Prioritization System for Building Maintenance Applications in Public Universities

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Abstract: This research present a system named Prioritization System (PS) to support the maintenance engineers while they are making the decision about the priorities for maintenance applications of school buildings. Distinguished from the other research done before, which built the priority model only with historical data, the PS presented in this research bases both on historical data and knowledge, which is deposited in a school maintenance knowledge base. The standard estimation criteria and electronic medicine documents of buildings are set into the PS, which will be integrated with a School Building Maintenance System (SBMS). Automatically prioritized by the system according to the estimation criteria could avoid mis-determining subjectively made by people themselves. Besides, the system enhances its decision support and reduces the replacement cost for management jobs.

Keywords: Prioritization System, Maintenance, School Building, Knowledge Base, University

1. Introduction

School buildings are not only a major group of public buildings, but also the largest essential hardware in development plans for schools. Therefore, the role that procedures of school building maintenance play in school administration is getting more and more important while the education development is promoted. There are more than one hundred and fifty colleges/universities in Taiwan; sixty percent of them are more than twenty years aged. The aging problems of buildings are appearing and the maintenance applications are increasing. No matter how many maintenance requirements increased, the unchangeable fact is that the maintenance budget is limited. Consequently, how to keep maintenance quality is becoming a stronger challenge than before. The main issue discussed in this research is how to make use of information technology to provide a platform with objective and standard estimation criteria for prioritization of school building maintenance. The main objects of this research are public universities in Taiwan. After literature survey, field survey, and questionnaire survey, the research schemed out an index architecture. Under the framework of a management system of school buildings, the documentation knowledge are used together with to knowledge in multi-media objects to reason out health states of school buildings. After that, the system will produce the maintenance priority automatically through the reasoning of estimation rules. This estimation system for maintenance prioritization is built to reduce the workload of routine jobs for maintenance engineers and avoid negative influences for school building management, such as improper allocations of limited maintenance resources, possible endangering of public safety, accelerated deterioration of building health, or obstacles of entire school development.

Compared to the Bridge Management System, which has been developed in Taiwan, Japan, and U.S.A., the elements consisted of the Building Maintenance System are more complicated. However, development of the Building Maintenance System in Taiwan is still insufficient. Take the sixty public universities of Taiwan as examples, only twenty-two percent of them have built relative maintenance management systems. The functions of these systems are simply applying and querying. That is one of the most important reasons that the PS could not be built into a complete Building Maintenance System and verify its effects on prioritization support. That is also the major limitation of this research.

2. DISCUSSION ON PRIORITY MANAGEMENT AND COMPUTING

For a long time, either public or private institutions paid much more attention to constructing than to maintenance. Not only the ignored attitude but also short of budget and resource are reasons for neglect of maintenance [1]. Limited maintenance budget accompany with limitless maintenance requirements is the fact that administrators of universities are forced to face. Therefore, through the support from a knowledge base (KB) to prioritize required

maintenance of school buildings could bring the higher efficiency for usage of limited resources. Currently, there are few research on building maintenance prioritization, and most of them discussed about maintenance prioritization and hazard determination of dams, bridges and road pavement, but not of buildings. Regarding the buildings, Al-Majed presented a set of standard estimation criteria of public building maintenance in 1998. He divided twenty-three factors into two dimensions, management and execution [2]. In this research, the architecture of the PS is based on an estimation benchmark of school building maintenance proposed by Chang Chih-yuan in 2004. In his research, the estimation benchmark of prioritization is composed of sixteen factors, which are grouped into three dimensions included urgency, health and economy. To avoid subjective estimation, he merged applicants' and engineers' feelings into consideration when he designed the estimation factors [3].

