An Information Visualization Approach to Intelligent Building Assessment

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Abstract: This paper presents a Knowledge-oriented Information Visualization (KIV) approach to facilitating the implementation of building rating systems such as the Asian Intelligent Building Index (AIIB) for the post-assessment of Intelligent Buildings (IBs). The KIV approach is introduced by using a prototype of KIV for IB assessment. The KIV model consists of several toolkits, including an IB Casebase for the Applications of Sustainable Technology (called IB-CAST), a web-oriented information visualization toolkit for IB assessment using Microsoft Office (called IB-Radar and IB-Compass), and a Geographical Information System (GIS) toolkit for bridging knowledge (called IB-GIS) in IB assessment, etc. A case study is used to demonstrate how the KIV approach can be applied to support IB assessment.

Key words: Intelligent building; Assessment; Methodology; Model; Information visualization

1. INTRODUCTION

For building assessment, the currently most popular way is to use rating method. For example, the U.S. Green Building Council [11] has developed the LEED Green Building Rating System for developing high-performance, sustainable buildings. Regarding the assessment of Intelligent Buildings (IBs), the authors have reviewed six IB assessment systems adopted or to be adopted all over the world, including AIIB method developed by the Asian Institute of Intelligent Buildings [1], BRE method developed by the Building Research Establishment Ltd. in UK [3], CABA method developed by the Continental Automated Building Association in North America [5], TIBA method developed by the Architecture and Building Research Institute in Taiwan, China [12], IBSK method developed by the Intelligent Building Society of Korea in Korea [8], and SCC method developed by the Shanghai Construction Council in China [10]. Among these IB assessment systems, the IB Index is identified as the most comprehensive one with more potential utilizations in IB assessment.

. However, it is also noticed that all building assessment systems stop at achieving a score for each building under assessment. Regarding how to improve the building based on assessment results, there is still lack of necessary replenishments. One possible explanation to this query is to further review audit paper for detailed information regarding which part of the building need to be revised to get a higher score. However, this is usually time consuming and not accurate. In this regard, toolkits to support the post-assessment of IBs are in demand.

Information visualization is an inherent means in the building professions no matter whether computer is used or not. It can be realized by means of various diagrams, maps or photos etc. For example, Bouchlaghem, Sher, and Beacham [4] made an application of digital imagery and visualization materials to aid building technology related modules in higher education. In order to facilitate the post-assessment of IBs, including active gap identification and reliable decision support, this paper will introduce a knowledge-oriented information visualization (KIV) approach is introduced in this paper. The KIV approach comprises a group toolkits including a casebase for the knowledge management of IBs, called IB-CAST,

a radar chart made in Microsoft Excel to illustrate current and gap scores of IBs based on their rating, called IB-Radar, an internet-enabled portal for IB information navigation based on IB-Radar chart, called IB-Compass, and a geographical information system for spatial information management of IBs, called IB-GIS. A case study will be conducted to demonstrate how to use the KIV approach in the post-assessment of IBs.

2. METHODOLOGY

The methodology adopted in this research comprises several methods focusing on detailed objectives mentioned above. First of all, an extensive literature review is required to explore achievements in the areas of information visualization, knowledge management, decision support, and building assessment etc. After that, system analysis will be used to develop a prototype for applying the KIV approach to IB assessment. For each toolkit of the KIV approach, system analysis and development techniques will be adopted to realize their various functions. In addition, software tools such Microsoft Office will be used to make toolkits easy to be used in the building professions.

3. THE KIV MODEL

The KIV model is a prototype to describe the theory of the KIV approach for IB assessment. Figure 1 illustrates a conceptual KIV model.

