The Kaléidoscope System
to Organize Architectural
Design References
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References

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The presentation of a new computer-based tool to assist architectural conception demands reflection on the process of creation itself. There is an articulation between typical conceptual procedures and computerized means. We chose one of these procedures: the utilization of external references (not necessarily architectural) to stimulate new design ideas. This is the basis for the experimental computational model “kaléidoscope”, which is characterized as an open reference system for architectural design. There are two essential qualities for such a system: 1) The system should permit an individual interpretation and construction of the referential knowledge, considering that 2) references may proceed from fields other than architecture. The computational model begins with a reference, formed by the association of an image to concepts and/or texts. The concepts are graphically represented and organized in thematic thesauri. The “kaléidoscope” system includes several search and navigation modes, allowing access to references as a means to rouse new design ideas.
1. Introduction

The construction of new tools to assist architectural conception generally involves the understanding of the different creation processes used by architects. This study assesses one of these processes: the use of elements outside the design issues that may favor the emergence of new ideas. These elements shall here be called references for architectural design. References may be architectural cases, classes, a smell, or even a sound. As regards the scope of the present study, special attention was given to image as main source of references.

The use of references as of creation is based on a process of knowledge transfer from a source domain or element to a target domain or element. This process starts with a fractional and personal cross-sectional analysis of the source element.

One of the main objectives of this study is the establishment of a computational tool to organize and render this referential knowledge available. During the architectural conception process, the user will retrieve and navigate through the references stored in the system in order to find images that stimulate new ideas for the design. This knowledge is constructed, stored and organized by the architect, in his own memory, and the process is directed by his professional and personal experience. The references created by the architect must be interpreted as a form of knowledge that may potentially favor his own creation process.

2. CBR systems

The majority of the research laboratories engaged in the elaboration of computerized systems to organize what we here called design references works in the development of CBR (Case-Based Reasoning) or CBD (Case-Based Design) systems. Generally, the notion of case is associated to example or precedent. In architecture, a case describes the knowledge stored as an example that can be re-used and adapted to a new design situation. According to Ann Heylighen [1], the essence of the process lies in abstracting, representing, and rendering this specific knowledge intelligible to the computer. CBR systems are largely based on the dynamic memory theory formulated by Schank [2], which states that the storage of everyday events takes place inside our memories as scripts of stereotyped situations. When face to face with a new design problem, we search for the scripts that most closely recall this new situation, adapting these scripts and using them to solve the original problem. The research carried out by Ann Heylighen and Rivka Oxman [3] on CBR systems, to mention only two examples amongst so many others, was essential to the development of the present study. Nevertheless, some issues have not been addressed by those researchers, and these were the issues that paved a distinct and yet complementary pathway throughout the conduction of this study.
3. Open reference system for architectural design

It is evident that several forms of knowledge are involved in the design process. As far as CBR systems are concerned, knowledge concentrates around actual architectural cases. These systems go much beyond the managerial organization of architectural projects. Ann Heylighen prefers to call the CBR knowledge “conceptual knowledge”. This postulate is undoubtedly correct, but it leaves unanswered other sources of references that frequently take part in the creation process, such as, artistic expression (painting, sculpture, etc), and that have largely influenced architectural creation along history. The analogical reasonings, which are essential to the use of references, do not usually respect the boundaries of one domain alone. Thus, we suggest another kind of tool, complementary to the CBR systems, which will here be called Open Reference System for Architectural Design. The term “open” was used in the sense of disclosing the totality of possible references that are to be organized. During the first phase of this research, a prototype called “Kaléidoscope” was generated, which was used in the first experiments presented at the end of this paper.

