People Recognition for Entering and Leaving a Video Surveillance Area

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***Abstract* — The authors proposed a people recognition method for moving people of entering and leaving a video surveillance area employing the spatial-based feature of single-pedestrian image in conjunction with color vector. The spatial-based features are employed for its different location from variant parts of the human body. A histogram-based framework is used to describe the color vector of variant parts of the moving people. This method is able to track and identify the moving people successfully in different outdoor environment based on variance of samples. A series of experimental results illustrate that this method can track and identify automatically while the moving people enter or leave a video surveillance area.**

***Index Terms* — computer vision, video segmentation, color-vector, object tracking, people recognition**

I. Introduction

Nowadays, the DVR (digital video recorded) system has replaced the traditional analog closed-circuit system completely. A newly developed intelligent surveillance system plays a core role for the security surveillance. However, this intelligent surveillance system is not good enough, for its security is still need to monitor by the security guards. It is also a time consuming task for these security guards. That situation usually makes guards feel tired for both their body and mind, so as to reduce the efficiency of maintaining safety. To assist security management, therefore, the authors proposed a people recognition method for both moving people of entering or leaving a video surveillance area just like the early fire-alarming system [1] and the intelligent vehicle counting system [2] for traffic surveillance.

Both of the previous literatures and technical researches mainly focused on the people recognition systems that identified the whole features of the static image extraction and recognition, besides, the people images were taken by a specific spot for example, face recognition [3], fingerprint verification [4], etc. As to this paper, the authors proposed a new method to extract and recognize the feature from the moving people which go through the specific region. The extraction of moving people increases the difficult level of recognition.

For tracking pedestrians enter, waver or leave the surveillance area, this computer vision system is suitable for tracking and identifying pedestrian's movement automatically. This proposed system is composed of three sub-models, namely, detection model, tracking model, and identification model. The detection model adopts high efficiency background subtraction to detect pedestrian. And, the tracking model uses the pedestrian's geometric position, measure of area and color-vector to track pedestrian. As to the identification model, which divides the pedestrian's image into several non-overlapping area, then, this model adopts each color vector as the pedestrian's characteristics, finally, translates the color vector and space information into the pedestrian's characteristics.

In this experiment, this system process pedestrian's tracking, identify pedestrian's relationship, more over, provide corresponding tracking tags to count appearance times and count similarity for the same pedestrian entering and leaving the same surveillance area.

II. The Related Work

Due to the dynamic changes of the background image, the motion detection turned into fairly complicated. Until now, the algorithms of motion detection can be divided into three categories as follows.

A. Background Subtraction

A background image without any moving object was set in advance for comparing the differences from the image captured by a static camera. Rider [11], K. Karmann [12] and D. Koller [13] utilize Kalman-Filter to make background image can be re-flashed adaptively. The Kalman-filter based active contour model was adopted for tracking of non-rigid objects in the combination of spatio-velocity space. Thus, the system can work in change of light, and it will overcome the weather and change of illumination. These approaches can be used in images that contain stationary moving object of background without interference. The background model of Pfinder was proposed by Wren et al [14]. They established a Gaussian model for each pixel and initiates indoors without foreground. This means achieves the

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single-movement detection and the tracking in indoors. During the interval from 1998 to 1999, both the C. Eveland and C. Stauffer et al proposed more than two models of the Mixture of Gaussians to represent the color distribution of each background pixel for adapting the change of outdoors. This approach established a background model that can adapt the effects of multiple interferences according to whether the background is affected by light or shadow, and re-flash the parameters of Gaussians promptly. Gloyer [17] et al supposed that if the time of background pixel appearing is more than half of the whole training interval, the mean value of the whole under training pixels is set to be the background pixel. I. Haritauglo et al [18] proposed a system which utilizes the means as Gloyer et al. L. Li et al [21] proposed a means that combine spectral, spatial and temporal to represent the dynamic and static background pixels, and utilizes the Bayes decision to distinguish foreground pixels and background pixels for adapting slow or once-off change of background.

B. Frame Difference

Lipton et al [20] use the Frame Difference to detect the moving object in video frames and classification and tracking by moving object. M.-P.D Jolly et al [19] proposed an advance method. Three frames were instead of two frames for getting the moving object more complete. The extra partition leads to much better result.

