Study on the Utility of Emergency Map in Emergency Response

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ABSTRACT

As modern cities expand rapidly, the loss of emergency has been more serious. To reduce or even avoid losses caused by disasters, using emergency maps to collect, aggregate, analyze, and communicate information is a prerequisite for efficient response. In this paper, we analyzed the impact factors of information transfer efficiency, and constructed the communication model provided by Emergency Map. By comparing the difference with case deduction between the traditional communication mode in emergency response and the new communication mode based on Emergency Map, which is called Group Communication Mode. We proved the Group Communication Mode had the advantages to improve information transfer efficiency in emergency response. Emergency Map can be an effective tool for the timely transfer of information among departments, which put forward a novel communication mode in emergency decision-making process.

Keywords

Emergency Map, communication model, Group Communication Mode, order degree, information transfer efficiency.

INTRODUCTION

On account of the unexpectedness, tremendous conflict and social influence of the emergency, emergency become the focus of the public concern and need timely response to decrease loss once emergency occur. As cities expands rapidly with great human and resource aggregation, the loss of disasters would have been more serious, and how to reduce life and property loss is the primary issue for decision-makers. The information delay and distortion in emergency response process caused the more serious loss. In 2003, the SARS broke out. Because of the poor information communication, it was difficult to integrate varieties of emergency resource, and the diffusion of epidemic situation lost control (Fan, 2007). The Indonesia tsunami in 2004 was predicted by the Pacific Tsunami Warning Center located in Hawaii, but the failed communication with Indonesia delayed the tsunami early emergency seriously (Hu&Wang, 2008). The WenChuan earthquake in 2008, the poor information communication caused the confusion rescue command and there were the problems of insufficient or excess rescue force at the rescue scene (Ministry of Civil Affairs Chinese National Disaster Reduction Center, 2009).

Grasping the emergency information timely is the premise of making appropriate decision. The emergency information transfer restricted the betimes and effectiveness of emergency response directly, which affected the returns to scale of emergency management. (Sheng&Guo, 2013). Since the events such as 9·11 that underscored the failure of prior governmental information sharing, public organizations had shifted from a model that emphasized information protection to one where cross-organization information sharing was the new goal (Yang&Maxwell, 2010). There are usually many difficulties perplex the emergency management around information, such as difficult to obtain, organize, share and apply. In the process of emergency response cooperated by multiple participants, the information was the tie to implement the communication and cooperation effectively. So the information sharing became an indispensable link in the emergency response process, and even bottleneck problem (Chen & Zeng, 2017).

In China, the functional department as a basic unit constituted the emergency management system (Liu et al.,2013), and intra-departmental information transfer was timely and effective (Ruan&Yang et al., 2010). However, when significant emergency occurred, emergency management required multiple departments to share information and make decision together (Zhang et al.,2016). Then the development of the situation can be effectively controlled, which can avoid a wider range of losses. So Chinese emergency management still need some effective means of information communication to handle significant emergencies (Jing et al., 2010). As a multi-party cooperative consultation system, Emergency Map can be an important aid in emergency decision-making process (Beijing GSAFETY Technology Co., Ltd., 2011). The consultation participants plotted on the same map to share their own information, so other participants could get information by the plotted map at the same time.

In this paper, we provide a novel communication mode based on the Emergency Map, which is called Group Communication Mode. On the basis of the impact factors analysis of information transfer, we clarify the process of Group Communication Mode and the traditional communication mode of emergency response in China. We introduce the timeline of emergency response and the order degree of the information transfer system in methodology section. Finally, we compared the Group Communication Mode and the traditional communication mode of emergency response in China by a case study, including time consuming and order degree of information transfer.

THEORETICAL ANALYSIS AND HYPOTHESES

Based on the analysis of impact factors of information transfer efficiency, we sort out three impact factors. And among them, we can improve the information transfer efficiency by improve the connection relation. We compare the main characters of the information transfer models and clarify the processes of traditional communication mode and the Group Communication Mode in emergency response.

