A DYNAMIC SIMULATION OF CROWD FLOW IN TAIPEI RAILWAY AND MRT STATION BY MULTI-AGENT SIMULATION SYSTEM

Kuo-Chung Wen
Associate Professor, Department of Architecture and Urban Design, Chinese Culture University
55, Hwa Kang Road, Yangmingshan, Taipei 111, Taiwan; Tel: +886-2-28611801ext.41326
E-mail: wenkc@ms1.hinet.net

KEY WORDS: Multi-Agent Simulation System, Crowd Flow, Building Space, Dynamic Simulation, Simulation-Based Evaluation

ABSTRACT: Taipei MRT station which contains a number of flow transport behavior, such as high-speed rail, rail and MRT transport of each other. How to flow through each other, collision and crowded together? The behavior of the timing and location has an established pattern to follow? Then how to improve in the form of moving lines to increase the flow of people moving with the performance? How to reduce the possibility of disaster? These are important issues in the urban environment. In this study, the establishment of multi-agent simulation system architecture assessment of flow dynamic simulation method combined time and patterns that behavior analysis to act as a path performance and inspection certificate is one of effective tools.

1. INTRODUCTION

Crowd together in Taipei City, Taipei Station, which contains a number of flow transport behavior, such as Taiwan High-Speed Rail (HSR), Taiwan Railway (TRA), Taipei MRT and transit transport of each other. Especially the daily average of 30 million passengers transit transport, every rush hour are all crowded, and with the MRT train classes vary from regulation, coupled with the four moving lines underground space to link, into a complex network. In the end is How to flow through each other, collision and crowded together? The behavior of the timing and location has an established pattern to follow? Then how to improve in the form of moving lines to increase the flow of people moving with the performance? How to reduce the possibility of disaster? These are important issues in the urban environment. In this study, the establishment of multi-agent simulation system (MAS) architecture assessment of flow dynamic simulation method combined time and patterns that behavior analysis to act as a path performance and inspection certificate is one of effective tools. Theoretical studies include MAS, geographic information system (GIS), spatial statistical analysis, dynamic simulation methods to explore. As the crowd with a time-varying and non-linear flow characteristics, etc., so the phenomenon is very complex spatial behavior in the simulation, but also to the space environment for the overall model of institution building, and conduct activities related to import and spatial information content calculations, and joined the crowds cycle and behavior patterns related to analysis, the final establishment of the crowd flow patterns of dynamic simulation system for authentication.

2. REVIEWS

2.1 Crowd Simulation

Crowd behavior simulation has been an important goal of computer animation; there are considerable research in motion simulation, path planning and navigation, which includes acts of large-scale virtual reality simulation environment and cognitive patterns in both directions. However, the mass flow of the study consists of three main models: the social dynamics and cellar automata (CA) inference rule three. Despite considerable efforts devoted to each of which try to have realistic simulation results, but there is no one model can improve the mass density. Social dynamics simulations to establish the flow of particles tend to look more like the movement of people like, CA model for movement and space are at high density be limited to inference rules of the model cannot control the fact, or large masses of high density scale panic action situation.(Pelechano and Badler 2006; Bandini, Federici et al. 2007; Banerjee, Abukmail et al. 2009; Paris and Donikian 2009; Oguz, Akaydin et al. 2010; Zhou, Chen et al. 2010) Basically, all agents use the same rules of operation, although the resulting uniform act, but to pay an agent a different psychological attributes (such as impatience, panic, personality traits) and physiological attributes (such as exercise, energy levels), local trigger different behavior, coupled with each agent are also given for the static and dynamic objects and the space in the vicinity of the other agent's perception and response. (Morillo, Fernandez et al. 2004; Pelechano and Badler 2006)

2.2 Multi-agent Simulation System (MAS)

In this study, MAS theory is as an analog system simulation concepts and theoretical basis. The main actors will be the basis of mode and grid mode combine to produce dynamic simulation scenarios. Multi-agent systems can be defined in a common environmental group of actors in interaction; actors can go to fix themselves and their environment. MAS extends the research tools and results, few are as follows: 1. Biological cluster of Boids Model (Reynolds 1987); 2. Apply parallel update the concept of construction of CA; 3. Cognitive behavioral interactions The SWARM and MAML.; 4. Simulate of natural phenomena and the formation of Starlogo learning and NetLogo; 5. Integrated regional transportation system analysis environment Transportation Analysis Simulation System (TRANSIMS); 6. Simulate different levels of pedestrian movement STREETS(Haklay 2001).

