APPROXIMATION, BROKEN LINE OF MINIMUM LENGTH WHEN DEFINING THE CONTOURS IN THE COLOR IMAGE

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The discrete boundary can be approximated as precisely as possible by a polyline. The approximation becomes accurate when the number of polyline segments is equal to the number of border points (which is true in the case of a closed border) and each pair of neighboring points connects its own segment. In practice, the goal of polyline approximation is to use as few segments as possible to approximate the "essence" of the border shape. In General, this task is not trivial and its solution often results in labor-intensive re-sorting schemes. However, some approximation methods that are characterized by moderate computational complexity are well suited for digital image processing. Among these methods, one of the most powerful is the representation of the border by a polyline of minimal length (LLD), which we will now consider.

An intuitively attractive approach for constructing an algorithm for finding the LMD is the following. Divide the image into square elements and select a set of connected elements that enclose the border of the area (figure 2.1.1 (a)), as shown in figure 2.1.1(b). This approach allows us to consider the boundary of the area as a rubber band located between two walls corresponding to the internal and external borders of the specified chain of elements. When you pull the tape, it will take shape, forming a polygon with a minimum perimeter that corresponds to the geometric shape of this chain of elements. Note that in this drawing, all the vertices of the LMD coincide with the corners of either the inner or outer border of the formed chain of elements.

The accuracy of polyline approximation is determined by the size of the elements that the area containing the border of the source object is divided into.

In the limit where each partition element corresponds to one pixel of the border, the amount of deviation of the actual border from its LMD approximation inside any element does not exceed $\sqrt{2d}$, where d — the minimum distance between pixels, i.e. the sampling step when getting the original digital image. This deviation can be considered half as much if the center of the corresponding pixel is taken as the reference point of the element. The task is to use the partition elements of the largest possible size, so that the resulting LMD contains the minimum number of vertices and provides sufficient approximation accuracy for a particular application.

In this section, we will formulate a procedure for finding the vertices of such a polyline

According to the described approach based on cellular partitioning, the shape of an object enclosed within the initial boundary is reduced to the area that is bounded by the formed chain of elements, similar to the dark color shown in figure 1(b). In figure 2 (a), the source object is marked in dark gray. As you can see, its border consists of 4 connected straight lines. We will go around the border of the object in a counterclockwise direction. Each encountered turn will be either a convex or concave vertex, depending on the value of the internal angle of the 4-connected boundary at this point. In figure 2 (b), convex and concave vertices are marked with white and black dots, respectively. Note that all these vertexes belong to the inner

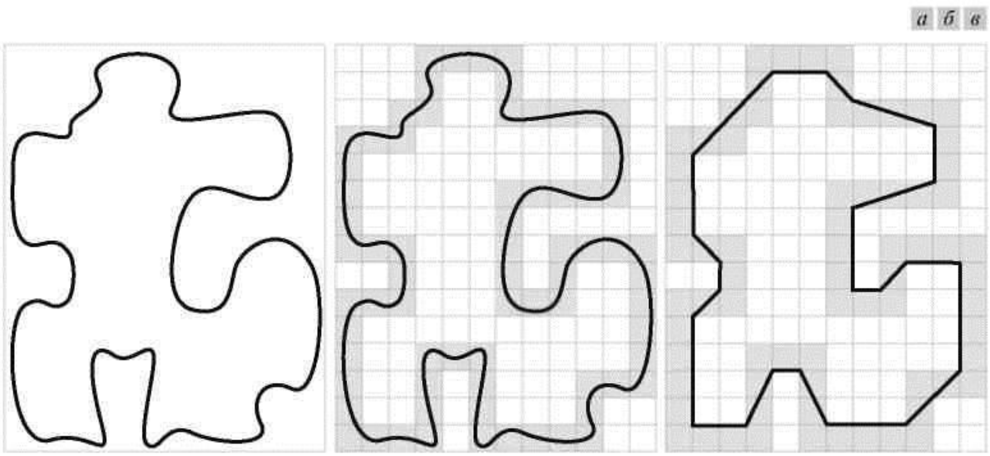

Fig. 1. (a) object Border (black curve). (b) the border of an object enclosed within a chain of elements (highlighted in dark color). (C) Polyline with the minimum length, resulting from the tightening of the border. The polyline vertexes match the corners of the internal or external borders of the selected area

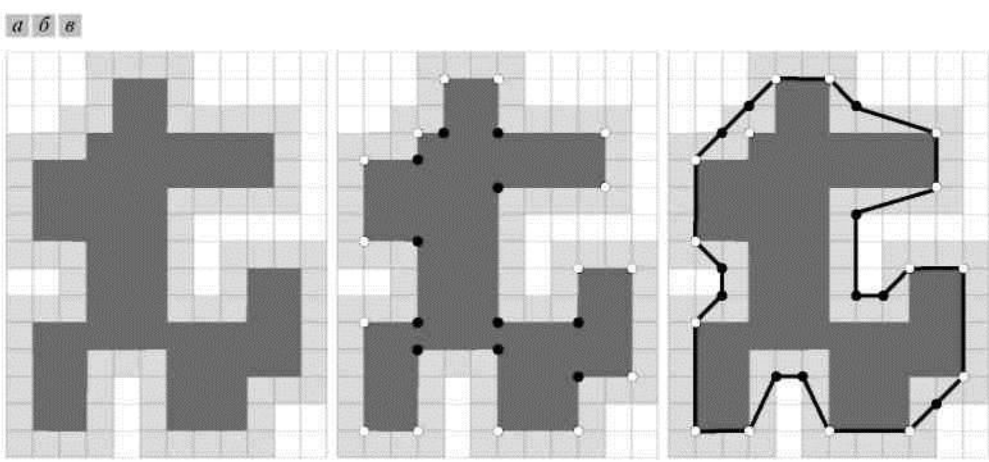

Fig. 2. (a) a Dark gray object whose border is enclosed in a formed chain of elements (see figure 1). (b) Convex (white) and concave (black) vertexes found when traversing the border of a dark gray object counterclockwise. (C) Concave vertexes (black dots)

moved to diagonally opposite points on the outer border of the formed area, highlighted in light gray; convex vertexes in their former places. The black line for clarity shows the LMD 2 (b), and that for each concave vertex of the border of the object (black dot), there is a "mirror" point of the outer border of the specified area, located in the diagonally opposite corner of the corresponding subdivision element. The mirror points of all concave vertexes are shown in figure 2 (C), where for clarity, similarly to figure 1(C), the LMD is superimposed. As you can see, the vertices of the LMD coincide either with the convex vertices of the inner border of the formed light gray area (white dots), or for concave vertices with their mirror points on its outer border (black dots). It is easy to guess that only the convex vertices of the inner border and the concave vertices of the outer border of the surrounding region can act as the vertices of the LME. So our algorithm should only focus on such vertices.

A convex vertex is the middle of three points if they form an angle in the interval $0° < \theta < 180°$; similarly the angle at a concave vertex is in the interval $180° < \theta < 360°$. Corner 180° means a pronounced vertex (located on a straight line connecting two neighboring points) that cannot be a vertex of the MD, and angles of 0° or 360° mean that the path turns in the opposite direction, which is not possible in this case.