Visual Emergence in Creative Collaboration

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A conceptual framework to support creative collaboration in a Web-based design environment is proposed and discussed. We demonstrated this approach in our work on visual emergence. First, our model of visual emergence of design schema is presented. Following, a conceptual framework to support this model in CAAD environment is developed and introduced. Finally, a web-based computational environment is presented. One that may support visual emergence as part of a creative collaboration process

Keywords: *Web Design, Collaborative Design, Visual Design, Design Thinking, Visual Emergence*

Introduction

Current research and applications of Web-technologies have contributed to the development of certain properties that assist the designer in collaborative design. The Internet and the WWW have proven to be a useful tool to communicate, share and select relevant information (Rodgers, 1998). Despite the fact that the advancement of Web technology has contributed to a strong medium that assists collaboration particularly in the areas of information exchange and communication, it cannot yet be said to provide a creative collaboration employing a *design medium*. As a prerequisite we identify issues for achieving computational environments which provide not only the rich selection of information resources which have become associated with the Web, but which also recognize and accommodate the special requirements of design.

In previous papers (Oxman, 1999) we have presented a classification of web-based environment for collaborative design. These are presented below:

The web as a communication medium

Internet applications that facilitate communication among individuals, members of distributed groups and teams exchanging information about design enhance the function of the Web as a communication medium. This facility is based on the use of Web tools for exchanging text, graphics, animation, or for running communications software in distributed computers. These types of applications have been employed in distributed design environments in which the team located at different locations employed Internet technology as a *communication medium* to support CAD animation, visualization etc. Such applications have rendered communication and distributed collaborations more effective, but have not resulted in fundamental changes in the way we 'think creatively'.

The web as a social medium

Applications that have enhanced the operation of the Web as a communications medium also have social implications. As the level and quality of communication rapidly improves, the sociology of the Web begins to provide a level and intimacy of interaction between distributed design collaborators that is unique. With respect to collaborative design, the Web may now be considered as a *social medium*.

Designers can now meet in distributed and virtual environments and share their ideas and comments in real-time discussions. The content of design is built up by the team itself through the exploitation of tools such as interactive bulletin boards, discussion sessions, exchanges of graphical representations, collaboration protocols and personal images. These have contributed to interesting applications in various fields such as virtual design; virtual design studios; synchronic and asynchronic collaborative design virtual space for design education etc.

The web as an information medium

In its most common function, the Web is employed as an *information* medium, providing connectivity to, and representation of, information sources. Generally, a search and, often, a navigation medium enables access to the diverse and huge resources of this open system.

Despite the fact that these Web technologies have contributed to design collaboration they do not provide a visual design medium *which can support the creative thinking in design collaboration, the way designers do*.

Our work on visual emergence demonstrate the significance of the following conditions for the employment of the web as a visual design medium: *a shared common representational schema; visual transparency to the user; and the ability to modify visual representations*.

Design representation in visual emergence

Reinterpretation and restructuring of design representations is a fundamental property of visual reasoning in design thinking. This reasoning is generally facilitated by the interaction between the designer and the visual representations of the design (Schon and Wiggins 1992). The process of recognizing new emergent properties within existing representations characterizes what is termed, emergence.

Most current research on emergence in design computation deals with graphical emergence in shape interpretation (Stiny, 1993) through shape grammars. In our work, rather than dealing with shape emergence, we have attempted to understand and model how generic representations of design prototypes can support the phenomenon of visual emergence. Our theoretical assumption is that knowledge of design classes and their generic representations is one of the forms of knowledge of the experienced designer. Furthermore, in previous papers (Oxman, R. E., 1998) we have attempted to study and model how the exploitation of generic knowledge of typological representations operates in the emergence of new typological schema in visual thinking in design.

In this paper we report on experimental work towards the support of visual emergence in collaborative design. In the study *creative collaboration*, we have investigated how emergence can be utilized and supported in a distributed workplace. In this case the two designers, or teams, do not share the same workplace (either in space or in time), but may share and participate in a *common representational environment*. Within this representational environment knowledge of design schema may be represented in a manner which enhance the possibility of collaborative thinking on the emergence of new schema. In the following sections, conceptual issues in visual emergence are discussed. Following this a computational approach which can support emergence in collaborative design is suggested.

