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Design of Pedestrian Flow Detection System for Playground Entrance/ Exit

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Abstract

College students' bodies are damaged due to the pressure of school work and daily life habits such as frequent internet surfing, low exercise intensity and low frequency of exercise, which affect their study and life. In order to strengthen students' exercise, many schools have arranged students for running. However, there are still some students who do not participate in sports and avoid running sports through various illegal means. To address the above problems, an OpenCV-based pedestrian flow detection system for playground entrances and exits is proposed to enhance the monitoring of sports numbers in schools, thus alleviating the problem of college students avoiding sports by means of violations.

Keywords

Top View; HOG; SVM; Pedestrian Tracking; Pedestrian Flow Statistics.

1. Introduction

1.1 Background

In the context of the global spread of new coronavirus (COVID-19), the health status of college students has become one of the focuses of governments at all levels and the whole society. Most schools have taken many effective measures to prevent the spread of the epidemic on campus. Among various preventive measures, one of them is to enhance students' own immunity. Moderate exercise is a benign stimulus to enhance the immune regulation of the body [1-2]. Therefore, in order to obtain more students' sports information, schools need to know the playground utilization and the number of people.

1.2 Research status at home and abroad

The pedestrian detection is a kind of target detection, which is widely used in intelligent monitoring, security, auxiliary driving and other fields.

At present, the image information of pedestrian detection mainly comes from visible light and infrared light. The image formed by visible light contains clear and copious information. And the price of corresponding monitoring equipment is relatively cheap. However, the detection effect is greatly affected by light. And the target detection is inaccurate in harsh environments such as night, cloudy day and rainy day. As for infrared cameras, it is mainly based on the heat emitted from the object surface to generate images, which is not easily influence by external conditions such as illumination, shadow, pedestrian clothing, skin color [3]. At night or when the light source is not strong, the target imaging is also comparatively clear.

In terms of pedestrian detection algorithms, it is divided into the traditional way and deep learning algorithm [4] according to whether the features need to be manually extracted. The traditional way has lower requirements for computer hardware, which is suitable for condition without high-performance computers. In addition, when the pedestrian target is small and cannot extract enough features for learning, the traditional way can also identify pedestrians well [5]. On the other hand, the

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pedestrian detection algorithm based on deep learning solves the shortcomings of traditional target detection such as sliding window selection and manually extracting features, and greatly improve the accuracy and real-time performance of target detection by introducing convolutional neural network (CNN) to self-learn target features [6], the region candidate boxes or direct regression method.

Target tracking is that after feature extraction and analysis of the target in the first frame of the video sequence, similar features and regions of interest (ROI) are automatically found in the following continuous frame images [7]. So far, many target tracking algorithms have been proposed. According to development process, they are mainly divided into two types: traditional and deep learning target tracking algorithms [8].

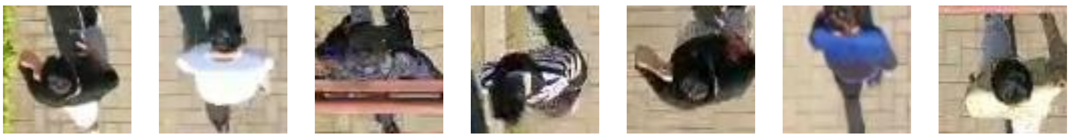
2. Top view pedestrian detection

Raspberry Pi is the device on which the program runs. Considering its computing power, this paper mainly uses Histogram of Oriented Gradients (HOG) and Support Vector Machine (SVM) algorithm belonging to traditional pedestrian detection algorithm. Currently, HOG is an extremely widely used pedestrian feature descriptor. HOG features are constructed by calculating and counting gradient direction histogram in image local area, so the edge features of human body can still be effectively described in the case of illumination change and target small offset. Dollar [9] compared several of the highest-level pedestrian detection methods in traditional algorithms, and concluded that no single feature can surpass HOG. After that, the HOG features of image all local areas are sorted and sent to the SVM classifier in succession. Finally, the classification prediction is output.

2.1 Sample preparation

First, the surveillance camera angle at the playground entrance and exit is set to overhead. The shooting screen is shown in Figure 1.

Figure 1. Top view of playground entrance



(a) positive samples

(b) negative samples

Figure 2. Partial sample examples

Based on this background, we prepare a positive and negative sample library, set the part that contains pedestrians to positive samples, and adjust the sample size to 64×64 pixels. The total number of positive samples is 633, and some examples are shown in Figure 2(a). The non-pedestrian part is set to negative sample library, including 1528 pictures. Some examples are shown in Figure 2(b).

