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The Study of Following Behavior to Bi-direction Pedestrian Flow with the Dynamic Preconscious Effect

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***Abstract*—In view of the preconscious behavior of pedestrian and walking speed differences, a lattice gas model of bi-direction pedestrian flow is established in this paper. According to the characteristics of pedestrian following behavior and preconscious dynamic change in different walking conditions, bi-direction pedestrian behavior model based on dynamic preconsciousness is constructed to study the bias decision-making behavior of pedestrian movement. Through numerical simulation, the influence of regional size, asymmetry and speed deviation on the Bi-direction pedestrian flow is analyzed. Results indicate that dynamic preconscious behavior enhances the stability of the system and reduces pedestrian congestion. The passing behavior of the high-speed pedestrian is the main cause for the congestion in the situation of high density. The speed difference will largely influence the anti-congestion ability of the system, so keeping the unity of the speed and group order would maintain the stability and the anti-congestion ability of the system for the whole system.**

Keywords-bi-direction pedestrian; dynamic preconscious effect; following behavior; lattice gas model; probability distribution

I. INTRODUCTION

In recent years, there has been a frequent occurrence of emergencies due to the entire channel system congestion caused by bi-direction pedestrian conflict. This phenomenon has resulted in greater property damage and a threat to the physical safety of pedestrian traffic participants. Thus, the effective control of pedestrian congestion is of extreme importance. As the main component of the walking traffic system, pedestrian individuals can produce strong social force between the characteristics with autonomous behavior, a greater degree of random decision-making, compressed space, and the non-fixed shape. Therefore, pedestrian research is often more difficult than motor vehicle traffic. As a result, it is of great significance to establish a reasonable pedestrian flow model to explore its macro-behavior characteristics and the formation of congestion mechanism, which contributes to enhance the level of basic theory and application on pedestrian traffic in China.

In 1971, Henderson presented a macroscopic model of the pedestrian flow, arguing that pedestrians in free-flowing states had properties that were similar to those of gas molecules. This model can describe the macro characteristics of the traffic flow in detail, but the micro characteristics of the traffic flow cannot be described. Therefore, there is no scientific explanation for self-organizing phenomena in the traffic flow [1]. In 2002, Hughes improved the pedestrian flow model and proposed the dynamic structure of macro pedestrian flow, regarding the pedestrian behavior as a continuous fluid described by two-dimensional spatial density evolution mechanism [2]. Thereafter, Hoogendoorn and Bovy proposed a deterministic pedestrian equilibrium distribution model based on the assumption of complete traffic information [3,4]. Through the previous study, Huang further put forward the condition of the pedestrian equilibrium condition and realized the numerical solution, which verified the model scientifically [5,6]. Based on the ability of the pedestrian to respond to the route and the environmental memory, Xia proposed a hybrid selection strategy to explore the bypass problem of pedestrian [7, 8]. Jiang reflected the congestion characteristics of the traffic flow through the numerical simulation of the high order macro flow model [9]. By using the relationship between rate and time to establish the pedestrian flow behavior model of single row longitudinal channel, Lv et al. carried out the pedestrian movement evaluation and evacuation model of public export channel [10]. Hoogendoorn et al., for example, consider the behavior of path selection before and after the departure, and proposes the pedestrian flow model of multi-level continuous medium [11]. Hänseler et al. established a macro-load model of time-bound traffic in the public travel area, which can describe the isotropic framework of real-time potential conflict propagation of multiple pedestrian groups [12]. Considering the factors of impact of local density and personal space, safe distance, neighbors, direction and other information together, Xiao et al. introduced the Voronoy diagram method into the pedestrian flow heuristic analysis model [13]. Fu et al. carried out a simulation study of the popular epidemic patterns of emotional transmission and found that the spread of panic sentiment with the trampling incident would lead to an increase in the expected speed of pedestrian flow [14].

In retrospect of the pedestrian flow model, most scholars tend to use the uniform system which is a system that does not consider the variability of pedestrian properties. For instance, pedestrian's own characteristics are ignored and the unlimited speed is set to $V_{\max} = 1$, which is mistaken in reality.

