New Method of Boundary Points Description with Given Accuracy for Objects Recognition

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Abstract

Nowadays digital video and image are made with very high speed. The computing power of modern computers allows the development of new methods to automate the data analysis process. The speed of useful information extracting from this digital data are very important. A review of the papers of recent years shows that the methods and means for obtaining and processing of digital image continue to develop. The article deals with the problem of image processing for analyzing video data. High-resolution videocamera increases the number of contour points and re-assigning points with curves or array of points with given permission variable (accuracy) significantly reduces time of processing. A method for the obtaining of boundary points with a given accuracy to select objects with different levels of detailing is proposed.

Keywords

Information security, digital image processing, pattern recognition, edge detection, array of boundary points, curve fitting, approximation accuracy

1. Introduction

In information security to organize technical protection against unauthorized access as one of the key sources video stream data is used. Successful prevention of unauthorized access depends on the analysis of data. The level of automation of video processing in real time is important. Many scientific works of recent years are devoted to this topic, aimed at improving the quality of receiving, analyzing and recognizing of video information. Quality of recognition depends on the speed of processing and presentation of data, which mainly rely on data about the shape of the suspicious objects.

2. Image processing in the field of information security

Technical security includes the installation of video cameras. The processing of data received from security cameras for searching and recognizing objects remains an important topic, this is a subject of many works of the last period (e.g. [1-3]). Automation of this task allows to promptly extracting information about suspicious objects, their actions and anomalous behavior.

In addition to ordinary video cameras, data from cameras of unmanned aerial vehicles, 3D scanners, X-ray scanners, terahertz security cameras that are safer for human health, thermal imagers, etc. are used. [4-7]. In all these video systems, along with the mode of manual search and detection of dangerous objects, automated data processing in real time is used. The most effective methods for automating detection and recognition are used in field of artificial intelligence with a neural network [8 - 10].

Object recognition in the automation of video data processing is based usually on the analysis of contours; there are a large number of methods for identifying boundary points of objects. In this case, it is necessary to take into account the influence of interference during image formation and at the stage

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of preprocessing and to remove the arisen hardware noise and aberrations [2, 13-15]. Due to the modern calculating power of computers, the developed methods show high accuracy and reliability of the intelligent systems.

One of the key factors for the qualitative object detecting is the determination of such characteristics of the object as shape, texture, description of the contour and other geometric characteristics of the object. It is especially important to automate the process of accurate contour obtaining. To do this it is possible to vary the value of the permissible variation (accuracy) for extracting boundaries while receiving data on an object. The accuracy is a distance between source and approximate values of boundary points and provides required accuracy. Changing the value of the contour accuracy at different stages increases speed of the image search and analysis process. When a suspicious object is detected, the accuracy value is reduced for more detailed and accurate information extraction.

3. Edges description

As one of the most important parts of object recognition segmentation and edges detection, accurate contour description methods are still developed [16 - 26]. There are many different methods to get information on contour points of object in problems of object recognition. One of the most popular of them is curve fitting on the base of boundary points using approximation or interpolation methods. The curve fitting by approximation method when some points must belong to curve or have to be smooth in some of them are presented in [27-29].

Usage of high-resolution camera by one side increases image quality and by another side gives big array of points for processing. Curves fitting and substitution of boundary points array with other points allows reducing time of processing, increases speed of object's recognition. Therefore, the method of boundary point's chain determination has been worked out. In this method of geometrical modeling of object boundary, the array of source points substitutes with a set of points, which provides required accuracy on object for further processing.

After obtaining boundary points, we can get more information on the object's features such as area, perimeter, etc. One of the main advantages of it is curve's smoothness. Making approximation of the object's boundary with circular arc gives dataset on curvature values for reference objects. Curvature is a constant characteristic, which does not, depends on the object's location, or rotation and other transformations, therefore may be used in recognition problem. The contours of recognizing and reference objects are compared on their curvature.

In [27, 28] the method to substitute the boundary of an object with segments of polynomials – a composite curve – was described. The fitting curve is formed according to requirement of first degree of smoothness, so this approves obtaining of first derivation in each point. A computational experiments show that reduction of information of source points was approximately 45 times less. This method allows to obtain the value of curvature what is invariant to rotation, scale and useful to recognize partially visible objects. Curvature values are used to measure similarities of shape of recognized object and reference object.

4. Boundary points substitution

In some cases, it is necessary to get reduced array of boundary points. The problem of curve reassigning with circular arcs also as reassigning with straight-line segments is a task that is relevant for many computer-aided design and recognition systems. New array of points will reduce noises or not important parts on image. However, the new points array may have deviation from source points within given permissible variation – given accuracy ε that is different and depends on tolerance of solving problem or applied field.

