

Towards Active Support Systems for Architectural Designing

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Keywords

CAAD systems, active designing support, situatedness.

Abstract

This paper proposes the application of a situated learning approach in designing integrated with a conventional CAD system. The approach is implemented in SLiDe (Situated Learning in Designing) and integrated as SLiDe-CAAD, to provide interactive support in designing exemplified within the composition of architectural shapes. SLiDe-CAAD is proposed to assist in maintaining the integrity of shape semantics or desired design concepts of interest in the design composition. SLiDe-CAAD is introduced to provide a collaboration between the designer and the computer during the process of designing.

1. Introduction

The use of computers as designing support tools has implications for the way designing is carried out. During the last three decades of the twentieth century CAD systems provided support for calculation, documentation, animation and modelling of designs. In architectural designing most of the current CAD systems can only be used at the very late stages of the design process after most of the ma-

ior design decisions have been made and very few can be used during the conceptual stages of designing. During the process of designing, solutions are fluid and emergent entities generated by dynamic and situated designing activities. The ability to provide useful designing support at the conceptual stages of designing to accommodate the situated and fluid nature of early schematic designing is important in designing.

2. Situated Learning of Architectural Shape Semantics

In architectural designing, as in many other design disciplines, shape composition is an important design activity. The formation and discovery of relationships among parts of a design composition is a fundamental task in designing. The abstraction and explicitness of these relationships in a recognised drawing can therefore lead to a closer and better understanding of shape semantics. Shape semantics are the interpretation of visual patterns or visual forms of groups of shapes in the drawing.

Designers interpret and perceive their designs differently and discover various shape semantics

related to their interest from their design compositions. Multiple representations provide the opportunity for a wide range of interpretations where each interpretation reveals certain shape semantics. Shape semantics are recognised in terms of similarity of spatial relationships as well as physical properties. A group of shape semantics recognised in each representation forms an observation. A set of observations can be constructed from a set of multiple representations.

Situated learning of architectural shape semantics is mainly concerned with locating shape semantics in relation to their situations within which they were recognised in the design environment. This situatedness of any of the shape semantics is not determined a priori but constructed based upon what is there in the design environment.

3. SLiDe: A Computational Situated Learning System in Designing

A computational system for situated learning in designing (SLiDe) is implemented and exemplified within the domain of architectural shape semantics (Reffat and Gero, 2000). Its underlying concepts could be used in other domains. SLiDe consists of three primary modules: Generator, Recogniser and Incremental Situator. The Generator is used by the designer to develop a set of multiple representations of a design composition. This set of representations forms the initial design environment of SLiDe. The Recogniser detects the design environment and produces a set of observations, each of which consists of a group of shape semantics recognised in each representation. The Incremental Situator consists of two sub-modules: Situator and Restructuring Situator. The Situator module locates the recognised shape semantics in relation to their situations by constructing the regularities of relationships among shape semantics across the observations and clustering them in

situational categories organised in a hierarchal structure. The Restructuring Situator updates previously learned situational categories and restructures the hierarchy accordingly.

4. Active Support for Architectural Designing

Maintaining the integrity of desired and developed concepts while designing is one of the ways in which SLiDe-CAAD could provide support in architectural designing. A simplified approach to maintaining the shape semantic of interest in the design composition has been proposed by Gero and Jun . The shape semantic that is to be kept is constrained to exist independently of other operations based on the sufficient and necessary conditions of that shape semantic, ie situation independent. It is proposed here to maintain the desired shape semantic through preserving both its necessary (predetermined) conditions and applicability (constructed) conditions within which it was recognised across the constructed set of observations in SLiDe. This would help not only to maintain the shape semantic of interest but also its situatedness.

This is achieved through maintaining the other shape semantics within which the shape semantic of interest is situated. The Generator module can be used to develop a set of representations from an initial representation of a design composition. The Recogniser module in SLiDe can be used to detect shape semantics in each of the developed representations. The result of using the Recogniser module to detect shape semantics in the developed set of representations is a set of observations constructed as shown in Table 1 from the developed representations. The Incremental Situator module in SLiDe can be used to learn the applicability conditions (situatedness), of recognised shape semantics across the observations constructed using the Recogniser module. The result of using the Incre-

mental Situator module is a set of situational categories, each of which includes the regularities of relationships among a group of shape semantics within which they were recognised. These situational categories present the applicability conditions of the recognised shape semantics.

Representation No.	Corresponding Observation (O_n)	
N_1	O_1	$R_{n'}, A_d$
N_2	O_2	$R_{n'}, A_d$
N_3	O_3	$R_{n'}, C_{e'}, A_d$
N_4	O_4	$R_{n'}, C_{e'}, A_d$
N_5	O_5	$R_{n'}, A_d$
N_6	O_6	$R_{n'}, A_d$

Table 1. A set of observations produced using the Recogniser module to detect shape semantics in the developed representations. A_d represents the semantic adjacency, C_e centrality and R_n cyclic rotation.