Analysis of Impact Factors of Information Transfer Efficiency

Defined by informatics, the information transfer process includes the information coding of senders, information transfer between senders and receivers and the grasping information of receivers (Hwang&Kim, 2007; Kimmerle et al., 2011). As for emergency management, the senders should choose and describe the information, and the information should be passed to the receivers through specific channel and tools (Li et al., 2013). The factors that influence the information transfer efficiency in the process of information transfer are shown in Table 1. They are divided into three aspects: information itself, information subject and connection relation. It is undoubtedly that the prime factor which can affect the information transfer efficiency is the information itself. The information characteristics affect not only the coding efficiency of senders but also the decoding efficiency of receivers. The complexity of information is one of the impact factors, and the bigger the information complexity is, the lower the information transfer efficiency is. The standardization degree of information is the other impact factor, the higher the standardization degree is, the higher the information transfer efficiency is. And the information subject is another factor that affects the information transfer efficiency, which depends on both senders and receivers' information literacy. As for senders, the capability of sending message determines the coding distortion. While for receivers, the information demand is the impact factor of the transfer efficiency, including current demand and potential demand. The current demand is the standardized demand of emergency information, for instance, the prescriptive information in emergency response plan. And the potential demand is the non-standardized demand of emergency information, which is still in subconscious and described inaccuracy, for instance, the information demand for an unprecedented emergency. However, due to the uncertainty and diversity of the emergency, the potential demand of the information is the primary stage of the current demand, and the amount of it is also far more than current demand. There are many characteristics of the potential demand, such as potential, massive, fuzziness and conversion property. The connection relation of the information subject is also a main impact factor of the information transfer efficiency. When various parties in the information chain communicate by different connect methods, the information transfer efficiency is affected by out-degree, incoming degree, diversity, centrality degree, and so on (Pfeiffer&Velthuis, 2009).

How to improve the efficiency of information transfer in emergency management process is the main issue, and it needs to be solved by emergency management participants. We assume that the emergency response participants have the professional ability. It means that the information subjects do their best to avoid coding distortion and clear current demands. As mentioned above, we should start with the information itself and the connection relation to improve the information transfer efficiency. On the one hand is reducing complexity degree and promoting standardization simultaneously degree of emergency information. The Emergency Map provides a platform of emergency deliberation and the plotted map figurative emergency information from the abstract text. On the other hand is adopting a more reasonable communication connection mode of nodes, which can both reduce the time cost of information transfer and approach the effect of communication sufficiently.

Table 1. the impact factors of information transfer efficiency

Impact factors	**Impact mode**	
Information	Information complexity	
	Standardization degree of information	
Information subject	Capability of send massage	Coding distortion
	Information demand of receivers	Current demand (Standardization)
		Potential demand (non-standardization)
Connection relation	Node connection pattern	

The Communication Mode

American psychologist Levitt divided the information transfer process into five models, including Chain Model, Ring Model, Wheel Model, Complete Channel Model and Y Model (Huang, 2000; Levitt, 1986). Figure 1 shows the characteristics of the five communication models in information transfer process. The information flow in Chain Model transfers one by one, and the information distortion is the main problem of this model. The Ring Model is a closed information transfer mode, so the information flow constitutes a closed loop. And the information transfer velocity of Ring Model is much slower than other transfer models. There is an information center in Wheel Model, which is responsible for the distribution and collection of the information. The information centralization degree of the Wheel Model is the highest, but the communication channels are indirect among group members. All information subjects can participate in the communication by Complete Channel Model, so that they can share information or get information from the specific object directly. However, the rapid growth of time consuming will become an unavoidable problem. The information subjects are divided into multiple levels, so the information transfer processes are only between two adjacent levels to maintain information order degree. But the higher information centralization degree and stronger property of organization are sources of both advantages and disadvantages. The higher efficiency of information transfer coexists with the information distortion, due to the deletion of the transverse communication and arrogation. Based on Emergency Map, we define a new communication model which is called Group Model. The information plotted on the map transfer by the Emergency Map, so the other participants can grasp the information directly.