4. Interaction, apprehension, and generation of knowledge

In order to build the “Kaléidoscope” system, several definitions were necessary. The first refers to the establishment of an open reference system. The second contemplates the particular, individual use of that system, taking into account the user’s needs and the way this user sees the world around himself. The organization of references in “Kaléidoscope” does not rest upon image – the main reference source – but on the individual interpretation each user imputes to image. Interpretation is the action unto which an architect takes an image, ascribing one or several significations to it. The architect transforms a general piece of information into a particular set of knowledge. There is an interaction between designer and the surrounding medium, which may be considered an act of creation. According to Gandon [4], “to apprehend knowledge is more than just acquiring information: it is understanding the given information, integrating it to one’s knowledge, under one’s own point of view.” The need to interpret an image is illustrated by the difference between how the general individual and the architect in particular perceives the world. The manner through which we perceive images that have become references is implicitly associated to our past, culture, and experience. The image of a derelict, polluted and dangerous harbor in a Latin American city may evoke a happy childhood in one individual, but indignation and rejection in another. The way in which one same image is apprehended will most likely be different from individual to individual.

The two paramount questions addressed in the present research are: (i) how to allow reference sources not necessarily pertaining to the
architectural domain to be organized, and (ii) how to make these sources be individually apprehended, by a given user. The prototype called “Kaléidoscope” was designed and built in order to attain these objectives. Rather than suggesting a closed, consummated system, this tool foments and redirects our investigation.

5. Kaléidoscope

In the Kaléidoscope system, a reference is the smallest functional knowledge unit, and the set of references forms the knowledge potentially available to the user as of the design situation. The three elements composing a reference are:

• an image;
• one or several concepts that interpreted that image;
• a text that complements the act of interpretation.

An image alone will not be considered as a reference in “Kaléidoscope”. In order to become a reference, an image will have to be interpreted (apprehended) by the user. An interpretation may be carried out in two ways: the linking of two or more concepts to the image, or the linking of one or more texts to the image.

5.1. Image

Several are the definitions to be ascribed to the term “image”. For instance, an image may be the depiction of a landscape, a god, or the personality of a politician. In the present study, particular interest is given to two definitions of the term: image as design idea (result of a design process), and image as an element of stimulation in that process. To Françoise Schatz [5], the former image type may be defined as images inscribed in the conception, and the latter type as images read in perception. Our interest lies in understanding how images read in the conception are retrieved, apprehended and re-interpreted by the architect to therefore behave as stimulation elements for design. According to Philippe Boudon:

“If the architect is able to perceive, the logic in the conception of buildings in the physical space, then he is equally able to form an exact perception of the images and signs which will not only provide information for his future professional output, but also give impulse to that output. [...] The images discerned in the physical space and the act of discerning itself are potentially stimulating agents to design.” [6]

5.2. Concept

In the “Kaléidoscope” system, concept is a unit of content which forms a reference when associated to an image by the user. An image may be
associated to several concepts, just as a concept may be associated to several images. This association is a slow, dynamic process that changes with time. Since concepts are essential to the interpretation/apprehension of images as sources for references, it was necessary to beget an efficient structure to represent and organize those concepts. In this line of thought, we proposed that concepts in “Kaléidoscope” be graphically represented by coded images, and that these be organized under a specific structure called “visual concept thesaurus”. Traditional thesauri generally provide for typical terms that behave as representatives of a category. In the present study, we have decided to use typical images to represent the concepts. An image representing a concept must necessarily be concise and economical. At the same time, this image has to be clear enough to cause the concept to be recognized by the user. This representation has an iconic aspect of similarity, and a symbolic and conventional aspect as regards the concept it represents. This ambivalence is very common in architectural language. The codified images that represent the concepts allow the storage and transfer of a significant amount of information. We are interested in the non-binary character (true or false) of the concept graphically represented, inasmuch as it may lead to a certain degree of inaccuracy in the manner with which the user interprets the reference image. This inaccuracy will bring out unexpected answers as of the reference search, furthering diverging reasonings, and calling forth design hypotheses. These considerations are essential in the initial architectural design steps.

