

An Agent Facilitated Design Conversation System for Facilitating the Designer in Creative Thinking in Architectural Design

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Abstract. The paper discusses a current research that investigates if a computer aided conversation system can be created to support the human thought process in the early stages of architectural design. It argues that design conversations are an essential premise for designing, especially at the early stages, when the designer has to brainstorm ideas to generate creative conceptual solution-conjectures. The paper also argues that design knowledge is mainly dependent on a designer's experiences. But experiential knowledge, stored in the long term memory is difficult to recall. Based on these arguments, an agent-based knowledge system, *Design Thinker*, is designed to allow for an efficient design conversation that triggers the experiential memory of the designer for recalling and associating the right experiences. It is also designed to enhance and add to the existing design knowledge of the designer by enabling them to view the knowledge through different perspective or domain lenses. The paper describes the conceptual structure of the knowledgebase used in the prototype followed with a brief overview of the empirical study.

Introduction

The early stage of architectural design is often the most creative period in the design process. It is in this stage that the designer begins to formulate ideas for developing conceptual solution conjectures. A two-way interaction begins between the designer and the developing design, leading to further new ideas for the design situation. Donald Schön (1995) in his seminal work, compares this dynamic, cyclic and unfolding nature of the design process as the designer having a *reflective conversation* with the design situation. In other words, a designer talks to their drawings and the drawing speaks back as if showing a new perspective of the design situation.

A meaningful design conversation is based on the knowledge of the design conversationalists. In this study, the focus is on the experiential knowledge of the designer. Generally in architectural practices, a team of designers discuss ideas to arrive at a suitable design concept or solution for a specific design situation. Each designer brings with them knowledge in terms of their design experiences. This experiential knowledge is shared by the designers and in turn triggers the generation of new ideas. The experiential knowledge is not necessarily through work experience alone, but is collected over time through the designer's exposure to various design elements like design precedents, pictures and also elements from other related design fields like fashion, photography etc. This experiential knowledge is stored in the long term memory of the designer and is generally very difficult to recall unless triggered. Lawson (2004) highlights the role of conversations in this respect, where one idea triggers another, apparently remote from it. This also suggests the significance of words as most conversations involve words to communicate thoughts and ideas.

Based on the arguments, it is hypothesized that a computer aided conversation system can aid the designer in triggering ideas during the early stages of the design process.

The aim of this study is to test the hypothesis. To achieve this, there is a need to gain insight into the state-of-art computational technologies in knowledgebase systems and artificial intelligence. Based on this study, a design conversation prototype, *Design Thinker*, is proposed and implemented as a dialogue between the user and domain-specific computational agents.

In this paper, the focus is on the design and architecture of the prototype, *Design Thinker*. Section 1 presents the arguments for the hypothesis. Section 2 presents the design of the implemented prototype, with an emphasis on the structural representation of the knowledgebase and the conceptual design of domain agents. In section 3, the empirical study used to test the performance of the system is described briefly, followed by the results and conclusions drawn from the study in section 4.

Design Conversations

In the early stages of the design process, architects usually begin with a pre-briefing session with the clients to gain an understanding of the basics of the design problem. This is followed by interpreting and often developing the design brief, understanding the requirements, visiting the site and holding further meetings with the clients. The design thinking period begins from the pre-briefing stage and continues throughout the design process (Luck and McDonnell, 2006).

Architectural design, by nature, is also a response considerations that span a wide range of domains such as aesthetic, functional, material and ecological. These are often inconsistent, but are nevertheless brought together through architectural design in a novel way (Haapasalo, 2000). It is through a reflective conversation with the design situation, generally informed by active conversation with experts from many different domains, that the designers display a capability for integration, evaluation and synthesis of complex ideas from the different domains of architectural design. Conversation is an intrinsic part of human nature. The dictionary defines conversation as an informal talk with somebody about opinions, ideas, feelings or everyday matters. Apart from the reflective nature of design conversations, Loke (1997) also identifies the

generative nature of design conversations since, in a design conversation, not only known information is being transferred between the conversationalists, but new information and insights are discovered which neither conversationalist would have known. The reflective and generative aspects of design conversations highlight the significance of design knowledge gained through a design conversation.

