Research on Abnormal Fall Behavior Detection Algorithm

Wei Wang, Shuang Liu, Hongyu Qian

College of Computer science and Engineering, Dalian Nationalities University, 116600, Dalian, China

Abstract

Abnormal fall behavior identification is one of the important part of human behavior recognition and analysis. This paper puts forward the hierarchical detection of abnormal behavior identification algorithm. In the hierarchical detection of abnormal fall behavior identification algorithm, the first level detection method uses the area of the moving target contour feature to filter the invalid goal which is larger or smaller; The second level detection method is to judge the condition of standing or non-standing; The third level detection method is to determine whether the target happened to fall. The experimental results show that the algorithm meets the requirements of real-time detection. The accuracy of real-time detection of moving target effectively and the recognition rate of fall in the pedestrian behavior detection achieves above 95%

Keywords

Abnormal Behavior Identification;HMM;Moving Objects.

1. Introduction

In recent years, as an important part of behavior identification, application research of abnormal fall behavior identification algorithm makes great sense.

To solve these problems effectively, an improved moving object detection algorithm and abnormal behavior identification algorithm of hierarchical detection based on Gaussian Mixture Model is proposed in this paper, to a great extent improve the accurate recognition rate of traditional abnormal behavior identification system, achieve the real-time monitoring.

2. Fall Behavior Identification

2.1 Behavior Identification Algorithm

Behavior Identification is the process that what the computer has monitored translated into the human language.The behavior recognition is realized through extracting, analyzing and judging the eigenvector of moving targets, and use the high-level language to show the results of analysis. Now, there are two common methods: template matching-based behavior identification algorithm and state space-based behavior identification algorithm .

The template matching-based behavior identification algorithm[1] uses human template as the main basis, through the specific transformation method to extract the human template which containing the image training set of human behavior and classified according to the behavior.To identify the behavior, simply use the classification template of training to match the human behavior to be detected.Wu[2] and others through extracting the edge characters of images to train SVM to divide the monitored human behavior into two categories, normal and abnormal behavior. Zhang et.al[3] put an idea forward to establish the continuous state HMM model of non-rigid body target, when the behavior model is changed, the abnormal behavior can be detected by the established model.

The state-space-based behavior recognition method defines each human body static posture as a state, the state sequences were linked through the use of a certain probability operator, and state of maximum probability sequence is the classification criteria of behavior identification. Any movement behavior in the video image is treated as a traversal process of different static states. Yamato et al[4] in order to identify the hitting behavior of tennis players, the clustering method is used to generate

code book feature from contour feature,then the HMM modeling is used to classify the strokes. Ahmad [5] uses the Hybrid HMM to establish a similar motion sequence, this method has the advantages of convenient and simple calculation compare with other parameters such as the position and size of human behavior. The detection accuracy of this method is high, but because of the large computational cost, the real-time performance is not good. This paper proposes a hierarchical abnormal behavior identification algorithm, with a fast calculation speed and strong robustness.

2.2 Fall Behavior Identification Algorithm

2.2.1.Feature Selection

1.The area of the moving target rectangle contour area A

In the static monitoring environment, the objects that the camera detected include pedestrians, animals, vehicles, plants and even some tiny movements caused by natural phenomenon (rain and snow) and the wind blowing. But as for the abnormal behavior detection system, the effective surveillance targets are only the pedestrians. After comparing the characteristics of each moving object in video sequences, we know that other moving target contour area don't need to be monitored is far from the contour area of pedestrian.Therefore, this paper selects the area of the moving target contour area A as one of the characteristics of pedestrian falling down detection,which defined as follows:

$$A=(Xmax-Xmin)\times(Ymax-Ymin) \quad (1)$$

Among them, Xmax, Xmin denotes respectively for the maximum and minimum horizontal axis of moving targets rectangle contour area, Ymax, Ymim denotes respectively for the maximum and minimum vertical axis of moving targets rectangle contour area. By comparing the size between the area of the moving destination rectangle contour area A and the threshold, the smaller or larger monitoring scenes of moving objects can be filtered out.

$$\begin{aligned} D1&= 1 , \quad TAmin\leq A\leq Tamax \\ D1&=0, \quad others \end{aligned} \quad (2)$$

The threshold TAmin is used to filter smaller moving objects, and the threshold TAmax is used to filter larger moving objects.

2.The perimeter of the moving target rectangle contour area C

When pedestrians are in a state of upright (normal walking), the perimeter of moving target minimum rectangle is much bigger than the perimeter of that when the pedestrians are not upright.Therefore, in this paper the change of the characteristic is used to distinguish the upright and the non-upright position of pedestrians. Specific criteria see formula (9) :

$$\begin{aligned} D2&= 1 , \quad C\leq TC \\ D2&=0, \quad C>TC \end{aligned} \quad (3)$$

TC is the lower limit critical threshold of the perimeter of minimum rectangle frame when the pedestrians is upright.

3.The rate of moving objects height change HRate

The rate of height change HRate between the pedestrians in non-upright position (squats or falling) and in upright position(normal walking) has a very obvious dividing line.Therefore, this system chooses the rate of height change HRate as one of the characteristics of abnormal behavior detection. The operation process is:

$$HRate= (Ymax-Ymin)*Height \quad (4)$$

Height is the average height of the object being detected.