In this phase of our study, two visual concept thesauri were generated. These thesauri served the purpose of testing the system. In the future, each user will build his own thesaurus. The construction of these two thesauri emerged from the postulate stating that it is possible to associate architectural concepts to non-architectural images. Our intention is to enable an easier knowledge transfer process, which is typical in the use of references, via the recognition of familiar elements in totally or partly new situations the architect is faced with. Thus, the first two concept thesauri are architectural concept thesauri, whose generation was based on two works of architecture theory, which were interpreted in terms of architectural concepts.
The first thesaurus was based on the book “Architecture, Form, Space, and Order” by Francis D. K. Ching [7]. We translated this study as a simplified structure of concepts. Our objective is not to render a faithful representation of the ideas proposed by Ching, so some elements were suppressed or placed in a different context. With this thesaurus, a user may, for instance, form an opinion about a plant leaf considering its color or geometric characteristics, or still, its vascular structure.

The second thesaurus is based on the study “Architectures comparées” by Dominique Raynaud [8]. Starting with an intra- and inter-cultural comparison, Raynaud proposes a topological relationship between architectural forms and symbolic forms that could accept a schematic representation. We transformed these schematic representations proposed by Raynaud in concepts applicable to references.

Our objective was never to generate an absolute, universally acceptable system. This operation to generate two thesauri of concepts associated to architectural forms may as well go ahead by means of other experiments. We did not envisage the generation of a system that meets all requirements, or applicable to all designs. We believe that the architect is gifted, with several design strategies, and that universal solutions do not exist.

5.3. Text

The association of concepts to images allows the generation of a semantic network that is essential to the future exploratory enterprises in a set of references. Nevertheless, the graphical concepts will often be insufficient to interpret a reference image. The text will act as an important complementary agent in image interpretation. This complementation will promote the generation of hypertext links, an alternative way to navigate through the base references.

From these three basic elements that form a reference – image, concept, and text – the user builds a semantic network of references. Each designer builds his own references and uses them accordingly.
5.4. System and interface modeling

The experimental version of “Kaléidoscope” rests on a three-level architecture, which is in turn based on the current web design technologies. The first level is the user interface, the second deals with the possible information pathways, and the third involves the information objects stored in the relational database. The JavaScript and HTML technologies were used in the first level. The PHP language was used to develop the dynamic HTML pages of the second level, and "MySQL" was used to construct the database of the third level. The idea of constructing “Kaléidoscope” as a set of web pages reveals our intention to devise a multi-user platform in the future.

The totality of the modeling process of the system will not be presented in this study. The Conceptual Data Scheme (Figure 3) provides an array of information items on how data are organized in the “kaléidoscope” system. This scheme follows the definitions in 5.1, 5.2, and 5.3. Taking the object “reference” as a starting point, we may say in brief that:

1. A reference will always be associated to an image (“i – reference”), as the visual image is the main reference source in this system. This reference image can be associated to several textual information items (“properties”) by the user, such as source, place, date, and author of the image and project (when the image belongs to the architectural domain).
2. A reference can be associated to a “keyword” by the user.
3. Finally, a reference will have to be associated to a graphically represented “concept”, which is ultimately the main form a user employs when conveying what an image represents to him.

In order to make it easier to understand how the system works, two typical use cases will be presented: (i) generation of references, and (ii) navigation through references.
Case 1 – Generation of a reference

The user accesses a system using any web navigator. As this is still a prototype system, it has not yet been made available on the web. The user enters his login and password, and next chooses between (i) generate a new reference or (ii) navigate through the existing database references. In the example that follows, the user came across an image outside the system (internet, a digitalized magazine image, a picture taken with a digital camera, etc.) and wants to make this image a reference in his database. In order to do so, he clicks on “reference generation” (Figure 4).

The user then accesses the reference generation interface. The first step consists in downloading the image stored in his computer. The user opens the image of an oil painting, and then interprets the reference image associating it to two graphically represented concepts (Figure 5).

