УДК 004.93

Алгоритм фильтрации помех в задаче выделения контура изображения для системы искусственного зрения роботов

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Аннотация
Изображение, полученное видеокамерами робота, проходит через несколько этапов преобразований. На первом этапе цветное изображение конвертируется в черно-белое, затем с выбранным значением порога контрастируется. Предполагается, что помехи имеют вид кривых минимальной толщины (в один пиксель) или отдельных точек. Фильтр удаляет все помехи. Далее к полученному изображению применяется пороговый фильтр, который в отличие от масочных алгоритмов типа Собеля работает значительно быстрее и точнее. В программе используются операторы системы Maple.
Ключевые слова: фильтр помех, контур, изображение, Maple

Algorithm of noise filtering in the problem of extracting the image contour for the system of artificial vision of robots

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Abstract
The image obtained by the robot's video cameras passes through several stages of transformation. At the first stage, the color image is converted to black and white, then with the selected threshold value is contrasted. It is assumed that the interference has the form of curves of minimum thickness (one pixel) or single points. The filter removes all noise. Next, a threshold filter is applied to the image obtained, which, unlike the Sobel type masking algorithms, works much faster and more accurately. The program uses the operators of the Maple system.
Keywords: noise filter, contour, image, Maple, isolating the contours

In the control and navigation system, a group of robotic devices includes, as one of the important components, a program for isolating the contours of objects. The simplest purpose of the contour form of an image is to count individual objects in the visible area of view. In more complex tasks, the contours of objects give more compact information about the object, highlighting the main thing from it. The contours can later be recognized using the Hopfield algorithm and other neural network approaches. One of the most famous and popular methods is the Sobel's algorithm [1]. This algorithm is based on the discrete differentiation of the image using a special matrix — a mask moving along the image and collecting (with some coefficients) the intensity of the pixels on the border of the mask in its middle. There are known works to improve the work of the algorithm [2-4] and the practice of its application [5-9]. One of the most successful was the work of Hanno Scharr [10, 11], who proposed his matrix mask, which differs from the Sobel mask with a different (but similar) filling of the mask matrix.

Sobel filter

The Sobel filter uses the discrete differentiation of the pixel intensity distribution function under special masks $\mathbf{F}_1$ and $\mathbf{F}_2$, in two directions. The matrices are mutually transposed and have the form

$$\mathbf{F}_1 = \mathbf{M} = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}, \quad \mathbf{F}_2 = \mathbf{M}^T = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}.$$

The image is encoded by the pixel intensity values. One matrix takes information around the pixel α_{ij} on row i and column j. According to this information, the sum is obtained

$$X = \sum_{k=1}^{3}\sum_{m=1}^{3} F_{1,km} b_{km},$$

where b_{km} are the elements of the image submatrix around the pixel with intensity α_{ij} . An analogous sum having the meaning of a discrete derivative in the direction perpendicular to the first is collected by the second, transposed matrix

$$Y = \sum_{k=1}^{3}\sum_{m=1}^{3} F_{2,km} b_{km}.$$

The Sobel operator changes the intensity α_{ij} to a new value $\sqrt{X^2 + Y^2}$.

Threshold filter

The filter algorithm [12,13] is implemented in the computer mathematics system Maple [1]. Operators of the special ImageTools package are used to process images. Accepted: white color of the pixel corresponds to intensity 1, black — 0. The threshold filter works according to the principle of the scanner. First, the image is converted to black and white and a threshold pixel conversion with a preselected threshold H is applied. The threshold value is selected experimentally, usually for images with an average contrast of H = 0.5. Pixels, the intensity of which is less than the threshold, are converted to black, the rest to white. Scanning line by line pixel in one direction, the filter selects boundaries of image parts in each line, replacing its internal parts with white pixels and arranging black borders on the borders. The same scanning is performed in a perpendicular direction. The scan results are added, which is equivalent to multiplying the pixel intensities. The speed of the filter is significantly higher than the speed of the Sobel filter. With the increase in image size, the advantage in speed increases [12]. However, this filter also has a noticeable drawback. When processing images with noises, for example in the form of dots and lines, not just one pixel (Figure 1), the filter gives false contours (Figure 2).

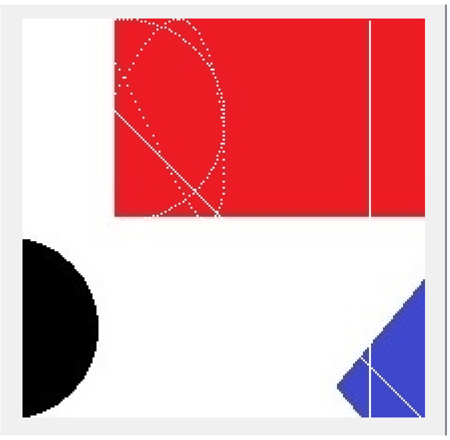

Figure 1 - Noise image

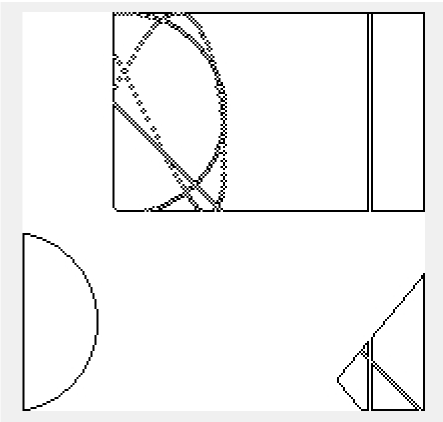

Figure 2 - False contours

Noise Filtering

Noise elimination is performed in two stages. First, all rows are scanned and the places where the intensities of the three pixels 1-0-1 alternate occur. A pixel with an intensity of 0 is assigned a value of 1 (Figure 3). Then the same operation is performed for scanning vertically (Figure 4). The corresponding Maple operators are:

```
> for i to w-1 do
> for j to h do
   if im[i,j]=0 and  im[i+1,j]=1 and  im[i+2,j]=0
   then im[i+1,j]:=0: end;
  end;
end;
```