In addition, influenced by regional culture, laws and regulations, pedestrian characteristics and customs, pedestrians unconsciously develop certain preconscious behaviors in the course of their progress. For example, in the country or region whose provisions of the road transport vehicles on the right, such as mainland China or the United States, pedestrians with many years of experience, unconsciously show some behaviors. They unconsciously walk along the right side of the road while exceed from the left, as well as avoiding the opposite pedestrian flow on the right. Meanwhile, preconscious awareness can lead pedestrians to make independent judgments about the surrounding traffic and even make decision predictions ahead of time. As a result, compared with the conventional uniform system, in the pedestrian flow modeling, if the pedestrian's previous consciousness caused by the movement trajectory and the rate of different can be shown more, the reality of pedestrian flow situation can be more truly reflected.

Preconsciousness, the intermediate link between the subconsciousness and consciousness, is the awareness that people can predict the occurrence and consequences of others or their own affairs in advance. Unlike the subconscious instincts, the preconsciousness reflects more of the behavioral patterns of pedestrians making quick decisions and judgments about the form of traffic. Also, this behavior pattern may be dynamically adjusted depending on the form of change. This behavior pattern not only stems from unconscious thinking and years of experience, but also reflects the pedestrian's independent judgement on the surrounding traffic environment, even the psychological characteristics of early decision making. And this is an indispensable part of the action decision. Factors that affect the preconscious behavior of pedestrians include regional culture, rule of law, pedestrian characteristics and customs. In the modeling of pedestrian flow, If the difference between movement trail and speed caused by pedestrian's preconsciousness is more shown, the authentic pedestrian flow would be more reflected.

Aiming to simplify the analysis, we do not consider the factors that affect the speed of the pedestrian, and simply put forward the hypothesis that the pedestrian is classified as high-speed and low speed. In another words, only two types of pedestrian speed are set. To avoid the collision and interference with the opposite traffic flow, pedestrians tend to develop the habit of walking on one side of the road, which is also related to the country's traffic rules. For instance, people in mainland China generally show a right-walking habit, while the British or Japanese do the opposite [15,16]. Based on these considerations, this paper mainly studies the preconsciousness of right-side walking. At the same time, pedestrians feel a strong sense of security due to going along the right side of the road. Their nerves relax and they lower the speed unconsciously. Hence, under the reality circumstances, low-speed pedestrians tend to move along the right side of the road, which also reflects the differences in the specific performance of pedestrians. High-speed pedestrian due to preconsciousness will tend to exceed the low-speed pedestrian of the same direction from the left side. In the process of opposite pedestrian interweave, pedestrians tend to move on the right side to avoid collision and conflict. In general, pedestrians have preconscious behaviors that tend to walk on the right side, exceed from the left, and avoid to the right side. While in practical pedestrian traffic, pedestrians tend to walk safely and comfortably, following the same pedestrian movement in order to reduce unnecessary conflict. In the process of movement, according to their surrounding environment and the surrounding circumstances, pedestrians decide whether to accelerate, slow down, follow or change their movements. Different local environments cause pedestrians to follow behavior in different enclosed spaces. And the magnitude of waiting probability is changing. For example, when a pedestrian finds that there is a walker in front of him moving at the same speed, he will be more inclined to trail after. In this case, the intensity of the behavior in the enclosed space, which is the waiting probability, is relatively large. However, the current pedestrian will have the preconscious behavior to exceed the person from the left direction who is walking at a low speed in front of him. At this time, the waiting probability is relatively slight. As a result, under different circumstances, studying the changes of pedestrian following intensity will contribute to further depict the micro-motion of a pedestrian. The characteristics of macroscopic behavior of traffic flow and the formation of complex phenomena would be thoroughly understood.