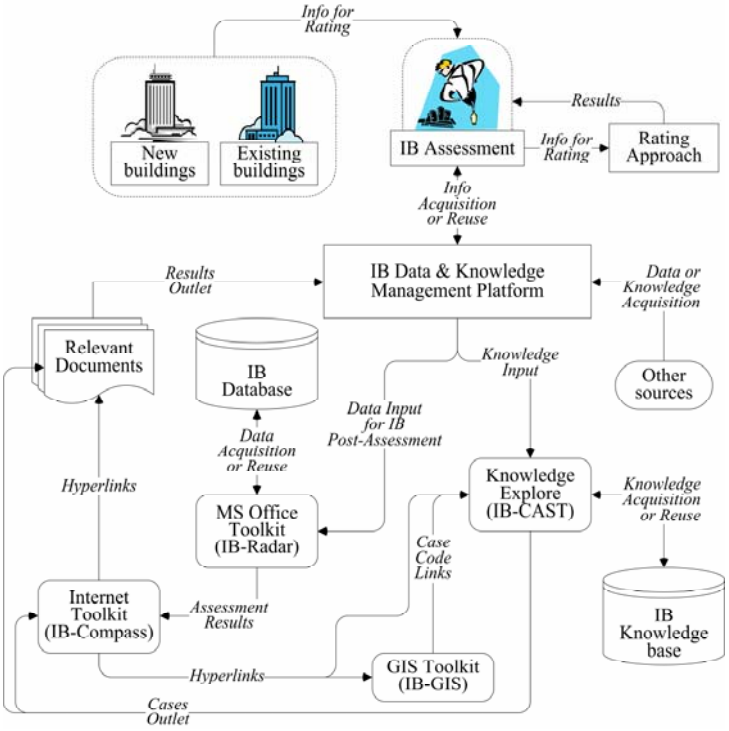

Fig.1 The prototype of KIV for IB assessment

In order to realize the function of IB assessment for the KIV approach, several toolkits are integrated to an IB Data & Knowledge Management Platform (IBIMP), which is an open information platform by system users including Building Designers, Construction Contractors, Property Managers, Recyclers or Manufacturers, and Educators, etc. to share their data or knowledge with the community or their peers [7]. There are three main toolkits, including an IB Casebase for the Applications of Sustainable Technology (called IB-CAST), a web-oriented information visualization toolkit for IB assessment using Microsoft Office (called IB-Radar and IB-Compass), and a Geographical Information System (GIS) toolkit for bridging IB knowledge between IB-Compass and IB-CAST in IB assessment (called IB-GIS). For each toolkit, its functions and relations to other components of the KIV model are

explained below:

3.1 The IB-CAST Toolkit

The IB-CAST is a casebase for the knowledge management of IBs. It is a result of a series of research focusing on system prototype, knowledge classification, case assessment, and knowledgebase. The system prototype is a product model for IB-CAST system development. The knowledge classification is a category of buildings for sorting IB-CAST case materials. The case assessment is a case selection process for evaluating case materials for the IB-CAST based on a knowledge-driven multi-criteria decision-making model. The knowledgebase is a consummative knowledge system with various e-book formats. To facilitate the utilization of IB-CAST, both online and offline versions are developed. For example, the IB-CAST portal is to be used for online education, training and consultancies in the area of IB, and the IB-CAST DVD is an e-book detached from IB-CAST portal and to be used for offline education, training and consultancies in the area of IB. In order to facilitate knowledge management, IB-CAST shell as a KM tool is adopted to accumulate knowledge materials for the IB-CAST portal. Figure 2 illustrates one of the main interfaces of the IB-CAST [2], in which a case study on the Hong Kong International Finance Centre (IFC) complex is shown.