Shared representational schema in visual emergence

The emergence of new schema is a fundamental cognitive capability of creativity in the human designer. A paradox of creative design is how the human designer can discover new schema while working with the generic content of existing schema. An early recognition of this phenomenon appeared in

Dickemann, (Dickemann, 1930) who illustrated how a transformation process can occur in which specific prototypes (of chairs) can be transformed and thus result in other types. His and subsequent work demonstrates two important phenomena in visual design thinking. Firstly, visual transformations within types are the result of formal operations upon the class variables of the type. Secondly, new schema may emerge through the transformation process of the original type. A new schema may be a substantive modification of the class variables, or in their relationship. This and other works raise an interesting question regarding creativity in design: how can typological knowledge that is specific contribute to the emergence of new types in creative thinking?

Schema emergence appears to be a unique, and highly significant, form of emergence. Our previous research has attempted to model this class of emergence (Oxman, 1998). The cognitive model of emergence is based upon an interpretation of typological knowledge in design and of the generic processes that are associated with the exploitation of typological knowledge.

Typological knowledge in visual reasoning may be graphically formulated as a series of generic representations that are associated with specific design problem types. The knowledge of the variables of the type is organized in a hierarchical order of representations of which the highest level is that of the schematically represented class description. Generic design in visual reasoning is the exploitation of this structured knowledge in a graphical form. Typologies are also well known in the context of evolutionary design. However, exploration process in which new types emerge, and the employment of generic design in these processes is not yet well understood. In our modeling of this process, we have proposed that the designer can graphically explore how to reformulate, or re-structure, the graphical representation. We have found that this occurs in design, and that in creative design evolutionary processes are often supported cognitively by knowledge of existing schema (Oxman, 1997).

We can now demonstrate by an example how the concepts of visual design, design typologies, generic representations, and schema emergence are related. For example, in the case of chair design, the typology of the chair can be represented visually by diverse combinations of sub-components (two are illustrated). Within each particular element of the generic structure of the components of the type, modification is also possible as a means to differentiate the design image, and eventually to result in the emergence of new sub-types. Transformations may be achieved through parametric variations, substitutions and other formal operations. Figure 1 illustrates analyses of possible schema emergence of a chair that is derived from the same graphical presentation of components. In the first case, transformations are achieved through parametric variations on components. In the second case, a sub-scheme of the first case, transformations are achieved through various formal operations upon the graphical components. Emergence may be said to occur in design when the underlying structure is modified.

Visual emergence of design schema in computational environment

This typological model of schema emergence has been a basis for the development of a computational environment that supports visual emergence. The computational environment provides a graphical interactive design medium that is supportive of the cognitive capabilities of the designer. Schema emergence is supported by providing an interactive interface that assists in the construction of new design structures which can be derived from existing ones. The representational system operates through the maintenance of the schema while enabling modifications within the type. The generic knowledge acts in the background while the designer interacts with the representation dynamically to achieve transformations. Once the limits of transformation within a typological schema have been explored by the designer, it is possible to discover a new structure,

and its design generics. The designer can then interact visually with the new current schema and explore variations within the new typological framework.

We may illustrate this through figure 1. As the legs of the chair are extended in the width dimension, they are transformed from a “leg” type to a “plane” type system. The designer then explores the generics of this second sub-type.

We are currently developing a graphical interface to support visual emergence, as well as continuing experiments into the cognitive validity of the model. The work is extending our knowledge of schema representations and of how generic knowledge of design classes contribute to creative thinking in design. It also demonstrates how the interaction with, and re-representation of, schema enables a significant form of emergence in design. Generic knowledge in design appears to be one of bases of interacting with and transforming graphic representations, and thus, one of the significant classes of visual design thinking.

In order to support schema emergence in CAAD several problems and issues are currently explored:

a. Representation of class knowledge behind the geometrical object

How can typological knowledge of the experienced human designer be represented in a CAAD system? Current CAAD systems describe object attributes which do not include typological knowledge of the geometrical object represented and associated variables. In order to do so, we need a theoretical basis to provide a representation of an object which would underlie the geometric properties of an object.

b. Interpretation of generics within types and re-representation of new types

How can a computational system *interpret* the generics within a current representation and re-represent a new representation of an emergent type once it has emerged?

c. Graphical support for interactive exploration of the type

How can the associated modification of the new type be supported in a graphically interactive environment?

