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Research Article

Smart Community Emergency Evacuation Management System and Risk Assessment Based on Mobile Big Data

Yongjun Han,[1,2] Li Huang ,[1,3] Tao Xiao,[1,4] Aihua Yuan,[1,5] Yi Yu,[6,7] Yanfei Feng,[1,4] Junshuai Cheng,[1] Ling Di,[1] Jiabao Zheng,[1,4] and Zengshu Ye[2]

[1]*Institute of Industrial Development and Governance Innovation, Zhejiang Guangsha Vocational and Technical University of Construction, Jinhua, 322103 Zhejiang, China*
[2]*School of Journalism and Communications, Communication University of Zhejiang, Hangzhou, 310018 Zhejiang, China*
[3]*School of Business, Yulin Normal University, Yulin, 537000 Guangxi, China*
[4]*School of Education and Humanities, University Tun Abdul Razak, Kuala Lumpur, 50400 Kuala Lumpur, Malaysia*
[5]*College of Business Administration, University of the East, Manila, 40441 Manila, Philippines*
[6]*College of Art Design, Hangzhou Vocational & Technical College, Hangzhou, 310018 Zhejiang, China*
[7]*Art Theory, Krirk University, Bangkhen, 10220 Bangkok, Thailand*

Correspondence should be addressed to Li Huang; hl1338@zjgsdx.edu.cn

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In recent years, with the continuous expansion and development of cities, urban population has become more and more dense. At present, there are few researches on community emergency evacuation management system in China. Therefore, the establishment of community emergency evacuation management system based on mobile big data can not only meet the efficient, fast, smooth, and orderly evacuation and settlement needs of the masses but also minimize emergencies. All kinds of losses and influences caused by accidents have very important practical significance. In this paper, an emergency evacuation management system is developed and designed on smart community platform based on mobile big data technology. In the process of development, it is found that the service integration method of mobile big data and application model is the best combination of this system. The construction process of community emergency evacuation management system framework is introduced in detail. Through the research and design of the system, and then test and analysis of the experiment, the sixth grade teachers and students of a primary school group experiment, there are 50 people in each group. The experimental group is familiar with the system operation in advance, and the knowledge of emergency evacuation management is previewed in advance. It is concluded that the class with emergency evacuation management system has much faster response time and decision-making time to emergencies than the class without emergency evacuation management system, and the injury situation of the class is much better. The study shows that the emergency evacuation management system plays an important role in dealing with emergencies, improving the escape rate and reducing the number of injured. I believe it will be further promoted in the future.

1. Introduction

1.1. Background and Significance. Before 2003, research on emergency management mainly focused on disaster management research. Since the mid-to-late 1970s, with the intensification of earthquakes, floods, and droughts, a number of important research results have been achieved in Chinese academic circles in individual disasters, regional comprehensive disasters, disaster theory, disaster mitigation strategies, and disaster insurance. With the rapid social and economic development and the continuous increase of urban population, problems such as the serious vulnerability of urban lifelines have become increasingly obvious. In recent years, urban disasters have occurred frequently, causing serious losses to the country and people. The establishment and improvement of urban emergency evacuation systems have received more and more attention from the state. The community is the basic unit of the city. After responding to emergencies, community workers will promptly place people in the area to a safe zone. This is an important measure to prevent and reduce casualties and avoid secondary disasters. Therefore, in order to reduce disaster losses, it is necessary to rely on big data smart technology to implement disaster risk emergency management system for the community.

1.2. Related Work. In recent years, research on emergency evacuation in densely populated areas in cities has attracted widespread attention from scholars. Bo et al. have established a research framework for emergency evacuation of urban business circles in view of the particularity of emergency evacuation in urban business circles with dense floating population and concentrated commerce [1]. Huixian et al. designed a simulation experiment system for the emergency evacuation of urban complexes to provide decision-making assistance and support for the virtual drill and emergency rescue of urban disaster events [2]. Diantao et al. proposed an indoor positioning evacuation solution based on iBeacon base station on the current situation of fire emergency evacuation [3]. Zhang SP et al. designed a building emergency evacuation navigation system based on mobile terminals for complex building emergency evacuation problems [4]. Yang and Zhu used PyroSim software to establish the fire model and evacuation model of the terminal building, and conducted simulation analysis on this, and proposed a targeted terminal evacuation design plan [5]. Mingmin et al. proposed targeted emergency evacuation strategies for the emergency evacuation of people in subway stations, their research proves that targeted emergency evacuation strategies can effectively avoid most incident losses [6]. In summary, it can be seen from the previous research status of emergency evacuation that most of them are studying emergency evacuation strategies and using model construction to study how to propose emergency evacuation strategies, but few design an emergency evacuation strategy based on models and technologies, management system to assist and support emergency evacuation decisions.

1.3. Innovation in this Article. Based on previous research on emergency evacuation systems, this article applies mobile big data to community emergency evacuation management systems and makes the following innovations: (1) apply the GIS theory and technology based on location services to the emergency evacuation model; (2) proposed a spatial data organization method of subscale and level; (3) use .NET component programming technology to develop emergency evacuation management system framework; (4) E-R diagrams are used to describe the topic of emergency evacuation; and (4) the designed system obtains the data result through test analysis and comparison.

2. Related Theories and Technologies for the Development of Community Emergency Evacuation Management System Based on Mobile Big Data

2.1. Related Theories Based on Mobile Big Data. "Mobile big data" can not only capture accurate data information in real time but also create detailed customer portraits to indicate accurate customer data information [7]. Mobile data mainly refers to the medium of mobile Internet, from the application of mobile user terminal access to huge amounts of data in the process of flow, within a reasonable period of time to manage the processing and analysis, and as for human interpretation by the numbers according to the floorboard of the information. At present, in the academia for mobile data, there is no uniform definition and there is no systematic classification. Typical application fields of mobile big data can be classified into entertainment content, service, life, shopping, consumption, Internet, collaboration, and other fields.

2.1.1. Practical application of Mobile Big Data

(1) Combination of Mobile Big Data and Electronic Maps. The combination of mobile big data and Baidu deeply integrates the location service technology of mobile big data into Baidu Maps. With life services as the core, it reflects the commercial value of Baidu Maps; AutoNavi is a very good digital map content, navigation, and location service solution in China. The solution provider, the Gaode map developed by the solution provider, not only provides accurate free map navigation products but also has become the "new favorite" of many companies with its advanced mobile big data technology [8].

(2) Combination of Mobile Big Data and the Internet of Things. Based on the application of location services on the Internet of Things, it mainly provides users with integrated positioning services such as GPS and base stations. Users can track vehicles or goods by installing positioning terminals. The Internet of Things mobile big data application is a comprehensive application of various remote sensing technologies. Through radio frequency identification, infrared sensors, global positioning systems, laser scanners, and other information sensing equipment, according to the agreed agreement, items are connected to the Internet and information exchange and communication. The Internet of Things can realize the connection of most items to the network, facilitate identification, management, and control, and bring more convenience to people's lives. Human society will gradually enter the era of the Internet of Things, and the combination of mobile big data and the Internet of Things can combine location service function of mobile big data that is maximized. In other words, when the Internet of Things era comes, the spring of mobile big data location marketing will also come [9].

