

An Intelligent Network Planning Algorithm for Emergency Communication with Deep Learning

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Abstract. With the increase amount of the natural disasters and terrorist activities, emergency communication management research which often involving local conventional communication system severely reduced or even paralyzed has been paid more attentions in recent years. And there has also arisen the need to develop applications to establish emergency communication in the shortest time and rebuild all kinds of the communication systems in the affected areas. This paper presents a network model of emergency communication, and clarifies the requirements of the network planning task. By introducing deep learning neural network to the network intelligent planning task, this paper puts forward an efficient, reliable and intelligent planning method of emergency communication network.

Keywords: Emergency Communication, Network Intelligent Planning, Deep Learning.

1. Introduction

1.1 Research Background

When sudden natural disasters and public safety incidents such as typhoons, earthquakes, tsunamis and terrorist attacks occur, accompanied by a large number of casualties and property losses, the communication infrastructure at the site usually has performance such as serious damage or lack of function. In order to understand the disaster, organize the power of emergency rescue and stabilize order of the disaster areas, we need rapid establishment of a stable and reliable emergency communication network.

In emergency communication, the communication environment can't be predicted, and the existing communication infrastructure often can't adapt to these changeable and unpredictable needs[1]. The complexity of the communication environment, the variability of information demand and the urgency of ensuring the communication have put forward higher requirements for the organization of emergency communication network. How to design and plan the emergency communication network better and faster has become a hot issue in the communication field, and has also aroused the full attention of the governments all over the world.

1.2 Research Status

1.2.1 Emergency Communication Network Construction

Early researches on emergency communications in the world are mainly concentrated in developed countries such as the United States, Europe and Japan[2]. As early as 1970s, the United States has built an emergency communication network. After the incident of "9.11", the United States has invested a large amount of funds and manpower for emergency communication technology, and built the emergency communication system of the emergency communications of the highest strategic authorities of the United States and the emergency communications in the accident scene, which has been set up for the government. The special network for urgent communication has been integrated various communication technologies in the network implementation, such as satellite communication, microwave communication, and self-organizing network technology.

European countries mainly adopt satellite communication technology, including Hot Bird series live communication satellite, Galileo global navigation satellite system, Sky Bridge communication

satellite constellation and so on. At the same time, the emergency communication system based on public telecommunication network and cluster emergency communication system also play an important role.

Because of its geographical location in the frequent occurrence of major disasters such as earthquakes, tsunamis and typhoons, Japan has always attached great importance to the development of emergency communication technology. A more perfect emergency communication network with the core of the central disaster prevention wireless network, which combines the satellite line, the cable communication and the mobile communication link, has been built now, and the communication ability for maintaining the normal work of the government and disaster relief work can still be maintained at the time of most disasters.

1.2.2 Emergency Communication Network Planning Research

Emergency communication resources are usually transferred in emergency after disaster, temporarily replacing and restoring rescue command and dispatching, and public communication services in disaster stricken areas. Due to the sudden incident and bad environment, there is few equipment that fully meet the communication needs of the affected areas, and cover many communications areas, such as cable communication, wireless communication and interconnected communication and so on. The planning of emergency communication network should take into account the comprehensive utilization of all kinds of resources.

In order to ensure emergency rescue and the necessary communication services in the disaster area, the communication network planning in the emergency scene mainly solves the contradiction between the increase of the communication users, the increase of communication and the serious shortage of the existing communication resources[3]. The network planning objective can be abstracted to obtain the capacity of the minimum in given resources and get the balance between expansion, network coverage and quality of service.

In order to solve the problem of rational planning of emergency communication network, a series of methods are proposed to solve the user access problem, such as the access control and load balancing algorithm. The channel allocation problem is solved by channel allocation mechanism, and the power allocation problem of equipment and terminal is solved by the energy control algorithm[4] [5] [6]. But an efficient network resource planning method should take into account system throughput, energy efficiency, user fairness, quality of service requirements, resource sharing, power constraints and constraints. In order to solve these prominent contradictions, in the actual application process, the mathematical models are established according to the communication means, the key points and the constraints, and a variety of network planning algorithms are proposed, as shown in Table 1.

