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Two-Stage Mutual Causal Filtration and Segmentation of Heterogeneous Images

S. V. Vishnevyy and S. Ya. Zhuk

National Technical University of Ukraine "Kyiv Polytechnic Institute" (NTUU KPI), Kyiv, Ukraine

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Abstract—Using the mathematical technique of mixed Markovian processes in discrete time optimal and quasi-optimal algorithms that combine results of one-dimensional filtration and segmentation of heterogeneous images are synthesized. Analysis of the quasi-optimal algorithm is conducted on a model example using statistical modeling on PC.

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Segmentation is one of the main stages of processing in many image analysis applications such as space pictures of Earth surface, medical images, etc. As a result of performing segmentation procedure the image is divided into its component regions that are characterized by some heterogeneity [1]. Such properties as color, intensity level, or texture may serve as homogeneity criteria [2].

A frequently used region segmentation criterion based on intensity of brightness values is the most developed. As part of this approach threshold processing method, boundary determination method, and region separation method are developed [1, 3, 4]. However many images are characterized by unequal intensity within the boundaries of texture region's heterogeneities. This applies to such texture types as bushes, grass, trees, etc. During image segmentation using the intensity criterion such textures will be split into many small regions. In this case the use of such texture properties as correlation function, power spectrum, parameters of image stochastic models [2, 4, 5] is more reasonable.

Real images are often subject to distorting influence of noises. That is why together with segmentation image filtering should be performed as well. However statistical optimal filtering algorithms are characterized by immense complexity of implementation [6].

This work aims to develop a two-stage method of mutual filtering and segmentation of heterogeneous images. Peculiarity of the method consists in independent causal processing image processing along rows and columns at the first stage. At the second stage further optimal combining of the obtained data occurs. The use of such image processing technique allows significantly decreasing computational costs, if compared to the two-dimensional methods, and providing high processing efficiency. Such approach was developed in work [7] for image filtering.

Optimal and quasi-optimal algorithms of filtering processes with random structure that are used at the first stage during image processing along rows and columns are described in detail in [8, 9]. In the considered problem the process texture type corresponds to the image texture along the row or column respectively. Hence in order to decrease the article volume they are not covered in this work. Only their output data are used for the second stage of processing.

Following the methodology of non-linear filtering theory, first we synthesize in a general form the algorithm of computing a mutual posterior distribution of image element and type of its texture based on posterior distributions of processes with random structure, obtained at the first stage during image processing along rows and columns. Then we refine the obtained results for the case when heterogeneous image regions along rows and columns may be represented by conditionally independent Gaussian processes with random structure [9].