J Inf Process Syst, Vol.13, No.5, pp.1243~1258, October 2017
https://doi.org/10.3745/JIPS.04.0042
ISSN 1976-913X (Print)
ISSN 2092-805X (Electronic)

JOURNAL OF INFORMATION PROCESSING SYSTEMS JIPS

Modeling and Simulation of Scheduling Medical Materials Using Graph Model for Complex Rescue

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Abstract

A new medical materials scheduling system and its modeling method for the complex rescue are presented. Different from other similar system, first both the BeiDou Satellite Communication System (BSCS) and the Special Fiber-optic Communication Network (SFCN) are used to collect the rescue requirements and the location information of disaster areas. Then all these messages will be displayed in a special medical software terminal. After that the bipartite graph models are utilized to compute the optimal scheduling of medical materials. Finally, all these results will be transmitted back by the BSCS and the SFCN again to implement a fast guidance of medical rescue. The sole drug scheduling issue, the multiple drugs scheduling issue, and the backup-scheme selection issue are all utilized: the Kuhn-Munkres algorithm is used to realize the optimal matching of sole drug scheduling issue, the spectral clustering-based method is employed to calculate the optimal distribution of multiple drugs scheduling issue, and the similarity metric of neighboring matrix is utilized to realize the estimation of backup-scheme selection issue of medical materials. Many simulation analysis experiments and applications have proved the correctness of proposed technique and system.

Keywords

Bipartite Graph, BSCS, Drug Scheduling, Medical Rescue, Optimization Matching

1. Introduction

China is a big country which is prone to experience natural disasters [1,2] easily because of her huge population and widespread territory. In spring 2003, the severe acute respiratory syndrome (SARS) virus first broke in Guangdong Province. Just in several months, this disease swept most areas of China even in many big cities like Beijing and Shanghai. Hundreds of people lost their life by a kind of undiscovered pneumonia and more than 7 thousand people were infected in that incident. In May 12, 2008, a serious earthquake took place in southwest China. The Wenchuan area in Sichuan Province of China was destroyed by an 8.0 earthquake. According to the official information, till September 25, 2008, 69,227 lost their life, 17,923 were missed, and 374,643 were injured. In April 14, 2010, Yushu county in Qinghai Province of China faced a serious earthquake too. More than 2 thousand people lost their life in that disaster.

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Manuscript received March 23, 2016; first revision December 21, 2016; accepted January 31, 2017.
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Now we realize it is necessary to build an emergency response and resource scheduling system to guard against the extreme accident or disaster not only for the government department but also for some professional medical organizations. Many efforts have been done to make progresses in solving that problem in recent years. In [3], the authors developed a collaborative optimization model and a software system to accomplish the multiple traffic management and traffic incident processing issue. In [4], the authors proposed a resource dispatch model for the emergency of forest disasters. This reported system was believed to decrease the response time dramatically. In United States, many other related systems have also been developed. For example, in [5] the engineers utilized the wireless sensor to build a fire rescue application system. The habitat monitor, the environment, and the structural monitor were all realized by that system.

The building of intelligent information processing system cannot omit the design of mathematic models. When solving the optimal resource scheduling problem, many mathematic methods have been developed. For example, in [6] the authors used the BP neural network to implement the automatic plan generation of a fire rescue. In [7], the authors employed the potential field model to solve the resource management issue of a hospital. In [8], the authors built a distributed system and utilized the machine learning technique to monitor and predict the grid resource. According to the reports above, these proposed techniques are effective for their respective applications; however regarding the problem of the medical materials scheduling issue for the urgent rescue, this system should have its own characters:

- First, the rescue and the resource information should be classified into different types according to typical rescue requirements and resource restore states. Many practical experiences indicate that an improper propaganda of rescue activity will arouse panic in some extreme difficult situations. Thus the BeiDou Satellite Communication System (BSCS) is used to perform a fast and classified information transmission task in this system. Here the BSCS is the third global positioning system in the world.