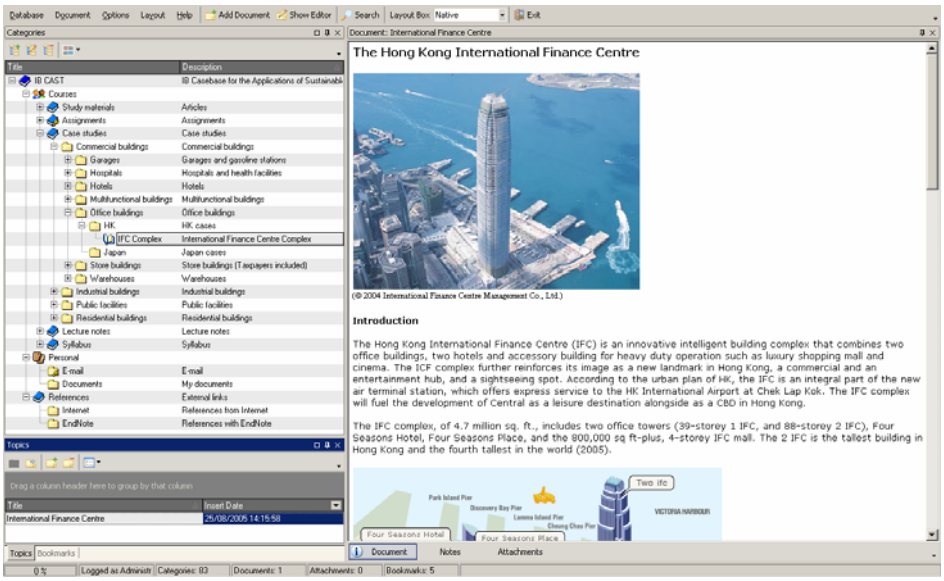

Fig.2 A screenshot of the IB-CAST

3.2 The IB-Radar Toolkit

The IB-Radar is a radar chart made in Microsoft Excel to illustrate current and gap scores of IBs based on their rating. It uses an n-dimension diagram to illustrate the status of an IB in accordance with its scores corresponding to each dimension. The number of dimensions of the IB-Radar equal to the number of clusters, which are used to classify indicators for IB rating. For example, the Asian Intelligent Building Index [1] adopts a multi-dimension IB rating system covered ten models including Green Index module, Space Index module, Comfort Index module, Working Efficiency Index module, Culture Index module, High-tech Image Index module, Safety and Structure Index module, Management Practice and Security Index module, Cost Effectiveness Index module, and Health & Sanitation Index module. The IB-Radar is useful in describing the status of an IB regarding its score, and indicating the gap between current status and further efforts. It is a visual measurement for IB assessment, and can facilitate decision-making in the design or management of IBs. Figure 3 gives an example to show how IB-Radar can be applied in IB assessment. The example has been conducted by using an existing IB case, previously conducted by Chow and Choi [6] using the

IB Index [1]. There are two main radar charts adopted by the IB-Radar to illustrate current status of the building under rating from the IB Index [1], and further effort required for a better design or utilization with respect to expected targets for the building. Based on visual information provided by the IB-Radar (see Figure 3), building auditors can use the IB-Radar as an effective visualization approach to showing the results of assessment and measuring the gap from current status to ideal status of the IB under assessment. It is called IB post-assessment. Therefore, the IB-Radar is a necessary complement of building rating method such as the IB Index [1] in IB post-assessment.

