AN ANALYSE OF EXPERIMENT RESULTS TO IMPROVE AN IMAGE INDEXATION METHOD: Application to the design process

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Abstract. In our research work we proposed a method to construct an image data base from which designers can find solutions for their design problem. In our approach, an image is not only a media representing existing objects or existing scenes, but it is a support which allow the designer to advance in solving his problem. In this paper we tackle the particular question of the analyses of the results obtained thanks to an experiment which aims to validate a method to index and retrieve images. The objective of this experiment is to evaluate the real contribution of the images retrieved by our system to the designer when he looks for solutions to a design problem. By the analyse of the indexation terms we aim to evaluate the real help that this reference image database can bring to the designer during his creation work.

Keywords. Image database, indexing process, design process, thesaurus describers.

1. Introduction

During his design work, the designer manipulates several kinds of data. Whatever the complexity and the precision level of the data presented into the design program, these data doesn't constitute all the essentials and the operative elements to define a solution (Heylighen A, 2000) for the designer's problem. Several researches have shown that to find a solution for a design problem, the designer has to introduce external references. Then he can be inspired by various kind of references (images, sounds, …). In our research work we reduce the references field to images illustrating real architectural realisations. These realisations could be represented partially (built work) or entirely, and these realisations belong to the wooden architecture domain.

To assist with the design process, we constructed an image data base from which the designer can infer and construct new semantic systems oriented toward their project. To construct this data base we proposed an indexation method adapted to a semantic description of images.

(S.Kacher J-C Bignon and G.Halin, 2003). This semantic description concerns only the physical parts of architectural realisations visualised in images. The objective of this restriction is to reduce the potential variety of the designers' interpretation. In this paper we tackle the particular question of the analyses of the results obtained thanks to an experiment. This experiment has been carried out with a designer subject using our research system to solve a specific design problem. More specifically we will detail the indexation process (Kattnig C, 2002) that allows us to index images retrieved with our system. We will present how through the indexation terms, the system analyses and identifies efficiently the user's need to present the relevant images to a request formulated by the designer during a research.

2. The method and the prototype

To construct an image database we suggested a method to better describe, index and access images. To construct the database (Joly, 1993) we suggest these principles:

2.1. DEFINING THE CONTEXT OF THE WORK

Even if we have decided to focus on the architecture domain, the person that will define and propose a semantic indexation method has to reduce and limit the field to be described. It's a necessary task because architecture is a wide-ranging domain and the objective is to define a vocabulary which aims to represent and describe as much as possible a precise domain (Kacher S bignon J-C and.Halin G, 2003).

2.2. DEFINING THE STRUCTURE OF THE CHOSEN DOMAIN

Nowadays there are a lot of vocabularies applied to describe various domains (ontology, thesauruses, lexicon, etc).The most widespread kind of existing vocabularies are "thesauruses" (Aitchison, 1987).These thesauruses possess deep structure or hierarchy. In our case we used a proposition made by Eleanor Rosch (Rosch, 1977) to classify the natural categories in the cognitive psychology domain. She suggested classifying all the objects of the real world on only three hierarchical levels (Intermediate, superior and inferior level) (S.Kacher J-C bignon and G.Halin, 2003).

2.3. DEFINING A WAY TO QUANTIFY THE VISUAL IMPORTANCE OF AN ELEMENT

To describe an image in a better way we have to organise the terms inside the image indexations. Then we focus only on the description of what is visually expressible by our thesaurus words in images. In our case the visual parts concern the physical parts of architectural realisations. We propose a classification or an organisation of the terms used for image indexation (Kacher S, Bignon J-C, Halin G ,2004). This classification depends on the visual significance of the illustration and is related to the angle from which the picture is shot.

2.4. IDENTIFYING A SPECIFIC RESEARCH PROCESS

To make the problem formulation and solution easier for the designer we have defined a search mode adapted to the designer's state. Nowadays, the common access to images proposed by existing system is the search mode using text. This mode requires using text to express a need. But in the architectural design process the needs are rarely precise and expressible in words. For this we proposed a particular kind of research mode which is the search with

images. This kind of research uses images to access other images (Kacher S Bignon J-C and.Halin G, 2005).

