International Journal of Electrical and
Electronics Engineering (IJEEE)
ISSN(P): 2278-9944; ISSN(E): 2278-9952
Vol. 5, Issue 1, Dec – Jan 2016, 1-8

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

AN AUTOMATIC DETECTION ALGORITHM OF ABANDONED OBJECTS AND ABANDONER FOR SURVEILLANCE SYSTEMS

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ABSTRACT

Nowadays, in the field of public security surveillance, the issues of abandoned objects and abandoner detection become more and more popular. If the public places are threatened intentionally by the dangerous objects or obstacles on the way of the bus and railway, it will cause lots of society security problems and we should reduce relative risks. Besides, people often leave something in the public region accidentally. For the aforementioned events, institution checks the videos by people to find the abandoned objects and abandoner after events happen. In this paper, we design an intelligent video surveillance to reduce the loading of human resource, enhance the security and reliability of surveillance system.

There are three contributions of this paper. First, this paper proposes a set of features, including the invariant moments and histogram of gradients to detect the abandoned objects more accurately. Second, this paper proposes an analysis of projection vector and estimation of angle to improve the accuracy of the abandoner detection. Finally, a prototype is designed to detect the abandoned objects and their own abandoner.

KEYWORDS: Intelligent Video Surveillance, Abandoned Objects Detection, Abandoner Detection

1. INTRODUCTION

Recently, there were numerous terror attacks at public places in the international community. Terrorists may intentionally leave the inflammables, explosion-prone objects, bombs, and so on in public places. Due to above of reasons, we need to improve the public security and abandoned objects detection for surveillance systems.

As for the research on the abandoned objects detection, in the references [1-3], we analyze their similarities and differences. In the part of similarities, the references [1-3] all view detection of temporally static objects (TSO) as abandoned objects; in the part of differences, the references [1-3] use CDEBOOK and background subtraction, Gaussian mixture model (GMM) and Gaussian mixture model for two backgrounds respectively. Thus we know that above of references, they don't need to train the classifier to distinguish and they may produce false alarms when they view pedestrians who stay here for a time as abandoned objects.

In the aspect of the abandoner detection, most researches analyze the relationship between pedestrians and abandoned objects. The reference [4], recording the motion analysis of each foreground image, then returns to search abandoned objects after those objects have been detected. However, in the crowded public space, there is a usual situation that the outlier passes through the abandoned object after the abandoner puts it down. Hence, the system will make a mistake of distinguishing abandoned objects and lack for the efficacy of abandoner detection.

2. SYSTEM ARCHITECTURE

The main process of this chapter consists of image pre-processing stage, abandoned objects detection stage, abandoned objects tracking stage, and abandoner distinguishing stage.

2.1 Image Pre-processing

In the image pre-processing stage, we can obtain complete foregrounds, as the flow chart of the image shown in Figure 2.1. And the example of the image pre-processing results was shown in Figure 2.2

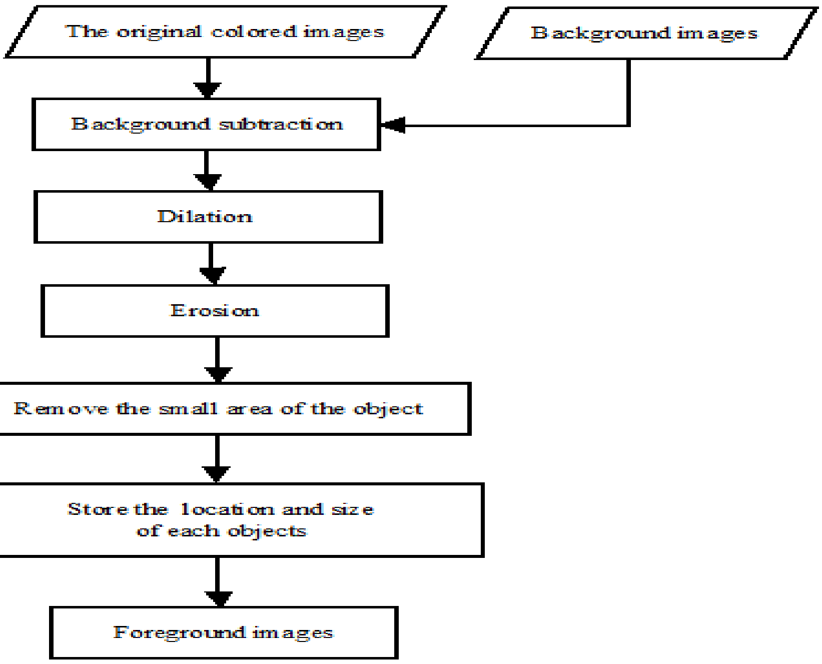
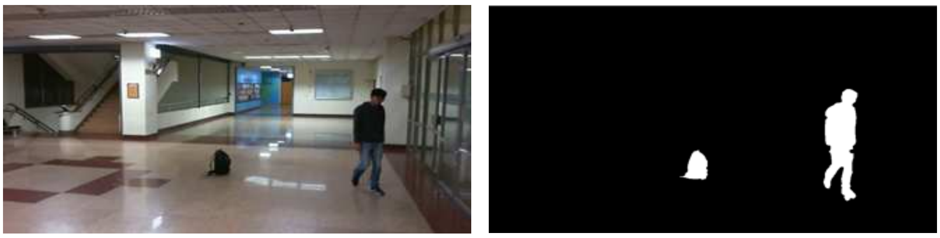


