Evacuation of building fire personnel based on BIM+GIS: A review

LIU Jiaxi¹, ZHANG Rui¹, YAN Weidong¹, SUN Li¹*

¹School of Civil Engineering, Shenyang Jianzhu University, Shenyang, Liaoning, China
*Corresponding author’s e-mail: jxliu@sjzu.edu.cn

Abstract. As the consequences of building fire evacuation continue to be severe, some experts and scholars have proposed to combine building information modeling (BIM) technology with geographic information system (GIS) technology to construct a three-dimensional space scene of building fire evacuation. BIM has the advantages of refined three-dimensional modeling, and with the help of evacuation software, people evacuation and its characteristics are simulated, GIS has powerful spatial analysis functions to analyze the path. In this kind of evacuation simulation method, the two technologies complement each other to achieve quantitative analysis of qualitative indicators and efficient visualization of evacuation emergency management. This paper summarizes and analyzes the research on personnel evacuation in recent years by summarizing the current research situation in China, and puts forward the existing problems, hoping to provide ideas for the further research.

1. Introduction
In recent years, BIM and GIS technology have been widely used, and the research of combining the two and applying them in the field of fire evacuation is relatively new. BIM provides refined three-dimensional modeling, GIS performs spatial analysis, integrates model information and path three-dimensional, and provides the best evacuation plan for firefighting. In this paper, the evacuation of people in building fires based on BIM+GIS is studied in depth. Through the CitespaceV software, the literature search is carried out in the fields of BIM+evacuation research, GIS+evacuation research, and BIM+GIS+evacuation, and the relationship between keywords is found through quantitative analysis, in order to present the research status in this field completely and clarify the direction for subsequent research.

2. BIM+evacuation research
The CNKI database was used for advanced search, and a total of 213 valid journal articles were collected. Through the CitespaceV software, the visual analysis can be performed to obtain the co-occurrence analysis table of the BIM evacuation keywords in Table 1.

| sort | keyword         | Frequency of occurrence | Centrality | Year of occurrence |
|------|-----------------|-------------------------|------------|-------------------|
| 1    | Bim             | 74                      | 0.66       | 2011              |
| 2    | Bim technology  | 69                      | 0.56       | 2012              |
From Table 1, it can be found that experts and scholars first conducted BIM (Building Information Modeling) research in 2011, the main research object was subway stations, which was applied to the related research of evacuation. With the rapid development of science and technology, the issue of safety management during evacuation has gradually attracted attention, and most experts and scholars began to expand their research in 2015. At the same time, it can be found that "safety management" and "personnel evacuation" appear more frequently as keywords, as well as their centrality is high, which indicates that personnel evacuation and safety management based on BIM are the research hotspots of domestic scholars at present. The specific quantitative research contents are shown in Table 2.

| sort | subject | author | journal | Main research contents | remarks |
|------|---------|--------|---------|------------------------|---------|
| 1    | Research on dynamic planning of building fire rescue path based on BIM and cellular automata (2020) | Ye Jihong etc | China Civil Engineering Journal | This paper proposes a dynamic planning system for firefighter rescue path based on BIM technology and cellular automata. Add a dynamic obstacle model and a random catastrophic fire model to the fire scene, and use real-time detection methods to study the real-time impact of the dynamics of the real fire scene on the rescue path of firefighters, and formulate the best building fire prevention and rescue strategy. | The innovation of this research is the establishment of a new BIM-based intelligent model of cellular automata path planning. The model uses scene layering and collision detection methods to automatically identify various components and internal environments of buildings. To achieve efficient and accurate rescue and smart fire protection. |
| 2    | Research on building fire evacuation path planning based on BIM (2019) | Zhou Peng etc | Fire Science and Technology | This paper uses BIM technology to establish a building fire evacuation model, combined with an adaptive ant colony algorithm to plan building fire evacuation paths, and realizes three-dimensional real-time dynamic planning of building fire evacuation paths. This paper takes the library of a Cadre College in Baise, Guangxi as an example, uses Revit software to build a 3D model and imports it into Pathfinder through PyroSim model is established to study the influence of smoke diffusion, temperature distribution and visibility on evacuation and escape of the library in case of fire. | The research uses BIM technology to establish a three-dimensional fire evacuation model of buildings, and combines with adaptive ant colony algorithm to realize the real-time planning of building fire evacuation paths. The study imported the BIM model into the evacuation simulation software and fire simulation software, and studied the influencing factors and evacuation time during the evacuation process. |
| 3    | Research on fire simulation and safe evacuation based on BIM (2017) | Deng Langni etc | Construction Technology | This paper proposes a dynamic planning system for firefighter rescue path based on BIM technology and cellular automata. Add a dynamic obstacle model and a random catastrophic fire model to the fire scene, and use real-time detection methods to study the real-time impact of the dynamics of the real fire scene on the rescue path of firefighters, and formulate the best building fire prevention and rescue strategy. | The innovation of this research is the establishment of a new BIM-based intelligent model of cellular automata path planning. The model uses scene layering and collision detection methods to automatically identify various components and internal environments of buildings. To achieve efficient and accurate rescue and smart fire protection. |