Via questionnaire survey, the research discovers that almost all public universities in Taiwan have no standard estimation criteria, except few military colleges or universities. However, the professed standard estimation criteria of the military colleges/universities are made by few people subjectively, and not produced by scientific research methods. Besides, their purposes are to determine importance of essential military facilitates. At present, there are only thirteen universities have related maintenance management systems. And functions of these systems for end users are only applying and querying. Besides that, from the functions of the systems, which are provided to the end users, we can find that only National Taiwan University of Arts has considered building a KB about construction, but no related maintenance management system has been concerned. Through questionnaire survey, this research found that there is no other public universities in Taiwan reveal any consideration of using KB to support maintenance prioritization. (See Table1)

Table1. Maintenance Management Systems of public universities in Taiwan.

Universities		Main System	Prioritizatior Using of KE
01	National Chengchi Uni.	On-line repair applying system.	×/×
02	National Chiao Tung Uni.	Construction works applying/querying system	×/×
03	National Central Uni.	On-line repair/maintain system.	×/×
04	National Taiwan Ocean Uni.	Repair/maintain service system.	×/×
05	National Ilan Uni.	School building repair booking system.	×/×
06	National Changhua Uni. of Education	Dormitory repair booking system.	×/×
07	National Sun Yat-sen Uni.	Repair booking system.	×/×
08	National Kaohsiung Normal Uni.	Repair/maintain booking /progress report system	×/×
09	National Uni. of Kaohsiung	Repair booking system.	×/×
10	National Kaohsiung First Uni. of Science and Technology	On-line repair applying system.	×/×
11	National Pingtung Uni. of Science and Technology	Repair/maintain service system.	×/×
12	National Tainan Teachers College	School building repair/maintain service system.	×/×
13	National Taipei College of Nursing	Repair booking system.	×/×

In the final report of plans for knowledge management of construction industry, which are instructed by Construction and Planning Agency of Ministry of Interior (CPA), the knowledge management of construction industry has been well planed[4], but there is no detailed illustration about how to implement and execute practically, not to mention the plans of making use of knowledge management in educational institutions and real maintenance jobs. In Mohamed's research, 1996, he has built a network optimization model into a Bridge Management System to control two major types of activities in bridge management works. Besides, the more important is that he used the model to figure out the best resolution for execution time and resource allocation of maintenance jobs [5]. As to Ramadhan's research in 1998, effective factors and a predictable model are brought up for a road pavement management system. He built the model by gathering information from experts and the past experiences to prioritize the importance of the road sections that required maintenance [6]. However, the model is built based on the historical information and how to keep its effectiveness and accuracy is a big challenge. Most maintenance management system nowadays tend to provide maintenance flow control and execution, but how to use tacit knowledge hided in brains of maintenance engineers or in maintenance organizations to support management jobs are not been much concerned. 2004, C.Y. Chang presented Anthropopathy Health Efficiency Indicators of Building Management（AHEI）= Gi (Geographic Climate) *(X_1E（Regular Effects）+ X_2Q（Ratio of Quality Depreciation after Building）+ X_3M（Ratio of Annual Maintenance after Building）) in his research on

Anthropopathy Health Efficiency Indicators of Building Management[7]. The formula of maintenance factors may deposit in the PS to offer the system a standard for priorities determining, in order to avoid misadvising because of subjective recognition.

3. PS APPLICATION IN SCHOOL BUILDINGS

This research intends build a system to estimate the priorities of school building maintenance. For this reason, the system is designed mainly from the views of maintenance engineers and administrators in universities. The three main roles included in the system are inspectors, managers and maintenance staff; inspectors are responsible for building inspecting (generally served by school maintenance engineers or outsourcing professionals); managers are in charge of and make use of buildings; maintenance staff performs and manage maintenance works. The system divided all school into different areas depending on particular use units, and then analyzed health states of each building. In each building, there are many different maintenance types, such as construction, water and electricity, decoration, and so on. Each maintenance type consisted of various items, such as construction patching, pipes and wires replacement, wall covering, and so on. The PS estimates the priority for each item according to its weight of ranking, degree of measurement and knowledge from KB.

In this paragraph, the essential operations in the framework of the system will be described in Section 3.1. Section 3.2 will illustrate the base of the PS, which is the content of school building maintenance KB and its operation methods. The last section 3.3 is going to discuss operation situations performed by three main roles of the system.

