Establishment and Research of Multi-agent Based Multi-Departmental Collaboration Model

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Abstract. In order to ensure the smooth operation of the city and the safety of residents, each city in China has established a sound emergency management system. However, with the frequent occurrence of various types of major emergencies, China's urban emergency management has also revealed a number of problems: departmental division, lack of unified command, low degree of information resource sharing, etc. These problems limit the emergency management system to play its role. Therefore, multi-sectoral collaborative emergency response in emergencies is an urgent problem in China's emergency management. In this paper, with the background of the earthquake in Luding County, Sichuan Province, on September 5, 2022, using Net Logo simulation software, a collaborative model in the earthquake is established, on the basis of existing research, with the help of Collaboration Theory, Multi-Agent Theory, etc. The information, resource and task collaboration in the process of earthquake emergency rescue is considered, and the modelling and simulation of multi-sectoral emergency response collaboration in earthquakes is carried out, which has a certain significance for guiding the earthquake rescue work and possesses certain guiding significance and practical value.

Keywords: Multi-Agent, Earthquake rescue, Collaboration, model Simulation

1 Introduction

Along with the rapid development of urbanization in the national region, more and more people are entering the city, which makes the frequency of sudden events such as governmental governance, environment, health and natural disasters increasing. Emergency response departments should make efficient use of limited resources, implement various preventive measures and disaster relief in a planned manner, and improve the ability of emergency response departments to deal with sudden events[1]. However, as a whole, the emergency management of urban emergencies in China still stays at a low level. The following two aspects are mainly reflected: the current departments are different in emergency management and programme selection, resulting in various types of emergency resources are difficult to be optimally configured, although there is a

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unified emergency command Centre, but it is still in the initial stage of construction, and the emergency information fed back by various departments cannot be fully utilized. In this paper, the operation process of each emergency department is studied, multi-Agent network and Net Logo simulation software [2] are used to analyze the cooperation and interaction between each emergency department, and the multi-departmental collaborative emergency response to urban emergencies is analyzed and studied, so as to improve the overall capacity of emergency rescue and emergency response. It provides reference to the on-site rescue activities of other emergencies, and also provides a scientific basis for emergency management [3].

2 Multi-Agent Theoretical Basis and Collaboration Model

Collaboration refers to the mutual cooperation of a group of subjects to complete a series of common activities. In the response to emergencies, the strength of synergy between departments has a great impact on the response effect, and different strengths of synergy in the rescue of the efficiency and capacity are very different [4]. In this paper, combine with the actual situation of emergency response in earthquakes, three types of synergy mechanism models are identified: no synergy, weak synergy and strong synergy. Considering the complexity of the rescue situation in earthquakes and the connection between the departments involve in the rescue, the strong synergy model will be used in this design for analysis [5].

In emergency situations, multi-sector collaborative emergency response (CER) [6] is based on the idea of cooperation and competition to achieve efficient communication and information sharing through coordination theory and technical means, and to establish a collaborative mechanism to optimize emergency response effects. In this paper, the collaborative and interactive behaviors of departments in rescue in earthquakes are studied, and a hybrid structure is adopted to achieve effective management and information transfer. This structure combines the advantages of centralized and distributed and is suitable for complex environments.

3 Simulation

3.1 Framework Design

In this chapter, the simulation takes the September 2022 Ganzi Luding Earthquake in Sichuan as an example to study the impact of multi-electoral collaboration model on rescue efficiency in rescue operations. The simulation of the software is achieved by writing the logic flow code, setting the corresponding parameters and carrying out the visualization design to facilitate intuitive operation and data statistics. The logic flow diagram is shown in Fig. 1, and the simulation interface diagram is shown in Fig. 2.