To solve this problem the method of boundary points' substitution has been worked out. This task is implemented during describing array of points as chain of curves [27] and algorithm is presented below. As a result of previous step we have curve $g(x)$ and the value of given accuracy ε. New points

are defined on arcs of tangent circumference between two offset (equidistant) curves [30-35] on offset distance of given accuracy ε – tube of tolerance.

The proposed method is based on a technique that allows finding a conjugate arcs one of the offset curve and a normal line at a given point. Below the solution of this problem is consider and then propose a technique for redefining the source points with a points on circular arcs is described.

The algorithm of this technique is shown on figure 1.

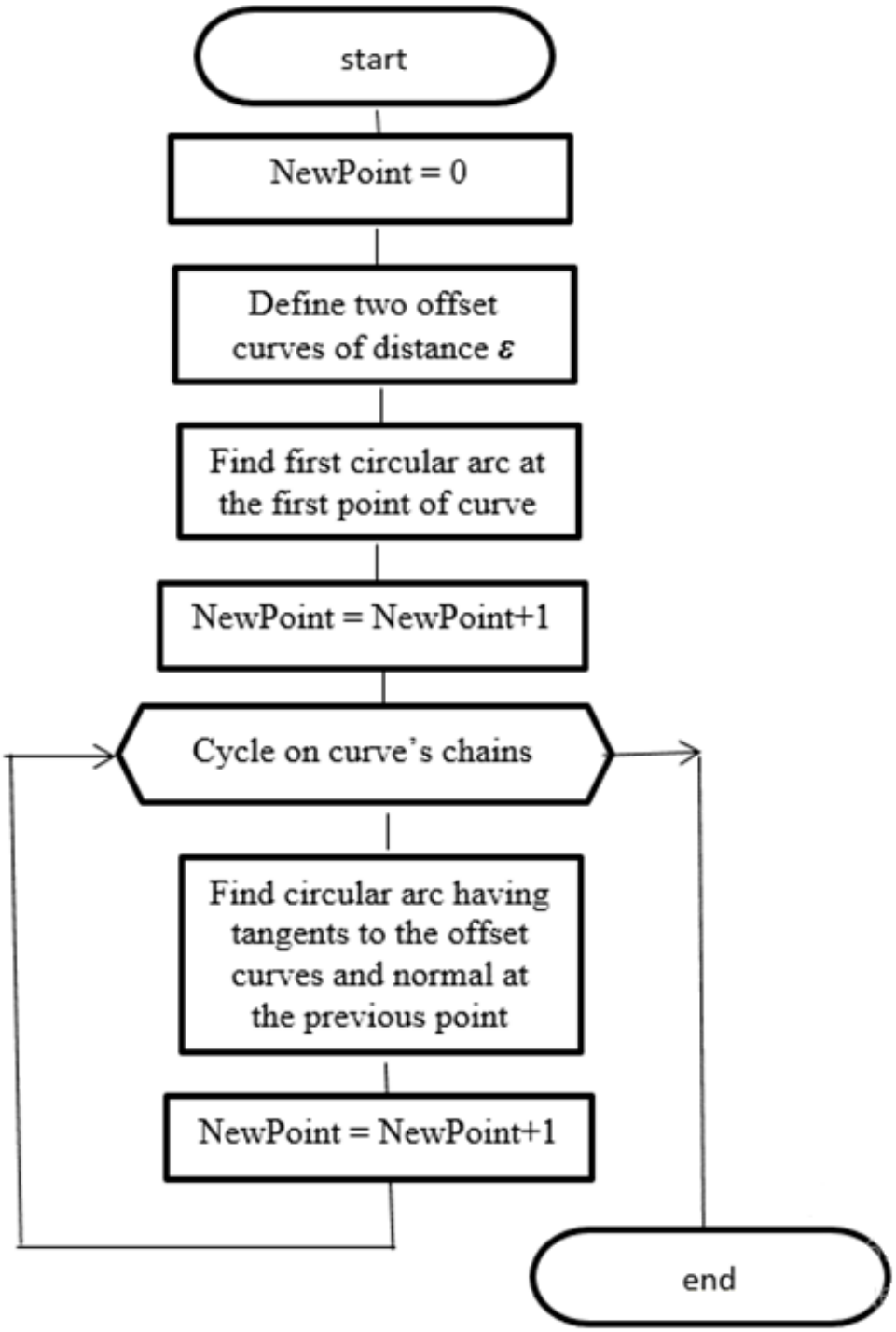

Figure 1: The algprithm of points substitution method

4.1. Define the first arc of chain

1. Determine two equidistant curves ***g1(x)*** and ***g2(x)*** laying above and below from the source curve using distance ***ε*** (Figure.2) on normal to points of curve ***g(x).*** Normal passes through the point perpendicular to the curve tangent at this point.

