Chapter 43
Three-Dimensional Information Retrieval (3DIR): Exploiting 3D Geometry and Model Topology in Information Retrieval From BIM Environments

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ABSTRACT

An increasing amount of information is packed into BIMs, with the 3D geometry serving as a central index leading to other information. The 3DIR project investigates information retrieval from such environments. Here, the 3D visualization can be exploited when formulating queries, computing the relevance of information items, or visualizing search results. The need for such a system was specified using workshops with end users. A prototype was built on a commercial BIM platform. Following an evaluation, the system was enhanced to exploit model topology. Relationships between 3D objects are used to widen the search, whereby relevant information items linked to a related 3D object (rather than linked directly to objects selected by the user) are still retrieved but ranked lower. An evaluation of the enhanced prototype demonstrates its effectiveness but highlights its added complexity. Care needs to be taken when exploiting topological relationships, but that a tight coupling between text-based retrieval and the 3D model is generally effective in information retrieval from BIMs.

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1. INTRODUCTION

In building modelling environments, more and more information is being crammed into 2D/3D building and product models. This is particularly true given the rise of Building Information Modelling (BIM, Eastman et al., 2011). The Three-Dimensional Information Retrieval (3DIR) project investigates information retrieval from these environments, where information or documents are linked to a 3D building model. In these situations, the 3D visualization or 3D geometry of the building can be exploited when formulating information retrieval queries, computing the relevance of information items to the query, or visualizing search results. Managing such building information repositories in this way would take advantage of human strengths in vision, spatial cognition and visual memory (Lansdale and Edmonds, 1992; Robertson et al., 1998).

Information retrieval is associated with documents, and a critic might argue that documents are relics from the pre-BIM age that are no longer relevant in the era of BIM. However, the challenge of information retrieval is pertinent whether we are dealing with documents which are coarse grains of information or building object parameters/attributes as finer grains of information. Demian and Fruchter (2005) demonstrated that traditional retrieval computations can be applied with good results to 3D building models where textual or symbolic data are treated as very short documents. In this sense, it is almost a question of semantics whether the information being retrieved comes from object properties embedded in the BIM, or from external documents linked to the BIM. The challenge remains of retrieving non-geometric or textual information.

This paper describes the findings of the 3DIR project whose aim was to improve information retrieval when retrieving information or documents linked to a 3D artefact, or non-geometric information embedded in the model of the artefact. The central objective was to develop an information retrieval toolset for documents/information linked to 3D building models which exploits 3D geometry and model visualisation. Such a toolset is essentially a search engine for retrieving information with a BIM platform. As a further objective, the toolset should leverage topological relationships in the 3D model to enhance information retrieval.

2. RELATED WORK

Building design, construction and operation are information intensive activities. For example, even over a decade ago in the UK construction industry, on average, one computer-aided design (CAD) document was produced for every 9 m^2 of building floor space (Gray and Hughes, 2001). Several researchers (Leslie, 1996; Veeramani and Russell, 2000; Ugwu, 2005) have reported the problem of "information overload" in the construction sector.

It is interesting to put this construction problem of "information overload" within the context of information in modern life. The vast amounts of information available and the unprecedented ease with which information can be stored and transmitted in our current "information age" make information retrieval and information management very important everyday challenges. For example, Lyman and Varian (2003) estimated that in 2002 five exabytes (10^{18} bytes) of new information was produced by human activity. More recently, Bohn and Short (2009) analysed numerical data from the US Census and estimated that the average American in 2008 consumed information for 12 hours per day, corresponding to 100,500 words and 34 gigabytes per person per day. Although only peripherally relevant, the question