Figure 2.1: the Flow Chart of the Image Pre-Processing



(a) Input Image **(b) Captured Foreground Images**

Figure 2.2: Example of the Image Pre-Processing Results

2.2 Feature Extraction

This section will explain how the system to extract effective features to detect abandoned objects. The main section is divided into two parts, including the data training stage and abandoned objects detection stage. First, this paper will elaborate on the data training. It proposes a set of features, which combine the histogram of gradients [5] as well as invariant moments [6]. The dimensions of the histogram of gradients have 81 dimensions and invariant moments have 7 dimensions. And then it converted x to the new feature space through transformation matrix $\mathbf{W}$, like the formula (2.1). As formula (2.2) shows, the transformation matrix elements w_{ij} will have the higher clustering in the new feature space after the transformation [7].

$$\mathbf{x}' = \mathbf{W}\mathbf{x}, \quad \mathbf{W} = \begin{bmatrix} w_{11} & 0 & \cdots & 0 \\ 0 & w_{22} & & \vdots \\ \vdots & & \ddots & 0 \\ 0 & \cdots & 0 & w_{nn} \end{bmatrix}, \tag{2.1}$$

$$w_{ii} = \frac{1}{\sigma_i^{2} \sum_{i=1}^{n} \sigma_i^{-2}} = \frac{\sigma_i^{-2}}{\sum_{i=1}^{n} \sigma_i^{-2}}. \tag{2.2}$$

Then according to the value of the weight for the feature selection, we choose a part of original data features set to express the data, and use the minimum feature dimensions to reach the most effective recognition results. We will retain characteristics from the large feature weight to small feature weight, using the retained feature vectors distinguish the training data, and then calculate the Error rate by the formula (2.3). Figure 2.3 is Error rates of the training data identified by different dimensions. We can observe that the fewer retained dimensions are, the higher the error rate will become. The red circle represents the lowest part of the error rate, when eight feature dimensions are retained.

$$Error\ rate\ = \frac{Quantity\ of\ \ errors}{All\ quantity\ of\ \ training\ data}. \tag{2.3}$$

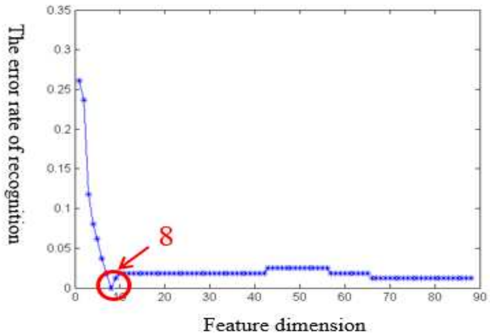


Figure 2.3: Error Rates of the Training Data Identified by Different Dimensions

Finally, we train the Adaboost classifier by the eight features. The complete flow chart of Adaboost training is shown in Figure 2.4.