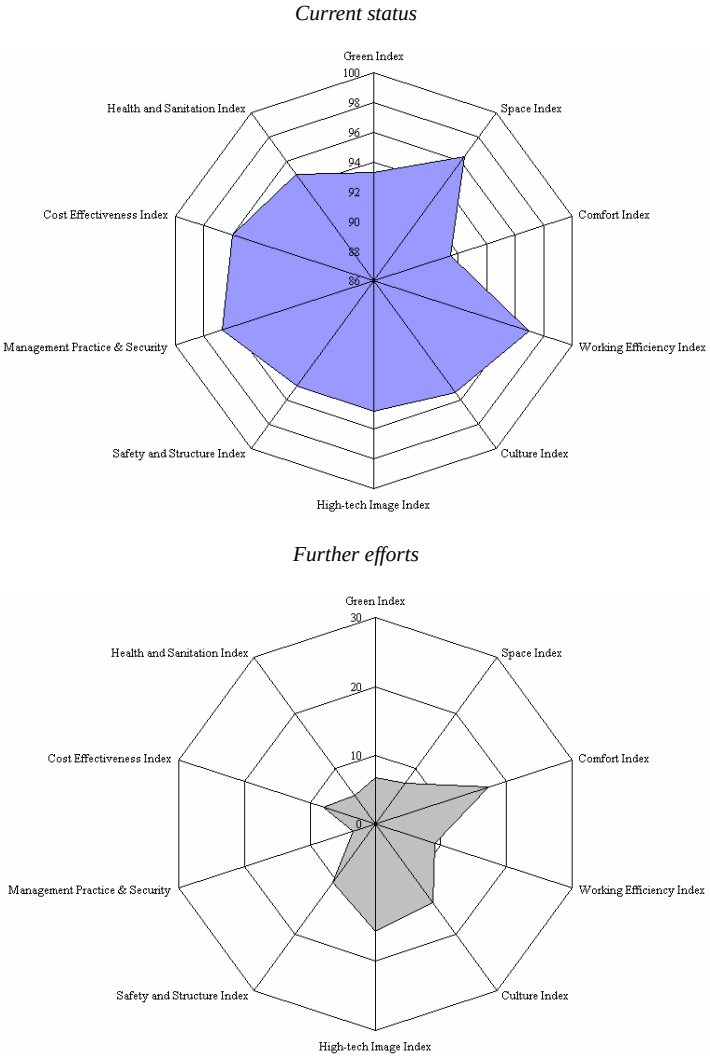

Fig.3 A screenshot of the IB-Radar using MS Excel

3.3 The IB-Compass Toolkit

The IB-Compass is an internet-enabled portal for IB information navigation based on IB-Radar chart. Generally speaking, the IBIMP (see Figure 1) can lead all potential participants from each life-cycle stage of IBs to release or to acquire relevant data and knowledge via Internet. As a matter of fact, all participants including Building Designers, Construction Contractors, Property Managers, and Academic Educators, etc. can benefit from the IB-CAST and the IB-Radar regarding the IB post-assessment and the content management of IB projects. However, they are actually demanding a more efficient delivery approach to facilitating IB post-assessment or others relevant to content management of IBs. As mentioned by JC&A [9], of all the applications of the Internet in the design professions, none has more wide-ranging

significance than web-based project management. In this regard, the internet-enabled portal called IB-Compass is developed to further support the post-assessment of IBs. Figure 4 gives an example of the IB-Compass in Microsoft Internet Explore. As shown on the IB-Compass (see Figure 4), different IBs are located at different places on relevant axes based on their IB scores to each dimension of assessment. The ten-dimension radar chart for the IB Index [1] is adopted here. Although this example uses the chart of IB-Radar for the HK IFC complex (see Figure 2) as a compass, the compass can generally use an empty radar chart too. By using the IB-Compass, IBIMP users can go through each IB project for relevant data and knowledge previous collected by the IB-CAST or the IB-Radar by clicking on embedded hyperlinks to each building. Hyperlinks embedded to IBs will lead to other webpage or knowledge management toolkits such as the IB-CAST or the IB-GIS (see Section 3.4 below).