When the pedestrians walking upright, the rate of height change HRate should close to 1 (0.9 in this paper);However, in the event of non-upright behavior such as squat or fall, the rate of height change HRate will be less than 0.9. As a result, variable HRate can also be used to distinguish the status of pedestrian between upright and non-upright.

$$\begin{aligned} D3&= 1 , \quad HRate\leq 0.9 \\ D3&=0, \quad HRate>0.9 \end{aligned} \quad (5)$$

4.The rate of moving object barycenter change QRate

The centroid of moving target Q(Xθ,Yθ) is the center of mass, in the pedestrian motion detection, it is the center of the weight. QRate is used to characterize the change rule of the moving speed through calculating the rate of barycenter change of moving target contour between adjacent picture frame.

$$D4= 1 , \quad QRate \geq Tq$$
$$D4=0, \quad QRate < Tq \tag{6}$$

Among them, Tq is the upper critical threshold of the rate of barycenter change in the normal walking state.

5.The projection area of moving object Carea

The system selected the projection area of the moving object CArea to distinguish the characteristics between fall behavior and crouching posture as shown in formula (7) :

$$D5= 1 , \quad CArea \geq TCA$$
$$D5=0, \quad CArea < TCA \tag{7}$$

in which TCA is the upper limit threshold of projection area in the state of squats.

The aspect ratio of the moving target area rectangular outline HWRate

The smallest external moving target is chosen as the aspect ratio , the calculation formula is shown in formula (8).

$$HWRate= (Ymax-Ymin)/(Xmax-Xmin) \tag{8}$$

$$D6= 1 , \quad HWRate <= 0.9$$
$$D6=0, \quad HWRate > 0.9 \tag{9}$$

2.2.2 Algorithm Introduction

Due to the complex and changing scenes as well as a wide variety of body posture, fall behavior detection algorithm takes the form of hierarchical classification to determine the fall behavior. Fall hierarchical detection algorithms and processes are as follows.

The 1th level detection uses the value of D1(that is, rectangular outline area of moving target) to filter out the larger or smaller moving objects in the scene. When D1=0, there is no pedestrian targets appear in the frame of the image, the system will identify the image as a zero target image frames and finish the processing. When D1=1, it means there are pedestrian targets in the image, and the system will put the frame into the next level detector for further processing.

The 2nd level detector detects pedestrians target image from 1th level detector, based on the values of D2 and D3 (that is, the perimeter and height change rate of the rectangular outline of moving target) to differentiated human standing state and non-standing state. When D2=1&&D3=1, it indicates that objectives of the image frame can be identified as a non-standing state of pedestrian and hand them over to the 3rd level detector for further processing; other cases are considered as normal standing state, and the processing will be finished by the system.

In the 3rd level detector, the values of D4, D5 and D6 are used to determine whether there has a falling down behavior occurred in a non-standing status.When D4=0, we found that the pedestrian regain its balance after adjustment, it is considered as normal state and the process is finished. When D4=1, the values of D5 and D6 are calculated to filter squatting and other similar gestures, the fall detection is achieved. Namely: if D5=1and D6=1, falling down behavior detection is true, and the system marks the behavior and alerts.

3. Experimental results and analysis

3.1 Fall behavior hierarchical detection algorithm performance analysis

Fall detection algorithm performance behavior is mainly manifested in two aspects: First, different exercises false detection rate, the other is the correct detection rate of falls in different situations. In this regard, the natural light conditions, indoor and outdoor 320 * 240 pixel video files were selected

in the experimental analysis. Table 1 shows the correct detection results of fall under different circumstances.

Table 1 Fall detection accuracy in different situations

Motion	Number of test videos	Number of correctly detected	Correction rate
Fall forward	25	25	100%
Fall backwards	25	25	100%
To fall on both sides	30	29	96.7%
Adjusted fall again	20	19	95%

As can be seen from the table above, under the relatively stable supervision environment, fall correct detection rate can reach more than 95% in the system when people walk normally and then fall in different directions. Compared with reference [6], the recognition rate in this paper has improved to some extent.

4. Conclusion

A hierarchical detection of abnormal behavior identification algorithm is proposed in this paper. The experimental results show that the algorithm meets the requirements of real-time detection. The fall behavior recognition rate achieves above 95%.

References

[1] Bobick A F,Davis J. The recognition of human movement using temporal templates[C]. IEEE transactions on pattern analysis and machine intelligence.2001, 257-267.
[2] Xinyu Wu, Yongsheng Ou,Huihuan Qian and et al. A detection system for human abnormal behavior[C]. Proceedings of the IEEE Conference on Intelligent Robots and Systems. 2005.
[3] Zhang D, Gatica-Perez D, Bengio S, and et al. Semi-supervised Adapted HMM for Unusual Event Detection[C]. IEEE Computer Society Press, 2005.
[4] Yamato J, Ohya J and Ishii K. Recognizing human action in time-sequential images using hidden Markov model[C]. Proc IEEE Conference on Computer Vision and Pattern Reeognition, Champaign, Illinois, 1992, 379-385.
[5] Ahmad M, Lee S W. Human action recognition using shape and CLG-motion flow from multi-view image sequences [J]. Pattern Recognition,2008,41(7):2237-2252.
[6] Shen Bingqian, The Implementation of Indoor Body Fall Detection Method based on Video Analysis [D]. South China University of Technology, 2013.