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Design and Development of Comprehensive Collaborative Dispatching and Disposal System for Urban Frequent Emergency

Xiangyu Zhang[a]

Xing He (Shanghai) Industrial Development Co., Ltd., Shanghai, China
[a]zhangxiangyu9910@163.com

Abstract: *Emergency rescue is currently the most critical supporting element in the development of human society. However, due to overly detailed departmental divisions, the collaborative handling of rescue needs across multiple departments has been hampered. Addressing these issues, this article designs and develops a comprehensive collaborative dispatch and disposal system for emergency response. This system consists of four modules that achieve coordinated scheduling of rescue forces through emergency demand collection, assessment, matching, and task generation. By effectively integrating different emergency rescue needs and coordinating the comprehensive emergency rescue linkage among multiple departments, this system enhances the timeliness and accuracy of emergency rescue operations.*

Keywords: *Frequent emergency, Coordinated dispatching and handling, Emergency rescue linkage*

1. Introduction

Data released by the China Fire and Rescue Bureau shows that in 2022, the national fire and rescue teams responded to and handled 2.092 million various emergency calls, mobilizing 224.72 million person-times of fire and rescue personnel, dispatching 4.013 million fire trucks, rescuing 168,000 trapped individuals, and evacuating 267,000 individuals in danger [1]. When it comes to emergency rescue, the priority of emergency vehicles' passage is often the first thing that comes to mind, and this is also the main focus of current research by scholars both domestically and internationally. Gedawy [2] plans optimal routes for emergency vehicles based on real-time updates of traffic congestion and travel time delays for social vehicles, utilizing the location information of emergency vehicles, and sends the route information to the traffic signal control system to implement feedback priority control. Djahel et al. [3] propose a method that combines adaptive and fuzzy control for route selection and signal priority, updating the specific forms of priority control in real-time, such as phase changes and route modifications, through the analysis of intersection congestion. Anand et al. [4] use onboard devices to obtain the location of emergency vehicles, match them with the dynamically planned optimal routes by the real-time emergency center, and simultaneously implement priority passage for emergency vehicles through the control of intersections along the route using proprietary protocols. Min et al. [5] consider the time-varying characteristics of traffic flow conditions, represent priority control and dynamic path planning as a quadratic programming problem, and propose an emergency vehicle control method based on time-reliable paths. Das et al. [6] consider potential bottlenecks in the mixed passenger and freight areas of emergency roads and design a priority control system and algorithm for emergency vehicles that can dynamically detour based on vehicle-to-vehicle communication. Unlike the above, Wu et al. [7] investigate the combination of lane-level emergency vehicle priority control and dynamic path planning in a vehicle-to-vehicle communication environment from a micro-perspective, while So et al. [8] study the priority control of emergency vehicles under fully automated driving conditions.

However, with the continuous aging of the population and the scale of urbanization, the demand for emergency services such as ambulance, fire, police, and rescue has also increased dramatically. Especially when multiple emergency needs are coupled, it is necessary to combine several rescue forces to form a joint rescue effort to complete the rescue task. After the 9/11 incident, developed countries represented by the United States have begun to effectively integrate rescue forces and achieve efficient rescue coordination through integrated dispatching. As a large country with routine emergency needs such as ambulance and fire rescue, China established the Ministry of Emergency Management in 2018, aiming to integrate rescue forces and meet emergency rescue needs. However, there are currently issues in the comprehensive coordinated scheduling and disposal of emergency rescue, such as scattered reporting of alarms, inability to comprehensively assess emergency events, ineffective collaboration among various emergency departments, and inability to guarantee the principle of minimizing the time for emergency tasks. These issues lead to the inability to form a joint force in emergency rescue, delaying and reducing the timeliness of the response.