At present, BIM technology is applied to evacuation, using the visual characteristics of BIM...
technology to optimize the evacuation model, propose the best evacuation guidance scheme, carry out safety management, and finally realize intelligent, scientific and precise evacuation. Ye Jihong\cite{1} and others organically combined BIM with discrete evacuation models, and established a new intelligent path planning model of cellular automata to formulate the best emergency rescue strategy. Zhou Peng\cite{2} and others combined the BIM model with the adaptive ant colony algorithm to plan the building fire evacuation path. Deng Langni\cite{3} and others imported the BIM model into evacuation simulation software and fire simulation software to study the factors and time of evacuation.

3. GIS+evacuation research

The CNKI database was used for advanced search, and a total of 238 valid journal articles were collected. Through the CitespaceV software, the visualization analysis table of GIS evacuation keywords co-occurrence can be obtained in Table 3.

| sort | keyword                      | Frequency of occurrence | Centrality | Year of occurrence |
|------|------------------------------|-------------------------|------------|--------------------|
| 1    | GIS                          | 80                      | 0.63       | 2004               |
| 2    | Geographic information system| 41                      | 0.4        | 2001               |
| 3    | Emergency evacuation         | 20                      | 0.18       | 2007               |
| 4    | Personnel evacuation         | 9                       | 0.06       | 2008               |
| 5    | Emergency shelter            | 7                       | 0.06       | 2012               |
| 6    | GIS technology               | 7                       | 0.05       | 2010               |
| 7    | Decision support system      | 6                       | 0.05       | 2003               |
| 8    | Emergency rescue             | 6                       | 0.03       | 2007               |

From Table 3, it can be found that experts and scholars conducted GIS (Geographic Information Model) research as early as 2004. The main research contents include emergency evacuation, personnel evacuation and emergency rescue, and put forward the best decision-making scheme, and gradually pay attention to the emergency shelters and the selection of evacuation routes, which has great social significance. At the same time, it can be found that "emergency evacuation" as a keyword appears frequently and its centrality is high, indicating that the emergency evacuation based on GIS is a research hotspot of domestic experts and scholars. The specific quantitative research contents are shown in Table 4.

| sort | subject                                      | author | journal | Main research contents                                                                 | remarks                                                                 |
|------|----------------------------------------------|--------|---------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| 1    | Research on the evacuation model of building | Du Weiwei etc | Microprocessor | This paper is based on GIS technology, divides the geometric space of college buildings, and uses the A* algorithm to distinguish between space and time. Simulate the fire occurrence process in university buildings in multiple dimensions, and formulate a targeted evacuation plan for the dynamic assessment realized. | The institute established a dynamic evacuation model. Based on the original evacuation passage in the university building, the dynamic evaluation of the evacuation passage is realized. |
This paper combines GIS with Multi-Agent technology. The dynamic simulation of evacuation was studied, and an evacuation simulation model based on GIS and Multi-Agent technology was constructed, which presented the dynamic evacuation process of people in disaster situations.

The research realizes the dynamic expression of GIS spatial information data, which is of great significance to the formulation of emergency plans, the construction and management of disaster relief facilities, and the development of emergency evacuation.

This paper is based on the Repast simulation platform and constructed an urban emergency evacuation based on GIS and multi-agent system Simulation framework, and use the platform to study the behavior rules of emergency evacuation and selection of refuge space in emergencies.

The platform developed by this research can be used for the human interaction behavior based on the urban road network, especially the research of emergency evacuation.