Design Knowledge

Design is essentially a collaborative process. As stated above, the early stages of design mark the need for an outstanding capability for integration, evaluation and synthesis of concepts. For these reasons, it is generally common for architectural practices to employ design teams rather than individual project designers. The former provide a rich collective experience from different domains. So how does this experiential knowledge build up? Lawson (2004) highlights the use of the 'precedent'. He identifies the precedents as a wide variety of knowledge related to design that gets stored in the designer's 'experiential' memory. Such precedents are described as employed solutions by the designer or other famous designers, buildings, landscapes, towns seen during travel and even through media images. It can also include elements from other design fields like fashion, photography, products and others. All this exposure is said to build a designer's knowledge, especially the experiential knowledge which the designer can draw upon in future design problem-solving. Comparative studies between experts and novice designers clearly indicate the use of experiential knowledge as a vital factor in the design process (Cross, 2006, Goker, 1997). Cross (2006) identifies the development of design ability to be through 'experience'. In his comparative observations between experts and novices, he argues that experienced designers are able to draw on their knowledge of previous experiences in their field of design using solution- conjectures for a rapid exploration of the problem. He states, (Cross, 2006, pg 26)- 'They (experienced designers) use early solution attempts as experiments to help identify relevant information about the problem. In comparison, novice designers often become bogged down in attempts to understand the problem before they start generating solutions'.

Every designer, including the novice, has a certain level of design experience gained from childhood, but there still seem to be some designers who can recall their experiences to a particular problem efficiently and are seen to have better design ability.

This highlights two needs – one of informing the designer and adding to their experiences while designing and the other of aiding the designer by triggering their experiential knowledge from their long term memory for solution conjectures in exploring the problem.

The essence of any conversation is the sharing of thoughts and ideas through 'words'. Words in design, rather than pictures are seen to be more useful triggers for design knowledge. Loke (1997) comments that a picture triggers the sensual experiences, but these experiences are hard to remember at will. Words label experiences whereby the latter acquire more meaning and are easily recalled when needed. Words in combination with pictures can provide a powerful tool for conducting design conversations.

The Prototype

Taking the analogy of Schon's reflective conversation theory, a prototype, Design Thinker, is proposed as a dialogue between the user and domain-specific computational agents. The dialogue is intended to trigger the experiential memory of the user and associate significant experiences from different domains of the design problem to stimulate creative thinking. This model represents 4 different design activities theorized by Schon- *naming, framing, moving* and *reflecting* (Schon, 1995, Valkenburg and Dorst, 1998). The user begins the system by naming a design consideration. The *framing* agent frames alternative ideas for the design consideration from the system knowledgebase. Once an idea is selected, it marks the beginning of the design conversation. The moving and reflecting phase involve an interaction between the user and *domain* agents in which domain agents provide their individual perspectives in return to a user-selected response and the process continues. These domain perspectives are drawn from a filtered view of the overall knowledgebase, derived from an understanding of each domain agent's area of focus or interest.

THE KNOWLEDGE-BASE

The agent system is based on a *Blackboard Architecture* in which a blackboard forms a temporary database. At the core of the agent system is the knowledgebase (or ontology) that forms the basis of agent reasoning. The ontology for the system is adapted from the knowledgebase of the book, 'The Metapolis Dictionary of Advanced Architecture.' This dictionary defines the practice of architecture in a contemporary perspective by providing definitions and meanings to a wide variety of terms that are associated with what has come to be called 'Advanced Architecture'. This ontological dictionary serves as a fine example of the semantics and associations between words in a particular domain of architectural design, making an appropriate resource upon which to build this prototype system. The ontology is structured in the book, as shown in Figure 1, providing a straightforward structure for the knowledgebase that lies at the heart of *Design Thinker*.