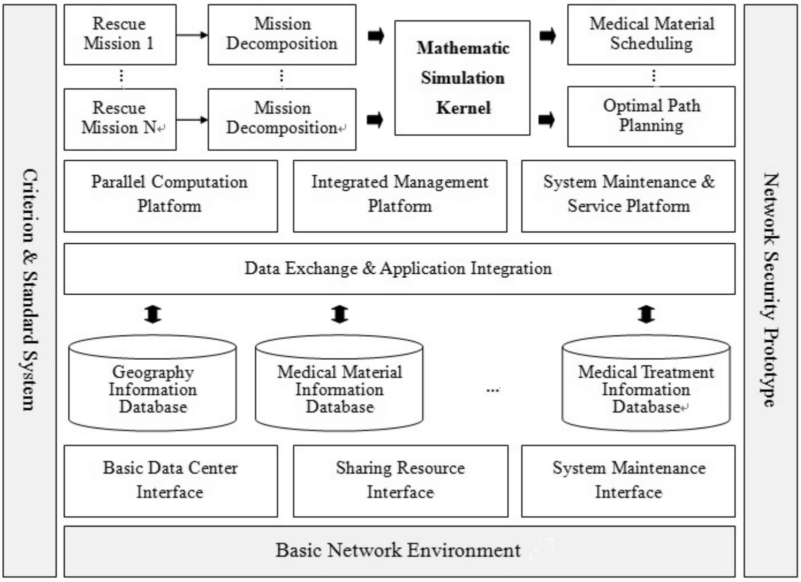


Fig. 1. The distributed emergency response and resource scheduling system for hospital.

- Second, although this system still employs a distributed design mode, all of the rescue materials, especial the medical drugs, should be registered, managed, and allotted elaborately by a center computer. The intelligent and logical resource scheduling methods should be designed and applied for the emergency.
- Third, since China has a widespread territory, the response efficiency will be low if this system is developed only for the government management department. Thus a professional interactive medical application should be considered.

To realize such an application, a medical material scheduling system and its modeling method for the complex rescue are presented in this paper. In Fig. 1, unlike the resource scheduling system only for the government management department, this system emphasizes the professional knowledge and the knowledge reuse of drug data scheduling. As a powerful complementary channel of the Special Fiber-optic Communication Network (SFCN), the BSCS [9,10] is utilized to transmit important rescue and data information. A geography information database [11] is considered to storage and display the resource scheduling situation for each hospital in different areas. In order to allot the drugs properly in emergency, the bipartite graph modeling method is utilized to compute the optimal medical drugs scheduling problem. They include the sole drug scheduling problem, the multiple drugs scheduling problem, and the backup-scheme selection problem. The Kuhn-Munkres algorithm [12,13], the spectral clustering-based method [14,15], and the similarity metric technique of bipartite graph, are all considered to solve the modeling and the computation tasks of resource scheduling.

The main contributions of this paper include: first a professional medical rescue system is proposed. Unlike the design method of an earthquake rescue system, this system emphasizes the system development for the professional medical organizations. Second the bipartite graph models are employed to solve the resource optimization scheduling and dispatching problem. Comparing with other complex and abstract models, these models are easy to be used and understood by the medical experts.

In the following sections, first the hardware and the software designs of the emergency medical rescue system are presented. Then the core medical materials scheduling methods are introduced. Finally some simulation and evaluation experiment results are shown.

2. Emergency Medical Rescue System

2.1 Design of Hardware System

The basic hardware design of medical materials scheduling system for the multiple level hospitals is shown in Fig. 2. In logic, the whole system is constituted by three parts: the distributed hospital terminal, the information transmission system, and the respective disaster units. The distributed hospital terminal has one medical command center and several secondary hospital sub-systems which are selected from different locations around the disaster area. The medical command center is charge with the drugs scheduling, the information management, and the material dispense tasks; while its secondary hospitals only need to collect the storage information and dispense these resources to the appointed areas. The information transmission systems include the SFCN and the BSCS. The BSCS can transmit the classified information rapidly. Currently, by using a kind of BSCS portable device, it can transmit 60 to 80 Chinese characters each time [16]. Other unclassified information can be transmitted by the SFCN if it still can work after the damage of disaster. Finally the disaster units need to report their location, the disaster situation, and the rescue requirement to the secondary hospital and the medical command center by all kinds of methods.

