Research on Epidemic Prevention and Management Measures in University Based on GIS and ABM – Taking South China University of Technology (Wushan Campus) as an Example

Mingxi Chen(✉)

South China University of Technology, Wushan. 381, Guangzhou 510630, China

Abstract. Prevention and management of epidemic is a protracted war. As large community in city, universities are key regions in the anti-epidemic period. However, the current epidemic prevention and management measures in many universities do not compatible with the spatial form and the characteristics of the population, likely to lead to waste of resources and cause conflicts. The research simulates campus environment by constructing GIS model, and simulates the behavior of campus crowd by ABM. Under the coupling effect of the two, the real-time calculation of the spread of epidemic in universities can be calculated in real-time, making up for the deficiency of GIS model which can only do static data analysis. On this basis, research takes South China University of Technology as an example and assumes three epidemic prevention management measures, i.e. closed-off management, zoning management and self prevention, respectively to simulate the spread of the epidemic, sum up the results of different management measures and provide certain suggestions.

Keywords: Epidemic simulation · Prevention and management · GIS · ABM

1 Introduction

As large community gathering a large amount of people in city, universities are the most important areas during the epidemic, thus proper epidemic prevention measures should be adopted during the normal period of epidemic. However, most universities fail to formulate effective management measures in combination with the spatial form and population characteristics of the university. On the one hand, it leads to the waste of human source and materials, and the low efficiency of epidemic prevention. On the other hand, it is likely to trigger conflicts, which is not conducive to the management of the epidemic.

In view of the above problems, this research attempts to take South China University of Technology (Wushan campus, hereafter referred to as SCUT) as an example, to obtain real-time and dynamic data through coupling GIS model and ABM[1] [1, 3], and

[1] ABM(Agent-Based Modeling): a modeling method used to simulate complex system, such as traffic and crowd.

P. F. Yuan et al. (Eds.): CDRF 2021, *Proceedings of the 2021 DigitalFUTURES*, pp. 148–157, 2022.
https://doi.org/10.1007/978-981-16-5983-6_14

to simulate the effects of different epidemic prevention and management measures, providing more intuitive guidance on epidemic prevention and management strategies for universities.

2 Methodology

2.1 Research Scope

SCUT is located in Wushan Street, Tianhe District, Guangzhou, with a total area of 294 hectares. SCUT is relatively open campus, which is adjacent to South China Agricultural University and Wushan metro station in the east, Tianhe Coach Terminal in the north, and several vocational colleges in the west, which leads to complicated crowd around SCUT (as shown in Fig. 1).

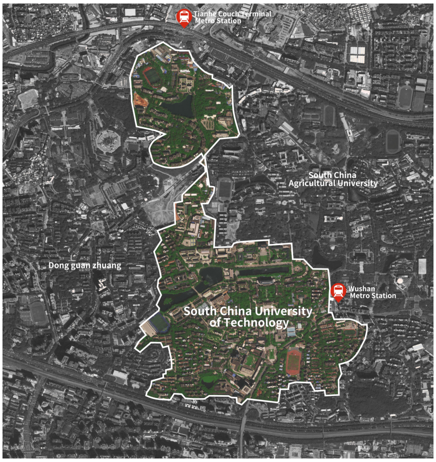

Fig. 1. The scope of SCUT

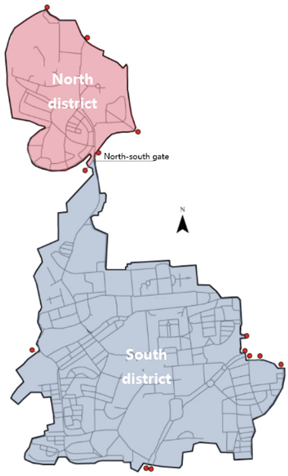

Fig. 2. Zoning and access gates of SCUT

2.2 Research Data

The whole model consists of two parts: one is to build the spatial model of SCUT using GIS based on geospatial data; the other is to build the behavior model of related people living and working in SCUT using ABM. GIS model is the workspace of ABM model, and the simulation process of ABM model will be reflected in the space in real time, and the corresponding results will be fed back together with the GIS model. The relationship between the two is shown in Fig. 3.

2.2.1 Spatial Analysis Based on GIS

To carry out GIS spatial analysis, a geographic information model is firstly constructed through spatial data, including road network, open spaces, buildings, boundary, and access gates.