II. MODELING CONSTRUCTION AND ANALYSIS OF OPPOSITE PEDESTRIAN'S TRAILING BEHAVIOR BASED ON DYNAMIC PRECONSCIOUSNESS

A. Modeling Analysis of Pedestrian's Trailing Behavior in Enclosed Space Based on Preconscious Behavior

As shown in Fig.1, pedestrian's modeling in enclosed space is established in a two-dimensional system bounded above and below. The length of the system is L and the width is W. the pedestrians are prohibited to cross. There are four types of pedestrians defined in the system: high-speed pedestrians to the right (right triangle), low-speed pedestrians to the left (circle), high-speed pedestrians to the left (left triangle) and low-speed pedestrian to the left (cross). The pedestrian can only occupy one frame and cannot move backward.

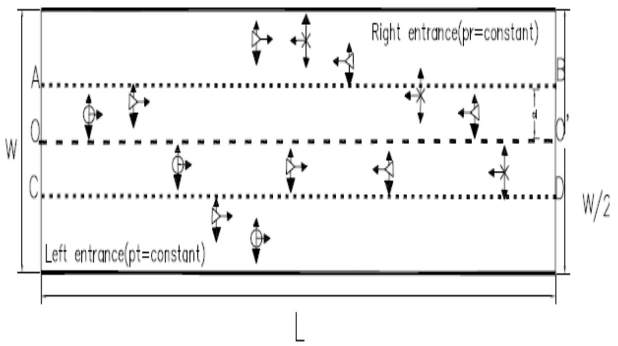

Figure 1. The multi-type pedestrian system in the enclosed space

The arrows indicate the direction that pedestrians can choose, and the bold arrow indicates the direction of motion that makes the person prone to preconsciousness. In another words, different types of pedestrians in the process will be subconsciously move to the area that they feel safe and comfortable. For example, when high-speed and low-speed pedestrians to the right are located in the upper parts of the middle line OO', they all have the right side preconsciousness in the movement. That is to say that they tend to move towards the lower part of the middle line OO' and the low-speed pedestrian to the right are more likely to walk in the lower area of the cutting line CD.

Therefore, based on real circumstances, the stable speed of high-speed (the average speed of free flow which is regarded as the maximum speed) pedestrian's movement is about 1.6 m/s, the stable speed of low-speed pedestrian is about 0.8 m/s. Then the actual time for each step in the simulation is about 0.5s.

Given the respective special space state in preconsciousness following behavior of high-speed and low-speed pedestrians, it is necessary to set a low-speed and high-speed to right direction in the space that the pedestrian may encounter during the course of the movement. As shown in Fig.2 and Fig.3, the blocking states that pedestrians may encounter from front, left and right direction are presented. The solid circles refer to the pedestrians to the right direction. Bold arrows indicate the possible direction of motion. The crossing shapes are on behalf of the position occupied by other pedestrians, and the corresponding movement directions are indicated by the thin arrows. In the system, pedestrians can only choose to follow the arrows or wait.

The four probabilities shown in the Fig.2 and Fig.3 are explained as follows: Pt,x refers to the probability of moving to the right direction, Pt,y stands for the probability of moving up (moving to the right direction), Pt,-y means the probabilities of going down (moving to the right direction), Pw represents the probability of waiting. After thinking about the preconsciousness of pedestrians, based on the classic lattice gas model, some theoretical formulas have been improved. Except that the original reference D indicating the bias intensity of heading direction, reference B is newly added to identify the bias angle of preconscious direction.

To truly reflect the complex behavior of pedestrians, the different sets of probabilities of moving to right direction should meet the following rules.

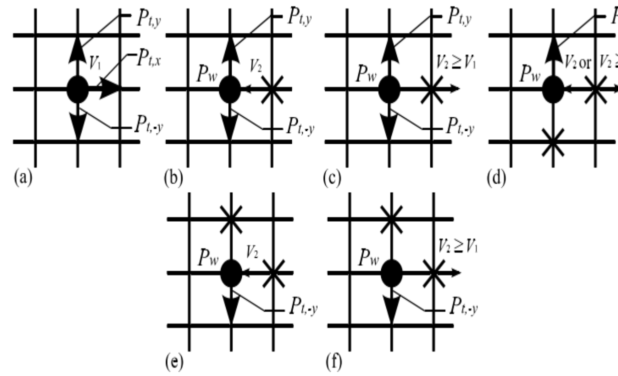

Figure 2. The space state and walking probability distribution of the right-direction pedestrians with low speed