(3) Combination of Mobile Big Data and WeChat APP. WeChat "people nearby" is one of the most accurate

marketing and promotion methods. In this way, you can locate an area most effectively and then send preferential information to users in this area. The effect is usually good. After the merchant clicks to view “people nearby,” it finds nearby WeChat users based on their geographic location and pushes promotional messages to nearby users for accurate delivery. The emergence of mobile big data has further enhanced the marketing power of WeChat. WeChat uses mobile big data for precise positioning. You can set any point as the center. As long as there are people nearby using WeChat, they can send their own information through greetings. The arrival rate is 100%, and the effect is relatively intuitive. And WeChat mobile big data is very suitable for many industries, such as hotel, real estate, and education. However, WeChat officially launched the mobile big data service [10–12]. When Tencent launched the 2.5 version in 2011, it added the mobile big data function, which attracted vendors such as streetside, shopper, and Kaikai, and provided very strong support for the development of mobile big data. Domestic mobile big data vendors have sprung up, but due to the lack of support from social networks, initial development is more difficult, and many users are still relatively unfamiliar with the concept of mobile big data. Therefore, the emergence of WeChat mobile big data has broken the barriers between QQ friends, Tencent Weibo, and mobile phone address books. The seamless replication of the user’s friend relationship is realized. The addition of social networks has made the development of mobile big data smooth [13].

2.2. Related Theories of Emergency Evacuation

2.2.1. Types of Emergency Evacuation. When an emergency is approaching or has already occurred, the organized transfer of people in the dangerous area to a safe area is an emergency evacuation. Emergency evacuation includes two types: local evacuation and large-scale urban evacuation. When an emergency is about to occur or has occurred, the type, nature, characteristics, and possible impact of the emergency should be used to determine what type of emergency evacuation is to be organized. And to do these points, (1) keep calm, make correct judgments, and act quickly; (2) learn to protect yourself and avoid tripping and collision during evacuation; and (3) obey the command and evacuate according to the predetermined order and line [14]. Specifically, there are the following types:

The emergency evacuation system includes evacuation command agencies, evacuation plans, evacuation drills, evacuation sites, and evacuation guarantees. Chinese attaches great importance to the construction of an emergency evacuation system. Today, the construction of an emergency evacuation system in each city has followed Chinese system for many years, and the civil defense department is responsible for the specific implementation.

The evacuation command organization is the leading department that conducts evacuation drills in peacetime and organizes and implements urban emergency evacuation during emergencies and wartime. Its main responsibility is to lead the public security, fire protection, transportation, civil air defense, communications, medical, rescue, and other departments to participate in urban emergency evacuation and to coordinate the work of various departments.

The evacuation plan is a guiding plan for the organization and implementation of urban emergency evacuation. The evacuation plan clarifies the evacuation conditions, actual conditions, number of people, organization and command organization, the correspondence relationship between communities and evacuation areas, evacuation routes, and evacuation guarantees under various emergencies. The evacuation plan specifically includes evacuation marshalling methods, marshalling plans, vehicle security, determination of assembly areas, determination of evacuation routes, and control and adjustment of evacuation traffic flow. Streets and communities are the main bodies that ultimately implement the evacuation plan, and the evacuation plan of the superior must be strictly implemented [15].

Evacuation sites are the final destinations for urban evacuation. Evacuation points, evacuation bases, and evacuation areas constitute a “three-in-one” urban emergency evacuation system, which satisfies different types, properties, and emergencies with different consequences. Urban emergency evacuation needs under incident conditions.

2.2.2. Features of Emergency Evacuation

(1) Suddenly. Due to the sudden nature of emergency events, for urban emergency evacuation decision-making departments, the organization and implementation of urban emergency evacuation is also carried out without preparation; at the same time, the general public also received evacuation instructions without any expectation. People have made great progress in predicting natural disasters, but they are still at a loss for man-made emergencies.

(2) Urgency. Urgency is a distinctive feature of urban emergency evacuation. Since emergencies have the characteristics of suddenness, uncertainty, destructiveness, and proliferation, once the emergencies are handled improperly and the evacuation time is delayed, it will cause significant loss of people’s lives and property. The urgency of urban emergency evacuation runs through the entire process of emergency evacuation. From emergency warning to release, from emergency evacuation decision-making to deployment and implementation, it reflects the urgency of time.

(3) Organized. The task of urban emergency evacuation is to transfer the population in dangerous areas to safe areas in an orderly and rapid manner. From the urban emergency evacuation task, it can be concluded that organization is another characteristic. Loss of organization can easily cause confusion, affect the efficiency of emergency evacuation, and cause unnecessary casualties.

(4) Uncertainty. Urban emergency evacuation is uncertain. First, the organization and implementation of urban emergency evacuation is uncertain. Due to the different types and nature of emergencies, the scope of impact and consequences is also different; second, the process of urban emergency evacuation is uncertain.

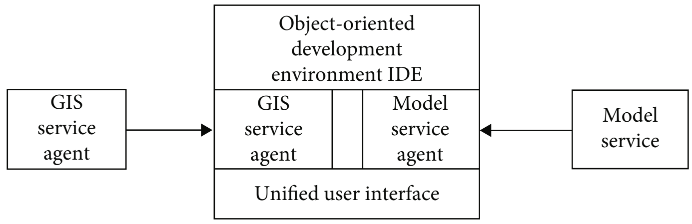

Figure 1: Service integration method of GIS and application model.

2.3. GIS Technology. GIS is a processing tool and technology for spatial data information. It can collect, store, process, and analyze spatial data information. After years of development, it has become a separate subject independently. The application of GIS technology can play the role of route command, obstacle handling, and advance induction in community emergency evacuation management [16]. In the past few years, it has received widespread attention and ushered in a development climax in the continuous research and application process. Driven by the continuous advancement of information technology, the digital age has fully arrived. From a theoretical point of view, GSI can play its own value and role in any industry. From the perspective of disciplines, GIS has already become a single subdiscipline under computer science. From the system point of view, the structure and functions of the GIS system are very reasonable and complete. In terms of technology and application, this technology can effectively solve many space problems. In terms of functions, GIS technology can complete a series of tasks for spatial data, such as data collection, storage, presentation, editing, and analysis. In summary, GIS is a system that can analyze and manage spatial object information. The most significant difference between it and DBMS is that it belongs to geographic information system, while DBMS belongs to the category of information system [17].

The biggest feature of GIS lies in the following: First, it is a computerized technical system in form. It includes multiple subsystems that are widely and closely related to each other. It is a system for processing spatial data and can be used to analyze the geographic target composed of points, lines, and areas. Second, the advantage of GIS technology lies in its realization of data integration, simulation and spatial analysis functions, and more attention and importance to the organization system and the role of people. The GIS system provides powerful functional support for the entire process from data collection to application. The system is mainly used to solve these problems: location problems, condition problems, model problems, simulation problems, and forecast changes [18, 19]. The realization of GIS technology is based on data collection technology, communication technology, software technology, information security technology, virtual reality technology, etc. GIS technology can not only effectively manage various resource and environmental information with spatial attributes, conduct rapid and repeated analysis and testing of resource and environmental management and practice models, facilitate decision-making, and conduct scientific and policy standard evaluations but also can effectively dynamic monitoring, analysis, and comparison of resource and environmental conditions, and changes in production activities during the period, data collection, spatial analysis, and decision-making processes can also be integrated into a common information flow, which can significantly improve work efficiency and economic benefits and provide technical support to ensure sustainable development [20, 21].

