

METHODS OF COLOR IMAGES PROCESSION FOR FURTHER IDENTIFICATION OF THE OBJECT

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Abstract: The offered paper deals with the problems of color images preliminary procession. Among these are: interference control (local ones and noise) and extraction of the object from the background on the stage preceding the process of contours extraction. It was considered for a long time that execution of smoothing in segmentation through the boundary extraction is inadmissible, but the described methods and the obtained results evidence about expedience of using the noise control methods.

Keyword: NOICE REDUCTION, FILTERING, SEGMENTATION, EDGE DETECTION

Introduction

A number of the images' procession problems are connected with a search of specific form objects on a complex multi-object image. Among these problems are, for example, detection and recognition of the target on the television observation systems, detection and tracking of the transport means movement in the real conditions in the real time, recognition of symbols randomly located on the sheet of paper (for example, letters and conventional signs on the geographical maps) and many others. The key features of this type of problems is: the presence of a small number of standard images (a car silhouette, a detail profile); an essential characteristics of the object are its form and not linear dimensions, position in space etc. To perform recognition i.e. comparison of standard images with the object's boundaries, it is necessary to perform transition to the figures' contour images. The given work is devoted to the problems of segmentation, noise filtration, the object extraction from the background, definition of boundaries for the subsequent identification of the object. The problems of recognition will not be considered directly.

Review

While on the subject of filtering it should be noted that the investigations being performed are directed to the choice of smoothing methods used on the stage preceding the contours extraction. The main problem is to preserve the structure of the objects and to avoid colors distortion.

The simplest noise suppression algorithm is the sliding averaging filter. A mask of some dimension is generally chosen for smoothing and the smoothed image is built in the form of convolution of the initial image with a mask, for example, as follows:

$$F_1 = \frac{1}{9} \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix} \quad F_2 = \frac{1}{10} \begin{pmatrix} 1 & 1 & 1 \\ 1 & 2 & 1 \\ 1 & 1 & 1 \end{pmatrix} \quad F_3 = \frac{1}{16} \begin{pmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{pmatrix}$$

It is easy to note that each of the masks meets the main requirement to the masks of the smoothing filters, namely: the central element of each mask is not less than any of the rest and the sum of all elements taking into account the coefficient is equal to 1. All the elements making part of the mask are positive numbers.

Gauss filter is one of the most popular filters used as a component of many algorithms for boundaries' extraction. Significant noise suppression takes place in its operation, but the image structure changes greatly. In particular, thin lines (particularly those ones whose thickness is two pixels) and sharp corners are distorted significantly.

To suppress the local noise the median filters are used the algorithm of sorting and ordering of massive elements (one dimensional or two-dimensional) either by non-decrease or lack of increase. The meaning of the color found in the central place of the window as a result of permutation is called the median. Just this meaning substitutes the color of the filter raster being at the given moment under the central element of the median filter. The given filter is intended for suppression of the local noise, but with small dimensions of the window the pulse noise suppression takes place (in this case the meaning of the window central point color is often not taken into account). One of the greatest shortages of the median filter is the sharp corners of the image structure "rounding off"; furthermore, the lines whose width doesn't exceed one half the window widths disappear, this is really unacceptable with further extraction of the contours.

All the above methods of noise suppression cannot be used in the case of further boundary extraction as the preliminary noise suppression doesn't emphasize the objects' boundary on the image but fuzzify them. But the contour extraction from the initial image gives many redundant contours; solution can be found in using the smoothing filters intended for noise removal with the image structure preservation.

The SUSAN filter (S.M. Smith and J.M. Brady) was developed for structure preserving noise reduction. The main object used in the SUSAN filter is a round mask with the central pixel named the "nucleus". The points whose brightness is approximately equal to the nucleus brightness form the so-called "Univalue Segment Assimilating Nucleus" or USAN. The concept of some point association with the local area having the similar brightness is the basis of the SUSAN method. This region includes much important information on the structure of the image around some point. From the dimension and location of the SUSAN region the boundaries (one- or two-dimensional characteristics) and corners, intersections (two-dimensional characteristics) can be defined. As can be noted, the dimension of the region is a maximal one when the nucleus of the mask is located on the smooth part of the image, it is equal to one-half the area of the mask when the nucleus is located on the smooth boundary and is a minimal one inside the corner.