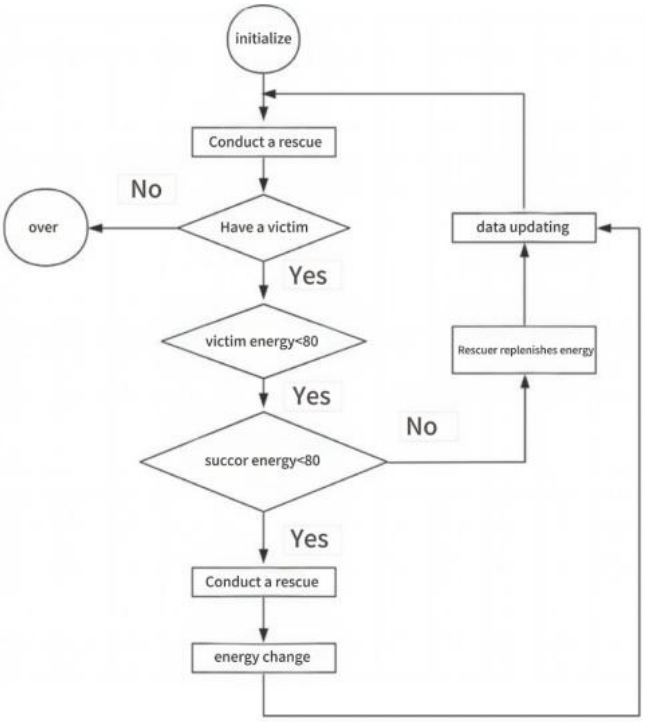

Fig. 1. Logic flowchart for simulation

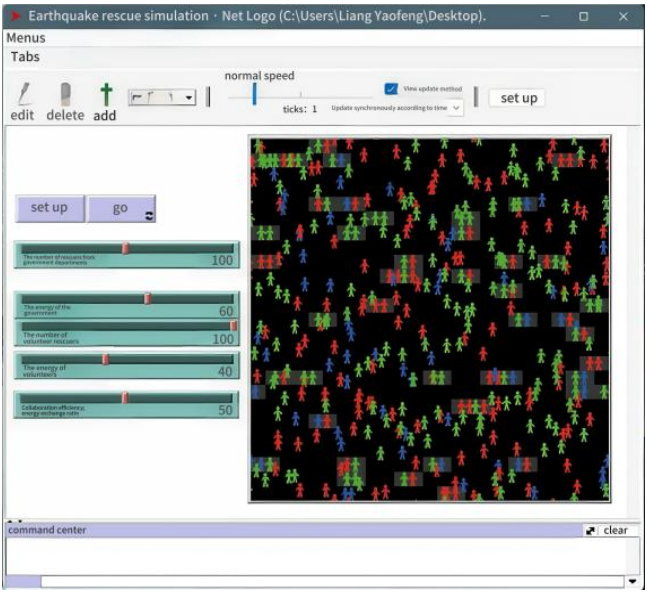

Fig. 2. Interface diagram for simulation

3.2 Determination of Initial Values

The number of people and ENERGY values of the two main organizations involved in the rescue are determined based on the public data from the relevant websites of the departments of the central state organs. In this simulation experiment, the size of the rescue ability of the rescue subject and the difficulty of the task object to be rescued are expressed in terms of energy (ENERGY). The specific values are set as shown in Table 1.

Table 1. Initial value setting table

Parameter	Initial value
Number of affected persons	150
Number of governmental rescue departments	100
Number of volunteers	100
Initial value of energy of disaster victims	1~60
Government energy initial value	60
Volunteer energy initial value	40

4 Analysis of Simulation Results

4.1 The Relationship between the Strength of Synergy and Rescue Efficiency

This section will analyze the impact of no synergy, weak synergy and strong synergy on the rescue efficiency, and then analyze the relationship between the strength of synergy and rescue efficiency, the size of the energy conversion ratio of the rescuers during the interaction is used to express the size of the synergistic interaction efficiency between each department, and the energy conversion ratio before and after the specific interaction is shown in Table 2.

Table 2. Expression of synergy strengths and weaknesses

	No synergy	Weak synergy	Strong synergy
Proportion of energy value before exchange	0	10%	50%
Proportion of energy value after exchange	100%	90%	50%

Based on the synergy efficiencies in the table above, a simulation is carried out in Net Logo and the resulting values are plotted as a line graph for comparison, see Figure 3.