C. Optical Flow

Meyer et al [22] utilizes the tracking algorithm that is based on contour to initiate via calculating the Optical Flow Field of moving object. It can also detect independent moving object for moving video camera. Gutchess et al [23] quoted the model of establishing background images in calculating Optical Flow Field. It will avoid the moving object be included in background image due to longer residence time when background image re-flash. However, calculating Optical Flow Field would increase the time of the computation, hence, the complexity of algorithm would be much worse.

There are some lectures related with tracking of moving people. The Kalman-filter based active contour model was adopted for tracking of non-rigid objects in the combination of spatio-velocity space [5]. To reduce its computational complexity is its merit, however, it is difficult to initiate the initial contour. In 1997, C.R. Wren et al, a small regional characteristics of the single indoor track will be part of image pixels belonging to the body is divided into different regions, through the follow-up of these small regions to complete the entire human body tracking. In 2000, I.A. Karaulova et al use the stick figure to establish a human model for the single-lens imaging sequences to track the human body. The downside of this method is emerging, this system is unable to tell whether the same person who entered and leaved the region, for tracking system tag pedestrians a tracking tag, it is not allow tagging the same tracking tag repeatedly.

III. THE PROPOSED ALGORITHM

In order to implement the tracking and recognition model, the proposed method uses the adaptive background subtraction method [8] to detect the image of a moving object. The procedure of the proposed tracking and identification method of moving people is described in Fig. 1. The details of each step in the proposed method will be discussed in the following sections.

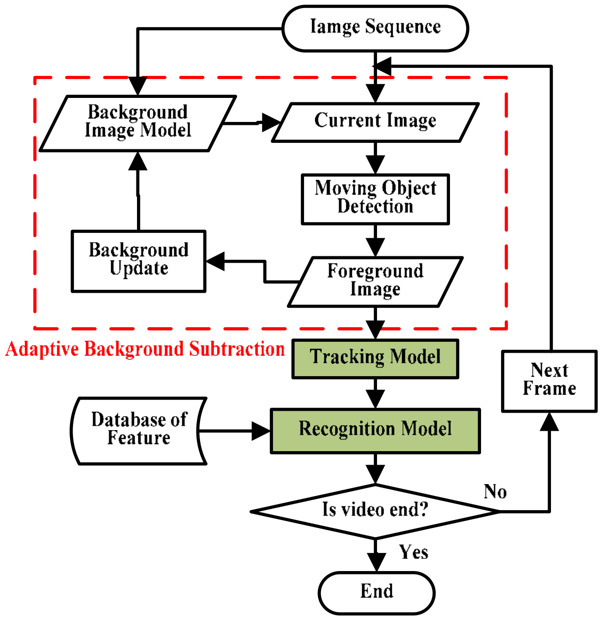


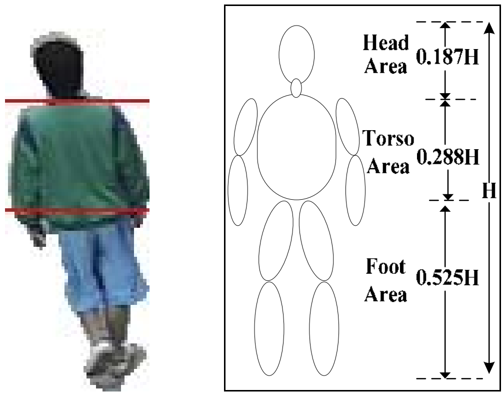
Figure 1. The flow-chart of the proposed tracking and identification system for moving people

IV. FEATURE DETECTION MODEL

What we concern in this paper is for the recognition of the pedestrians, most of the pedestrians in the observation can be found, if the human visual system identify pedestrians are based mainly on the clothing color and texture features, and the color of clothing and pants are different. Therefore, the authors combine the characteristics of color and spatial distribution as the recognition feature of the pedestrians.

A. Spatial-based feature

The Spatial-based feature is based on the difference in colors that reflected from various parts of the body. Division criteria are based on the size ratio of the body [9] which was retrieved by a single-pedestrian image. The pedestrian image is divided into three non-overlapping regions of head area, torso area, and foot area. The proportions of the human body are shown as Fig. 2, where H denotes the height of single-pedestrian image. The weights of head area, torso area, and foot areas are 0.187H, 0.288H, and 0.525H, respectively.