The SUSAN noise suppression algorithm as well as some available technologies of image filtering preserves the image structure at the cost of smoothing with only those neighbors that make part of the "homogeneous region" with the central pixel. The SUSAN filter calculates the mean value of all the points in the area inside the USAN. Generally the central point is excluded from consideration; this allows suppressing weak pulse deviation of brightness. It is evident that the USAN includes the greatest number of the suitable neighbors for finding mean value not affecting any points of independent area. By this means the image structure is preserved.

In respect of eliminating the limits fuzzing on the image it is clear that on the fuzzion boundaries the points will be contracted into the area where their values are closer. Thus, the SUSAN filter can improve significantly the quality of the image not changing its structure. Another peculiarity is that using the filter iteratively it is possible to achieve more powerful noise suppression without the image quality loss (generally more powerful noise suppression corresponds to greater smoothing of the initial image structure). Moreover, the level of smoothing doesn't affect the characters' localization; this advantageously differentiates it from other filters, for example, median one. The fact that the suppression of the pulse noise with the given filter is hampered (in the case of the pulse noise emergence the USAN area is equal to 1 i.e. it includes only the nucleus and that is why no variations with this point will be referred to its shortages).

Furthermore, the investigation was directed to obtaining the image gradient, it is also called the spatial differentiation or, more simply, the contour extraction with different methods. To detect and exclude the contours on the image (obtaining of the gradient image) the differential operators are used as a rule not higher than of the second order [4]. In the general form such operator is written in the following way:

$$a_{11} \frac{\partial^2 f(x,y)}{\partial x^2} + a_{12} \frac{\partial^2 f(x,y)}{\partial x \partial y} + a_{22} \frac{\partial^2 f(x,y)}{\partial y^2} + a_{10} \frac{\partial f(x,y)}{\partial x} + a_{01} \frac{\partial f(x,y)}{\partial y} + a_{00} f(x,y) = z(x,y),$$

where $a_{ik}; i, k = 0, 1, 2$ – are prescribed coefficients.

If, for example, we assume $a_{11} = a_{22} = 1$ in this expression, and the rest coefficients equal to zero then we'll receive Laplace operator which is widely used in image procession.

In the majority of the similar cases the contours exclusion the masks with the dimensions (3*3) are used as the most optimal ones. Such widely used operators as the operators of Roberts, Kirsh, Sobel Previtte, the differential operator and others functioned according to one and the same principle. When extracting the contour with the given methods the convolution of the initial image by each mask separately is performed. After this the vector norm is defined Depending on what method of the vector norm finding is choosing the output image is finally formed.

Thus, for example, one of the most widespread masks [2] was applied to the Roberts operator

$$H_1^{(1)} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{pmatrix}, \quad H_1^{(2)} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & -1 \\ 0 & 1 & 0 \end{pmatrix};$$

the convolution of the initial image is performed by each mask separately using the formula:

$$d_1(i, j) = B(i, j) * H_1^1; \quad d_2(i, j) = B(i, j) * H_1^2.$$

After the vector norm is defined using one of three possible ways:

- geometric sum of the components d_1 and d_2 is found;
- the components with the maximum module $|d_1|$ and $|d_2|$ are chosen;
- the algebraic sum $|d_1| + |d_2|$ is found;

The output image is formed depending on what way of finding the vector norm was chosen. To improve the final results a number of procedures is performed such as preliminary smoothing, making the obtained contour contrast, etc.

The SUSAN [5] operational principles differ significantly. The main object used in the SUSAN filter is a round mask with a central pixel named a "nucleus". The points whose brightness is approximately equal (similar) to the brightness of the nucleus make up the so called "Univalued Segment Assimilating Nucleus" or the USAN. The concept of association of some point with a local area having such brightness is the SUSAN method basis. This area contains many important information about the structure of the image around some point from the dimension and location of the SUSAN area the boundaries (one-dimensional characteristics) and corners, intersections (two-dimensional characteristics) can be defined. As can be noted the dimension of the area is a maximal one when the center of the mask is on the plane part of the image, it is equal to one-half the mask area when the nucleus is on the plane boundary and it is minimal inside the corner.