2.4. GIS and Application Model Set Service Integration Method. Based on web service technology, the functions of GIS are released in the form of services, and the application model is encapsulated and released in the form of services. The integration of GIS and application mode services solves complex geographic environment problems.

As shown in Figure 1, service integration has the characteristics of openness, maintainability, transparency, and reusability and is an advanced mode for GIS and application model integration. In the service-based integration method, GIS and application models are provided to developers in the form of services. Application models can be run in different locations, on different servers, or even on different platforms. However, the description method of application models, the dynamic discovery and integration of application model services, and the specific implementation technology of GIS services and application model services are still to be studied [22].

2.5. NET Component Programming Technology. .NET is a free and open source development platform for building a variety of applications, web applications, etc. and can be developed using a variety of languages, editors, and libraries [23]. .NET is a new generation of Intel-based distributed computing application platform launched by Microsoft. .NET framework has three core parts: common language runtime environment CLR, common class library, and ASP.NET. CLR realizes the independence of programming language based on .NET through mechanisms such as intermediate language (CIL).

At the same time, CLR also brings platform independence to the .NET framework. The .NET class library provides developers with a unified object-oriented, asynchronous, hierarchical, and scalable class library, including many highly available types and interfaces. The .NET platform not only supports procedural languages but also has nearly perfect support for object-oriented languages. ASP.NET is built using the class library provided by the .NET framework and provides a web application model, which consists of a set of controls and a basic structure. In the software development process, developers can directly call the ASP.NET control set, which makes it very easy to build web applications. The specific .NET component development process is as follows:

(i) Build .NET components

(ii) Define the component interface

(iii) Realize component functions

(iv) Register deployment components

2.6. Related Model Formulas

2.6.1. Personnel estimation of accurate demographic data. When the building entity in the database contains information about the permanent population, the emergency evacuation population should be estimated based on accurate demographic data. Assuming that an evacuation area T is given, the population that needs to be evacuated in the area T is equal to the sum of the permanent residents of the buildings in the area. The calculation formula is as follows:

$$Z_{\mathrm{N}\mu\mathrm{m}} = \sum_{\mathrm{i}=1}^{\mathrm{n}} \alpha B_{\mathrm{N}}, \quad (1)$$

$$\alpha = \frac{\mathrm{B}_{\mathrm{s1}}}{\mathrm{B}_{\mathrm{s}}}. \quad (2)$$

In the formula, (1) $\mathrm{Z}_{\mathrm{N}\mu\mathrm{m}}$ is the total population to be evacuated; (2) B_{S1} is the area where building B falls into evacuation area T, B_{S} is the total area of the building, and α is the ratio of the area of the building falling into the evacuation area to the building area [24].

2.6.2. Building Classification and Population Density. In the case of building classification, the characteristics of population distribution can be found while analyzing each building type, and the population density function of each building can be established separately. The population density function must reflect the influence of time on population distribution. Assuming that the population density of the same type of buildings is the same, there are the following population density functions:

(1) Density of Residents. According to the characteristics and laws of the population distribution of residents, the population density is a function of the urban permanent population, the bottom area of the residential buildings, and the number of floors. The formula for calculating the population density established in this article is as follows:

$$d_1 = \beta_1 \frac{P_T}{\sum_{i=1}^{n}\sum_{j=1}^{m} S1_{\mathrm{ij}} \times N1_{\mathrm{ij}}}. \quad (3)$$

In the formula, (1) d_1 is the population density of the residential area, unit: person/㎡; (2) P_T is the urban permanent population, unit: person; (3) $S1_{\mathrm{ij}}$ is the bottom area of the jth building in the ith residential area, unit: ㎡, $S1_{\mathrm{ij}}$ obtained from the base map of the residential area; (4) $N1_{\mathrm{ij}}$ is the number of floors of the jth building in the ith residential area; and (5) β_1 is the population density correction coefficient of the residential area, and its value is between (0 and 1). the β_1 value is 1 between 22 : 30 at night and 7 : 00 the next day.

(2) The Office Population Density Formula. Office population density can be calculated based on the city's total population of office buildings, government agencies, and enterprises and institutions, and the bottom area and number of floors of office buildings. The population density calculation formula established in this article is as follows:

$$d_2 = \beta_2 \frac{P_2}{\sum_{i=1}^{n}\sum_{j=1}^{\mathrm{m}} S2_{\mathrm{ij}} \times N2_{ij}}. \quad (4)$$

In the formula, (1) d_2 is the population density of the office area, unit: person/㎡; (2)P_2 is the total number of people in the city working in office buildings, government agencies, and enterprises and institutions, unit: person; (3) $S2_{\mathrm{ij}}$ is the ith office area. The bottom area of the jth building, unit: ㎡, $S2_{\mathrm{ij}}$ can be obtained from the base map of the office area; (4) $N2_{\mathrm{ij}}$ is the number of floors of the jth building in the ith office area; and (5) β_2 is the population density correction coefficient of the office area. Suppose here that working hours are from 9 to 5, the population density of the office area reaches the maximum, $\beta_2 = 1$, and the rest of the time period, $\beta_2 = 0$.

(3) School Population Density. The population density of a school can be obtained from the sum of the number of teachers and the number of students in the school, as well as the bottom area and number of floors of the buildings in the school. The school population density formula established in this article is as follows:

$$d_3 = \beta_3 \frac{P_3}{\sum_{i=1}^{n}\sum_{j=1}^{m} S3_{\mathrm{ij}} \times N3_{ij}}. \quad (5)$$

In the formula, (1) d_3 is the population density of the school, unit: person/㎡; (2) P_3 is the total number of teachers and students in the school (excluding universities, which are counted as residential areas), unit: person; (3) $S3_{\mathrm{ij}}$ is the ith. The area of the bottom of each building, unit: square meters, $\mathrm{S3}_{\mathrm{ij}}$ can be obtained from the base map of the campus building; (4) $N3_{\mathrm{ij}}$ is the number of floors of the jth building in the ith campus; and (5) β_3 is the correction coefficient of the campus population density. Time (8 : 00-12 : 00 in the morning, 14 : 30-17 : 00 in the afternoon) campus population density reaches its maximum, $\beta_3 = 1$; in the rest of the time, $\beta_3 = 0$.

(4) Population Density of Commercial District. The population density of a business district can be obtained from the sum of the number of employees in the business district

and the number of urban residents attracted by the business district, as well as the bottom area and number of floors of the business district buildings. The formula for calculating population density established in this article is as follows:

$$d_4 = \beta_4 \frac{P_4 + \gamma_4 + P_T}{\sum_{i=1}^{n} \sum_{j=1}^{m} S4_{ij} \times N4_{ij}}. \quad (6)$$

In the formula, (1) d_4 is the population density of the commercial area, unit: person/㎡; (2) P_4 is the total number of people working in the commercial area in the city. You can refer to the commercial population data in the statistical yearbook published by the city, unit: person; (3) $S4_{ij}$ is the bottom area of the jth building in the ith commercial area, unit: ㎡, and $S4_{ij}$ can be obtained from the base map of the commercial area; (4) $N4_{ij}$ is the number of floors of the jth building in the ith commercial area; and (5) γ_4 is the absorption rate of urban residents in the business district. It is assumed here that the shopping mall is not in business hours (22 : 30-7 : 00 the next day), $\gamma_4 = 0$; the absorption rate in business hours can be purchased from urban residents circumstances.