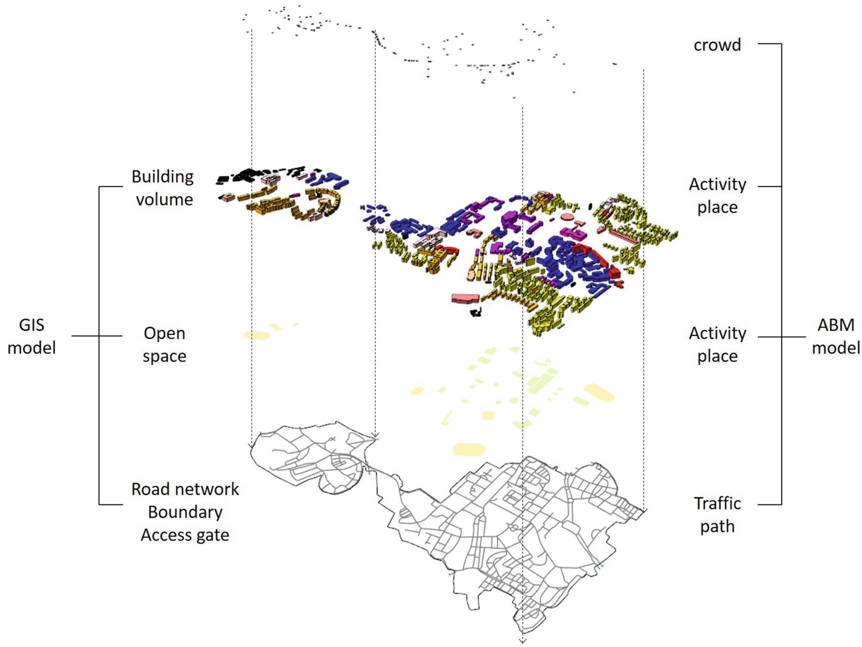

Fig. 3. The relationship between GIS model and ABM model

On this basis, this research analyses static geographical elements with GIS model, and simulates crowd activities though ABM model. Crowd activities data will be processed with kernel density analysis, which reflects areas of high concentration of activity that need to pay more attention to.

2.2.2 Behaviour Simulation Based on ABM

ABM is a modeling method used to simulate complex system. The components in a system such as people and buildings can be described as "agent", and the interaction between "agent" is the relationship between the components in the system.

This research uses GAMA (GIS and Agent-based Modeling Architecture) platform to build ABM model. Agent in the ABM model can interact with the environment and other agents to change its own state. Each type of agent has a consistent list of attributes, goals, and ways of behaving, just as human shares same characteristics. The attributes, purposes and behavior of each agent may vary, just as individuals differ from one person to another.

In addition to spatial data of GIS model, the construction of ABM model also includes a series of heterogeneous data used to simulate crowd activities [2], such as types of people, number of different kinds of people (see Table 1), the schedule of people and behaviours of peoples (see Table 2).

The above data can be used to simulate the activities of different groups in SCUT in the ABM model. The crowd distribution at a specific moment can be exported as a SHP file recorded with "points", and then imported into ArcGIS to reflect the aggregation of

Table 1. Simulation number of different kinds of people

Type	Number of people (1:100)
Student	543
Teacher	57
Campus community residents	221
Total	821

Table 2. Schedule for various groups of people

Time	T1	T2	T3	T4	T5	T6	T7
Behaviors	Breakfast	Work/research	Lunch	Work/research	Dinner	Free time	Sleep
Students	5:00–10: 00	6:00–11:00	11:00–13:00	13:00–15:00	17:00–19:00	19:00–21:00	21:00–1:00
Teachers & Staff							
Campus resident							

crowd at different time by kernel density analysis. In addition, the spread of the epidemic can be simulated using ABM model and the infection rate can be shown through chart.

3 Result

3.1 Analysis of General Elements

3.1.1 Analysis of Space Utilization

The building function layout of SCUT is shown in Fig. 4. Due to the long history of SCUT, its overall form has evolved into a relatively complex state. The campus has formed an obvious axis organization along the East Lake in the north-south direction, and there are large community groups in the southwest, southeast and west sides. Research buildings such as laboratories on campus tend to cluster, while other types of buildings do not have obvious aggregation features.