$$c(\vec{r}, \vec{r}_0) = \begin{cases} 1, & \text{if } |I(\vec{r}) - I(\vec{r}_0)| \leq t \\ 0, & \text{if } |I(\vec{r}) - I(\vec{r}_0)| > t \end{cases}$$

where \vec{r}_0 – is the position in the nucleus of two-dimensional image, \vec{r} – is the position of any other point within the mask, $I(\vec{r})$ – is the brightness of the point, t – is the brightness threshold which for ordinary monochromatic images is ± 27 gradations, and c – is the comparison result. The comparisons are performed for every point of the mask and then the total value of n is calculated using the formula $n(\vec{r}_0) = \sum_{\vec{r}} c(\vec{r}, \vec{r}_0)$.

This total value is the area of the USAN region. t parameter defines the minimal contrast of characteristics and the maximal depth of the ignored noise.

Then n is compared to the fixed threshold g (geometric threshold), which is set on $3n_{\max}/4$, where n_{\max} – is the maximal value taken by n . The preliminary result is obtained using the following rule

$$R(\vec{r}_0) = \begin{cases} g - n(\vec{r}_0), & \text{if } n(\vec{r}_0) < g \\ 0, & \text{else} \end{cases}$$

The principle of the SUSAN consists in the following: a greater result corresponds to a smaller region.

When the boundaries are found in the absence of noise the geometric threshold is unnecessary. But to obtain the optimal noise suppression the threshold is set on $3n_{\max}/4$. The use of the threshold g will not result in the screening of the right limits for the following reasons. If the staircase boundary is detected the value n will be either less or equal to $n_{\max}/2$ from any side of the boundary. Thus, the boundary will not be rejected. If the edge is not an ideal staircase boundary and its form is fuzzy, n will be even less, that is why the risk of rejection of the limit is lower.

The cited algorithm gives good results, but more sensitive expression for c , is $c(\vec{r}, \vec{r}_0) = e^{-\left(\frac{I(\vec{r}) - I(\vec{r}_0)}{t}\right)^6}$.

This expression makes it possible to consider the pixels' brightness variation more flexibly.

The results received when using this method are more satisfactory, less details of the background are observed as contours. But with suppression of the whole background this method failed.

Realization

The above filters feature significant shortages; this doesn't allow using them in the initial form in the general case. The problem of noise suppression can be solved through integration of their best properties.

The SUSAN filter was chosen for the basis of the developed method of noise suppression on the color images as the most preserving the structure of the initial image. But the given filter is not intended for pulse noise elimination that is why the following solution was offered:

- An image is processed with the SUSAN filter;
- In the case when the USAN region is less than some threshold ξ , the two-dimensional median filter with a window dimension of 3 by 3 square and the center in the SUSAN nucleus point is used.

The obtained method offers all merits of the SUSAN filter, in particular, it preserves accurately the image structure (boundaries of the homogeneous regions, lines and their intersections, corners), in this case both the form and properties distribution are preserved. The filter suppresses the pulse noise well; using it iteratively it is possible to achieve the noise level close to zero. In this case it doesn't inherit shortages of the median filter such as smoothing of corners and thin lines' elimination

Investigations showed that extracting the edges directly from the color image we often have not only the contour of the object and its details but a great number of the background details' contours as well, particularly if it is a complex background. Solution of such a problem was found. An algorithm allowing to perform segmentation and to extract the whole object from the background was developed.

The algorithm's operation is based on the concept of the hue. As the input image is presented in the RGB system it is necessary to transform it into the HSB format. Further on the hue component is extracted and a histogram $H(h)$ is built with it, where h – is a hue. In this case the background hue will correspond to the maximum on the histogram, and the hue of the object that should be localized will correspond to the second maximum $M = H(m)$. Then it is necessary to choose the range of the hue $[t_1, t_2]$ values, where all the points of the localized object are included. Values of t_1 and t_2 are calculated by the formulas

$$t_1 = \min(m - b_1, m_1)$$

$$t_2 = \min(m + b_2, m_2),$$

where b_1 and b_2 – is the maximum spread in values of the hue, m_1 – is the maximal value of the hue not exceeding m , where $H(m_1) = M * k$ ($M * k$ – is a number of points sufficient for the dimension of the area occupied by them can be a part of the object's monochromatic region). The parameters $b_1 = b_2 = 15$, $k = 0.347$ acceptable for the majority of images were established as a result of investigations.

