The Use of PCA for Moving Objects Tracking on the Image Sequence

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Abstract: In resent research, the new generation sensors such as digital video cameras have attracted a lot of interests. Because the sequence of images provided by the digital video camera can preserve temporal information in detail, it has been largely used to trace the moving objects appear on the images. Since PCA (Principal Component Analysis) is generally used for extracting significant information from a large number of dataset, this study adopts the concept of PCA to provide an effective method for tracking the moving object on the video image. Three steps are used to achieve the goal: (1) Interested clip extraction; (2) PCA and (3) Track extraction. The experiment results demonstrate that PCA is able to extract the track of the moving objects from the sequence of images.
Keywords: Image sequence, Track extraction, Principal component analysis, Video image

1. Introduction

Digital video camera has largely been used for monitoring assignments in our daily life. For security purpose, the monitoring of the moving objects, such as human and vehicles, has become an important task of video camera. In some occasions, it is required to follow and extract the track of the moving objects automatically. Since the moving object acts as the dynamic information in a sequence of images, many image processing algorithms for object tracking have been developed. Lipton, et al. [1] considered three image processing steps for object tracking: (1) the image differencing is used to detecting moving object; (2) the Maximum Likelihood Estimation is then employed to classify the attributes of the moving objects; (3) a matching algorithm is developed to find out the path of each moving object. Heikkliä and Silvén [2] used Kalman filter and Learning Vector Quantization for tracking and classifying the target. Masoud and Papanikolopoulos [3] produced blob image with background subtraction and used both blob level and blob tracking to perform object tracking. Pai, et al. [4] propounded both pedestrian model and walking rhythm to detect and to track the walkers at crossroad in order to prevent them from being hit by the vehicles. KaewTrakulPong and Bowden [5] used a robust background model with the assist of the shadow detection algorithm to segment the moving objects in order to track small targets in different time, weather, seasons and activity situations. Since PCA (Principal Component Analysis) is generally used for extracting significant information from a large number of dataset [6], this study adopts the concept of PCA to provide an effective method for tracking the moving object on the video image. The organization of this paper is as follows: the methodology will be introduced in the next section, the test data and the experimental results and discussions will be presented in section 3 and the conclusions will be discussed in section 4.

2. Methodology

This paper is intended to generate the tracks of moving objects by the use of PCA. Three steps are used to reach the goal: (1) Interested clip extraction, the purpose to reduce the computational time of PCA; (2) PCA, the process to produce PC (Principal Component) images that contain both static and dynamic information on the image sequence; and (3) Track extraction, the step to extract the tracks of moving objects from each PC. The details will be presented as follows.

2.1 Interested Clip Extraction

Since the image sequence may contain the frames of no- moving objects or moving objects, the main task of this step is to rapidly ignore the frames that contains no-moving objects and pick and choose the frames that contains the moving objects. The task of interested clip extraction is performed in the following procedure. Firstly, in order to reduce the computing time, the resolution of each image frame in the sequence would be reduced to one quarter of the original resolution and the frame rate would also be reduced (1 frame per second for example). Secondly, this compact image sequence

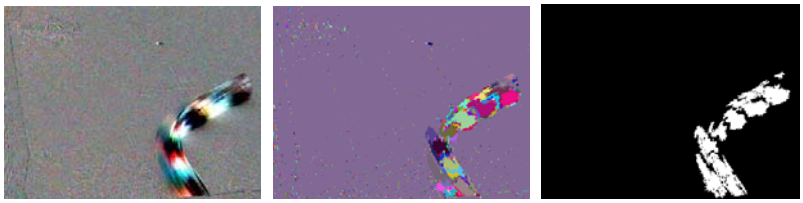
would be separated into several image clips. The main thought is to keep the number of frames fewer than 100 per clip, which is decide by experience. The main reason is because too many frames in a single clip may decrease the processing efficiency of the next step- PCA. Here is an example: If an original image sequence has duration of two minutes and frame rate of 30 per second, we might separate this sequence into 40 image clips in order to keep the number of frames per clip fewer than 100. Thirdly, for each clip, a background image is generated by averaging each corresponding pixel's value of every frame in the clip. Then, a series of difference images will be produced by the subtraction of the background image and every frame in the clip. The pixel in the difference image will be designated as the motion pixel if its value is greater than a pre-defined threshold. If the total area of the motion pixels is larger than the size of the moving object, it will interpret that the image contains the movement information of an object, and the clip will be regarded as the interested clip. On the other hand, the clip will be ignored if the image contains no moving object.

2.2 PCA

The purpose of PCA is to produce PC (Principal Component) images that contain both static and dynamic information on the interested clip. Firstly, since the video images normally include three bands (R, G, and B), every band in the interested clip will be assembled to form a single-band image set. Then, PCA is performed on every image set and produce a series of Principal Components for every individual band. Finally, all Principal Components are collected together to become a PC image sequence.

2.3 Track Extraction from PC Image

Since PCA is able to put the moving track together in certain PCs, it is the main aim of this step to extract the PCs that contain the tracking pattern. A region growing scheme is adopted to produce segmentation image for each PC (Fig. 1b). Normally three main regions can be observed in a segmented PC image: noise region, background region, and track region. Noise regions generally have small areas, which commonly are too small to be the track of the interested moving object. On the other hand, background regions generally come with relatively large areas and turn out to be the static information. As a result, the rest of the regions will be grouped together to become the track regions (Fig. 1c). In the end of track extraction, we compile the total area of track regions in pixel as the index of each PC image. The PC image with highest index would be the interested PC, which is able to represent the track of moving object.