SCUT interweaves with the surrounding urban areas, presenting an irregular campus boundary, and can be clearly divided into two areas, north and south (see Fig. 2). There are 13 access gates in the campus, and there are more access gates on the southeast side of the campus with more contact areas with the city, as shown in Fig. 5.

There are two types of residential buildings in SCUT, student dormitories and community residences, which are mainly distributed near the campus boundary. The population of each residential building is shown in Fig. 6. On the whole, student dormitories are more densely populated than community residences, while community residences account for a larger proportion of campus area.

3.1.2 Analysis of Crowd Activities

In this research, an ABM model is constructed according to behavior habits and schedule of different types of people, which can reflect the simulation results in real time. Agents

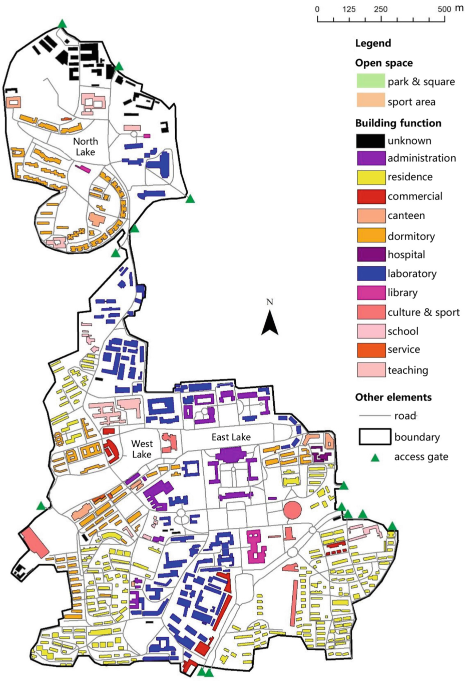

Fig. 4. Distribution of building function

can move to various locations on campus through roads, as shown in Fig. 7. And when the agent is infected, it will turn into red. If the building contains infected people, a gradient of red will reflect the proportion of infected people in the building, as shown in Fig. 8.

In the simulation process, the model simultaneously exports the location points of crowd in the format of SHP file, and then analyzes the aggregation of crowd at different time through kernel density analysis. The results are as follows (Fig. 9):

3.2 Comparison of Management Measures

3.2.1 Without Any Management

Before simulation, the model will randomly select a person in campus as the infected person. According to academician Zhong Nanshan's research on COVID-19 [4, 5], the probability of infection of close contact (within 2 m) is set to 5%. During the simulation, if a normal person is within 2 m with an infected person, the normal person will be infected with the probability of 5%.

In the absence of any management measures, the change of infection rate is shown in Fig. 10. It took about 3 days to reach 100%[2] infection rate.

[2] This research focuses on the impact of different management measures on the spread of epidemic, simplifying the relevant epidemiological principles, so it is assumed that the epidemic in this research is not fatal.

