Simulation Model Of Stampede Accident Based On Multi-Agent And Game Theory

Yang Sui
School of Information, Yunnan Normal University
E-mail:664679220@qq.com

Wang Baoyun
School of Information, Yunnan Normal University,
E-mail:wspbmly@163.com
(#corresponding author)

Li Linna
School of Information, Yunnan Normal University
E-mail:2938591360@qq.com

ABSTRACT

Crowd stampede accident, as one of the main man-made accidents in large public gathering places, has become a problem that science must face today. In order to explore the formation mechanism of crowd stampede in public places, this paper establishes a theoretical model of crowd evacuation based on multi-agent technology. This paper adopts a combination of theory-modeling-simulation method, with the Bandatia Bridge in India as the background, analyzes the changes in various stages of large-scale crowded stampede accidents from the walking path of the crowd, rationality and irrationality. The experimental results show that the model can simulate the behavior change of the crowd during evacuation, and provide theoretical and technical support for the study of the formation mechanism of crowd stampede.

CCS CONCEPTS

• **Computing methodologies** → Modeling and simulation; Model development and analysis; Uncertainty quantification.

KEYWORDS

Crowd stampede,Formation mechanism,Game theory,Theoretical analysis,Simulation

ACM Reference Format:
Yang Sui, Wang Baoyun, and Li Linna. 2021. Simulation Model Of Stampede Accident Based On Multi-Agent And Game Theory. In *2021 2nd Asia Service Sciences and Software Engineering Conference (ASSE '21), February 24–26, 2021, Macau, Macao.* ACM, New York, NY, USA, 10 pages. https://doi.org/10.1145/3456126.3456136

1 INTRODUCTION

With the improvement of social, economic and cultural level, the urban population expands rapidly, and more people gather in public activities. Once the hidden danger is triggered and malignant evolution, the stampede accident may occur, resulting in the loss of personnel and property and serious social impact. By studying the formation mechanism and evolution process of crowd stampede accidents, it is helpful to promote people to understand the law of crowd stampede accidents and to prevent and avoid crowd stampede accident in time. Combining relevant cases, existing literature, psychology, management and other theoretical knowledge, it is a hot topic in the field of safety to explore the formation mechanism and trigger factors of crowd stampede accidents.

Ren Changxing [1] through the analysis of stampede accidents in recent years, it is believed that the emphasis of accident prevention and control is to establish accident emergency mechanism. Zhang Lijuan [2] constructs intelligent decision model based on cellular automata, and the effectiveness of the model is verified by simulation of the evacuation process of large supermarkets. Bai Rui [3] according to the statistics of stampede accidents, the frequency of stampede accidents and the number of casualties were randomly distributed. Zhang Pengzhu [4] builds cooperative willingness degree model under the infinite cooperative game type is established to study the influence of the cooperative willingness degree and the average return rate of flexible thinking and rigid thinking under the emergency and cooperative environment. Tong Ruipeng [5] established a risk assessment model based on the probability and loss degree of stampede accident. Xu Hao [6] considered herd behavior in group emergencies and established an evolutionary game model for non-direct stakeholders participate in group emergencies. Chen Shi [7] constructed the pseudo-birth and death process to model the evolutionary game problem, and used the RG-decomposition method to calculate the limit probability distribution, and finally obtained the stable strategy of the evolutionary game. In general,the multi-agent-based model is still in the period of exploration and integration in the processing of information and decision-making.

Firstly, this paper analyzes the crowd stampede accident in the past years, distinguishes the strong crowd from the weak crowd, then introduces the A* algorithm to find the way for the agent, and finally combines with the game theory in crowd psychology.A crowd stampede simulation model based on multi-agent and game theory is constructed.The applicability of the model is verified by practical stampede case simulation, which provides a reference for studying the risk of stampede accidents.

2 SIMULATION MODEL THEORY OF CROWDED TRAMPLING ACCIDENTS

2.1 Trampling accident analysis

According to the statistics of crowd stampede accidents over the years, the main categories of crowded stampede accidents are: religious places,sports places,schools,entertainment places,transportation,other public gathering places [8].Most public places have complex functions, numerous activities and are prone

ASSE '21, February 24–26, 2021, Macau, Macao

ACM ISBN 978-1-4503-8908-2/21/02...$15.00
https://doi.org/10.1145/3456126.3456136

to crowd gathering, while their composition is complex,including youth,women,the elderly and children [9].Young people are relatively strong and belong to strong groups. The elderly, women, and children are vulnerable groups because of some physical weaknesses, such as slow movement and weak anti-squeeze ability, which can easily become the source of crowded stampede accidents.

