

# Study on Zenithal Pedestrian Detection Algorithm

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**Abstract**—Pedestrian detection is a hot and difficulty topic in computer vision. This paper presents a zenithal pedestrian detection algorithm designed with the circular feature of pedestrian head in case of top view. It is a reliable pedestrian detection strategy for intelligent illumination control system. The active edge detection algorithm extracts the pedestrian edge, and grads Hough transform detects the circular feature of pedestrian head. Matlab simulation experiments show that the detection method can effectively detect pedestrian and eliminate the interference.

**Keywords**—pedestrian detection; hough transform; edge detection; matlab

## I. INTRODUCTION

Nowadays energy conservation and environmental protection is a hot topic. Energy-saving lamps and scientific management is very important for illumination. For example, in large supermarkets, illumination consumes 33% of total electricity consumption[1]. Using the energy-saving lamps with scientific management can achieve the target of energy conservation.

Scientific management of the illumination system is based on pedestrian, which reasonably controls the illumination based on the position of the pedestrian appearing. So illumination control system requires a device for pedestrian detection. Computer vision has broad application prospects and economic value, and pedestrian detection based on computer vision has become a hot topic. So this paper presents a pedestrian detection algorithm in case of top view, extracting the features of the pedestrian and detecting the pedestrian.

## II. STUDY ON PEDESTRIAN DETECTION ALGORITHM

Currently pedestrian detection system can be divided into three categories: infrared photoelectric sensor, multi-camera and single-camera of these, which is based on different information collection methods. Infrared sensor pedestrian detection adopts infrared radiation detection methods. If the light is interrupted by pedestrian, the pedestrian will be detected. If the flow is less and the pedestrian passes through one by one, the detection device will have higher detection accuracy. However, the sensor can easily be blocked and coverage, which will make the detection accuracy of test results greatly reduced. And infrared sensor detects a limited distance, not suitable for large venue. Multi-camera pedestrian detection uses two or more calibrated camera to obtain the depth of the scene with the three-dimensional depth algorithm, and split the pedestrian information from the depth image. For example, Terada et al proposed that using binocular stereo

vision to detect pedestrian[2]. The main problem is that the multi-camera pedestrian detection system requires multiple camera calibrated accurately, which has large volume and high cost. What is more, the calculation of algorithm is large, and the motion tracking is not reliable. Monocular camera pedestrian detection is based on the shape, size and color of the pedestrian's head and shoulder, and color detection pedestrian area of the shoulder. For example, Borislav Antic et al proposed a method eliminating background, and then separating the target block from the foreground, at last using the k - means to segmenting the pedestrian information from target block [3]; Chen T et al proposed a method counting the pixel of an area to estimate the number of the pedestrian [4]. Some of the above method does not detect the specific features of pedestrians, and some takes over-reliance on the minutiae of pedestrian. And operating results of these methods has yet to be verified.

Algorithm presented in this paper is also based on monocular camera, and the camera is mounted with top view. The algorithm is shown in Figure 1.

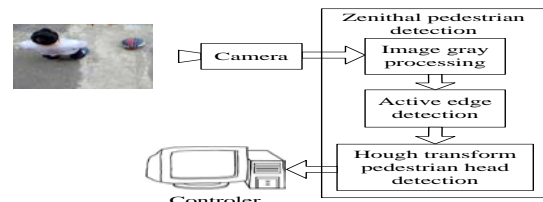


FIGURE I. ALGORITHM BLOCK DIAGRAM

The benefit of placing the camera with top view is that the pedestrian will not cover each other, and the head of the pedestrian present circular feature [8]. In view of this situation, Hough transform is used to detect the circular feature of pedestrian head as the core algorithm. Hough transform is susceptible to the circular object or similar circular objects in the background, which produces the error detection. So active edge detection is adopted as auxiliary algorithm, which can eliminate the factors influencing the detection results and reduce the pedestrian detection range. It can not only increase the accuracy of Hough transform pedestrian detection, but also improve the speed of detection. The algorithm consists of image gray processing module, active edge detection module, Hough transform pedestrian head detection module.

