Conference Paper

Identification of Links Between Points By Series of Images

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Abstract

The article presents solution to the problem of objects detection by series of their images without any prior information about outer characteristics (shape, color, etc.). The presented approach is based on detecting connections between separate points of objects. The authors developed an algorithm that uses movements of a fixed number of points measured at discrete instants of time as input data. It was tested using real experimental data. As a result, a matrix of links was obtained, which can be used for identifying separate objects. In future articles, the authors will offer the improvement of the proposed approach for quantifying the nature of connections between different points of a single object. It will help determine the object structure, it's weak and strong parts, internal defects, etc.

Keywords: series of images, points movements, links between points

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1. Introduction

One of the main tasks of image processing is object recognition [7]. It is actual in various fields of science and technology. This is due to the desire to create systems that can perceive images in the same way as a person, and perform the task at the required speed and quality.

Some characteristics (e.g., shape, color, etc.) are needed to identify objects by their images [1, 2, 4]. These characteristics should be stored in the computer's memory, but this is not always acceptable [6]. In this article, we suggest to use series of images instead of stored patterns to detect objects. In this case, we need to obtain objects' movements less than one pixel. One of the possible algorithms of detection movements less than one image pixel is represented in [5].

2. Materials and Methods

To detect individual objects, we use the well-known fact that all things are interrelated, and an object consists of points strongly related to each other and weakly related to points of other objects. The purpose of this article is to determine the links between the points of the image, using information about the small movements of each point. To achieve this, we developed an algorithm based on known Fourier transform and the link matrix that consists of points relations.

The efficiency of the developed algorithm is confirmed by experimental data on the small movements of points of three objects hanging on one support. The experimental data included arrays of small plane movements of nine points (three points for each object).

3. The Algorithm Description

The input data for the algorithm are arrays

$$\{x_i(s), y_i(s)\}_{s=1:N;i=1:T}, \tag{1}$$

where $x_i(s)$ is x coordinate of movement of point *i* measured in discrete time moment *s*.

The authors use the Fourier transformation [3] for each array (1) according to:

$$f_i(m) = \sum_{k=1}^{N} r_i(k) \cdot e^{-\frac{j2\pi}{N}m(k-1)}, m = 0, ..., N-1, \tag{2}$$

where *N* is the number of time intervals, *r* is the movement of the *i*-th point, *k* and m are indices of time and spectral samples.

After that, they calculate the average value of the Fourier transforms for each point:

$$f_i^* = \frac{f_i}{N}. \tag{3}$$

To find the links between the *i*-th and *j*-th points, they use matrix *D*, whose elements are determined by the formula:

$$D_{ij} = \frac{a(i) \cdot a(j)'}{\sqrt{(a(i) \cdot a(i)') \cdot (a(j) \cdot a(j)')}}, \tag{4}$$

where *a* = {*f* (*0*)... *f* (*N-1*)} is a vector of Fourier amplitudes for one point.

Two matrices *D* should be constructed for the movements along the *X* and *Y* coordinates.

The authors determine links by grouping points using the following rule. Two points i and j are linked if D_{ij} is an element of the maximum of a column and a row. Then, matrix D should be transformed. The new matrix D consists of the old one, but instead of two rows and two columns i and j, they write one row and one column that consist of the maxima of each pairs in the rows and columns i and j. After such a combination, the two points i and j are treated as one point.

During transformation of the matrices D for X and Y coordinates, the authors draw a transition tables to visualize the results of combining points by their movements along X and Y coordinates.

Then, they construct a single transition table according to the rule from the following example. If points 1 and 2 are determined to be linked along the X axis, and points 2 and 3 are determined to be linked along the Y axis, then all these points (1, 2, 3) are considered as one group of linked points.

Thus, the algorithm for combining points is as follows:

1. obtaining experimental data in two-dimensional arrays of movements for each point;

2. calculating the FT for the x and y movements of each point;

3. calculation of the matrices of links D;

4. combining points using the matrices of links D (drawing the transition tables for X and Y coordinates) until the dimension of these matrices become equal to 1; and

5. compilation of a single transition table and analysis of the results.

