

URBAN EMERGENCY EVACUATION DATA FUSION BASED ON “ONE MAP”

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KEY WORDS: Emergency; Emergency Evacuation; Spatial Data Fusion; One Map

ABSTRACT:

Urban emergency evacuation is a complicated systems engineering, which relates to many departments. How to fuse different scale, different format, different mathematical base spatial data effectively provided by such as police, fire protection, medical and health organization, traffic, emergency rescue and so on is a realistic matter that decision-makers are faced with. This paper analyses the characteristic of multisource spatial data in urban emergency evacuation and sorts it, brings forward the fusion strategy of multisource spatial data based on “one map”, designs the frame of multisource spatial data fusion, makes an experiment in the end. The experiment indicates that the efficiency and level of urban emergency evacuation decision-making advances remarkably supported by multisource spatial data fusion.

1. INTRODUCTION

With the increasingly rapid urbanization of our country, the population and wealth congregates in the city rapidly, the development of city is faced with serious safety issues, the public safety of city is threatened by the emergency such as toxic gas leak, fire, earthquake, mountain torrents and mud-rock flow, terrorist attack and so on, how to reduce the loss of life and property caused by emergency farthest is one significant task in face of decision-maker (Bowei Wen 2012). Urban emergency evacuation as an important measure to deal with emergency gets more and more attention, the rationality and scientificness of emergency evacuation decision-making impacts the success of evacuation.

Geographical information system as an important aid decision making tool plays an important role in many areas such as resource and environment, agriculture and forestry, mineral resources, hydrology, urban planning and management, disaster evaluation and forecast, electronic government and so on (Jiayao Wang 2010). With the fast development of GIS, its application deepens incessantly, integrating into every aspect of our life, the affair as long as related to geographical spatial information can be visualized and analysed on the map supported by GIS. Urban emergency evacuation decision-making is an affair related to geographical spatial information nearly, because that spatial location selection of evacuation area, evacuation zone demarcation, evacuation population estimate, selection of lash-up evacuation route cannot be inseparable from the support of geographical spatial information. Urban emergency evacuation decision-making is a complex systems engineering which refers to many departments such as traffic, police, air defence, medical, geology, hydrology and so forth. The before-mentioned departments produce different format, different sort and classification, different coding, different mathematical base, different semasiology multisource data according to own operation requirement. When the moment of emergency, the department of urban emergency evacuation needs to exert these information comprehensively to know the actuality of the event, forecast the development trend. How to fuse these multisource data efficiently, express the urban emergency evacuation information on “one map”, realize the

share of urban emergency evacuation data, reduce the repetitious production and waste of data resource, advance the efficiency and level of urban emergency evacuation decision-making is a very meaningful task.

2. THE CHARACTER OF URBAN EMERGENCY EVACUATION MULTISOURCE DATA

Data is the foundation of urban emergency evacuation decision-making. The more information the decision-maker acquires, the high quality the data has, the less unbeknown and uncertain factors in the process of decision-making, the more rationality and scientificness the urban emergency evacuation decision-making has. The multisource data in urban emergency evacuation can be classified into urban basic geographic information data and emergency evacuation thematic data by theme. The urban basic geographic information data mainly contains data of urban jurisdiction(1:100 thousand scale), 1:50 thousand scale topographic map data, 1:10 thousand scale urban data, 1:5 thousand scale urban data, remote sensing image data of 0.6 meter resolution; emergency evacuation thematic data mainly contains the distribution data of emergency shelters(evacuation point, evacuation base, evacuation zone), danger source, defence target and guarantee resource (Li Li 2011). We can discover that urban emergency evacuation data has three characters through analysis.

1. multi-scale character

The multisource data in urban emergency evacuation has a large range on temporal and space, which takes on an obvious multi-scale character. Space scale reflects the detail degree that spatial data expresses the urban spatial environment, at the same time space scale reflects the verisimilitude of spatial data. Urban emergency evacuation as a complex system engineering can be disassembled into many specific affairs such as spatial location selection of evacuation area, evacuation zone demarcation, evacuation population estimate, selection of lash-up evacuation route, evacuation time estimate, evacuation thematic factor management, evacuation command and so forth. These affairs have different detail degree requirements of urban geographic environment, for example, 1:10 thousand scale and 1:5

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thousand urban data reflect urban basic geographic environment from different arrangement and detail, which mainly apply to evacuation thematic factor management, evacuation zone demarcation, evacuation population estimate and evacuation command. 1:50 thousand scale topographic data covers comprehensive factors, especially topographic and traffic data are detailed, which mainly applies to spatial location selection of evacuation area and selection of lash-up evacuation route. Urban emergency evacuation decision-making cannot be made without the support of historical data, for example, in order to realize better decision-making, it's very important to study the law of flood through history data when the flood happens.

