Method Article

Obtaining Pedestrian Interest Regions Using Experimental Methods

ABSTRACT

In simulating pedestrian flow, the use of pedestrian interest region can solve the problem of redundant and complex data and lack of representation within the pedestrian glance range, and establish an efficient pedestrian collision avoidance behavior model. The real-time eye movement behavior data of one-way and two-way pedestrian flow was collected by the eye tracker, and a mathematical model of pedestrian flow density and the radius and angle of each region of interest was established. Analysis of experimental data found that the region of interest is affected by the density of pedestrian flow. The angle of the region of interest generally does not exceed 90°, and the radius of the region of high interest and the region of low interest is negatively correlated with the pedestrian flow density, and when the pedestrian flow density reaches a certain level, the radius of the high interest region and the low interest region approach to a fixed value respectively. Compared with the two-way pedestrian interest region, the one-way pedestrian flow has a wider range and is more flexible. The findings of the pedestrian region of interest provide design guidance for developing local interaction models for the development of pedestrian flow simulations with different densities.

Keywords: Pedestrian flow; Region of interest; Eye movement behavior

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1. INTRODUCTION

The complexity of pedestrian behavior comes from the existence of collective behavior mode, which is evolved from the interaction between a large number of individuals within a certain range. Therefore, building an effective range of pedestrian interaction becomes a key point of pedestrian flow model. However, the range of pedestrian interaction in different models is different. In the cellular automata model [1-4], the pedestrian interaction range is represented in the form of neighborhood, which is defined by using rules such as Von Neumann type, Moore type and extended Moore type. In the social force model [5-6], the pedestrian interaction range is expressed in the form of a parameter of the decline length of social repulsion. In other models, there are two typical methods to construct the scope of inter-bank interaction. The first method considers topological distance [7-8], and takes a fixed number of the nearest pedestrians as the pedestrian interaction range. The second method considers visual information [9-10], and sets a sector area around a single pedestrian to define its radius and angle. These models assume a certain area as the pedestrian interaction range, and rarely have been calibrated and verified on the validity of real data and parameter details.

In practical situations, pedestrians do not care about the global information in the moving scene, but only pay attention to the local area information that they are interested in. Pedestrian interest points are usually points with rich content and high information content. These points are the most representative points in the motion scene. From this, it can be obtained that the interest area composed of interest points also has high information content. Therefore, instead of considering the global information of the moving scene, only the local area information of interest to pedestrians is extracted. Based on pedestrian eye movement behavior experiments, this paper proposes a method to obtain pedestrian interest regions. Considering how one-way and two-way pedestrian flows, which are common in daily life and have different densities, affect the range of pedestrian interest areas, a mathematical model of one-way and two-way pedestrian flow density and the radius and angle of each interest area is established.The research on the pedestrian area of interest provides data support and theoretical guidance for the development of pedestrian simulation collision avoidance algorithms with different densities, thereby helping to further improve the pedestrian simulation model.

2. EXTRACTION METHOD OF PEDESTRIAN INTEREST REGION

This paper mainly collects real-time data of eye movement behavior of participating experimenters with the help of eye trackers, which allows to build and study virtual environments, which are impossible to reproduce in the real world [11]. First, the method of simultaneously recording pedestrian flow videos horizontally and overhead is used to collect pedestrian motion scene information; secondly, the eye movement behavior data information related to the gaze intensity, such as the gaze rate and gaze duration of pedestrians, is obtained through the eye tracker; The threshold method is used to extract points of interest and eliminate outliers; finally, a pedestrian attention formula is introduced to measure the degree of stimulation of pedestrians by static and dynamic factors, and different divisions of interest regions are realized by filling in the cluster.