2.3 NetLogo

NetLogo is a natural and social phenomena used to simulate the design of programmable modeling environment. It is Uri Wilensky in 1999, initiated by the connected learning and computer-modeling center (CCL) is responsible for continued development. It was particularly suitable for the time evolution of complex systems modeling (Batty 1999). Modelers can run to hundreds of separate agents to issue instructions. This allows to explore the micro level of individual behavior and macro mode possible link between these macro-model is composed of many individual interactions emerged between. The simulation model covers the natural and social sciences in many fields, including biology and medicine, physics and chemistry, mathematics and computer science, and economics and social psychology. NetLogo platform has been widely used in the majority of users (Sklar 2007). Some study land use changes along the MRT (Yan 2005; Zhang 2006; Lin 2008), and another to discuss the building's contours and visitors fixed-line analog winning good interpretation of the capacity (Song 2006). Some explore the impact of spatial cognition choice behavior to establish the spatial relationship between a reasonable and appropriate for the network (Feng 2002; Cheng 2004; Lee 2007) (Yang, Liu et al. 2009).

3. THEORY

3.1 Field Model

Mass flow behavior during the simulation, we must consider the social psychology of the important elements of the action taken its determinants, to set the rules for the simulation. In the case of calm, people will be directly along the shortest path to the exits. However, the more emotional confusion, easily influenced by others, and changes their actions, blindly follow others. The presence of the domain model, the judge should follow along the shortest path to escape the action of others or the extent of crowd evacuation action is decided the most important factor. The ratio between the two or assume that the Panic Level. The higher panic the stronger to follow others, if we want to follow the others, which will deviate from the shortest path to the exits. Consider the domain model to follow in the presence of other people's property, is assuming the footsteps of people will stay on the ground, then the more likely follow the more others are set to move the footprint, the more places. The number of information in this footprint is called Dynamic Field, the shortest distance information as Static Field. Footprint based on the number of changes at each time point, it is dynamic, shortest distance does not change, it is static. As according to the static field or the field decide where to move one cell forward, the decision is based on probability, the higher the level the more likely to panic than the lattice footprint mobile, the more likely the lower level of panic to the shortest path to move (Nishinari 2008).

3.2 Globe and Local Field

This study also set the crowd type properties and select the direction of the Field's role related, basically can be divided into the Global and the Local, such as building components (walls, columns, doors and windows, etc.) Field is part of a global field, all types of people are subject to its role; another example footprint, indicators, weights, etc. from the field is a part of the regional field, only some of the relevant population by its role type, such as footprint for those who have a role to follow. However, Field is from the weight of a particular space for specific populations and the formation of attachment, such as the space inside the distance weighted to leave room for those who only have a role, and if the exit door for most of the refuge by key will be useful, but its panic or those who cannot get enough information about the role of space greatly reduced. Another concept is the sight range, in this first assumption of their sight range of different groups should differ according to their attributes are different, so the sight was not referring to really see the sights, but a sense of space awareness, sometimes with work experience relevant to the mandate, may sometimes be related to its properties.

3.3 Flow and Density

Flow simulation is mainly used flow and the pedestrian density to describe these two parameters, while the flow and density is its relevance. Flow per unit time through a number of points or sections of lines, and generally 1 min or 15 min. In this study, simulations can be directly output per unit of time the number of people, and some areas may be to estimate the traffic flow changes can be understood by the regional distribution of pedestrian movement. Pedestrian density is per unit area or study area, walkway or pedestrian queuing area in the average number of units of human / m^2. In the sparse crowd, the pedestrian can choose their preferred velocity, but in crowded conditions, the flow and speed will decrease. In this study, the spatial density of the simulation system within the grid by the number of analog systems and spatial statistics to calculate the number by which two values of flow and density changes observed in the simulation system of relations.

4. SIMULATION

4.1 Simulation Place

The Taipei MRT is divided into the TRA, HSR and MRT mass transit system; terms of building structure, six stories above ground, underground four-story building (Figure 2). Ground floor main hall, the TRA, the ticket booth and HSR passenger seating area; TRA, HSR platform layer on the ground floor on the second floor; MRT Bannan Line (blue line), Danshui line (red line) are located underground third and four. From the above we can see the spatial distribution, and from

HSR, TRA and rapid transit routes and take mobile platforms almost all concentrated in the basement to the ground floor four, the sight of such a complex and lack of external environment, the user whether it is in turn by or through the ground floor space, are likely to face the problem of path finding. In this study, mainly for passengers to use public space for research to explore the engine room, office and other employees can use only the space not covered by the study of range.