(5) Population Density of Catering, Accommodation and Cultural, Sports, and Entertainment Places. The population density of catering, accommodation and cultural, sports, and entertainment venues can be obtained from the sum of the number of people working in these venues and the number of citizens attracted, as well as the bottom area and number of floors of buildings in these venues. The formula for calculating the population density of catering accommodation and problem entertainment venues established in this article is as follows:

$$d_5 = \beta_5 \frac{P_5 + \gamma_5 + P_T}{\sum_{i=1}^{n} \sum_{j=1}^{m} S5_{ij} \times N5_{ij}}. \quad (7)$$

In the formula, (1) d_5 is the population density of catering, accommodation and cultural, sports, and entertainment venues, unit: person/m^2; (2) P_5 is the total number of people working in catering, accommodation and cultural, sports, and entertainment in the city, unit: person; (3) $S5_{ij}$ is the area of the bottom of the jth building in the i dining (accommodation, sports, and entertainment) place, unit: ㎡, $S5_{ij}$ can be obtained from the base map of the catering accommodation and cultural, sports, and entertainment venues; (4)$N5_{ij}$is the$i$th dining (accommodation, sports, and entertainment) number of floors of the$j$th building in the place; (5) γ_5 is the attraction rate of catering accommodation and problem entertainment places to urban residents; and (6) β_5 is the correction coefficient of population density of catering accommodation and problem entertainment places.

(6) Hospital Population Density. The population density of a hospital can be obtained from the sum of the number of doctors in the hospital and the number of patients absorbed, as well as the bottom area and number of floors of the buildings in the hospital. The formula for calculating hospital population density established in this article is as follows:

$$d_6 = \beta_6 \frac{P_6 + \gamma_6 + P_T}{\sum_{i=1}^{n} \sum_{j=1}^{m} S6_{ij} \times N6_{ij}}. \quad (8)$$

In the formula, (1) d_6 is the population density of the hospital, unit: person/㎡; (2) P_6 is the total number of doctors in the city, unit: person; (3) $S6_{ij}$ is the bottom area of the ith building, unit: ㎡, $S6_{ij}$ can be obtained from the base map of the hospital building; (4) $N6_{ij}$ is the number of floors of the jth building in the ith hospital; (5) γ_6 is the hospital to urban residents; and (6) β_6 is the correction coefficient of the hospital population density. Since the population in the hospital is constantly changing in different periods, the population density correction coefficient needs to be introduced.

(7) Warehouse Population Density. The population density of the warehouse can be calculated based on the total number of employees in the warehouse and the bottom area and number of floors of the warehouse building. The formula for calculating the population density of the suffering population established in this article is as follows:

$$d_7 = \beta_7 \frac{P_7}{\sum_{i=1}^{n} \sum_{j=1}^{m} S7_{ij} \times N7_{ij}}. \quad (9)$$

In the formula, (1) d_7 is the warehouse population density, unit: person/㎡; (2) P_7 is the total number of people working in the warehouse, unit: person; (3) $S7_{ij}$ is the bottom area of the jth building in the ith warehouse, unit: square meters, $S7_{ij}$ can be obtained from the base map of the heron building; (4) $N7_{ij}$ is the number of floors of the j building in the i warehouse site; and (5) β_7 is the warehouse population density correction coefficient.

2.6.3. Estimation of Population in Evacuated Area. After calculating the population density of each type of building above, the population of a given area can be estimated. The total population of a given evacuation area U is equal to the sum of the product of each type of building area and the corresponding population density in the U area. The specific calculation formula is as follows:

$$P_N = \sum_{i=1}^{m} \left(\sum_{j=1}^{n} \alpha_{ij} \times d_i \right). \quad (10)$$

In the formula, (1) P_N is the estimated total number of people in the evacuation area; (2) α_{ij} is the area of the jth building in the area with building type i; (3) d_i is the population density with building type i; and (4) i represents buildings. The type of $i = 1, 2, \cdots, n$.

2.6.4. Emergency Accident Model

(1) Leakage of Hazardous Substances. The leakage of hazardous substances has a serious impact, which will directly affect the safety of surrounding people and property. The analysis of the leakage of hazardous substances includes the area of the leakage, the type of the leakage, and the diffusion rate of the leakage. It is of great significance for the emergency management of the leakage of hazardous substances to measure hazardous substances according to a unified standard. The concept of "poison load" puts forward by the European department can measure the degree of harm of leakage.

$$\mathrm{TL} = K \times C^n \times t^m. \tag{11}$$

In the formula, (1) TL is the toxic load, which mainly measures the degree of poisoning of personnel; (2) K is a constant coefficient, generally <1; (3) C is the concentration of the substance expanded; (4) N is the degree of influence of toxic substances on humans; (5) t is the incident in which the person received poison; and (6) m is the impact on the person in the contact incident.

(2) Fire Accident. The fire contains a lot of radiation, which will have an impact on the surroundings, and in severe cases, it can cause serious damage to surrounding buildings, personnel, and property. The loss caused by a fire generally depends on the impact and damage caused by the fire on people and objects. Through the division of units, the calculation formula for thermal radiation is as follows:

$$Q = \eta \mathrm{QoHe}. \tag{12}$$

In the formula, (1) Q is the unit quantity of radiation; (2) η is the fire radiation coefficient, which can be 0.35; and (3) Qo is the radiation speed and He is the heat.

(3) Explosion Accident. Explosion accidents are a kind of disaster with relatively large impact. Explosion accidents generally include the explosion of gas, compressed gas, and liquefied gas.

When the gas explodes, the energy released is

$$E = \frac{\mathrm{PV}}{10(\gamma\text{-}1)}\left[1\text{-}\left(\frac{10^5}{p}\right)\right]^{\gamma-1/\gamma}. \tag{13}$$

In the formula, (1) P is the pressure inside the gas; (2) V is the volume of the container; and (3) γ is the specific heat capacity of the gas.

When compressed gas explodes, the resulting explosion is

$$E = \frac{\Delta P^2\text{-}\mathrm{V}\beta}{2}. \tag{14}$$

In the formula, (1) ΔP is the change in volume after the explosion; (2) V is the volume of the container; and (3) β is the compression ratio.

When the liquefied gas explodes, in addition to the volume expansion caused by the treatment, it will also boost the explosion of the container:

$$E = (H_1\text{-}H_2)\text{-}[(S_1\text{-}S_2)T_1]W. \tag{15}$$

According to the energy of the explosion, the impact range of the explosion can be drawn.

3. Design of the Community Emergency Evacuation Management System Framework Based on Location Services

3.1. System Framework Goals. The goal of the system framework is to realize a GIS system for community emergency evacuation. Computer, GIS, network, database, and auxiliary decision support technologies are applied to emergency evacuation of emergencies to provide auxiliary decision support information for community emergency evacuation. In peacetime, it can also provide decision makers with supporting information on shelter construction, evacuation drills, etc. and provide the general public with the latest information and trends of community emergency evacuation through the emergency evacuation information network. People can inquire about emergency evacuation information related to themselves; in case of emergencies, it can provide decision makers with timely, rapid, scientific, and reasonable decision-making support: realize the scientific determination of the emergency evacuation area, the accurate calculation of the population in the evacuation area, and the optimal choice of emergency evacuation route strength, so as to improve the scientificity of the emergency evacuation area, save emergency evacuation resources, improve emergency evacuation efficiency, and effectively reduce casualties, lives, and property purpose of the loss [25].