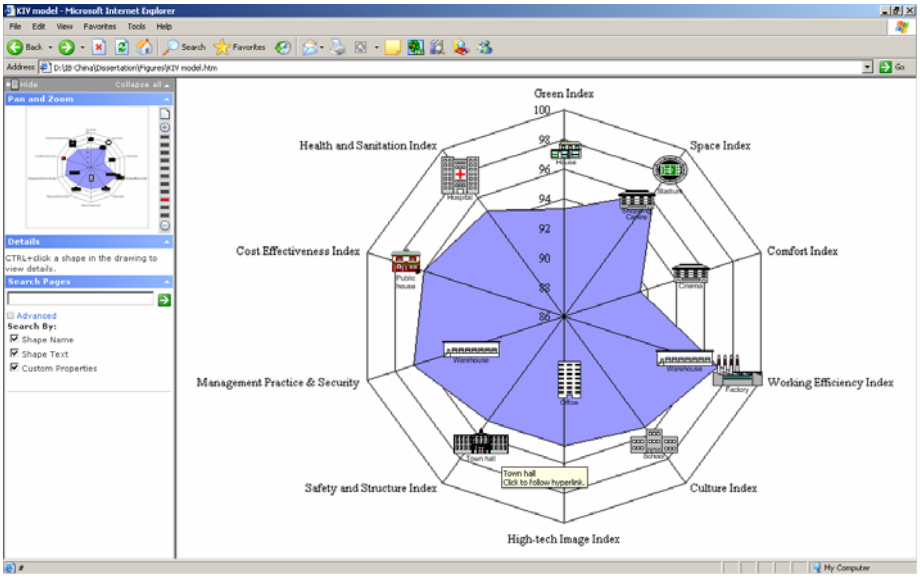

Fig.4 A screenshot of the IB-Compass in MS Internet Explore

3.4 The IB-GIS Toolkit

The IB-GIS is a Geographical Information System (GIS) for spatial information management of IBs. The IB-GIS is another information visualization toolkit to support the post-assessment of IBs. The main reason why the GIS is adopted is that a comprehensive IB assessment actually requires an extensive information support. In other words, although the IB-CAST and IB-Radar can provide some relevant information for IB post-assessment, they are not able to support decision-making regarding suggestions to single building development or local area regeneration. In this regards, the GIS is introduced to the IBIMP (see Figure 1) to integrate a decision-making function. As illustrated in Figure 1, the IB-GIS is linked from the IB-Compass, and linked to the IB-CAST. To further support decision-making within the IB-GIS, integration with the IB-CAST is required. Figure 4 gives an example to apply GIS for IB information management. The HK IFC Complex is also used to demonstrate its usability. Google Earth is adopted as a novel GIS shell for the IB-GIS because it uses aerial color photography as mapping interface that involves much information than hand-drawn maps.

4. A CASE STUDY

The Hong Kong International Finance Centre (IFC) is an innovative intelligent building complex that combines two office buildings (IFC I (39 storeys) and IFC II (90 storeys)), two hotels and accessory building for heavy duty operation such as luxury shopping mall and cinema. It is located adjacent to the narrowest crossing of Hong Kong (HK) Victoria Harbour, one of the most beautiful urban sites in the world, marking a new gateway to the HK Island.

After the completion of the IFC II in 2003, it became the new headquarters for the Hong Kong Monetary Authority, and the ICF complex further reinforces its image as a new landmark in Hong Kong, a commercial and an entertainment hub, and a sightseeing spot. The project reflects the importance of HK as a world financial centre. According to the urban plan of HK, the IFC is an integral part of the new air terminal station, which offers express service to the HK International Airport at Chek Lap Kok. The IFC complex is playing an important role to accelerate the development of Central as a leisure destination alongside as a CBD in Hong Kong.