The occurrence of crowd stampede accidents usually shows some commonness.This paper summarizes the frequent phenomena and can obtain the stage theory of the accident: the crowd stampede accident will present different phenomena in different time stages.In the early stage of crowd formation, the crowd is moving freely and the individuals do not interfere with each other.When the population density increases and approaches three,the moving speed of the crowd will decrease as a whole, and the flow of the whole space will show a slow flow state [10].When the speed of the crowd approaches zero,the crowd will stagnate.If the crowd appears panic, there is a strong interaction between the individual and the individual, and the crowd shows a state of crowding and confusion.Some people, such as vulnerable individuals,are suddenly subjected to the force of the strong crowd, and the vulnerable people fall down, and the stampede will occur in the crowd. On the contrary,if the crowd queue or more regular exit movement, the crowd will not stampede.In general, the crowd stampede process is divided into four stages: free movement stage, movement stagnation stage, crowd crowded stage, crowd stampede stage [11].During the stampede period,when the crowd density reached the limit, people would be trampled to death. The evacuation phase will be linear layout, indicating that people leave the exit in an orderly manner.

2.2 Multi-agent theory

2.2.1 Introduction to agent. Agent refers to a computing entity that can continuously and autonomously play its role in a certain environment and has the characteristics of autonomy, interactivity, reactivity and initiative.Multi-agent contains two or more agents, which interact with each other.A single agent has some limitations on dealing with problems.Therefore, in order to solve some complex problems, several agents are combined according to human sociality to form a system with certain structure [12].

2.2.2 Intelligent pathfinder algorithm. Based on A* algorithm, the algorithm is implemented in static grid. Each agent is constantly searching and moving the path to its destination [13].Only one agent is searching for a path at any time in the system. At the same time, All agents other than the path-finding agent themselves are regarded as obstacles.

A* algorithm is a method to solve the shortest path in static road network. Establishment of valuation function F (n):

$F(n)=G(n)+H(n)$

where F(n) is the estimated cost of n from the starting state through the intermediate state to the target state. G(n) is the actual cost of n from the starting state to the intermediate state in the state space.H(n) is the estimated cost of the optimal path from the intermediate state to the target state. In this paper, Manhattan distance is selected as the cost estimation of the valuation function.The algorithm sets the starting point and ending point as P_{start} and P_{end} respectively, and the current position of the agent is P_{curr}. Then the actual cost G(n) and estimated cost H(n) in the evaluation function are:

$G(n)=||P_{start}-P_{curr}||_2$

$H(n)=||P_{curr}-P_{end}||_1$

Where $||.||_1$ and $||.||_2$ represent 1-norm and 2-norm, respectively.

According to this function, the cost of each node can be calculated. Through this heuristic function, each point that can be reached in the next step is evaluated.Each search finds the point with the minimum value, and then continues to search.Table OPEN holds all the nodes that have been generated but not examined, and table CLOSE records the nodes that have been visited.

The most time consuming part of the A* algorithm is to find the node with the smallest F value in the OPEN table. its search speed is largely affected by the storage method of nodes in the OPEN table and also depends on the size of the search map.Therefore, this article uses the binary heap to store the nodes in the OPEN table.The experiment is to find the node with the smallest F value in the OPEN table, so the smallest heap method is used to store the nodes in the OPEN table.With only a few comparisons, we can insert the new node into the right position.After several comparisons,the nodes in the binary heap are removed.The binary heap is in order after the node is removed.

2.3 Trampling theory based on rational and irrational crowd game

The individual's psychology and behavior during the crowded stampede process will have a significant impact on the result of stampede. In the event of an emergency, people often produce panic,tension, conformity and other psychology,and these psychologies will lead to the change of human behavior from rational to irrational, or from irrational to rational.Rational people usually choose to line up, and irrational people usually choose to push others. In some unconventional cases, other behaviors will occur, which affects the cognition and decision-making of pedestrians in the crowded process.

2.3.1 Game of crowd crowding and trampling. This paper analyzes the psychology and behavior of crowd evacuation,and obtains that crowd density,panic psychology and pessimistic optimism determine the rational and irrational degree of people and the strong of people themselves to express the strong and weak of individuals.On the whole, the game in the crowded stampede process is determined by two major factors: human rationality and irrationality, human strong and weak.

Here we set the game rule as 2×2,the relationship is shown in Table 1.When two people choose at the same time, Different choices have different benefits.If both choose to line up, a1 is your income,a2 is the benefit of others.If both choose to push, d1 is your income,d2 is the benefit of others. If you choose to line up, Others choose to push, b1 is your income. b2 is the benefit of others.If you choose to push, Others choose to line up, c1 is your income,c2 is the benefit of others.

- Both sides are rational people's games. Individual is rational person, individual tendency adopts "Queue" strategy. For yourself, the benefits are a1>c1,b1>d1.For individuals under the same conditions can obtain higher game income, there

Table 1: Correlation Matrix of Game Model 2×2

		Others	
		Queue	Push
Yourself	Queue	a1,a2	b1,b2
	Push P	c1,c2	d1,d2

are two situations: when others choose to queue, your current income a1>c1, the advantage strategy is "Queue" strategy,"Push" strategy is inferior strategy.When others choose to push,your own profit b1>d1,the advantage strategy is "Queue" strategy,"Push" strategy is inferior strategy.