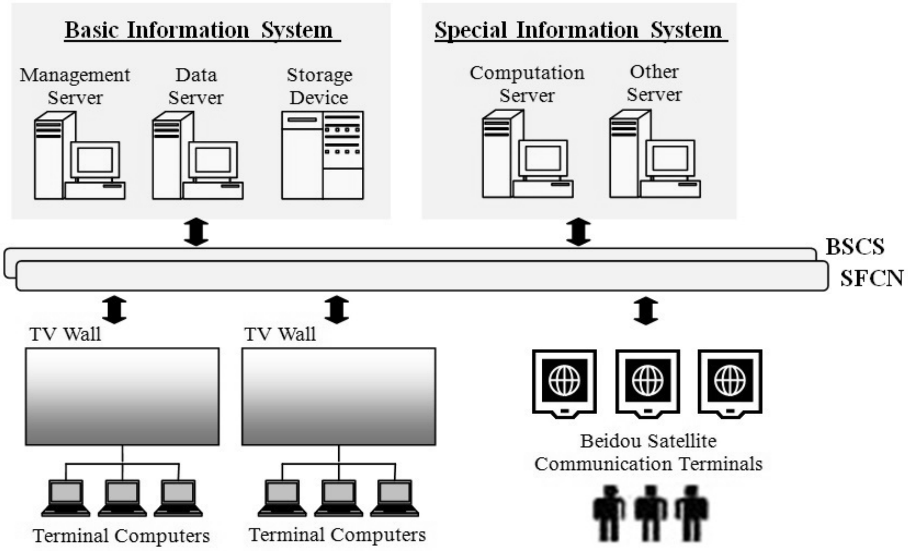


Fig. 2. The hardware design of emergency medical rescue system.

The BSCS is the basic facility in our proposed system; thus it should never fail to work because many BeiDou portable devices have been equipped to the secondary hospitals or the disaster rescue teams currently. If a temporary failure happens because of the line fault or the weak signal transmission problem, the BSCS portable devices will reconnect the BeiDou satellite time after time until the communication link can be built. Different from the BSCS, the SFCN may fail when the serious damages happen. In that situation the SFCN will not be used and only the BSCS can be employed. And if both the SFCN and the BSCS cannot be used permanently in a serious situation, the unmanned aerial vehicle (UAV) [17] may be used as a communication relay station for the disaster rescue in future. The UAV can carry the visible light camera to implement the information collection task and it also can take the wireless communication relay terminal to realize the wireless information transmission for other ground equipment.

2.2 Design of Software System

Like other software systems [18], the proposed software system also includes four parts: the presentation tier (the user interface, such as the computer browsers or the BSCS handheld terminals), the business tier (including the Business Logic Layer [BLL] and the Data Access Layer [DAL]), the data tier (including some basic databases), and the resource tier (including all kinds of tool, data and reusable knowledge). Fig. 3 shows the software logical design of this system. First, the presentation tier is developed by the ASP.NET and other corresponding communication techniques. The users can input their demand information to implement an interactive human-computer operation [19]. Second, the business tier executes the logical data management or data retrieval, update, and exchange functions. To improve the usability [20], some artificial intelligence algorithms are developed to realize the automatic resource scheduling. Third, the data tier uses the Oracle database to save and manage the basic rescue and medical information. Finally, the resource tier can manage and use/reuse some software tools, the standard data, and the historical knowledge to improve the working efficiency of whole system. By connecting the center command system to the secondary hospital systems, this system can implement a kind of distributed data management and communication.

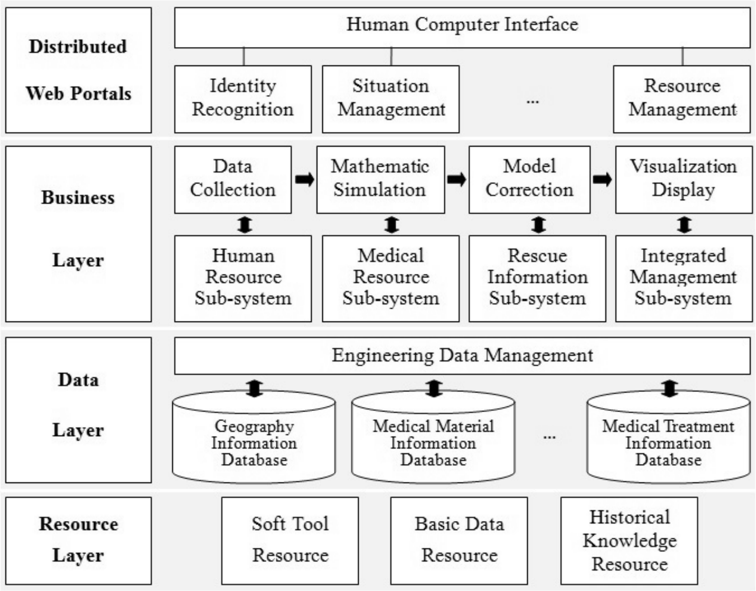


Fig. 3. The software logical design of emergency medical rescue system.