(a) (b)

Figure 2. (a) A single-pedestrian image; (b) The proportions of the human body.

B. Color-based Feature

To simulate the color sensing properties of the human visual system, the RGB color information is usually transformed into a mathematical space that decouples the brightness information from the color information. Among various color models, the HSI (H: Hue, S: Saturation, I: Intensity) color model is very suitable for providing a more human-oriented way of describing the colors, because the hue component is intimately related to the human beings perceive color. For converting colors from RGB to HSI, it is necessary to give an image in RGB color format, then, the H, S and I components of each RGB pixel can be deduced [10].

To distinguish the individual pedestrian, the hue model indicates the color inform ration the pedestrian's clothing successfully due to it's good discriminative feature. When the three color components, namely R, G and B of a pedestrian's image, which captured by a color camera are equal to each other approximately, in another words, it implies that the degree of saturation will deteriorate to zero, and thus it becomes meaningless to define the value of hue. In such a situation, the intensity will be introduced to replace the role of hue.

At first, the authors calculated on the average of the sub-region of saturation, to determine the choice of characteristics for the hue or intensity.

$$AS = \frac{1}{N}\sum_{s=0}^{100} s \times his(s)$$
$$N = \sum_{s=0}^{100} his(s) \quad (1)$$

where: s denotes the degree of saturation, and the range of s(saturation) is supposed from 0 to 100. *his*(*s*) denotes the pixels-number of the *s-th* bin of the saturation histogram. *N* denotes the pixel-number in this sub-region. *AS* denote the average of saturation.

Suppose that the hue is ranged from 0° to 360°. The 360° divided by a slicing factor *D*, and *K* slices were obtained (namely 360/*D*=*K*), and one of the slices means a *D*-degree interval of hue. The level of each slice is defined as the hue value which has a maximal pixel-number within that interval (i.e., slice). For numerical representation, now, let the HS_i represent the hue level of the *i-th* slice, where *i* = 1, 2, …, 360/*D*. To reduce the matching complexity and enhance the discrimination, a moderate quantity of larger-level hue slices are extracted for forming a distinguishing vector, so-called "color vector", denoted as *CV*. Therefore, for person identification, an *n*-dimensional color vector composed of *n* significant hue levels (i.e., HS_i) label to each pedestrian, such a hue-based color vector is formed as

$$CV_{\mathrm{H}} = \max_n \left\{ AV(HS_i), i = 1, 2, \ldots, \frac{360}{k} \right\}$$
$$= AV(HS_{\max-1}), AV(HS_{\max-2}), \ldots, AV(HS_{\max-n}) \quad (2)$$

where the operator of $\max_n$ {} is defined *to* select in amount of *n* significant values of HS_i, which are denoted as HS_{max-1}, HS_{max-2}, …, HS_{max-n}, by pixel-number orderly. The operator AV(•) is defined as calculate the average value of slice of HS_i.

By the same deduction procedures of formula (1), the following formula is obtained:

$$AV(HS_i) = \frac{1}{N}\sum_{u=(i-1)\cdot D}^{i\cdot D} u \times his(u) \quad (3)$$

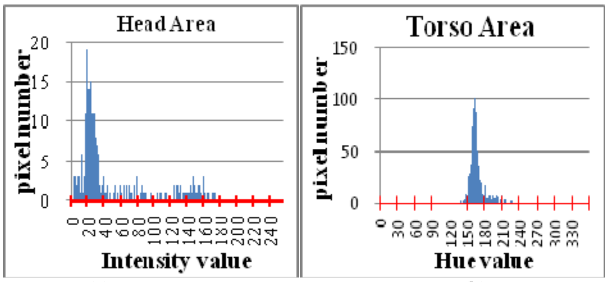
The *u* and *N* denote the value of hue and pixel-number of the *i*-th slice, respectively.