These two concepts were not enough to conceive the meaning or the importance the user ascribes to the oil painting. So he decides to complement the interpretation by the association of the word “vert” (green). In order to finish the reference generation process the user clicks on “ok”, and the reference is then added to his personal database of references.

The user could as well associate other general or architectural properties to that image at will, as represented in the conceptual data model.
Case 2 – Navigation through the references

In this case, the user has already slowly and gradually constructed his reference base. The user has started a design situation and wishes to search for images that act as an element of stimulation to new ideas to the project he is developing. By again using the web navigator, the user accesses the system, enters his login and password, and signals that he wishes to navigate through the database (Figure 4). A new window is opened, establishing the navigation interface, similarly to the reference generation interface. Figure 6 shows the navigation interface and the four zones that form it:

1. Interpretation zone: The user formulates search criteria. Up to 8 graphically represented concepts can be chosen, as well as the image properties (architectural or not), one keyword, or a random search;
2. Result zone: Starting from a multi-criteria search, the system looks for the references that were associated to the criterion input. The result zone exhibits one visual list of references found;
3. Reference zone: Shows one reference selected in the result zone or in the historic zone, in detail. All elements associated to this reference are exhibited and enable hypermedia navigations;
4. Historic zone: Each reference exhibited in the reference zone will be inserted in the historic zone as a thumbnail. The user can click on any image and access the reference in detail.

In order to start navigating, the user defines the reference search criteria in the “Interpretation zone”. In this instance, the user clicks on one of the 8 squares available for the choice of graphic concepts and selects three concepts that work as search criteria: format, hierarchy, and symmetry. The user could have formulated other criteria using keywords or properties.
associated to references stored in his database. Next, the user clicks on “go” and a list of references is displayed on the “Result zone” (Figure 7).

This list recovers all references associated to the 3 selected concepts. The reduced image of a plant leaf is chosen and then appears magnified on the “Reference zone”, with all the data associated to it (graphic concepts, keywords and general properties). All the data work as hyperlinks (Figure 8).

The user goes on to click on the keyword “vert” (green), which had been associated to the leaf and now a new reference list is displayed in the “Result zone”. The user lastly selects the small image of an oil painting that had been associated to the keyword “vert”, and the painting appears in the “Reference zone” (Figure 9).

This is only an example of a possible navigation process. The user could go on and navigate through several other pathways. The user is faced with
unexpected, surprising elements, which may motivate analogical and divergent reasonings, thus favoring the generation of design hypotheses.

6. Experiments

The experiments aimed mainly to shed new light onto the hypotheses as postulated in this research rather than test the usefulness of the “kaléidoscope” system as such. These new experiments provided new cues to the research and the generation of new design assistance tools which differed from the traditional CAD softwares. Two well-defined aspects were investigated: (i) the possibility to index image-reference via graphically represented architectural concepts (icons, in both computational and current acception of the term), and (ii) the manner with which system users navigate through the references as of the design situation. The “kaléidoscope” system must be considered as a research tool. Nowadays it
6.1. The choice of an experimental method

The development of the experiments was based on the studies by Christian Brassac (Codisant team of the laboratory “Psychologie de l’Interaction”, University of Nancy 2, France). The method used by Brassac consists in inviting an experimental group of human subjects to design a given object. These subjects interact verbally, at times with one another, at times with the object they are designing. This object may be of any kind, such as an advertising brochure, the organization of a service, an electronic circuit, or even a building. Brassac defines this interaction as a “collaborative conception”.

The experiments are conducted and recorded on video (computer screen images, gestures performed by the designers), and sound (“briefings” and “debriefings”). Every sketch drawn on paper as of the experiments is likewise collected. This experimental material is used by Brassac to carry out an analysis whose purpose is to understand the way in which subjects design, progressively, a given object all through a cooperative conceptual process. The term “co-construction” is adopted by Brassac to refer to this process [9].