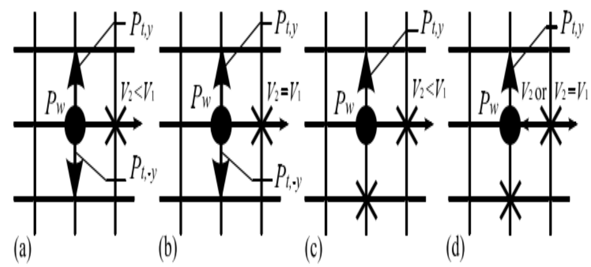

Figure 3. The space state and walking probability distribution of the right-direction pedestrians with high speed

As a low-speed pedestrian moving toward right direction, if the front lattice point is not occupied, generally low-speed pedestrians do not choose to wait. However, there exists some probabilities of moving toward left or right direction, which are related to bias intensity of moving forward and preconscious direction (left or right side). If the front lattice point is occupied by right pedestrian in the same direction while the right lattice point is not occupied, no matter how fast if the pedestrian, the waiting probability of the pedestrian is higer. Because of under this circumstance, pedestrians are more willing to keep their direction of motion and follow the pedestrians of the same direction. If the front lattice point is occupied by the pedestrians of the opposite direction, then the probability pt,-y of moving to the right direction is high. The reason is that pedestrians have a preconscious bias habit towards avoiding collisions to the right direction. if the right and front lattice grid are both occupied by other pedestrians, then the waiting probability Pw of this pedestrian is high. It is because that when the left-side pedestrian is ahead, the low-speed right-side pedestrians following the right-side traffic rules and preconsciousness are inclined to keep stationary, expecting to avoid collision with the left-side pedestrian moving toward right direction. As shown in Fig.2(d), when the right-side pedestrian is ahead, the following behavior in enclosed space will be more likely to occur.

As a high-speed pedestrian moving toward right direction, if the front lattice point is not occupied, then the behavior is the same as the low-speed pedestrian moving toward right direction, shown in Fig. 3(a). If the front lattice point is occupied by the low-speed pedestrian in the same direction, then the probability Pt,y of moving toward left direction is low. The reason is that pedestrians develop a preconscious habits exceeding from the left side, which is shown in Fig. 3(a) and (c). If the front lattice point is occupied by the high-speed right-side or opposite-side pedestrians, then the probability Pw is high. This is the result of following effect and right-side bias preconsciousness, which is shown in Fig. 3(b) and (d).

To show the speed difference between the different types of pedestrians, the sports rules of FI cellular automation model is introduced. If pedestrians meet the requirements of walking probability Pt,x, then in unit time (time step taken as the unit), these pedestrians can move forward x(n) lattice points. The value of x(n) is the small value of the nth pedestrian's maximum speed and the number of spaces. Because of human nature's great flexibility and adaptability, the individual can realize short time acceleration. Stable velocity can be achieved without obstacles ahead. Therefore, it is reasonable to choose the sports rules of FI model.

Based on these analyses, in view of these two different pedestrian space conditions, the space state distribution of low-speed pedestrians is as follows:

$$P_L=\left[p_{t,x},p_{t,y},p_{t,-y},p_w\right]=\begin{bmatrix} D+\frac{1-B}{3} & \frac{(1-B)(1-D)}{3} & \frac{(1+B)(1-D)}{3} & 0 \\ 0 & \frac{(1+B)(1-D)}{3} & D+\frac{1-D}{3} & \frac{(1-B)(1-D)}{3} \\ 0 & \frac{(1-B)(1-D)}{3} & \frac{(1+B)(1-D)}{3} & D+\frac{1-D}{3} \\ 0 & \frac{(1+B)(1-D)}{2} & 0 & D+\frac{(1-B)(1-D)}{2} \\ 0 & 0 & D+\frac{(1-B)(1-D)}{2} & \frac{(1+B)(1-D)}{2} \\ 0 & 0 & \frac{(1-B)(1-D)}{2} & D+\frac{(1-B)(1-D)}{2} \end{bmatrix} \quad (1)$$