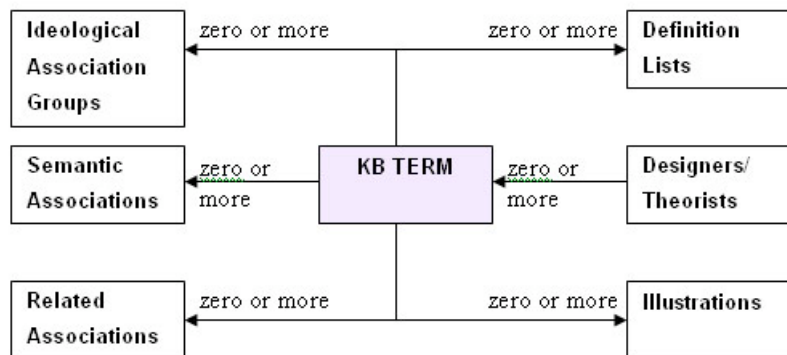


Fig 1. Structure of the knowledgebase as presented in the 'The Metapolis Dictionary of Advanced Architecture'

Each KnowledgeBase Term (KB Term), which is a main term in the knowledgebase related to architectural design has 3 sets of associations (with other KB terms: Ideological, Semantic and

Related) as well as supplied textual definitions and illustrations. In addition, there is a list of designers and theorists who in turn are associated with a list of key terms.

The knowledgebase segments are described in more detail as follows:

1. *Ideological associations*

A key term is associated ideologically to zero or more groups of analogical associations consisting of *KB Terms*. This association is the first point of consultation/lookup for the domain agents.

2. *Semantic associations*

Each *KB Term* may or may not be related to a semantic association. A semantic association is used when the *KB Term* is close enough to be explained through the definition of another term. The semantic association is the second point of consultation for the domain agents.

3. *Related associations*

Each *KB Term* is provided with a list of links, that is, a series of words related to that term. These terms provide more information on the current *KB Term*. The related associations form the third point of consultation for the domain agents.

4. *Definitions*

The definitions following each *KB Term* provide an understanding of the *KB Term* from different authors' perspectives. The definitions are the fourth point of consultation for the domain agents.

5. *Designers/ theorists*

The book provides an index of architects, designers, critics, engineers, philosophers with a list of *KB Terms* associated with them. It is a tool to understand what kind of architecture, which position or which theme everyone deals with. The list of designers' et al are the fifth point of consultation for the domain agents.

6. *Illustrations*

Each *KB Term* may have zero or more referenced illustrations along with the definitions to facilitate quick consultation and explanation of the terms. Most of the illustrations are from architectural projects and show the characteristics identified in the definition of the corresponding *KB Term*. These form the last point of consultation for the domain agents.

THE FRAMING AGENT

A user enters a word as a *Design Consideration*, which is picked up by the framing agent. The task of the framing agent is to identify *Candidate Ideas* from the knowledgebase that are significant to the *Design Consideration*.

The framing agent carries out a text search for the *Design Consideration* in the list of *KB Term Definitions* segment of the knowledgebase. When it finds a match, the corresponding *KB Term* is added to the list of *Candidate Ideas*. A list of *Candidate Ideas* is determined. Each *Candidate Idea* is assigned a score and the first 3 ideas with the highest score are presented to the user as

Ideas. If the user is not satisfied, he/she can prompt the framing agent to provide further ideas in groups of 3.

THE DOMAIN AGENTS

As the name suggests, domain agents belong to a particular domain and respond to the *Focus Term* on the blackboard based on their own *View* of the knowledgebase. This *View* is a subset of the entire structure of the main knowledgebase. The user can also create additional domain agents which can be added to the system.

SCORING OF CANDIDATE RESPONSES

When an *Idea* (returned by the Framing Agent) is activated by the user to initiate a conversation, it is picked up by each domain agent and becomes the *Focus Term*. Each domain agent searches for *Candidate Responses* in each KB segment of its *View*. It compiles a list of *Candidate Responses* from each KB segment and scores them. A conceptual basis for the choice of *Candidate Responses* from each KB segment is as follows:

1. Ideological associations

Each key term is associated ideologically to a group of zero or more analogical associations. In response to a *Focus Term*, the domain agent determines a list of *Candidate Responses* that are most relevant. For a term to qualify as a *Candidate Response*, it must contain the *Focus Term* in one of its association groups. Each *Candidate Response* is assigned a score reflecting its importance.

2. Semantic associations

In response to a *Focus Term*, the domain agent determines a list of relevant *Candidate Responses* that are most relevant as semantic associations. For a term to qualify as the *Candidate Response*, it must contain the *Focus Term* as one of its semantic associations. Each *Candidate Response* is assigned a score reflecting its importance.

3. Related associations

In response to a *Focus Term*, the domain agent determines a list of *Candidate Responses* that are most relevant as related associations. The agent locates the *Focus Term* in the *KB Terms* of its knowledgebase. If it finds a match, the related associations for that *KB Term* become the *Candidate Responses*. Each *Candidate Response* is assigned a score reflecting its importance.