3.2. System Framework Requirement Analysis. The modification and analysis of community emergency evacuation management system is the basis of the overall design of community emergency evacuation, and it is related to whether the system built can meet the needs of community emergency evacuation. The following is a demand analysis for community emergency evacuation.

3.2.1. Management of Community Basic Geographic Environment Information. Graphicalization is the most intuitive and effective means of conveying information. The basic geographic environment information of the community should be conveyed to decision makers in the form of graphics and images. The basic geographic environment information of the community is the basis for carrying out the emergency evacuation work in the community. Whether it is the site selection of the usual refuge site or the emergency evacuation decision of the community in the event of an emergency, it is inseparable from the basic community geographic environment information support [26].

3.2.2. Management of Thematic Elements of Emergency Evacuation. The management of thematic elements of emergency evacuation mainly includes the spatial distribution of community shelters, the maximum number of people that can be evacuated, the use of shelters, infrastructure construction, corresponding street communities, the spatial distribution of emergency rescue teams, the size and scope of responsibilities of emergency rescue teams, and medical and fire fighting. Information such as the size of the unit's spatial distribution directly affects community emergency evacuation decisions under emergencies.

3.2.3. Disaster Model Management. The disaster model is the basis for scientific and reasonable decision-making in the event of large events. The system should be able to support the addition, modification, and improvement of disaster models. Decision makers can schedule and use these disaster models during emergencies, which has reached a quantitative analysis of the impact of disasters and improved the level of decision-making [27].

3.2.4. Decision-Making Assistance. The system should provide simple auxiliary decision-making tools such as distance measurement, area measurement, and slope and aspect analysis tools: with the support of the auxiliary decision-making model, it can obtain the service scope of the refuge site, dispatch the rescue team with the farthest distance, and select the best evacuation routes, etc.

3.2.5. Evacuation Plan Management. The evacuation plan is the basis for community emergency evacuation drills and the organization and implementation of urban emergency evacuation for emergencies. With the support of the model, according to the type, nature, and characteristics of emergencies, evacuation plans for various emergencies can be formulated more quickly, and the evacuation plans can be modified and updated.

3.2.6. Evacuation Information Release and User Query Analysis. With the support of network technology, the system should be able to determine and release the latest emergency evacuation plan, laws and regulations, common sense, and precautions for emergency evacuation. With the support of the back-end database and server, the community can freely inquire about the assembly points, emergency rescue vehicles, shelters, docking families, and other information that correspond to them during emergencies on the Internet. At the same time, they can also perform map measurement and analysis.

3.3. System Framework Design Principles

3.3.1. Practicality. Emergency evacuation GIS is related to the safety of people's lives and property and social harmony and stability. Therefore, the construction of the system should put the practicality in a prominent position.

3.3.2. Scalability. The system uses today's most mature software development technology and concept-component technology to ensure that the system has good scalability. When a new disaster model needs to be added, the user can add new disaster model components to achieve system function expansion.

3.3.3. Reliability. Reliability means that the decision support information provided by the system must have a strict mathematical and theoretical basis, so that the decision support information obtained has reference value and significance. At the same time, reliability is also reflected in the design of disaster models and auxiliary decision support models.

3.3.4. Security. System security is an important content of system construction. Because the system adopts a mixed architecture of C/S and B/S, the security of the system is placed in a more prominent position. The system takes certain measures to physically separate the intranet and the extranet to prevent the illegal intrusion of the intranet by users from the extranet. At the same time, it classifies the community emergency evacuation topic information and the basic geographic environment information with higher security requirements and sets the corresponding browsing authority.

The contingency and urgency of emergencies require efficient emergency evacuation decisions. When designing disaster model and auxiliary decision-making model, the system adopts the best theoretical technology to shorten the emergency evacuation time from the decision-making level [28].

3.4. Overall Framework Design of the System. The system framework is shown in Figure 2. The overall system framework includes a community emergency evacuation application platform, a community emergency evacuation service platform, a community emergency evacuation comprehensive database, and a community emergency evacuation hardware platform. The community emergency evacuation application platform is mainly to meet the emergency evacuation decision-making and the public's demand for emergency evacuation information by the emergency departments and civil defense departments at all levels in the city; the community emergency evacuation service platform includes a basic geographic information sharing platform and a special emergency evacuation information sharing platform; the emergency evacuation comprehensive database is the basis of the application platform and service platform; and the community emergency evacuation hardware platform includes computer network systems, communication network systems, and safety systems [29]. The E-R relationship of important entities in the community emergency evacuation GIS database is shown in Figure 3.

3.5. Architecture Design Based on the Combination of C/S and B/S. The software architecture of GIS application system is divided into client mode (C/S) and server mode (B/S). In the client mode, GIS applications need to be loaded. Most business processing is done by the client. The GIS data is concentrated on the server, and the server is responsible for processing part of the transaction. The advantage of this mode is high security and can realize complex GIS spatial analysis functions. The working principle is that the client