The space state distribution of high-speed pedestrians:

$$P_L=\left[p_{t,x},p_{t,y},p_{t,-y},p_w\right]=\begin{bmatrix} 0 & D+\frac{1-D}{3} & \frac{(1-B)(1-D)}{3} & \frac{(1+B)(1-D)}{3} \\ 0 & \frac{(1+B)(1-D)}{3} & \frac{(1-B)(1-D)}{3} & D+\frac{1-D}{3} \\ 0 & D+\frac{(1+B)(1-D)}{2} & 0 & \frac{(1-B)(1-D)}{2} \\ 0 & \frac{(1-B)(1-D)}{2} & 0 & D+\frac{(1+B)(1-D)}{2} \end{bmatrix} \quad (2)$$

Similarly, we can see that the preconscious behavior of pedestrian characteristics to the left and right direction is exactly the same.

B. Dynamic Preconscious Intensity and Behavior Modification Based on Early Warning Perceived Distance

Preconscious intensity discussed in the previous section is set to a static parameter. In the reality, however, pedestrians are able to adjust the direction of the trend according to the position and characteristics of their environment when walking. As a result, there is certain dynamism in the bias preconscious intensity of pedestrian. This dynamic characteristic is reflected in the condition that a pedestrian is constantly correcting his or her distance from the pedestrian or obstacle in front of him to choose the opportunity to avoid or exceed. At the moment, the bias preconscious intensity increases with the distance of the person ahead. The probability of a pedestrian being able to exceed or avoid in the same direction in advance is also increasing. As a result, without considering the specific factors of pedestrian perception, the forward traveler early warning perceived distance parameter and self-admissible distance is added in the paper. Then the parameter B can be approximated as:

$$B=B_0(1+\frac{D_2-D_1}{D_2}) \quad (3)$$

Formula (3) stands for initial preconscious intensity. That means pedestrians feel comfortable and safe before seeing pedestrians ahead. With pedestrians ahead entering the awareness range, people will feel sense of urgency and the bias preconscious intensity will be increased to boost the deviation probability. The parameters change depending on the person's personality. Generally speaking, the distance that casual and careless people can mentally endure is always big. While for those who are sensitive, the distance will be smaller. In addition, due to the limitation of increased consciousness intensity, a threshold value can be set for intensity. When the conscious intensity of pedestrians has achieved to the maximum value, it will not grow as the pedestrian approaches. When a pedestrian perceives that someone in front of him will enter his or her perceived warning distance, the distance between them actually has to do with the difference value of velocity vector. When the two walk oppositely to each other, the reduction rate of D1 is the sum of the two's speed. However, when the speed of the pedestrian in the front is smaller, the reduction rate of one is the difference in the quantity of the two. In conclusion, after introducing the warning timing variable (The step is calculated from the forward warning distance), the formula (3) can be rewritten as:

$$B=\min\left[B_{\max},B_0(1+\frac{(V_i-V_{i+1})\Delta t}{D_2})\right] \quad (4)$$

After introducing the dynamic preconsciousness, for the people who enter the self-admissible distance in the same or opposite direction, pedestrians may respond with preconsciousnesss in advance. In another words, pedestrians may take the bias or waiting action in advance before achieving the people ahead (the front lattice point has not been occupied by other pedestrians). Therefore, the range of lattice points occupied by pedestrians ahead can be extended from one lattice point to all lattice points within perceived warning distance, which can be calculated by formula (1) and (2).

III. NUMERICAL SIMULATION AND ANALYSIS

In view of enclosed space condition, numerical simulation and analysis of the model are carried out in this paper. At the beginning of system operation, four types of pedestrians are randomly distributed within the system. The values are generated by random sequences and compared with direction converted probability to implement the location update for the pedestrian. Meanwhile, the system is set as a periodic boundary. When the pedestrian to the right direction reaches the right boundary and disappears, from the left side the regenerated individual enters the system. And for the pedestrians to the left direction, the same method is set [14]. As a result, in every time step, the number of people in the system is always kept constantly.

