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Study on Abnormal Behavior in Elevator Based on Computer Vision

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Abstract. As the violent issues occurred in the elevator are increasing, this paper discussed a detection algorithm of abnormal behavior. The characteristic differences were analyzed between normal behavior and violent behavior through the video image sequences captured in the elevator. The movement characteristics and kinetic energy of corner were composed a five dimensional feature vector as the identification basis of SVM to implement the violence detection. Comparing with the traditional threshold method and optical flow method, the algorithm was of low computation and higher recognition rate.

Keywords: video image sequences; kinetic energy of corner; SVM

1 Introduction

At present, in the field of abnormal behavior detection, related work can be divided into two categories preliminary: One is based on motion object detection and tracking, also known as the microcosmic method. Microscopic methods such as optical flow information [1] and movement [2] could be applied in the monitoring scene which could not be known in advance. The other is based on the classification of the low-level features, also known as the macroscopic method [3][4]. But its accuracy rating largely depends on the precision of the edge detection.

2 System Fundamentals

Considering the special environment of the elevator, this paper adopts Gaussian mixture model and background subtraction method to extract the target prospects, analyzes the dynamic characteristics of target mass, uses the Lucas-Kanade algorithm to obtain the velocity vector information of corner to establish a feature vector of the corner kinetic energy modal and movement characteristics of target prospects as the basis for violent behavior detection. The algorithm overcomes the limitations of the existing abnormal behavior recognition algorithms in single judge standard and requiring a lot of artificial threshold values, and improves real-time and accuracy of abnormal identification.

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2.1 Foreground Image Extraction and Identify the Number of People

This paper takes the Gaussian mixture method to build background model because of its strong ability to adapt to the changes of environment. It is easy to get the information about each connected region after detecting connected domains. This paper adopts the method that based on statistics the number of outlook connected region pixels to distinguish both single-player and multiplayer which is described in literature [5]. The main idea is to make statistics about total numbers of the pixels in the connected regions which including different numbers of the human and summarize the number of pixels when different numbers of people appearing in the connected regions.

2.2 Extract Characteristics and Calculate Kinetic Energy of Corner

It is difficult to build a model of human body because of the detailed characteristics of human bodies are not obvious in the video. Considering that fighting and robbery these two kinds of abnormal interaction, the movement is intense and the motion characteristics have great differences when they happen. The selected movement characteristics in this article are as follows: the change rate of area $r\left(s_i^t\right)$; the change rate of external rectangle length-width ratio $r\left(c_i^t\right)'$; distance between the targets $d_{i,j}^t$; the angle difference of target movement direction ϕ_{ij}^t.

The corner minimizes the important information of the image, considering each corner as a particle. The corner can effectively reduce the amount of data information and meanwhile keep the important characteristics of graphic. Harris operator is adopted in this paper and Lucas-Kanade method is used to calculate the optical flow of each corner. The L-K algorithm assumes that in a small neighborhood area Ω, the motion vector remains constant, then using the weighted least squares to estimate the optical flow. In a small neighborhood area of Ω, optical flow estimation random error is defined as：

$$\sum_{(x,y)\in\Omega} W^2(x)\left(I_x u + I_y v + I_t\right)^2 \tag{1}$$

$W(x)$ represents the weight of the window. If $V=(u,v)^T$, $\nabla I(x)=\left(I_x, I_y\right)^T$, the solution of formula (1) is given by the following equation：

$$A^T W^2 A V = A^T W^2 b \tag{2}$$

$A^T W^2 A$ is a 2×2 matrix：

$$A^T W^2 A = \begin{bmatrix} \sum W^2(x) I_x^2(x) & \sum W^2(x) I_x(x) I_y(x) \\ \sum W^2(x) I_y(x) I_x(x) & \sum W^2(x) I_y^2(x) \end{bmatrix}$$

The summations are obtained from all points in the neighborhood area of Ω. Therefore, the result of formula (2) is $V=(A^T W^2 A)^{-1} A^T W^2 b$.

Videos are not just seen as the accumulation of image frames in the time domain, the links and changes between the pixels of frame sequences also imply abundant energy information. In this paper, starting from the idea that the moving objects have kinetic energy, each corner is viewed as a particle. Inside the elevator, when the behavior is normal, the total kinetic energy will be generally stable, and there is little change, but when fighting, robbery, such abnormal behavior happens, the total kinetic energy will increase and change obvious. This paper could get the kinetic energy formula of the i^{th} corner in a frame by imitating the kinetic energy formula:

$$E_i(x,y) = w_i(x,y) \bullet V_i^2(x,y)$$

$E_i(x,y)$ refers to the kinetic energy of the i^{th} corner; $w_i(x,y)$ is the weight of the i^{th} corner; $V_i^2(x,y)$ is the velocity model value of the i^{th} corner.

The messier the velocity direction of pixel is, the more likely abnormal behavior happens. The weight $w_i(x,y)$ is calculated by the change angel of the corner velocity vector in two adjacent frames, the bigger change it is, the bigger weight there will be. Given $angle_i^{k-1}(x,y)$ is the velocity direction value of the i^{th} corner in $K-1^{th}$ frame, the weight is:

$$w_i(x,y) = \frac{\left|angle_i^k(x,y) - angle_i^{k-1}(x,y)\right|}{\pi}$$

The kinetic energy calculation formula of the n^{th} frame is:

$$E(n) = \sum_{i=1}^{m} \frac{\left|angle_i^k(x,y) - angle_i^{k-1}(x,y)\right|}{\pi} \bullet V_i^2(x,y)$$

3 Experimental Results and Analysis

The data sets come from video surveillance segments of the elevator monitoring and the fighting videos are collected by the research team. The author conducts an experiment on different kernel functions, the results are shown in Table 1.

Table 1. The recognition results contrast of three kinds of kernel function classifier

Kernel function	Polynomial	RBF	Sigmoid
Parameters selection	q=5	δ^2=2.75	v=4，γ=0.7
The number of support vectors	18	14	20
Accuracy rate （%）	89.2	91.3	88.5

It can be seen in Table 1, the RBF shows the he highest recognition rate and the least number of support vectors. It is proved through a series of experiments that the recognition rate of this algorithm turns to be the best when $C=4, \sigma^2=2.75, \gamma=0.15$.

In order to verify the accuracy of algorithm in this paper, through a number of experiments conducted in the elevator platform in the laboratory, and comparing with the manually setting thresholds method in literature [6] as well as the optical flow method in literature [7] ,the results are shown in Table 2.

Table 2. The comparison results of all kinds of arithmetic

Arithmetic	Two People	Three people	Four people	Frames per unit (fps)
Threshold method	89.2	88.2	85.4	27
Optical flow method	89.7	89.5	87.2	30
Algorithm in this paper	92.1	90.8	90.1	28

It is shown in Table 2, that the abnormal behavior recognition algorithm of this article has a significant advantage than other algorithms in the higher recognition rate and faster processing speed.

4 Conclusion

Aiming at the violence may occur in elevator，this paper extracts various kinds of movement information and uses the Harris operator to detect the corner. According to the velocity vector information included in the optical flow of corner, the algorithm establishes a modal of corner kinetic energy. The movement characteristics and whole kinetic energy values are merged together as the basis of recognition. The experimental results show that the method can accurately detect the most violent behavior with a low complexity thus can be applied to the real-time video monitoring system in high demand. In following studies, the author would process some special cases such as block serious to further improve the robustness of the algorithm.

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