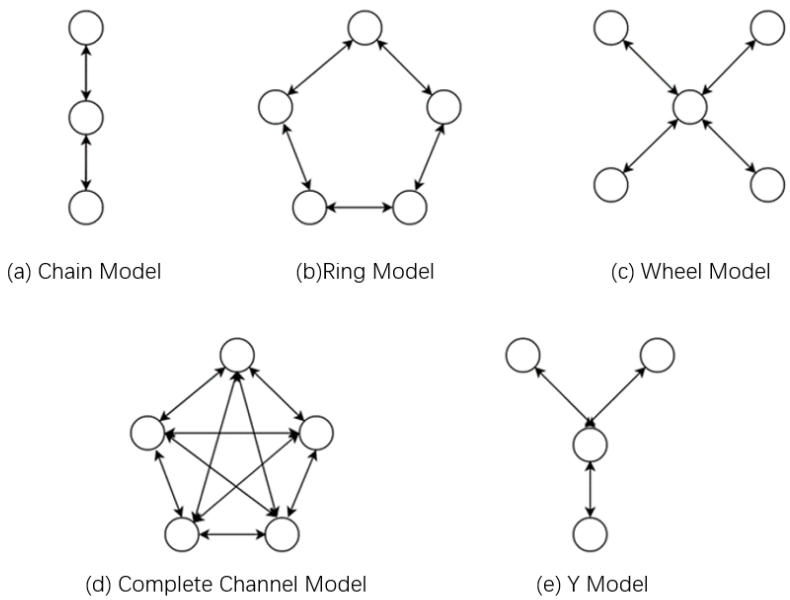

Figure 1. characteristics of the five communication models in information transfer process

Table 2. the main characters of the information transfer models

Information transfer model	Main character
Chain Model	The most probability of causing information distortion
Ring Model	Closed information transfer mode
	Slow transfer velocity
Wheel Model	Highest centralization degree
	Lack of communication paths
Complete Channel Model	The most sufficient communication
	The most time consuming
Y Model	High centralization degree
	Information distortion caused by deletion of the transverse communication
	Arrogation
Group Model	High centralization degree
	Straightforward information transfer paths
	High information fidelity
	Communicate sufficiently by adequate communication channels

Traditional Communication Mode of Emergency Response in China

In traditional communication mode, the emergency management process of Chinese government is shown as Figure 2. After emergency, the local government clears the emergency object on the basis of the emergency response plan pre-established by China State Council firstly. Then the local government divides the relevant functional departments into several decision-making groups, and each group has its own emergency object. Secondly, after the establishment of decision-making groups, every group member shares information with others and takes the Wheel Model way of communication within groups. Then every group generates a group decision and own concession baseline, and reports them to the local government. Thirdly, the government discriminates and gathers disputes in the received reports. Then the disputes feed back to the groups, and they resolve the dispute between groups. Finally, if the decision is accepted by others, the government summary and generate the overall decision. In emergency management process, with the situation evolving, the communication process is repeated until the emergency response finished.

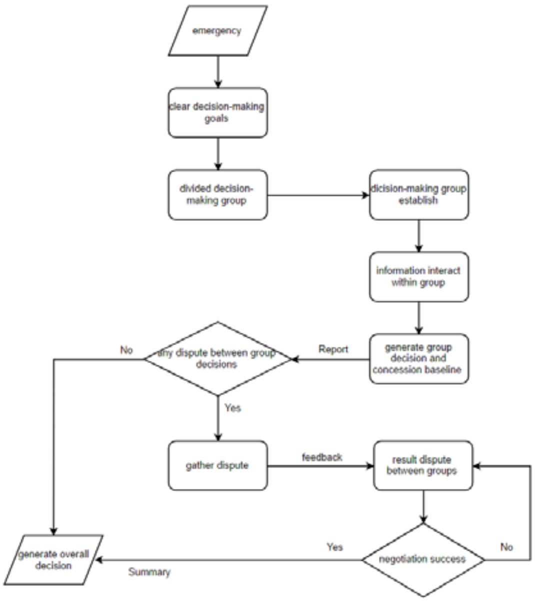

Figure 2. The traditional communication mode of emergency response in China

Group Communication Mode Based on Emergency Map

Based on Emergency Map, a new communication model is defined in information transfer of emergency management process, which is designed as "Group Model" in table 2. The information holder can plot his emergency information on the Emergency Map provided by a shared GIS server, with which the plotted map is distributed to other emergency decision makers simultaneously, and there is no need to transfer information to each decision maker one by one. It can be considered as a Wheel Model with a virtual and alterable center, which distribute information to others at the same time. But better than the Wheel Model, there is ample communication channels in Group Model and the communication between each two is realizable. Therefore, the time consuming can be greatly reduced to the equal level of Wheel Model information transfer mode, and the participants of emergency management can make sufficient communication. The Group Model inherits the high centralization degree and straightforward transfer path derived from Wheel Model, so the information fidelity can be maintained at a high level. Meanwhile, it discards the disadvantages of Wheel Model and achieves the communication effects of Complete Channels Models.