Parameter m and h are introduced in this paper to represent the ratio of pedestrian to the left and high-speed pedestrian respectively. The non-equilibrium characteristics of system pedestrian behavior are shown.

On this basis, the total density of the important representational parameters, average speed and average flow rate of the simulation result is set in this paper. The total density is the ratio of total pedestrian number and system area size ($W \times L$). The average speed is defined as the ratio of moving speed and the total pedestrian number in a single time step. The average flow is the number of pedestrians passing through the destination boundary (ie, right-hand pedestrians through the right border, or left-hand pedestrians through the left border). According to the measurement needs, this paper takes the mean flow from the right flow and the leftward flow as the average flow. To sum up, the parameters are expressed as (5) - (7).

$$p = \frac{N}{W \times L} \tag{5}$$

$$\overline{V} = \frac{1}{TN} \sum_{t=t_0}^{T+t_0-1} \sum_{i=1}^{N} v_i \tag{6}$$

$$\overline{V} = \frac{1}{TN} \sum_{t=t_0}^{T+t_0-1} \sum_{i=1}^{N} v_i \tag{7}$$

The numerical simulations would use an average of 20 samples to reduce the effect of initial random distribution effect. Every random sample runs 10,000 time steps. The average speed and the average flow are to take the last 8000 steps to calculate the results.

The relationship curve between average speed and average flow and pedestrian density in different area sizes is shown in Fig.4. In Fig.4 (a) (c), the size of W is changed successively. In Fig.4 (b) (d), the size of L is changed in turn.

As shown in Fig.4 (a) (c), when the pedestrian density is less than critical density, as W grows, the average velocity decreases, but the flow is increasing. The reason is that in the same density, the increase of W enlarges the area of space, so the number of pedestrians will increase, resulting in increased interference between pedestrians. Pedestrians get more resistance and can't move smoothly, so the average speed drops. Meanwhile, as shown in Fig.4 (a), when W is over 40, the system's congestion density is approximately 0.74. It indicates that when L is the same and W is larger, congestion density is no longer affected by region size. Besides, as shown in Fig.4 (a) a system space with a square (width of 100), the transition of the pedestrian flow is more gradual than the other types. In addition, comparing all the lines, we can know that the closer the W is to the L, the transition process of traffic congestion will be slow.

From Fig.4 (b) (d), when the pedestrian density is less than critical density, for different L, the average velocity is the same as the average flow rate, and the variation trend is consistent. However, when pedestrian density exceeds critical density, average velocity and average flow rate decrease rapidly with density. Then the trend slowed until it was completely congested. The increase of L will accelerate the transition from free flow to congestion. In addition, when L exceeds 150, the system's congestion density is approximately 0.72 constantly, which indicates that in the same area, the congestion density is not affected by region size when L is large. In conclusion, in the same regional condition, increasing the ratio of the width of the system to the length of the system will improve the system's ability to resist congestion.

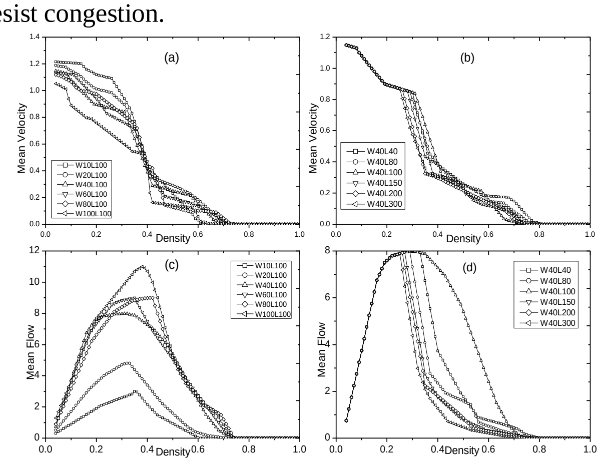

Figure 4. The flow diagram of average speed and flow as density changes with different size of area

Fig.5 shows a diagram of the relationship between the average velocity and average flow over density when m is different. As shown in Fig.5, the congestion density gradually decreases as the m changes from 0 to 0.5. When m = 0.5, the congestion density is minimal.