The experiments according to Brassac are always carried out with at least two experimental human subjects. A design situation in which two (or more) subjects work together leads invariably to a dialogue between the participants who are expected to express verbally (and/or graphically, as in the present study) their coinciding or conflicting points of view. This is the reason why it is interesting to place together people of diverse professional backgrounds or life experience. The orally expressed reasoning can be recorded, and later analyzed. Our interpretations were limited to a qualitative inspection of the material collected, avoiding the complex assessment of “logic translation” of the construction process of an object, such as originally proposed by Brassac.

We carried out 4 experimental sessions, with two human subjects taking part in each. In total, 8 people worked in the experimental use of the system. As mentioned before, the objective was not to obtain quantitative information, but to find clues to further re-direct our research. Each pair of individuals was formed by an architect and an architecture student of the Ecole d’Architecture de Nancy. The subjects’ different personal experiences and knowledge paved the way to dialogue and co-construction of ideas, which is the main point of the Brassac method.

For the first experiment, a set of 21 images was presented to subjects. The images had to be associated to a set of architectural concepts graphically represented and organized, called “visual thesaurus of architectural concepts”. For the second experiment, a set of references...
previously generated was provided. A conception situation was requested (the design of an area around the hearth of a fireplace in a private home). The manner in which “Kaléidoscope” users navigate through the system, searching for stimulating images, was observed.

6.2. Some examples of traces observed

The first example refers to one of the fundamental aspects of our research, that is, that the references used by an architect to stimulate the process are often external to the proposed situation, and even outside the domain of architecture. When references are used, the analogical transfer occurring between source object and target object is in most cases much richer than one simple formal copy/paste between source and target. This could be verified in many cases, as when one of the subjects who was navigating through the references to find stimulating images comes across the image of a boat (Figure 11). The incomplete and hardly recognizable boat in the image enabled the construction of a concept for the “hearth” space that was being designed. The subject comments on his wish to design a hearth space with an industrial “look”, resembling a furnace and developing, according to the user’s own words, a “contemporary object”. The user will pursue this concept up to the end of the experiment. In another passage, the image of the Ronchamp chapel is subverted and curiously transformed into a fireplace (Figure 12).

The second example concerns the various moments in which subjects take control of the experiment and alter the proposed system. This wish manifested by the user’s reinforces our intention of devising a system that is able to adapt to the specific needs of the user, and not the other way round. Thus, the following is seen in many passages: definitions given to architectural concepts composing the thesaurus are contested or differently assimilated as compared to our definitions. New concepts are suggested and
proposed just like new references generated by us will receive a different interpretation, many a time antithetical to ours. As of the first experiment (association of concepts to images), one of the subjects proposes the concept “finir” (terminate) to the image of a canal. Another subject contests this approach and affirms that the most appropriate would be to add number 1 before the term “finir”, forming the French term “infini” (infinite), to the term listed in the original thesaurus proposed.

A third example occurs when one group of subjects spends more than 16 minutes interpreting one image of the Taliesin lamp by Frank Lloyd Wright (1925). This image received at least 5 distinct interpretations. Interpretation and appraisal took into account dimensions and color, its comparison to the gallows or the hangman word game, its topological relationship with the armchair present in the image, and functional aspects (lighting). This example illustrates the potential an image may entertain, as
reference, within the architectural design process, and demonstrates the fact that subjects did not meet our expectations when they discussed aspects of the image we ourselves had never imagined.

The two experimentations provided new indicators to the continuity of our research. It was possible to observe the viability of the association of visual images to architectural concepts, even when these images did not belong to the architectural domain (a plant leaf, a painting, or a sea landscape). Our choice to use image as the main reference source was reinforced by the array of interpretations produced and the multiple deconstructions that were possible for one given image. The cooperative construction of ideas enabled by the method used in this experiment opened the gates for more accurate notions as to how system users construct what we call references.