The working state of the whole software system is dynamic. That means the collected information should be updated constantly with the advancement of the rescue task. The software system can update its working and display states automatically. The World Wide Web technique is used here; and some communication protocols such as the TCP/IP protocol or the UDP protocol are also considered. The network sniffer and monitoring technique will be used [21] to change the information flow in real time. The proposed software system obeys the software engineering development standard, thus the inner software fault can be avoided effectively. Several databases and memory units are used to store the changeable information. As a result, the geography information, the medical material information, the rescue state information, and the medical treatment information can all be processed and displayed in the TV wall of the medical command center.

3. Medical Materials Scheduling Method

3.1 The Computation Flow Chart of Scheduling Method

The logical flow chart of proposed medical materials scheduling method [22] is shown in Fig. 4. First, when a disaster happens, this system will select several hospitals which are located around the disaster area to generate the secondary hospital candidates. Second, it will inquire the medical material storage information of each hospital, collect and evaluate the disaster situations of the disaster area by all kinds of methods including using the remote sensing information, the internet web information, or the reported media information as well. If the disaster situation cannot be reported timely, this system will make an automatic setting of disaster situation according to the accumulated expert's opinion. The "expert's opinion" should consider all the factors such as geography, climate, population, and traffic factors [23], etc., simultaneously. After that the system will use the bipartite graph theory to dispatch the limited medical materials to the disaster area: the sole drug scheduling problem, the multiple drugs scheduling issue, and the bipartite graph-based backup-scheme selection technique, are all processed. Finally, once this processing course is finished, the corresponding information will be transmitted by the BSCS or the SFCN.

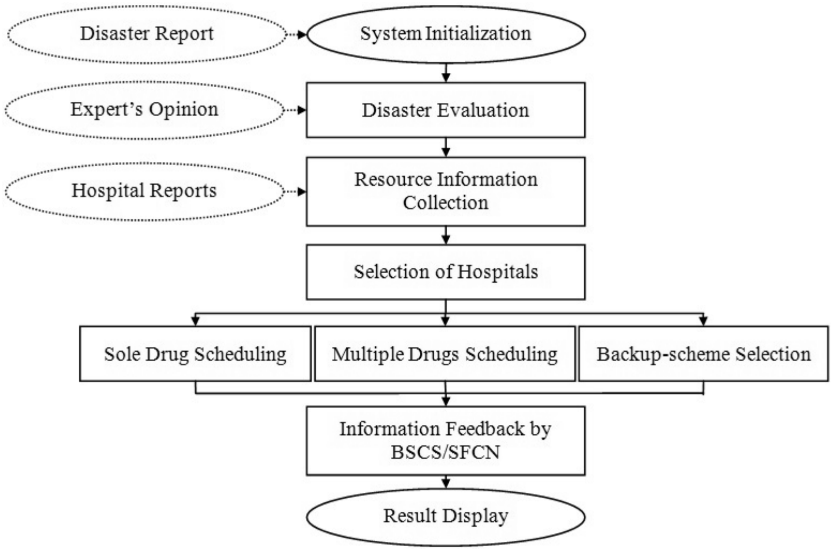


Fig. 4. The calculation flow chart of proposed resource scheduling method.

3.2 The Sole Drug Scheduling Modeling Technique

The sole drug scheduling modeling technique is used to solve the optimal drug distribution problem of one medical drug to one rescue area. This problem can be described as: if several hospitals locate near the multiple disaster places, the cost (including the traffic, the weather, or the urgency level, etc.) of dispatching drugs to each rescue area is various; so how to allot these drugs properly so that the final transportation cost is minimum. This problem widely exists in the field of drug distribution. For example, when the disaster happens in Wenchuan, Sichuan Province in 2008, the requirements of the first aid drugs, such as the anti-inflammatory drug, the water purifying agent, or the life detector, is needed by several counties. So how to use the limited resources to realize an optimal rescue is a momentous problem. From the engineering mathematic point of view, the resource distribution of sole source to sole destination is a typical optimal problem of bipartite graph.

If the vertex in a graph is defined as a set V, it represents a kind of drug in the secondary hospitals near the disaster area; and all the disaster units are defined as a set B; then a matrix U can be used as the weight for the match of vertices V and B. Here the matrix U should be relative to the medical function of drug, the traffic state, the weather situation, and the urgency degree factors etc. The weights setting are collected by a digital questionnaire. Then the processing methods such as the Hungarian [24] or the Kuhn-Munkres algorithms can be used to solve that optimal matching problem. The Hungarian algorithm is an operational tool which can search the augmenting path and solve the maximum matching of bipartite graph. The Kuhn-Munkres algorithm can be described as a tool which can construct a maximum weight perfect matching in a bipartite graph. It can find an optimal solution to the maximum weight sum. In this paper the Kuhn-Munkres algorithm in [25] is used to solve the optimal matching problem above.