4. Results

To check the algorithm, they considered three moving objects with common support. Each object consisted of three points (Figure 1).

Figure 1 shows the relative positions of all nine points. The result of combining these points according to our algorithm with movements at short time intervals as an input data is shown in Figure 2.

As can be seen from Figure 2, first of all, groups (1,2,3), (4,5,6), (7,8,9) are formed, and then all of them are united in one group.

The result of combining these points according to our algorithm with movements at long time intervals as an input data is shown in Figure 3.

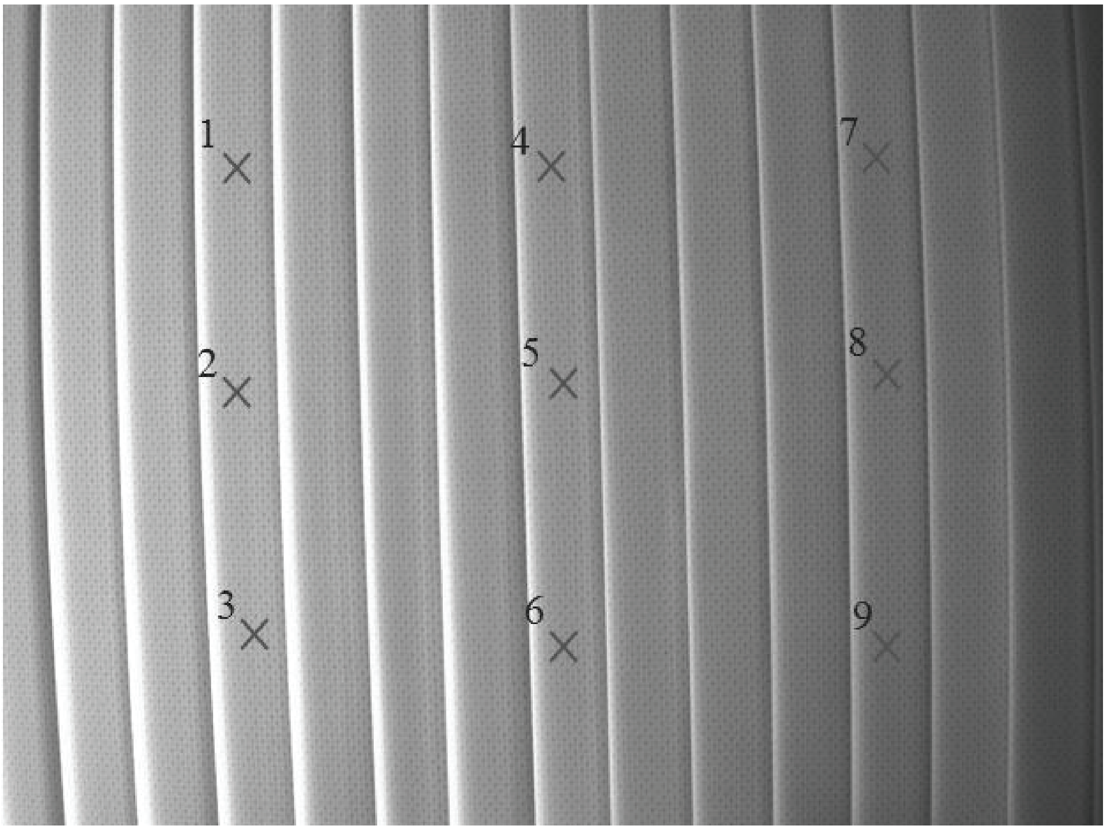

Figure 1: Relative positions of points.

