NOISE REMOVING IN THE HALF-TONE PICTURE

Vladimir KIYKO and **Michail SCHLESINGER**
Institute of Cybernetics,
Ukrainian Academy of Sciences

40, Prospect Akademika Glushkova
252207, Kiev, Ukraine
tel.: (044) 266-25-69 Fax: (044) 266-1570
schles%image.kiev.ua@ts.kiev.ua

Vladimir Kiyko and **Michail Schlesinger. Noise Removing in the Half-tone Picture.**
An algorithm of noise removing in the half-tone pictures is proposed. The most important property of the algorithm consists in, that after noise removing in the half-tone picture, followed by thresholding of this picture with any threshold, the resulting binary picture does not contain the noise. The algorithm is implemented in the software for detecting the objects in the pictures. Experimental results of using the algorithm are described.

1. Introduction.

Usually a pre-processing of the half-tone picture v_0 consists in binarization B(Θ) (Fig. 1,a) of this picture by some threshold θ and subsequent noise removing S in the binary picture v_1 **.** This preprocessing is preferable for contrast and homogeneous enough pictures because it is not too difficult to choose binarization threshold for such pictures. At the same time satisfactory results while processing not contrast and noised pictures most likely can be obtained using not one but certain amount of binarization thresholds. In this case more preferable is other variant of preprocessing of the picture (Fig. 1,b). On the initial stage of this preprocessing noise removing of the picture v_0 is fulfilled and on the next stage the noise-free picture v_3 is binarized by different threshold values θ**.** The algorithm of noise removing in half-tone picture v_0 is considered in this paper. The most important property of this algorithm consists in, that under any threshold value θ the binary picture v_4 is obtained,that exactly coincides with the picture v_2 **.**

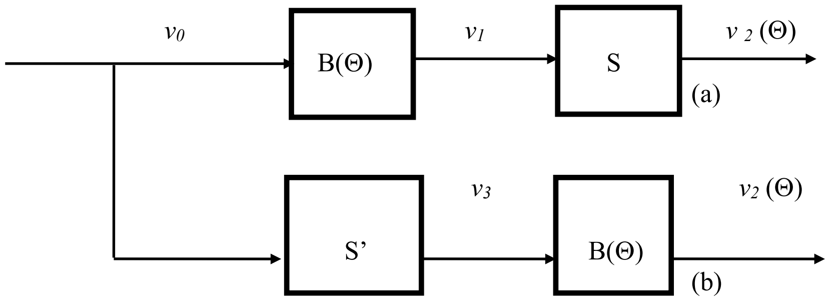

Fig. 1

2. Statement of the problem.

Let us define the operation of noise removal in the binary picture. Let v be a binary picture, defined on the set T of the pixels, i.e. $v : T \rightarrow \{0,1\}$. The set of pixels t for which $v(t) = 0$ will be denoted as T_0 , and the set of pixels with $v(t) = 1$ as T_1 . The sets T_0 and T_1 consist of one or several number of connected subsets. The connected subsets with small sizes are considered as noises. In other words, a noise is a small black spot on a white background or a small white spot on a black background. The removing of noise consists in the inverting of its brightness. The result of thresholding of the picture v with the threshold θ will be denoted by $v' = B(v,\theta)$ and a result of noise removing in the binary picture v' will be denoted as $S(v')$. Let us suppose that the certain criterion $F(v,e)$ of the matching the binary picture v with the binary picture e is defined. This criterion can be generalized for a case when one of these pictures, for example v, is not binary, but multilevel one. This generalized criterion Q will have a form

$$Q(v,e) = \min_{\theta} F(B(v,\theta),e). \qquad (1)$$

If one takes into account, that one can neglect small noises in the binary picture $B(v,\theta)$, the criterion (1) is to be transformed into the form

$$Q(v,e) = \min_{\theta} F(S(B(v,\theta)),e) \qquad (2)$$

The immediate calculation of criterion (2) is rather complex, because the certain not very simple operator S for noise reduction is to be fulfilled for the binary picture $B(v,\theta)$ with every threshold value. This complexity could be essentially reduced, if it would occur to be possible to permutate the operator S for noise reduction and operator B for binarization, i.e. to find such operator S' for noise reduction in the multilevel picture v, that equality

$$B(S'(v),\theta) = S(B(v,\theta)) \qquad (3)$$

would be valid for every multilevel picture v and every threshold value θ .

The problem under solution consists in constructing the operator S', that satisfies (3).The concrete form of the transformation S' , that satisfies (3), is described below.

3. Description of the algorithm.

Noise removing in the half-tone picture consists of the following parts:

1) ordering pixels of the picture in increasing their brightness;
2) "white" noise removing in the picture;
3) ordering pixels of the picture in decreasing their brightness;
4) "black" noise removing in the picture.

Ordering of the pixels in their brightness is fulfilled while two-fold scanning of the pixels using additional array with the length equaled to the number of different brightness of the pixels in the picture. During first scanning the numbers of the pixels with correspondent brightness are stored in this array: the number of the pixels having brightness ***k*** is stored in the ***k***-th cell of this array. Each of these numbers is then replaced on the beginning address in the array of ordered pixels for storing index numbers of pixels with brightness ***k*** and this storing is fulfilled during the second scanning of the picture.

Let us consider the “white” noise removing in the picture. The “white” noise removing is carried out during one-fold scanning of ordered in brightness pixels of the picture. Let t_i be the current such pixel with the brightness $v(t_i)$. Processing of the pixel t_i consists in checking whether there exists "white" noise region ***G*** that contains this pixel. This region is constructed step by step by the following way. Initially the region ***G*** contains only the pixel t_i. Then the region grows so that under the certain conditions several pixels are included in the region. Some pixel t' is included into the region if:

a) t' is a neighbour of the region ***G;***

b) $v(t') \geq v(t_i)$.

The region grows until one of the following two conditions fulfills:

a) the size of the obtained region ***G*** exceeds the pre-defined size. In this case the region ***G*** is not considered as a noise and the next pixel t_{i+1} with the brightness $v(t_{i+1}) \geq v(t_i)$ is processed;

b) no new pixel can be added to the region. In this case the current region is considered as a noise and the brightness of all pixels of this region are equaled to maximal brightness of the neighbouring pixels of the obtained region *G*.

Removing of "black" noise is similar to "white" noise removing.

4. Experimental results.

The algorithm proposed is implemented in the software for detecting the objects in the not contrast and noised half-tone pictures. Noise removing in the picture is carried out during two-fold scanning of the picture. Noise removing with the size of the noise not more than 5x5 pixels in the part of the picture, that consists of 250x250 pixels , takes 2-3 sec. on the Pentium 120 system.