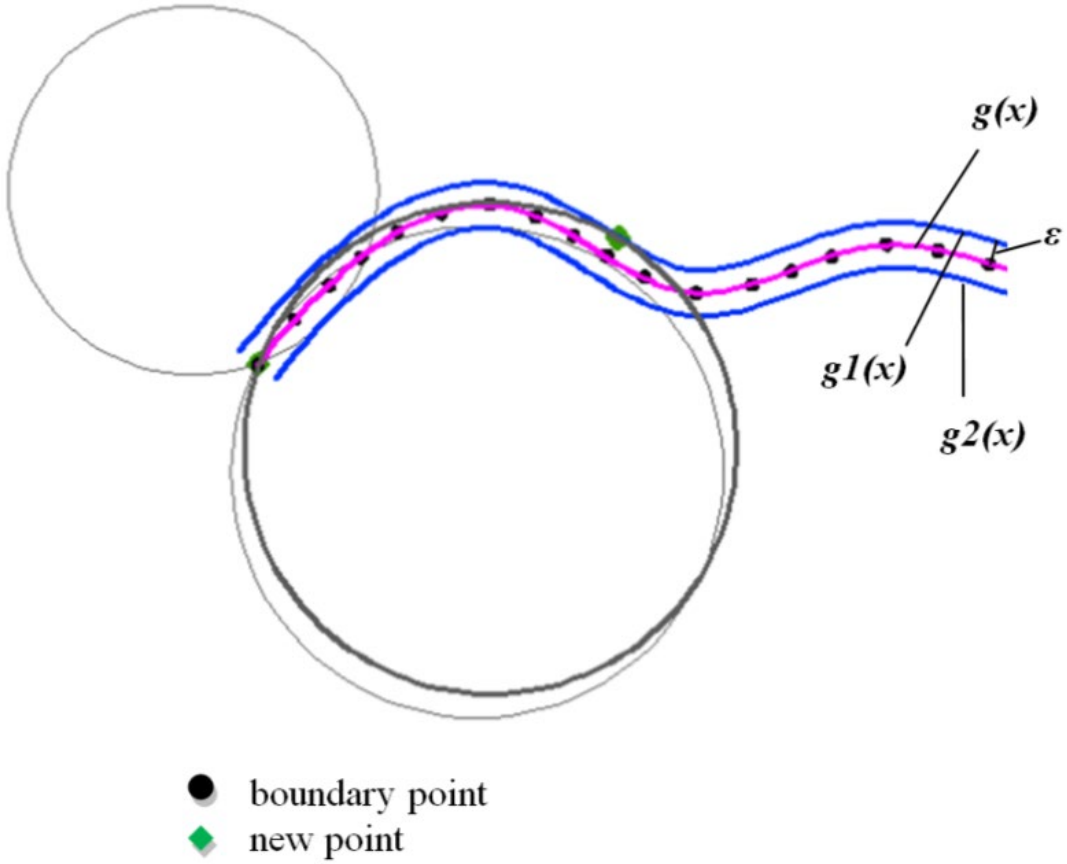

Figure 2: Defining of the first tangent circumference

2. Define circumference passing through the starting point on ***g(x)*** and having tangents to equidistant curves ***g1(x)*** and ***g2(x)***. Of all defined tangent circumference, the circumference with maximal radius or maximal distance from the starting point is selected. For example, on the figure 2 between two green points of the new array are 8 black boundary points of source curve. So information on this section is reduces 4 times keeping necessary accuracy of the given permissible variation ***ε.***

4.2. Define remaining arcs of the chain

3. Calculate the angle of inclination of the tangent ***t*** at the point of tangency to the previous circular arc on the equidistant curve.
4. The next circumference is selected from the bundle of circumference (Figure 2) passing through the tangent point of the previous circumference. Centers of bundle circumference are on the normal ***n***. If several circumference of the bundle are satisfied to the conditions of step 2, and then the circumference of bundle of the largest radius is selected. On figure 2 the arc of maximal radius of circumference bundle is inside of the tube of tolerance. So, between the start and the end points of this arc are six points of source boundary array which are substituted with one new point.
5. Add tangent point to the new array of substitution points and define next arc of tangent circumference..