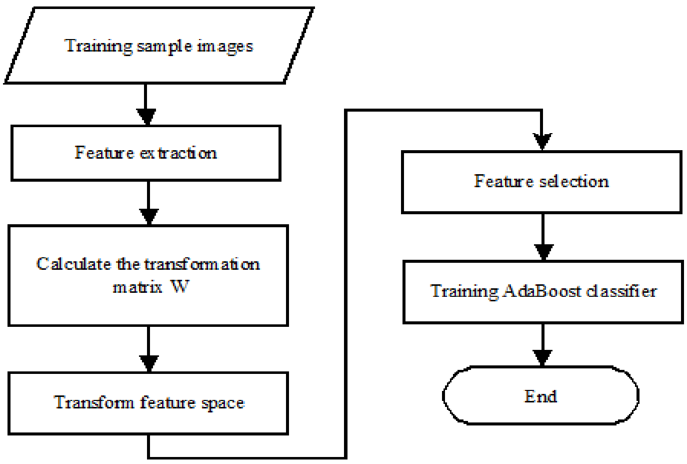


Figure 2.4: The Flow Chart of Adaboost Training

After finishing the Adaboost training step, we will enter the step which detects the abandoned objects. First, set the region we are interested in to get the foreground information and object images. Second, extract features and normalize the object images. Then, start to transform feature space. Finally, enter the Adaboost classifier to determine whether it is the object or not. If the result of classification is a stationary object without pedestrians around over a period of time, the system will determine that it is the abandoned object. The flow char of the abandoned object detection is shown as Figure 2-5.

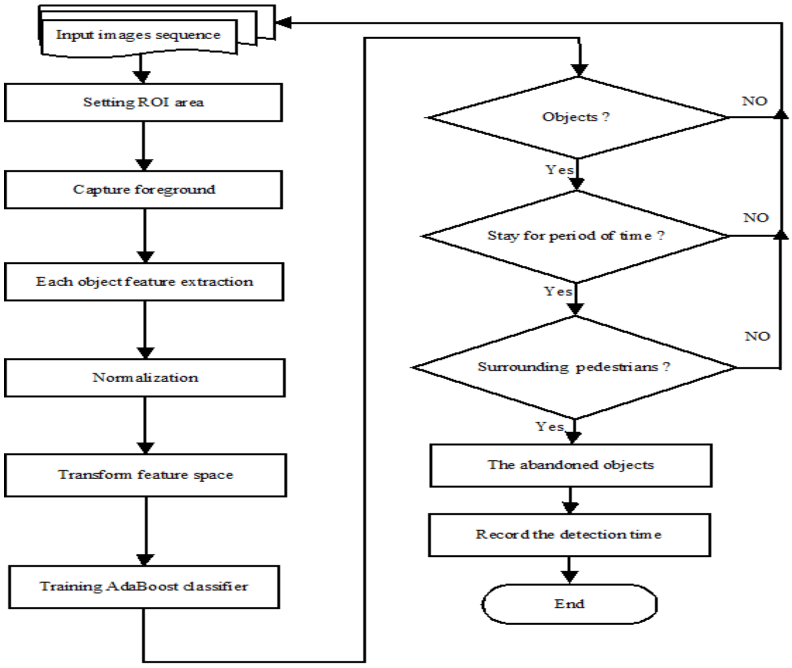


Figure 2.5: Abandoned Object Detection

2.3 Tracking Pedestrians around Abandoned Objects

This section is divided into two parts. Section 2.4.1 introduces how to determine who the suspicious pedestrian is. Section 2.4.2 introduces the tracking process.

2.3.1 Filtering Suspicious Pedestrian

Owing to the overlapping degree of the warning range and pedestrians' range the system defines the $Area_{person}$ as the warning range and $Area_{alert}$ as pedestrians' range. If the overlapping degree is more than a given threshold (here is set to 5000), the system will identify the one as the suspicious pedestrian. And the equation is defined as formula (2.4).

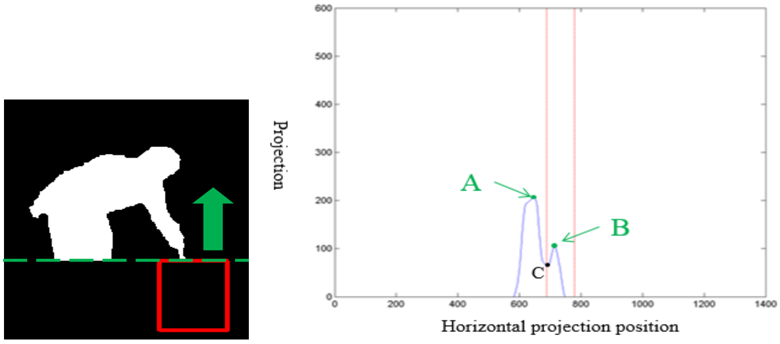
$$\chi = Area_{person} \cap Area_{alert}. \qquad (2.4)$$

2.3.2 Tracking Process

The system will filter the suspicious pedestrian from section 2.4 and use Camshaft algorithm [8] to track it, in order to facilitate the subsequent abandoner identification. So for this problem, this paper uses background suppression algorithms [9]. It may reduce the impact of the background, by reducing the proportion of the background color which is projected. It will highlight the importance of the target color, in order to increase the accuracy of object tracking.