3.1 Prioritization System

The PS may be considered as a subsystem under the architecture of the School Building Management System basically (See Figure1). It is performed in two ways, an active way and a passive way. In active way, the system reasons automatically with rules of KB according to electronic medicine documents of buildings and inspecting results to comprehend the health states of buildings. In passive way, the system gets information of present condition of maintenance items from user interfaces when the maintenance cases are applied. After the cases are applied, the system will check experiences of the past cases, refer to their health states, and then reason with rules to decide priorities. One distinguishing feature of this operation model is that the system will record the health states of each building into their electronic medicine documents. The electronic medicine documents of building contain default information of the buildings, since they have been built up, and the following maintenance histories. No matter in active or passive way, the system could consult the electronic medicine documents to get health states of buildings as bases of estimation.

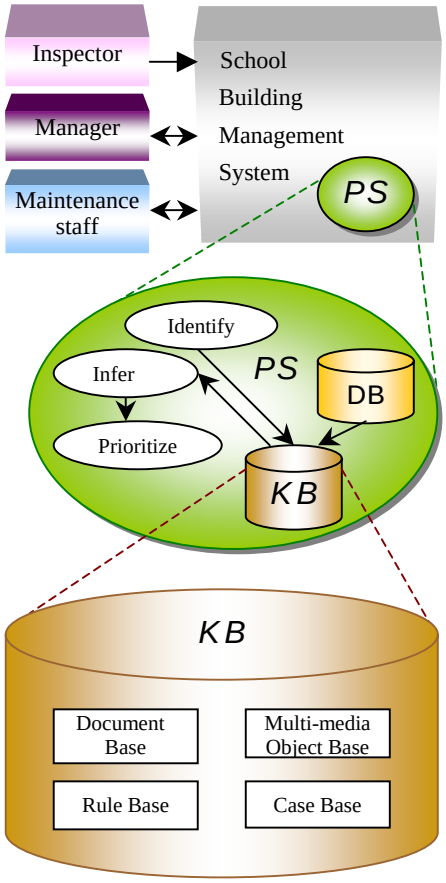

Figure1 Piroritization System

3.2 Maintenance Knowledge Base

Maintenance requirement does not cease. Every maintenance item has symptom cycles. The same symptoms may appear repeatedly in different buildings. However, such information and knowledge keep in brains of maintenance staff. Users of buildings have no idea about that and could not learn how to use the facilities correctly and maintain them carefully everyday without learning from the past experience. Therefore, the users are used to raising maintenance applications immediately whenever a single tiny symptom of damage appears. Incorrect customs of using facilities and neglectful attitudes to maintenance resources not only increase burdens to maintenance engineers, but also waste budget and resources. For this reason, this research presented the PS based on the KB to induce health states, case histories, estimation criteria and measure rules to become structural knowledge and deposit in the KB

for referring when maintenance jobs proceed. Knowledge in the KB could also be the educational or training resources referred by maintenance staff to guide users of school buildings. With accumulated knowledge, frequency of improper usage and replacement cost of management could be reduced down by the system.

Regarding utilities of KB to support maintenance management, although J. de Brito et al. presented a prototype of an expert to help decosion-making for concrete bridge management, the contents of the knowledge base they used are not particularly discussed [8]. Duing to difficulty in solving unstructural and complex problems with rule-based knowledge, Heng Li used the accumulated experience knowledge of past cases to solve the unstructural and complex problems, such as negotiation problems [9]. However, compared with concrete bridges, buildings consisted of more various elements, which made considerations of decision-making more complicated. Besides utilization of the past cases for diagnosing diseases of buildings, the usage of rule-based knowledge, in order to infer for the best maintenance priority, is also necessary. Therefore, the KB proposed in this research integrated various important kinds of knowledge about school buildings. It contains four knowledge depositors, the document base, the rule base, the multi-media object base and the case base. As Figure 2 displays, knowledge of each depositor is illustrated as followings:

1) The Document Base：deposits related laws, regulations, or stipulations, case or research reports, and forms or lists for school administration procedures, in order to be referred by users and maintenance staff when they proceed maintenance jobs.
2) The Rule Base：deposits estimation criteria and measurement rules of maintenance prioritization, in order to be referred by the system when it prioritize maintenance items.
3) The Multi-media Object Base：deposits building symptoms with multi-media object, in order to be referred by maintenance staff when they would like to know the states of building in remote and to reduced the cost of management.
4) The Case Base：deposits experiences of the past cases, and then integrates them into electronic medicine documents of buildings, in order to be the basic adjustment resources of measurement rules for maintenance estimation.