- Both sides are irrational people's games.Individual is irrational person, and the individual tends to adopt the strategy of push.For yourself, the benefits are c1>a1,d1>b1.For individuals under the same conditions can obtain higher game income, there are two cases: when others choose to queue,your current income c1>a1, the advantage strategy is "Push","Queue" is a disadvantage strategy.At present, when others choose to push, your own profit b1>d1, the advantage strategy is "Queue" and "Push" is inferior strategy.
- A game in which you are rational and another is irrational. For individuals under the same conditions can obtain higher game income, there are two situations: when others choose to queue,your current income are a1>c1, the advantage strategy is "Queue "," Push" is a disadvantage strategy. When others choose to push, your own profit is b1>d1, the advantage strategy is "Queue" and "Push" is inferior strategy.
- A game in which you are irrational and another is rational. For individuals under the same conditions can obtain higher game income, there are two cases: when others choose to queue,your current income c1>a1,the advantage strategy is "Push","Queue" is a disadvantage strategy. When others choose to push,your own profit b1>d1,the advantage strategy is "Queue" strategy and "Push" is inferior strategy.

2.3.2 Improved rational and irrational game. In the process of actual evacuation, the degree of rationality and irrationality is not only determined by human factors, but also affected by external environment. Therefore, the crowd density is regarded as the external disturbance factor, and the emotion produced by the person itself is regarded as the decisive factor. Crowd density $\rho(0\leq \rho \leq 1)$ is used to describe the crowd congestion around individuals in the current situation. Since ρ can determine the degree of panic, it is considered that ρ can indirectly determine the rationality and irrationality of human beings. When the ρ is higher than a certain value $\alpha(0 \leq \alpha \leq 1)$, people will change their emotions because of the emotional action of the surrounding people, in which the optimistic individual is regarded as the rational person and the pessimistic individual as the irrational person.

The degree of pessimism and optimism is expressed by a value $\delta(0 \leq \delta \leq 1)$,and when δ is lower than a certain value $\delta_{\text{lim}}(0 \leq \delta_{\text{lim}} \leq 1)$, the individual tends to be irrational (is closer to 0, the higher the degree of individual irrationality). Considering that irrational people in real life will be significantly less than rational people, that is, most people will choose "queue" strategy during evacuation, and only a few will choose "push" strategy. Therefore, all optimistic individuals tend to be rational, while pessimistic individuals tend to be irrational when crowd density is higher than a certain value α.

2.3.3 Consider whether individuals are weak, strong, rational and irrational game. In the process of crowd evacuation, considering that everyone's ability to escape is inconsistent, the strong and weak of human beings are regarded as a setting of human action.However, many factors of people themselves will determine the strong and weak of people.This paper only uses the most intuitive factor, that is, the weight of people to express the strong and weak of people. In the game between individuals and groups, individuals can directly choose their own weight to express strong or weak. This article adopts a more direct method, using the average weight of the surrounding population to indicate the strength and weakness of the group.

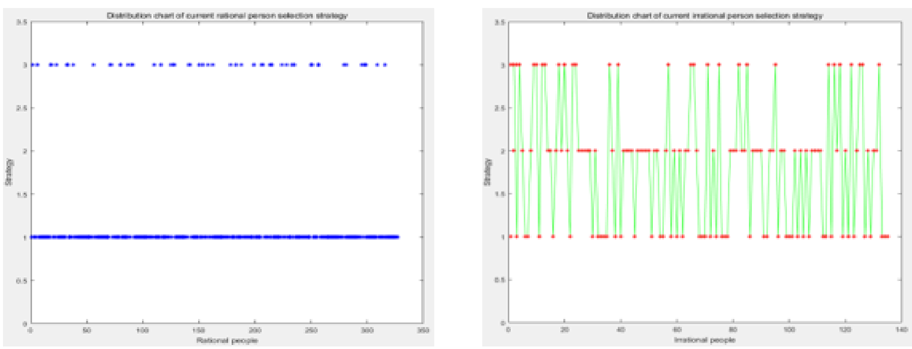
In the game, if other factors are not taken into account, no matter which strategy the weak people choose, the strong people will always get the best profit when choosing the "Push" strategy.Because of their own advantages is the "Push" strategy. But in real life, rational people, whether strong or not, tend to choose the "Queue" strategy. Therefore, this paper takes human rationality and irrationality as the first condition to determine the strategy, and strong weakness as the secondary condition to analyze the income of individuals and groups in the game. Add strong and weak conditions to human rationality and irrationality, and the game strategy maintains the original two types: Queue strategy and Push strategy. In the final game, there are 12 types of game situations, and the income matrix of the game is shown in Appendix 5.1 to 5.12.