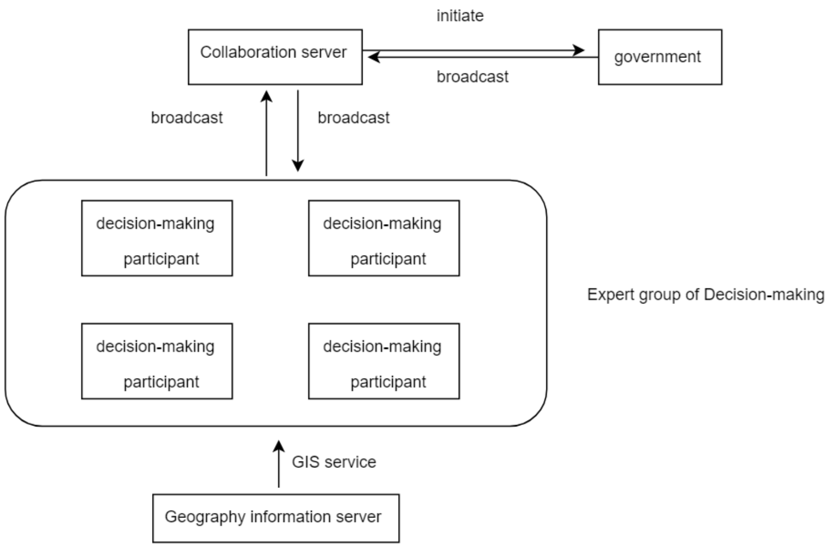

Figure 3. The Group Communication Mode of emergency response

METHODOLOGY

We clarify the timeline of emergency response process, from the emergency occurrence as the initial point to the successful response as the terminal point. And we introduce the order degree of the information transfer system, which is used to measure the comprehensive ability, including the ageing entropy and the quality entropy of information transfer.

Timeline of Emergency Response

Figure 4 shows the timeline of emergency response. The initial point is the occurrence time point of emergency. Then the information finders describe the collection information and send information to the others by specific mode. The time of describing information is T_1 , which is called information pretreatment time. On the basis of modern network communication technique, the transfer speed of network data remains high speed in the normal condition. So we can ignore the time consumption of data transfer under unobstructed communication condition. After receiving the emergency information, other decision-making administrations decode and accept the information. The time between the information receiving to obtaining is T_2, which is called relaxing time of information obtaining. The time for the members of emergency management to make deliberation and generate an emergency decision is called decision-making time, which is shown as T_3 in Figure 4. The time between emergency decision generation and successful response is called decision-implement time, which is shown as T_4 in Figure 4. Therefore, when emergency occur, there is limited time for emergency management administrations to response, which is shown in function (1) as W_t. To decrease loss as much as possible, the emergency administration should make optimal decision under current conditions and carry out it. Therefore, T_1 and T_2 should be shorten as much as possible to guarantee enough time for decision making and implementation. We consider that the decision-making participants communicate by group mode can significantly increase the efficiency of information transfer, which also shortens T_1. And the plotted map should be much more acceptable than traditional abstract text information, which shorten T_2 for participants in emergency response process.