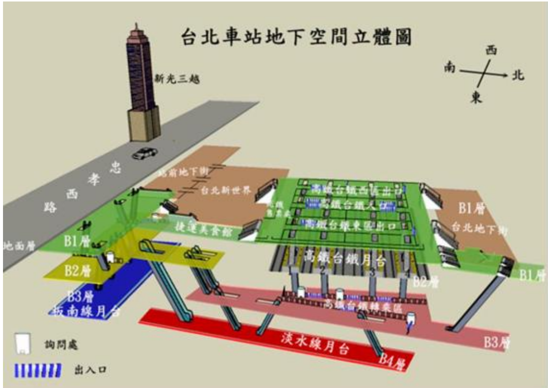


Figure 2, Overview map of Taipei station

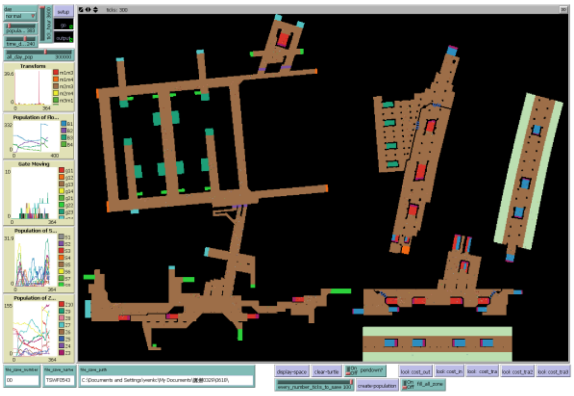


Figure 3, Taipei Main Station Simulator

4.2 Simulator

The simulator like Figure 3, to consider the operation of computer system performance and computing time required for analysis, while the grid scale as 1.5 m, in order to achieve efficiency and accuracy of the simulation the balance between. Simulation grid type classification system is based on the type of rapid transit stations within the space to do the segmentation and analysis of the project. First, the general perception of space in accordance with the type of plane is divided into entrance hall, platforms, stairs, escalators, gates, fire doors, and compartment.

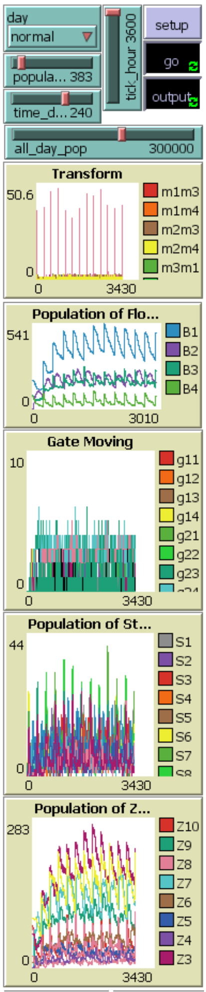
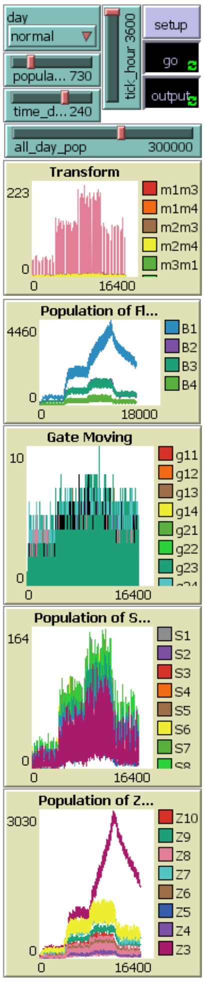
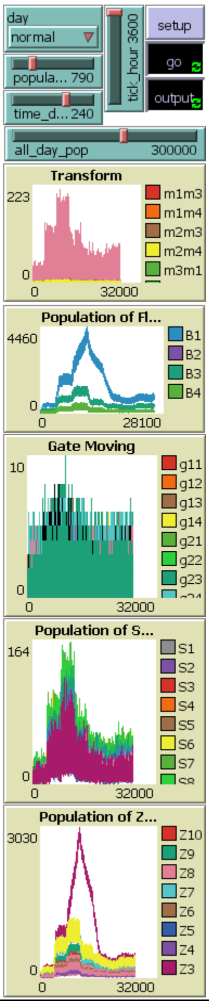
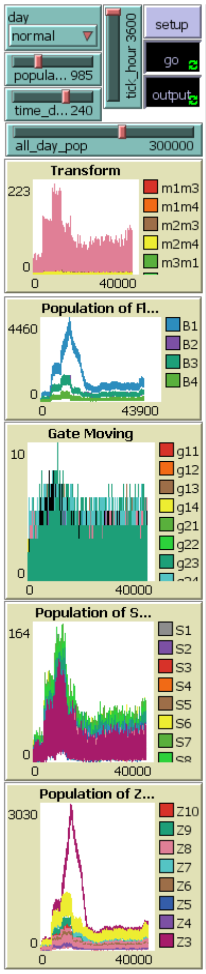
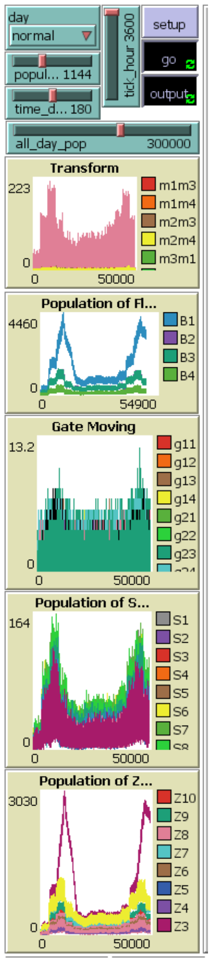
Table 1, The proportion of the Taipei MRT hour traffic (Source: MRT Corporation)

