Learning and recognizing behavior patterns based on comprehensive movement of people in surveillance images

Hiroaki IWABUCHI[a*], Shigeki AOKI[b] & Takao MIYAMOTO[b]

[a]*Graduate School of Engineering, Osaka Prefecture University, Japan*
[b]*College of Sustainable System Sciences, Osaka Prefecture University, Japan*

*iwabuchi@sig.cs.osakafu-u.ac.jp

1. Introduction

Recently, automatic video surveillance systems have become an active area of research. Typical methods of research detect irregular behavior based on a set of given irregular behavior models(1), and detect rare behavior as irregular(2). But these approaches must be relearn when the number of surveillance cameras are increased or their position is changed a little.

In this paper, we propose a novel method that detects irregular situations by learning and recognizing behavior patterns focused on comprehensive movement of people. Because our method uses common features in some environment, the existing problem of relearning when the position of the surveillance cameras changes is resolved.

2. Extraction of Behavior Patterns

2.1. Extraction of Comprehensive Movements

We extract comprehensive movements because it is difficult to keep track of people individually as occlusion occurs frequently in crowded places.

First, we divide the image into 20×20 [pixel] segments, as shown in Figure 1. And, we estimate the foreground image by background subtraction. Second, to extract the comprehensive movement, we calculate the optical flow of each pixel in the input image. After that, in each segment, we extract featu- res $\boldsymbol{v}_n(n = 1, 2, \ldots, N)$,where N is the number of segments, as shown in Table 1. Third, we regard the feature vector which is sorted the number of the foreground pixels in each segment as $\boldsymbol{V}_t = \{\boldsymbol{v}_1, \boldsymbol{v}_2, \ldots, \boldsymbol{v}_N\}$. Finally, dimensions of the feature vectors are compressed by Principal Component Analysis (PCA).

2.2. Extraction of Behavior Patterns

We regard the moment at which people appear in sight of the surveillance camera, the moment when the degree of congestion changes as the start of a new comprehensive flow, and we call this a division point. We decide the division point by referring feature vectors $\boldsymbol{V}_t$.

3. Learning and Recognition, Detection of Irregular Situations

First, when behavior pattern $\mathbf{I_p}$ is observed, we perform the comparison process (Figure 2. Compariosn) to confirm the existence of the same pattern in the database. We compare $\mathbf{I_p}$ with the past behavior patterns $\mathbf{R_q}$ $(q = 1, 2, \ldots, Q)$ in the database by computing the similarities $|\mathrm{cost}_q|$ $(q = 1, 2, \ldots, Q)$ using the dynamic programming, where Q is the number of reference patterns. Second, we carry out the

Figure 1. Image divided into 20×20 segments.

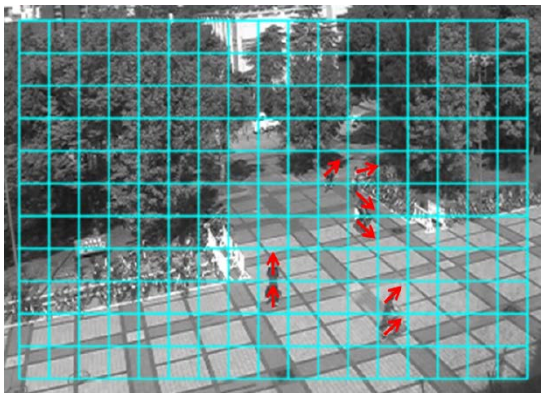

Table 1. Features $\boldsymbol{v}_n$ in each segment.

Mode values {*du*, *dv*} of optical flows	Numbers of the foreground pixels
Average of brightness values	Variance of brightness values
Subtraction of numbers of foreground pixels between present image and past image	Subtraction of averages of brightness values between present image and past image

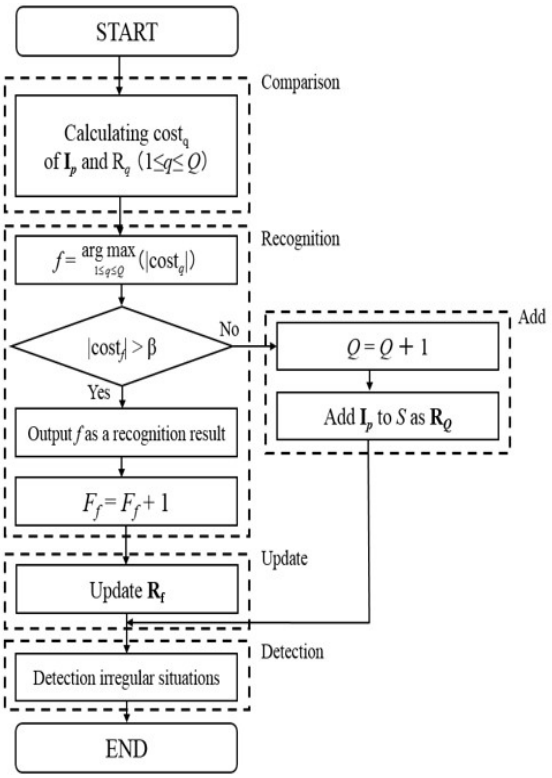

Figure 2. Procedure of learning and recognition of behavior patterns, constructing reference patterns and irregular situations detection.

recognition (Figure 2. Recognition) of $\mathbf{I_p}$. We choose $\mathbf{R}_f$ that has the highest similarity from the database. If $|\text{cost}_f|$ is higher than β, we recognize $\mathbf{I}_p$ as $\mathbf{R}_f$, and we add one to the frequency of observation $\boldsymbol{F_f}$ and we perform updating process (Figure 2. Update), where β is a threshold value for recognition. If it is lower than β, we add (Figure 2. Add) $\mathbf{I_p}$ to the database as a new reference pattern $\mathbf{R}_{Q+1}$. Finally, we perform detection process (Figure 2. Detection) of irregular situations.

4. Conclusion

We presented a novel method for detection of irregular situations by learning and recognizing the behavior pattern focused on comprehensive movement of people.

Acknowledgements

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