3.3 The Multiple Drugs Scheduling Modeling Technique

In many situations, the sole medical drug cannot fulfill the rescue tasks; other drugs are also needed in the rescue activities. The sole drug scheduling algorithm above is not fit to solve that problem anymore. To settle that problem, the multiple drugs scheduling technique is developed. This technique is designed to solve the group organization and resource scheduling of multiple drugs. A kind of spectral clustering-based method [26] is used here. As for the binary classification problem of graph, the spectral clustering-based method can transform the graph partition problem into the issue of the second eigenvector computation. Similarly, the multiple classification problem of graph can also be transferred into the calculation of eigenvectors according to their values. If the matrix U is defined as the weight for two vertices (the multiple drugs and the multiple disaster units) the processing steps of the multiple drugs scheduling algorithm can be presented below.

The multiple drugs scheduling modeling algorithm

Input: Matrix U of graph vertices.
Output: The Optimal Group Matching Result.
Step 1:
As for the matrix U, compute $U'=PUQ$, where P is a diagonal matrix whose units in diagonal are $p_{ii}^{-1/2}$, Q is also a diagonal matrix whose units in diagonal are $q_{jj}^{-1/2}$. $p_{ii}=\sum_j U_{ij}$, $q_{jj}=\sum_i U_{ij}$.
Step 2:
Calculate the left singular vector group m_2, m_3, …, m_{l+1} and the right singular vector group n_2, n_3, …, n_{l+1}, from the singular value of U'. Then these results can compose the new vector groups M and N, where $l=\lceil \log_2 k \rceil$, k is the classification number.
Calculate the dataset Z by the equation below:

$$Z = \begin{bmatrix} PM \\ QN \end{bmatrix}$$

Step 3:
Use the k-means algorithm [27] to implement the clustering function of dataset Z.
Step 4:
Output the results.

In a practical application, the sole drug scheduling and the multiple drugs scheduling algorithms can cover almost all kinds of drugs distribution problems except two situations. Regarding the first situation, the automatic resource scheduling will be intervened by the man-made order. For example the media reports will influence the resource allotment. To appease the pressure of public opinion some processing measurements have to be made. This phenomenon calls for a fast parameter correction of this proposed system. Regarding the second situation, the new disasters happen constantly; as a result the rescue requirements will also make changes. Therefore the whole proposed system should have the ability to update its estimation results almost in real time and transmit its data to the distributed terminals.

3.4 The Backup-Scheme Selection Technique

When an emergency happens, the practical situation is that the medical drugs are always insufficient; however, to cure one disease, many different combinations of the medical drugs or apparatus can be chosen. For example, the Penicillin, the Gentamicin, and the Erythromycin can all cure the inflammation; they have different curative effect in clinical application. Thus, under that situation when the supply is insufficient, the rescue team wants to know how to dispatch these drugs to different disaster areas; therefore the backup-scheme selection problem should be defined to find a substitution plan for the medical rescue task. The essence of that problem is to evaluate the similarity between different combination modes of medical drugs and apparatus. Here the concept of bipartite graph model can be used again. If the neighboring matrix of a bipartite graph is defined as $W=\{w_{ij}\}_{m\times n}$, where $w_{ij}=1$ means the vertexes *i* and *j* has a connection, otherwise $w_{ij}=0$; thus the similarity between different combination of medical drugs and apparatus can be defined by (1), (2), and (3), respectively.

$$S_{ij}=\frac{\sum_{k=1}^{n} w_{ki}w_{kj}}{\min\{Sum(x_i), Sum(x_j)\}} \tag{1}$$

$$Sum(x_i)=\sum_{k=1}^{n} w_{ki} \tag{2}$$

$$Sum(x_j)=\sum_{k=1}^{n} w_{kj} \tag{3}$$

where $min\{a, b\}$ means the computation of minimal value between data *a* and *b*.

4. Application Cases and Discussions

In this section, the simulation experiment method and the related experiment results of each computation module are presented. First, an experiment result of the sole drug scheduling model is introduced. Then an experiment result of the multiple drugs scheduling model is given. After that the experiment of the backup-scheme selection method is shown. Finally some discussions are addressed. All the algorithm simulation experiments are implemented by C, Java and Java Script, etc.

