# Digital Technology in the Field of Emergency Response in China

Xiaoguang Li[a,*], Shiji Wang[b]

Changchun Institute of Technology, Changchun, China

[a]lixiaoguang52038@126.com, [b]wangshiji271@163.com

**Abstract.** This paper discusses the application status of digital technology in the fields of risk early warning, emergency plan, emergency drill, emergency material management, emergency response and rescue, emergency communication and emergency personnel training in China, analyzes the research progress in various fields, points out the problems existing in the application of digital technology in the field of emergency, and finally looks forward to the key direction of digital technology to improve emergency response capacity. The research results of this paper can promote the deep integration of digital technology into the emergency field.

**Keywords:** digital technology; risk; emergency

## 1 Introduction

Under the background of the continuous advancement of modern information technology, the application of digital means in the field of emergency response has become more and more common. It has greatly improved the accuracy and timeliness of risk early warning and the efficiency of emergency management. At present, it has become an important force to promote the modernization of disaster and safety risk early warning and emergency management. However, the application of digital technology in the field of emergency also faces some challenges and problems. This paper aims to summarize the application status of digital technology in China 's risk early warning, emergency plan, emergency drill, emergency material management, emergency response and rescue, emergency communication and emergency personnel training, analyze the research progress in various fields, and explore the problems and challenges. Finally, the key research directions of digital technology in the field of emergency are prospected.


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# 2 Application of Digital Technology in Emergency Field

## 2.1 Risk Early Warning Application Aspects

Risk early warning aims to identify and assess potential risks in a timely manner by collecting, analyzing and integrating relevant data and information, and using professional risk assessment models and methods, and take corresponding measures to reduce or avoid risk impacts. Digitization technology can significantly improve the accuracy and efficiency of risk early warning. By integrating and analyzing data, valuable content can be extracted from a large amount of information. The establishment of intelligent and automated early warning system can realize real-time dynamic early warning and monitoring.

Sun et al. [1] (2010) constructed a risk early warning system based on fuzzy comprehensive evaluation and dynamic fuzzy neural network technology to predict accidents that may be caused by major hazard sources. Yuhang District Emergency Management Bureau [2] (2020) uses the ' urban brain + intelligent safety supervision ' system, integrates big data and Internet of Things technology, and builds an accident prevention application system, which effectively improves the intrinsic safety level of Yuhang District. Zhang [3] (2022) proposed an automatic generation method of geological disaster risk early warning product description information based on GIS technology. Zhang et al. [4] (2023) proposed a fire risk intelligent perception early warning method based on big data technology. Chen [5] (2024) explored how to use power big data to monitor the operation status and power load of power grid in real time in emergency management, and how to improve the accuracy and efficiency of disaster warning.

## 2.2 Application of Emergency Plan

Emergency plan is a pre-planned action plan to deal with emergencies. It has the key characteristics of scientific, systematic, comprehensive, customized, flexible, rapid response, compliance, dynamic management, clear organization and command, risk assessment and resource investigation. They need to be formulated according to law, approved and filed, and regularly evaluated and revised to adapt to changes. Through information management, digital emergency plan can significantly enhance the practicability of emergency plan and improve the response speed in emergency.

Liu et al. [6] (2009) designed a storage strategy for digital power emergency response plans using an ontology-based knowledge expression framework. Yao [7] (2011) deeply studied the digital technology of railway emergency plan. Zhang Ying et al. [8] (2014) focused on the key digital technology of earthquake emergency plan, discussed the formal expression and digital coding strategy of the plan, and analyzed how to effectively integrate the digital system of earthquake emergency plan with other related emergency response systems. Based on the digital concept, Wang Jingjing et al. [9] (2018) proposed a method of structured decomposition of emergency plans and a process-based technical implementation plan. Lin Lin [10] (2019) designed an efficient and practical emergency plan information system construction scheme for the construction party of rail transit construction projects and contractors involved in construction and supervision,