2. multisource and isomeric character

Urban emergency evacuation data has a typical multisource and isomeric character. Urban emergency evacuation data has an extensive origin, mainly consisting of basic geographic environment data, real-time and dynamic data (GPS orientation data), every urban department's data and model data. Due to the difference of geographic environment cognition and software of data collection, there is big difference among this data such as data format, data model, data classification, data coding and mathematical base and so on. For example, traffic department and hydrology department both have a suit of urban basic geographic environment data, with the difference in the aspect of expressing traffic factor and water factor. Traffic department makes a detailed and accurate classification and grade of traffic factor, but synoptical classification and grade of water factor; the hydrology department makes a detailed and accurate classification and grade of water factor, but synoptical classification and grade of traffic factor. At the same time, this data with different department has variance in geometry location, property semantics and logic, etc.

3. model character

Application model is an important and intimate part in the process of urban emergency evacuation decision-making. In order to advance the rationality and scientificity of emergency evacuation decision-making, it needs to establish the domain model according to the character and property of emergency. For example, it needs to establish flood model in order to deal with flood; it needs to establish toxic gas leak model in order to deal with toxic gas leak; it needs to establish blast model in order to deal with blast. Application model has a self-governed data system, which has a close coupling relationship with data. This close coupling relationship results that the adaptability of model is weak, in case data structure or format changes, application model needs corresponding change.

3. THE STRATEGY OF URBAN EMERGENCY EVACUATION DATA FUSION BASED ON "ONE MAP"

The multi-scale character, multisource and isomeric character and model character of urban emergency evacuation data restrict urban emergency evacuation decision-making. Forming a unitive urban basic data frame is the sticking point to make emergency evacuation decision-making efficiently through urban emergency evacuation data fusion, so this paper brings forward one fusion strategy of urban emergency evacuation data based on "one map".

"One map" is one mode of data application and integration, which takes spatial position information as main index, a normal system of open network services and data integration, a service platform of bringing forth and sharing information of

different type comprehensively (Bingzhong Gu 2011). The concept of "one map" was advanced by American troops, as the form of "currency battle map" applying military affairs. Later "one map" was introduced into these areas such as construction of national spatial information infrastructure (Deren Li 2006), management of mineral resource (Wenting Duan 2011), traffic management (Jing Chen 2011) and so forth. For example, the target of European Union's "one map" is that producing data once and using it repeatedly, sharing by most consumers and application system.

Urban emergency evacuation data especially emergency evacuation thematic data distributes different department. Every department has produced large numbers of data according to its own data standard, formed a self-governed data system, which brings these problems that it's difficult to share information resource among different department because of partition of information. The start of urban emergency evacuation data fusion based on "one map" is that integrating different source, different format, different classification and grade, different coding, different mathematical base, different semantics efficiently, establishing a unitive urban emergency evacuation basic data frame, forming a high quality data resource system of urban emergency evacuation. The target of urban emergency evacuation data fusion based on "one map" is that to reduce repeated production of data, to save the cost of data production, to provide urban emergency evacuation decision-making with basic spatial data frame, to advance the quality of urban emergency evacuation data, to realize sharing urban emergency evacuation information. When emergency happens, decision-maker superimposes the emergency thematic data on the basic data frame of urban emergency evacuation according to the character of emergency, transfers corresponding model to operate, expresses the operation result by visualization on the frame of urban emergency evacuation basic data. Decision-maker accomplishes decision-making according to visualization result.

The key to realize urban emergency evacuation "one map" is that integrating mathematical base, different data model, different classification and grade seamlessly. Basing on large scale data, integrate different scale urban basic data to form unitive urban basic data frame through mathematical base conversion, data model conversion, data classification and grade conversion. There are two rules that data fusion process should follow. (1) Take the target that advancing data quality. Choose the data that has high authority, better verisimilitude, detailed property information, high precision, when the variance appears between homolog. (2) Be advantageous to share urban basic frame data among different department.

4. THE FRAME OF URBAN EMERGENCY EVACUATION MULTISOURCE DATA

Basing the idea of "one map", this paper establishes a frame of urban emergency evacuation multisource data fusion, as shown in figure 1. From the figure we can get that urban emergency evacuation multisource data fusion contains two steps: data integration and data fusion. Data fusion is that pre-processing of remote sensing image data of 0.6 meter resolution, 1:10 thousand scale urban data, 1:50 thousand scale topographic map data, 1:100 thousand scale urban data based on 1:5 thousand scale urban data.