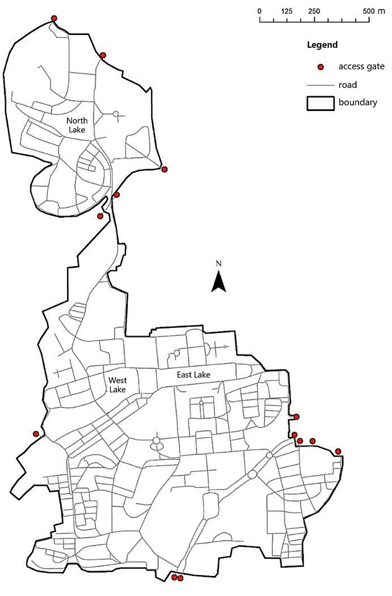

Fig. 5. Campus gates location

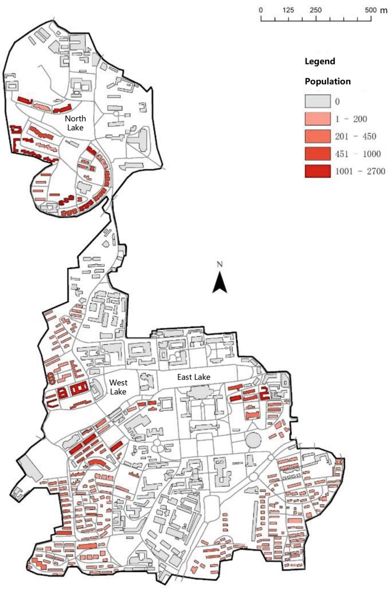

Fig. 6. Distribution of population

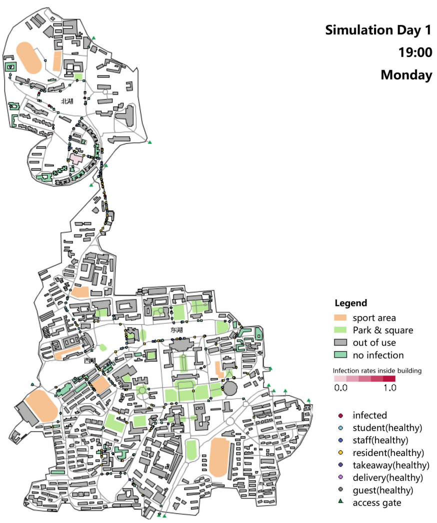

Fig. 7. People agent move around campus

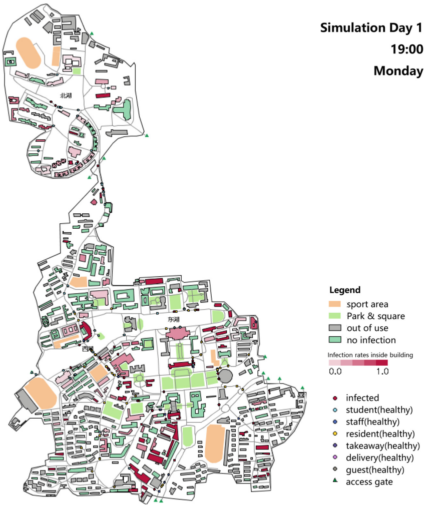

Fig. 8. People or building get infected

3.3 Closed-Off Management

Closed-off management restricts people entering and leaving the campus. Under this management measure, the campus would be prohibited from entering from outside, and all the staff, students and community residents would live inside the campus.

