Interactive Patterns for Associating Ideas during Brainstorming

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Idea association is an important behavior to generate diverse ideas during brainstorming. Through three linking principles (similarity, contrast and contiguity), idea association involves a dynamic linking process between ideas and design cases. Based on the knowledge representation issue-concept-form proposed by Oxman (1993), three interactive patterns between ideas and design cases are investigated. Finally, some computational mechanisms for supporting the linkage of idea association are discussed.

Keywords: *idea association, linking, case representation, case based reasoning, brainstorming*

Introduction

Design is a creative behavior that depends on the evolution of many ideas. Many architectural firms use brainstorming as a creative problem solving technique to assist design groups in generating a wide variety of novel ideas, thus obtaining an overview of potential design directions (De Bono, 1970; Lugt, 2000). During brainstorming, idea association, as identified by Osborn (1963), is an important behavior for generating diverse ideas. Furthermore, idea association involves a dynamic linking process by linking not only participants' ideas, but also prior design cases (Lai, 2004). Through three principles of idea association (Osborn, 1963), there are three interactive patterns for linking ideas with design cases dynamically. These patterns provide an interesting research area that might provide some computational needs for associating ideas.

There is a tendency to use design cases as references and to extract past experience for associating ideas. Therefore, a computational mechanism, called case-based reasoning (CBR) (Kolodner, 1993), is brought into our implementation consideration for understanding the interactive patterns described above. Briefly speaking, CBR support design by reminding designers of previous experiences that can be helpfully applied to new situations (Maher et al., 1995; Schank, 1999). In employing knowledge from prior designs in order to aid in current design problems, relevant design ideas may be accessed from design cases. Thus, the knowledge representation of design case plays an important role to interact with ideas in the linking process. Knowledge representation such as function-behavior-structure has been employed for the representation of performance of elements in structural design (Rosenman et al., 1992). However, the suitability of

the formalism to the architectural design domain may not be generally applicable.

In this research, we concentrate on generating design ideas related to spatial organization in the early conceptual design stage. Therefore, the role of design cases should support the conceptual knowledge to inspire designers to generate related ideas, which are in conjunction with those of the other participants' ideas. Oxman (1993 and 2004) decomposes design case knowledge into separate independent idea entities (called chunks), which provides a potential method for exploring the interactive patterns for associating ideas. By elucidating the interactive patterns, some computational mechanisms for supporting the linkage of idea association are discussed in this paper.

Representing ideas and cases

Idea association involves in a dynamic linking process among ideas as well as between ideas and design cases (Lai, 2004). During a design process, designers always decompose a design into several architectural elements, and use these elements' attributes as keys to link relevant ideas within prior design cases. Before understanding the interactive patterns between ideas and cases, the knowledge representation of ideas and cases and their relationships should be investigated firstly.

Ideas

According to our previous cognitive studies (Lai, 2004), ideas need to have been communicated to others, be related to the task at hand and provide some kind of a solution during brainstorming (Lugt, 2000). Besides, designers always express their ideas by using a domain concept vocabulary accompanied by multimedia during brainstorming. For example, a designer used a concept vocabulary "floating building" and a photograph of Villa Savoye designed by Le Corbusier to express the generated idea (Figure, 1).

Based on the above description, an idea contains two parts: a design problem and its solution. Furthermore, each solution includes an abstract concept and a concrete example represented by conceptual vocabulary along with multimedia. Therefore, each idea contains three elements: design problem, abstract concept and concrete examples.

Cases

Designers are used to selecting relevant ideas from prior design cases (called design precedents) for generating new ideas in a brainstorming session. In this research, we concentrate on generating ideas in the early conceptual design stage. Case representation more specifically focuses on representing the conceptual knowledge embedded within past designs, and making it fit to be searched and browsed within a computerized library of design

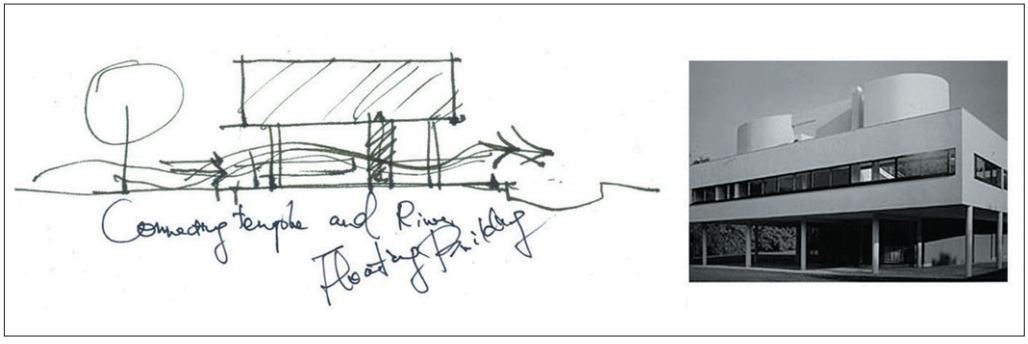

Figure 1
An idea "floating building" expressed using conceptual vocabulary along with visual aids

precedents. Oxman (1993) provides a potential method to decompose precedent knowledge into separate independent chunks. Each chunk can be considered as an idea entity that includes three properties: the issue, the design concept and the form solution as described below.

