Dynamic Evaluation of Pedestrian Flows by Traffic Line Distributions

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Abstract. *This paper describes the system to take traffic lines of pedestrian flows in traffic field and the investigation of dynamic characteristics of the flows by using the time transition of the density, direction and velocity distribution of them. The dynamic characteristics are so useful to evaluate the congestion and latent dangerousness of traffic field and also the arrangement of structures and public facilities.*

Keywords: Traffic Lines, Pedestrians Flow, Congestion Evaluation

1. Introduction

To realize smooth and safe walking of people outdoors in city or town, it is necessary to know latent characteristic (congestion and dangerousness) of the field where they are walking. The latent characteristic of field is estimated by analyzing pedestrian flows. Pedestrian flows are affected by the formation of road and square, field conditions, the arrangement of structures (buildings, houses, railway stations and so on), the position of entrances and exits of them and the public facilities (stairs, monuments, bus stops, crossing points, fountain and so on) . It is recognized that these are static factors. Additionally, pedestrian flows are also affected by the congestion density, walking directions and velocities of themselves. The direction, velocity and density of pedestrian flows change dynamically by time transition. It is recognized that these are dynamic factors. The dynamical state of pedestrian flows expresses the changing of congestion and the latent dangerousness of field where they are. To know the latent state of field is very useful to predict frequent accidents for pedestrians and to redesign the arrangement of structures/facilities and the formation of road/field.

This paper describes

1) the system to find the traffic lines of pedestrian flows and to construct the density, direction and velocity distribution of them in open square and street,
2) the static state (congestion) evaluated by density, direction and velocity distributions of traffic lines in a constant measurement time,
3) the dynamic state (congestion) evaluated by monitoring the time transition of density, direction and velocity distributions of traffic lines.

2. Measurement of Traffic Lines of Pedestrian Flow

To recognize pedestrians outdoor, several kinds of research works are reported[1-5]. To recognize the pedestrian flow in traffic field, this paper shows the measurement system to detect the moving track of pedestrian flow as a traffic line. Traffic lines were generated by image processing of the pedestrian flows recorded with digital video camera. Fig.1 shows the sample of frame image of video taken the situation of pedestrians walking in morning at Student University Festival in autumn 2007 in morning. In Fig.1, the right-top side area (circle_1) is the entrance of restaurant building. In this area, it was found that standing students and walking students in/out the building are confusing. And the five areas shown with circle_2 are street food stalls. In these areas, the students standing in the food stall and walking slowly to see foods and goods for sale were confusing. Around these areas, the density of students is higher and the walking velocity of them is lower. Video camera was fixed on wall on the roof of building (21m height). The recording was continued in several hours from morning. The record was stored into several video tapes. By special image processing, pedestrian movements in the video image were expressed as the connections of traffic line segments. In this experiment, the image processing was done by off-line. The image processing was done by 7Hz. The data of traffic line segments were stored to internal memory (RAM) and external database in storage (HD) each 1/7sec. At the same time, each 5min., the picture of traffic lines superimposed on static image (Fig.4) was stored as a JPEG file. By using these data, the dynamical situation of pedestrian flows and the effect of facilities/ field characteristics were evaluated in consideration on the density distribution, direction distribution and velocity distribution.

Fig.1 Static Video Image

Fig.2 Differential Image Frame

Fig.4 Traffic Lines of Pedestrians (5 min.)

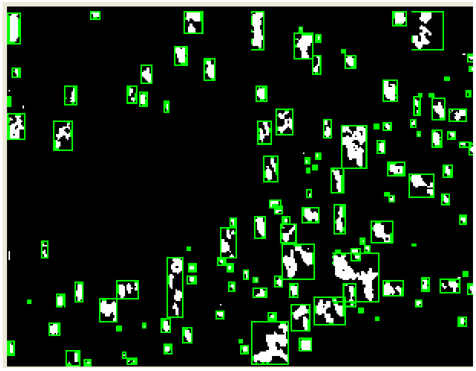

Fig.3 Recognition of Pedestrian Movement with Green Boxes

3. Density Distribution of Pedestrian Flows

The static congestion of pedestrian flows is evaluated with the density distribution of traffic lines. Fig.5 shows the image of absolute density distribution of traffic lines. The density distribution was constructed by counting the number of traffic line segments in each divided image block (10 dots square). Thick color areas show the state of high density of traffic lines. The density is expressed by 8bit. It is confirmed that entrance area of restaurant building (circle_1) and the street food stalls (circle_2) was crowded. The reason of this state is by students standing and walking slowly around the entrance of restaurant building and the street food stalls. In addition to that, upper and right parts at edge (dot circle_3 and circle_4) of lawn area centered in the image are also crowded. This means that pedestrians were walking slowly at edge of lawn, especially at the corner. Their behaviors became carefully near the off limit area like lawn. Around the bottom, there is high density area formed thick straight line (dot circle_5). Here is the Main Street of campus. Many pedestrians walked through freely not affected by area and facility characteristics. As mentioned above, the situations of density distributions of the characteristic four areas were expressed. But these density distributions were not constant. These situations are invisible in a static image and changes according to time transition.

4. Direction Distribution of Pedestrian Flows

Fig.6 shows the image of direction distribution of traffic line segments measured in 5 min. at 13:00. The directions of traffic line segments are expressed with the color distribution referred by Fig.7. In Fig.6, there are many traffic line segments drawn to various directions. Then, to clarify characteristics of direction distribution, the colored traffic line segments were classified into four regions as follows;

1) right side region : -45 to +45 [degree],
2) upper side region : +45 to +135 [degree],
3) left side region : +135 to +225 [degree],
4) down side region : +225 to -45 [degree].