Time	Traffic Volume(%)			Hour	Weekday	Holiday	Memo.
Hour	Weekday	Holiday	Memo.	15-16	3.75%	6.83%	
6-7	1.92%	1.08%		16-17	4.93%	7.20%	
7-8	7.83%	2.88%	Rush hour	17-18	8.50%	8.58%	Rush hour
8-9	11.97%	4.51%	Rush hour	18-19	11.39%	8.02%	Rush hour
9-10	5.52%	4.76%		19-20	7.63%	6.20%	
10-11	3.65%	4.91%		20-21	5.04%	5.23%	
11-12	3.11%	5.27%		21-22	5.55%	5.59%	
12-13	3.72%	6.56%		22-23	5.50%	5.24%	
13-14	3.95%	7.28%		23-24	1.84%	2.27%	
14-15	3.72%	6.86%		24-01	0.48%	0.72%	

4.3 Time and Population Setting

MRT Taipei Station, rush hour, the average class distance of about 6 minutes, overlapping interval of about 3 minutes off-peak periods, the average class distance is about 8 minutes, about 4 minutes intervals overlap. 23:00 in the evening after the shift to widen to 12 minutes, overlapping intervals of six minutes. If you want to simulate, simulation systems must correspond to real-time, tick the NetLogo simulated counter can be set to a certain number of times the system will stop the simulation, the same simulation time as a benchmark to compare the simulations to the differences. In this study, each tick is considered a real time of 1 second, corresponding to the actual time is 60 ticks a minute, which is given to simulate the performance limits of computing devices, for the sake of efficiency required for the actual time of the tick ratio adjustment is also easy to follow and compare the actual transit flow verification. Adjust the number and spacing of stops is sharp according to the MRT Taipei Station, off-peak hours to set. Operating conditions for the full day simulation, the simulation models should be 68400 ticks of the simulation (Table 1).

Table 2, The traffic statistics

Ticks=26100	Ticks=14500	Ticks=26100	Ticks=37700	Ticks=49300
				

4.4 Simulation Result

To observe changes in the flow space, and the overall transport system efficiency, the number of the simulation system is calculated as the number of transfer, the total number of statistics on each floor, each vertical stairs, each gate and each block. The main function of these calculations include: 1. Transporter demographics: transit performance evaluation, 2. The total number of statistics on each floor: space, size distribution, 3. The point flow statistics of the vertical movement: the efficiency of mobile stairs, 4. Traffic statistics of each gate: gate efficiency, 5. Statistics on the number of blocks: the spatial density calculation (Table 2).