GIS technology is used to analyze the geographical space, and the optimization model of emergency evacuation is constructed to provide scientific decision for emergency evacuation. Du Weiwei[4] and others based on GIS and used A* algorithm to simulate the evacuation of buildings and realize dynamic evacuation assessment. Liu Xiaochan[5] and Wu Jianhong[6] combined GIS with multi-agent technology to build an evacuation simulation model to realize emergency evacuation research.

4.BIM+GIS+evacuation research

In recent years, due to the combination of Bim and GIS in the field of fire evacuation research is relatively new, and there are few related literature, so this paper only conducts specific quantitative analysis of such research.

| sort | subject | author | journal | Main research contents | remarks |
|------|---------|--------|---------|------------------------|---------|
| 1    | The linkage mechanism of subway fire evacuation and rescue based on BIM+AHP (2020) | Wang Binghua | Civil Engineering Information Technology | This paper takes Nanning Chaoyang Square as an example, and a subway fire emergency management system based on GIS map module and BIM platform was developed, and AHP (Analytic Hierarchy Process) was used to form an emergency plan evaluation system. | The research is based on the GIS map module, using BIM technology and AHP method to integrate the subway fire evacuation and rescue linkage mechanism, making the fire rescue more information and scientific. |
| 2    | Crowd evacuation simulation based on GIS and multi-agent (2014) | Liu Xiaochan etc | Geographic Information World | This paper combines GIS with Multi-Agent technology. The dynamic simulation of evacuation was studied, and an evacuation simulation model based on GIS and Multi-Agent technology was constructed, which presented the dynamic evacuation process of people in disaster situations. | |
| 3    | Urban emergency evacuation based on GIS and Multi-Agent (2010) | Wu Jianhong etc | Journal of Tsinghua University (Natural Science Edition) | This paper is based on the Repast simulation platform and constructed an urban emergency evacuation based on GIS and multi-agent system Simulation framework, and use the platform to study the behavior rules of emergency evacuation and selection of refuge space in emergencies. | The platform developed by this research can be used for the human interaction behavior based on the urban road network, especially the research of emergency evacuation. |
Research on building fire evacuation based on BIM and GIS technology (2020) [9]

Xu Hanghang

This paper combines BIM technology with GIS technology to construct a three-dimensional space scene of building fire escape. Comprehensive consideration of six influencing factors of fire-fighting evacuation in buildings, and establishing a fire-fighting evacuation model in buildings to obtain the best evacuation path and visualize it in three dimensions to provide a basis for decision-making on fire-fighting evacuation in buildings.

Research on subway emergency evacuation method based on BIM-GIS integration (2019) [10]

Wang Jialiang

This paper combines BIM and GIS, using network models, to study the emergency of subway stations from the aspects of evacuation simulation, interaction between inside and outside stations, and emergency bus connections. The key issues of evacuation methods, a comprehensive discussion of the evacuation problems of subway stations.

5. Conclusion

This paper focuses on the three research directions of BIM+evacuation, GIS+evacuation and BIM+GIS+evacuation. Through the visual analysis and summary of the literature, the application of BIM and GIS in emergency evacuation is deeply studied, and the following conclusions are drawn:

- The research on evacuation guidance has gradually developed from a two-dimensional view to a three-dimensional view, and the evacuation path can be observed more clearly and intuitively.
- The current research on the safety of personnel evacuation is mostly evacuation simulation which is lack of application to actual buildings.
- The evacuation plan and strategy are constantly innovated and complete, but the path planning and implementation are still lack of real-time.
- The combination of BIM and GIS technology is a new direction to improve the evacuation dynamics model and optimize the evacuation guidance scheme.

BIM has the advantages of refined modeling, and GIS has powerful analysis functions. In recent years, experts and scholars have combined the two technologies to apply them in the field of fire evacuation, and continue to innovate and research. Among them, Wang Binghua [8] conducted integrated research on the linkage mechanism of subway fire evacuation and rescue based on the GIS map module, using BIM technology and AHP method. Xu Hanghang [9] and Wang Jialiang [10] combined BIM technology and GIS technology to construct a three-dimensional space scene of building fire-fighting dredging to form a three-dimensional path navigation.

The research uses the advantages of BIM refined modeling and the powerful spatial analysis function of GIS, combined with the establishment of a multi-objective decision-making mathematical model, obtains the fire-fighting evacuation model in the building through calculation and analysis optimization, and performs the three-dimensional space analysis of the path.

The research combines building information modeling (BIM) technology and geographic information system (GIS) technology to analyze evacuation problems in subway stations.
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