4.1 Experiment Evaluation of Proposed System

4.1.1 Simulation experiment design

To evaluate the correctness of proposed system and method, a series of simulation experiments are designed. Because this system is still under development and no actual earthquake rescue data can be utilized directly, as a result the simulation data are used here. Regarding a practical task, the following items list the most important drugs which are used in a disaster rescue task according to our past experiences: the cefradine for injection, the vitamin C for injection, the amikacin for injection, the ethamsylate for injection, the penicillin G sodium for injection, the glucose sodium chloride for injection, and the ten percent glucose for injection. Considering of some typical requirements, other two drugs may be added in this list; for example, they can be the stable drug or the dexamethasone for injection. Thus it is supposed nine drugs would be necessary in a rescue task. Regarding the rescue ability, because the rescue teams in the neighbor provinces will always participate in the rescue task in China when a disaster happens; thus currently we suppose nine disaster rescue teams can be employed. They include the China international rescue team, four provincial rescue teams, two earthquake professional rescue teams, and two unofficial local disaster rescue teams. Finally, according to the analyses of the rescue materials and the rescue ability above, in this paper we consider the nine-to-nine scheduling problem of medical materials.

4.1.2 Experiment results of the sole drug scheduling model

The sole drug scheduling model is used to solve the optimal matching issue between the drugs and the corresponding disaster areas. When using the Kuhn-Munkres algorithm for matching, first the cost matrix, i.e. the neighboring matrix w_{ij}, should be built. Table 1 shows a sample of the cost matrix. The cost matrix describes the relationship of the matching degree between the medical drugs and the disaster areas (i.e., the rescue team). The symbol A_i (i=1,2,…,10) represents the multiple medical drugs and the symbol B_j (j=1,2,…,10) means the individual disaster units. The estimation of w_{ij} is decided by the opinion of experts. Currently it can be computed by an experiential Eq. (4). In (4), the weight w_{ij} is related with the transportation difficulty, the requirement urgency level, the inventory amount of medical drugs, and the cure effect of medical drugs. Once the cost matrix is built, the Kuhn-Munkres algorithm can be used to find an optimal matching between the drugs and the disaster areas.

$$w_{ij} = n_0 w_{ij}^{TD} + n_1 w_{ij}^{RU} + n_2 w_{ij}^{IA} + n_3 w_{ij}^{CE} \tag{4}$$

$$\sum_{i=0}^{3} n_i = 1 \tag{5}$$

where w_{ij}^{TD} is the transportation difficult degree factor, w_{ij}^{RU} is the requirement urgency degree factor, w_{ij}^{IA} is the inventory amount factor of medical drugs, and w_{ij}^{CE} is the cure effect factor of medical drugs; n_0, n_1, n_2, n_3 are weights. In this paper, the factors w_{ij}^{TD}, w_{ij}^{RU}, w_{ij}^{IA}, and w_{ij}^{CE} can be chosen from the data scope of [0.0, 1.0]; and n_0=0.136, n_1=0.347, n_2=0.216, and n_3=0.301.

Table 1. The data samples of the weight matrix

w_{ij}	B_1	B_2	B_3	…	B_9
A_1	0.0143	0.0918	0.2980	…	0.0085
A_2	0.0538	0.0276	0.1750	…	0.0967
A_3	0.0290	0.0437	0.4210	…	0.0006
…	…	…	…	…	
A_9	0.0287	0.0745	0.3170	…	0.0075

Table 2. The optimization matching results of the Kuhn-Munkres algorithm

Medical resources	1	2	3	…	9
Disaster areas	4	8	6	…	2

Table 2 shows the optimal computation results of the sole drug scheduling method of Table 1. From Table 2 the Kuhn-Munkres algorithm can find an optimal matching between the inventory drugs and the disaster areas according to the cost matrix in Table 1. In Table 2, nine kinds of medical resources are dispatched to nine disaster areas by nine disaster rescue teams. Traditionally, the Kuhn-Munkres algorithm is an effective method which can be used to solve the linear assignment problem. It updates the solutions iteratively until the primal solution becomes feasible. When Kuhn-Munkres algorithm works, first it sets the feasible vertexes initially; then the Hungarian algorithm is used to search the perfect matching. If the algorithm cannot find a proper perfect matching, it will modify its feasible vertexes. This process will be repeated until a perfect matching is found. For example, regarding different drugs with the similar function, or the same drug manufactured by different supplier, they are needed to assign to different disaster areas; in this situation the sole scheduling model can be used.