$$\max(T_3 + T_4) = \max[W_t - (T_1 + T_2)] \quad (1)$$

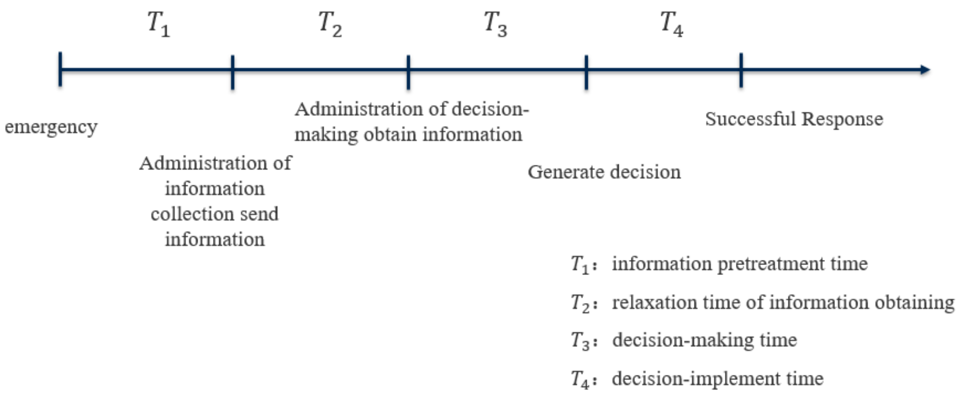

Figure 4. Timeline of emergency response

We combine the information pretreatment time (T_1) and relaxation time of information obtaining (T_2) together to be taken into consideration, which includes time consuming within groups T_i and time consuming between groups T_o.

$$\mathrm{T} = T_1 + T_2 = T_i + T_o \quad (2)$$

We obtain the irrelative function of T_i.

$$T_i = \sum_{i=1}^{m} A_{n_i}^2 t_1 \quad (3)$$

t_1 is the time consuming of communication between two group members. n_i is the participates member of decision-making group. m is the groups member that divided by emergency objects. Therefore, we obtaine the function of T_o.

$$T_o = A_m^2 t_2 + m t_3 \quad (4)$$

t_2 is the time consuming of communication between two groups. t_3 is the time consuming of communication between the government and groups.

The Order Degree of the Information Transfer System

To measure the comprehensive ability of information transfer in emergency response, we introduce the concepts of the system order degree (Qiu, 2011; Yan et al., 1997). The order degree of the information transfer system depended on two aspect of factors, which are quality and ageing of the information transfer. To quantify the two index, we introduce the concept of ageing entropy and quality entropy, like information entropy. The information entropy theory was put forward by Claude Elwood Shannon in 1948 (Shannon, 1948), what was used to describe the uncertainty of the information system, just like the thermal entropy was used to describe the confusion degree of the molecularity in Thermodynamics. The calculation formula of information entropy is $\mathrm{H} = -\sum_{i=1}^{n} P_i \log_2 P_i$. And the entropy is a measure of the disorder of the entropy, and the order degree of system can be measured by the function, $\mathrm{R} = 1 - \mathrm{H}/H_m$. H_m represents the maximum entropy of the system, which is the most confusing system of the system. The probability of symbol in the information entropy theory is used to describe the number of microstate of the information transfer in ageing and quality entropy. Moreover, we consider that, the information ageing and the information quality have the equal status for emergency response. Therefore, the function of order degree of the information transfer system is obtained.

$$\mathrm{E} = (E_1 + E_2)/2 \quad (5)$$

E_1 is the information transfer ageing, and E_2 is the information transfer quality.

Ageing Entropy of Information Transfer

Ageing entropy of information transfer represents the ageing uncertainty of the information transfer, and it used to measure the swift degree of information transfer. According to the function of information transfer determination from Qiu (Qiu, 2011), we obtain the interrelated calculation function based on the principle of information transfer ageing improvement by increased direct connection.

$$M_1 = \sum_{i=1}^{N}\sum_{j=1}^{N} L_{ij} \tag{6}$$

Among them, M_1 is the total number of microstate of the information transfer ageing. The microstate means the node state observed through one angle, and there are several states of one node usually. The realizable probability is the ratio of the node microstates number and all nodes microstates number. L_{ij} is the shortest path between the two nodes in the information transfer system, which is called as connection length of two nodes. If the two administrations connect directly, the connection length is 1. If the two administration connect through other administrations, the connection length should (be added 1 to) add 1 after each administration. To determine the ageing microstates of each administration, we should calculate the shortest connection lengths of every administration L_{ij} according to the characteristics of information transfer system. Among them, i and j are the number of the administrations, i,j=1,2,…,n.

$$A_{1m} = log_2 M_1 \tag{7}$$

A_{1m} is the maximum ageing entropy of the information transfer.

$$P_1(ij) = L_{ij}/M_1 \tag{8}$$

$P_1(ij)$ is the realizable probability of ageing microstates of information transfer between administration i and administration j.

$$A_1(ij) = -P_1(ij)\, log_2 P_1(ij) \tag{9}$$

$A_1(ij)$ is the ageing entropy of two arbitrary information transfer. Therefore, we obtained the determination function of total ageing entropy of information transfer.