2.5. THE PROTOTYPE

In order to help the designer to find solutions to his design problem, an interactive and progressive research system by image was developed by the MAP-CRAI[1]. Within the framework of this research, our work consists of defining a structured vocabulary, "a thesaurus" (Aitchison, J and Gilbrichrist, A. 1987), to describe architectural elements illustrated by the image databases. That defined vocabulary will be inserted into the system developed by the MAP-CRAI in order to better meet to the user's needs. For each image presented by the system and visualised by a user, the user can choose, reject or not give an opinion. A method of relevance feedback is used to propose new images for his query. The indexing document is represented by a weighted vector of thesaurus terms. A vectorial matching model is then used between the query and the indexing document. The results of this matching will be given as an ordered list of images representing the user's choices. We supposed that our image retrieval system can provide a significant help to designer in the earlier stages of the design process when his needs are fuzzy and not precise. Indeed, when a designer has in his mind a precise need that he can formulate by word, it is better to him to use an image retrieval system which proposes a query formulation based on words or on natural language expression.

3. Experiment

To validate the relevance of the method presented in our work, we carried out experimentation with designers in a design situation. We gave to every subject a design problem and asked him to propose a timber structure covering a swimming pool with 25X50 meter size.

3.1. THE SELECTED SUBJECTS

The subjects who participated to these experiments are divided in three groups: (1) Architects in the wood construction domain (2) architects researchers (3) architectural students having experience with design process.

3.2. THE EXPERIMENTATION PROTOCOL

This experimentation has been carried out in four stages:

Stage N 1 : During this stage, we asked the subject to draw a first sketch according to the early mental images appearing in his mind.

Stage N 2 : We took the first sketch from the subject which has been drawn in the first stage. Then we asked him to start the research.

Stage N 3 : During the third stage, the subject selects, rejects or does not give any opinion on every image on a mosaic (Figure 1) presented to him by the system. We can see

[1] "MAP-CRAI" Architecture and landscape Modeling - Research Center in Architecture and Engineering, Architecture School of Nancy.

that this mosaic can illustrate various built work elements such as wall glass, board, roof covering, etc.

Stage N 4 : The last stage was performed by asking the subject to redraw his early design problem.

3.3. RESULTS

In this part we will analyse an example results obtained thanks to this experimentation. We will detail and compare the drawings produced by a designer to progress through his design problem when he uses our system and product sketches to formalise his mental idea (Denis M, 1982). These sketches drawings constitute concrete trace of the designer's thought (Lebahar, 1997). We can clearly identify (Figure 2) that this first sketch is relatively purified. This drawing includes a group of repetitive elements. The lines representing these elements are simple. We can also notice that the shape of the roof is a sloped one and the proposed framework consists of a succession of porticos with a small roof overhang.

Figure 1: The final mosaic visualised by the subject

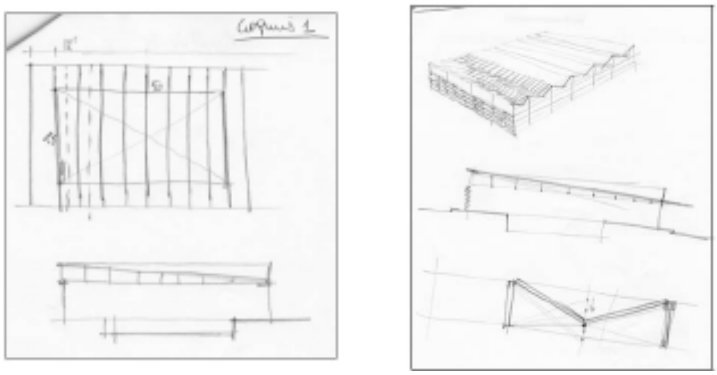

Figure 2: the subject sketches Left: First sketch – Right: Final sketch

For this subject illustrated concepts (Ching, F.D.K, 1996) (Dauzats M, 1994) in images are various. The final sketch (Figure 2) is more provided that the initial one. The subject crosses from 2 dimensions sketch to a 3 dimensions sketch. The final graphic production of the subject is composed by three drawings. No technical plan has been drawn but the subject added a

perspective view and a joist detail between the repetitive elements composing the roof, when their sides change direction.