Nevertheless, it should be noted that the angle definition of H (hue) will be meaningless if *AS* less than the threshold. In such a situation, the I (intensity) component will be introduced to form the color vector, CV_I. By the same deduction procedures of CV_H, we can obtain:

$$CV_{\mathrm{I}} = \max_n \left\{ AV(IS_i), i = 1, 2, \ldots, \frac{256}{k} \right\}$$
$$= AV(IS_{\max-1}), AV(IS_{\max-2}), \ldots, AV(IS_{\max-n}) \quad (4)$$

where the range of I (intensity) is supposed from 0 to 255, IS_i denotes the level of the *i-th* slice of the intensity histogram and IS_{max-1}, IS_{max-2}, …, IS_{max-n} denote *n* significant ones of IS_i in order of pixel-number. The operator of AV(•) is defined to calculate the average value of slice of IS_i.

Fig. 3(a) shows the intensity value of head area which is mentioned in Fig. 2(a). In the I-histogram slices, with a slice factor *D*=8 and color-vector dimension *n*=3（three color elements）. The higher peaks are located at the intensity peaks value of 20, 26, and 34, respectively. Fig. 3(b) describes the hue in torso area which is also mentioned in Fig. 2(a). In the H-histogram slices, with a slice factor D=10 and color-vector dimension n=3（three color elements）. The higher peaks are located at the peaks value of 163, 155 and 172, respectively.



(a) (b)

Figure 3. Analysis of a single-people image: (a) the I-Histogram of the head area; (b) the H-Histogram of the torso area.

C. Feature matching

The feature has to be matched when the multi-people pattern happen to be split for tracking model or the single-people pattern crossed the specific area for recognition model.

At first, the matching degree (DM) was calculated for every element of color vector.

$$DM_i = \begin{cases} (100 - e_i \times \delta) \ , if \ \ e_i < \tau_e \\ 0 \qquad\qquad\qquad , otherwise \end{cases} \qquad (5)$$
$$where \ \ \delta = 100 / \tau_e$$

where e_i denote the difference between an observation object and a target object for *i*-th element of color vector of *n*-dimension. τ_e and δ denote the range of error tolerance and the degree of attenuation, respectively.

Then, the similar rate (*SR*) is calculated for sub-region of single-people pattern, head area, torso area and foot area, respectively.

$$SR = \sum_{i=1}^{n} DM_i \times w_i$$
$$where \ w_1 > w_2 > ... > w_n \ \ and \ \sum_{i=1}^{n} w_i = 1 \qquad (6)$$

the range of *w* is supposed from 0 to 1. Where w_i denotes the weight of the *i*-th element of color vector. *DM* denotes the degree of matching of the *i*-th element of color vector.

Finally, the *SP* (similar percentage) is calculated for single-people pattern.

$$SP = \sum_{body} SR_{body} \times w_{body} \qquad (7)$$

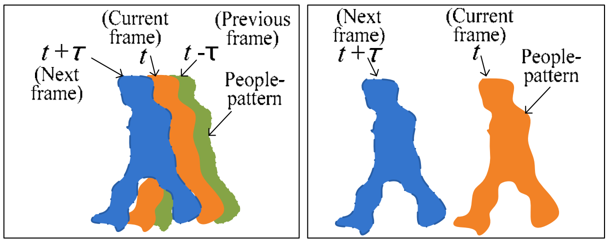
where the w_{body} denotes the set of weights for head area (*HA*), torso area (*TA*) and foot area (*FA*), and $w_{TA} > w_{FA} > w_{HA}$, and the summation of the weights equals 1. SR_{body} denotes the set of similar rate of HA, TA and FA.

V. Tracking and Recognition Model

The authors built the tracking model and recognition model to track and the detected moving people that appear in a surveillance area.

A. Tracking model

As illustrated in Fig. 4, in which an overlap case is described in the subfigure (a) and disjointed case in the subfigure (b). If any two identical people-pattern in consecutive image was captured while an intersection exists (e.g. the current and next frames), we can judge whether the both patterns are generated from the same person or not. On the contrary, two separated people-patterns may not represent the identical person while people-patterns have no intersection. It is noted that the time interval τ shall be adjustable and this value is dependent on the frame-sampling rate.



(a) (b)

Figure 4. Trailing of a people-pattern for (a) intersectional case and (b) disjointed case.

