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Multi-disciplinary collaborative building design—A comparative study between multi-agent systems and multi-disciplinary optimisation approaches

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ABSTRACT

The importance of collaboration between different design disciplines has been widely recognised by the building industry. Traditionally this is achieved through physical meetings between the representatives of different design groups. However, this is facing more challenges when dealing with large and complex design problems. Various approaches have been introduced to tackle this problem, such as multi-agent systems (MAS) and the multi-disciplinary design optimisation (MDO) approaches. The former represents an advanced, ICT-based framework which facilitates collaborative design through communication, data and knowledge sharing and negotiation while the latter represents a theoretical modelling approach which facilitates collaborative design through a thorough analysis of the technical problems. By comparing the strengths and weaknesses of these approaches in facilitating collaborative design, this paper provides a roadmap study for the development of collaborative building design.

1. Introduction

Building design is a complex, multi-disciplinary engineering activity that requires making difficult compromises to achieve a balance between competing objectives such as safety, reliability, performance and cost [1]. A typical building design involves a wide range of disparate disciplines – architecture, structure, building services, quantity surveyors – working together for a relatively short period on the design of a building. Each designer makes decisions based on the design requirements, constraints and inputs from other disciplines. Due to the fragmented knowledge, no single professional has all the knowledge needed to design a complex facility.

Although many building designers still work in parallel and independently using different engineering tools, the benefits of collaborative working are being recognised [2–4] including optimising functions, minimising costs and reducing mistakes. Plume and Mitchell [5] pointed out that a good 'whole' design cannot be achieved by concentrating on the 'parts', since each part may pull the project in a direction that might seem regressive to the other 'parts'. As a result, collaboration between different disciplines is found to be critical and hence a lot of attention is being given to the establishment of collaborative building design environments which facilitate information sharing, task coordination and conflict resolution [6].

The prevalence of new design theories and information and communication technology (ICT) applications has opened new possibilities for coordinating and managing multi-disciplinary design. Researchers suggest that collaboration design can be achieved by employing a combination of techniques and theories developed to support group internal or external communication, information sharing and decision making [7–9].

Traditional approaches to sharing design information among designers include the development of integrated sets of tools and the establishment of data standards. These approaches are becoming insufficient to support collaborative design because of the diverse and complex forms of information, interdisciplinary collaboration, heterogeneous analysis systems and software tools. Emerging technologies such as distributed objects and Web technologies and distributed artificial intelligence have been proposed to implement collaborative design systems. The latter, implemented in the form of intelligent agents/multi-agent systems (MAS), has demonstrated a significant potential for use in building design. MAS consist of self-contained, knowledge-based systems that are able to tackle specialist problems and which can interact with one another (and/or with humans) within a collaborative framework [10]. Some of the recently developed MAS-facilitated collaborative design systems are found in refs. [11–17].

In addition to the use of ICT, new theoretical approaches such as multi-disciplinary optimisation (MDO) have also been developed to facilitate collaborative building design. MDO is a methodology used for the optimisation of large and complex engineering designs. It models the interaction between the different components of the problem through analysis and formal optimisation. It is based on a

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