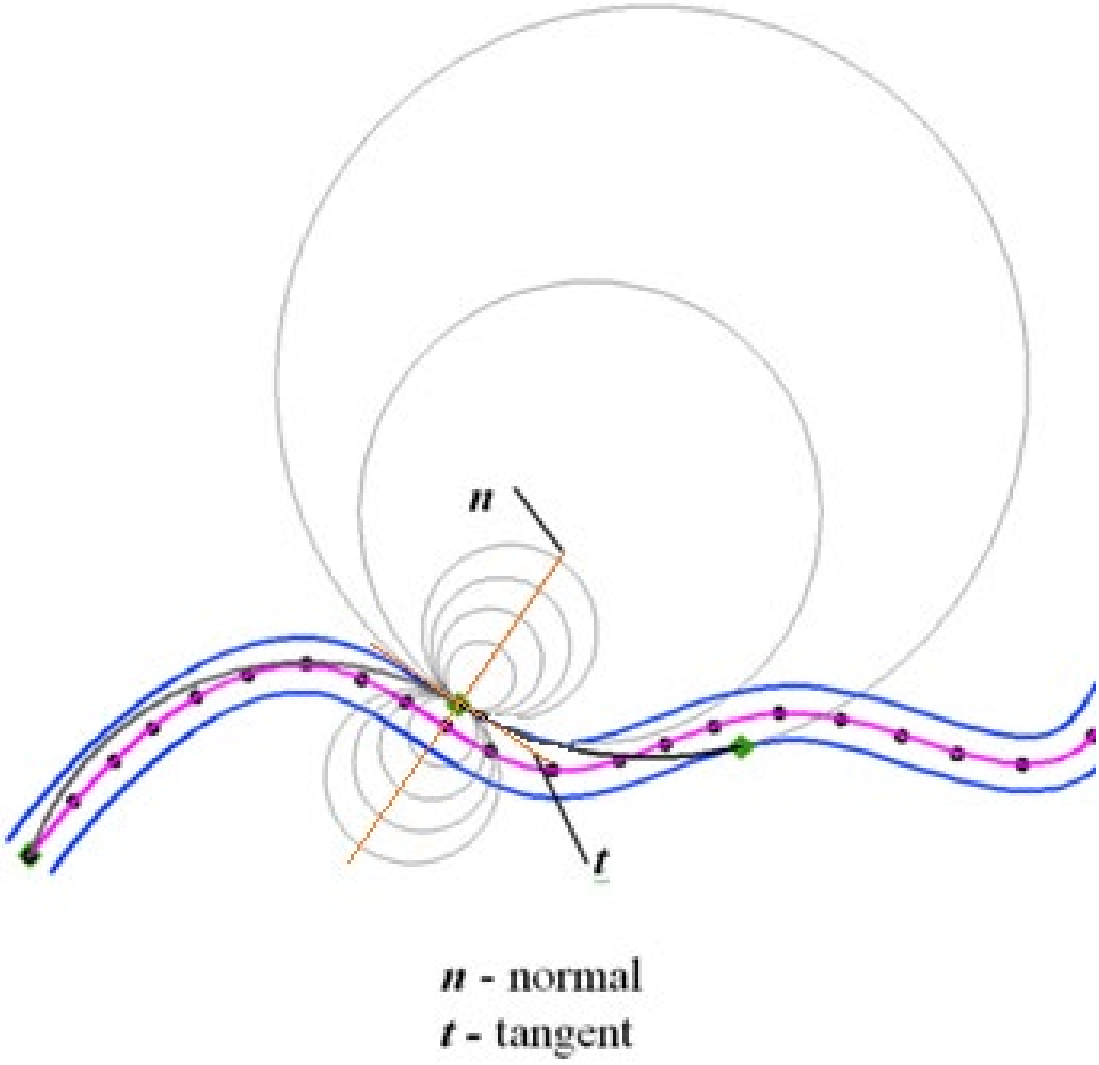

Figure 2. Defining next tangent circumference from the bundle of circumferences

5. Conclusion

The method of creation of new array of boundary points allows getting information on objects with different values of given accuracy and decreases time of digital images processing. Moreover, the implementation of the method of boundary points' substitution allows changing of fitting curves by chains of circular arcs with the first degree of smoothness in tube of tolerance and gives dataset on curvature values. The computational experiments shows that the described algorithm provides high speed of processing of array of boundary points of objects and reduces array of source points about 20-25 times on curves with complex shape.

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