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IFC model viewer to support nD model application

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Abstract

Today, building information modelling (BIM) plays a crucial role in the research and development fields of construction information integration and interoperability. This paper, from an information technology point of view, outlines the definition and aims of the "3D to nD Modelling" project, a platform grant-funded project by UK's British Engineering and Physics Sciences Research Council (EPSRC). It presents a scenario of widening BIM implementation into the overall aspects involved in the whole life cycle of a building project. Industry foundation classes (IFC) as a standard BIM specification has been adopted as a central information repository in order to deliver the integrated building information throughout the nD-driven assessments, evaluation and decision-making. This paper also focuses on the development of an IFC-viewer, which is defined as the holistic interface of the nD modelling tool. The techniques and methods including the auxiliary tools adopted in this development are detailed. This development presents a practical and economic way to reveal and retrieve the information of IFC models inclusively, structurally and visually.

Keywords: Building information modelling (BIM); nD modelling; Industry foundation classes (IFC); VRML

1. Introduction

Although CAD systems have been used in the architecture, engineering and construction (AEC) industry for decades, information fragmentation within CAD drawings has always been an obstacle to information sharing and exchange in construction among different design aspects and different design phases. [7,11,6]. Since it is introduced in the last few decades, the building information model (BIM) has been believed to be essential in AEC and the real-estate industries to manage, share and exchange information among project stakeholders, such as architects, engineers, contractors, owners and facility managers [5].

BIM is a standard digital information repository of building design, which may also contain information about the building's construction, management, operations and maintenance [9]. Generally, a BIM consists of two kinds of information—building elements and their attributes represented in building design terminology and the relationships between these building elements. In comparison to earlier CAD systems, BIM-based CAD systems are building object-oriented systems, in which the basic components of drawings are building elements like walls, doors, windows and so on, rather than geometric elements in earlier CAD systems, such as dots, lines and polygons.

Today, although many CAD systems have already become the BIM-based CAD systems, they use different specifications developed by various CAD software vendors. This means that standard specifications and methods of the building information modelling are still rare. On the other hand, using BIM rather than CAD geometric models to represent and deliver the information and data throughout the lifecycle of a building project is increasingly becoming a consensus between the researchers and practitioners in the AEC industry. The processes of building information modelling are to classify and standardise design and planning information, which usually fragmentally exists in a variety of phases and aspects of a building project. Moreover, another reason to apply BIM is to standardise and format the building information to suit the requirement and

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format of interfaces, databases, file and data exchange in computer applications. As the core of building information integration, an ideal integrated BIM should include the following characters:

i. The basic elements of an integrated BIM should be the physical components of a building, such as walls, doors and windows, which are consist of a set of CAD geometric elements and described and dimensioned by the phrases and methods of building design, construction and management instead of the CAD geometric elements, such as dots, lines and faces.
ii. An integrated building information model should also include the information of construction and maintenance activities linked to the relevant building physical components. These activities should also be described by the phrases of building construction and management.
iii. The relationships among the building components and activities are another crucial factor to an integrated BIM. All the elements in a BIM should somehow be linked to others. The relationship can be classified into two typical structures—inheritance (a tree shape) and polymorphism (a net shape).

Currently, two types of building information model specifications—STEP and IFC (industry foundation classes)—are widely adopted in the researches and developments of IT applications of building design, construction and facility management. STEP is an ISO standard (ISO 10303). It is a set of specifications represented in EXPRESS language, which enables users to model information of various industries, including the automotive industry, aerospace industry, construction industry and so on. These specifications can be used to describe integrated information of a product including geometry, topology, tolerances, relationships, attributes, assemblies, configuration and others of a product's whole lifecycle.

IFC is developed by the International Alliance for Interoperability. It is also represented in the EXPRESS language as well. However, IFC is a kind of modelling specification particularly focused on the product and process modelling of the AEC/FM industry. Therefore, it may present building information more effectively and efficiently. The IFC model defines an integrated schema to depict the main physical and logical building objects, their characteristics and their inter-relationships in the form of a class hierarchy. The IFC hierarchy covers the core project information such as building elements, the geometric and material properties of building product, project costs, schedules and organizations. Moreover, IFCs enable interoperability among AEC/FM software applications and this means the end-users in the AEC/FM area can effectively share the model data through IFC files. Today, most of the major CAD systems support the export of drawings into IFC model files. So far, IAI has officially published several different versions of IFC files including version 1.5.1, 2.0, 2.X [10].

At present, although there are several IFC viewers developed by some institutes around the world, such as CSIRO in Australia and TNO [14] in the Netherlands, these viewers are developed for either pilot studies or specifically for certain IFC-based software tools and no API or SDK is provided to enable other users to implement these tools in their own development. Meanwhile, although there are also some IFC-based developing systems like ActiveX components, or libraries, such as the IFC Model Server developed Eurostep [8], most of them are commercial software applications and are costly. Nevertheless, an interface and environment that enable end-users to browse the IFC model file must always be a fundamental and inevitable section of any IFCs-based software systems. It seems that there are not many convenient and cheaper development tools, which can be directly adopted to develop an IFC viewer or other IFC implementations. Therefore, for many developers, especially those who are just embarking on IFC development or do not have the immediate capabilities to conduct large and complicated software developments, the IFC viewer development described in this paper may provide users with an optional approach to develop their own IFC viewer quickly and cheaply.

This paper presents the details of the development of an IFC viewer, which is designed to be an integrated interface for nD modelling applications. This development is a fundamental part of nD modelling prototype tool development. It aims to provide users with an integrated and interactive environment to visually retrieve the information of an IFC model file. It also shows that the methods and techniques adopted in this development form as a practical and economical way to develop this kind of IFC viewer. All of the auxiliary tools applied in this development were free. Before detailing this IFC viewer development, nD modelling is introduced as a backdrop to the IFC viewer development.

2. Notions of "3D to nD Modelling"

"3D to nD Modelling" is a research project funded by a platform-grant by British Engineering and Physical Science Research Council (EPSRC). It aims to develop a multi-dimensional computer model that will portray and visually project the entire design and construction process, enabling users to 'see' and simulate the whole life of the project [12]. This will help people to reduce the uncertainties in the decision-making process and to realise true 'what-if' analysis. The nD model is an extension of the building information model, which incorporates multi-issues of design information generated and required throughout a building project lifecycle, such as accessibility, sustainability, energy saving, costing, crime-prevention, acoustic, thermal, etc. The 3D here indicates that nD models should initially derive from design outcomes produced in 3D BIM-