A Timely Occlusion Detection Based on Mean Shift Algorithm

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Abstract. Mean shift algorithm has attracted much attention in computer vision and has recently shown promising performance in the challenging problem of visual tracking, but it is difficult to deal with occlusion. In this paper, a timely occlusion object detection based on mean shift is proposed. By analyzing occlusion process, it is evident to find that occluded size is increasing and occlusion patch lies to edge of objects at the beginning. So object model is divided into several parts. In order to reduce computation, only edge patches is considered. If Bhattacharyya coefficient of one patch decreases greatly and other patches change faintly, it means that object is occluded in this area. In this method, object model is divided into two parts, one is occlusion part, the other is no occlusion part, the no occlusion part of the object can be obtained to track object continuatively until object is occluded totally. Experiments show that compared with whole object model judges, it is timely to detect occlusion and deals with occlusion successfully.

Keywords: object tracking, occlusion detection, mean shift.

1 Introduction

Object tracking is an important and challenging task within the field of computer vision. The growth in this area is being driven by the increased availability of inexpensive computing power and image sensors, as well as the inefficiency of manual surveillance and monitoring systems. Detection and tracking of moving objects can be applied in many different applications such as surveillance, perceptual user interfaces, augmented reality, object-based video compression and driver assistance [1].

Recently, mean shift algorithm has attracted much attention in computer vision and has recently shown promising performance in the challenging problem of visual tracking [2, 3]. Hager, Dewan, and Stewart propose a modification using multiple kernels [4]. The mean shift algorithm can also be applied to tracking objects with scale changes by Collins [5]. However, all these approaches require the entire object patch in each frame be visible. So object occlusion will cause tracking failure because of the invisibility of object occlusion parts [6]. Traditional mean shift tracking algorithms do not consider occlusion effects caused by inevitable object overlapping

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for occlusion objects. Consequently, during the process of tracking occluded objects, the pixels that belong to the occluding objects are regarded as those of the occluded objects. This causes disturbances that lead to tracking failures [7].

By analysis of occlusion course, it is evident to find that occluded size of object is increasing. Firstly occluded patch is very small, then the size of occluded patch becomes bigger and bigger as time goes away. According to analyzes above, a timely occlusion object detection method based on mean shift is proposed in this paper. The remainder of this paper is organized as follows. Section 2 presents relation work about occlusion object tracking. Section 3 reviews the relevant aspects of mean shift algorithm briefly. Section 4presents proposed method to detect and track occlusion object. The experimental analysis of the proposed approach and the conclusions are given in Section 5 and 6.

2 Relation Work

Plenty of work has been done on occlusion object tracking. Various methods have been proposed to detect and handle occlusion object tracking. Senior et al. proposes an approach to track objects through occlusion using appearance models [8]. The appearance model is applied to determine the depth ordering of object during occlusion. But heavily and totally occluded object cannot be solved by this approach. Kaucic et al. and Amitha Perera et al. propose an approach to solve total occlusion during long gaps [9, 10]. The two segment of the moving object trajectory should be linked when the object has been occluded by the background for a long time. When the moving object has been totally occluded by the foreground objects in a long gap, the efficient approach of handling spilt-merge would be used to maintain the identity through long sequences. Han et al. suggests a multiple object tracking algorithm [11]. During tracking, the moving object's current state is estimated based on a state sequence instead of one previous state. So the optimal state sequence that maximizes the joint state-observation probability can be found. Temporal distractions such as occlusion, background clutter, and multi object confusion can be conquered. Zheng Li introduces a method to tracking occlusion object which based on velocity and appearance in [7]. Occlusion object is divided into two parts. One is occlusion patch, other is no occlusion patch. When object is occluded, according to no occlusion to locate object, but it does not deal with how to judge when object is occluded. Most of the tracking techniques use subjective evaluation method. E. Loutas proposes mutual information based metrics as measures of tracking reliability. Moreover, the use of the metric is extended to the analysis of partial and total occlusion in object tracking [12]. But the computation of method is huge, it is difficult to realize in object tracking.

3 Review Mean Shift Algorithm

The heart of mean shift algorithm is computation of an offset from location vector x to a new location $x' = x + \Delta x$, according to the mean-shift vector.

$$\Delta x = \frac{\sum_a K(a-x)w(a)a}{\sum_a K(a-x)w(a)} - x \tag{1}$$

w is the weight. K is a suitable kernel function and the summations are performed over a local window of pixels a around the current location x. A "suitable" kernel K is one that can be written in terms of a profile function k such that $K(y)=k(\|y\|^2)$ and profile k is nonnegative, nonincreasing, piecewise continuous [4].

An important property of the mean-shift algorithm is that the local mean shift vector computed at position x using kernel k points is opposite to the gradient direction of the convolution surface

$$J(x) = \sum_a g(a-x)w(a) \tag{2}$$

Where g satisfies $g(x) = -k'(x)$. $J(x)$ is designed by using Bhattacharyya coefficient to measure the similarity of two kernel histograms representing the object model and the candidate model respectively. The algorithm finds the maximum of the Bhattacharyya coefficient given an object model and a starting region. Based on the mean shift vector, which is an estimation of the gradient of the Bhattacharyya function, the new object location is calculated. This step is repeated until the location no longer changes significantly.