2. System architecture

In response to the existing issues in current emergency rescue coordination, we have designed and developed an integrated collaborative dispatching and handling system for emergencies. This system consists of four main modules: an Emergency Alarm Comprehensive Access Module, an Emergency Event Assessment Module, a Task Generation and Support Module for Emergency Response, and a Comprehensive Evaluation Module for Emergency Handling Outcomes, as illustrated in Figure 1. Specifically, the Emergency Alarm Comprehensive Access Module consolidates alarm information and carries out filtering while extracting certain critical contents from it. The original alarm details, along with these extracted key elements, are then transmitted to the Emergency Event Assessment Module. This module conducts a comprehensive evaluation by incorporating data such as the distribution of emergency rescue forces and information from collaborating departments, thereby forming a complete alarm report. The comprehensive alarm report is subsequently forwarded to the Task Generation and Support Module for Emergency Response, which uses this information to formulate the final emergency tasks and distribute them to the relevant departments. Once the emergency tasks are completed, the system confirms their completion and compiles all the information related to the event for a comprehensive evaluation of the effectiveness of the emergency handling measures.

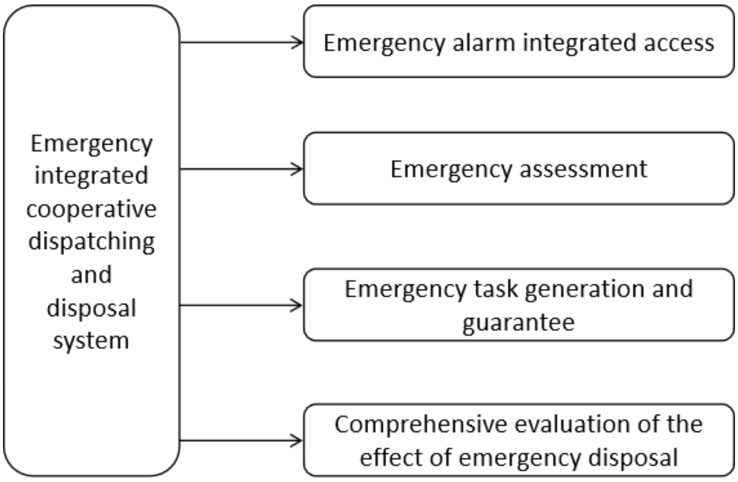

Figure 1: System architecture

3. Core functions of the system

3.1 Integrated access to emergency alarm and emergency event evaluation

(1) The alarm information input through various alarm methods includes both structured and unstructured data. Therefore, a combination of speech recognition, text information recognition, and manual recognition is adopted to extract the key content of the alarm information, converting the original alarm information into standardized structured alarm information data, as shown in figure 2.

(2) Among the structured alarm information data, the abnormal/invalid structured alarm information data is identified and processed. Abnormal/invalid alarm information includes continuous alarms of the same type multiple times, alarms from abnormal mobile phone numbers, the inability to extract valid alarm information, and silent alarms from phones, etc.

(3) The processed structured alarm information data is stored in the emergency event assessment module.

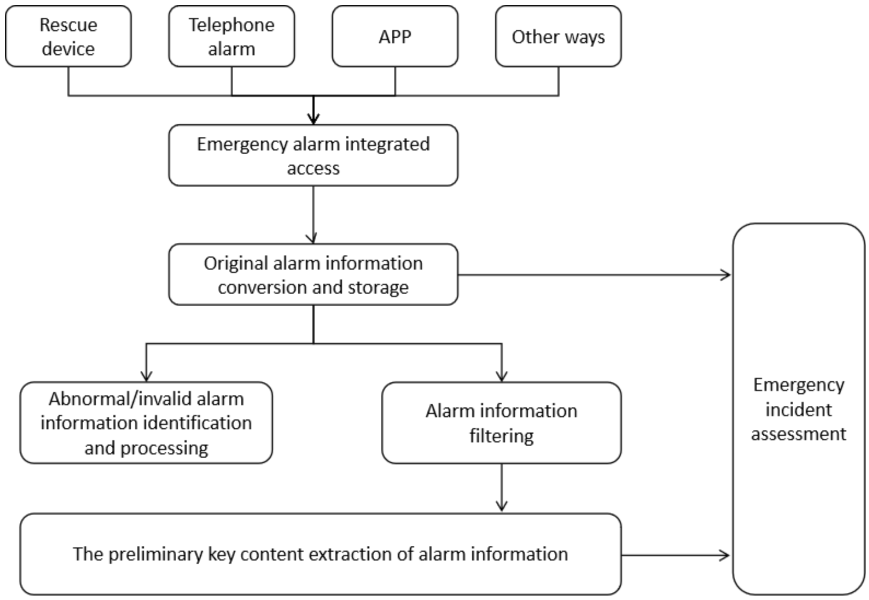

Figure 2: System business process 1

3.2 Emergency task generation and guarantee

(1) The complete alarm information generated by the emergency event assessment module will activate the generation of emergency tasks based on the content of the alarm information.