2.3.4 Verification of population evacuation based on rational and irrational game. At 500, The rational and irrational numbers of people under different rational coefficients and different strategies are shown in Table 2. First listed in the table are rational coefficients, Used to determine the number of rational and irrational people in the initial state. The second and third columns represent the number of rational and irrational people produced under the current rational coefficient, On average, at 500, The rational number is 364, The number of irrational people is 136. The fourth and fifth columns indicate the number of rational and irrational people when the dominant strategy is Queue strategy, Out of the rational population ,76% chose the queue strategy, Thirty-six percent of irrational people choose Queue strategy. The sixth and seventh columns indicate the number of rational and irrational people when the dominant strategy is a push strategy, That irrational people choose to push, while 43% of the irrational chose the push strategy. Columns 8 and 9 indicate the absence of an optimal strategy (i.e. uncertainty of the human selection strategy), Twenty-four percent of rational people are unsure of their strategy, Twenty-one percent of irrational people were unsure about the strategy.

In the verification, the strategy set A={1,2,3} is experimentally set. Use "1" to represent "Queue" strategy as advantage strategy,"2" means "Push" strategy is the dominant strategy, "3" means that there is no dominant strategy in the current situation.Of the 500 people randomly generated, Each rational person chooses the strategy as shown in Figure 1(a).The ordinate is the policy set, the abscissa represents the number of rational people.Figure 1(b) is a distribution

Table 2: Number of rational and irrational persons under different rational coefficients and strategies (total 500)

Rational coefficient	Numbers of people		Advantage strategy				No Advantage Strategy	
			Queue strategy		Push-out strategy			
	Rational	Irrational	Rational	Irrational	Rational	Irrational	Rational	Irrational
0.9	378	122	302	44	0	52	76	26
0.8	375	125	281	41	0	59	94	25
0.7	371	129	269	59	0	45	102	25
0.6	365	135	286	41	0	69	79	25
0.5	363	137	266	53	0	60	97	24
0.4	360	140	282	52	0	56	78	32
0.3	358	142	275	53	0	52	83	37
0.2	356	144	267	56	0	60	89	28
0.1	351	149	270	45	0	72	81	32
Average value	364	136	278	49	0	58	87	28



(a) Rational People's Choice Strategies (b) Irrational People's Choice Strategies

Figure 1: Selection Strategies of Rational and Irrational People

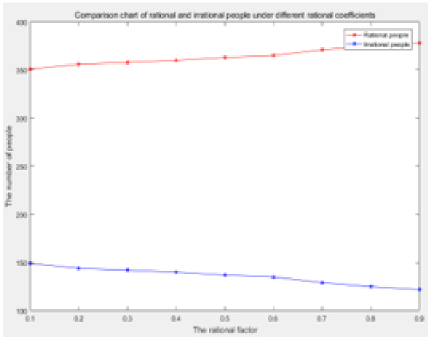
map of each irrational selection strategy in a randomly generated 500 population, the abscissa represents the number of irrational people.

In the process of evacuation, the experiment takes into account the proportion of rational and irrational people, and introduces the rational coefficient$\phi(0 \leq \phi \leq 1)$, the larger the number of ϕ, the less the irrational number. At the same time, in the process of evacuation of 500 people, the game between rational person and irrational person is compared under 9 different rational coefficients. From the 12 kinds of income matrices in the appendix, the comparison of rational and irrational human games is obtained: Figure 2(a) describes the distribution of rational and irrational numbers under different rational coefficients of randomly generated 500 people.This leads to conclusion one: when the total number of people remains unchanged, the greater the rational coefficient, the less irrational people and the more rational people.

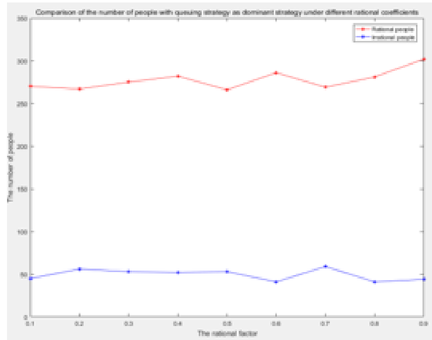
Figure2(b) describes the comparison of rational and irrational numbers of people who choose "Queue" strategy as dominant strategy under different rational coefficients of randomly generated 500 people.This leads to conclusion two:when the total number of people is constant, there are more rational people than irrational people who choose the "Queue" strategy as the dominant strategy under different rational coefficients. And with the increase of rational coefficient, the rational number of people choosing "Queue" strategy as the dominant strategy will increase (because all of us in the experiment are random, so there are some points that conflict with the conclusion).