$$A_1 = \sum_{i=1}^{N}\sum_{j=1}^{N} A_1(ij) \tag{10}$$

Then we obtain the determination function of the information transfer ageing.

$$E_1 = 1 - A_1/A_{1m} \tag{11}$$

Quality Entropy of Information Transfer

The quality of information transfer is the measure index of information transfer accuracy between administrations. The quality entropy reflects the quality uncertainty of the information transfer, which is used to measure the distortion degree of information transfer. According to the function of information transfer determination (Ping et al., 2013), we obtain the interrelated calculation function based on the principle of information transfer quality improvement by decreasing direct connection.

$$M_2 = \sum_{i=1}^{N} K_i \tag{12}$$

Among them, M_2 is the total number of microstate of the information transfer quality. K_i is the number of administrations which have direct connection with the administration, and it is called amplitude of administrations connection. To determine the amplitude of administrations connection, we should calculate quality microstates of each administration K_i according to the characteristics of information transfer system. Among them, i is the number of the administrations, i =1,2,…,n.

$$Q_{2m} = log_2 M_2 \tag{13}$$

Q_{2m} is the maximum quality entropy of the information transfer.

$$P_2(i) = K_i/M_2 \tag{14}$$

$P_2(i)$ is the realizable probability of quality microstates of information transfer, which belong to the administration i.

$$Q_2(i) = P_1(i)\, log_2 P_2(i) \tag{15}$$

$Q_2(i)$ is the quality entropy of the administration i, which is used to measure the uncertainty of the information distortion in the information transfer process. Therefore, we obtained the function of total quality entropy of information transfer.

$$Q_2 = \sum_{i=1}^{N} Q_2(i) + \log_2 M_2 \tag{16}$$

Then we obtain the determination function of the information transfer quality.

$$E_2 = 1 - Q_2/Q_{2m} \tag{17}$$

CASE STUDY

A maneuver in Guangxi Zhuang Autonomous Region for nuclear accident was utilized as a case study. There were 12 administrations which participated in the emergency response according to the National Nuclear Emergency Plan established by China State Council for traditional communication mode. These administrations are shown in Table 3, including Environmental Protection Department (EP), Health and Family Planning Commission (HF), Transportation Department (TD), Development and Reform Commission (DR), Public Security Department (PSD), Civil Affairs Department (CA), Information Office (IO), Headquarter of Military Area Command (HM), Weather Bureau (WB), Power Supply Bureau (PSB), Maritime Bureau (MB), and Telecommunications Administration (TA) directly. In traditional communication mode, they should be divided into several groups by decision-making goals in order to make the appropriate decision. According to the maneuver scripts and the emergency objects perspective in the National Nuclear Emergency Plan, the 12 participates were divided into 9 groups. They are also shown in Table 3, including mitigation and control of radiation accident, radiation monitoring and consequences assessment, personnel radioactive protection, covert and evacuation placement, decontamination and medical treatment, access and port control, market regulation, social order maintenance, and information report directly. The summary of group results is shown in Table 3. Moreover, the other mode was Group Communication Mode. In this mode, all 12 participates from a large group were involved in decision-making based on the Emergency Map. Then, we compared the result calculated by traditional communication mode and Group Communication Mode.

Table 3. the summary of group results

No.	Decision-making object	Group participants
1	Mitigation and control of radiation accident	EP, HM, TA, PSD
2	Radiation monitoring and consequences assessment	EP, HM, MB, WB
3	Personnel radioactive protection	DR, HF, EP, WB, PSD
4	Covert and evacuation placement	HF, TD, PSD, CA, IO, HM, PSB, TA
5	Decontamination and medical treatment	HF, HM
6	Access and port control	PSD, MB, IO
7	Market regulation	DR, IO, TD, EP
8	Social order maintenance	PSD, MB, IO
9	Information report	IO, EP, TA, PSB, WB, PSD

Time Consuming of Information Transfer

In this maneuver process, we used two communication modes, including the traditional communication mode and the Group Communication Mode, to determine the information transfer time consuming in emergency response. The time consuming is shown in Table 4, which is coming from the experiments carried out in the course of the maneuver. Therefore, the time consuming decrease greatly by using the communication mode, which can reach 94%.

