The transformation and homogenization system Ortra for the transformation of the Bavarian Real Estate Cadastre to ETRS89/UTM

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Introduction
The introduction of the European geodetic reference system ETRS89 has been or will prove to be a challenge for all Länder in the Federal Republic of Germany. For the transformation of the Bavarian Real Estate Cadastre to ETRS89/UTM, the Bavarian National Mapping Agency for Digitalization, High-Speed Internet and Surveying (in German: Landesamt für Digitalisierung, Breitband und Vermessung, abbreviated to LDBV) has decided to develop the transformation and homogenization system Ortra. The name ortra is an abbreviation of the basic principle of the approach, a concatenated orthogonal transformation.

The transformation and homogenization system Ortra
The transformation approach Ortra uses an adjustment technique for the transformation of different cadastral feature type groups of the Official Real Estate Cadastre Information System ALKIS (ALKIS is the German abbreviation of Amtliches Liegenschaftskatasterinformationssystem). Ortra is closely related to classic map homogenization approaches, which were primarily used for data acquisition from the early 1990s. Prof. Benning of the RWTH Aachen University proposed further complementing the classic geodetic coordinate transformations by means of the map homogenization method, which is minimally adapted for the transformation process [Benning Scholz 2010]. Map homogenization systems usually use least square adjustment with distance and direction observations, which comply with standard geodesy practice. The observations are generated as pseudo observations based on the ground plans of geospatial datasets, which reconstruct the geometry and topology of the data precisely. If a map homogenization method is used as the transformation method, it does not merely transform the data from the initial to the target system, it also reduces inconsistencies such as network distortions. In this way, the method homogenizes the data and enhances the global accuracy of the positional geo-
metry, while retaining the relative spatial accuracy of the data well.

Fig. 1: Pseudo observations built for cadaster parcels, the example shows a subarea near Munich

For the Ortra transformation, each juristically relevant ALKIS ground plan will be accurately reconstructed and further stiffened by pseudo observations.

**Analogy of the Ortra geodetic network to a mechanical truss**

The pseudo geodetic network of the classic map homogenization method does not act like a mechanical system. When larger forces impact on identical points, this major disadvantage results in the risk of geometrical and topological errors due to collapsing effects caused by the adjustment. If the observation equations are modified from geodetic distance and direction observations to orthogonal observations, an invaluable analogy is built up in the system between adjustment and mechanics. This adjustment system is analogous to an elastic mechanical system, that is in a state of equilibrium. If net distortions enforce exterior forces at the identical points, the mechanical truss tries to preserve the geometry through the minimal principle of energy. The scientific work of this thesis intends to prove the laws of mechanics for the Ortra transformation approach. From the point of view of the transformation, a specific mechanical law, i. e. the second theorem of Castigliano, the theorem of least work, shall prove the important basic principle of optimal maintenance of the geometry. The observed behavior of the Ortra transformation system exhibits good geometry preservation without producing intolerable deformations and topological errors.

**Practical implementation**

For the transformation of Bavarian cadaster data, large normal equation systems will be created in the related least squares adjustment procedure. The normal equations will be solved by sparse matrices technologies. The Ortra approach will be applied in various forms to different feature type groups of ALKIS.

**References**