A comparison between the rational number and the irrational number of people who choose the "push and squeeze" strategy as the dominant strategy under different rational coefficien ts of the randomly generated 500 people is shown in Figure 3(a).This leads to conclusion three: when the total number is constant, the irrational number is always more than the rational number, and the rational person will not choose the "push" strategy as the dominant strategy under different rational coefficients.Figure 3(b) can draw a conclusion four that when the total number is constant, the rational number without dominant strategy under different rational coefficients is always more than the irrational number. The experimental analysis shows that conclusion four is caused by conclusion one and conclusion three, that is, the dominant strategy of rational people is only "Queue" strategy, while the dominant strategy of irrational people is "Push" and "Queue" two strategies.

Figure 4(a) can draw a conclusion 5: when the total number of people is constant, the dominant strategy of rational people

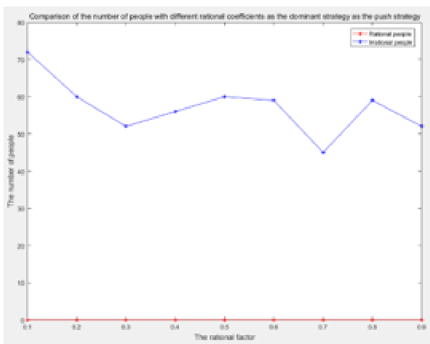


(a) Comparison of Total Rational and irrational numbers

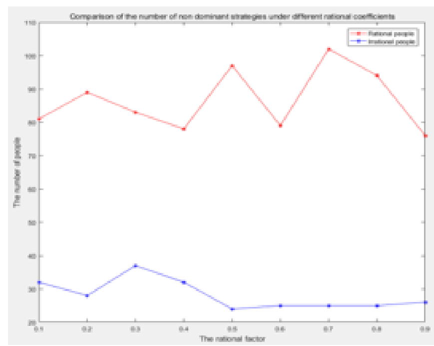


(b) The dominant strategy is Queue

Figure 2: Comparison of rational and irrational numbers under different rational coefficients



(a) the dominant strategy is a Push strategy



(b) there is no dominant strategy

Figure 3: Comparison of rational and irrational numbers of different dominant strategies under different rational coefficients

under different rational coefficients is "Queue" strategy, while some rational people have no advantage strategy. And rational people will not choose "push" strategy as advantage strategy. Figure 4(b) can draw a conclusion 6: when the total number of people is constant, the dominant strategy of most irrational people under different rational coefficients is "Push" strategy, some irrational people's dominant strategy is "Queue" strategy, and some irrational people have no advantage strategy.

3 THE SIMULATION MODEL TEST OF CROWD STAMPEDE ACCIDENT

For the crowd stampede model, we use the EnterP rise to carry on the preliminary structure to the software, through the fast prototype model method to carry on the implementation to the software. About half a million Hindu devotees visited a temple in the Darthia area to celebrate the Hindu Goddess Day. During this period, some worshippers attempted to jump in line and deliberately spread rumors that the bridge where the queue was located was "about to break ", causing panic and stampede, killing 91 people.

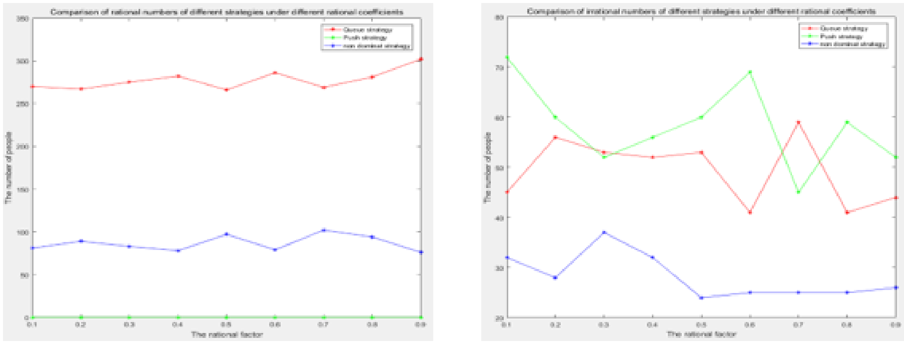
3.1 Case of scenario presentation

The stampede at the Banda Tia Bridge in India is a typical stampede.According to the research situation of agent path finding and accident mechanism improved by A* algorithm, this paper describes the model of accidents under the condition of normal walking and overload of people on the Madhya Pradesh Bridge in India, as shown in Figure 5. In this scene, the green part is the lawn outside the bridge, the blue part is the river water, the middle white and gray part is the bridge and the road surface connecting the bridge. In the simulated scene, people in other areas can not walk except roads and bridges.

3.2 Analysis of road finding

In the process of evacuation and searching, the crowd is divided into two different situations: one is the problem of finding the road on the bridge under normal circumstances, the other is the problem of finding the road in the event of an accident.