B. Merge-split processing

In general, people may walk alone or together with their friends, different combinations will result in one single-people pattern, several single-people patterns, one multi-people pattern, several multi-people patterns, or their mixed patterns in a captured surveillance area. As some reasons mentioned previously, each moving object may happen to be split or merged within a range of the captured surveillance area and this merge-split procedure may confuse the tracking. For merge-split, to check if there is a merging case or splitting case to happen, the area change of the moving pattern provide a fundamental parameter for judgment, as shown in Fig. 5. A merging case will be detected if two separated moving patterns move in the current frame (the frame of time t) and then, they are combined form an overlap pattern in the next frame (the frame at time *t* +τ). Besides, the color vector also requires to be calculated for the separate moving patterns before the merging case is happening, and recording into the database.

Inversely, a judgment of splitting case will be detected. if an overlap pattern move in the current frame (the frame at time *t* +τ) and then, this pattern is separated into two individual patterns in the next frame (the frame at time *t* +2τ). Besides, the color vector be calculated for the separate moving patterns after the splitting case to happen, and identified as database.

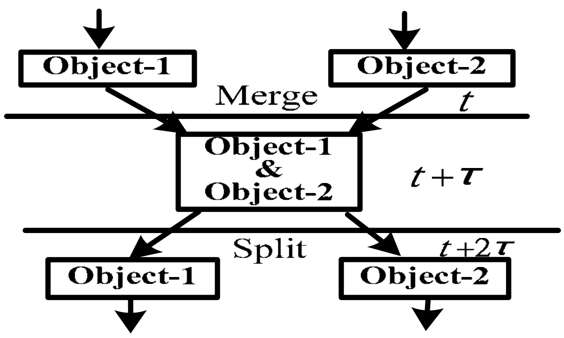


Figure 5. Schematic of the merge-split process

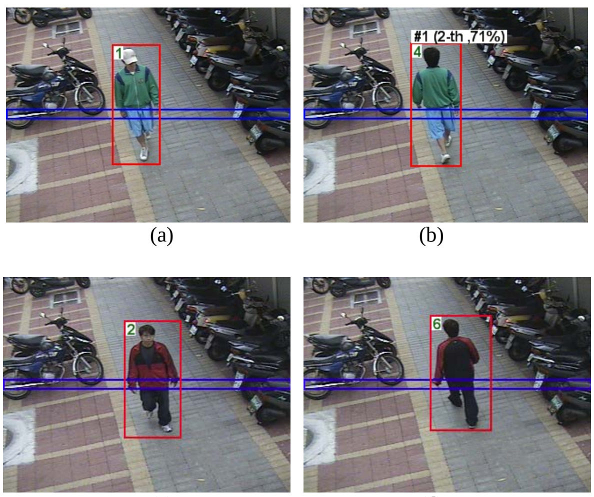
C. Recognition model

In order to recognize pedestrian as the moving people in a video surveillance area, we suppose pedestrian entered the specific area (the blue-bounding box in Fig. 7). In this model, the color vector captured and recognized in one single-people pattern that when enter the specific area. If the recognition result has the highest similar rate and high than 55%, then, recording in the database, and showing the corresponds to the matching label and similar rate. On the contrary, it is first time for the single-people pattern that without any associated information. For example, the blue-bounding box is the specific area for recognition in Fig. 6 When pedestrians go through the specific area and the identification of people implemented simultaneously. If there is no target similar with the previous detected moving people (i.e., the target is the first appearance), then the system won't show the additional information. The case is shown as in Fig. 6(a). Contrariwise, the detected moving target is similar with the other target in the database, then the system show the result of identification, shown as the inset text in Fig. 6 (b).

VI. EXPERIMENTAL RESULTS

A theoretical analysis about 'the proposed people tracking and identification method' has been introduced in the previous section, and several tests have been carried out to verify the proposed method. In this experiment, the tested video sequences of size 320×240 pixels which captured by color CCD camera were saved as AVI file. The algorithm implemented in C# Language with an Intel® Core™2 1.86GHz microprocessor, and 3GB RAM were mounted.