4. Designers/ theorists

In response to a *Focus Term*, the domain agent determines a list of relevant *Candidate Responses* that are designer names. The agent locates the *Focus Term* in each designer group containing a list of *KB Terms*. If it finds a match, the corresponding designer names become the *Candidate Responses*. Each *Candidate Response* is assigned a score reflecting its importance.

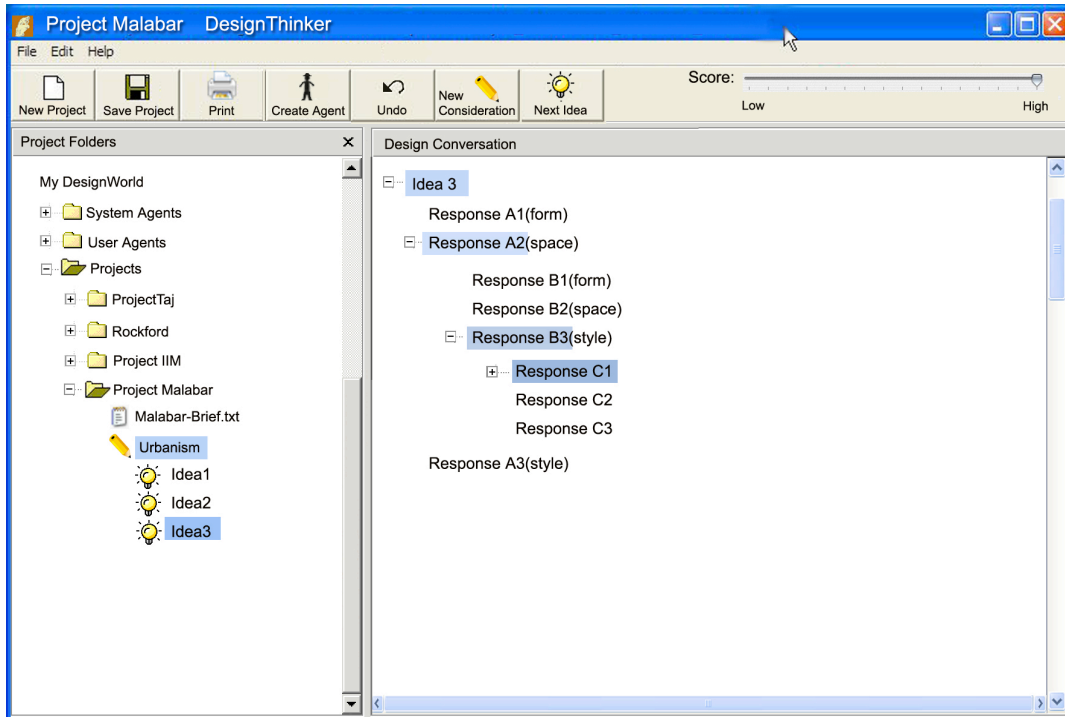


Fig 2.Design Thinker as an Explorer Interface

THE CONVERSATION WITH DESIGN THINKER

Design Thinker has been implemented as a design conversation system to facilitate the designer in the generation of ideas at the early stages of the design process. Figure 2 shows the working interface of Design Thinker. For a particular design project, a designer enters the project brief and a Design Consideration that is an issue related to the project and of the designer's interest. When a Design Consideration is entered into the system, the framing agent is activated, who prompts a set of three Candidate Ideas from the overall knowledgebase as per the scoring system. The designer can choose to interact with the framing agent for more relevant ideas by changing the score on a displayed score bar on the interface and clicking the 'Next Idea' button.. At this stage, the designer can also change the Design Consideration, to be prompted for more ideas by the framing agent. Once an idea is selected by the designer, it is picked up by each domain agent in the system and becomes the Focus Term. Prior, to this the designer can also create new domain agents or choose the domain agents from the available list to make them active for a design conversation. Each domain agent returns one Response to the interface The user can continue the conversation by selecting a response through a double click on the word. The selected response is highlighted on the interface and is transferred to the blackboard as a *Focus Term*. In return, the domain agents provide new *Responses* from their *Views* based on previous scoring methods and the conversation continues. On right-clicking a response, a user can choose to view the detailed definition and illustrations for the respective response to facilitate an explanation for the term.