## III. REALIZE THE ZENITHAL PEDESTRIAN DETECTION ALGORITHM

According to figure 1, the core of the algorithm is Hough transform used to detect zenithal pedestrian head. According

to the circular feature of zenithal pedestrian head, Hough transform detect pedestrians by searching the center position of zenithal pedestrian head. But Hough transform is susceptible to the circular object or similar circular objects in the background, which produces the error detection. So active edge detection is adopted as auxiliary algorithm. Active edge detection module is used to detect the edge of pedestrian, which can eliminate the factors influencing the detection results.

Active edge detection and Hough transform mainly depends on the gray image, so it is necessary to convert RGB image into grayscale image.

Grayscale formulas:

$$H = 0.299R + 0.587G + 0.114B \quad (1)$$

#### A. Active edge Detection

Active edge detection is adopted as auxiliary algorithm to eliminate the factors influencing the detection results and reduce the pedestrian detection range. The common active edge detection method is mainly divided into two methods: background difference and adjacent frames difference [6]. According to the need of application, the following optimization method is taken: increase of interval frames between two frames of image points. Multi interval frame difference has more frame interval than the adjacent frame difference so that the moving target has bigger displacement, which is convenient to detect moving object and ignore the illumination change in images. The frame interval in this paper is ten frames. In this algorithm, it takes frame difference to detect the moving object; next, takes difference image binaryzation and edge detection; then, detects the edge of current frame; in the end, makes the edge images of current frame and difference image do AND operation to get the edge of the moving target in current frame. After actual operation, we found that there was a slight deviation between the difference image's edge and the original image's. So the edge of difference image is expanded before AND operation. Active edge detection processing is shown in Figure 2.

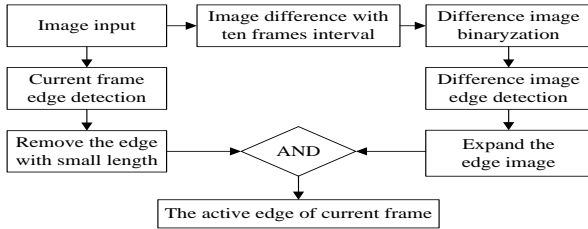


FIGURE II. ACTIVE EDGE DETECTION FLOW CHART

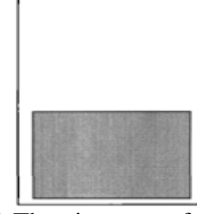
Image difference with ten frames interval:

Assume the image sequence as  $(I_1, I_2, I_3 \dots)$ . The difference image  $D_{t,t-10}(x, y)$  can be expressed as eqn. (2) :

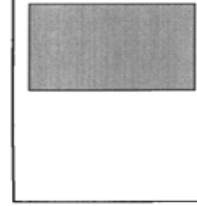
$$D_{t,t-10}(x, y) = I_t(x, y) - I_{t-10}(x, y) \quad (2)$$

where  $t$  represent the different moment,  $D_{t,t-10}(x, y)$  represents the difference image,  $I_t(x, y)$  represents current frame,

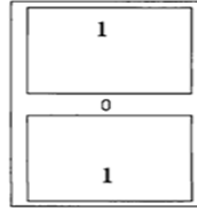
and  $I_{t-10}(x, y)$  represents the picture ten frames before.



(a) The picture ten frames.



(b) Current frame:  $I_t(x, y)$



(c) Difference image:  
before:  $I_{t-10}(x, y)$   $D_{t,t-10}(x, y)$

FIGURE III. IMAGE DIFFERENCE WITH TEN FRAMES INTERVAL

There is Gauss noise in the difference image with ten frames interval, so Gauss filtering is required. Assume that the pixels in the difference image are in line with the Gaussian distribution. According to the "3 $\sigma$ " rule of probability theory, more than 99% of the points should fall in the range of  $(\mu - 3\sigma, \mu + 3\sigma)$ , and the rest are considered to be noise.

$$I_{bin} = \begin{cases} 0 & D(x, y) \in (\mu - 3\sigma, \mu + 3\sigma) \\ 255 & \text{otherwise} \end{cases} \quad (3)$$

Where  $D_{t,t-10}(x, y)$  represents the difference image,  $I_{bin}$  represents the binary image.

Eqn. (3) is used to obtain the binary image of difference image, and then edge detection using Sobel operator as the edge detection template is performed. Sobel operator can effectively reduce the blurring of the edge image with pixel position weighted approach. Sobel operator is also used to detect the edge of current frame, and the edge with small length is removed

Finally, AND operation obtains the active pedestrian edge from the edge image of difference image. Because of the slight deviation between the difference image's edge and the original image's, the edge of difference image is expanded before AND operation. Figure 4 is the edge image of current frame; figure 5 is the edge image after AND operation. It is obvious that the basketball (at the top right corner of Figure 4) is filtered out.



