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$L_1$ generalized procrustes 2D shape alignment. (English) Zbl 1446.68179

Summary: This paper describes a new method for resistant and robust alignment of sets of 2D shapes wrt. position, rotation, and iso-tropical scaling. Apart from robustness a major advantage of the method is that it is formulated as a linear programming (LP) problem, thus enabling the use of well known and thoroughly tested standard numerical software. The problem is formulated as the minimization of the norm of a linear vector function with a constraint of non-zero size. This is achieved by using the Manhattan distance between points in the plane. Unfortunately the Manhattan distance is dependent on the orientation of the coordinate system, i.e. it is not rotationally invariant. However, by simultaneously minimizing the Manhattan distances in a series of rotated coordinate systems we are able to approximate the circular equidistance curves of Euclidean distances with a regular polygonal equidistance curve to the precision needed. Using 3 coordinate systems rotated $30^\circ$ we get a 12 sided regular polygon, with which we achieve deviations from Euclidean distances less than 2\% over all directions. This new formulation allows for minimization in the $L_1$-norm using LP. We demonstrate that the use of the $L_1$-norm results in resistance towards object as well as landmark outliers. Examples that illustrate the properties of the robust norm are given on simulated as well as a biological data sets.

MSC:

68U10 Computing methodologies for image processing
68U05 Computer graphics; computational geometry (digital and algorithmic aspects)
90C90 Applications of mathematical programming

Keywords:
procrustes analysis; linear programming; shape analysis

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References:


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