In the maneuver process, we used two coding methods, including text information and plotted map information to code the emergency information. The time consuming of information transfer is shown in figure 5, and the time consuming decrease greatly by using plotted map information. The decrease of time consuming is different in each group, which depends on the amount and complexity of information. In this maneuver, the maximum decrease ratio is 71.3% in group 8, and the minimum decrease ratio is 47.8% in group 6.

Table 4. the time consuming of two communication modes

	Plotted map information	Text information
Traditional communication mode	57372	151242
Group Communication Mode	3418	8413
The ratio of time consuming decrease	94.1%	94.4%

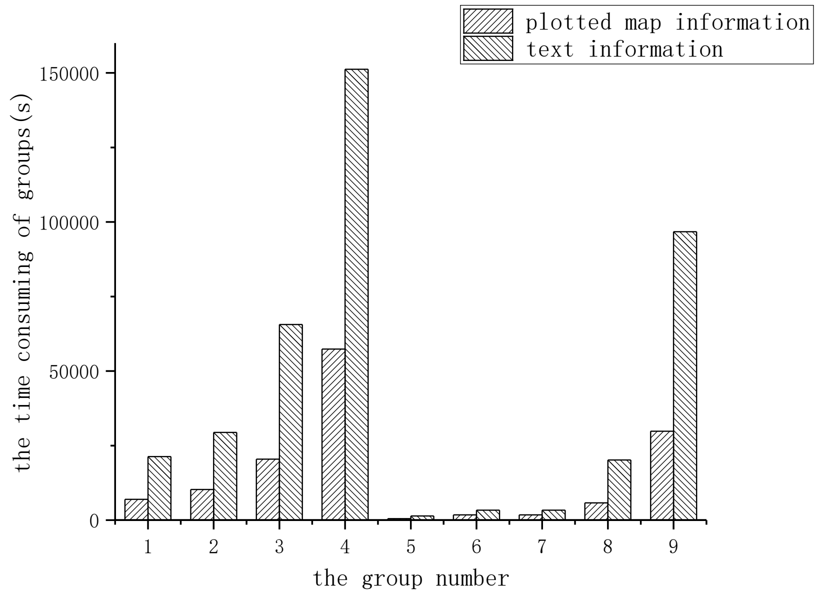

Figure 5. the time consuming of information transfer by two coding methods

The Order Degree

The order degree of two communication modes and the compared results are shown in Table 5. Every participant in Group Communication Model has equal position, so their own state observed through one angle is completely identical, which means there is one microstate of each participants. So the total ageing entropy and total quality entropy are both zero. The information transfer ageing of traditional communication mode is 0.348, and the Group Communication Mode is 1, which is increased by 1.87 time. The information transfer quality of traditional communication mode is 0.528, and that of the Group Communication Mode is also 1, which is increased by 89.4%. Therefore, the order degree of the traditional communication mode is 0.428, and the Group Communication Mode is 1. The order degree of information transfer system can be increased by 1.28 times with Emergency Map.

Table 5. the order degree of two communication modes

	Traditional communication mode	Group Communication Mode
Microstates number $\boldsymbol{M_1}$	39	12
Total ageing entropy $\mathbf{A_1}$	3.446	0
Maximum ageing entropy $\mathbf{A_{1m}}$	5.285	3.585
Information transfer ageing $\mathbf{E_1}$	0.348	1
Microstates number $\boldsymbol{M_2}$	106	12
Total quality entropy $\mathbf{Q_2}$	3.176	0
Maximum quality entropy $\mathbf{Q_{2m}}$	6.728	3.585
Information transfer quality $\mathbf{E_2}$	0.528	1
Order degree $\boldsymbol{E}$	0.438	1

CONCLUSION

At last the conclusion and future work are proposed. When extensive emergency occurs, there are urgent needs about information sharing (among departments) and the collaborative treatment, which can control the situation timely and avoid the wider range of losses. Based on the analysis of the impact factors of information transfer efficiency, the Emergency Map is a consultation platform to solve these problems in emergency response. We provide a novel communication model based on emergency map that is different from traditional five communication models. The communication model is called Group Model. Compared with other communication models, it has high centralization degree and information fidelity by straightforward information transfer paths, and communication sufficiently by adequate communication channels. And the emergency map provides a novel communication mode for multi-party collaborative in emergency response, which has great advantages compared with the traditional communication mode in China. The Group Communication Mode can decrease the time consuming of information transfer in emergency response process greatly, which helps to gain much more time for decision-making and implementation. The order degree of the Group Communication Mode is better than that of the traditional communication mode. The participants can plot their information on the map, and the plotted map information can further decrease the time consuming of information transfer in emergency response, which can also enhance the realistic and immersion of participants. Moreover, we determine the time consuming decrease by a case of maneuver in Guangxi, China, and compare the order degree of traditional communicational mode and Group Communication Mode in this case.

