Application and Development of Artificial Intelligence in Emergency Logistics: Taking Earthquake Rescue as an Example

Chao Liu[1,*] and Yixiang Zhu[2]
[1]School of Economics and Management, Hefei University, Hefei ,230601, China
[2]School of Management Engineering, Xuzhou University of Technology, Xuzhou, 221111, China
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Abstract: Since the beginning of the 21st century, to better ensure the livelihood of residents in earthquake-stricken areas, how to improve the efficiency of the emergency logistics system has become an increasingly important issue in the academic circle. In this paper, artificial intelligence algorithms, cloud computing, Internet of Things and other technologies in earthquake rescue cases in different regions are studied. While fusing various schemes, the technical route of this research always adheres to the principle of people-oriented. The conclusion of this study indicates that, with adequate information guarantee and appropriate selection of schemes, the benefits brought by new technologies such as artificial intelligence to emergency logistics are very significant.The significance of this research lies in providing a practical and technologically advanced framework for enhancing emergency response capabilities, thereby minimizing human and economic losses during disasters. Furthermore, it offers valuable insights for policymakers and disaster management agencies to optimize resource allocation and improve coordination efficiency in future earthquake rescue operations. Additionally, this study underscores the transformative potential of integrating cutting-edge technologies like AI and IoT into humanitarian logistics, setting a benchmark for innovation-driven disaster resilience strategies.

1 INTRODUCTION

Since the dawn of the 21st century, human society has been rapidly advancing while concurrently confronting the repercussions of natural disasters. A crucial practical challenge that has emerged is how to safeguard the livelihoods of residents in disaster zones during such events, particularly with regard to leveraging emerging technologies to enhance the efficiency of emergency logistics.

Looking back on history, during the early exploration phase spanning from the mid-20th century to the late 20th century, computers were initially utilized for processing seismic data, yet they were not effectively integrated. Subsequently, in the sluggish development phase from the early 21st century to 2010, emphasis was placed on the collection and organization of earthquake-related data, and basic information management systems started to be implemented in earthquake emergency responses. However, the application of artificial intelligence (AI) technology in emergency logistics was relatively limited. Moving into the rapid development phase from 2010 to 2020, scholars began to focus on optimizing earthquake emergency logistics through AI. Gradually, AI technology was introduced into the field of earthquake emergencies, albeit mostly remaining at the stages of theoretical research and experimentation.

Currently, as technologies such as deep learning, big data, and the Internet of Things continue to evolve and converge, artificial intelligence (AI) is increasingly integrating with GIS, GPS, IoT, big data, and other technologies. Consequently, intelligent decision support systems are also maturing, and AI is offering more robust technical support for various aspects of earthquake emergency logistics. Nevertheless, emergency logistics still encounters numerous challenges, with the most pressing issue being high costs and low efficiency, necessitating urgent measures to reduce costs and enhance efficiency.

Specifically, at present, there have been many research and achievements in earthquake and

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* Corresponding author

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emergency logistics, but there is still room for discussion in the cross-field of artificial intelligence. Therefore, the main content of this paper is to focus on agility and promote the integrated application of artificial intelligence and traditional emergency logistics. In short, it is to comprehensively analyse the specific situation of earthquake rescue cases in different regions, adhere to the people-oriented concept, better integrate traditional emergency logistics with new technologies such as artificial intelligence, cloud computing and Internet of things, and improve the comprehensive ability of emergency logistics, so as to better respond to earthquake disasters.

The purpose of this study can be divided into two aspects: Theory and reality. In terms of theory, the research aims to fill the gap between the theoretical basis and the target field and lay the foundation for subsequent research. In terms of reality, we hope to help social organizations, enterprises and institutions, and organs better apply emerging technologies such as artificial intelligence to the field of emergency logistics, so as to better respond to frequent natural disasters, improve rescue capabilities, and protect people's lives and property.

2 CASE ANALYSIS

The core viewpoint of this article is that "the application and development of artificial intelligence in emergency logistics can be reflected in different regions and environments." According to the characteristics of different regions, people can combine artificial intelligence and other new technologies with traditional emergency logistics to reduce costs and increase efficiency.