5. CONCLUSION

The study found that pedestrians based on space perception of the Static Fields the shortest path, vulnerable to others arising from the Dynamic Fields effects of change. In this study model analysis of space density and the relationship between delay time and found that overall efficiency increases as the density level of delay, delay variability also increased, reduction in the flow channel shows a high density can cause system instability, but to some extent after the move to form a stable state. Subsequent use of high-flow analysis to find space within the congestion position, the current MRT system often uses the body's moving-lane operation, found to effectively improve the overall efficiency and to obtain the optimal solution can be improved using multiple simulation tests. Because of the time and hardware constraints, the study only in-depth analysis of the MRT Taipei Main Station stop, the proposed follow-up study to the other to observe the various types of rapid transit stations and simulation to compare the flow characteristics of the same type of station. Especially walking space environment observations, the export of all types of transport blocks influence the flow of people, but taking into consideration issues such as time and data collection, commercial interior space for more stations ignored the follow-up study included more detail within the commercial space analysis of the attractiveness of transit passengers. Transport due to lack of rapid transit system for more statistical data, making this study the adjustment of the simulated data is not precise enough with the shortcomings, the future if such detailed data obtained, will be able to adjust in and out of stations is more accurate, so that the overall simulation more realistic situation.

6. REFERENCES

Bandini, S., M. L. Federici, et al. (2007). "Situated cellular agents approach to crowd modeling and simulation." Cybernetics and Systems **38**(7): 729-753.

Banerjee, B., A. Abukmail, et al. (2009). "Layered Intelligence for Agent-based Crowd Simulation." Simulation-Transactions of the Society for Modeling and Simulation International **85**(10): 621-633.

Batty, M., Dodge, M. and Jiang, B. (1999). GIS and Urban Design. Berlin, Springer-Verlag.

Cheng, J. D. (2004). Agent-based Modeling of Spatial Configuration and Pedestrian Movement. Institute of Bulding and Planning, National Taiwan University. **Master's Thesis**.

Feng, C. M., Zeng, P.Y. (2002). "Shin Kong Mitsukoshi Department Store Plaza pedestrian observation of the phenomenon of self-organization and simulation analysis." Urban Plaaning **29**(4).

Haklay, M., O'Sullivan, D , Thurstrain-Goodwin,M , Schelhorn,T (2001). "So go downtown: simulating pedestrian movement in town centers." Environment and Planning B **28**: 17.

Lee, Y. (2007). A Study on Cognition Investigation and Simulation in Large Scale Underground Space, Chang Jung Christian University**:** 104.

Lin, F. T. (2008). from http://bp119.bp.ntu.edu.tw/netlogo/netlogoprogs.htm.

Morillo, P., M. Fernandez, et al. (2004). "A grid representation for distributed virtual environments." Grid Computing **2970**: 182-189.

Nishinari, K. (2008). Congestion Study: Population, Car, Ants, Networks, Cell - All the Way Through the Secret. Taipei, Jiou Jing Press.

Oguz, O., A. Akaydin, et al. (2010). "Emergency crowd simulation for outdoor environments." Computers & Graphics-Uk **34**(2): 136-144.

Paris, S. and S. Donikian (2009). "Activity-Driven Populace: A Cognitive Approach to Crowd Simulation." IEEE Computer Graphics and Applications **29**(4): 34-43.

Pelechano, N. and N. I. Badler (2006). "Modeling crowd and trained leader behavior during building evacuation." IEEE Computer Graphics and Applications **26**(6): 80-86.

Reynolds, C. (1987). Flocks, herds and schools: A distributed behavioral model. SIGGRAPH '87: Proceedings of the 14th annual conference on Computer graphics and interactive techniques.

Sklar, E. (2007). "Software review: NetLogo, a multi-agent simulation environment." Artificial Life **13**(3): 303-311.

Song, S. W. (2006). Taroko National Park Visitor Center visitor behavior studies. Institute of Horticulture, National Taiwan University. **Master's thesis**.

Yan, Z. Y. (2005). MRT along the land-use change simulation model construction and application. Institute of Transport, National Chiao Tung University. **Master's thesis**.

Yang, L. Z., S. B. Liu, et al. (2009). "INFORMATION-BASED EVACUATION EXPERIMENT AND ITS CELLULAR AUTOMATON SIMULATION." International Journal of Modern Physics C **20**(10): 1583-1596.

Zhang, D. (2006). MRT station area land use changes in the simulation - the Taipei MRT Mucha line for example. Institute of Transport, National Chiao Tung University. **Master's thesis**.

Zhou, S. P., D. Chen, et al. (2010). "Crowd Modeling and Simulation Technologies." Acm Transactions on Modeling and Computer Simulation **20**(4): -.