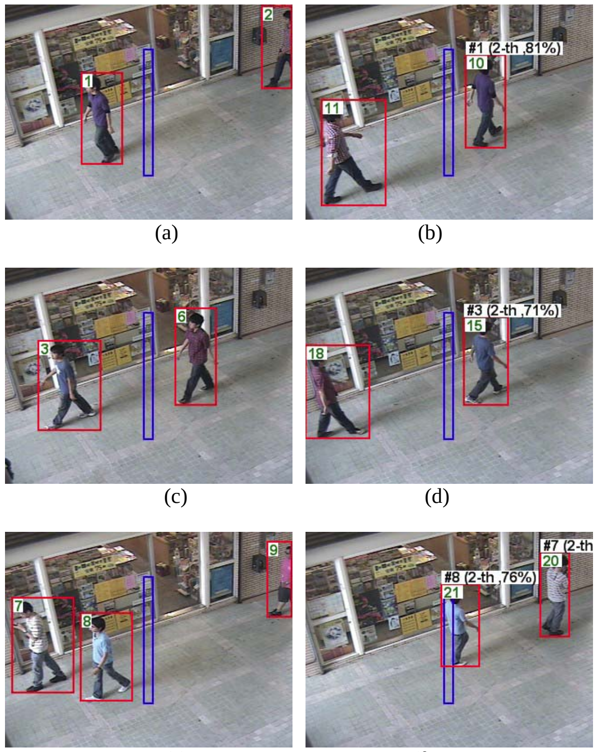
Fig. 6 describes the same pedestrians appeared at different times in the same surveillance area, were labeled as 1 and 4. The main difference lies in wearing hat or not. The inset text describes the results of identification in Fig. 6(b). The result of block 4 compared to the block 1 (#1) with a 71% similarity at the appearance of the 2nd time.



(a) (b) (c) (d)

Figure 6. The results of identification: (a) wearing a hat; (b) not wearing a hat; (c) the front of a pedestrian; (d) the back of the same pedestrian in (c).

Fig. 7 describes the same pedestrians appeared at different times in the same surveillance area, which was blocked as 16 and 29. The inset text describes the results of identification in Fig. 7(b). The result of block 29 compared to the block 16 (#16) with a 93% similarity at the 3rd appearance.



(a) (b) (c) (d) (e) (f)

Figure7. (a), (b) present the identification results of a same pedestrian in frame number 242 and 1007; (c), (d) present the identification results of a same pedestrian in frame number 482 and 1342; (e), (f) present the identification results of a same pedestrian in frame number 684 and 1565.

(a) (b)

Figure 8. The results of identification: (a) the first appearance for block 16; (b) the 3rd appearance for block 29.

(a) (b)

Figure 9. The results of identification: (a) the first appearance for block 1; (b) the 2nd appearance for block 8.

(a) (b)

Figure 10. The identification results: (a) the first appearance for block 2; (b) the 2nd appearance time for block 6.

The Table I denotes the experimental results for the test video sequences. The proposed method has good accuracy. However, the illumination conditions have a powerful influence to the pedestrian identification. When the color of the illumination is similar to which the wearing clothes is, it maybe result in erroneous identification.

Table I. ACCURACY RATE OF PEOPLE RECOGNITION.

	Number of Pedestrian	Correctly identify the number of pedestrian	Accuracy Rate in%
Park	16	15	93.7
Shop	19	15	79
Plaza	36	30	83.3

VII. CONCLUSIONS

In this paper, a people recognition method for moving people of entering and leaving a video surveillance area was presented. The whole system could be divided into three main parts, namely, the feature detection model, the tracking model, and the identification model. For moving objects sensing, the simple background subtraction algorithm method was employed to remove the shadow area, and a moving area with higher accuracy was obtained.

The characteristic of the overlapping image of the adjacent people could be utilized to the pedestrian tracing without complicated computation. To enhance the efficiency of the system execution, what we need to do just retrieving the color vector while the merge-split phenomenon is occurring. By combination of the color feature and spatial information for people identification and similarity computation, it is also feasible to accumulate the frequencies that the pedestrian entered the video surveillance area. The color feature is lack of uniqueness and robustness, especially for the long term surveillance, in another words, it is unable to distinguish the different people with the same color feature. Hence, further studies for improving the color feature uniqueness and robustness are necessary urgently. In addition, performing the proposed method to realize multi-camera is also interesting for the future researches.

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