Cost reduction and efficiency improvement can be broken down into cost reduction and efficiency enhancement.

In order to improve efficiency, this study found the following commonalities after interpreting different literature: First, the level of data acquisition and analysis, and evaluation in disaster areas is limited, which makes it difficult to formulate plans. Second, the decision-making strategy is not perfect enough and performs poorly when facing an uncertain environment. Third, problems such as insufficient transportation capacity are caused by limited equipment selection and insufficient development of usage methods.

First of all, an algorithm suitable for the mobilization of emergency supplies is necessary. Li's research proposes an emergency logistics resource scheduling algorithm in the cloud computing environment, called Emergency Supplier Distribution Mobile Edge Computing (ESD-MEC), to address the dual constraints of where to store emergency logistics equipment and where to dispatch rescue vehicles(Li, 2024). This method uses road transportation for local delivery. Suppliers can obtain information and manage data in the emergency supplier management system. The cloud computing platform allocates and calculates a large amount of data in densely populated areas through multiple MEC servers and uses these to strengthen the connection among all emergency logistics network nodes and reduce costs, minimizing time expenditure and transportation costs. With the algorithm, practical data is needed. The research of Ding et al. proposed an earthquake emergency logistics technology system based on Internet of Things (IoT) technology. It can realize the systematic application of Internet of Things technology in all stages of earthquake rescue (Ding, Zhao and Li, 2020). In this way, various devices can better obtain and exchange information with the help of the Internet of Things. For example, through RFID technology, inventory can be visualized, and when performing allocation tasks, it can be quickly located and accessed, facilitating subsequent management and allocation. Sorting out the information is as important as conducting a preliminary analysis. The research of Cao proposes to achieve intelligent and flexible disaster management by using AI for Smart Disaster Resilience (AISDR) technology(Cao, 2023). For example, Remote Sensing (RS) technology (satellites, unmanned aerial vehicles, etc. can be used as shooting equipment) and combined with autonomous visual recognition AI models to analyse the disaster situation in the disaster-stricken area, such as water pollution, air pollution, damage to ground buildings and road conditions, etc. When the situation in the disaster-stricken area is not fully understood, RS technology can make up for some deficiencies and help decision-makers sort out the complex information as much as possible to assist in making wise decisions. As for decision-making, although traditional centralized systems can process all information centrally, they may not respond promptly in the face of unexpected situations due to overly long chains. The research of Han proposed the Distributed Vehicle Routing Algorithm (DVRA), each vehicle in the system has the ability to collect, identify information and make decisions, meeting approximately 70.7% of the demand and achieving about 95% of the optimal solution target. Compared with the centralized system, this distributed system can better cope with the uncertainties on site(Han and

Jeong, 2025). This technology not only makes the means of information acquisition more abundant, but also decentralizes the decision-making power, which greatly reduces the possibility of losses caused by the failure of the centralized system to respond to sudden changes. Since the decision is made, appropriate equipment needs to be selected to perform the task. For example, if materials are transported only by vehicle, they will not only be subject to road conditions but also make the management of materials of different emergency degrees and natures chaotic and unable to be sent to the needed areas in time, resulting in irreparable consequences. Edwards et al. 's research mentioned that using drones to transport light and small emergency supplies such as vaccines and water purification tablets can compensate for part of the ground capacity when it is insufficient, reducing the pressure on ground work (Edwards, Subramanian and Chaudhuri et al, 2024). In this way, ground transportation capacity such as vehicles can concentrate on transporting large and heavy materials such as food, tents, emergency furniture, and mechanical equipment, which is expected to reduce the possibility of casualties caused by the untimely transportation of emergency materials, and lower the damage rate and distribution difficulty of materials during transportation due to the mixture of sizes and types. In addition, it is also very important to prepare a method that can improve the deployment efficiency of emergency materials and optimize the routes. Yang et al. 's research proposed Optimization of a Two-Stage Emergency Logistics System considering public psychological risk perception under earthquake disaster. Particle Swarm Optimization (PSO) is used to improve the Sparrow Search Algorithm (SSA) to further solve the model (Yang and Zhang et al, 2024). This study takes public psychological risks into account. Considering the urgency and the inability to complete the optimal deployment in the first place, the method of deploying first and then optimizing was adopted, which minimized the psychological and physiological losses of the affected people.