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2.1 Pedestrian interest point extraction

Pedestrian interest points are usually points with rich and high amount of information. These points are the most representative points in the pedestrian motion scene. They are points that select useful information from a large number of information and guarantee the effectiveness of pedestrian walking perception process. Research shows that human eyeballs mainly have three basic forms of movement: fixation, saccade and smooth tracking [12]. Look at the behavioral movement to locate and observe the content you are interested in, and the duration is between 100ms-1200ms. If the gaze exceeds 1200ms, it is considered to be dazed. The saccade behavior movement is that the fixation point position jumps quickly from one observation area to the next. Smooth tracking motion means that when the pedestrian's head remains stationary, in order to keep the fixation point always on the observation object, the eyes should follow the observation object to make compensation motion. In this paper, we use the time threshold method to extract the points of interest. When the participants' fixation time exceeds the threshold T_i, they are considered as the points of interest. As shown in Figure 1, the blue diaphragm in the figure represents the pedestrian gaze. In this paper, if a pedestrian continuously looks at the same point for more than 3 frames, the gaze point is considered as the point of interest. If the point of interest of the next frame falls on the same object and is within 3 ° from the axis to the original gaze position, it is considered to gaze at the same point of interest.

Fig. 1. An eye tracker tests a frame in a video sequence

2.2 Pedestrian interest region extraction

The pedestrian region of interest is composed of current pedestrians and points of interest, but it is impossible to fully understand the extent of the pedestrian area of interest, even with state-of-the-art neuroscience [13]. To simplify the experiment, the region of interest consists of 3 parameters: interest level, radius, and angle. Here, referring to the literature[14], the interest level is divided into high interest region, low interest region and no interest region (Figure 2（a）). This paper mainly studies regions of high interest and regions of low interest. In order to realize the division of interest regions, the degree of attention is introduced to measure the degree of stimulation of static and dynamic factors to pedestrians. con(p, i) is used to indicate that the participating experimenters are at the current position of pedestrian p. The attention degree of the point of interest i, its calculation formula is as follows:

$$\text{con}(p,\ i) = \frac{N(p,\ i)}{N(I)} \times \frac{N(i,p)}{N(P)} \qquad (1)$$

N(p, i) represents the frequency of the participant's gaze at the point of interest i at the current pedestrian p position, N(I) represents the total number of interest points frequency of the participant at the current pedestrian p position, N(i, p) represents The number of points of interest at i, N(p) represents the total number of participants in the experiment.

If the participants in the experiment pay the highest attention to a point of interest within a certain number of consecutive frames, the point of interest is considered to be a high point of interest. The distance from the position of the first frame of the high interest point to the current

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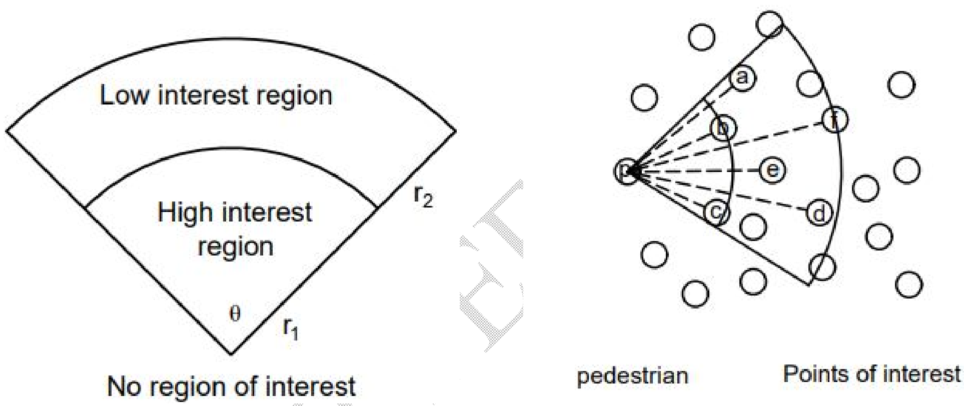
pedestrian position is the radius r_1 of the high interest region, and the maximum distance from all the interest points of the participants to the current pedestrian position is the radius r_2 of the low interest region and all the interest points of the participants. The maximum angle formed by the two points of , and the current pedestrian position is the region of interest angle θ. In the process of interest point detection, some points are not regarded as interest points, but these points are actually part of the interest region, and can be regarded as interest points by the method of inner filling. As shown in Figure 2（b）, the interest points of the participants at the current position of pedestrian p are a, b, c, d, e, f, and pedestrian b is the high interest point of the participants, then the distance from the position of pedestrian p to the point of interest b is recorded. is the radius r_1 of the high interest region, the distance from the position of the pedestrian p to the interest point f is recorded as the low interest region radius r_2, and the angle of the interest region is the angle θ between the interest points a and c and the current row p. The unmarked pedestrians in the figure are not points of interest, but the components of the region of interest are clustered and filled as points of interest.