It can be seen that these network programming methods are essentially the optimal search of feasible solutions under various conditions to achieve the convergence of the set of feasible solutions. It is still a "machine thinking" inherited from the "exhaustive" violent search. There are still many restrictions on the scope and accuracy of its application and the period of its search is also too long. It is often difficult to get the best network planning scheme, and sometimes even needs to rely on the work experience of the planner to implement the artificial influence and intervention in the feasible solution set.

Table 1. common network planning algorithm

Category	Advantage	Disadvantage	Typical Algorithm
Heuristics Algorithm ^[7]	It can be converted to the optimal search problem of multi-objective constraints, which is easy to implement in engineering.	It is impossible to prove the gap between the solution and the optimal solution, the global optimization ability is not strong enough, there is even no guarantee that a feasible solution can be obtained.	Tabu Search, Simulated Annealing, Immune Algorithm, Clustering Decomposition Method, Greedy Algorithm
Approximation Algorithm	We can clearly get the gap between the solution and the optimal solution, and find a feasible solution.	The complexity of the solution is reduced by obtaining the quality of the solution, and the accuracy of the solution is affected by the approximation factor.	Approximation Ratio Algorithm
Genetic Programming	The search and controllability of the solution have been greatly improved, and a feasible solution can be obtained within a limited margin.	In the process of computation, the convergence speed of the algorithm is not fast enough, easy to converge to the local optimal solution rather than the global optimal solution.	Genetic Algorithm
Improved Genetic Programming ^[8]	Fast convergence to global optimal solution	The problem of balance between multiple goals is not considered.	SEAMO,PESA,SPEA2 and SGA-II
Game Theory ^[9]	The coverage, capacity and quality of the network have been balanced with some intelligent features.	The accuracy of the solution needs further optimization.	Asynchronous Distributed Price Algorithm

2. Emergency Communication Network

2.1 Various Emergency Communication Means

At present, the main means of emergency communication include satellite communication, trunked mobile communication, short wave radio communication and microwave relay communication. These 4 methods all use wireless communication, with good mobility and rapid communication equipment, so it is very suitable for emergency communication.

According to the comparison and analysis of the communication means above, it can be concluded that the satellite communication is suitable for the long-distance communication guarantee. However, because of the limited number, it can be used mainly as an important means of communication for emergency rescue command department and the superior or important rescue team, and the cluster mobile communication system has a strong dispatching function. But the coverage is limited, and it can be used as a means of communication in a certain area; the communication of microwave and radio station can jointly construct a raster complex emergency communication network, which constitutes the main part of the emergency communication network, and its structure is shown in Fig.1.

2.2 Emergency Communication Network Model

2.2.1 Emergency Communication Network Structure

Table 2. Comparison of the advantages and disadvantages of 4 kinds of emergency communication methods

Means	Advantage	Disadvantage
Satellite Communication	Coverage is large and insensitive to distance, No-Gap, No blind area coverage(within the satellite coverage area), Unlimited to geographical environment, climate conditions and time.	Finite Capacity, High Cost
Trunking Mobile Communication	Support group calls, calls quickly, no need to pick off when be called, makes networking convenient and flexible.	Coverage is limited
HF Radio Communication	Communication distance is far away, ability to resist damage is strong, the capability of independent communication is strong, operation cost is low, short-wave radio is small in size, light in weight and convenient for maneuvering.	Limited frequency resource, Signals are easily affected by terrain, ground objects and weather
Microwave Relay Communication	Communication capacity is large, communication quality is stable, the link can be formed quickly across mountains and waters, and the disaster resistance is strong, it can provide many kinds of services.	Poor diffraction ability, Among microwave stations must be inter-visibility, High frequency, high transmission loss, etc.

Emergency communication network can be regarded as structure of "backbone + user network" that is composed of layers. The main features are as follows:

1) There are various kinds of trunk channels used to build backbone information transmission networks. In addition to the microwave relay mode, there are other wireless communication modes, such as satellite, air relay platform and other wireless communication modes, and optical fiber such as optical fiber.