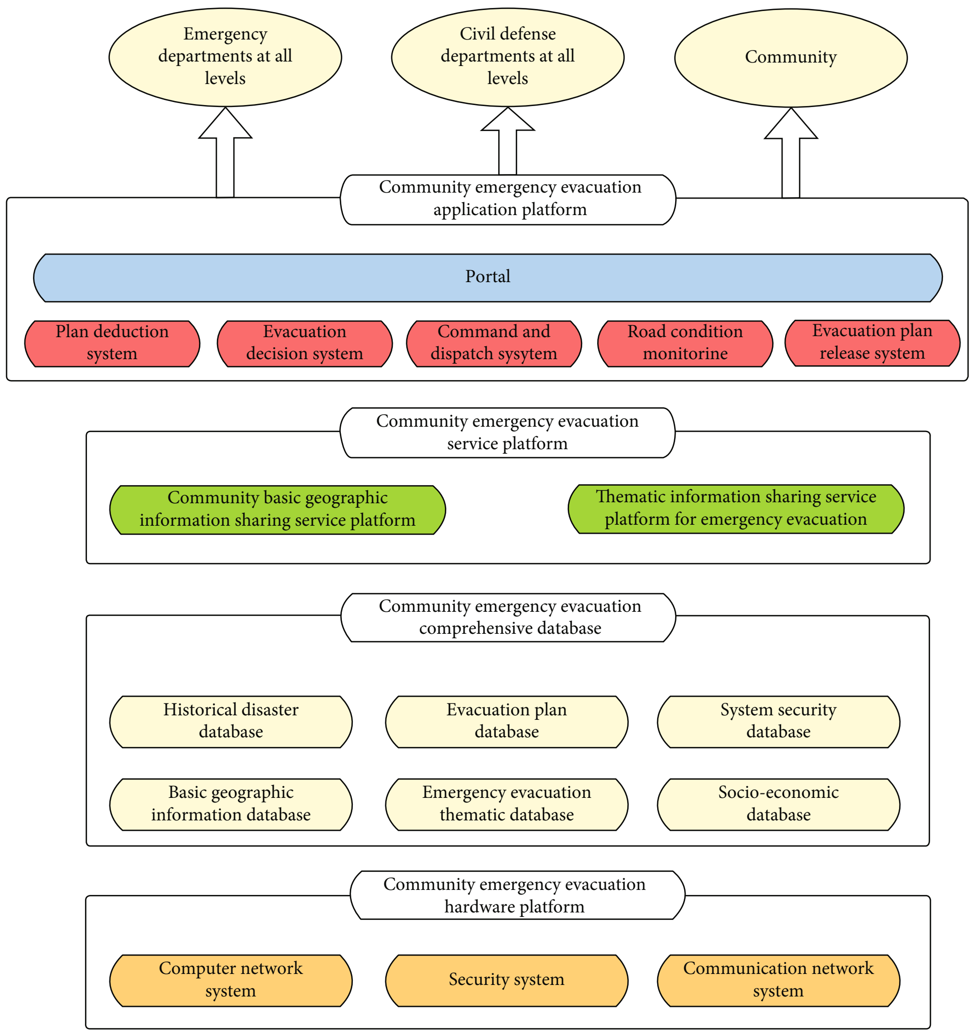

Figure 2: Community emergency evacuation GIS management system framework.

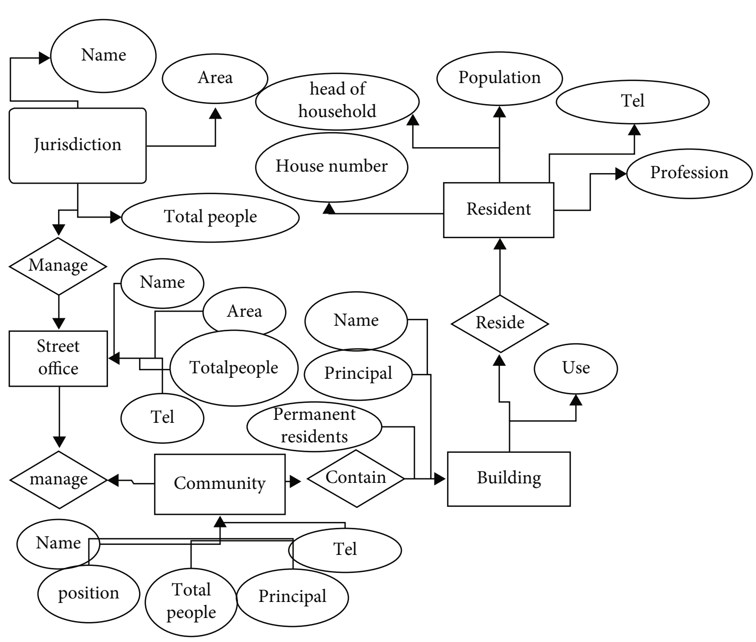

Figure 3: The E-R relationship of important entities in the community emergency evacuation GIS database.

Table 1: Community attribute table design.

Field name	Field type	Field length	Description
SmID	Long integer	4	Primary key
SmUserID	Long integer	4	Foreign key
Area	Double precision	8	Cannot be empty
SmJdID	Long integer	4	Foreign key
Name	Text type	50	—
Address	Text type	50	—
Total houses	Long integer	4	—
Total population	Long integer	4	—
Principal	Text type	20	—
Tel	Text type	20	—
SmSqID	Text type	20	—

Table 2: Design of building attribute table.

Field name	Field type	Field length	Description
SmID	Long integer	4	Primary key
SmUserID	Long integer	4	Foreign key
Area	Double precision	8	Cannot be empty
Perimeter	Long integer	8	Cannot be empty
SmSqID	Text type	4	Foreign key
Area	Long integer	50	—
Number of layers	Long integer	4	—
Total population	Long integer	4	—
Permanent residents	Text type	4	—
Principal	Text type	20	—
Tel	Text type	20	—
Use	Text type	50	—
SmJzWID	Long integer	4	Cannot be empty
SmYbID	Long integer	4	Cannot be empty
SmJzDID	Long integer	4	Cannot be empty

sends a request to the server, and the server processes the user request and transmits the processing result to the user in the form of pictures. This architecture client does not need to install any GIS plug-ins, and the network load is light. The client only needs to install a standard IE browser. The system adopts a hybrid system architecture combining C/S and B/S, giving full play to the advantages of C/S and B/S, and achieving complementary advantages.

The C/S and B/S hybrid architecture has the same database. In order to ensure the integrity and consistency of the database, users in the C/S mode are given the authority to manage the database, and ordinary users in the B/S mode only have the authority to query the database, at the same time, simple spatial analysis functions are realized by sending a request to the application server. This design model not only takes advantage of the strong spatial analysis capabilities and high security of the C/S model but also allows the majority of community residents to query and analyze the emergency evacuation information of the city they care about through the Internet.

Table 3: Comparison of community demographics and estimates.

	Statistical population	Estimated population	Error (%)
JinShan	38756	35011	-9.8
DaZheHu	32012	27915	-9.6
QiaoKou	5339	5771	30
BaiShaZhou	13468	13404	5.6
DingZiWan	14532	13331	-7.5
HuangJinYuan	5469	6003	6.4
XinKang	27956	25301	-8.7
ChaTing	33688	29876	-9.2

3.6. System Database Design. Database design occupies an important position in the construction of community emergency evacuation system. Database design directly affects system application, maintenance management, and data update. The content and structure of the database determine the quality and function of the system and directly affect the use of the system by users. Therefore, designing a database with a reasonable structure, rich attribute information, and strong current status is the key to determining whether the urban emergency evacuation system can provide effective auxiliary decision support information.

To realize the storage of GIS spatial data and attribute data in the spatial database requires a certain spatial data model and the design of spatial data model. The design of spatial data model includes conceptual model design, logical model design, and physical model design. The detailed steps of building the community emergency evacuation GIS database are as follows:

(i) Determine the entities in the urban emergency evacuation GIS database

(ii) Determine the attributes of each entity

(iii) Determine all connections between entities

(iv) Draw a spatial E-R diagram representing a solid unit

(v) Combine and optimize the spatial E-R diagrams of each unit

(vi) Transform the spatial E-R diagram into a data model acceptable to GIS software and RDBMS

(vii) Determine the storage method in the computer

It mainly includes the following: analysis of spatial database requirements, determining the relationship between geographic entities and entities to be expressed, logical expression of spatial entities, selecting appropriate data models, and organizing spatial data sets.