based on the advantages of structured and digital technology, from a technical point of view.Cui Hao [11] (2019) designed and implemented a digital management platform for public security emergency plans. Wang Pu et al. [12] (2020) proposed a method combining ontology and deep learning for the digital management of high-speed railway emergency plans, aiming to improve the response efficiency and implementation effect of the plan. Feng Jiarui [13] (2021) carried out research on the digital theory and practice of emergency plans for construction projects. Xu Haiyao [14] (2021) carried out digital research on airport emergency rescue plans. Xu Xiangsong et al. [15] (2022) designed a digital emergency management process optimization strategy for complex scenes in emergency situations. Yan Shiju et al. [16] (2023) systematically studied the digital platform of network security emergency plan in railway business environment based on modular design and machine learning technology. In order to break through the bottleneck of traditional emergency plan formulation, Yang et al. [17] (2023) explored the application of digital technology to improve SEIR model in emergency plan formulation. He et al. [18] (2024) studied the key technologies of digital emergency plan for rail transit operation.

### 2.3 Application of Emergency Drills

Emergency drill is a kind of practical activity to simulate real emergency events, which aims to test and improve the preparation level and response ability to deal with emergencies. It includes the testing of contingency plans, the validation of emergency response processes, and the training and coordination of emergency personnel. Emergency drills include both simulated desktop exercises and field simulation exercises. Digital technology can improve the authenticity of emergency drills, enhance the repeatability and scalability of drills.

Zhang Qingsong et al. [19] (2015) developed a drill method for civil aviation emergency events based on geographic information system, which manages the emergency drill process through visual means, and establishes a spatial database of airport emergency rescue to digitally manage emergency resources. Wang Jianing et al. [20] (2021) introduced the application of sensory digitization in food quality detection and the application of virtual reality technology in emergency drills. Xu Haiyao [21] (2021) developed an airport emergency rescue virtual drill platform with the support of Unity 3D engine. Pan et al. [22] (2023) designed a set of digital system for combined transportation of spent fuel that can effectively assist emergency drills.Guo Xingyuan [23] (2023) developed and designed a simulation platform for fire accident simulation exercises based on mixed reality technology relying on hydropower station generating units. Lv Nan et al. [24] (2023) designed a virtual emergency drill platform architecture for urban rail transit dispatching based on the existing traffic dispatching command architecture. Ling et al. [25] (2023) introduced the gas station simulation emergency drill system developed and applied by Jiangsu Expressway Energy Development Co., Ltd.based on advanced technologies such as mobile Internet and virtual reality. Zhou et al. [26] (2024) simulated the whole process of super-standard flood defense in the Cao 'e River Basin based on the digital platform of ' Cao 'e River Digital Twin Basin '.

### 2.4 Application of Emergency Material Management

The management of emergency materials covers the comprehensive management of the planning, purchase, storage, distribution and application of materials before and after the occurrence of emergency events. It involves the classification of materials, inventory management, demand forecasting, deployment strategy and other aspects, to ensure that in emergency situations can quickly and effectively provide the required materials, reduce disaster losses, protect people 's lives and property safety. The application of digital technology in emergency material management can improve the management efficiency and accuracy, enhance the response speed, and realize the whole life cycle management of materials.

Zhou Wei [27] (2018) developed an emergency rescue material management system based on radio frequency identification technology. Fang Jiaqi et al. [28] (2018) designed the emergency and peacetime integration mechanism of digital reserve management of emergency materials based on analytic hierarchy process. Li Li [29] (2018) conducted an in-depth study on the material reserve of emergency medical rescue teams for public emergencies. Li Qing et al. [30] (2021) constructed time-varying demand and Bayesian sequential decision-making emergency material demand forecasting models based on the infectious disease model in the context of the new coronavirus epidemic. Xu Degang et al. [31] (2021) applied the optimized fireworks algorithm to the emergency scheduling of medical supplies. This method is faster and fairer than the traditional medical material allocation method. Zhao Qingkai [32] (2021) carried out risk monitoring, early warning and research on the key links of the whole supply chain of power grid materials, and developed a power grid material plan control and early warning platform. Luo Xuliang et al. [33] (2022) developed a digital management system for emergency package materials in view of the imperfect emergency package management of power grid companies.

