of graphically-based maps (Čuček, 1979, Mivšek, 1991, Oven, 1993, Wiens, 1984) mainly discussed the appearent forms of errors within sheets and (the distribution of) their influence transformed data/parcels. The basic building elements of the DLC, however, are sheets/cadastral maps. In order to successfully join sheets within cadastral communes it is necessary to search for/define a new transformation or procedure for graphically-based sheets to solve the problems of sheet form.

3 IDEA

The presented starting points and problem were first written as a list of rules or boundary conditions:

- Deformations on individual sheet edges are independent of transformation on other edges.
- The corners of sheets sections are without deformations (the only known points).
- The transformation function must be continuous and continuously derivable.

- □ Forced correction (straightening) of sheet edges or the influence of errors which accumulate at sheet edges should have a minimum influence on parcel shape; the influence depends on the degree of deformations.

The following solution attempts to fulfil the above boundary conditions:

- □ influential areas of corrections due to deformations of individual sheet edges were limited by sheet diagonals "watersheds" (Figure 3) - sheets were divided to 4 parts; it follows from this that:
  - there are no corrections of diagonals due to sheet edge deformations (the influences of two different edges converge here),
  - at the diagonal intersection = sheet centre we therefore obtained points without deformations (same as corners of sheet sections),
  - sheets were roughly divided into 4 circular cutouts.

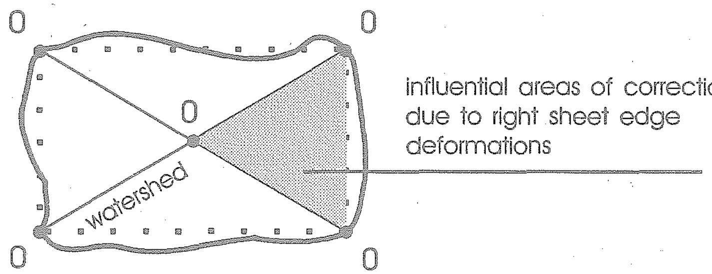


Figure 3: Determination of influential areas of corrections due to individual sheet edge deformations

- □ Within influential areas corrections due to sheet edge deformations extend radially from the sheet centre (Figure 4) and are gradually reduced from the sheet edge towards the sheet centre. It follows from this that:

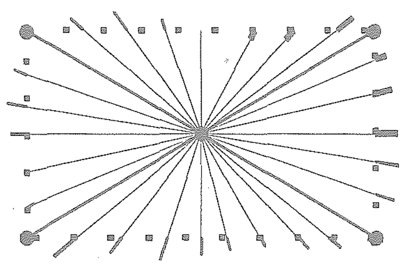


Figure 4: Direction of the influence of corrections due to sheet edge deformations

- □ The correction function must fulfil two conditions that partially exclude each other (reducing the influence of sheet-edge deformations as you move further from the sheet edge and maintaining the relative relationships among the sheet contents - Figure 5: discrete transformation).

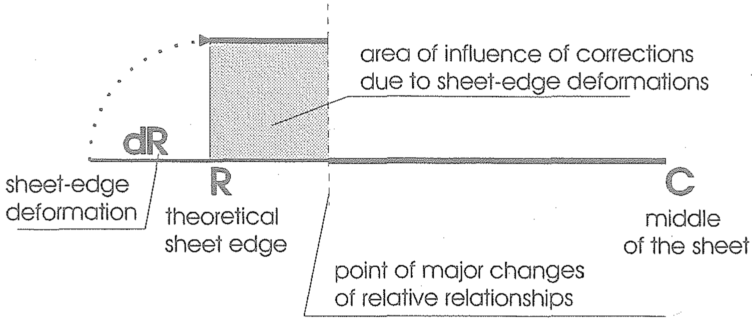


Figure 5: Example of the discrete transformation function to transfer the influence of sheet-edge deformations

- For the correction function for deformations in radial directions, we have chosen part of a sinusoidal curve $\sin^n$ (Figure 6), which is continuous and continuously derivable, to ensure a continuous and smooth transformation and a more even distribution of the influence of sheet-edge deformations.

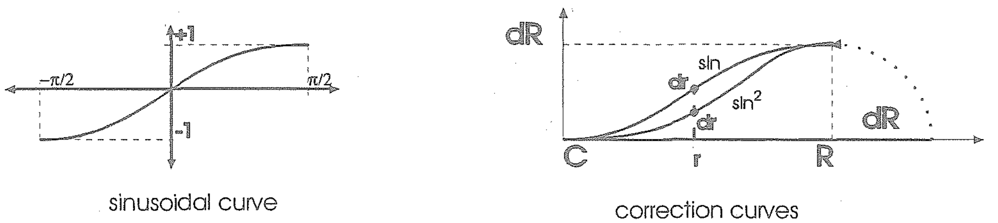


Figure 6: The selected type of correction curve

- The degree of n = 2 was selected. (On the basis of empirical findings, it distributes the influence of sheet edge deformations most "naturally"; in order to determine optimum degrees of the sinusoidal curve it would be necessary to perform a more extensive analysis of concrete data) - Enclosure 1 illustrates curves for the transfer of corrections from the sheet edge towards the centre of the sheets for different n values.
- The spatial deformation plane above the sheet is formed on the basis of five points without deformations, sheet-edge deformations and the correction function (Figure 7).