(a) (b) (c)

Fig.1 (a) a sample PC image; (b) PC image after segmentation; (c) track regions extracted from PC image

3. Experimental Result and Discussions

The experiment is designed to test the proposed method for detecting and tracing the object moving in the image sequence. The duration of whole test video images is 108 seconds, and two moving objects with different sizes (one regular car and one motorcycle) are the main targets in the test. The result of interested clip extraction is shown in Fig. 2. The x axis represents the serial number of the frames and the y axis indicates the number of motion pixels. Two significant peaks can be evidently observed in the graphic, in other words, there are two periods that contain moving objects are detected. The interested clips of two periods are respectively shown in Fig. 3a (regular car) and Fig. 3b (motorcycle). After extracting the interested clips and converting to PC space, a series of corresponding PC image sequences are revealed in Fig. 4. By calculating the area of track region from each PC image, the relative histogram can be drawn in Fig. 5. The PC image with maximum area of track region is regarded as the major image to extract the trace of moving object, as the results,

the major trace image are extracted in PC11 in the first period and PC7 in the second period; thereupon, the track of both moving objects can be correctly detected from the PC images (Fig. 6).

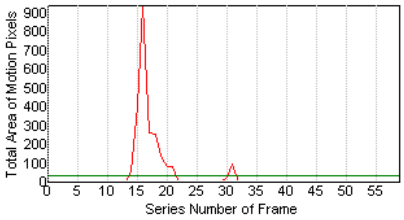
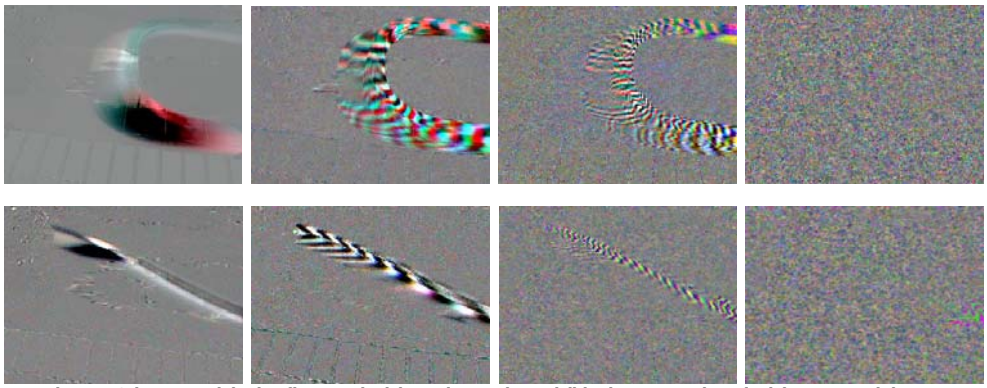


Fig. 2 Result of interested clip extraction

(a) (b)

Fig. 3 Two extracted clips of moving object. (a) The first period (regular car), and (b) The second period (motorcycle)



(a)

(b)

Fig. 4 PC images. (a) The first period (regular car), and (b) The second period (motorcycle)

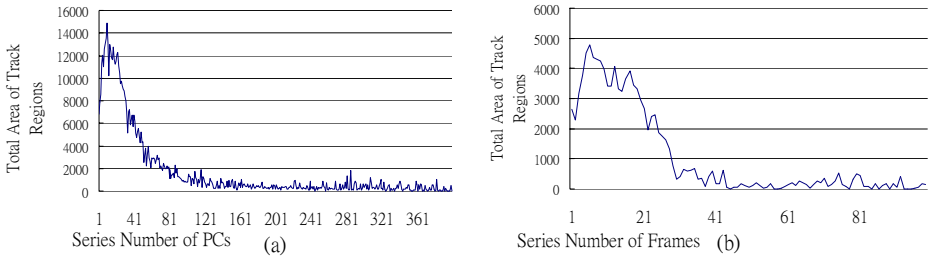


Fig. 5 Chart of track extraction. (a) The first period (regular car), and (b) The second period (motorcycle)

(a) (b)

Fig. 6 Track of moving object. (a) The first period (regular car), and (b) The second period (motorcycle)

The results of experiment indicate that the proposed method can track the moving object successfully; moreover, the trace of object can be also extracted and the tracking result is unconcerned with the size of moving object. Although the wind will cause some pseudo moving events in the video images, the proposed method still can track the interested target and filter out the noise by checking the size of moving regions.

4. Conclusion

This paper proposed a PCA-based approach for moving object tracking in video image sequence. In order to improve the efficiency of tracking task, the interested clips will be extracted from the images at the beginning. Because the PCA is generally used for extracting significant information from a large number of dataset, therefore, this approach uses the concept of PCA to detect the trace of the moving object by converting the video image domain to the PC domain. The experiment consists of two different sizes of moving objects is tested in this study. The results show that the proposed method can not only track the moving objects correctly but also extract the trace of the moving objects clearly.

5. Reference

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