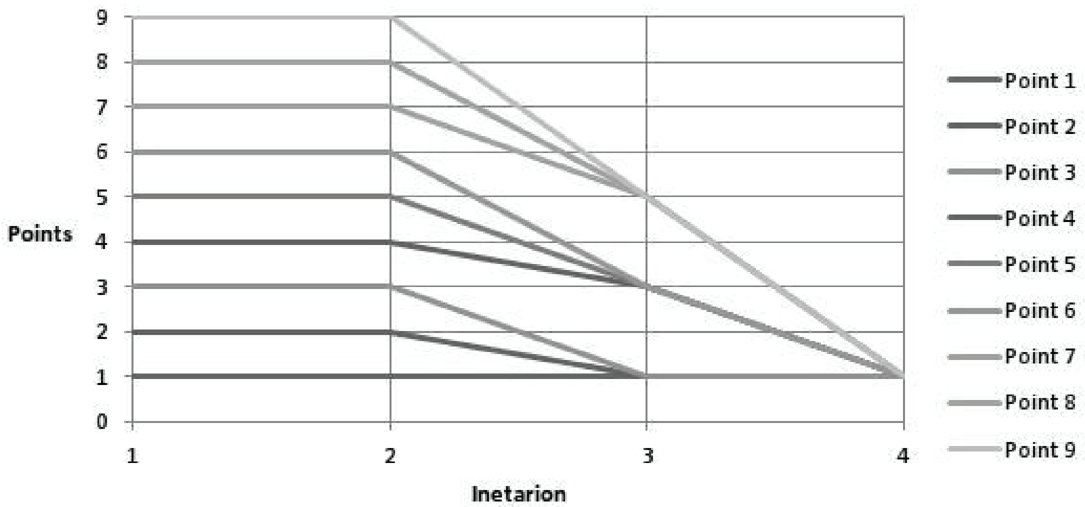

Figure 2: The result of combining points by their movements at short time intervals.

Unlike the previous result, the group (7, 8, 9) is absent. This can be explained by the poor quality of the images (see Figure 1), which caused large errors in detecting motions taken as input.

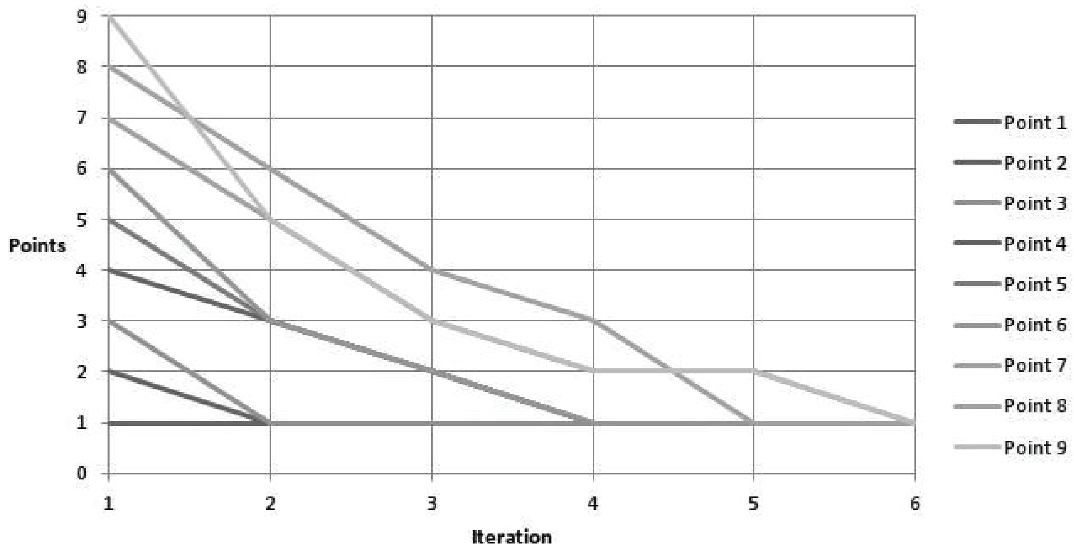

Figure 3: The result of combining points by their movements at long time intervals.

The points are grouped correctly for short time intervals movements. In the case of long time interval movements, we have the wrong result. So we need to improve the requirements for the primary processing of movements as our input data.

5. Discussion

It is possible to identify separate objects without any prior information about their outer characteristics using developed algorithm. In further articles, we will offer the improvement of the proposed approach for quantifying the nature of connections between different points of a single object.

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