(2) The generated emergency tasks will be simultaneously sent to both the execution department and the support department. The execution department is responsible for organizing the response to emergency tasks, mobilizing rescue forces, and arriving at the scene to carry out rescue operations as quickly as possible. The support department is responsible for real-time monitoring of traffic conditions and ensuring the smooth flow of emergency vehicles along planned routes. This is primarily achieved by the traffic management section through traffic signal control, vehicle routing guidance, and other methods to ensure route safety, as shown in figure 3.

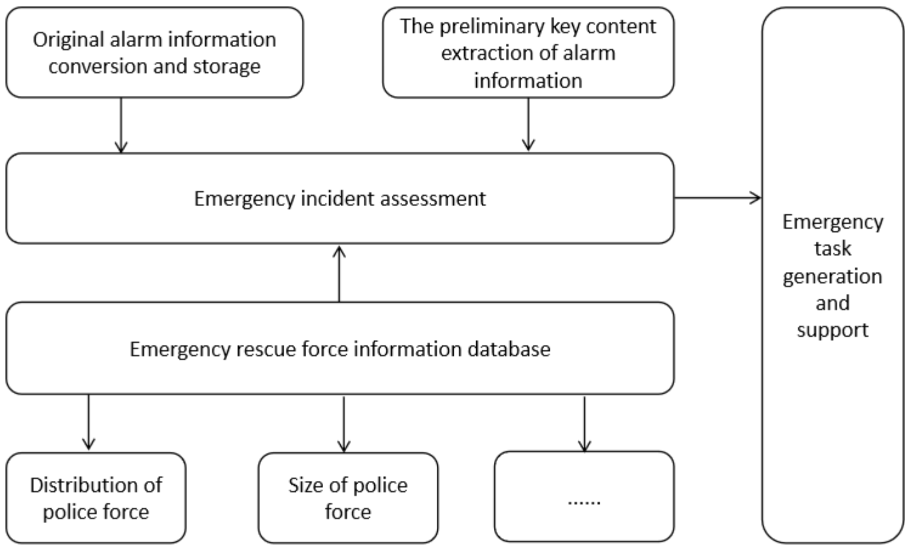

Figure 3: System business process 2

3.3 System display

The frequent emergency control brain can effectively integrate different emergency rescue needs, coordinate the comprehensive emergency rescue linkage of multiple departments, and improve the timeliness and accuracy of emergency rescue, as shown in figure 4.

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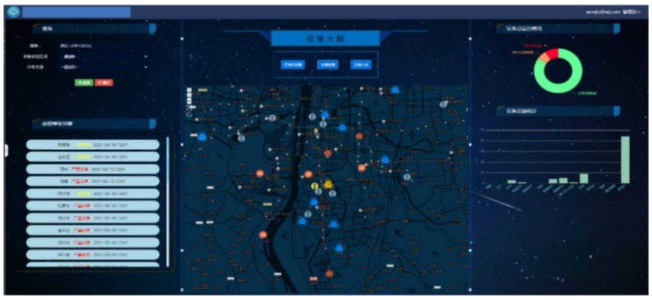

Figure 4: System display

4. Conclusion

This article takes into deep consideration the existing issues in current emergency rescue collaboration, and designs and develops a comprehensive collaborative dispatch and disposal system for frequently occurring urban emergencies. The system consists of four main components: comprehensive access for emergency alarms, emergency event assessment, generation and support of emergency tasks, and comprehensive evaluation of emergency response effectiveness. Through effective processing and information extraction of complex alarm information, the system can quickly assess and identify the matching degree between emergency needs and rescue capabilities, further generating comprehensive and collaborative emergency rescue tasks. This allows for the collaborative work of various emergency rescue forces. Given the increasingly widespread demand for emergency rescue in China, the system developed in this article will provide support for improving the timeliness and accuracy of emergency rescue operations.

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