2.2 Pedestrian detection algorithm

This system mainly uses HOG and SVM for pedestrian detection. In terms of HOG feature extraction, the window size, block size, block sliding distance, cell size and gradient direction of the gradient histogram are sequentially set to 64×64 pixels, 16×16 pixels, 8×8 pixels, 8×8 pixels and 9 pcs. In summary, the HOG feature vector dimension generated by a single sample is 1764.

Then linear SVM algorithm is used for all samples for data classification. The principle is to determine the hyperplane parameters $\boldsymbol{w}$ and $\boldsymbol{b}$ maximizing the distance between the support vector to the segmented hyperplane. Considering that the dimension of HOG feature vector is 1764, the hyperplane parameter $\boldsymbol{w}$ is also 1764-dimensional vector. Afterwards, we combine the parameter $\boldsymbol{w}$ with $\boldsymbol{b}$ to form a 1765-dimensional vector. At last, the 1765-dimensional vector is stored into an array so that it can be used in the Raspberry Pi.

In forward prediction process, the pedestrian target in the picture will not change significantly. Therefore, after determining the height of the camera, there is no need to enlarge or reduce the detection window. This means that the parameter scale in hog.detectMultiScale() function can be set to 1. After the algorithm is implemented, the actual effect of the detection is shown in Figure 3.

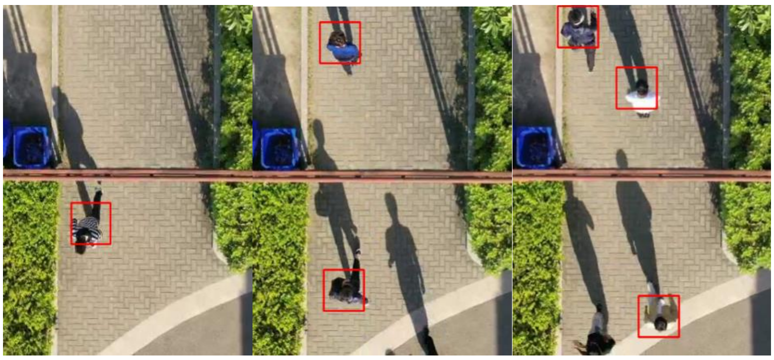


Figure 3. Detection effect

3. Pedestrian tracking

In order to count the number of people at entrance and exit,it is necessary to correlate the detected pedestrian targets in two consecutive frames and determine the moving direction of these targets. The program flowchart of the entrance and exit pedestrian statistics is shown in Figure 4. After the detection is successful, the program will return the target rectangle parameters [x, y, w, h], which respectively represent the x, y coordinates of the rectangle’s upper left corner, rectangle width and height. We judge the distance between the target [x, y, w, h] in the current frame and the target represented by each row, the target rectangle parameter, in the previous target matrix. If the distance is close, the two targets in the continuous frames are the same target. We need to replace the corresponding row elements in the original target matrix with the rectangle parameters of the current target. Otherwise, if the distance is far, the rectangle parameters [x, y, w, h] of the new target will be added to the original target matrix. Then, the error detection targets in the target matrix are eliminated.

After that, a matrix named Position is introduced, in which the i-th element represents the position information of the i-th row of the target matrix. As shown in Figure 5, the image is divided into 3 areas. If target i is in other areas, Position[i] is unchanged. If it is outside, Position[i] is -1. And if it is inside, Position[i] is 1. Finally, the current position matrix minus original position matrix equals a new matrix, in which the number of -2 and 2 respectively indicate the number of targets leaving and entering.