(a) (b)

Fig.2.(a)Division of regions of interest,(b) Regions of interest extraction

3. EXPERIMENT AND ANALYSIS

3.1 Experimental design

This experiment is divided into two parts: the collection of pedestrian motion scene information and the collection of eye movement behavior data. Pedestrian motion scene information collection experiment, using the method of horizontal and top-down simultaneous recording of pedestrian flow video (Figure 3（c），（d）). Horizontal and top-down recordings were taken with a head-mounted camera and a handheld camera, respectively, with a camera frame rate of 30 fps. The experimental site is the hall on the first floor of a teaching building of a university. The shooting time is when students go to and from get out of class. The size of the floor tiles is 600×600mm, which can well realize video recording of pedestrian flow with different densities and estimate the distance between pedestrians. 5 videos were recorded, each 25 seconds long. If the eye tracker is used for too long, the experimenter will experience cognitive fatigue[15]. In

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the eye movement behavior data collection experiment, a total of 30 people participated in the experiment, including 15 females and 15 males, all of whom were college students, and all had normal vision or corrected to normal. The experimental site is a laboratory, and the experimental equipment adopts Tobii Eye Tracker 5. In order to prevent the psychological impact of the participants, make sure that the participants have not watched the video in advance, and do not give the subjects any observation tasks. Participating in the collection of experimental personnel's eye movement behavior data, each video needs to be warmed up for 5 seconds. The eye tracker needs to be recalibrated every time the participants in the experiment are changed. When the interest point of the participating experimenters appeared, the first frame of the interest point and the following 20 consecutive frames were taken, and the attention of the 30 participating experimenters to the appeared interest point in the consecutive 20 frames was calculated. Through the extraction of interest points and the calculation of attention of formula (1), the parameter data of pedestrian interest area is obtained.

(c) (d)

Fig.3.(c) Shoot a frame in the scene horizontally,(d) Look down and shoot a frame in the scene

3.2 Analysis of experimental data

We collected eye movement data of 30 participants and obtained 90000 frames of eye movement behavior data. Through interest point processing and attention calculation, 180 groups of pedestrian interest area parameter data of one-way and two-way pedestrian flow under different densities are obtained. Thus, the relationship between different densities and regions of interest under one-way and two-way pedestrian flow is obtained.

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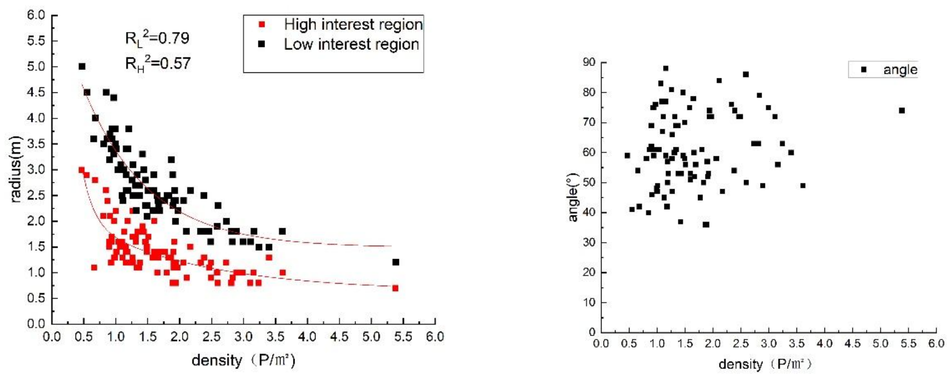
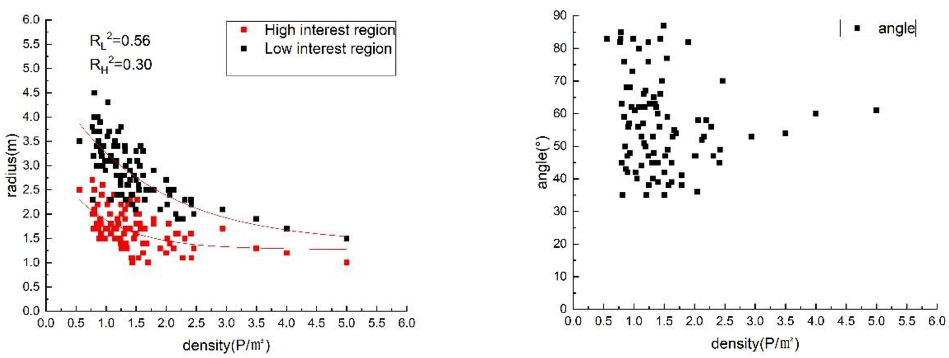