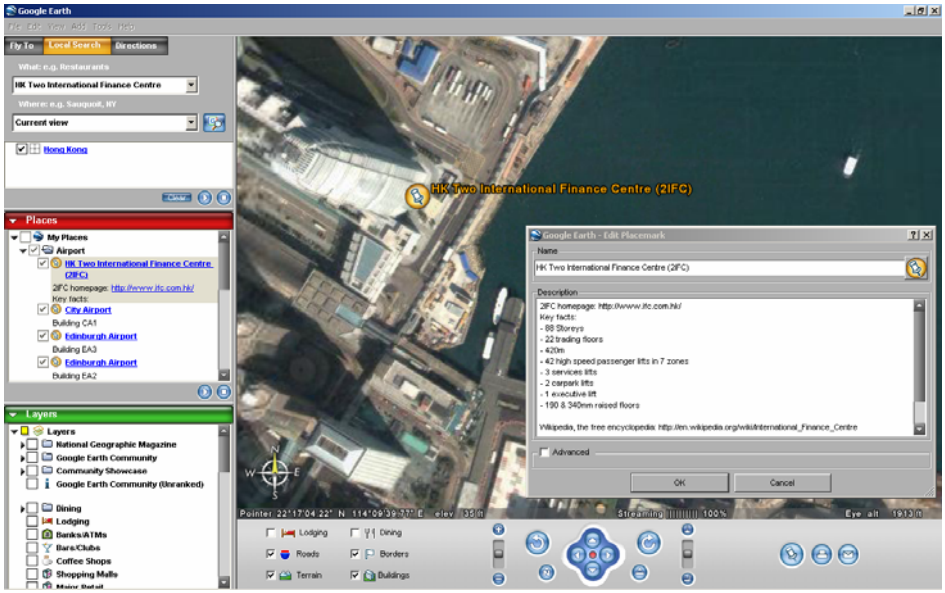

Fig.5 A screenshot of the IB-GIS using Google Earth

According to the characteristics of IFC II, an IB Index based assessment was conducted to the tallest building in Hong Kong by the AIIB in 2004 [6], and it has been identified that the IFC II is the most intelligent building in Hong Kong compared with all other buildings their had audited. Table 1 gives some of their assessment results for the IFC II in accordance to the ten modules adopted by the IB Index [1].

Tab. 1 The assessment results of the IFC II [6]

Modules		Scores		
		Current	Target	Gap
1	Green Index	93	100	7
2	Space Index	96	100	4
3	Comfort Index	91	100	9
4	Working Efficiency Index	97	100	3
5	Culture Index	95	100	5
6	High-tech Image Index	95	100	5
7	Safety and Structure Index	95	100	5
8	Management Practice and Security Index	97	100	3
9	Cost Effectiveness Index	96	100	4
10	Health & Sanitation Index	95	100	5

For the post-assessment of IFC II using IB-KIV approach, the following steps are adopted:

- Step 1: make a case study using IB-CAST (see Figure 2);
- Step 2: make radar charts using IB-Radar (see Figure 3);
- Step 3: make compass pages using Microsoft Office (see Figure 4);
- Step 4: make place-mark with description using Google Earth (or other GIS shell) (see Figure 5);
- Step 5: study the gap information indicated in IB-Radar;
- Step 6: click on relevant hyperlinks on IB-Compass for improvement;
- Step 7: review relevant information from IB-CAST and IB-GIS;
- Step 8: make decisions to fill in the gaps.

In this case study, target scores to each module are set to 100 (see Table 1), accordingly gap scores to each module are calculated using Table 1 in Microsoft Excel. Based on this result, it is identified that Comfort and Green issues are the most important ones for improvement in IFC II. In order to find appropriate solutions to improve the levels of Comfort and Green, suggestions are searchable from other existing buildings marked on the IB-Compass (see Figure 4) (The compass background can be replaced by a radar chart of Gaps), which links to IB-CAST and IB-GIS to provide detailed suggestions. Regarding how to improve the status of Comfort Index and Green Index of IIFC II, this paper doesn't provide more details.

5. CONCLUSIONS

Although building rating method such as the IB Index is currently adopted in IB assessment, it is noticed that toolkits to support post-assessment of IBs are in demand. In this regards, a knowledge-oriented information visualization (KIV) approach is introduced in this paper. The KIV approach comprises a group toolkits including IB-CAST (a casebase for the knowledge management of IBs), IB-Radar (a radar chart made in Microsoft Excel to illustrate current and gap scores of IBs based on their rating), IB-Compass (an internet-enabled portal for IB information navigation based on IB-Radar chart), and IB-GIS (a geographical information system for spatial information management of IBs). A case study on the IFC II is conducted to demonstrate how to use KIV approach in the post-assessment of IBs.

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