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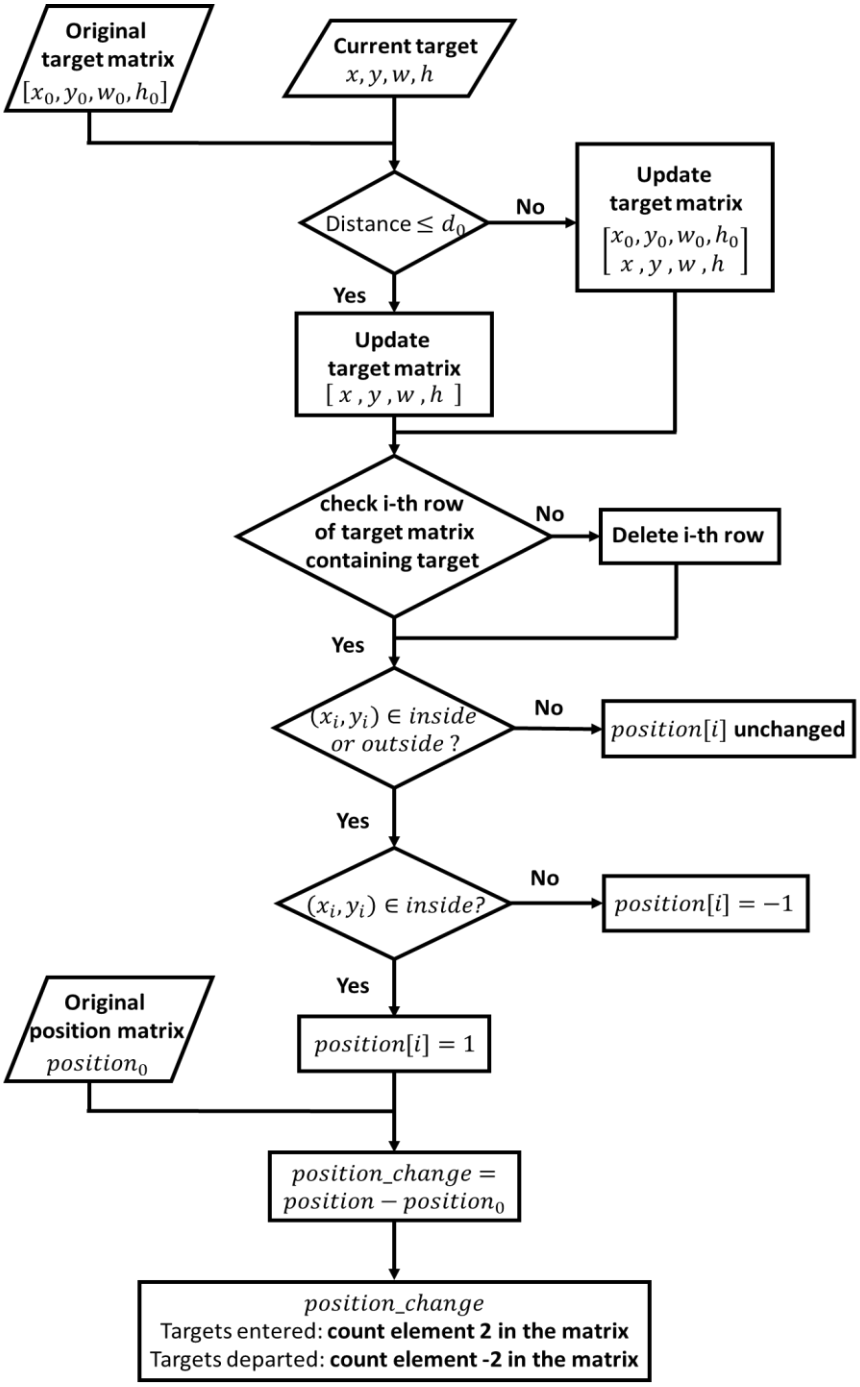

Figure 4. Pedestrian tracking flowchart

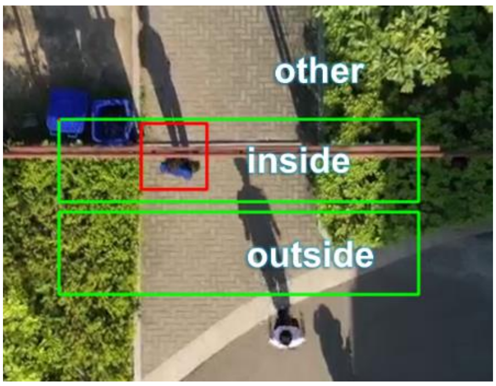

Figure 5. Image area division

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4. Conclusion

For pedestrian detection in campus playgrounds, we adopt HOG feature extraction and linear SVM algorithm. This method reduces the network parameters and computation, and improves the detection speed and accuracy. The SVM hyperplane parameters obtained from the HOG feature of pedestrians in the top view can be deployed in embedded devices and used in campus playgrounds to count the number of people in the playground.

In addition, this detection method is not only applied to schools. The pedestrian flow data collected by the pedestrian detection system are indispensable for the management and decision-making of public places such as large shopping malls, shopping centers, chain stores, airports, stations, museums and exhibition halls. For retail industry, population flow is a very basal indicator. By counting the population flow of the entrance and exit, we can grasp the rational degree of the entrance and exit channel setting. Through the statistics of the flow of people on the main floors, the reasonable distribution of the storefront is carried out. Furthermore, the crowd status of shopping malls, shopping centers, museums or airports can be obtained. And these high-precision data can be used to effectively organize and operate.

Acknowledgments

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