Several interface problems in the prototype emerged and have to be treated under a new perspective. In future experiments, two aspects will demand greater attention: the reference base will have to be generated by system users themselves, and the time variable will have to be re-assessed, especially when the experiment proposes a conceptual exercise.

Our idea of proposing a system that is apprehended by the user was translated, many times, by interferences the subjects expressed, underlining the notion that in a system to assist the initial steps in architectural design the user ought to have a central importance. More than a mere user of knowledge, the user must be the producer of this knowledge.

7. Conclusions

Our intention to set forth a tool that is appropriate to architectural design is emphasized by the adoption of a specific procedure, that is, the use of references as an element of stimulation. Admittedly the use of references is not an absolute answer to meet every need of the architect; it is rather a partial reply, as it were, to help some architects at some point in the design process.

Nevertheless, new paths to this knowledge area are opened by the acceptance of the fact that references may belong to non-architectural domains, side by side with the setting of a new system that enables the organization of these references in such a way that is familiar to architects. This point represents a new input and constitutes our main contribution to the research of new design assistance tools.

The notion of an Open Reference System seems to be a topic still little acknowledged by research laboratories that tackle the design of assistance tools for the initial steps of architectural design.

The “kaleidoscope” system prototype was conceived as a web-based design tool. Although it has not yet been made available on the web, the system may represent another innovation aspect and an important approach as regards new project tools. What kind of interaction and conversation takes place between individuals using the same reference database?
The adoption of a specific conceptual procedure – the use of references as a stimulating element in design – underlines our intention of setting forth an assistance tool in keeping with the current way in which architects develop their first design ideas. The purpose is to find a balance between the new and the traditional, bearing in mind the fact that the development of new computerized design assistance tools lead to changes in the design process itself. Therefore, the presentation of such means must never be detached from a detailed discussion on the theory of architectural design.

Similarly to the architectural design, the path from design theory to the development of a computerized system was never easy. The dialogue between architects and software designers – very often using different language registers – demanded the use of models and representations that enabled the establishment of communication bridges linking distinct knowledge fields.

As regards the present study, the continuity of the developments will be rendered possible by the cooperation between the University of Vale do Rio dos Sinos, UNISINOS, São Leopoldo, Brazil, and the Centre de Recherche en Ingénierie et Architecture, CRAI, Ecole d’Architecture de Nancy, France. The second phase of the project will address the insertion of the “Kaléidoscope” system in four different contexts, which will be handled as “clinical cases”. A clinical case, according to Dewarrat [10], consists in considering a concrete situation without any commitment to reach a given immediate efficiency. The usefulness of clinical cases rests on the theoretical conclusions we arrive at from the observation of actual cases involving the use of the “Kaléidoscope” system as a prototype. The experiments carried out in the present study provide the cues to likely changes in the system interface, and at the same time validate essential aspects such as the notion of architectural concepts visually represented as chief interpretation mechanisms of the reference images. Other findings may emerge as of the proposition of four new contexts:

• The investigation of the likely relationships between “Kaléidoscope” and other existing assistance tools in the initial steps of architectural design, with a view to how these different tools work together and what the necessary adaptations are;
• The investigation of “Kaléidoscope” in other design situations, providing to users longer use times and the possibility to generate their own references.
• The investigation of “Kaléidoscope” in a teaching situation, effecting the adaptations needed. Our hypothesis is that student users resort to references very often thinking that these references are to be reproduced literally. On the other hand, students do not usually have much experience in the architectural domain and so look for references in other knowledge fields. To place “Kaléidoscope” in a...
teaching situation may provide assessment elements different from those established when the system is operated by experienced users.

- The observation of “Kaléidoscope” in other design activities such as fine arts and media.

This first stage of the research has shown (i) the viability of an open reference system in architectural design, (ii) the need to ascribe to the user the main role in the generation of references, and (iii) that further developments have now a basis to move ahead.

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References

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