In terms of cost reduction, it might be that the rescue workers made a wrong prediction of the demand in the disaster-stricken area, resulting in the input of the wrong types or quantities of resources and causing waste. It could also be due to improper site selection or excessive reliance on government rescue, resulting in excessively high costs. The research of Lin et al. mentioned a method for earthquake emergency medicines based on Gradient-Boosting Decision Trees （GBDTs) and Attention-Free Transformer and Long Short Term（AFT-LSTM), this model achieved an average absolute percentage error of 1.67% predicted by the benchmark test, an average square error of 4.6%, and a square correlation coefficient of 0.96, which are highly consistent with the actual number of affected people(Lin,Yan and Zhang et al, 2025). This model enables emergency relief supplies to be better distributed with the support of mathematical methods, reducing waste. Geng et al. ‘s research proposed an optimization plan for warehouse location selection and material allocation, considering the perception of disaster victims' pain under the collaborative rescue efforts of the government and enterprises. While reducing costs and increasing efficiency, it introduced the sustainable development concept of "people-oriented" into disaster relief work (Geng and Hou, 2021), reducing the waste of time and energy in transportation caused by improper location selection and lowering the possibility of excessive reliance on government rescue. Besides, the Post-Earthquake Emergency based on a multi-objective genetic algorithm based on adaptive large neighbourhood search proposed by Pu et al, Logistics Location-Routing Optimization Considering Vehicle Three-Dimensional Loading Constraints, in 20 instances, compared with multi-objective evolutionary algorithms, etc. It was significantly superior in 17 and 16 instances respectively. When averaging the mean and variance of 20 runs, this algorithm shows a larger average mean and a smaller average variance, indicating that its performance is superior to that of the comparison algorithm (Pu and Zhao, 2024). This plan can incorporate practical factors such as the physical conditions of vehicles into the site selection considerations, and it is also a very important part of cost reduction and efficiency improvement.

As for evaluating the implementation of the plan, the amount of loss is one of the important indicators to judge the success of this rescue. Akter et al. 's research mentioned the monthly and annual average nighttime light data collected through the visible and infrared imaging radiometer suite instrument as an alternative method for capturing non-economic welfare losses (Akter, Chairunissa and Pundit, 2024). At the same time, the assessment should also be combined with methods including but not limited to continuing to compare the living standards of the people in the disaster-stricken area and the establishment of the emergency logistics system before and after receiving disaster relief through objective detection equipment (such as visual recognition models + optical images for analysis), comparing with other similar disaster-stricken areas, and randomly interviewing the people in the disaster-stricken area. Such a series of operations can yield a relatively more objective and accurate actual effect of the plan implementation compared to a single method.

Certainly, when it comes to a specific rescue operation, it cannot be mechanically applied. Instead, it should be discussed in a classified manner based on the actual situation. For example, if there is a road available, use a car; if there is no road available, use a boat. When there is sufficient information, the route and materials are directly formulated without assessment; when there is insufficient information, assessment is conducted first and then the relevant plans are formulated. When the transportation capacity is sufficient, cost should be considered; when the capacity is insufficient, emergency supplies should be given priority.

3 ADVISE

Although the problems that emergency logistics needs to deal with are complex, they are often universal, so some suggestions are interchangeable.