- Under normal circumstances, there are fewer people on the bridge and there are no accidents without exceeding the maximum bearing capacity of the bridge. We first analyze the



(a) Comparison of rational numbers | (b) Comparison of irrational numbers

Figure 4: Comparison of the number of rational and irrational people in different strategies under different rational coefficients

Figure 5: Simulations of the Datia Bridge in Madhya Pradesh, India

situation of people finding their way: in the state of few people, there will be no irrational situation and no harm to other people. Suppose there are few people on the bridge (suppose 10 people), as shown in Figure 6, the walking process of one of them (people in the black box) is tracked.

According to the idea of smart path finding algorithm, if there is no obstacle between people and goals, people will find the shortest path to the destination. According to the actual route of the tracking point, it is found that the crowd is almost straight on the bridge interface. If there are others in front of people, in terms of current people's vision, other people are regarded as obstacles, the current people will choose to bypass obstacles, continue to find the shortest path to the destination, and finally complete the search.

- In the event of an accident, the biggest problem is overloading. The crowd overcrowding causes the scene chaos, causes the human psychology to change, namely produces the irrational person, at this time exists the game situation. The final goal of the crowd is to reach the destination, but during the walk will be affected by the people around the situation changes. Although it seems to the current people that other people are still obstacles, because of the crowded scene and too many obstacles, many people have great differences in their horizons during the evacuation process, so they can not quickly find their final destination.

Suppose that when the front of the crowd is blocked, the crowd cannot find the direction of walking, and the person will stop and wait until he can find the way forward.

3.3 Analysis of population

When an accident occurs, considering people's psychological level, the existence of panic leads to people's emotions changing from relaxation to tension, which distinguishes two types of people, rational and irrational. Rational people do not have much influence on others. The irrational people will push the people in front of them in the process of evacuation, which will affect the judgment and route choice of others in the process of evacuation. From the physical point of view, due to the different attributes of people (height, weight, evacuation ability, etc.), different forces between people are produced, and the strong and weak people are distinguished.

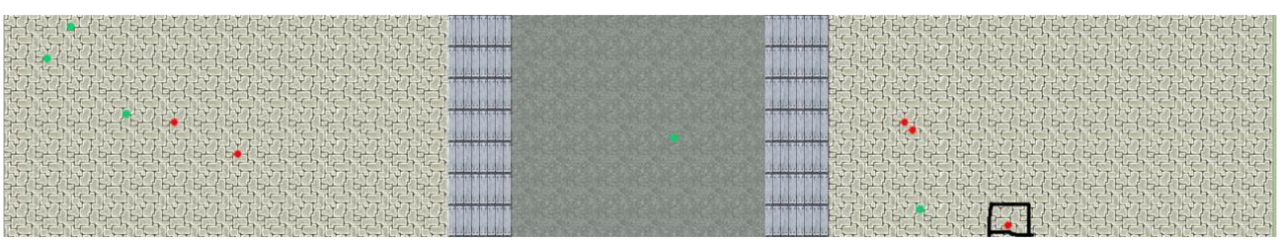


Figure 6: Initial state

Table 3: Population evacuation classification

Psychological status	Rationality or irrationality	Group	Vulnerability
Relax	Rationality	Stronger	No
Relax	Rationality	Vulnerable	No
Tension	Rationality	Stronger	No
Tension	Irrationality	Stronger	No
Tension	Rationality	Vulnerable	Yes
Tension	Irrationality	Vulnerable	Yes

From the physical point of view, due to the different attributes of people (height, weight, evacuation ability, etc.), different forces between people are produced, and the strong and weak people are distinguished. Under normal circumstances, we divide the crowd into four categories, that is, youth, women, the elderly, children. Strong groups exist in the scope of young people. Women are divided into vulnerable groups because of the influence of children and their own reasons. Old people and children are divided into vulnerable groups. In the process of evacuation, when psychological factors are not taken into account, the strong crowd causes more harm to others than the weakness. The vulnerable people will be more injured in the evacuation process, which is also the key cause of casualties.

Summarizing the two situations, whether the crowd will be injured during the evacuation process will have the following situations, as shown in Table 3

From the table you can see that vulnerable people are vulnerable, strong people are not vulnerable. Among them, irrational people in vulnerable groups are more vulnerable. In the process of evacuation, due to the need to consider the existence of psychological, physical, and crowd base factors, irrational crowds tend to push forward in the crowd, causing greater force. If the irrational people belong to the strong group, it is easy to push down one of the nearby vulnerable people, resulting in the stampede accident.

According to the data, the scene of the accident was not completely flat. There are steps at both ends of the bridge, plus the influence of the field of vision, people walk to the steps prone to fall. When everyone is in a rational state, even if no one helps the fall, there will be no crowd passing through him. When the vast majority of people are in a state of panic, rational people usually choose to go around the past and continue to move forward, while irrational people choose to cross from the fallen person and eventually lead to human death.

3.4 Analysis of individual

For individuals, this paper sets the walking interval of each person to a different value.If the person is a strong group, the walking time interval will be shorter, if the vulnerable group will walk each step of the time interval will become longer, so as to distinguish the speed of walking.