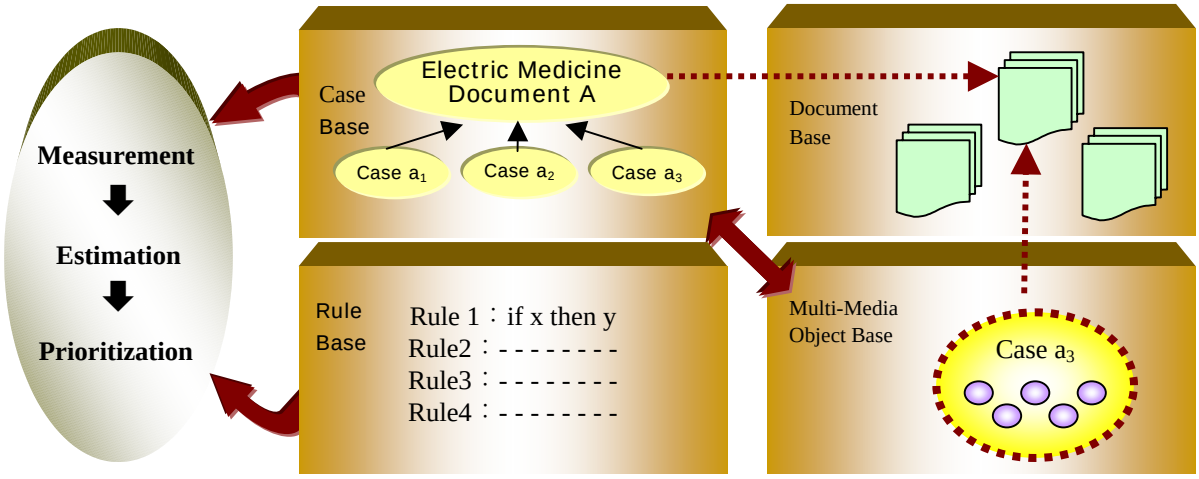

Figure 2 Knowledge Base of PS

The default information of an electronic medicine document is the basic data of a building, which were set when it was built. The following maintenance states will modify the related parameters in the electronic medicine document of the individual maintenance item and then produce a real document into the document base. States of buildings or items in case base may be indexed according to their superiors and deposited in multi-media object forms. When the cases are referred to, their related multi-media objects will also be provided by the system automatically. Maintenance staff could get information about states of building or maintenance items. According to the health histories of the buildings, the system could determine maintenance priorities after it reasoned with estimation criteria and measurement rules.

3.3 PS Operations

There are three main types of the system users, which are inclusive of inspectors, managers and maintenance staff. The different operational situations for these three main roles are described as followings:

1) Inspectors: inspect buildings routinely and accidentally. The inspected information of building states will save return to the system, in order to modify the electronic medicine documents of the

buildings, and the system will then transfer it into the document base.

2) Managers: are graded into two levels. The first level is indicated building manager, and the second level is partial building manager. Two levels have been delegated different authorities. Partial building managers are people who have right to use the buildings, but indicated building managers are not only the building users, they are also persons in charge of the entire buildings. Both levels have right to raise maintenance applications, when necessary, with multi-media object attached. The system will find the similar cases for referring to reduce inconvenience in waiting time of the maintain procedures.
3) Maintenance staff: will be assisted by the system with related documents or regulations searched with keywords, in order to comprehend the maintenance progress and matters that need their attention. In the meanwhile, the system gets the medical documents of buildings from case base and prioritizes the maintenance items based on the information obtained from the user interfaces of the system and estimation criteria obtained from the rule base to support the staff.