(e) (f)

Fig.4.(e) The relationship between one-way pedestrian flow density and the radius of each region of interest,(f) The relationship between one-way pedestrian flow density and the angle of region of interest



(g) (k)

Fig.5.(g) The relationship between the density of two-way pedestrian flow and the radius of each region of interest,(k) The relationship between two-way pedestrian flow density and the angle of region of interest

In Figure 4, non-linear fitting is conducted for different density of one-way pedestrian flow and radius data of interest region. According to the fitting function, it is found that the radii of regions of high interest and regions of low interest are negatively correlated with pedestrian flow density. The fitting index between different densities and the radius of high interest region under one-way pedestrian flow is relatively general (R^2=0.57), and the fitting index between different densities and the radius of low interest area is relatively good (R^2=0.79). According to the statistical data, the one-way pedestrian flow density is mainly concentrated between 0.47-3.61P/m^2. The angle distribution of the region of interest ranges from 36 ° to 88 °, mainly between 40 ° and 75 °. The radius of high interest region and low interest region of pedestrians are mainly between 0.7-2.2m and 2.0-4.0m respectively.

In Figure 5, non-linear fitting is conducted for different densities of two-way pedestrian flow and radius data of interest region. According to the fitting function, it is found that the radii of regions of high interest and regions of low interest are negatively correlated with pedestrian flow density. The fitting index between different densities and the radius of high interest region under two-way pedestrian flow is poor (R^2=0.30), and the fitting index between different densities and the radius of low interest region is general (R^2=0.56). According to the statistical data, the two-way pedestrian flow density is mainly concentrated between 0.56-2.46P/m^2. The angle distribution of the region of interest ranges from 35 ° to 83 °, mainly between 40 ° and 60 °. The radius of high interest region and low interest region of pedestrians are mainly between 1.0-2.2m and 2.0-4.0m respectively.

4. CONCLUSION

Region of interest extraction With the help of eye tracker, the pedestrian eye movement data of one-way and two-way pedestrian flow under different densities are analyzed. The different divisions of pedestrian interest regions are realized, and the mathematical models of one-way and two-way pedestrian flow and radius and angle of interest regions under different densities are established. The following conclusions are drawn:

(1) The radii of high interest region and low interest region of one-way and two-way pedestrian flow are negatively related to the pedestrian flow density, and when the pedestrian flow density increases to a certain extent, the radius of the high interest region and the low interest region approach to a fixed value respectively. The angle of pedestrian interest region generally does not exceed 90 degrees.

(2) The pedestrian interest region is variable and flexible. Even the pedestrian flow with the same density has different regions of interest.Compared with two-way pedestrian flow, one-way pedestrian flow has a wider range of interest region and is more flexible.

As pedestrian simulation becomes more and more complex, establishing an effective pedestrian interaction range will help to more complex performance of collision avoidance behavior in pedestrian simulation. The influencing factors of pedestrian interest region are various, so it is necessary to further study pedestrian interest region. In the future, we will continue to improve the method of pedestrian interest region extraction to improve the accuracy and robustness of the model.

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