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Statistical approach to the image matching

Vadim V. Mottl, Andrey V. Kopylov
(Tula State Technical University, Russia)
Sergei Yu. Zheltov
(GosNIIAS, Moscow, Russia)

The analysis of stereoscopic images has a significant place among the problems of image processing. The problem of relief restoring from air and space photographs should be mentioned as an especially prominent example of its application. By a stereoscopic picture is meant a pair of plane images of the same three-dimensional object, which are taken from two close but different point of view. A stereoscopic identification of a pair's components remains an integral and the most difficult part of the processing algorithm. Stereoscopic identification is considered to mean finding pairs of points in the two pictures so that the matched pairs could be interpreted as two projections of the same point on the surface of the original three-dimensional solid

An automation of matching the points of a stereoscopic image pair presupposes a solution of, at least, two main problems. The first of them implies the choice of an adequate formal measure of the image similarity within some vicinities of the points being checked as potential partners for forming an eventual elementary pair in the desired stereoscopic relation as a whole, Such a measure is usually accepted in the form of the scalar product of some image local feature vectors within vicinities of the points being compared

The second and, perhaps, most difficult problem consists in establishing a joint matching relation between similar points of the stereoscopic picture components, so that the geometrical laws, that govern forming an object' s twofold projection, would be met. The algorithmic scheme of stereoscopic matching two pictures, that is considered in this paper, is based on treating the images under processing as realizations of two observable components of a three-component random field, in which the role of the third hidden

component is played by the sought-for binary relation between the points of two visible pictures. The matching field is considered as that of vector shifts bringing the points within the raster of the one picture into coincidence with the identical points within the raster of the other, assuming that the pictures are superimposed

The principal model assumption is that the variety of all possible binary relations along with their mutual preferences can be expressed in the form of a known probability distribution, i.e. in the form of a hidden random field of local shifts. In addition, a conditional probability distribution over the set of all image pairs is assumed to be preset for each realization of the shift field. The problem of stereoscopic matching is considered as the formal problem of restoring the hidden component of the three-component random field, based on analysis of the two observable components. Such a problem is actually one of the classical problems of statistical inference for spatial processes known under the name of interpolation problem and usually considered under some Markov assumptions on the probabilistic properties of the bidden random field

The algorithm being considered in this paper is based on a compromise approach to the interpolation problem. First, instead of a complete prior model of the hidden matching field, some partial models are used that determine the probabilistic properties only of its horizontal and vertical sections as one-dimensional Markov processes. Second, the interpolation is performed in two steps. At the first step, the algorithm leans upon a prior model of the hidden matching field in the form of a combination of linear Gaussian random processes in the horizontal and vertical direction. Such a model allows, generally speaking, for realization that may be contradictory to the geometrical laws of projection. The relevant restrictions are taken into account at the second processing step that consists in choosing the most probable admissible realization of the matching field, the posterior probabilistic properties of which had been determined at the first step.