### 2.5 Emergency Response and Rescue Applications

Emergency response and rescue refers to a series of emergency actions taken to protect people 's lives and property and reduce disaster losses when emergencies or disasters occur. The role of digital technology in emergency response, emergency decision-making, emergency rescue and emergency dispatch capabilities is multifaceted, covering the whole process from technology empowerment to system reshaping. Digital technology not only improves the speed and accuracy of emergency response, but also improves the level of decision-making and command.

Feng [34] (2017) developed an earthquake emergency classification response information system based on GIS. Zhang [35] (2019) developed an emergency rescue command and management system based on SpingMVC. Yang Jixing et al. [36] (2023) developed a set of digital combat system for emergency rescue with reference to the construction concept of military tactical network and cutting-edge technology. Zhao Hongwei et al. [37] (2023) designed a digital emergency command system for public emergencies. Fan Baitao et al. [38] (2024) introduced the digital well control system of CNOOC 's offshore well control emergency rescue in detail, and pointed out that for

the well control problem that the overflow is not found in time, it is necessary to further establish an intelligent well control barrier.

### 2.6 Emergency Communication Applications

Emergency communication is a special communication mechanism. It is enabled when natural disasters or man-made emergencies occur. By integrating various communication resources and technologies such as wired, wireless, satellite and cluster, it temporarily establishes communication connections to respond to emergency needs. This mechanism has the temporary characteristics of responding to emergencies and is specifically used to deal with the communication needs during emergencies. Digitization technology can improve the efficiency of emergency communication, enhance the resilience of communication network, realize data sharing and business collaboration.

Chen Gang [39] (2016) developed a digital emergency broadcast communication system in coal mine. Dong Qingyu [40] (2023) proposed the construction measures of digital mode in fire emergency communication, including strengthening the construction of digital infrastructure, promoting digital communication technology, and establishing digital mode emergency plan. Deng et al. [41] (2023) discussed the demand, technical implementation and networking scheme of 5G customized network emergency communication. Ming Chaohui et al. [42] (2024) developed an integrated communication link erection scheme based on the ' emergency rescue digital battlefield ' platform.

### 2.7 The Training and Application of Emergency Management Talents

The cultivation of emergency management talents refers to the cultivation of talents with professional knowledge, skills and practical experience through education and training to cope with various emergencies and emergencies. Digital technology can improve the efficiency and effectiveness of education and training, promote the integration of interdisciplinary knowledge, strengthen the cultivation of practical ability, and optimize the allocation of educational resources.

Xu Wei et al. [43] (2023) deeply explored the training path of emergency management talents in colleges and universities from the perspectives of digital technology, digital tools and digital platforms. Wei Linshan [44] (2024) proposed the training path of emergency management professionals in colleges and universities under the digital background from the aspects of top-level design, talent training program, practical activities and teaching staff. In the process of studying the construction path of safety emergency specialty group in higher vocational colleges, Wang Yanhua et al. [45] (2024) put forward the implementation of " intelligent + " plan to accelerate the digital transformation and upgrading level of practice training, teaching resources and teaching reform.

In addition, many foreign scholars have also done in-depth research on the application of digital technology in the field of emergency. For example, Diana Fischer-Preßler [46] (2024) reviewed the application of digital technology in disaster management, and discussed the specific performance of digital transformation ( DT ) in disaster management ( DM ) from a theoretical perspective. Hakan T. Otal [47](2024) discussed how to

use large language model ( LLM ) to assist crisis management and build an advanced emergency response model.