To enhance effectiveness and accuracy of health histories which are referred when prioritizing, the system deposits each maintenance case into case base for updating health states of buildings and accumulating the relative experience knowledge. Besides, maintenance managers get decision support for maintenance jobs through user interfaces, which are provided by the system according to the documents, regulations, case experience and multi-media objects of the KB.

4. CONCLUSION AND SUSSESTION

The priority index architecture presented in this research is results, which is analyzed from the professional opinions of the maintenance authorities in sixty public universities in Taiwan and could be standard estimation architecture for maintenance prioritization of school buildings. The PS is differed from other related systems, it emphasizes that the estimation based on the KB could assist maintenance staff to avoid improper resource allocation caused from misdetermining. Interoperations of various types of knowledge strengthen effectiveness and accuracy of maintenance prioritization. For example, when the system estimates priorities with standard criteria of rule base, it also refers to the electronic medicine documents, in order to assure that the decision is made while the health states of buildings are quite well comprehended and the opinions of building managers are considered. It could also avoid determining in biased views and causing damages of buildings and danger of people lives because of neglecting of real health states of buildings. The PS based on the KB determines maintenance priorities under the support of maintenance knowledge automatically. It helps the decisions to be made objectively and promptly, to reduce workload of maintenance staff of universities, and to promote quality and effectiveness of maintenance jobs. By accumulated knowledge, the system could enhance its decision support to maintenance management jobs and decrease cost of management replacement.

After the literature survey, the interview with professionals, and field survey, this research found that research both on index architecture of building maintenance prioritization and implementation of maintenance knowledge base are in the beginning in Taiwan. The objects of this research are buildings of public universities of Taiwan. There are only thirteen universities have related building maintenance systems and the functions they offered are simply applying and querying. Therefore, this research could only propose design and develop suggestions for the initial model of the current integration or the system blueprint for the future plans. Regarding testing effectiveness of the system, real experiments have to wait till the complete SBMS is built in few years. Besides, as to operations of KB, the future researches could try to increase its searching efficiency of document base or case base. For example, to make use of the Ant Algorithm to classify the cases first for speeding its searching, to compare speed of keywords searching with that of ontology searching, or to mobilize the system.

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REFERENCES

[1] Chih-yuan Chang et al., 2004, “Application of an Agent Mechanism to the Small-Scale Maintenance of School Buildings”, ICCCBE-X international conference, Bauhaus- Universität Weimar, Germany.

[2] Al-Majed, Mohammed Hassen Yousef, 1998, Priority-rating of public building maintenance work in Saudi Arabia, Thesis, King Fahd University of Petroleum and Minerals, Saudi

Arabia.
[3] C.Y. Chang and S.M. Huang, 2004,"Maintenance Priority Indicators of Universities Buildings", The 8th Construction Management Conference, National Taiwan University, Taipei Taiwan.
[4] China Engineering Consultants, Inc. (CECI), 2003, "A Report on plan for system engineering of construction knowledge management", Construction and Planning Agency of Ministry of Interior, Taiwan.
[5] Mohamed, Hosny Abbas Hosny, 1996, Development of Optimal Strategies for Bridge Management Systems (Priority Setting, Funding), Dissertation, Carleton University, Canada.
[6] Ramadhan, Rezqallah Hasan Fayyadh, 1998, Modeling of pavement condition and maintenance priority ranking for road network, Dissertation, King Fahd University of Petroleum and Minerals, Saudi Arabia.
[7] C.Y. Chang and S.M. Huang, 2004, "Anthropopathic Health Efficiency Indicators of Building Management", The 16th Architectural Research Conference, National Taipei University of Technology, June, Taipei Taiwan.
[8] J. de Brito et al., 1997, An Expert System for Concrete Bridge Management, Engineering Structure,Vol.19, No.9, pp.591-526.
[9] Heng Li, 1996, Case-based reasoning for intelligent support of construction negotiation, Information & Management, Vol.30, pp.231-238.