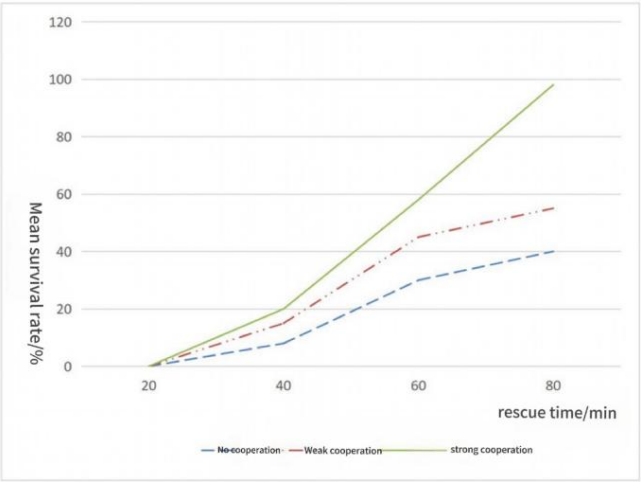

Fig. 3. Relationship between synergy strength and rescue efficiency

4.2 Government Power and Interaction Capacity in Relation to Rescue Activities

The government's rescue power is expressed by its energy value, by changing the size of the energy value, the relationship between the government's rescue power and the survival rate and rescue time is recorded [7], and its trend is shown in Fig. 4. The interaction power between the government and the volunteer rescue team is expressed by the energy exchange ratio, and the ratio is set to be in the range of 0~90%, and the interaction of the rescue power is recorded with the relationship between the survival rate and the rescue time is plotted in the graph, see Fig. 5.

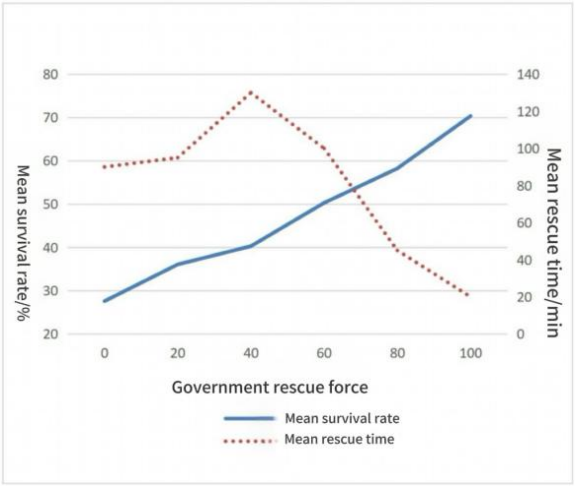

Fig. 4. Line plot of government management capacity versus rescue time and survival rate

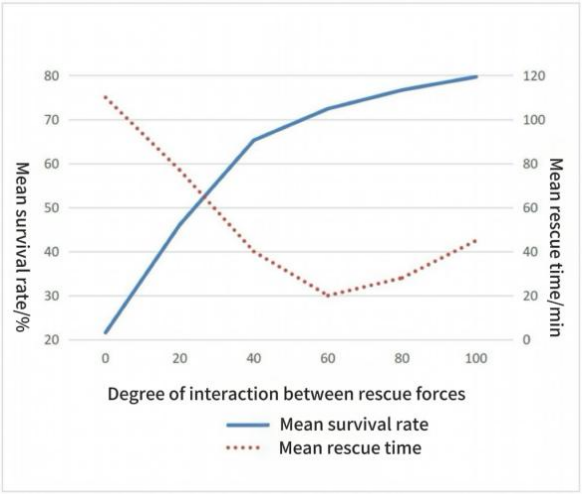

Fig. 5. Line plot of rescue force interaction versus rescue time and survival rate

5 Conclusion

In this paper, multi-Agent theory and Net Logo simulation software are applied to study the multi-sectoral collaborative rescue in Luding earthquake [8]. By comparing the no-collaboration and strong-collaboration modes, the advantages and efficiencies of collaborative co-operation are highlighted, and a set of collaborative co-operation modes from the government to the professional and volunteer rescue teams are designed and validated by simulation. The results show that the rescue efficiency of the strong synergy mode is much higher than that of the no synergy mode and the weak synergy mode [9]. Therefore, in the actual rescue, it is necessary to reasonably plan the cooperation between various departments, in order to make the rescue operation the shortest time and maximize the rescue efficiency.

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