Cost Reduction for Motion Detection in Sequential Images Using Hough Transform

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by

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Synopsis

In image analysis, it is one of important problems to detect motion of objects from the corresponding points among frames in sequential images. Hough transform is very effective to detect straight lines and parametric geometrical curves in a still image, but defective in computation of calculation and memory. Then, we propose a method of making the Hough transform low-cost to detect the motion vector from sequential images in this paper. In addition, we also describe a technique of removing errors in the extracted points.

Keywords : computer vision, Hough transform, voting, image analysis, shape from motion, correspondence problem

1. Introduction

In computer vision, various methods to detect the motion vector from the sequential images on VTR have been attempted in many researches[1,2,3]. A lot of methods using the Hough transform which is one of techniques for extracting parametric curves have been proposed[3,4,5,6].

The Hough transform is a method by which decides geometric parameters, for example, coefficients of a straight line by voting on the parameter space from the image space. It has the advantage to detect them from even noisy images, but its fault is the need of much computation cost of memory and calculation to vote on the parameter space. As the image becomes complicated and the resolution becomes high, the cost increases very much. Therefore, the cost reduction is an important problem when putting it to practical use.

Then, our purpose is the motion detection in sequential images and we propose a method of cost reduction in the Hough transform. At the same time, we consider a method of removing errors in extracted points for making it to high accuracy.

2. Constraint Conditions on Sequential Images

The sequential images in this paper is basically expressed by 3-D (2-D image + 1-D time)

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space (see Fig. 1). Therefore, when the tracks of the motion in sequential images are detected by the Hough transform, the 3-D Hough transform is applied. Then, the computation cost becomes huge and the transform is unpracticable. Here, we impose the following constraint conditions:

[Condition 1] The candidate points of the moving object are obtained beforehand.

[Condition 2] It is assumed that the motion is constant and the images are sampled in a short time. That is, the points exist only in equal intervals on the time axis, and the track can be approximated as a straight line.

[Condition 3] There is only one point which corresponds to each track in each image.

The low-cost method by the 2-D Hough transform and the buffer for the detection of the motion vector are discussed in the next section by using these constraint conditions.

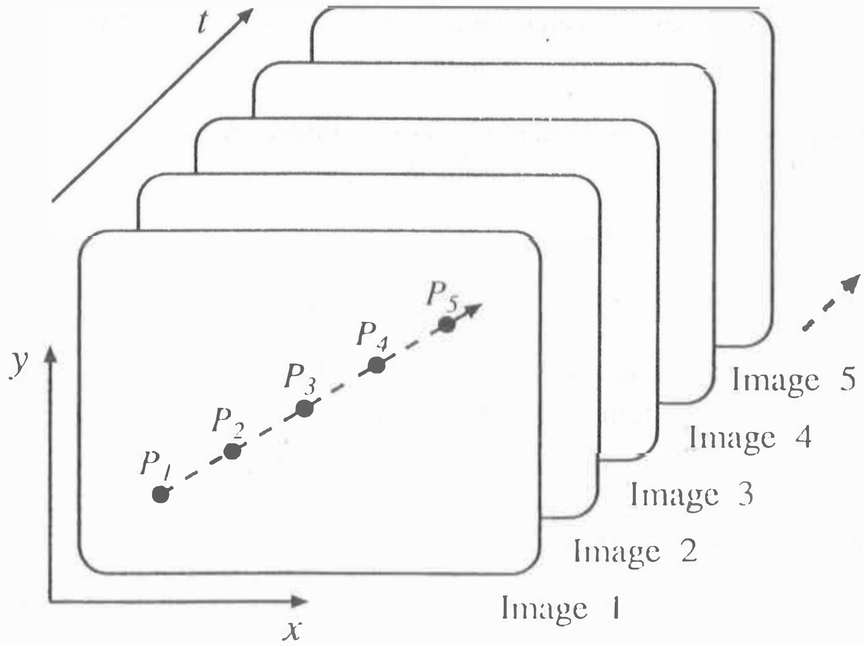

Fig. 1. Object motion in sequential images.

3. Motion Vector Detection Using Hough Transform and Buffer

Let each candidate point be P_i (x_i, y_i) on the x-y plain at each time, and a straight line is extracted using $\theta-\rho$ Hough transform:

$$\rho = x_i\cos\theta + y_i\sin\theta \tag{1}$$

When voting on the $\theta-\rho$ space, the coordinate (θ, ρ) which has the maximum value represents the line. Then, the x and y of the point (x, y) existing on the extracted straight line in each image are stored separably in the 1-D buffer (see Fig. 2) in order of time sampling. The increase and decrease of the x and y are sure equal if points on the straight line are correctly extracted from [Condition 2]. Moreover, because only one point exists in each image from [Condition 3], the point to incur a contradiction can be removed as noise by combining these conditions.

