SMOOTHED CONTOUR DETECTION METHOD FOR ARBITRARY SHAPE OBJECT OF IMAGES

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Summary. Description of initial raster image objects by a set of contour vertices coordinates leads to increase efficiency of the retrieval, classification and recognition of graphical data in information systems. In this paper the smoothed contour detection method for objects of raster images is considered. The developed method is based on application of interpolation function for partial differential equation solutions and smoothed function for post-processing of detected contours. The accuracy of contour reproduction for raster image objects is increased on 4.87% by applying the developed method compared to the discrete method of contour detection.

Keywords: smoothing image, contour detection, gradient method

Automated image analysis and expert decision-making based on it allow to avoid mistakes, complications and reduce the need for operative intervention in facial recognition systems [1-3], traffic control systems [4-5], intelligent security systems [6-7], geographic information systems, robotics [8] and medical practice [9-10].

Image analysis by content and/or dynamics of changes is based on the parameterization of informative image features and the expert decision-making based on them. Image contour is one of informative image features. Contour description of images provides a concise representation of the component objects of images, their shapes, area and other metric characteristics that can increase the efficiency of retrieval, classification and recognition.

Image edge detection is based on detecting the image homogeneity or heterogeneity. Threshold analysis methods, region growing methods, morphological analysis methods, classification methods describe the approach of edge detection by homogeneity retrieval. Differential operators, directional filters and gradient methods describe the approach of edge detection by heterogeneity retrieval. The result of such transformation is the image of edges described by a set of pixels with 0 or 1 brightness values. The graph search (or traversal) techniques, Hough transforms and local processing methods, for example contour tracing methods [11-
are applied to obtain the ordered \((x, y)\) coordinates of contour vertices. This integrated approach of detecting and describing the contours is characterized by the appearance of the wide contour curves, their ruptures and fragmentation and is dependent on the noise in the images also. In such cases, the smoothing method is applied as preprocessing procedure in edge detection stage [13]. Another approach is to apply the smoothed function as post-processing procedure of contour detected by spline interpolation of partial differential equation solutions [14-16].

Let image contour detected by spline interpolation is described by (1):

\[ C = (c_1, c_2, \ldots, c_i), \]  

where \(c_i\) is contour point, \(c_i = (x_i, y_i)\), \(x_i, y_i\) are coordinates of contour point, 
\(i = 1, 2, \ldots, N, N\) is the quantity of points.

The smoothed function is based on scanning the contour with vectors which are described by (2):

\[
\begin{align*}
wx & = (x_k, x_{k+1}, \ldots, x_{k+v}) \\
wy & = (y_k, y_{k+1}, \ldots, y_{k+v}),
\end{align*}
\]

where \(x_k\) is \(x\)-coordinate of contour points \(C\), \(k = 1, 2, \ldots, N - v\), \(y_k\) is \(y\)-coordinate of contour points \(C\), \(v\) is parameter, which is defined the size of \(wx, wy\) vectors.

For example, for a contour point \(c_i \in C, i = 1\) with coordinates \((x_1, y_1)\) and \(v = 4\), these vectors are described by (3).

\[
\begin{align*}
wx & = (x_1, x_2, x_3, x_4, x_5) \\
wy & = (y_1, y_2, y_3, y_4, y_5)
\end{align*}
\]

The next stage is to redistribute values of vectors (3) and to determine the median. Let after sorting the \(wx, wy\) values are described by (4).

\[
\begin{align*}
wx & = (x_3, x_2, x_5, x_1, x_4) \\
wy & = (y_3, y_4, y_1, y_2, y_5)
\end{align*}
\]

Then \(x_5\) and \(y_1\) are medians of \(wx, wy\) vectors accordingly. The initial coordinates of contour points are changed and the coordinates of \(c_i\) point are \((x_5, y_1)\).

The developed method was applied to arbitrary shape objects of images, in particular for medical images. The test images are the images of brain computed tomography (fig. 1a). At the first the image contour is detected by spline interpolation of partial differential equation solutions (fig. 1b). The next is to apply the contour smoothed function (fig. 1c).

Another approach to detect contours is to apply median filtering, segmentation method in [17] and Moore-Neighbor tracing method (fig. 1d). This transformation sequence will be called later in the article as discrete method.
Fig. 1. Object contour of test image №1: a) the image of brain computed tomography and the object of interesting; b) the object contour detected by method in [14-16]; c) the object contour detected by developed method; d) the object contour detected by discrete method.

The developed method is more efficient than the discrete method (fig. 2). In fig. 2c and fig. 2d are presented the degree of deviation of the contour vertices coordinates from the template values (shown in red) detected by method in [14-16].

Fig. 2. Object contour of test image №2: a) the image of brain computed tomography and the object of interesting; b) template contour detected by method in [14-16]; c) the degree of deviation of the contour vertices coordinates detected by developed method (shown in black) compared to the method in [14-16]; d) the degree of deviation of the contour vertices coordinates detected by discrete method (shown in black) compared to the method in [14-16].
The degree of deviation of the contour vertices coordinates can be determined by (5):

$$R = \left(\frac{1}{N} \sum_{i=1}^{N} (x_i - \bar{x}_i)^2 + (y_i - \bar{y}_i)^2\right) \times 100,$$

(5)

where \((x_i, y_i)\) are template coordinates of contour points, \((\bar{x}_i, \bar{y}_i)\) \in \([0; 1]\), \((\bar{x}_i, \bar{y}_i)\) are test coordinates of contour points, \((\bar{x}_i, \bar{y}_i)\) \in \([0; 1]\), \(i = 1, 2, ..., N, N\) is the quantity of contour points.

The results of determining the accuracy of contour reproduction compared to the method in [14-16] for the test image set are presented in Table №1.

**Table №1**

<table>
<thead>
<tr>
<th>File name</th>
<th>Proposed method, (R)</th>
<th>Discrete method, (R)</th>
<th>File name</th>
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The vectorization of raster image contours will increase the informativeness of automated graphic data analysis in information systems. For this purpose has been developed method which is based on smoothed function application as post-processing procedure of contours detected by spline interpolation of partial differential equation solutions. To compare, determine the efficiency and estimate the contour reproduction accuracy of the developed method the discrete method is considered also. The discrete method is based on application of median filtering, segmentation method in [17] and Moore-Neighbor tracing method. The accuracy of contour reproduction for raster image objects is increased on 4.87% by applying the developed method compared to the discrete method.
References:


