DETECTING PERSONS USING HOUGH CIRCLE TRANSFORM IN SURVEILLANCE VIDEO

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Abstract: Robust person detection in real-world images is interesting and important for a variety of applications, such as visual surveillance. We address the task of detecting persons in elevator surveillance scenes in this paper. To get more passengers in the lift car, the camera usually installed at the corner of ceiling. However, the high and space of lift car are limited, which makes person occluded by each other or some parts of body invisible in captured images. In this paper, we propose a novel approach to detect head contours, which includes three main steps: pre-processing, head contour detection and post-processing. Hough circle transform is adopted in the second stage, which is robust to discontinuous boundaries in circle detection. Proposed pre-processing and post-processing methods are efficient to remove false alarms on background or body part. Experimental results show our proposed approach is time saving and has better person detection results than some other methods.

1 INTRODUCTION

Robust person detection in real-world images is interesting and important for a variety of applications, such as visual surveillance and driver assistance systems. For surveillance applications, examples include the estimation of queue length in retail outlets, the monitoring of entry points, bus or elevator terminals. Persons are one of the most challenging categories for object detection. A large variability in their local and global appearance is caused by various poses or styles of clothing (Leibe, 2005). Many techniques (Giebel, 2004, Schmid, 2004) have been made to detect in constraint settings. Often it is assumed that the people in the scene are well separated. While in many real applications several persons may be present in the same image region, partially occluding each other, which bring difficulty to detecting and counting them.

Various methods have been applied to person detection for surveillance applications. Among them, classification techniques by supervised learning can be applied to decide if a given image region contains a person. For example, (Nakajimia, 2000) uses Support Vector Machines to recognize people. (Gravrila, 2000) uses a tree based classifier to represent possible shapes of pedestrians. (Viola, 2001) proposes a framework for face detection, which use Haar wavelets and AdaBoost to build a cascade structured detector. However all above approaches requires certain training data to learn the parameters of the underlying model. Some other methods use contour or edge feature to detect person. (Zhang, 1995) introduces a Model-specified Directional Filter (MDF) to identify the pedestrian on an escalator by extracting the contour feature of pedestrian's head in an image with the camera installed right above. However, neither of above papers addresses the situation of crowded scenes where persons may be occluded by each other.

In this paper, we specifically address the task of detecting persons in elevator surveillance scenes. The goal is to detect all pedestrians, localize them and count them in the image. With the number of passengers, the elevator control system can minimize waiting time and ride time of passengers and reduce the unnecessary elevator stop, which can finally save electronic energy and reduce maintenance fee of elevator. For elevator application, the high and space are limited in lift car. The camera usually installed at the corner of ceiling in lift car to capture more passengers, which will deform the appearance of person and make some

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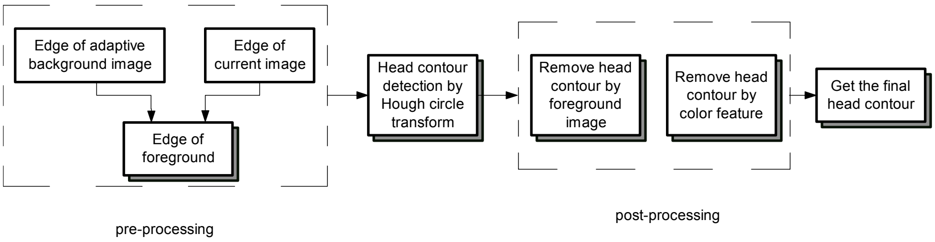


Figure 1: The framework of our approach.

parts of person invisible. On the other hand, persons often occluded by each other and pose of head are various in captured images.

Although detecting and counting persons in elevator application is a very difficult task, we can also see that the appearance of person head is similar as circle. In this paper, we propose a framework to detect person head based on Hough circle transform (HCT), which is proved useful in occluded situation.

Our approach is given in section 2. Experimental results of the detecting system are presented in section 3. Conclusions are given in section 4.

2 OUR APPROACH

2.1 Outline of Our Approach

For person detection in elevator surveillance scene, we propose a novel method as Figure 1 shows. The approach consists of three main steps: pre-processing, head contour detection and post-processing.

HCT algorithm is used in the second stage, which is based on the edge points in the images. So in order to reduce some interference by edge points on background field, certain pre-processing is needed. In pre-processing step, Canny edge detection is performed on adaptive background image and current frame. Then subtraction is used to get the edge of foreground, which can remove many edge points on background.

After above process, HCT based on gradient (Yuen, 1990, Bradski, 2008) is performed on edge image of foreground to get quasi circles. This step is detailed in section 2.2. After this step, some image regions satisfied HCT are decided as circles, which can be see as candidates of head contours. However, with the interference from background and clothing, some candidates are not related with person head. Finally, post-processing is adopted to remove some false alarms, which is detailed in section 2.3. After above three stages the final result of head contours can be obtained.

2.2 Hough Circle Transform

The Hough circle transform (HCT) shows considerable immunity to problematic object boundaries, such as ones partially obliterated by occlusion, overlapping effects and breakages, as well as boundaries distorted by interference noise, ambient illumination, object motion (Yuen, 2001).

(Kimme, 1975) gives probably the first known application of the Hough Transform to detecting circles in real images. In their work, they have made use of the direction of the gradient at each edge point. If a circle in the image is described as

$$(x-a)^2+(y-b)^2=r^2 \quad (1)$$

where (a,b) are the coordinate of the circle center and r is its radius, then an arbitrary edge point (x_i, y_i) will be transformed into a right circular cone in the (a,b,r) parameter space. If all the image points lie on a circle then the cones will intersect at a single point in (a,b,r) corresponding to the parameters of the circle. This would mean far greater memory requirements and much slower speed. (Yuen, 2001).

To solve these problems, Hough gradient method is propose in (Yuen, 2001). First the image is passed through an edge detection phase. Next, for every nonzero point in the edge image, the local gradient is considered. Using this gradient, every point along the line indicated by this slop from a specified minimum ($\min\_r$) to a specified maximum ($\max\_r$) distance is incremented in the accumulator.

For elevator application, color of person head may by darker or lighter than that of ambient background as figure 2 shows. So we remain two directions of slope to get candidate centers in our paper.

At the same time, the location of every one of these nonzero pixels in the edge image is noted. The candidate centers are then selected from those points in this accumulator that are both above some given threshold acc_thr and larger than all of their immediate neighbours. These candidate centers are sorted in descending order of their accumulator values, so that the centers with the most supporting pixels appear first. For each center, all of the nonzero pixels are considered. These pixels are sorted according to their distance from the center. Working out from the smallest distances to the maximum radius, a single radius is selected that is best supported by the nonzero pixels according to the threshold R_thr. A center is kept if it has sufficient support from the nonzero pixels in the edge image and if it is a sufficient distance from and previously selected center. (Bradski, 2008).

So we can see Hough gradient method can be decomposed the circle finding problem into two stages. First stage is to find candidate centers and second stage is to find satisfied radius of circle. A two dimensional array is required to accumulate votes along the normal of each edge point. To identify the radius of circles, the distance of each point from a candidate centre is calculated and a radius histogram is produced. The storage space required for the method is quite small, since only a single 2-D accumulator and a 1-D histogram are necessary. (Yuen, 2001).

This Hough gradient method run much faster and, more importantly, helps overcome the problem of the otherwise sparse population of a three dimensional accumulator. (Bradski, 2008).

2.3 Post-processing

After above step, some image regions satisfied HCT are decided as head candidates. While with the interference from background and clothing, some candidates are not related with person head.

Although edge subtraction of background is taken in pre-processing step, some circles at background are also detected after HCT process. So our post-processing should remove candidate circles according to foreground image firstly.