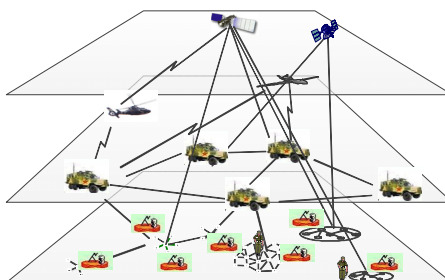


Fig.1. Schematic diagram of basic network structure of emergency communication network

2) It can use the cluster mobile system and the wireless access node system to expand the coverage of the network. It can also use the air relay platform and satellite communication to further expand at the same time.

2.2.2 Emergency Communication Network Planning Process

In order to realize the effective management and control of the emergency communication network, first of all, we should plan the resources (frequency, address, equipment and so on) of the emergency communication network according to the contingency plan, make a reasonable allocation scheme, form the network planning plan, provide the basic framework for the network initialization, and meet the needs of the emergency communication.

The network planning process mainly includes resource preparation, command center planning, network topology planning, resource planning, business planning and so on, which can be shown in Fig.2.

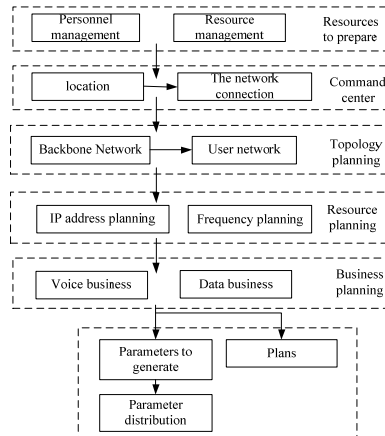


Fig.2. Network planning content and process

As the content of emergency communication network planning involves various aspects of the network organization, different planning methods can be put forward in different aspects. The network topology design is the unified deployment and deployment of network resources from the macro level, mainly to determine the number and name of the backbone network, user network and other networks, and the location of the network. The composition of network members and networking parameters are the basis of network planning for emergency communication network. Due to the limitation of papers, this paper focuses on the design of network topology, and intends to propose an intelligent planning method for emergency communication network topology.

3. Intelligent Network Planning Algorithm

The AlphaGo smart go system, developed by the DeepMind team in Google, in 2016, 4:1 wins the world's top chess player Li Shishi[10], which makes the prospect of application of depth learning technology in situational awareness and assessment favored by researchers.

3.1 Similarity Analysis between Network Planning Task and go Game Problem

1) The relationship between the scope of regional coverage and the chess board

The checkerboard is a rectangle composed of 19 vertical and horizontal lines. It can also limit the coverage area of the emergency communication network planning task to a certain area in a rectangular range according to the requirements of the communication guarantee, and use the coordinate grid to divide the coverage of the whole communication guarantee, and according to the value of the coverage of the communication node itself. To determine the scale of the grid, we can get a geographical range similar to the chess board, and the network planning task for the emergency communication network is carried out on this abstract "chessboard".

2) Protection object and black and white relationship

The network planning task can also be regarded as the result of two party game, which can guarantee the user object (the command center user, the special user, the ordinary user and so on) and the security force object (microwave relay station, cluster mobile communication station, radio access node station, etc.). We can consider the protection of user objects as the "black spots" in advance, and protect the objects of power as "white ones".

3) The relationship between network structure and chess game

The interconnected relationship between the protection force object node and the user object node can be regarded as the "mutual encirclement" between two kinds of "chessmen". From the position, it is to guarantee the user object node to encircle the security force node, and from the coverage area, the security force node surrounds the user object node. At the same time, the spatial location feature is more important than the number characteristic, so the network planning can be abstracted as the position of deploying all kinds of security force object nodes on the "chessboard".

4) The relationship between the optimal layout of network and the winning rate of the disk

The optimization of network layout is the ultimate goal of emergency communication network planning, which is used to reflect the satisfaction degree of emergency communication network planning. The evaluation of the advantages and disadvantages of the scheme can be referred to the victory rate method, and the current situation plus a comprehensive evaluation method of the position of one step is used to judge the satisfaction of the current network layout step by step, that is to say, the current network situation and the possible deployment position of the next node should be weighted to evaluate each evaluation.