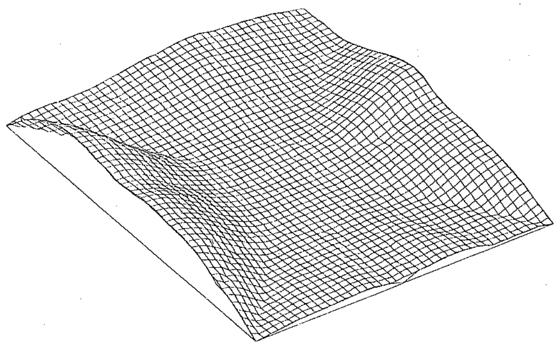


Figure 7: Spatial deformation plane above the sheet

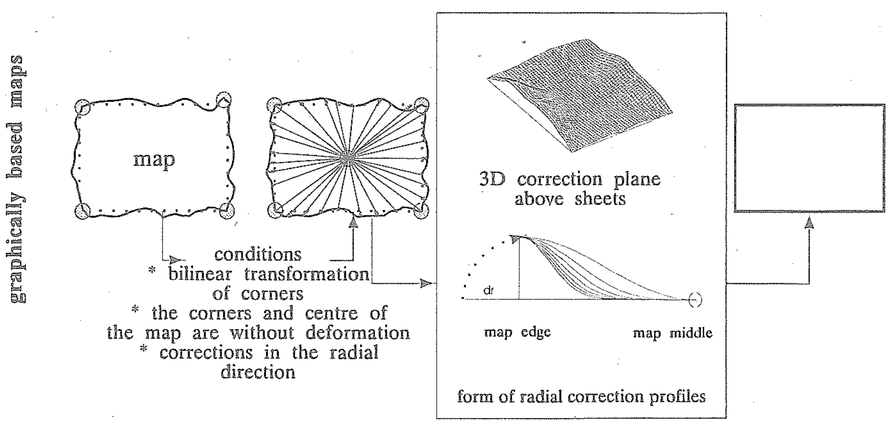
- Radial correction is calculated on the basis of the spatial plane for each pair x, y, i.e. according to the following equation:

$$\left[\sin\left(\frac{r}{R}\cdot\pi-\frac{\pi}{2}\right)+1\right]\cdot\frac{dR}{2}$$

This equation can be solved at the vector or raster level; transformation at the vector level is recommended, since

- it is less difficult,
- it is simpler to program,
- in the phase of data acquisition (sheet vectorization) it is not necessary to know the "true" coordinates,
- raster data are the basic archives and must not be corrected since the historical link would be lost.

Graphical presentation of the procedure:



Required input data:

- □ the collection of most equidistant points (thumb distribution, detail, optional points) on sheet edges,
- □ the coordinates of sheet-content corners,
- □ the form of the function for radial correction.

Enclosure 2 presents different forms of 3D correction planes above sheets.

4 CONCLUSION

The present transformation solution (preservation of the sheet form) for graphically-based sheets is the result of the theoretical and practical experience of the authors in their work for the DLC. This solution is simple and quick. A more extensive test is needed for systemic use, which would yield the answer to the question: Does the presented solution fulfil the DLC project requirements in every way?