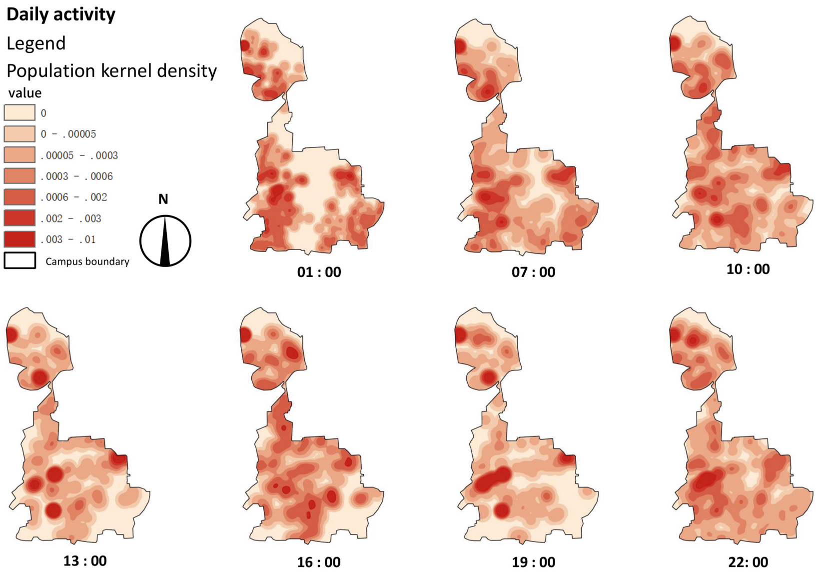

Fig. 9. Kernel density analysis of crowd aggregation

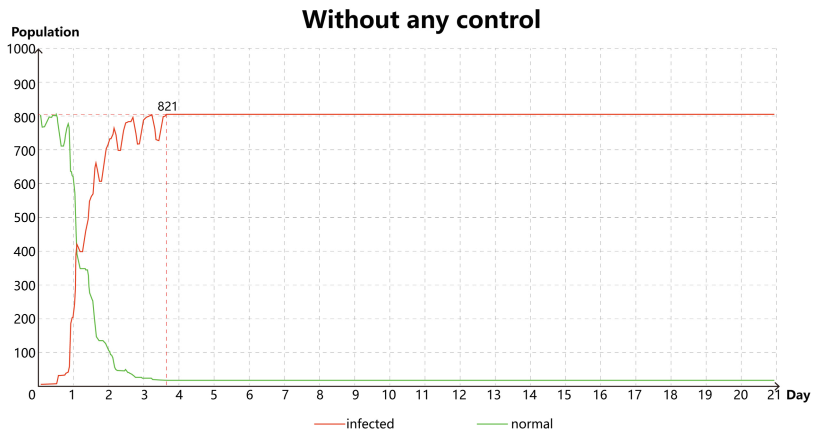

Fig. 10. Spread of epidemic without any management

The rate of infection with closed-off management over time is shown in Fig. 11, reaching 100% infection after about 4 days. Without considering medical measures, the closed-off management can prevent infected people from outside. However, it only slightly delayed the growth of the infection rate inside the campus rather than inhibit the spread of the epidemic.

Fig. 11. The spread of epidemics under closed-off management

3.4 Zoning Management

On the basis of closed-off management, zoning management divides SCUT into two zones, north and south, bounded by the north-south gate (see Fig. 2), which are managed independently. Since there is no residence in the North zone, teachers living in the South zone need to reach the North zone through the north-south gate for classes, which are not restricted by zoning management. Other school members are restricted to their own areas.

The infection rate of zoning management over time is shown in Fig. 12. The infection rate reaches 100% after about 4 days, which is not very different from closed-off management. This is because teachers, as a group that can travel freely between the two zones, are likely to become the host of the epidemic, bringing virus to other zones.

Fig. 12. Spread of epidemics under zoning management

3.5 Self Prevention

In order to simplify the simulation procedure, the research takes "wearing a mask" as the measure of self prevention, which reduces probability of infection to 2% [4, 5].

The infection rate of self prevention over time is shown in Fig. 13. The outbreak period was approximately 6–9 days after the start of the simulation, and it took approximately 20 days for reaching 100% infection rate.

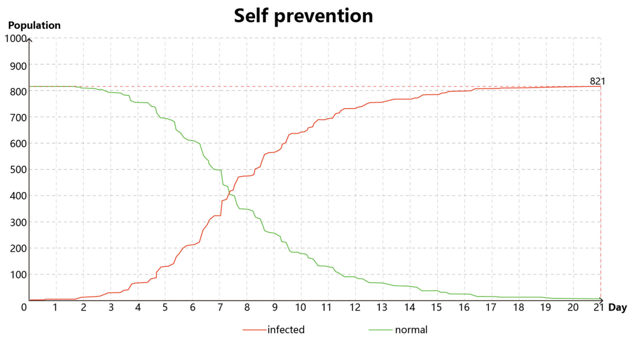

Fig. 13. Spread of epidemic under self prevention

4 Conclusion

According to the simulation of crowd activities, a large number of people will flock to certain dining places like canteen during dining time, which will cause a highly aggregation of crowd and cross-infection. Therefore, during the epidemic period, universities should set up temporary dinning place evenly on campus to reduce aggregation. In addition, different management measures lead to different effect: 1) Closed-off management cannot stop epidemic spreading if infected people are already inside the campus. 2) Zoning management requires different zones are able to operate independently. 3) Self prevention such as "wearing masks" is the most direct and effective measures of epidemic prevention and management. Universities should strengthen education about epidemic and enhance self prevention awareness.

Referencess

1. Crooks, A., Malleson, N., Wise, S., Heppenstall, A.: Big data, agents and the city. In: Big Data for Regional Science (2017)
2. Wei, D.: A modeling and computational experiment on disease transmission based on heterogeneous agent. In: National Defense University of Science and Technology (2014)
3. Gaudou, P.: Toward complex models of complex systems - one step further in the art of agent-based modelling (2016).https://doi.org/10.13140/RG.2.2.12909.38888
4. Wang, W., Tang, J., Wei, F.: Updated understanding of the outbreak of 2019 novel coronavirus (2019-nCoV) in Wuhan. J. Med. Virol. **92**, 441–447 (2020)
5. Yang, Z., Zeng, Z., Wang, K., et al.: Modified SEIR and AI prediction of the epidemics trend of COVID-19 in China under public health interventions. J. Thorac. Dis. **12**, 165 (2020)