For elevator application, pose of head are usually various in images. Sometime we can see back, side or front of head. So the color of head is usually different according to the pose of head. While without regard to wearing hat, the color distribution of head can be clustered. In this paper, we use GMM to get the color clusters around the center of head in marked images. To reduce the illumination interference, we transform the image from RGB color space to HSV color space. Here, H (hue) and S (saturation) values are used to color cluster.

In post-processing, we check the color feature of the region beside candidate center to decide whether this circle can be maintained. After this process, some candidates with different color feature as head can be removed.

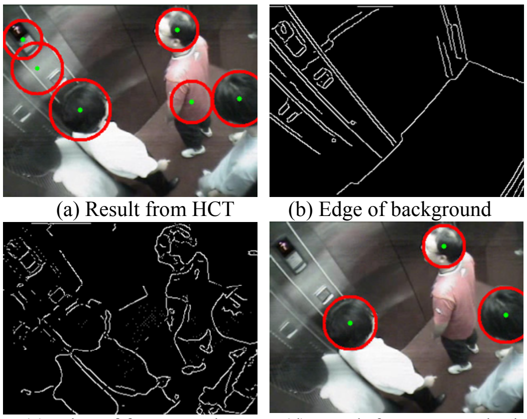
3 EXPERIMENTAL RESULTS

To compare our approach, we also realize another method based on Adaboost classifier (Viola, 2001). The train data come from videos captured in lift car. We use 783 images with 1788 head-shoulders as positive samples and 8000 images without person as negative samples collected from Corel Image Gallery. All manually marker samples are normalized to the size of 20×20 pixels. We train one classifier with 16 stages of cascade. Some detect results from this method are shown in figure2. The red rectangles are the results after head-shoulder detection based on Adaboost classifier. We can see that some false detections on body and background, while many head regions are missing in the second image in crowed situation.

Figure 2: Some results based on Adaboost.

We also test our approach to detect head contour in elevator surveillance video. Some results are shown in figure 3. Figure 3(a) is the result only using HCT method. The green points are the centers of circle and the red circles are the corresponding head candidates. Many head candidates are false alarms in this image, some come from regions on background and some located on body part, which have different color feature compare with usual head color. So we adopt pre-processing and post-processing to modify this condition.

Figure 3(b) is the edge image of adaptive background image after Canny edge detection. Edge image of current image is also obtained. Then subtraction is performed to get the edge of foreground as figure 3(c) shows, which reduce some interference edge points at background. Finally, figure 3(d) shows the result using our method. With pre-processing and post-processing, some false detection on background and body are removed. Figure 4 shows another result based on our approach and the corresponding values of some parameters are also shown in annotation of image. From the experimental results, we can see our approach has better performance than some usually methods for elevator surveillance application.



(a) Result from HCT (b) Edge of background

(c) Edge of foreground (d) Result from our method

Figure 3: Some results based on our approach. (acc_thr=25, $\min\_r$=10, $\max\_r$=40, R_thr=60).

(a) Result from HCT (b) Result from our method

Figure 4: Some results based on our approach. (acc_thr=25, $\min\_r$=10, $\max\_r$=35, R_thr=50).

4 CONCLUSIONS

In this paper, we present an approach for person detection in elevator surveillance application. To get more passengers in the lift car, the camera usually installed at the corner of ceiling. The high and space of lift car are limited, which makes person occluded by each other or some parts of body invisible in captured images. So it is a difficult task to detect person in this scene.

In this paper, we propose a novel method to detect head contours in surveillance video. The method includes three main steps: pre-processing, head contour detection and post-processing. Hough circle transform is adopted in head contour detection stage, which is shown robust to discontinuous boundaries in circle finding. Pre-processing can reduce some edge points on background, which can remove some interference. Hough gradient method is efficient and time saving for circle detections in the head contours detection step. The last step post-processing can remove many false head contours on background or on body part that has different color distribution as usual color of head. The experimental results show our approach has better detection performance than many other methods. In the future, we will test our approach on large dataset.

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