1. Issues: The design issues are related to the design tasks that are deliberated by the designer. It offers a convenient term to identify particular points in design problems. For linking idea entities effectively, we argue that ill-defined design issues can be decomposed into several well-defined sub-issues.
2. Concepts: The design concept is the formulation of an opinion in relation to a design issue or a design sub-issue. It is an abstract form of ideation related to the design task.
3. Forms: The form is the specific design artifact that materializes the solution principle. It is important to note that this is one element of the total building design that directly relates to the design issue or sub-issue.

Linking relationships between ideas and cases

Based on the knowledge representation described above, these idea entities are clustered into design cases, and form a dynamic linking network. Furthermore, these properties within idea entities are organized into a semantic net based upon the domain concept vocabulary accompanied by different kinds of information such as keywords or multimedia.

An idea entity within design cases can be considered as a design idea (Oxman, 1993; Lai, 2004). Basically, the three elements of an idea (design problem, abstract concept and concrete

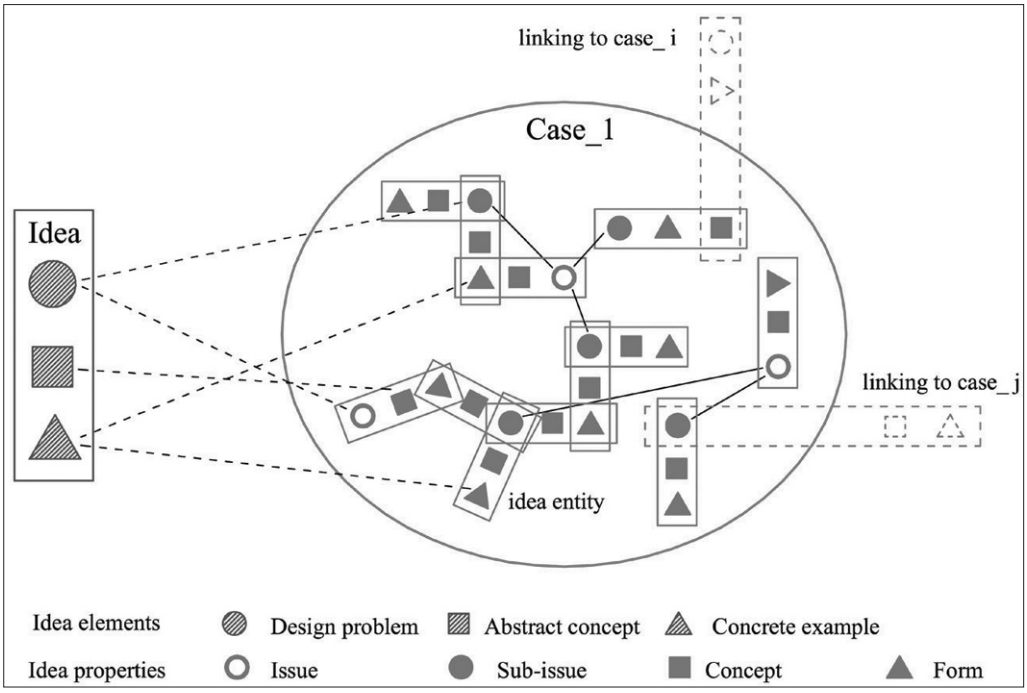

Figure 2
Linking relationships between an idea and design cases

examples) can be analogous to the three properties of idea entities (issue, concept, form) respectively. Thus, an idea has dynamic linking relationships with design cases seen in Figure 2. From any node of issue, concept or form in the idea entity network, any related idea entities within design cases can be linked dynamically.

Interactive patterns for linking ideas with cases

Basically, there are three interactive patterns for linking ideas with cases: similarity, contrast and contiguity. For providing a more semantic and flexible linking mechanism, any two elements within an idea can dynamically match two of the analogous properties within the design cases. Through the three interactive patterns, an input idea can stimulate designers for linking all possible idea entities as output ideas in the process of idea association.

Besides, these patterns are based on the following assumptions: 1) designers have the same design ontology, and 2) use the similar domain concept vocabularies to express ideas. The three interactive patterns are described in the following session.

Similarity pattern

An input idea uses a key-element pair (design problem, concrete example) to respectively match two properties (issue, form) by matching similar conceptual vocabularies. Hence, all related idea entities with new concept and form properties are associated (Figure 3). The purpose is to link similar idea entities with different design solutions.

Contrast pattern

Firstly, the abstract concept within an input idea is transformed into another abstract concept with a contrasting keyword, such as inside and outside, private and public, solid and void, figure and ground. Then the transformed input idea uses a key-element pair (design problem, abstract concept) to respectively match two properties (issue, concept) by matching similar conceptual vocabularies. Hence, all related idea entities with contrasting concept and form properties are associated (Figure 4). The purpose is to link contrast idea entities with contrast design solution.