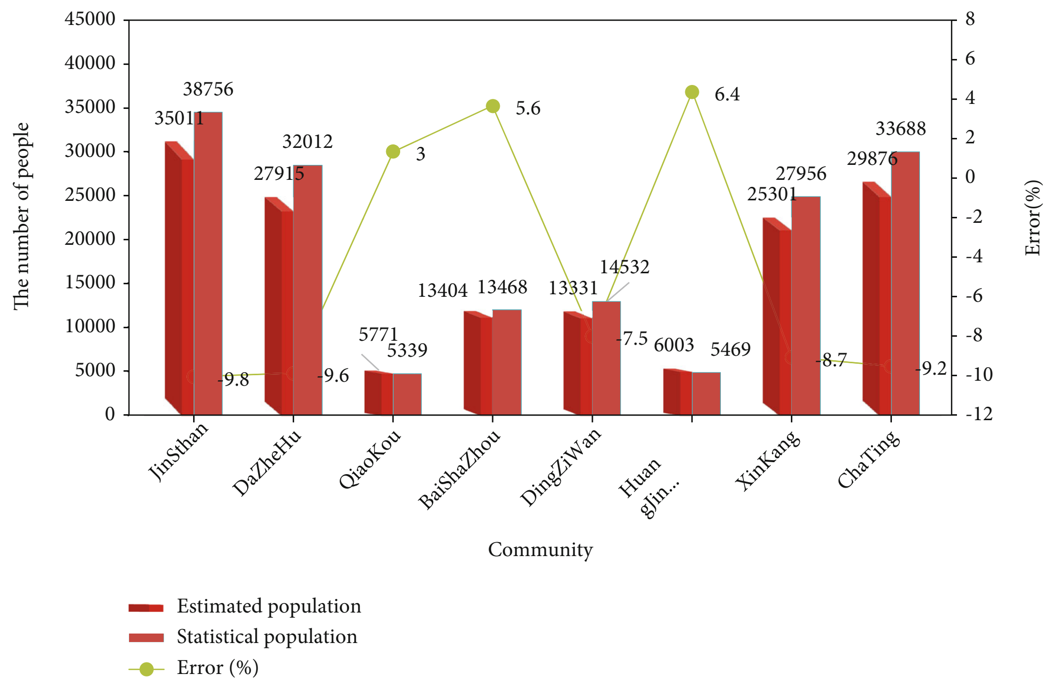

FIGURE 4: Comparison of community demographics and estimates.

TABLE 4: Adaptation system of different age groups.

	Reaction time	Evacuation time	Arrival time	Optimal path selection
0-18	3	4	8	0
18-38	2	3.5	7.5	3
38-58	2.5	4.5	8.5	5
58+	4	6	10	8

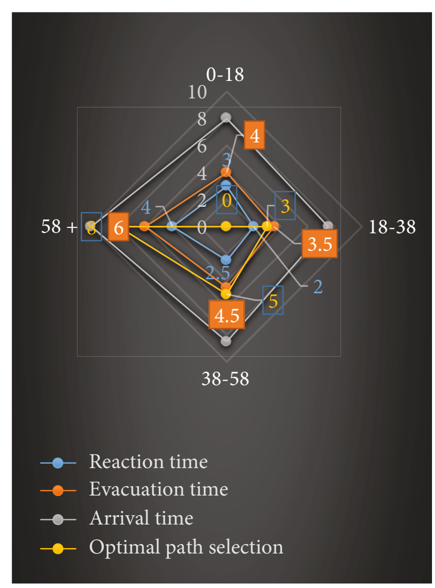

FIGURE 5: Adaptation system conditions of different age groups.

4. Organization and Realization of the Framework of Community Emergency Evacuation Management System Based on Location Services

4.1. System Framework Entity Modeling Expression

4.1.1. Express Conceptual Model with E-R Diagram. The database contains a series of entities such as jurisdictions, neighborhood offices, communities, buildings, households, and heads of households. These entities are related to each other. For example, a jurisdiction includes many neighborhood offices, a neighborhood office includes many communities, and neighborhood offices can only belong to one jurisdiction. Similarly, a community only belongs to one street office. Therefore, there is a one-to-many relationship between the jurisdiction and the street office and the street office and the community. Therefore, it is most appropriate to use E-R diagram modeling to express entity attribute information.

4.1.2. Supplement to the Logical Model Design of the System Framework. Logical data model refers to the description of the content and structure of data in the community emer-

TABLE 5: Group test results under different conditions.

	Reaction time	Decision time	Evacuation time	Arrival time	Injuries
A1	15	23	40	78	5
B1	8	11	28	57	0
A2	13	25	43	64	2
B2	7	10	30	47	0

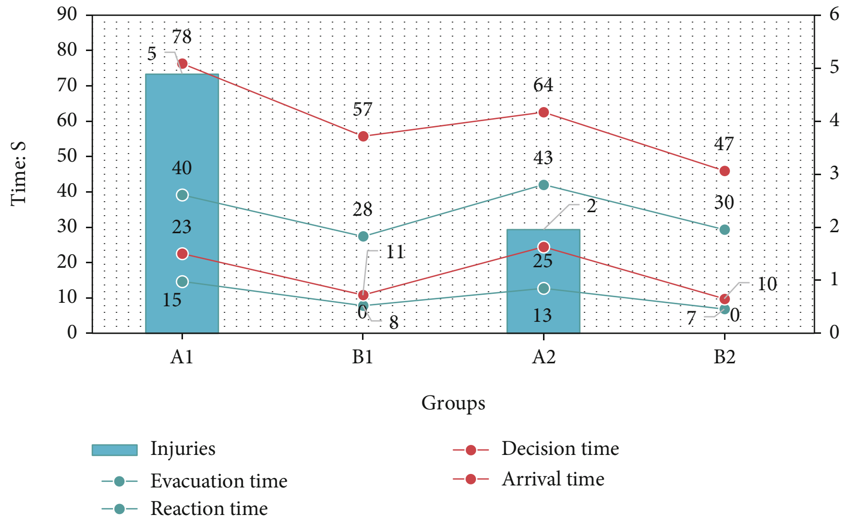

FIGURE 6: Group test results under different conditions.

gency evacuation database. It is the logical structure of data organization and the middle layer of data abstraction. This article uses relational data model to express the entities in the community emergency evacuation GIS database, as shown in Tables 1 and 2.

4.2. System Framework Application Test Analysis

4.2.1. Comparison of Population Statistics and Estimates by the System. Based on the data from the 2010 Statistical Yearbook of a certain city, this article exemplifies the population density of a certain city. Eight communities with accurate demographic data were randomly selected, and the demographic data of the community was analyzed and compared with the demographic data estimated in the article based on the use and area of the building. The comparison results are shown in Table 3 and Figure 4.

From Table 3 and Figure 4, it can be concluded that the system framework needs to be strengthened in calculation and analysis capabilities in practical application tests. The maximum estimation error of the data is -9.8%, and the minimum estimation error is 3%. The error between the estimated population data and the accurate population statistics data is within 10%. Judging from the error of the data, the estimated population is biased. There are two cases of overestimation and underestimation.

4.2.2. Comparison of Adaptability to Emergency Evacuation Management System of Different Age Groups in the Community. In order to test the adaptation of the emergency evacuation management system for people of different ages in the community, 10 people from 0 to 18 years old, 10 people from 18 to 38 years old, 10 people from 38 to 58 years old, and 10 people over 58 years old were randomly selected from a certain community. People are arranged to use the system in the same community for fire drills to evacuate from the community to the designated destination. The test data includes time-consuming reaction, time-consuming evacuation, time-consuming to reach the destination, and

TABLE 6: Group test results of different grades.

	Reaction time	Decision time	Evacuation time	Arrival time	Injuries
D1	12	26	31	63	2
D2	13	24	28	60	1
D3	10	25	32	61	1
D4	9	20	34	52	0
D5	9	19	28	48	0
D6	8	21	30	45	0

the number of evacuation persons who choose the optimal route. The test data results are shown in Table 4 and Figure 5.