The following step of the algorithm is separation of the image region, its points background is in the $[t_1, t_2]$ range established in the previous step.

The obtained image includes the local noise regions, which are eliminated with the median filter.

Then it is necessary to divide the image plane into rectangular segments. All the segments of the initial image, which non-empty segments on the image obtained in the previous stage correspond to, remain without variation; the rest segments are removed

The obtained region is the most possible place of the localized object emergence.

Having sharp boundaries of the object it is possible to separate then the contours of the received image including only the object itself and insignificant noise using any of the known methods.

Experimental investigations

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The considered experiments as well as the research work were directed to solution of two problems: to carry out filtering and to extract the object from the background with further extraction of the contours which in their tern will be used further on as evidences for further objects identification.

Investigations were performed both with the test problems and real images.

Fig.1 shows the initial image, the red car on a complex background and results of different filters operation work as well as the received contours.

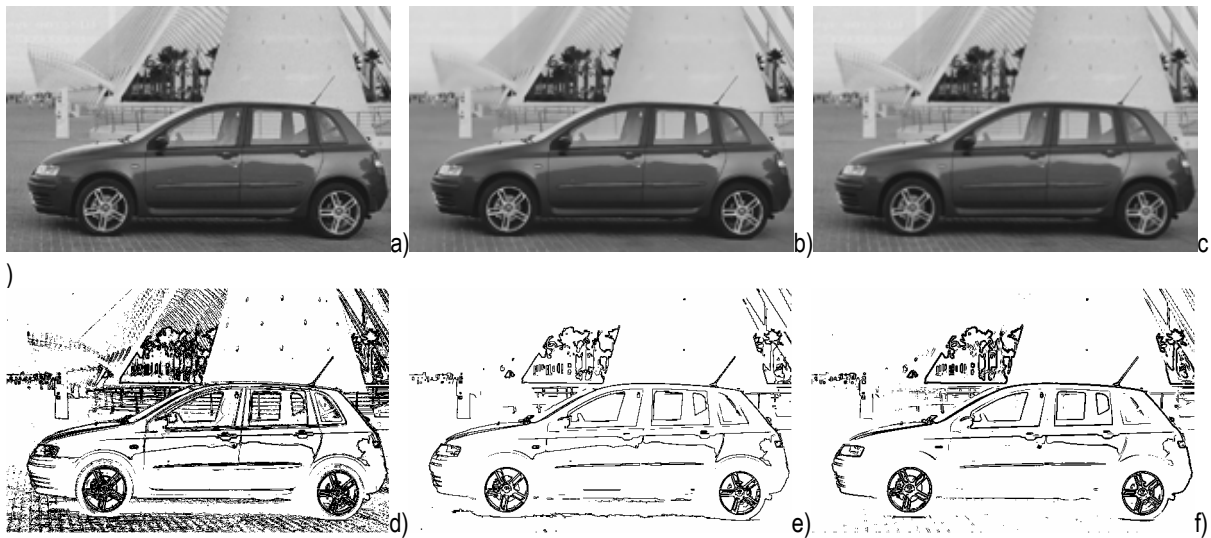


Fig.1.a) initial image; b) image smoothed with the SUSAN filter; c) image received after smoothing filter; d) contours separated from the real image; e) contours separated from the image smoothed with the SUSAN filter; f) contours separated after the smoothing filter

Both filters decreased a number of lines. It is difficult to define visually which of them functions better and preserves better the image structure. But if the procedure of smoothing is performed several times (8 times for the SUSAN filter, 6 times for smoothing filter) even a visual estimate testifies that the image appears fuzzy after the smoothing filter whereas after repeated use of the SUSAN filter the object's image stands out sharply against fuzzy background. The results are given in Fig. 2 a) and b). The contours extracted subsequently appear quite differently. After the smoothing filter the greater part of the contours is lost. The results are given in Fig. 2 c) and d).

