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Towards an integrated set of design tools based on a common data format for building and services design

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Abstract

The emerging technology in building product design using knowledge-based engineering (KBE), is currently exciting practitioners in the building construction industry. This paper investigates the use of KBE techniques and assesses the contribution this approach can make to the traditional design process. To do this, the investigation has developed an integrated set of design tools based on a common data format, for integrating 3D electronic prototypes with building services information for use in building design. This approach has been developed on the basis of an open framework and has been applied to the design of an airport terminal building and its plant room. Within the framework, the design process and the information needed, are divided into modules and represented in the form of 3D digital mock-up models (or electronic prototypes). Within the integrated system, an interface has been developed to facilitate the sharing of information with a thermal analysis software application, which contributes to the design process. In this paper, the methodology is discussed and its working system is illustrated and evaluated.

Keywords: Knowledge-based engineering; Product modelling; Knowledge management; Integrated design; Data sharing

1. Introduction

The building design process is about more than just teamwork; it also needs the interactive design input from multi-disciplinary design information sources and from the very early stages of design. Any inferior assessment, determination, misunderstanding or unavailability of relevant information or knowledge during the early stages of the design process, leads inevitably to less than an optimum design that can be unnecessarily expensive and difficult to correct/alter at later stages of a project [16,23]. In addition, when building products become more complex, it is essential to make the maximum use of the available knowledge and to deliver the knowledge at the right point in the design process. In particular, architects are concerned with obtaining advice on critical building services design issues, knowledge and information needed during the con-

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ceptual design process; while at the same time, they have to analyse the design parameters, variables, space performance and options to reach suitable design solutions.

The traditional design methodology or process has made only limited progress toward integrating building services information, such as thermal analysis data, at the early stage of the design process [1,6,9,20]. It is suggested that this is for the following reasons: (i) traditionally, building and services design has been on a 'one off'/'design to order' basis, and (ii) the complicated nature of building services design, requires specialist expertise. Often currently available computer-aided design tools do not support such an integrated design environment. This is because: (i) the present design tools/software are discrete and consequently the data and information produced by them support only a single discipline or task in a design process. Also (ii) the available design tools/software do not provide sufficient information and knowledge in a ready useable format to help the architect, who is not trained in the detailed knowledge of building services design.

Such observations have laid the foundation for establishing where a computer-based 'vision' model (electronic prototype), that facilitates the exchange of information and the representation of knowledge, can fit into the integration of building and services designers' activities. This is where knowledge-based engineering (KBE) systems [12,13] and object-oriented product modelling techniques [4,5,10,11,31], can help.

The subject appears therefore appropriate for the application of a KBE system to enhance the co-operation and integration of design information and knowledge. The object of the research covered by this paper is the implementation of an approach to create an integrated set of design tools based on a common data format, for integrating 3D product models[2] with other types of information used in the building design process [18]. The system is aimed at facilitating and improving the exchange of information regarding the building and services design from the very earliest inception and feasibility stages. The proposed system could be used to support the design team in finding design options, by ensuring that analytical building services information (such as heat loss analysis) is available to the design team in the way that it is needed.

1.1. Preliminary research: the observation of building design integration problems

It is difficult for the design professions to establish exactly what kind of tools they really need, because they are perhaps too close to the problem [19]. So, rather than asking the design professions what they think they need, the approach adopted by this research has been to observe designers at work and to identify the limitations of the currently available design tools that they use. This preliminary approach identified the research problem, generated an appropriate hypothesis and suggested a new computational methodology to improve the design process.

The study on which this paper is based involved one of the authors visiting Kajima in Japan for 3 months. The visit has provided a basic understanding of overall building design and the extensive use of office automation and computer-based systems (software) in the building design and the project process. These systems/software can range from computer-aided architectural design for building drawings, virtual reality tools, structural and services engineering analysis tools; to robotics/automation on the construction site. An observation, which the authors made, was that no one system offered much assistance in co-ordinating and exchanging information with other systems. This problem has been identified by others and described as 'islands of automation' [5,7,15]. The main problem is the diversity between automation and the computer systems. Consequently, the data and information produced by these systems/software can support only single disciplines or tasks in the design process.

This study has also carried out much more specific observations of early stage building design processes, with DEGW, an architectural practice in the UK. These observations have helped in the under-

[2] Product model is a pre-specified design scenario or object for a limited type of building (e.g. airport, hotel, office block etc.) and components (e.g. wall, column, plant room, floor, etc.).