Data Fusion mainly contains three aspects: mathematical base unification, data model unification, data classification and grade unification. The data from different department uses different coordinate system and projection. Mathematical base unification mainly solves the problem that the variance of spatial datum among urban emergency evacuation multisource data. The coordinate system of urban emergency evacuation data mainly contains: Beijing coordinate system 1954, Xian coordinate system 1980, CGCS 2000 and local coordinate system; the projection of urban emergency evacuation data mainly contains: Gauss-Krüger 6° zone dividing projection and Gauss-Krüger 3° zone dividing projection. Due to urban emergency evacuation “one map” adopting CGCS 2000 and Gauss-Krüger 3° zone dividing projection, the data fell short of this mathematical base needs to be switched to this standard system. Data model mainly solves the problem that the variance of data model. The data model of urban emergency evacuation can be fallen into cartographic data and topological relationship data model. Because of the cartographic data model lacks property and topology information, just reflecting the visualization character of entity, cannot meet the requirement of urban emergency evacuation decision-making analysis, this paper adopts topological relationship data model. Classification and grade unification mainly solves the problem that the variance of data classification and grade. Different spatial resolution data adopts different classification, grade and semantics description standard. In general, large scale data has detailed classification and grade, but the classification and grade of small scale data is sketchy. In the process of data integration, make mapped transformation to small scale data based on large scale data. Choose the data with detailed classification and grade as standard when the variance of classification and grade appears.

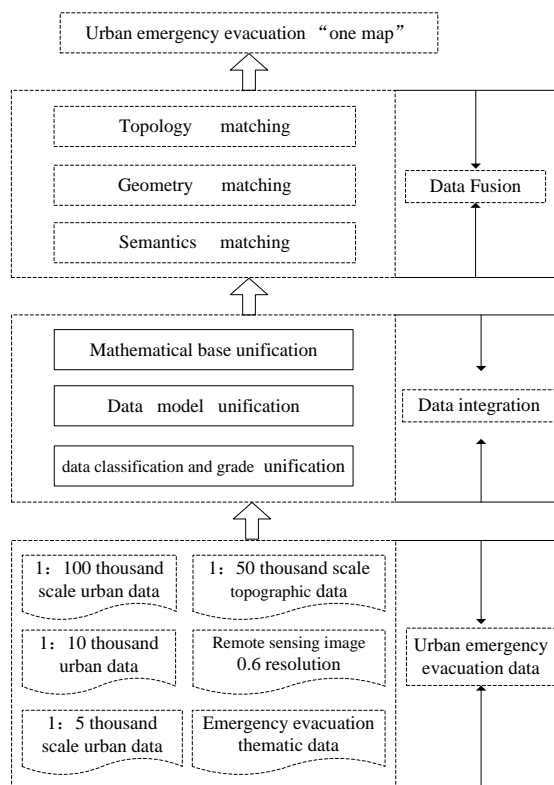


Figure 1 Frame of urban emergency evacuation multisource data fusion

Do urban basic data geometry matching, topology matching and semantics matching on the precondition that mathematical base, data model and classification are coincident. Realize the target that improve geometry precision of data; enrich the property information; gather head the verisimilitude of data through data fusion (Peng Lv 2011; Shengwu Hu 2008). General method of geometry matching is that compute the comparability of candidate homologous entity using the character of graphics. The metric space of geometry matching is Euclidean space, which chooses the character of graphics such as the length, distance, area as metric guide line. When the comparability between of the two entities is greater than the threshold, the two entities are homologous. Topology matching takes the topology relationship comparability of candidate homologous as basis (Shengwu Hu 2007). Semantics matching takes the semantics comparability of candidate homologous as basis, for example, if the name and properties of the two entities from different scale urban map are uniform, the two entities are homologous. In general, the three methods above are often composed together in the practice of urban emergency evacuation data fusion, because the single method has difficulty to ascertain homologous.

5. APPLICATION ANALYSIS

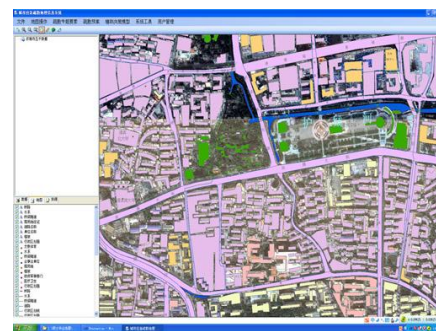


Figure 2 Urban emergency evacuation “one map”



Figure 3 Simulation effect of toxic gas leak

This paper practises preliminarily urban emergency evacuation data fusions based on “one map”, adopting 1:100 thousand scale urban data, 1:50 thousand scale topographic map data, 1:10 thousand scale urban data, 1:5 thousand scale urban data, remote sensing image data of 0.6 meter resolution as experiment data. The urban emergency evacuation “one map” is shown as figure 2, which is based on 1:5 thousand scale urban data and remote sensing image data of 0.6 meter resolution. Take toxic gas leak under condition of wind as an example; switch the data of toxic gas leak, lap the switched model data over the frame of urban emergency evacuation, the effect is shown as figure 3.

The simulation effect of toxic gas leak is better, which is based on urban emergency evacuation “one map”, so it can apply to urban emergency evacuation decision-making.

6. CONCLUSION

“One map” has the advantages that it can reduce the cost of data resource, and promote data resource share, etc. Because of the character of emergency evacuation data, urban emergency evacuation “one map” is supposed to the direction and target of emergency evacuation data fusion. Urban emergency evacuation “one map” built in this paper needs to prove in practice for the future.

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