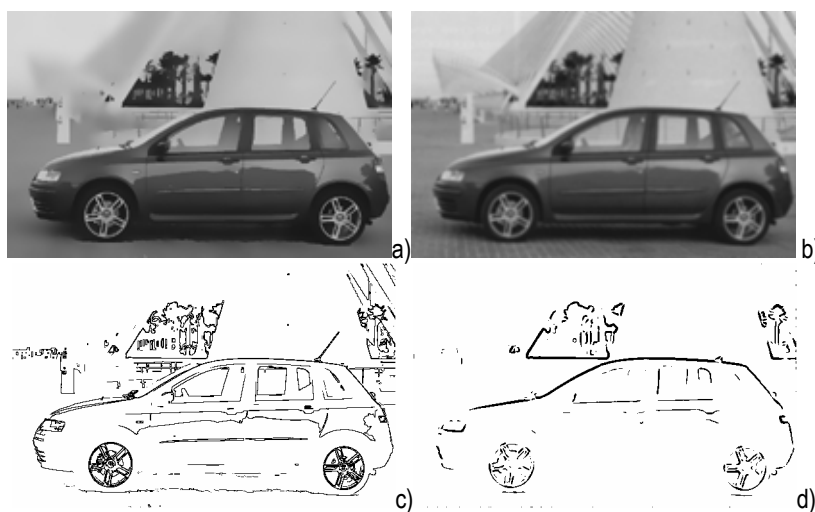


Fig. 2. a) the image after 8-fold use of the SUSAN filter; b) the image after 6-fold use of the smoothing filter; c) the contour obtained after using the SUSAN; d) the contours obtained after using the smoothing filter.

Let us consider one example more. The results of the automatic object extraction algorithm functioning and consequent extraction of the contour are given in Fig.3.

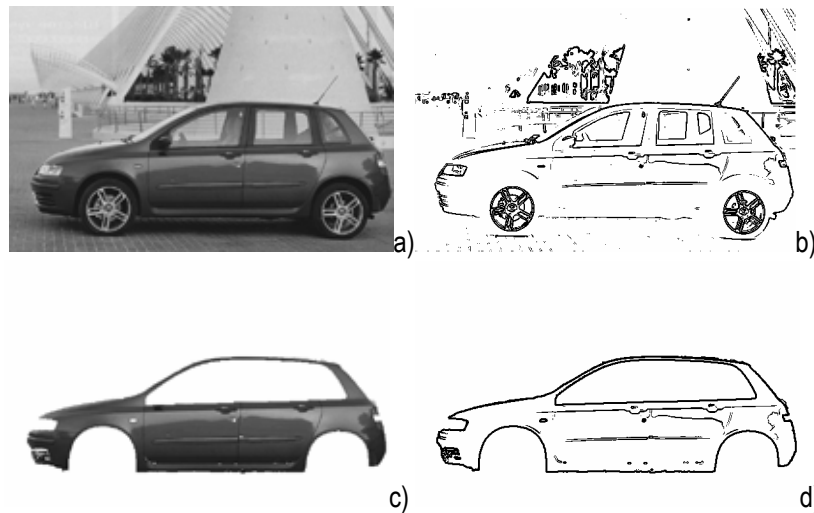


Fig. 3 Results of obtaining image gradient with the offered algorithm. The initial image (a); the contours extracted from the initial image (b); the object's localized region (c); extracted region contours (d).

In spite of the fact that part of the details of the object was lost (wheels, headlights...) it is possible to indicate that this algorithm gives satisfactory results owing to its functioning. The contour of the car body is a clear closed contour and the contour of the car body is one of the main standards making it possible to classify a car. The absence of the background will increase the object recognition rate.

Conclusion

The performed research showed that the considered methods produce "soft" smoothing preserving the image structure. Only uniform parts of the image are subjected to smoothing, edges and corners of the objects remain clear and not fuzzy. Application of the given method is possible both to the problems of the preliminary image procession preceding the process of segmentation through limits extraction and to the increase in the image quality, for example, photos.

The objects' extraction by the color hue gives a good result both for the problems where it is necessary to extract an object from the background and for the problems where it is necessary to pass to the space of indications, to get the objects' contours. The absence of noise in the form of the background will make it possible to perform the recognition quicker.

There are some shortages here: the given method functions only if one sufficiently big object (as compared to the background details) is on the image. The biggest region with one color is extracted automatically.

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