Solving Approximate Values of Outer Orientation Parameters for Projective Transformation

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In the recent years it is possible to notice quite outstanding introduction of photogrammetric methods for obtaining space information. The main reason of this phenomenon is especially improvement of quality of digital technologies in the area of acquisition and processing an image. As for data collection it is especially increase in resolution, speed, sensitivity and sensor size.

Wider use of digital photogrammetry is also connected with need of more thorough theoretical comprehension of the used mathematical apparatus. The basic relation for description of the central projection is projective transformation. Almost all other relations used in photogrammetry are based on this transformation. A disadvantage of this transformation is its non-linearity. The biggest problem of its applications is therefore inexpensive obtaining the approximate values of their parameters.

This article describes a simple procedure of calculating approximate values of outer orientation parameters for projective transformation.

There are several approaches of how to obtain these approximate values. One possibility is their direct measuring, which is used for example for aerial photogrammetry, but its application for terrestrial photogrammetry is not advantageous. Other possibility is their calculation by some approximate linear method, for example direct linear transformation, so-called DLT. Disadvantage of the DLT is that input points must not lie in a plane or near a plane, whereas creation and maintenance of a plane field of check points is simpler. A minimum number of points is also lower for a plane field when the suggested procedure is used.

A procedure based on homogenous coordinates and application of numerical methods for calculation of eigen-values, singular decomposition and QR decomposition is used in the community of computer vision. A disadvantage of this procedure is its excessive complexity, which complicates detailed comprehension of space geometric relations.

The procedure we suggest is developed from basic photogrammetric equations describing projective transformation and is in accordance with the approach in the photogrammetric community (see [1]). The procedure is original, simple from mathematical point of view and enables detailed geometric understanding of its single steps.

The principle of the method is based on modification of the basic relation between space coordinates of points and their image coordinates. Basic photogrammetric equations are also derived from this relation. In original relations there appears a scale number for each point. The adjusted relations represent linear homogenous equation system. It is necessary to choose a scale number of one point as an invariable for need of its unambiguous solution. In this way we obtain a linear inhomogeneous equation system, which can be simply solved by the least squares method. After calculating the adjusted parameters it is necessary to “normalize” them by multiplication by average norms of rotation matrix vectors. Values adjusted in this way can be used as approximate values for an exact calculation. The minimum number of points necessary for calculating approximate outer orientation parameters is six.
If all control points are situated in a plane or near the plane, a modification of the stated procedure is necessary. Firstly it is necessary to process an identity transformation of all control points into the coordinate system, where their \( z \) coordinate is zero (or almost zero). In the next solution it is possible to leave out the column of unknowns (vector of rotation matrix), which corresponded to the "\( z \)" coordinates. There are three unknowns less and the number of equations is kept in modified solution. Number of points in a plane necessary for calculating approximate values is four. The missing rotation matrix vector is calculated by the vector product and will therefore complete the right-handed system of coordinates. Other procedures are identical to the solutions with points not lying in the plane.

Use of the suggested procedure is wide. It is for example a solution of one- or more-image calibration of digital cameras with using a plane calibration field, a calculation of space coordinates in some scanning systems that are being developed (see [2]), a calculation of image coordinates for mapping textures onto a triangular mesh in the GUI (Graphic User Interface) PointClouder (see [3]) and adding quality information about colour of the measured points of the Leica HDS3000 scanning system.

Problem of the existing commercial solution in the last two stated applications is an unknown calculation algorithm, its low stability, an unknown method of removing distortions of an image (provided that some method is applied) and low level of user comfort. Therefore it is suitable to introduce the projective transformation including the stated approximate solution and a function based on it into the GUI PointClouder.

The stated solution of approximate values calculation of outer orientation parameters and also an exact solution of all projective transformation parameters in accordance with the least squares method was incorporated into the Alltran library [4].

References:


[4] B. KOSKA: *Project Alltran* [cit. 5. 1. 2008]

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