When each person is produced, he sets his own parameters (such as step size, waiting time, interval time, etc.), so that he can change his own parameters to complete the corresponding operation in special cases. For example, when people pass the stairs, they must change the waiting time to achieve the same deceleration effect as the actual situation. When an obstacle is observed, the direction is recalculated by deceleration, and then the normal speed is restored by acceleration. When dealing with someone nearby, the people in the model regard others as obstacles. In order to find the route through the intelligent path finding algorithm, it should be noted that in the case of too many people, the whole route may be blocked, and the path finding algorithm can not work effectively.So what we need to do is to process the pathfinding algorithm and change its goal in real time so that it can get the route in real time without stopping when it can't find the way. We divide the bridge and pavement from left to right into eight areas, and the points in each area end at the boundary of the area until they reach the final safe zone, as shown in Figure 7 below.

When there are many people in the scene (set 800 people), you can see in Figure8(a) that the people marked (there is a yellow line below) are moving from right to left. In the course of walking, it is found that there are pedestrians in front of the person and above the oblique. If the road finding algorithm is carried out, the person should choose the downward direction of the syncline to walk. In Figure8(b), the position of the crowd after moving can be observed. At this time, the marked person goes to the oblique lower side of the just position, and it can be confirmed that many people use the path finding algorithm.

If you add each person's force and force, start calculating whether the current force exceeds its maximum force. If the man falls, we turn the man gray. Grey indicates that the man was pushed down and did not die. If the person is still gray after two people, the point changes from gray to black, indicating death.According to Figure 9(a), the people who circle represent our current concern.The man was pushed down because the sum of the forces exerted on him by the man next to him exceeded his maximum bearing.As shown in Figure 9(b), the person changed from red to gray and no longer changed position. From observation, we find that the person we are concerned about is pushed, and the latter two people (both irrational people) surpass this person, who changes from gray to black, that is, the person was trampled by two people and died, as shown in Figure 9(c). It can be verified that when a person falls, it does not mean that the person is dead. If the person behind the fall is a rational crowd, it will bypass the person who falls, and the person who falls will turn red again and move on.If the person does not turn red and more than two irrational people trample on him, the point of the person becomes black, indicating that the person is dead.

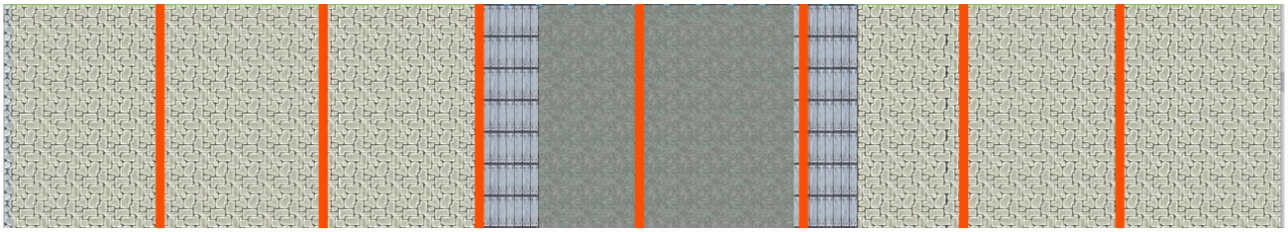
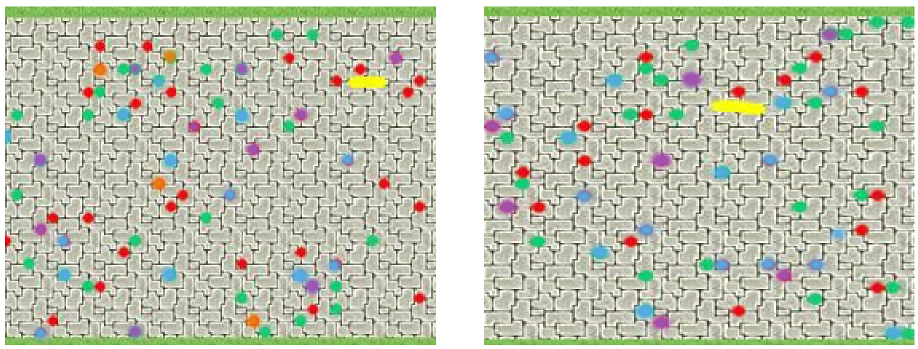
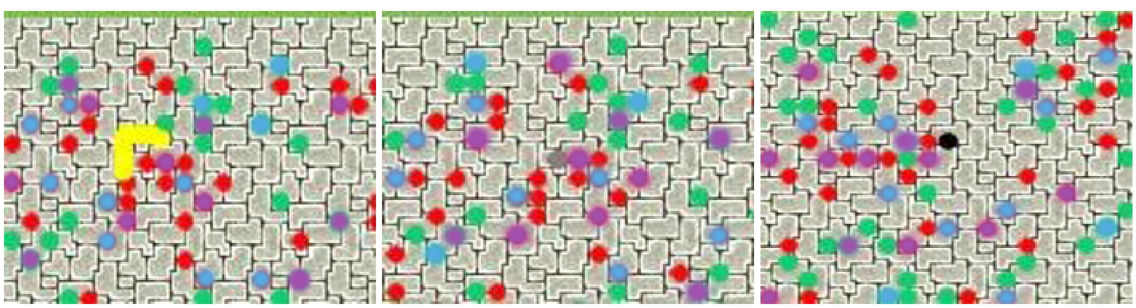