To search the coordinates of the straight line, the block of N×N along the line is slid and the x and y of the coordinate in the block are stored in the buffer. If two or more points exist in the block, -1 is stored in it and it is removed from the object of the following difference calculation of the buffer's value.

When the scan on the straight line completes, the difference of the buffer's value between each time is calculated. If the points on the straight line are correctly extracted in order, all of the differences must be almost equal in value (see Fig. 3). If the differences can be obtained at a time t, the coordinate of the moving object are

$$x = x_o + x_d t$$

$$y = y_o + y_d t \tag{2}$$

where x_d and y_d are the differences of x and y, respectively.

And, we adopt the point, which corresponds to these difference values from the image at that time and is removed from the candidate before, and exclude the other points from the candidate of this motion vector because they are possibly another motion vector or noise. When there are two or more motion vectors, We repeat the same operation after the point detected above is deleted.

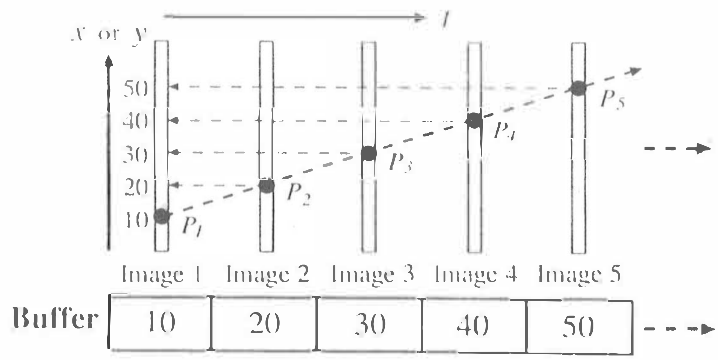

Fig. 2. 2-D image and 1-D buffer.

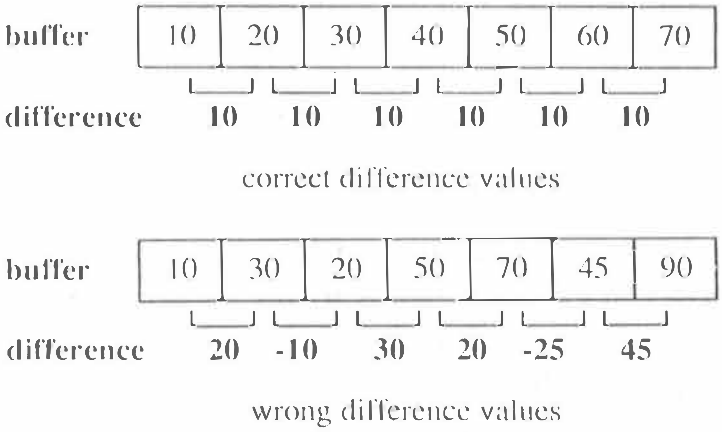

Fig. 3. Difference values in buffer.

In this method, the cost is reduced greatly compared with the 3-D Hough transform because of using 2-D Hough transform and 1-D buffer. Moreover, it is applicable by repeating the same procedure when there are two or more motion vectors, and the influence by noise can be reduced greatly at the same time.

4. Experiment

The results of the computer simulations are shown. Here, it is assumed that the magnitude of the motion vector is limited to one pixel. We experiment whether the motion vector is able to be detected accurately from noisy images.

Let the image space be 255×255 [pixel] and the origin be set at (128, 128). Using the Hough transform, we obtained θ=127 [deg], ρ=36 [pixel]. The values in the buffer by the results are shown in Table 1. The means of these differences are x_d=20 [pixel] and y_d=15 [pixel]. So, parameters of this motion are decided as shown in Table 2. From these results and Equation (2), we can know the motion.

Table 1. Values of x and y buffers.

t	0	1	2	3	4	5	6	7
x	28	48	68	88	-1	128	148	168
x_d	-	20	20	20	-	-	20	20
y	98	113	-1	143	158	173	188	203
y_d	-	15	-	-	15	15	15	15

Table 2. Parameters of detected motion.

θ [deg]	127
ρ [pixel]	36
x_0 [pixel]	28
y_0 [pixel]	98
x_d [pixel]	20
y_d [pixel]	15

We can see the effectiveness of the method for the motion detection in the sequential images using 3-D Hough transform and 1-D buffer through our computer simulations. As understood from the result of the experiment, we can accurately detect the motion vector even when the images contain noise. Moreover, previously described, it is able to reduce the computation cost considerably. However, it is necessary to execute the further experiment to examine whether the method can be also applicable to the actual image data.

6. Conclusion

We proposed the methods to reduce the computation cost for the motion vector detection and to remove errors in extracted points by the Hough transform in sequential images. Problems in the future are to detect the accelerative motion by changing the time interval of the buffer and so on.

7. References

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