2.4 Abandoner Reorganization

This section describes how to use the vertical projection to analyze the pedestrian's posture. And we observe that the abandoner placed abandoned objects with his bending, as shown in Figure 2.6 (a). In the same time, the essential postures of bending and stretching out one's hand occurred at the top of the abandoned objects. It will calculate the vertical projection, as shown in Figure 2.6 (b).



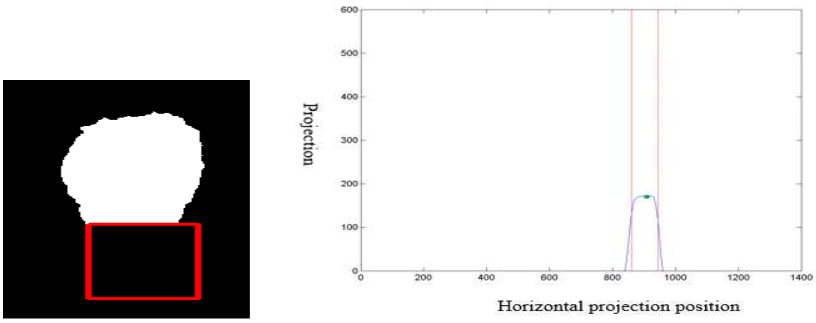
(a) (b)

Figure 2.6: the Analysis of Abandoner Vertical Projection.
(a) The Foreground Image above to the Top of Abandoned Objects;
(b) The Vertical Projection of Figure 2.6 (a)

There are some conditions can be followed. The first condition: the number of all local maximum value $\geq$ 2. The second condition: the number of all local maximum value within the horizontal range of the abandoned objects = 1.

Then, use the local minimum value to recognize the abandoner correctly. Define the limit of local minimum value as the abandoner conditions, whose projection of a local minimum value needs to be less than β times of the suspicious pedestrian's height H. This paper is setting β to 0.4.

The θ_p is greater than the threshold θ_t, it will view the suspicious pedestrian as the abandoner. This paper is setting θ_t to 120°, as shown in Figure 2.7(a) and (b).



(a) (b)

Figure 2.7: Back to the Camera Place Abandoned Objects
(a)The Foreground Image of the Upper Body of the Abandoner
(b) The Vertical Projection of Figure 2.7(a)

The flow chart of Abandoner recognition, shown in Figure 2.8

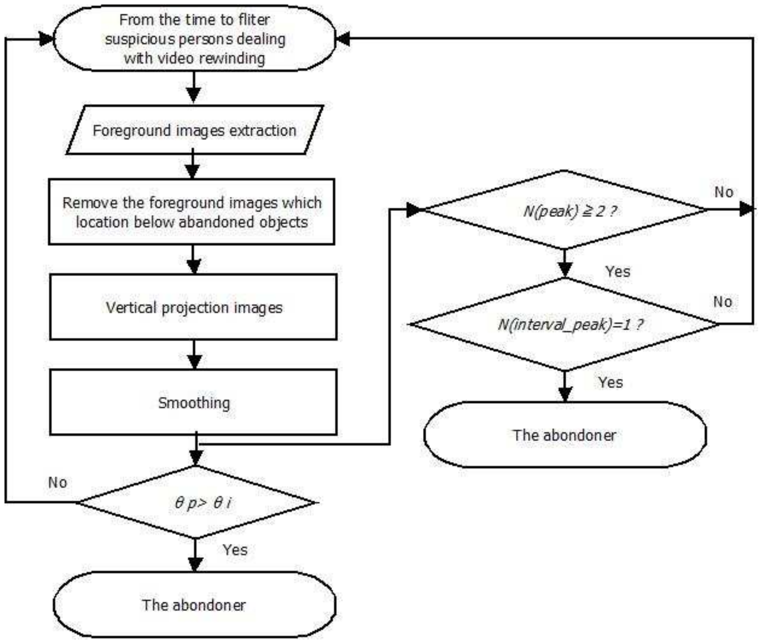


Figure 2.8: The Flow Chart of Abandoner Recognition

3. THE EXPERIMENTAL RESULTS AND ANALYSIS

This chapter is divided into two parts. Section 3.1 presents the experimental results of this paper. Section 3.2 discusses experimental results and compares the Error rate with other references.