This is because the pedestrian crowd can segregate from the organization when there is a larger difference in the direction, which can avoid confrontation between pedestrians leading to the decreases between pedestrian’s interactions. Then the flow efficiency of the whole system has been improved. Therefore, the non-equilibrium in the number of pedestrians can enhance the stability of two-way pedestrian flow and improve the system's anti-congestion ability. When the difference between the numbers of pedestrians is small, the system is more prone to congestion. Consequently, the proportion of left and right pedestrians can be controlled rationally according to the crowding level of the pedestrian to optimize pedestrian traffic.

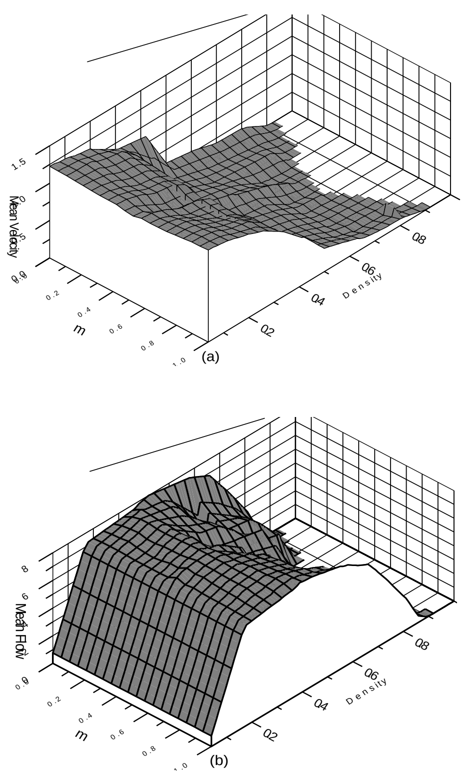

Figure 5. The flow diagram of average speed and flow as density changes with different setting of m

Fig.6 shows a diagram of the relationship between the average velocity and average flow over density when h is different. As shown in Fig.6, in the free flow condition, as h increases, the average speed and flow rate increases. But when h = 0, the density of congestion is greater than when h > 0. In this condition, pedestrians keep moving at a low speed. When the pedestrian density is low, the pedestrian will have greater movement space. The speed of them is little lower than the pedestrians ahead in the same direction. Then they can keep a large distance. The preconscious intensity is low and the change is stable. So there are few acts of exceed, bias or stopping. And moving at the maximum speed is adopted. At this point, the average speed and flow rate increases as the number of pedestrian increases unceasingly. As pedestrian density increases, the interaction between pedestrians increases. In addition, as the number of high-speed pedestrians increased, the probability of the difference between pedestrians front and back increased. The intensity of the preconsciousness also fluctuates significantly. As a result, high-speed pedestrians are more inclined to show the preconscious acts of exceeding (or exceeding in advance). And they may enter the moving area of pedestrians in the opposite direction.

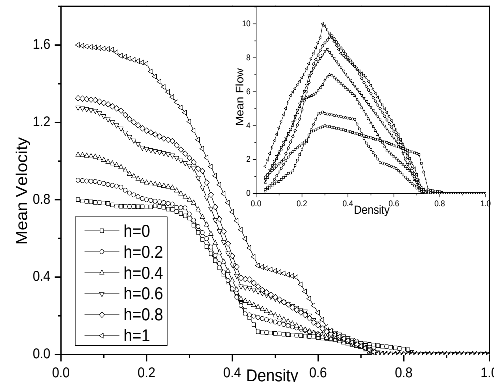

Figure 6. The flow diagram of average speed and flow as density changes with different setting of h

Meanwhile, as the number of high-speed pedestrians increases, it is easier to increase the intensity of the preconscious intensity of the pedestrian in the opposite direction. Then the increase in probability of taking early avoidance behavior (or waiting in advance) leads to a mutually obstructive situation between the pedestrians from the opposite direction. The collision between the pedestrians also intensifies, inducing small congestion and eventually blocking. Based on the above analysis, we believe that behavior of high-speed pedestrians' exceeding preconsciousness in the opposite direction is the major cause of pedestrian congestion. Preconsicousness behavior of avoiding in advance induced by it can aggregate congestion of pedestrian flow.