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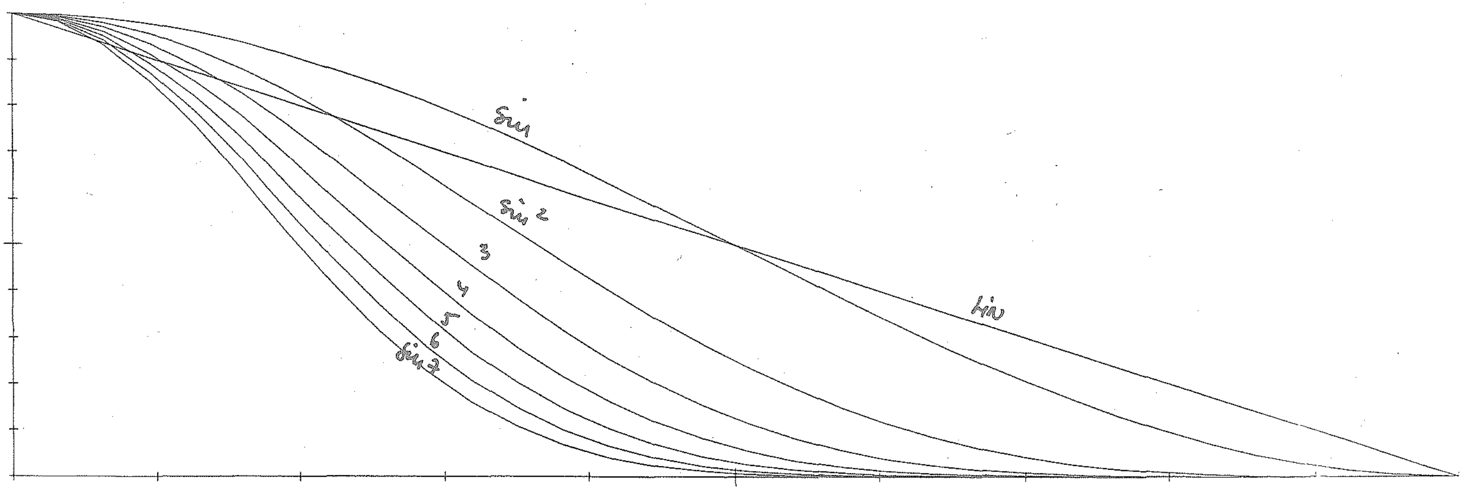
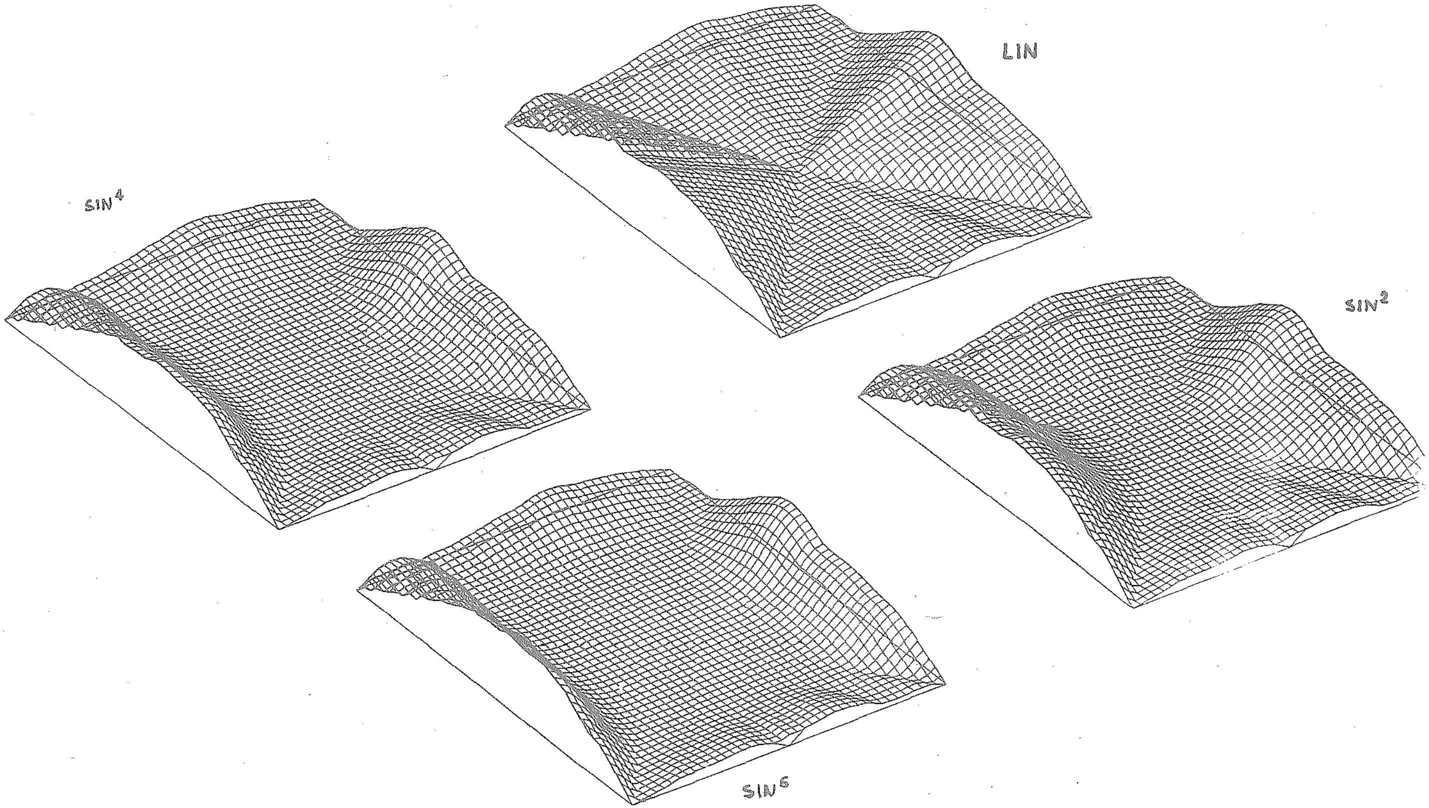


Enclosure 1: Curves for the transfer of corrections from the sheet edges towards the centre of the sheets



Enclosure 2: Different forms of 3D correction planes above the sheets