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Application of ontology in emergency plan management of metro operation

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Abstract

Emergency plans play a key role in the emergency management of metro operation. Well-prepared emergency response supported by plans can greatly mitigate the significant impact of metro incidents. However, most emergency plans remain as plain-text documents, which make it difficult to conduct efficient administrative work such as plan generation, documentation and maintenance. Operational use of plans such as rapid knowledge retrieval and acquisition cannot be performed as well, affecting emergency training during the preparation process as well as plan review at the scene of the accident. Additionally, the knowledge codified in emergency plans is mostly depicted by texts, which are not vivid and intuitive enough to clearly convey the instructions of response procedures and relative information. In this paper, an ontology-based knowledge management method is proposed, and a unified and formalized plan repository is built to facilitate the efficient administrative and operational use of emergency plans. BIM technology is applied to provide realistic visualization of the plan knowledge for better understanding. A prototype of emergency plan training system, which integrates BIM and the ontology-based plan repository, has been developed to demonstrate the feasibility and effectiveness of the method. A case study illustrates the knowledge management process and shows how staff training can benefit from the system.

1. Introduction

With the characteristic of high speed, punctuality and environmental protection, metro has gained its popularity in China recently. However, huge casualties or economic loss can be caused when metro incidents happen during

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operation, such as station fire, train breakdown and terrorist attack. The increasing scales of metro construction as well as the booming passenger flow have put forward higher demand for the emergency management of metro incidents. To better deal with these emergencies, Chinese government has issued national guidance to support the development of emergency plan systems in different cities. Hence, a large amount of emergency plans covering all possible incidents and all operation areas have been developed by local metro operation companies. The plans serve as a manual that mainly describes procedures for dealing with all kinds of emergencies [1]. These plans will be learnt during staffs' professional training to improve their proficiency of the knowledge so that they can act quickly at the scene. When metro incidents happen, the corresponding emergency plan will be initiated and support the on-site response work. The plans can also be improved and updated based on the implementation effect.

However, more than 80% emergency plans of metro operation in China are plain-text documents or rigid electronic files without semantic meaning, which makes it difficult to conduct efficient administrative work such as plan generation, documentation and maintenance. It also causes inconvenience in the use of plans. Since large amounts of knowledge fragments are scattered among various files without organization, rapid knowledge retrieval and acquisition can't be easily achieved, considerably affecting training effect for staffs as well as on-site knowledge support for decision makers. Thus, it is essential to organize and represent the plan knowledge in a structured and coherent manner to promote the efficiency both in administrative and operational use of emergency plans.

Meanwhile, the knowledge codified in emergency plans are mostly depicted by texts, and generalized descriptions of response procedures can't effectively convey the information about how to respond in a specific situation, which leads to the lack of pertinence and effectiveness of emergency plans in real situations. Therefore, combining response procedures with its associated environmental information is important to enhance the applicability of plans, and a more visualized method of knowledge display is needed to extend the capacity of metro staffs to better understand and memorize plans.

In this work, ontology has been introduced for knowledge management support. It can provide coherent and accurate conceptualization of domain knowledge [2] to integrate the relevant information in a common manner. Also, the knowledge can be presented in a standard and semantic way to avoid the ambiguity of natural language and enhance computer-aided information processing. Hence, to overcome the problems of traditional file management of emergency plans mentioned above, an ontology-based knowledge management has been proposed to improve the efficiency both in administrative work and operational use of plans. A prototype of emergency plan training system for metro staffs, which combines the ontology-based plan repository and BIM, has been developed to support efficient emergency plan training process for metro staffs. A case study illustrates the knowledge management process and shows how staff training can benefit from the system.

The remainder of this paper is organized as follows: In Section 2, we briefly discuss the related work in information management of emergency plans and BIM application in emergency simulation. Section 3 presents the design and construction of the ontology of emergency plans for metro operation. Section 4 discusses the establishment of the prototype system for metro staff training. Section 5 illustrates an example of applications. Finally in Section 6 we conclude the work, discuss the prospect of the ontology-based training system for emergency responders as well as future study directions.

2. Research review

To improve the management efficiency of emergency plans, various and individual information management systems have been developed for different research aims. Zhang, Li and Wang [3] have formed a digital plan database, based on which an emergency decision support platform was developed to support procedure retrieval. Dong, Li and Xu [4] have developed an information management system to enhance the automatic management of emergency plans such as adding, deleting, modifying and inquiry of plans. Canós et.al [5] introduced SAGA, a framework designed to provide support to the full lifecycle of emergency plan management and use, especially the administrative aspects. Ontology is also introduced to solve the semantic problem. Mejri [6] introduced ontology for the analysis of information function during the entire workflow of emergency management. Yu and Wang [7] also constructed an emergency ontology to reorganize the knowledge pieces from emergency plans for decision-making support. Wang, Yang and Dong [8] have built an emergency plan system ontology to promote the communication