According to this classification, Fig.6 was divided into four kinds of distinguished direction distributions (Fig.8). Around left and right side of lawn (dot circle_4 and 6), most of pedestrians were walking to the direction of left-down (colony of green line segments). Also, around upper side of lawn (circle_3), most of pedestrians were walking to the direction of left (colony of light blue line segments). In street at the bottom of image (circle_5), two kinds of pedestrian flows to right and left side were confused. In other regions, various kinds of directions were overlapped. That means that the pedestrians who walked to various directions were crossing.

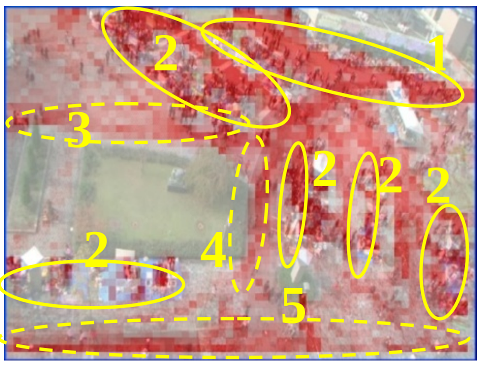

Fig.5 Density Distribution of Traffic Lines

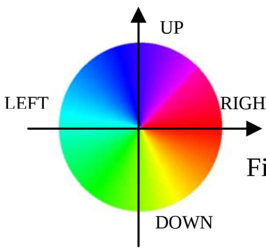

Fig.7 Matching Circle between Direction and Color

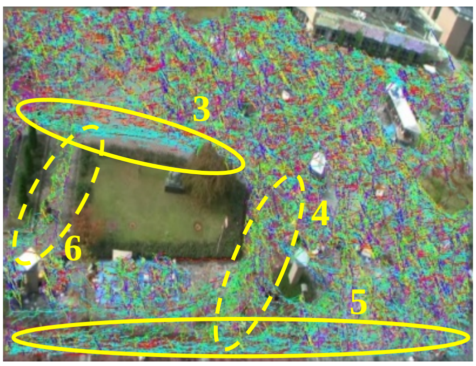

Fig.6 Direction Distribution of Colored Traffic Lines

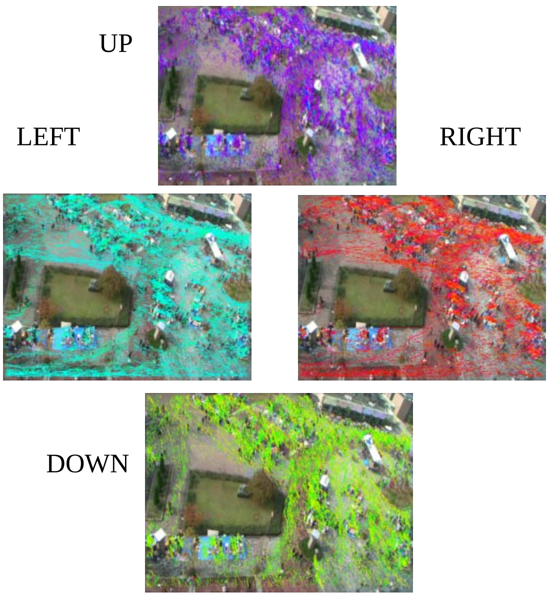

Fig.8 Direction Distributions classified into Four Kinds of Regions (UP, DOWN, LEFT, RIGHT)

5. Velocity Distribution of Pedestrian Flows

Fig.9 shows the image of velocity distribution of pedestrian flows in 5 min. at 09:45. The velocity distribution of walking pedestrians was constructed by dividing length of traffic line segments by flame rate (1/7 sec.) in each image block (10 dots square). Thick color areas show the state that pedestrians were walking by high speed. The velocity was expressed by 8bit. In morning, as pedestrians were not so much, the density of velocity distribution was low in average. The high and low strengths of velocity were express well.

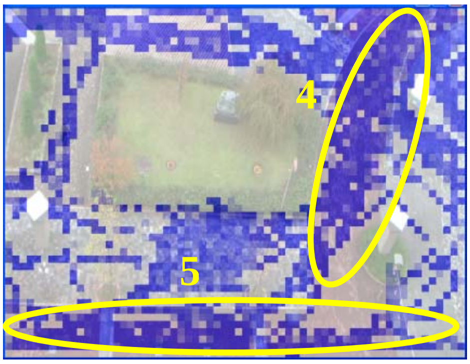

Fig.9 Velocity Distribution of Pedestrian Flows

6. Conclusions

This paper describes the measurement system to detect traffic lines of pedestrian flows and evaluates the latent characteristics (dynamic states of density, direction and velocity) of pedestrian field. These characteristics are not able to recognize with video and static images. They relate to the congestion and latent dangerousness in pedestrian field/area. They are not defined by only arrangement of buildings and facilities. They must be recognized as the dynamism of density, direction and velocity distribution of pedestrian flows.

By experiments and evaluations to analyze pedestrian flow in university campus, some invisible congestions and dangerous areas were confirmed. The situation of these areas were changing corresponding with the time transition. In future, authors will reconstruct the measurement system as an on-line system, and investigate the definition of the congestion and dangerousness of field/area estimated by the dynamism of density, direction and velocity distribution of pedestrian flows.

References

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