# 3 Problems

## 3.1 Risk Warning

There is a ' data gap ', that is, insufficient data integration and sharing between different departments or systems, resulting in the phenomenon of ' data island '. This limits the effective use of cross-sectoral collaboration and data, affecting the accuracy and timeliness of risk early warning. In the actual use process, the supporting facilities of the digital platform have not been followed up. There are problems such as insufficient deployment points of the visual command system and insufficient bandwidth of the front-end equipment, which makes it difficult to support effective visual scheduling operations. This limits the effectiveness of digital technology in risk early warning.

## 3.2 Emergency Plan

The challenge of digital construction of emergency plans is that the quality of stock plans is not high and it is difficult to practice. In addition, there is a lack of a unified emergency plan database.

## 3.3 Emergency Drills

The hardware used in emergency drills is expensive and difficult to operate by multiple people.

## 3.4 Emergency Supplies Management

The existing emergency material management system may come from different suppliers, and there may be compatibility problems between them, which makes it difficult to achieve seamless integration and sharing of data. In addition, digital systems require regular technical updates and maintenance, which may involve high costs.

## 3.5 Emergency Response and Rescue

Social forces are an important supplement to the government 's rescue forces. If digital products cannot be well coordinated with the government 's rescue forces, there will be a disconnect and the rescue efficiency will be reduced.

In an emergency, the digital system must be able to resist a variety of external interference, such as network attacks, power outages, etc., to ensure the smooth flow of information transmission and command scheduling. This requires continuous technological innovation and the establishment of multiple backup and failover mechanisms.

### 3.6 Emergency Communication

Different emergency communications equipment and systems may come from different manufacturers, and there may be compatibility issues between them, making it difficult to achieve seamless communication and data exchange. When disasters occur, traditional communication infrastructure ( such as base stations, satellite communications, etc. ) may be destroyed, affecting the stability and reliability of emergency communications. In emergency communication, it is very important to protect the security and confidentiality of transmitted data. The application of digital technology needs to ensure that data is not unauthorized to access or tamper during transmission. In an emergency, the surge in demand for communications may lead to network congestion, affecting the timely delivery of information. Emergency communication equipment needs to be able to quickly deploy and adapt to different environmental conditions. The application of digital technology needs to take into account the portability and rapid construction capabilities of the equipment.

### 3.7 Emergency Personnel Training

The construction of digital teaching resources and platforms is insufficient. Colleges and universities need to build digital emergency professional teaching materials and teaching resources platforms. However, the construction of these resources and platforms is still insufficient and needs to be accelerated and improved. The innovation of teaching means and methods is insufficient. The digital transformation of education depends on the digital ability of teachers. Some teachers will not actively try to use digital resources to carry out teaching, which hinders the cultivation of digital emergency talents. Emergency professional education has interdisciplinary attributes, which needs to combine medicine, psychology, communication, computer, engineering and other disciplines, which puts forward higher requirements for digital teaching mode, and needs to explore how to effectively integrate these interdisciplinary resources.

## 4 Conclusion

With the continuous advancement of digital technology, the emergency field is ushering in a profound change. In the future, the research and practice of digital technology in the field of emergency should focus on the following key directions.

- With the development of the new generation of information technology, the identification and assessment of unconventional and unknown risks will become an important task in the development of intelligent emergency. This involves the use of digital technology for early identification and early warning of risks, and improving the foresight and initiative of emergency response.
- Further promote the integration of digital technology and professional emergency technology, such as the digitization of rescue equipment, as well as fire robots, excavators, and drones that integrate AI technology, so that they have self-learning, self-adaptive, and self-lifting capabilities.

- Based on digital technology, a set of digital battlefield system for emergency rescue is constructed, which aims to improve the ability of communication support, on-site monitoring, decision support and command coordination, so as to realize the scientific, efficient and accurate rescue operation.
- Study the key technologies of resilient cities, build a resilient guarantee platform, and improve the city 's ability to cope with disasters.

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