3.2 Design Ideas of Intelligent Planning Method

Using AlphaGo intelligent go algorithm can solve the problem of organizing network planning of emergency communication network more reasonably. The design of the intelligent planning method of emergency communication network includes the following parts: data preparation, network planning and project evaluation three parts.

In this paper, an intelligent planning method for emergency communication network is proposed.

(1) data preparation

The data preparation part includes the collection, pretreatment and data processing of the raw data, as well as the abstraction of the core elements of the network planning task. The aim is to convert the network scheme of various emergency communication networks into the image sample data that can be used to train the convolution neural network. At the same time, it maps the core elements of the network planning task abstractly, and completes the problem migration of the network planning task.

(2) network planning

The main part of the network planning part is to build a network planning strategy neural network model, which can be used to realize the analysis and identification of network security objects and the autonomous planning of the network topology, for example, Figure 3.

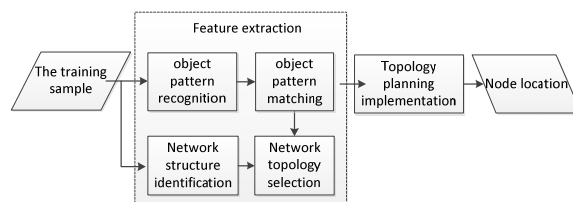


Fig.3. Basic process of network planning strategy

The following operations are completed in the planning learning phase:

1) collect and collate the plan data of the emergency communication network planning, get the original data set D , and note that each plan corresponds to a geographic information data (coordinate, elevation, river, road and so on) and a final satisfaction.

2) digitized sample data sets, which digitize two kinds of data sets representing node space location and connection relationship, and distinguish the training data set D_{train} (the total number of $2/3$) and test data set D_{test} (the rest $1/3$).

3) input the training sample data into the support pattern recognition and network structure recognition network, which mainly realizes the guarantee mode in the network planning scheme and the analysis and learning of the network structure.

4) the training data set is used to train two convolution neural networks for support pattern recognition and network structure learning, and the possible probability of deploying the power node (microwave relay station, cluster mobile communication station, radio access node) is constantly adjusted, and a network planning strategy network is finally obtained.

5) strengthen the planning ability of network planning strategy network through testing data, get an enhanced version of network planning strategy network, and use this enhanced network planning strategy network as the initial state of value evaluation network.

3.3 Scheme Evaluation

The planning evaluation phase is mainly to test and evaluate the planning results of the learning stage, and to adjust and optimize the planned results properly, as shown in Figure 4.

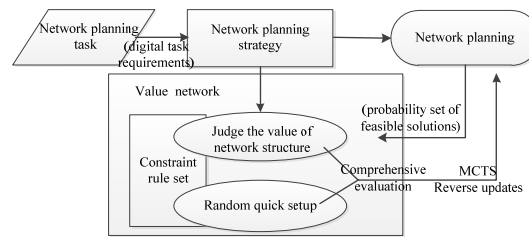


Fig.4. Basic process of value assessment network

The following operations are completed in the planning evaluation phase:

- 1) data network planning requirements;
- 2) in the process of the input network planning strategy, the security object features extracted from the requirements are identified and matched by the model of the object, and the feasible set and evaluation order of the network planning scheme are generated.
- 3) the feasible set of network planning scheme is input into the network structure value judgment network for satisfaction screening, that is to find the maximum satisfaction expectation of the planning scheme.
- 4) using the fast layout scheme and the network structure value judgment network to judge the expectation of the situation, calculate the maximum expected value of the two results and evaluate the value of the network structure.
- 5) update the probability of feasible set of the network planning plan according to the result of step D, and continue to select the probability scheme to search again.
- 6) when the cut-off time is reached, the search is stopped and the maximum probability scheme is chosen as the final planning plan.

4. Conclusion

This paper introduced the AlphaGo intelligent go algorithm to solve the similarity analysis of the network planning problem of emergency communication network, and drew on the idea and successful experience of the combined evaluation and prediction in the AlphaGo algorithm, proposed an intelligent planning method based on the depth learning technology, designed the network planning strategy and the implementation process of network value neural network, described the implementation process of intelligent planning method, and clarified the related problems of network planning at the same time.

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