Empirical Study

An experiment was conducted with ten designers with varying degree of professional experience. Only one participant participated in the experiment at any one time. Two design tasks were set for the experiment, one to be completed without using Design Thinker and one using Design Thinker. In both design settings, the participants had to express their thoughts aloud, right from the beginning to the end of the design process. The participants were given A4 sheets of paper for sketching their design ideas and both the sessions were recorded on video. The video recordings enabled the researcher to go through each session for further detailed analysis. The working of Design Thinker was explained to the participants before beginning the second design task. At the end of each design session, each participant mapped their design ideas from the beginning to the end of the design process in a concept map software program called 'CMaps'. These maps provided a cognitive view of the designer's design process. At the end of both the design tasks, each participant completed a questionnaire followed with an interview that allowed each participant to express their viewpoint on using Design Thinker during the early stages of the design process. Both the sessions were analysed using protocol analysis, segmenting and coding the activities based on Schon's paradigm of naming, framing, moving and reflecting. In addition, the design outcomes for both protocols were rated by external judges.

Results and Conclusions

The results indicated that for around seventy percent of the designers, Design Thinker did trigger their memory for ideas and solution conjectures in solving the design problem. Sixty percent of the designers were able to recall their experiential memory for ideas and think in parallel on several design issues. The ratings by external judges also demonstrated that the use of Design Thinker in the design process did trigger idea generation in some designers and had an impact on the quality of their solutions. An interesting aspect of the results was that participants with lesser experience benefited and appreciated the system more than designers with a higher level of experience. Based on this result, the study also indicates that Design Thinker could be a useful pedagogic tool in the education of architectural design.

References

- Cross (2006), *Designerly ways of knowing*, Springer, London
- Göker M H (1997) The Effects of Experience During Design Problem Solving *Design Studies* 18(4): 405-426
- Haapasalo, H. (2000), *Creative Computer Aided Architectural Design: An internal approach to the design process*, Academic Dissertation, Faculty of Technology, University of Oulu, Oulu.
- Lawson, B. R (2004), *What Designers Know*, Architectural Press, Oxford
- Lawson, B. R and Loke, S. M. (1997), Computers, words and pictures, *Design Studies*, vol.18, pp171-184
- Loke. S. M. (1997), 'Sketching with words ', PhD thesis, University of Sheffield, United Kingdom

Luck and McDonnell (2006), 'Architect and user interaction: the spoken representation of form and functional meaning in early design conversations ', *Design Studies*, Vol 27, No.2 pp 141 - 166

Schön, D.: 1995, *Reflective Practitioner: how professionals think in action*, New edn, Aldershot Press, England

Valkenburg and Dorst (1998), 'The reflective practice of design teams', *Design Studies*, Vol 19, pp 249 -271

GLOSSARY OF TERMS

Blackboard: An in-built database of user-selected *Focus Terms* respectively. The blackboard functions as an internal mechanism.

Candidate Ideas (ci): A set of potential ideas identified from the knowledgebase by the framing agent in return to a *Design Consideration*.

Candidate Response: A set of potential responses provided by the domain agents in return to a *Focus Term* on the blackboard.

Design Consideration (dc): A design key term for the current project entered in by a user that activates the framing agent.

Focus term (ft): A term selected from Responses or Ideas and placed on the blackboard.

Ideas (i): Ideas are a set of terms from an ordered list of *Candidate Ideas* provided by the framing agent that are identified and placed on the interface in groups of three.

Ideological Association (IA): The segment of knowledgebase containing the 'ideological dictionary' with its set of analogical groups for a key term.

KB Term (KBt): The main terms in the knowledgebase and agent views supplied with textual definitions and illustrations.

Knowledgebase (kb): The ontology or knowledgebase used for agent communication. In this prototype, the knowledgebase is adapted from the book, 'The Metapolis Dictionary of Advanced Architecture'.

Related Association (RA): The segment of knowledgebase listing the related associations for a *KB Term*.

Semantic Association (SA): The segment of knowledgebase listing the semantic associations for a *KB Term*.

View: A subset of the knowledgebase extracted by the domain agents by matching their characteristics to words in the *KB Term* definition segment of the knowledgebase.