Bidimensional regression: a novel algorithm for the computation of a viewing point in space based on the relation between the 2D projective transformation and space resection

Jason Borioli[1, 2], Catherine Brandner[2], and François Bavaud[1]

[1]Faculty of Geosciences and Environment, University of Lausanne, Switzerland, [2]Laboratory for Experimental Research on Behavior (LERB), SSP Faculty, University of Lausanne, Switzerland

Jason.Borioli@unil.ch

Keywords: Bidimensional Regression, Two-Dimensional Projective Transformation, Space Resection, Unknown Interior Orientation Parameters, Unknown Exterior Orientation Parameters

Mental maps, implying the comparison between a real-world and a mental spatial configuration, have been widely studied both in geography and psychology. One method for analyzing them is bidimensional regression, which Tobler introduced as a means to compare the similarity between two sets of two-dimensional data in relation to four transformation models: euclidean (similarity), affine, projective, and curvilinear [5]. The euclidean, affine, and curvilinear transformations have been explored to some extent [1, 2], while the projective transformation (P) has been given little attention. P is related to space resection (R), i.e. the computation of a viewing point in space [4]. So far, however, no contribution has explicitly shown the link between P (8 parameters) and R (9 parameters). The 9 parameters of R are composed of 3 interior-orientation parameters (IOPs) and 6 unknown exterior orientation parameters (EOPs), and to date, solutions for R have all assumed prior knowledge of the IOPs [3]. Building on Seedhamed's work [3], this contribution presents a novel algorithm for the retrieval of the EOPs without prior knowledge of the IOPs, which is the case when dealing with mental maps. The solution requires giving a fixed value, say unity, to the principal distance, one of the IOPs, and exploiting 6 of the 8 parameters of P to form a system of two equations resulting in a quartic equation ($\alpha x^4 + \beta x^3 + \chi x^2 + \delta x + \varepsilon = 0$). Solving this system leads to the direct computation of the IOPs and EOPs. The validity of the algorithm is shown through numerical examples based on urban mental maps.

References

1. Friedman, A. and Kohler, B., Bidimensional Regression: Assessing the Configural Similarity and Accuracy of Cognitive Maps and Other Two-Dimensional Data Sets. Psychological Methods, Vol. 8, No. 4, 2003, pp. 468-491.
2. Nakaya, T., Statistical Inferences in Bidimensional Regression Models. Geographical Analysis, Vol. 29, No. 2, 1997, pp. 169-186.
3. Seedahmed G. H., Direct Retrieval of Exterior Orientation Parameters Using a 2D Projective Transformation. The Photogrammetric Record, Vol. 21, No. 115, 2006, pp. 211-231.
4. Tobler, W. R., The Geometry of Mental Maps, in Golledge, R. G. and Rushton G., (eds.) Spatial Choice and Spatial Behavior: Geographic Essays on the Analysis of Preferences and Perceptions, Columbus, Ohio State University Press, 1976, pp. 69-81.
5. Tobler, W. G., Bidimensional Regression. Geographical Analysis, Vol. 26, No. 3, 1994, pp. 187-212.