Here w and h are the width and height of the image:

```
> w:=Width(im); h:=Height(im);
```

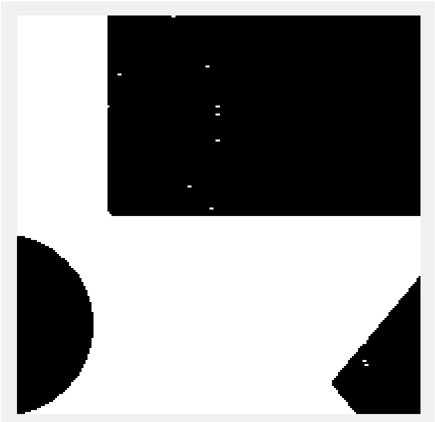

Figure 3 - Noise still exists

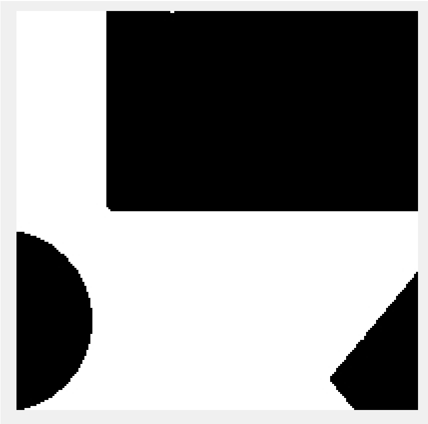

Figure 4 - Noise eliminated

Then the threshold filter [12,13] comes into operation. The result of scanning the contour vertically is shown in Figure 5, horizontally in Figure 6. The sum of the images (the result of the algorithm) in Figure 7 differs noticeably from the scanning of the unclean image (Figure 2).

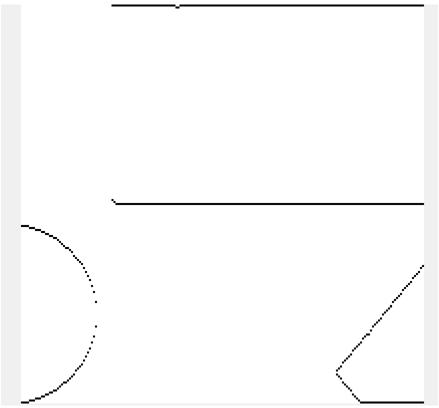

Figure 5 - Vertical scanning

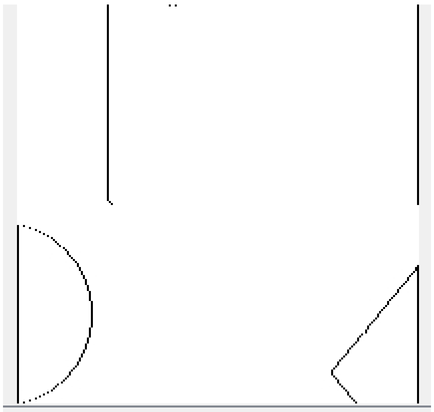

Figure 6 - Horizontal scanning

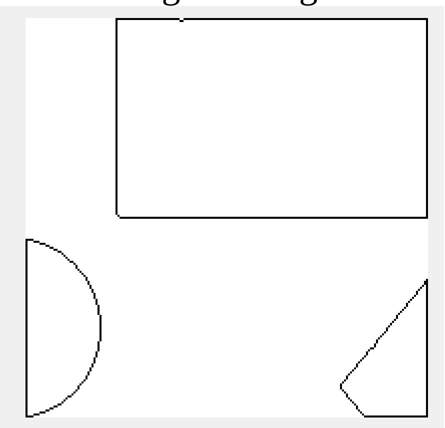

Figure 7 - Contours. Result

The contours representation of information is much more economical than displaying the entire image. In this case, the basic information about the object is preserved, only important details are not always lost. A filter with noise cleaning can be used in control systems of robot groups, together with algorithms for laying optimal routes [14-20]. The task of isolating contours is relevant and approaches to its solution are constantly evolving. Separately, one can single out papers [21-25] in this direction.

The next stage in the investigation of the problem of selecting a contour can be the search for a simple algorithm for closing contours and algorithms for isolating contours of given colors. A combination of the Sobel and the threshold filter is also possible. The Sobel filter, in spite of the fact that it yields blurred contours and requires considerable time, has some advantage in terms of stability with respect to the breakdown of the desired contour. A strongly broken contour Sobel filter perceives as some nebula and gives a contour with a shadow, while the threshold filter distorts the contour.

An estimate of the degree of contour fracture also requires solving a particular mathematical problem.

The work was supported by the RFBR grant No. 16-01-00429 a

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