Within each situational category, if a certain shape semantic is selected to be applied the remaining shape semantics within this category form the applicability conditions, ie situatedness, of that shape semantic. There are two learned situational categories: C_{s_1} and C_{s_2} . In C_{s_1} , there is a regularity among the shape semantics $R_{n'}$, C_e and A_d that refer to cyclic rotation, centrality and adjacency respectively. Within C_{s_1} , if cyclic rotation is selected to be applied, then both centrality and adjacency form the applicability conditions of cyclic rotation. In other words, cyclic rotation is situated within centrality and adjacency. In C_{s_2} , there is another situation where cyclic rotation is recognised in conjunction with adjacency. These applicability conditions for each recognised shape semantic can be used to maintain its situatedness in the design composition as well as the integrity of the design composition while revising the design. SLiDe-CAAD can help to dynamically change the association between the parts in a design composition based upon the

shape semantic of interest indicated by the designer by maintaining its applicability conditions.

For example, assuming that the designer selected one of the new developed representations to pursue. This selected representation becomes the current design composition that the designer acts on as shown in Figure 1(a). The designer indicated cyclic rotation (R_N) among the group of four shapes S_1 in the design composition as the shape semantic of interest. Some time later, the designer decided to add or insert a space, in the form of a new shape S_3 , between the two shapes S_1 and S_2 in the design composition as shown in Figure 1(b). Such addition required moving the shape S_1 from its previous location. Hence, the cyclic rotation (R_N) among the group of shapes S_1 is disturbed by moving one of the shapes S_1 and changing its distance from the rotation centre of its group. Yet, there is a possibility to maintain the cyclic rotation by moving the other shapes S_1 with the new distance from the rotation centre as shown in Figure 1(c). Maintaining the distance between each of the congruent shapes S_1 and the rotation centre is one of the necessary and sufficient conditions of cyclic rotation. In spite of maintaining the cyclic rotation in the design composition, the adjacency (A_D) between each of the shapes S_1 and S_2 is disturbed. From the learned situational category (C_{s_1}) in SLiDe, adjacency (A_D) is one of the applicability conditions of cyclic rotation. Since, cyclic rotation is the knowledge in focus, SLiDe-CAAD helps in maintaining the situatedness of cyclic rotation by preserving its applicability conditions. As a result, the shape S_3 is inserted between each of the shapes S_1 and S_2 to maintain the adjacency among them as shown in Figure 1(d).

5. Conclusion

This paper outlined how SLiDe-CAAD can provide conventional CAD systems with the capability to

maintain the integrity of shape semantics of interest in the design composition and its situatedness while designing. The purpose of SLiDe-CAAD is not to replace the designer, but to assist through a form of collaboration with the designer in design-

ing and producing a solution. This provides the potential to change the nature of currently passive conventional CAD systems to be more active and responsive CAAD support system at the very early stages of designing.

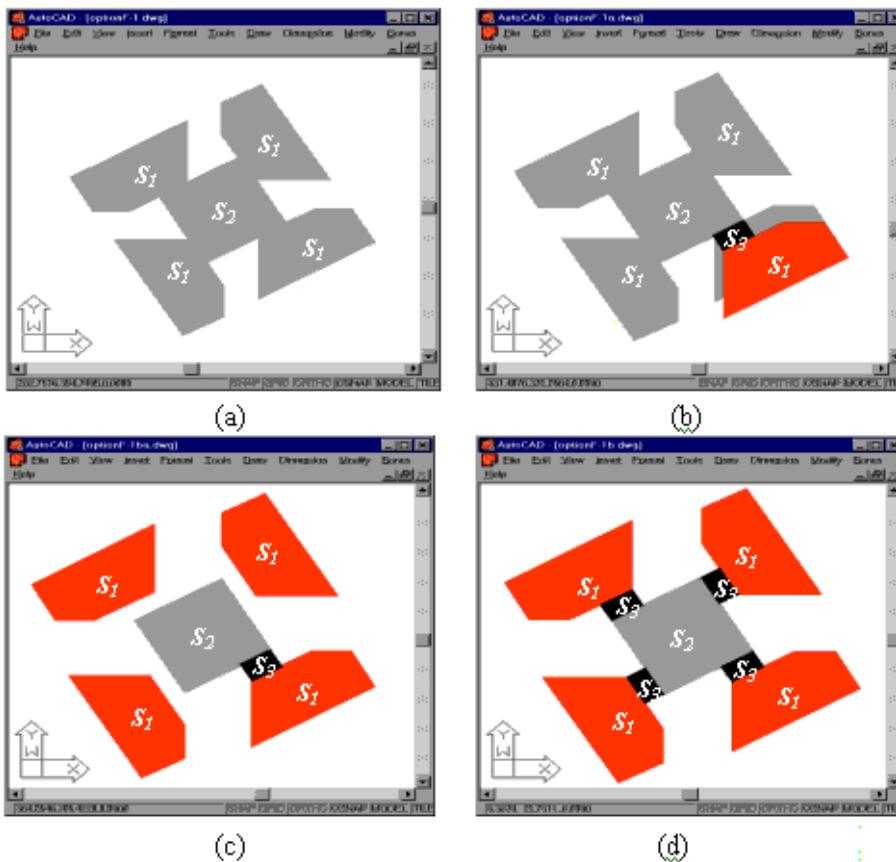


Figure 1:
 (a) One of the developed representations is selected by the designer to further pursue in designing; (b) a new space added by the designer at a later stage; (c) SLiDe-CAAD could help in maintaining the cyclic rotation; and (d) SLiDe-CAAD could help in maintaining the situatedness of cyclic rotation.

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