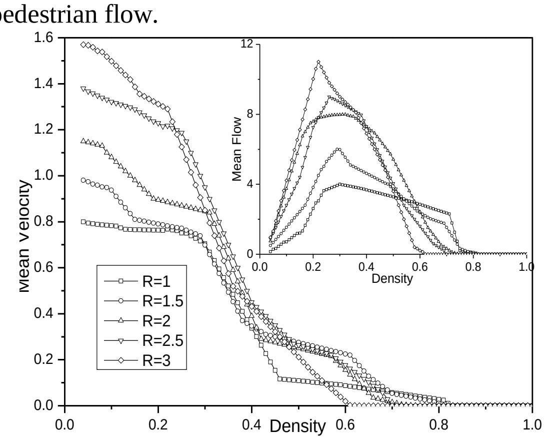

Figure 7. The flow diagram of average speed and flow as density changes with different setting of R

Without changing the ratio of high-speed and low-speed pedestrians, speed ratio parameter R is introduced into this paper. As shown in Fig.7, by adjusting the value of R, average velocity and average flow rate varying rule with density in the condition of different velocity can be further explored. From the Fig.7, we can see that as the ratio of pedestrian rates increases, the density of the congestion decreases, which indicates that the system's ability to resist congestion has gradually declined. At the same time, average speed and flow are also increasing. When R is smaller, the pedestrians are in the condition of free flow. There will be large space between the low-speed pedestrians. The intensity of the pre-consciousness will not fluctuate significantly. Therefore, there is less interaction between the pedestrians. They go their own way and the system is more resistant to congestion. When R is at a high level, the speed gap between pedestrians will increase. The bias preconsciousness of the pedestrian changes faster, whether the pedestrians are in the same or opposite direction. So they are more likely to show the acts of biased or waiting in advance based on awareness. In this case, the conflict between pedestrian and interference behavior occurrence probability is increasing and the system will gradually appear local congestion, until the entirety completely blocked. It is seen that velocity difference between pedestrians will largely affect the ability of resisting congestion. And there is contradiction between the two factors. Keeping the pedestrian speed unity and group order will maintain the stable and anti-congestion ability of the whole traffic system.

IV. CONCLUSIONS

Based on the lattice gas behavior model, we consider the direction probability value in different preconsciousness situation. Multi-speed pedestrians flow lattice gas model in opposite direction varying with intensity has been established. In the simulation part, we study the effects of system size, asymmetry, velocity difference and preconscious behavior intensity on the one-directional and bidirectional pedestrian flow. And the mechanism of the macroscopic phenomena of the pedestrian flow induced by following effects has been discussed. The following conclusions have been obtained.

Preconscious behavior is one of the main reasons for the overall well-organized traffic flow and the resulting self-organizing behavior. Pedestrian lattice gas model of dynamic preconsciousness based on warning distance can show some essential features or phenomena of bidirectional pedestrian flow and following behaviors, such as self-shunt, exceeding and avoiding in advance, waiting and so on. When the system width and length are large, congestion density will no longer change with system size. The ratio of width to length has some effect on the system's ability to resist congestion. The non-symmetry of the number of left and right pedestrians increase the stability of the system and can reduce congestion by self-shunt. Under the high density, exceeding behavior of high-speed pedestrian is the main reason of inducing the congestion of pedestrian flow. The preconscious behavior of bi-direction avoidance in advance will aggregate pedestrian flow congestion.

In conclusion, some research results of this article can provide useful reference for the rational design of buildings and the congestion control of pedestrians. For example, an obvious export symbol (such as “emergency exit” “safety exit ”) or the arrows indicating the direction of escape may be established within the building to avoid blindly following the pedestrian evacuation, thus improving the efficiency of evacuation. Taking advantage of research results of the asymmetrical effect, the ratio of left and right pedestrian number can be controlled properly by the congestion of opposite pedestrians to optimize pedestrian traffic.

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