The following research will be focused on the discussion of the mechanism of decoding methods impact the time consuming of the information transfer, and the analysis if there are any other ways to decrease time consuming of information transfer in emergency response, such as convert the information potential demands to current demands.

REFERENCE

Beijing GSAFETY Technology Co., Ltd.. Multi-Party Collaborative Consultation System of a Public Emergency Based on Emergency Map: CN201110207836.5[P].2011-12-21.

Chen Y, Zeng Y. Problems and Suggestions on Information Sharing of Emergency Collaboration in China[J]. Science and Technology Management Research,2017,37(09):191-195.

Fan W. Advertisement and Suggestion to Scientific Problems of Emergency Managements for Public Incidents[J]. Bulletin of National Natural Science Foundation of China,2007(02):71-76.

Hu W, Wang H. Preliminary Probing into Information Disclosure in Public Crisis [J]. Journal of Information,2008(11):141-144.

Huang R. The Research of Structure Models of Cooperative Learning [D]. Beijing Normal University, 2000.

Hwang, Y; Kim, Dan J. Understanding affective commitment, collectivist culture, and social influence in relation to knowledge sharing in technology mediated learning. IEEE Transactions on Professional Communication, 2007, 50.3: 232-248.

Jing K, Zhao X, Wang Y. Local Group Decision Making for Emergency under Uncertainty Based on Interval Preference [J]. Operations Research and Management Science, 2010, 19(02): 97-103.

Kimmerle J, Wodzicki K, Jarodzka H, et al. Value of information, behavioral guidelines, and social value orientation in an information-exchange dilemma[J]. Group Dynamics: Theory, Research, and Practice, 2011, 15(2): 173.

Li Y, Li J, Xie Y. Research Review of Abroad Factors Affecting the Willingness of Information Transfer [J]. Information Studies: Theory & Application, 2013, 36(7): 124-128.

Liu D，Wang H，Qi Chao，Wang Jian. Modeling Emergency Decision－making Organization based on MAS [J]. Journal of Public Management, 2013, 10(04): 78-87+140-141.

Ministry of Civil Affairs Chinese National Disaster Reduction Center, United Nations Development Program. Research Report on Disaster Relief and Relief Work in Wenchuan Earthquake[R]. 2009, 3: 34-37.

Pfeiffer T, Velthuis L. Incentive system design based on accrual accounting: a summary and analysis[J]. Journal of Management Accounting Research, 2009, 21(1): 19-53.

Ping J, Han Ch, Yu Zh. Evaluation of the Information Transfer Ability of the Government Emergency Organization Based on Entropy. Soft Science, 2013, 27.10: 126-130.

Qiu W. the Theory and Application of Management Decision Entropy [M]. Beijing: China Electric Power Press, 2011. 247-251.

Ruan P, Yang X. Structure Evaluation Model of Network Organization Based on Entropy [J]. Journal of Wuhan University of Technology, 2010, 32(23): 183-200.

Shannon C E. A mathematical theory of communication[J]. The Bell System Technical Journal, 1948, 27(3): 379-423.

Sheng M, Guo Q. Department Interest Obstruction in Linkage Emergency of Public Incidents and Its Governance [J]. Chinese Public Administration ,2014(03): 38-42.

Theodore Levitt. Marketing Imagination: New. Simon and Schuster, 1986.

Tung-Mou Yang,Terrence A. Maxwell. Information-sharing in public organizations: A literature review of interpersonal, intra-organizational and inter-organizational success factors[J]. Government Information Quarterly,2010,28(2).

Yan Zh, Qiu W, Chen Zh. Evaluation of System Order Degree as Viewed from Entropy [J]. Systems Engineering-Theory & Practice,1997(06):46-49.

Zhang Z, Wang L, Sun C, Ding H Wu G. research on shared framework of a picture for emergency information based on the service [J]. Engineering of Surveying and Mapping, 2016, 25(02): 47-51.