Computational framework for visual emergence

In the following section we present a computational framework which supports visual emergence of new typological schema in design. This framework is based on the visual representation of typological knowledge as defined by the three conditions above: knowledge representation; interpretation and exploration for emergence. The conceptual framework contains the following components as illustrated in figure 3:

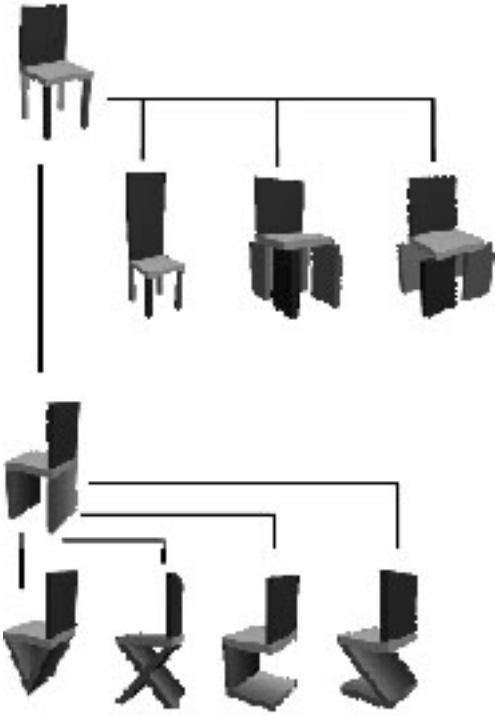


Figure 1 (left). Analyses of visual schema emergence in a chair design which is derived from the same generic representation.

Figure 2 (top right). A conceptual framework for visual emergence of design schema.

Figure 3 (bottom right): A computational environment for schema emergence in creative collaboration

a. CAAD interactive graphical interface

The environment which enables the designer to graphically manipulate the design object and to create instances within its own generic structure of representational possibilities.

b. Linkages to the typological structure(s)

The typological definitions are those that support emergence in the CAAD system, and the objects that implement the structure of the type class represent their generic definitions of elements, relationships and variables.

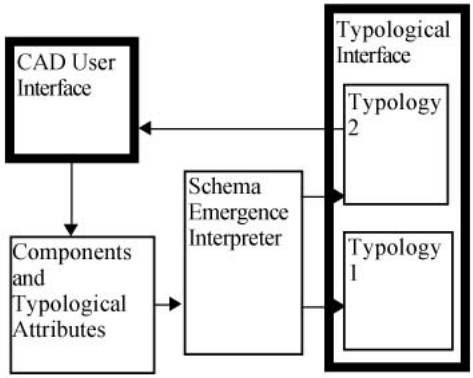
c. Interpreter

Our proposal is that the CAAD objects should be linked to a mechanism which knows how to interpret the geometrical object as a typological schema. A generic schema of one chair design type in our example, is defined by a set of components such as : back, seat, support and arm. Its typological schema can provide for the development of designs within this generic schema. Its associated typological operations are descriptions of transactions and operators on the component set and their structure.

The interpreter also can identify the emergence of new types. This component of our graphical environment still requires additional work and has not yet been fully implemented. We are currently working on a simplified interpreter which activates a new type and its generics once one element of a different typological class has been instantiated in an exploration process. For example, in figure 1, when the legs of the chair have been extended to the point in which they join to become planes, the new type emerges as a graphical representation which can be manipulated according to a new set of generics.

d. Typological Interface

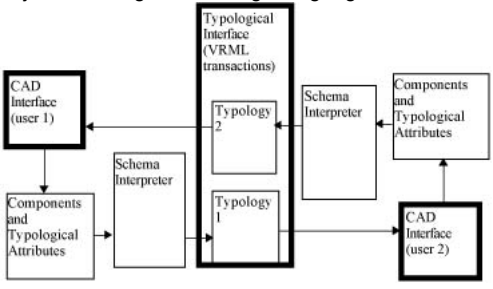
Currently, we have built a VRML interface that allows us to see a structured instance in a *visual mode* as a VRML model. In fact, through the VRML interface we will allow the user to interact with the presentation,



re-represent and define attributes and parameters including their associated dynamic operations.