3.4. ANALYSES

Comparing the section of the initial sketch and the final one, we can note that the final one, in addition to the elements of the beginning, includes the details of the front view of the frame, and the subject precise the under-tensed elements of the frame work. To understand how the systems presents that images on the final mosaic (Figure 1) we have to detail the indexation terms. For this we will present for every image of the mosaic the terms list and their weight used for the indexation:

Figure 3: Image "A" with a glass wall from the mosaic.

Table *1 : Indexing terms for the image "A".*

	Term 1	Term 2	Term 3
	School building	Wall glass window	Rafter framework
Weight	1	5	1

For the image above the most important built work is the wall glass window. Then the weight associated to this term is the maximum. We can also visualise a small part of the rafter framework in the upper side of the image.

For this image "H" (*Tableau 3*) from the mosaic the most important built work is the roof covering system. We can see a small part of a fence. As a result we can see that the images from the mosaic (Figure 1) illustrate various built work elements such as roof, fences, glace-walls, etc. when we visualise the final sketch we can note that the subject added repetitive element such as the board visualised on the image and the wall glass visualised on the image (Figure 3).

3.5. THE WHOLE CASES

The following table (Tableau 3) includes all images with their indexation terms and the weighted value associated to every term presented by the system to the subject in the last mosaic of his research. For example : the image "C" has been described with "Plywood" with a weighted value "4" and the image "D" has been also described with "Plywood" with a value "2". That means that the plywood looks more important in the image "C" than in the image "D".

Table 3 : the indexation of the images visualised on the mosaic

	Term1	Term 2	Term 3	Term 4	Term5	Term 6	Term 7	Term8 ...
	School building	Glass wall	Rafter frame work					
A	1	5	1					
	Exhibition building	OSB wood	Fitting junction					
B	1	5	5					
	School building	Glass wall	Plywood	Panel for wall covering				
C	1	5	4	4				
	School building	Glass wall	Plywood	Panel for wall covering	Fence			
D	1	5	2	4	1			
	Exhibition building	Plywood	Flap shutter	Horizontal window	Urban facility	Panel for wall covering	Horizontal sun breaker	Outside kiosk
E	1	1	5	5	3	5	3	5
	Outside construction	Fence						
F	5	5						
	Exhibition building	Mêlèz d	External board	breach window				
G	3	1	4	5				
	Urban fence	Board for roof covering	Board for wall covering	Activity building				
H	2	4	2	1				
	Sirgle house	Breach window	Sloping roof	Board for roof covering	Board for wall covering			
I	1	1	3	5	3			

When we analyse the indexation terms (Tableau 3) used to describe the mosaic images, we can say :

- The most frequent term with the most important weight is “glass wall”
- The second most frequent term is “panel for wall covering” following by “board for roof covering”.

When we asked the subject at the end of the research process about what the research gave him during his design process he answered “The principal concepts that inspired me in the visualized images are: lightness, the occultation, rusticity, composite wood”. For this subject, we can conclude that to advance into the formulation/resolution of the design problem he proceeds by a refinement and a precision of its first idea (Reed, S. K 1999). We can say that the system interpreted efficiently the subject need. For example the subject selected images illustrating “boards for wall covering” and “Plywood” elements which correspond to the “composite wood” need by the subject. Or we can also deduce that the lightness needed by the subject was illustrated by Glass wall into the visualised images (Figure 3).

4. Conclusion

In this paper, we presented the results of an experiment which aimed to validate our indexation method proposed to construct an image database to help the designer to find solutions to his design problem. The entire image database has been semantically indexed. Every indexation term is taken in the document model with his weight and its hierarchy. This document model is used with a vector model to select and to classify images at the end of a research. More specifically we detailed how our system proceeds to retrieve images according to the analyses of the indexation terms to answer to a user request. We saw that the subject doesn’t look for only one architectural element. He looks for several elements at the same time. The visualised information is not integrated directly into the project as illustrated in images. Even if the analyse results have shown that images presented by our system help efficiently the designer during his design process, we will test our system in a real project situation and even with student during a design process. We also aim to improve our interface the possibility of adding text to access images.

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