The computation of the sole drug scheduling model has the practical application meaning especially in the early stage of disaster rescue. According to our previous rescue experiences, the medical drug requirements of different disaster units always have their own characters. For example, site A locates in a basin, site B locates near a mountain, and site C locates near a river; after an earthquake, the secondary disaster in site A is the big rain, the secondary disaster in site B is the land slide, and the secondary disaster in site C is the flood. Each site also has many disaster units. Obviously the rescue needs of these units should be different. Thus how to dispatch the most important medical drugs to the corresponding units can be solved by the sole drug scheduling model well. This solution will look more useful especially when the medical drugs are limited in both species and quantities.

4.1.3 Experiment results of the multiple drugs scheduling model

The multiple drugs scheduling model can find an optimal group matching result among multiple medical drugs and multiple disaster areas. Before it is used, the relevance intensity between the drugs and the disaster areas should be evaluated. Here, the relevance intensity can use the same function of the cost matrix above. Thus the linear weighted computational method like Eq. (4) can be utilized to find the evaluation relationships again. For example, the transportation difficulty, the requirement urgency degree, and the inventory amount of medical drugs, can be considered. However the combinational cure effect of multiple medical drugs should be evaluated by the medical expert carefully. Table 3 shows a matching example of the multiple drugs scheduling. From Table 3 the multiple drugs scheduling model can solve the problem of multiple-to-multiple. This illustrated application has a significant practical meaning because lots of rescue task always needs more than one drug.

Table 3. The multiple drugs scheduling results sample of the spectral clustering based method

Multi-medical drugs	(3, 7, 8)	(1, 6, 9)	(2, 4, 5)
Multi-disaster areas	Area 1	Area 2	Area 3

When the supplies of the medical drugs are plenteous, the multiple drugs scheduling model can be utilized. This situation always happens during the post stage of the disaster rescue. In that stage, the rescue materials are always prepared well while the rescue needs of different disaster locations are also clear. Then the medical expert can use the multiple drugs scheduling model to dispatch the medical drugs reasonably. In contrast to other models, the proposed mathematic method can be understood by the nonprofessional medical expert easily; and its outputs are intuitionistic. The processing speed is also comparable fast.

4.1.4 Experiment results of the backup-scheme selection model

Customarily the doctor can decide the backup-scheme of a medical rescue problem in many situations; however if the authoritative doctor is absent, or the situation is urgent, or even the nonprofessionals have to make such a decision about the backup-scheme for a disaster area, then the backup-scheme selection model will be useful. The backup-scheme selection model can measure the similarity between different combinations of medical drugs automatic by graph theory. Not only the medical factor (e.g., the treat effect and the medical cost) are considered, but also the factors of the transportation difficulty, the requirement urgency level, and the inventory amount should be counted together. Table 4 shows an example of the similarity computation of backup-scheme selection model for the medical drugs in Table 1. From Table 4, the results compare the distance between different medical drugs according to the cost matrix; thus this system can choose the drug as the backup-scheme whose similarity distance is minimized.

Table 4. The results sample of the backup-scheme selection model

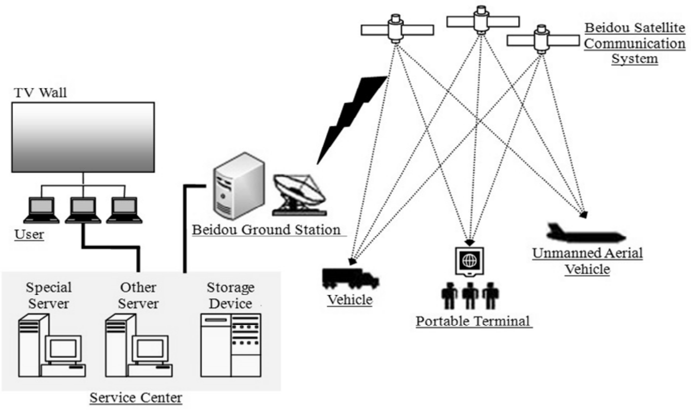
The medical drugs number	1	2	3	…
The best backup selection number	4	7	9	…

The backup-scheme selections of medical drugs are also very important during a disaster rescue task. First, it can provide a method to find the proper medical drugs for the victims. Some new developed medical drugs can be recommended. The non-authoritative doctors can use that processing function. Second, the medical rescue is not only to solve a medical therapy problem but it can provide some evidences or explanations to answer the media why some medical drugs are sent to one disaster area while others are not dispatched there. Some moral criticisms or even some law problems can be avoided by using a quantificational measurement.