Visual emergence in creative collaboration

In our approach to design collaboration a basic assumption is that the collaborating designers may share a common design language such as typological structures (Oxman, 1994). We propose that one such design language may be conveyed through a library of types, and that the units of this language can be conveyed by a graphical modeling language. We also assume that the content of a *structured graphical library of types* could be a collection of types or part of a more general design language. As an example, we are working on a design language for chair design as a general design language. Within the overall objective of a general design language, we are also



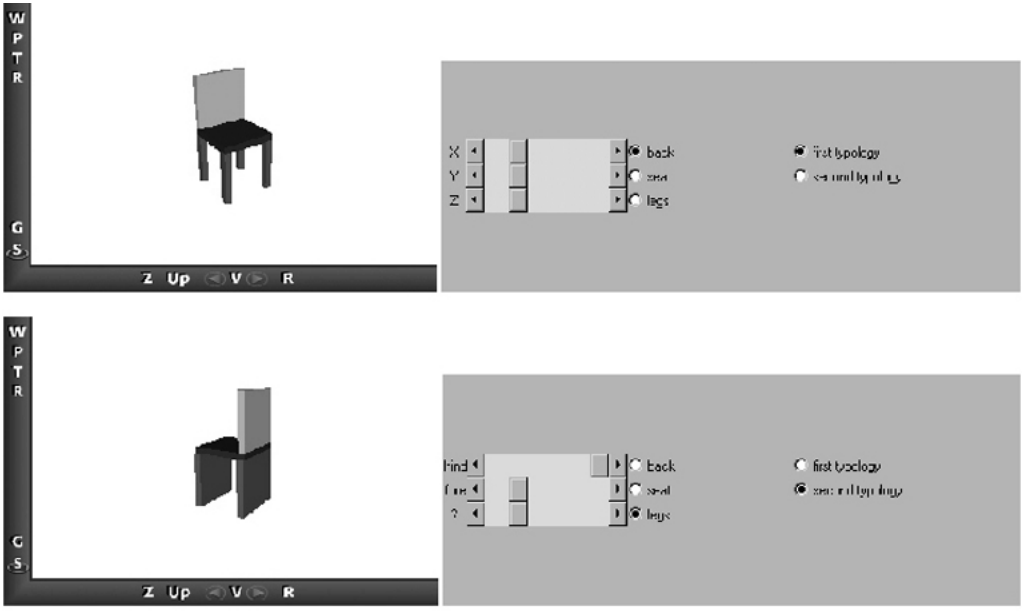


Figure 4 (top). A typological interface (working with current typology: typology no. 1)

Figure 5 (bottom). A typological interface (interpretation of a new typology: typology no. 2)

attempting to implement the system with a semi-automatic process and interactive mechanism for generating instances within the type.

Figure 3. illustrates in an extended diagram how schema emergence may operate in collaborative design. The difference between this diagram and the previous diagram of schema emergence in the individual designer, (see figure 2) is that here, emergence is achieved cognitively by the human designer. Since we currently do not yet know how to implement an automatic mechanism to support schema emergence, we propose a system architecture which allows the designer to make interpretations of a new schema, represent them and send them to the collaborator by using the interface. Figure 4 and figure 5 illustrate our current typological interface. It shows a scheme of the entire *extended emergence process* between two designers. Figure 4 shows how one designer may carry out a part of the process and passes the result to the other. Figure 5 shows how the collaborator, in turn, carries out the same process and passes the result back to his colleague.

We have presented a computational framework to support visual emergence of design schema in collaborative design We intend to test our proposed cognitive model of schema emergence in design employing the Web as a collaborative environment. We hope that this will provide a strong design medium which will contribute to creative collaboration among designers.

Conclusions

We see the functioning of visual design environments as one of the foundations of creative collaboration in design.

On the basis of a proposed cognitive model of visual emergence of design schema we have presented a computational framework to support creative collaboration in design. Our basic assumptions regarding the design process assumes

that designers share common forms of design knowledge, that this knowledge can be formalized and represented visually, and can be employed as the basis for communication in collaborative, distributed design. With the elaboration and expansion of our design language for chair design, we hope to test these basic assumptions in computational environment in a collaborative design sessions with our research partners employing the Web Technology. The construction of a small typological library; the provision within the library of a medium for graphical, interactive design exploration; its use as medium for visual thinking in schema emergence, these are the three main operative objectives which will be the operational framework for creative collaboration.

It appears to us that design media which can support schema emergence are feasible. Such cognitively responsive and dynamically interactive design environments must constitute one of the major objectives of the CAAD design community.

Acknowledgments

This work is supported by the German DFG grant. The following research students Ezekiel Golan, Eyal Nir and Daniel Brainin are acknowledged for contributing their thoughts and skill. Prof. Bernd Striech and Oliver Fritz are acknowledged for encouraging and stimulating our thinking. [A]

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Notes

[A] Some of the ideas presented in this paper also appear in a paper submitted to CAADRIA 99.

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