3.1 Imformation Support

In order to make effective decisions, emergency logistics needs to obtain sufficient information support. This can be divided into two aspects: sufficient information and accurate information judgment. On the one hand, in order to obtain sufficient information, it is not only necessary to make full use of emerging technologies such as the Internet of things, cloud computing and unmanned aerial vehicles, expand the means and perspectives of obtaining information, and improve the ability to obtain information, so as to obtain more direct information. Moreover, it is necessary to give full play to the analysis ability of artificial intelligence to receive and screen relevant information obtained by traditional methods such as the Internet and offline communities to the greatest extent, so as to better eliminate the false and retain the true, and improve the ability and accuracy of obtaining indirect information. On the other hand, to make accurate information judgment, we should reasonably use artificial intelligence technology on the basis of existing information, establish big data model, and then analyse existing information combined with the basic situation of earthquake disaster, improve the accuracy of demand prediction, provide support for realistic decision-making, so as to make better decisions, speed up the efficiency of emergency logistics system operation, reduce unnecessary waste of resources, and achieve efficient operation.

3.2 People Oriented

During the operation of emergency logistics, personnel safety should be taken as the highest criterion, giving priority to the effect of rescue, and then considering the cost. On the one hand, this requires giving priority to saving lives and protecting survivors. In short, on the basis of rapid and scientific needs assessment, it comprehensively considers the concerns of vulnerable groups such as the elderly, the weak, the sick, the disabled and pregnant, and provides safe and reliable guarantee materials for the disaster area at the fastest speed, so as to reduce the chance of their secondary injury as much as possible and ensure the life safety of the affected people to the greatest extent. On the other hand, it also requires comprehensive consideration of the psychological care for the victims. To put it simply, on the basis of ensuring the supply of materials, we should respect the local cultural customs, give full consideration to the mental health of the victims, provide them with certain psychological counselling service, reduce their psychological pressure and trauma, and enable them to better come out of the shadow of the disaster. In addition, the materials for disaster relief are not unlimited, which requires the rational use of AI algorithm on the basis of ensuring the supply of materials, further optimizing the logistics location and logistics route, reducing costs, improving efficiency, and preserving strength for future recovery and reconstruction.

3.3 Feedback Optimization

Emergency logistics should have perfect means to obtain feedback in order to continue to improve. On the one hand, it needs to expand the sources of feedback and improve the multi-level and comprehensive feedback network. Specifically, it is not only possible to recruit local volunteers on the basis of setting up message areas and manual information collection points, conduct regular visits to survivors and rescue related personnel, collect the needs of different regions and different groups, and summarize and report them, so as to form a perfect offline network. In addition, a simple feedback website can be established and a smooth feedback telephone can be provided, so that relevant personnel can carry out online feedback in a timely and efficient manner. On the other hand, it needs to ensure the efficiency of feedback optimization. Specifically, we should not only establish and improve the tracking mechanism, submit the feedback to the relevant system, and the system will estimate the time required according to the specific situation, and automatically track the processing progress. Moreover, on the premise of protecting the privacy of relevant personnel and allowing the actual conditions, we can make full use of the Internet and artificial intelligence, comprehensively analyse the suggestions of external personnel and the opinions of internal personnel, optimize the logistics process as soon as possible, improve deficiencies and improve efficiency.

4 CONCLUSIONS

Through research, this paper found that the impact of the earthquake is diverse. Emergency logistics not only needs to deal with the economic and non-economic impact of the earthquake and its secondary disasters, but also needs to consider the psychological impact of equipment, roads, personnel and other complex issues. Therefore, in order to better apply artificial intelligence to the field of emergency logistics, we should combine artificial intelligence to comprehensively consider various problems caused by the earthquake, establish a model suitable for emergency material mobilization, optimize the demand forecasting method, and implement and evaluate the specific situation of the scheme.

The contribution of this paper is to make up for the gap in improving the efficiency of emergency logistics by organically integrating traditional emergency logistics with new technologies such as artificial intelligence, cloud computing and the Internet of things, focusing on agility and adhering to the people-oriented principle, which is conducive to the application of artificial intelligence technology to the field of emergency logistics by the government and relevant organizations, and better protect the safety of people's lives and property. There are still some problems in the current research, such as the imperfect model of emergency material mobilization and the incomplete analysis of the specific situation of earthquakes. Future research should further improve the emergency logistics processing model and improve the applicability and accuracy of the processing, combined with the relevant data of more earthquake-prone regions.

AUTHORS CONTRIBUTION

All the authors contributed equally and their names were listed in alphabetical order.

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