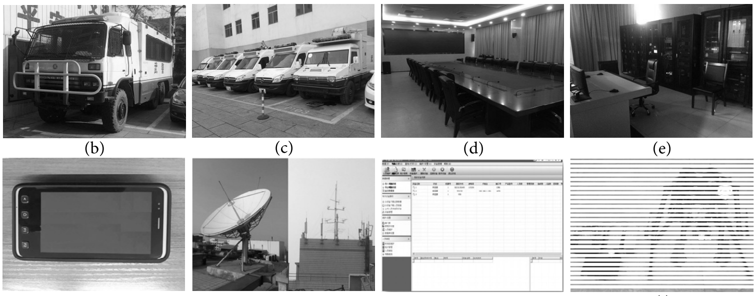
4.2 Discussions

The rescue scheduling is one of most important issues in the research area of rescue management. The ultimate target of rescue scheduling is to provide services and supports when the serious disaster happens so that the damages can be controlled to a minimized level. Many countries have developed their own medical rescue system. The United States has built a rescue information management system many years ago. This system includes the identity recognition sub-system, the resource analysis and planning sub-system, the medical rescue quality evaluation sub-system, the patient management sub-system, and the blood supply sub-system. It can be used by both the government department and the professional medical organizations. In Russia, a system which can be used to implement the information acquirement, the flow chart control, the patients carding, the medical materials allocation, and the medical materials query etc., was also developed. Therefore it is necessary to build a medical materials scheduling system for hospitals in China to realize the similar functions.

The typical functions of our proposed system include: (1) the system management function, including the medical materials and market information storage, the secondary hospital information storage, and the integrated information display, etc. (2) The emergency and rescue intelligent scheduling function, including the requirement forecast, the requirement classification, and the requirement scheduling, etc. (3) The information inquiring and feedback function, including the combination information query, the materials reports generation, and the information recommendation, etc. Comparing with the similar systems in United States, their rescue system can be divided into 3 levels in logic: the center command level which takes charge the planning and organization of entire rescue mission; the region command level which is responsible for the rescue of different local regions; and the basic unit command level which is in charge of the rescue of individual working unit. Obviously, our proposed system can cover most of the similar functions.



(a)



(b) (c) (d) (e)

(f) (g) (h) (i)

Fig. 5. The application cases of the BeiDou Satellite Communication System (BSCS). (a) is the application sketch map of BSCS; (b) is the photo of the command and control vehicle; (c) is the photo of the disaster rescue vehicle; (d) is the photo of the meeting center and the TV wall; (e) is the photo of the servicer center; (f) is the photo of the BeiDou portable terminal; (g) is two photos of the communication antenna; (h) is the photo of the application software interface; and (i) is the photo of unmanned aerial vehicle (UAV).

The automatic information process of the rescue task has to draw support from some mathematic tools. In this paper the Kuhn-Munkres algorithm, the spectral clustering based bipartite graph matching method, and the similarity evaluation method are utilized. As one of simplest graph model, the bipartite graph has the advantage in computation efficiency. The proposed system has two characters: first, this system emphasizes the practical application; second, this system focuses on the running reliability. To keep these characters, the proposed system uses the BSCS and the SFCN to transmit information and the bipartite graph models to implement the data processing functions. This system also has some shortcomings. For example, its data analysis ability is still limited [28,29]. The proposed system is still under development, in next step the response time factor, the state update factor, and other complex constrained conditions [30,31] should also be considered. The agent technique [32] can be developed to implement a top-to-bottom design of this system.

Fig. 5 shows the practical application of proposed system. All these photos are captured in our hospital. The important function of BSCS should be emphasized. The BSCS can provide not only the position information but achieving the information transmission function almost in real time. When constructing the bipartite graph model, it is needed to build the cost matrix firstly; thus the corresponding matrix information, such as the transportation difficulty and the requirement urgency level of disaster areas can all be transmitted by the BSCS. Comparing with the special fiber-optic communication system, the BSCS cannot be destroyed by the natural disaster easily and its information security level is high; thus the BSCS can be used for the complex rescue widely in future definitely.

5. Conclusions

In this paper an emergency rescue and medical material scheduling system and its data processing methods are presented. Both the BSCS and the FCS are employed to transmit the information of disaster and rescue. The former system is used to transmit the classified messages while the latter one is only employed to receive and dispatch the normal information. The Kuhn-Munkres algorithm, the spectral clustering based technique, and the similarity metric method, are all used to solve the sole drug scheduling problem, the multiple drugs scheduling issue, and the backup-scheme selection application, respectively. In future, more complex resource scheduling algorithms will be developed to improve the processing ability of proposed system. And it will definitely perform well when helping people to save their life and properties from disaster.

Acknowledgement

This paper is supported by the National Natural Science Foundation of China under Grant No. 61501016.

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