Contiguity pattern

An input idea uses a key-element pair (abstract concept, concrete example) to respectively match two properties (concept, form) by matching similar conceptual vocabularies. Thus, all related idea entities with new issues are associated (Figure, 5). The purpose is to link different design problems with the same design solutions.

In addition, each linked idea entity can continuously link with other related idea entities according to the three patterns described above. Thus, many related

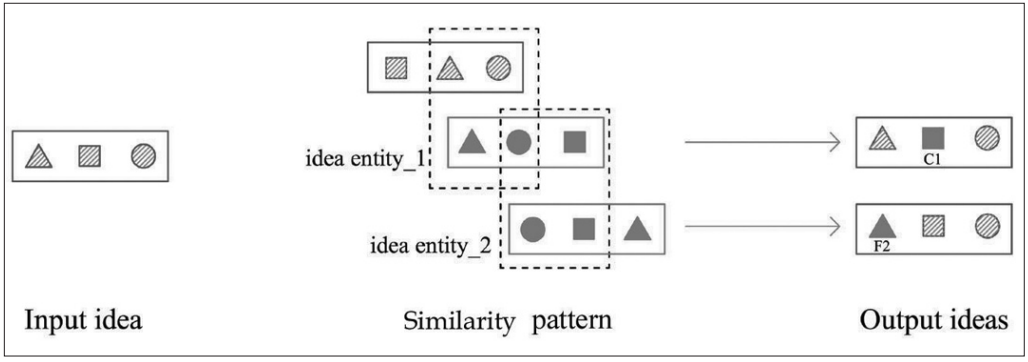

Figure 3
Similarity pattern

idea entities are linked together that constitute a meaningful and dynamic idea structure.

Discussion and Conclusion

This paper provides a basic understanding of the linking patterns between ideas and cases in the process of idea association. During brainstorming, the case representation issue-concept-form (Oxman, 1933) provides a powerful mechanism for linking diverse ideas within design cases in the conceptual design stage. Furthermore, the three linking patterns provide an effective indexing mechanism to support search and browsing related and meaningful ideas in conjunction with the other participants' ideas. In addition, these patterns provide the foundation for the following discussion.

Control strategies

While the idea entities are too many (over 20 idea entities), designers are unable to consider all possible solution (Liu and Bligh, 2003), and difficult to decide what the optimal ideas are. For making an understandable idea-map, some control strategies for deliberately decreasing the idea entity number should be made. According to designers' design preference, we argue that designers can select the linking principles and their relevant number of links to reduce the idea-map.

Similarity assessment

Basically, the method for computing similarity is based on textual matching. In the linking processes, each idea entities within design cases must be compared with the input idea and be assigned a degree of similarity according to conceptual vocabularies (or keywords). For assessing similarity dynamically and effectively, different dictionaries should be provided for analyzing these conceptual vocabularies based on the three linking principles. The issues will be studied in our future research.

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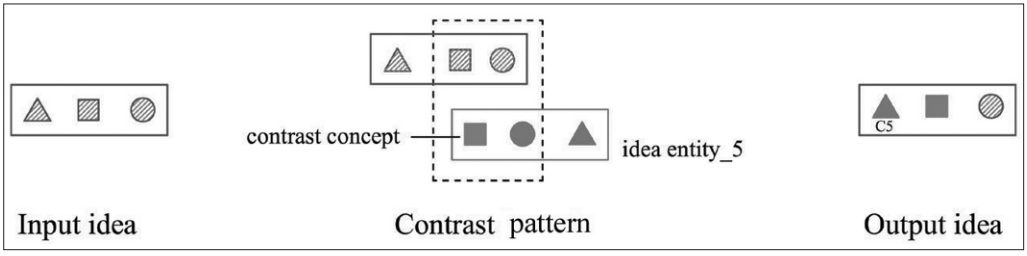

Figure 4
Contrast pattern

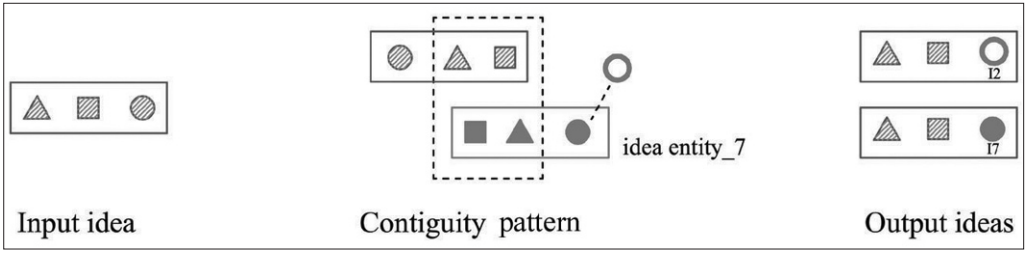

Figure 5
Contiguity pattern

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