4 Proposed Tracking Method

Analysis of occlusion process, it is easy to find that size of the occluded object is increasing and occlusion patch lies to the edge of object at the beginning. In order to timely detect when object is occluded and the occluded area, object model is divided into several parts. The number of patches is concerned with the size and shape of tracking objects, which is decided before tracking. In order to reduce computation, we only consider edge patches. As is shown in Fig. 1, object model is divided into three sections with two modes and we get four edge patches.

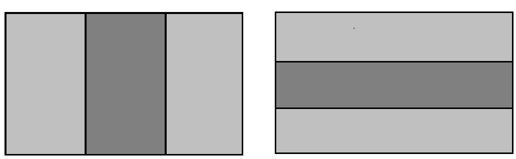

Fig. 1. Schematic diagram of model partition

During normal tracking process, Bhattacharyya coefficient of edge patches changes little among frames. When object is occluded, Bhattacharyya coefficient of occlusion part decreases greatly and other no occlusion parts change faintly. So occlusion is detected and the occlusion area is found. According to whether is occluded, object is divided into two parts. At the beginning, only partial object is occluded, object can be located based on no occlusion patch. According to information of velocity of object moving, the ratio of these two parts is adjusted automatically. When the proportion of occlusion part exceeds a threshold which is given before tracking, the remainder can not describe characteristic of tracking object. It is regarded that object is occluded totally.

When object is occlusion totally, all information of object is lost, traditional tracking algorithm can not locate object. In object tracking, Kalman Filter is often used to forecast object position [13]. In normal tracking, the state of object moving is recorded which is used to initialize Kalman Filter parameters. In order to avoid that forecast position of object appears large error, forecast process appends restriction which is based on object moving fitting curve getting according to object motion before occluded.

After a few frames, object maybe appears in the scene again, it is necessary to find object again. Whether finds object again is decided by performance of forecast algorithm and time consumption of occluding. We plan to search object around forecast position. The size of search area is determined by the length of occlusion time.

5 Experimental Results

The proposed algorithm is tested using VC.NET programs on an AMD 3.0GHz machine. In order to show performances of suggested method, the performances of proposed method is compared with traditional method.

Fig. 2 shows the tracking results of car sequence in which there are 500 frames of 720×576 pixels. In the sequence, car is covered by tree. The object model is marked with 120×60 pixels rectangle in sequence. It is divided into three sections in horizontal direction and four sections in vertical direction, so we get four edge patches. As is shown in Fig. 2, occlusion is detected in frame 188. Object is occluded totally in frame 196. Frame 205 shows forecast position and object is found again in frame 216.

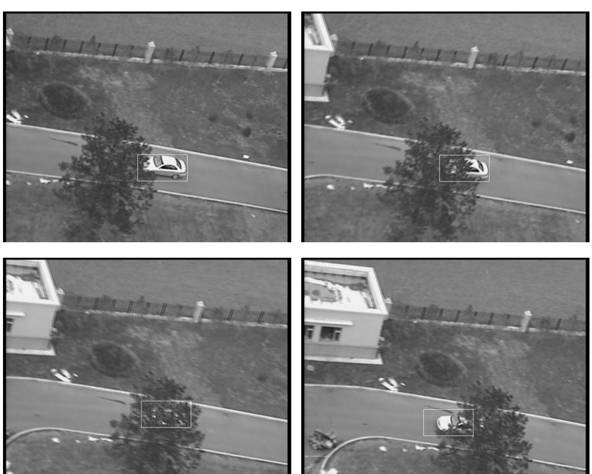

Fig. 2. The result of proposed method is shown (the frames 188,196, 205 and 216)

In general, occlusion is detected based on the whole model. That is to say, when Bhattacharyya coefficient of whole model decreases greatly, occlusion is detected. Fig. 3 shows traditional method to detect occlusion. As occlusion is not detected timely, tracking location deviates its actual position. Occlusion is detected in frame 194. Compared with proposed method, the performances of tracking become worse.

Fig. 3. The result of traditional method is shown (the frames 192,194, 205 and 216)

6 Conclusions

Occlusion detection is a challenging task in robust object tracking. A timely occlusion object detection based on mean shift is proposed in this paper. It divides object model into several parts and selects edge sections to compute Bhattacharyya coefficient. If Bhattacharyya coefficient of one of these sections decreases greatly and the other changes little, it means object is occluded. Then object is divided into two parts, according to no occlusion part, tracking process continues until object is occluded totally. During totally occlusion, Kalman Filter is used to forecast object position. Moreover, proposed method appends object moving fitting curve to restrict that forecast position appears large error. Experiments show that it is timely to detect occlusion and deals with occlusion successfully.

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