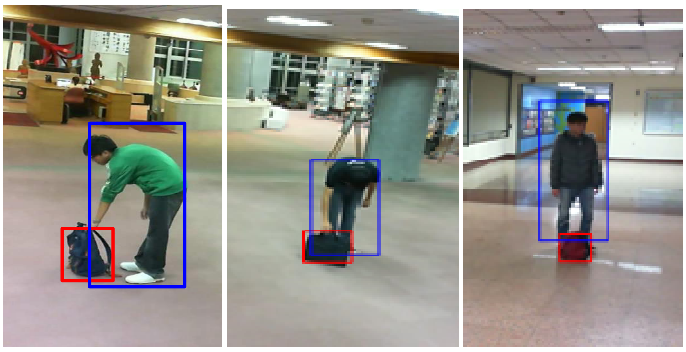
3.1 Experimental Results

The experimental results will be presented in two stages, the first is the abandoned objects detection stage, and the second is distinguishing the abandoner stage. First, at the abandoned objects detection stage, we only use invariant moments, the histogram of gradients to propose set of features and present their results, as shown in Table 3-1. We can observe that the results of abandoned objects detection in this paper, our Error rate are compared less than the rest of the method.

Table 3.1: The Results of Abandoned Objects Detection

Method / Result	Invariant Moment	Histogram of Gradients	Proposed Method
Quantity of errors	8	6	1
Error rate	$\frac{8}{20}$	$\frac{6}{20}$	$\frac{1}{20}$

Subsequently, it will perform experimental results of the distinguishing the abandoner stage. Figure 3.1 presents the results of this paper to distinguish the abandoner. Figure 3.1 (a) to (c) are the three different sections of the film, which will present only the key image of every section.



(a) (b) (c)

Figure 3.1: the Experimental Result Images of the Abandoner Detection
(a) For the Abandoner Placed the Objects and Turned His Side to the Surveillance Camera
(b) For the Abandoner Placed the Objects and faced to the Surveillance Camera
(c) For the Outlier Passes through the Abandoned Objects

3.2 DISCUSSIONS

In the abandoned objects detection stage, for fairness, we use the method for abandoned objects detection of this paper, and we will compare the distinguishing the abandoner stage with references. The reference [3] uses a motion analysis to establish the relationship between the blocks of each foreground in successive images. If the blocks break apart, we figure out that one split block is abandoned objects, and another block will be concluded that he is the abandoner.

In this paper, the experimental results of the reference [3] and [4], as shown in Table 2, we can observe the result of abandoned objects detection in this paper, which has less error rate of film than the rest of methods. As a result, this paper proposes a set of features, including the invariant moments and histogram of gradients, which can make abandoned objects detection more accurate and effective.

Table 3.2: Comparison of Experimental Results

	Abandoned Objects Detection		Distinguishing the Abandoner	
Method / Result	[3]	Proposed Method	[4]	Proposed Method
Quantity of errors	7	1	10	2
Error rate	$\frac{7}{20}$	$\frac{1}{20}$	$\frac{10}{20}$	$\frac{2}{20}$

4. CONCLUSIONS

According to the experiments and results, the proposed abandoned objects and abandoner detection system performs effectively. It can reduce the error rate of recognition or avoid the condition which is unable to detect abandoned objects. And it will prevent the system from the situation which the system has not entered the stage, but had already caused errors. Then detecting the abandoner by the projection analysis and angle estimation, it ensures that there are outliers around the abandoned objects. The system avoids false alarms on the abandoner detection and causing unable to detect the real abandoner. Thus in this paper, the security surveillance system enhances its robustness and practicality of detecting the abandoned objects and abandoner.

ACKNOWLEDGEMENTS

The work was supported by National Ministry of Science and Technology of Republic of China under contract MOST 103-2221-E-009-187.

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