FIGURE IV. EDGE IMAGE OF CURRENT FRAME



FIGURE V. EDGE IMAGE AFTER AND OPERATION

### B. Hough Transforms Pedestrian Head Detection

Pedestrian head shows circular feature in plan view, so pedestrian detection turns to circle detection [7]. Hough transform circle detection algorithm is used to detect the pedestrian. Grads Hough transform circle detection is a suitable algorithm. And it estimates center position with edge gradient, which not only simplifies the process of calculation, but also reduce the dimensions of accumulation array. It is almost considered as the standard Hough transform circle detection[5]. The circle in Figure 6 can be expressed by eqn. (4):

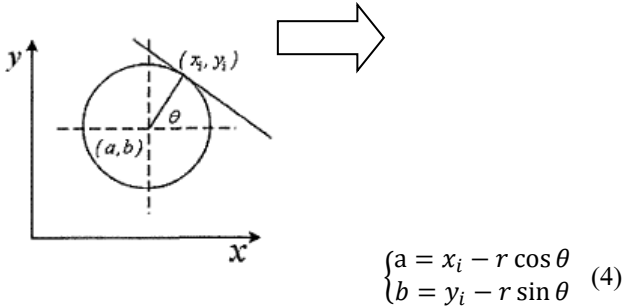


FIGURE VI. THE CIRCLE IN THE IMAGE SPACE

In eqn. (4),  $x$  and  $y$  represent the horizontal and vertical coordinates of the pixel point;  $r$  represents the radius, which changes in circulation;  $\theta$  represents the gradient orientation angle;  $a$  and  $b$  represent the coordinate of the center obtained by calculating.

The core of gradient Hough transform algorithm is as follows:

- 1) Scanning image to obtain gradient image;
- 2) According to the target edge obtained by active edge detection, calculate the gradient orientation angle of each pixel on the active edge, which is the  $\theta$  in eqn. (4). Using eqn. (4) to calculate the coordinates of the center;
- 3) Accumulating the center coordinates obtained from step 2) to the two-dimensional array;

4) After scanning the gradient image, the maximum value of the array is the center coordinates

The advantage of this method is to bring the accumulation array of Hough transform circle detection from three-dimensional space to two-dimensional space reduction, which saves storage space. And it transforms one to many mapping into a one-to-one mapping.

It does not need to compute and store the gradient orientation angle, because of eqn. (5). The sine and cosine of gradient orientation angle in eqn. (4) can be written as eqn. (5):

$$\begin{cases} \sin \theta = \frac{G_y}{\sqrt{G_x^2 + G_y^2}} \\ \cos \theta = \frac{G_x}{\sqrt{G_x^2 + G_y^2}} \end{cases} \quad (5)$$

Calculate the center coordinates with eqn. (5) into eqn. (4).  $G_x$  and  $G_y$  respectively represent the partial derivatives  $\frac{\partial f}{\partial x}$  and  $\frac{\partial f}{\partial y}$  of pixels in the X and Y directions, which is obtained by Sobel operator.

## IV. THE EXPERIMENTAL RESULTS

Grads Hough transform can effectively detect the pedestrian's head with a circular feature. When Hough transform is used to detect the pedestrian head, it will be interfered by the circular object in the background. For example, Figure 7. So active edge detection is adopted as auxiliary algorithm, which can eliminate the factors influencing the detection results and reduce the pedestrian detection range. It can not only increase the accuracy of Hough transform pedestrian detection, but also improve the speed of detection. For example, figure 8.



FIGURE VII. ZENITHAL PEDESTRIAN DETECT WITHOUT ACTIVE EDGE DETECTION



FIGURE VIII. Zenithal pedestrian detection with active detection

## V. CONCLUSION

Zenithal pedestrian detection algorithm presented in this paper is actually a zenithal pedestrian head detection algorithm. Active edge detection is adopted to eliminate the

factors influencing the detection results and reduce the pedestrian detection range. Grads Hough transform quickly and accurately locate the pedestrian head the circular feature. Pedestrian detection device designed with this algorithm is an important part of the intelligent illumination control system or other pedestrian-oriented control systems.

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