As shown in Table 4 and Figure 5, it can be seen that the reaction time-consuming ratio is in order 18-38 years old>0-18 years old>38-58 years old>58 years old and over; the evacuation time-consuming order is 18-38 years old>0-18 years old>38-58 years old>58 years old; the order of arrival time is 18-38 years old>0-18 years old>38-58 years old>58 years old; the number of optimal route selections is 58 years old above>38-58 years old>18-38 years old>0-18 years old. From the data results, young people are better than the elderly in terms of reaction time, evacuation time, and arrival time because of their good physical fitness. However, the most people who choose the optimal route are the elderly, especially those over 58 years old. In this fire drill, 8 people chose the best route to reach the designated destination. In summary, young people are more adaptable to the emergency evacuation management system, and the elderly are less adaptable to the emergency evacuation management system except for choosing the optimal path. This is also the place where the emergency evacuation management system needs to be strengthened later.

4.2.3. Comparative analysis of community emergency evacuation management system testing. After the design of the community emergency evacuation management system,

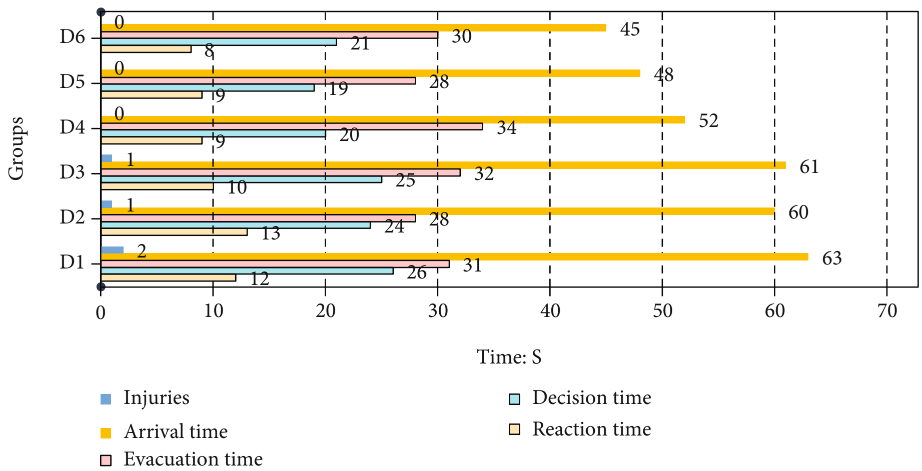

Figure 7: Group test results of different grades.

it is necessary to carry out actual test analysis, that is, the test uses the system and the unused system to compare with each other to find out whether the community emergency evacuation management system has an impact on the community's emergency evacuation work. This article takes a city's elementary school as an example, takes teachers and students as the experimental objects for test analysis and comparison, divides the 6th grade teachers and students into four groups, each with a fixed number of 60 people, and conducts the first round of grouping in the same teaching building on the same floor. Specific grouping situation is as follows: A1 group type is unused system and no advance notice; A2 group type is unused system and advance notice; B1 group type is used system and no advance notice; and B2 group type is used system and advance notice, test data including time-consuming evacuation (time-consuming to reach the flat ground on the first floor of the teaching building), time-consuming decision-making, time-consuming response, time-consuming destination (time from the teaching building to the playground), and the number of injured. The specific situation is shown in Table 5 and Figure 6.

It can be seen from Table 5 and Figure 6 that the data difference between using and not using the community emergency evacuation management system is still quite large. Among the number of injured, 5 people were injured in group A1, no one was injured in group B1, 2 people in group A2 were injured, and in B2, no one was injured in the group; the fastest response in the reaction time was 7 s in group B2, followed by B1, A2, and A1; the first two groups with the fastest decision time were also B1 and B2; the longest evacuation time was A2 Group, followed by group A1, B1, and B2 are the shortest; the fastest time to reach the destination is 47 s in group B2, and the slowest is 78 s in group A1.

In summary, it can be concluded that the emergency system can organize personnel to evacuate to the designated evacuation area in the fastest time. Most groups that do not use the emergency evacuation management system waste a lot of time, whether it is to withdraw from the teaching building. Or the command is unreasonable and unscientific. Regardless of whether the group is notified in advance, it is still much slower than the group that has used the system, which further confirms the importance of the community emergency evacuation management system. Time is of the utmost importance for emergencies. The fastest time to make the most correct decision is the assistance of the emergency evacuation management system.

In the second round of grouping, teachers and students in grades 1 to 6 use the system as experimental objects to test whether teachers and students of different grades have an impact on the work of the emergency evacuation management system. They are divided into 6 groups by grade: D1 group (grade 1), group D2 (grade 2), group D3 (grade 3), group D4 (grade 4), group D5 (grade 5), and group D6 (grade 6); test data includes evacuation time (arriving to the teaching building) time-consuming on the ground floor on the first floor, time-consuming decision-making, time-consuming response, time-consuming destination (time from the teaching building to the playground), and the number of injured.

It can be seen from Table 6 and Figure 7 that the time to reach the destination in different grades can be divided into two types, one is the slower time to reach the destination in grades 1 to 3, and the other is the time to reach the destination in grades 4 to 6. The time of evacuation, reaction time, and decision-making time is relatively fast, and it can be seen from the number of injured that only the students from grades 1 to 3 were injured, and there were no injured students from grades 4 to 5; evacuation time, reaction time, and decision-making time after using the system time data to the sixth grade are very close, indicating that the system's auxiliary support for decision-making can help decision makers make scientific and reasonable suggestions. To sum up, because the physical fitness of the lower grades is significantly lower than that of the upper grades, the experimental data has a large deviation in the time of arrival at the destination. Therefore, it can be concluded that the lower and upper grades of the experiment will not affect the emergency evacuation work.

5. Conclusions

The acceleration of the urbanization process has led to the continuous construction of new urbanized communities, and the high concentration of community population has made the safety of the community gain more attention. New urbanized communities have the characteristics of both urban and rural communities. They are densely built, complex in structure, large in personnel flow, difficult in management, generally weak in disaster-bearing capacity, and have difficulties in the evacuation of people after a disaster, which are one of the difficulties in urban governance. Therefore, it is very important to design an evacuation management system that can help decision makers make emergency responses in the face of emergencies.

This paper applies location-based GIS technology, database technology, application model technology, network technology, component technology, and platform building technology to the community emergency evacuation process and realizes the model expression of each link of community emergency evacuation. Combined with the successful development of the community emergency evacuation management system framework, good simulation results have been achieved. This article mainly completes the following aspects: (1) research on the related theories, practical applications, and technologies of GIS technology based on location services. The concept of emergency evacuation is explained, and the characteristics and principles of emergency evacuation are summarized; (2) established a service integration method of GIS and application models; and (3) put forward the goal of emergency evacuation system construction, established development principles, designed the overall framework of the system, proposed a subscale and layered spatial data organization method, described the thematic elements of community emergency evacuation with E-R diagrams, design the main entity attribute table, and design the system structure and functional category composition.

Emergency evacuation is a very systematic work. When an emergency occurs, whether the decision of the decision-making department is scientific and reasonable is related to the success or failure of emergency evacuation. Therefore, improving the scientific and reasonable decision-making of community emergency evacuation is to reduce the loss of people's lives and property.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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