Figure 7: Map of 8 districts



(a) The starting position (b) observed after the movement of a person

Figure 8: Changes in human position movement



(a) The captive person (b) become (c) become black

Figure 9: Changes in the color of the point represented by the person concerned

4 SUMMARY

This paper uses the method of combining data, theory and building to imitate the truth, taking the actual stampede case as the background, from the walking path of the crowd, the rationality and irrationality of the crowd, studies the changes of each stage in the process of large-scale crowded stampede, which provides theoretical and technical support for the study of the formation mechanism of crowd stampede.

Based on the crowded stampede model of intelligent body and rational and irrational crowd game, the concrete work can be divided into the following aspects:

- From the individual road-finding behavior, the crowd in the crowded environment to find the way. Starting from the change of individual and group's psychological behavior, the game behavior of rational and irrational crowd is combined to verify that rational decision-makers choose more queuing strategies and irrational decision-makers choose more pushing strategies when crowd is crowded, while the remaining rational and irrational groups choose different strategies with some probability.
- Use software to build a rapid prototype model, create case scenarios and analyze. This paper analyzes the basic

causes of the accident and summarizes the judgment of self-consciousness and escape ability. By analyzing the consequences of the accident, it is concluded that the number of people in most stampede accidents exceeds the maximum carrying capacity of the environment, and people will be accompanied by panic psychology, which makes the scene chaotic and disorderly. At the same time, vulnerable people will fall because of the squeeze around the stampede.

This paper studies and analyzes the crowd stampede accident from theory to model, but there are many influencing factors in the crowd stampede accident, and the influence factors are also complicated. In the future, more in-depth research on the simulation model of crowded stampede is still needed.

ACKNOWLEDGMENTS

The Grants Project: Project of Philosophy and Social Science in Yunnan Province (QN2015067).

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APPENDICES

Table 4: you: rational.he: rational.Strong or weak.

		Others	
		Queue	Push
Yourself	Queue	0.9,0.9	0.2,0.3
	Push P	0.3,0.7	0.1,0.1

Table 5: you: rational, strong.he: rational,weak.

		Others	
		Queue	Push
Yourself	Queue	0.7,0.8	0.2,0.3
	Push	0.5,0.6	0.4,0.1

Table 6: you: rational, weak.he: rational,strong.

		Others	
		Queue	Push
Yourself	Queue	0.8,0.8	0.2,0.3
	Push	0.2,0.7	0.1,0.3

Table 7: you: irrational, he: irrational. Strong or weak

		Others	
		Queue	Push
Yourself	Queue	0.4,0.4	0.1,0.5
	Push	0.6,0.4	0.6,0.6

Table 8: you: irrational,strong. he: irrational, weak

		Others	
		Queue	Push
Yourself	Queue	0.3,0.4	0.1,0.5
	Push	0.7,0.3	0.7,0.5

Table 9: you: irrational, weak.he: irrational,strong

		Others	
		Queue	Pus
Yourself	Queue	0.4,0.3	0.1,0.5
	Pus	0.5,0.3	0.5,0.7

Table 10: you: rational, he: irrational. Strong or weak

		Others	
		Queue	Push
Yourself	Queue	0.8,0.4	0.3,0.6
	Push	0.5,0.3	0.2,0.5

Table 11: you:rational,strong. he: irrational,weak

		Others	
		Queue	Push
Yourself	Queue	0.7,0.4	0.3,0.5
	Push	0.5,0.3	0.5,0.4

Table 12: you: rational, weak.he: irrational,strong

		Others	
		Queue	Push
Yourself	Queue	0.8,0.3	0.3,0.7
	Push	0.3,0.4	0.1,0.6

Table 13: you: irrational.he: rational.Strong or weak

		Others	
		Queue	Push
Yourself	Queue	0.4,0.8	0.6,0.3
	Push	0.3,0.5	0.5,0.2

Table 14: you: irrational,strong.he: rational,weak

		Others	
		Queue	Push
Yourself	Queue	0.3,0.8	0.3,0.4
	Push	0.7,0.5	0.6,0.3

Table 15: you:irrational, weak.he: rational,strong

		Others	
		Queue	Push
Yourself	Queue	0.4,0.9	0.1,0.4
	Push	0.5,0.8	0.5,0.4