A method to index images in the wooden architecture domain, Terms hierarchy and weight given to terms

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Terms hierarchy and weight given to terms

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Abstract: Architectural design is a domain where using pictures (drawing, photographs,…) is essential because the nature of the information transmitted by photographic image is often easier to interpret. The fact is that an image requires less interpretation than a text. The information transmitted by image (element shape, colour, light,...) is already "put in shape" and so can be more easily integrated into the design process. The following paper presents a way to index more efficiently an image databases of the wooden architecture domain. Images in our databases illustrate real architectural elements. This work aims to analyse the representation of the real element illustrated by images. The analysis will allow us to identify some criteria related to the visual features of each image. The identified criteria will be used in a discriminating way to associate a weight with an indexation term describing its representation illustrated by an image. The importance of that representation (according to what is seen at first) is evaluated depending on graphic rules which correspond to the graphic properties of the representation of the element in each image.

1. INTRODUCTION

Design process requires research into ideas and documentation to help the designer in his task (Heylighen A, 2000). The design process groups two distinguished parts where image use is essential. The first one

concerns the problem formulation (image allows the user to express his design question and enables him to advance in his problem formulation). The second one concerns the problem's solution (images illustrate several potential solutions to the design's problem) (Lebahar, J.-Ch. 1997).

When the designer has a design problem, he tends to transpose the elements appearing in his mind directly into the images that he visualises (Denis, M 1982). This transposition happens as a virtual simulation with virtual objects. This kind of reasoning is based on the information transmitted by an image, on the possibility to develop it and to reuse it later. More precisely, it is based on the principle of permutation between the elements that appear in mental images and those represented by real images. Martine Joly (Joly, 1993) defines this principle as a way of segmentation which aims to identify the various components of an image. The identification is possible by locating the “autonomous” elements illustrated by the image. Once these elements are recognised, this principle allows the viewer to identify and replace them by other elements situated in his mental images. To realise these mental operations (Denis M, 1989), the designer should have in mind other similar elements which are capable of being substituted which but are absent from the visualised images.

The objective of this research work is to better use the help that an image can give to the designer during a design process. More precisely, the proposition is not to suggest help to the designers who want to index their own image database. It is an indexation method that will be used in an information resource centre to offer an information service to designers. For this, in this paper we present a set of hypothesis and an experiment to define the best way to construct our image database. At first we will present the importance of image in the design process. Then we will show our proposition to index in a better way our image databases. And finally we will present an experiment which aims to validate our proposition.

1.1 The research system

In order to help the designer to find solutions to his design problem, an interactive and progressive research system (Bignon, J.C., Halin, G.and Al, 2000) 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

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

defined vocabulary will be inserted into the system developed by the MAP-CRAI in order to better meet to the user's needs. The distinctive features of our research engine are divided in two parts. The first one concerns the assignation of a weighted value to every thesaurus term, which has been used for indexing images. The second one concerns a research process using images. 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.

2. SEMANTIC IMAGE DESCRIPTION

One of the limits of the image is the " wrong semantic interpretation" which happens when the receiver interprets iconic information in a different way from that wanted by the transmitter. To reduce this wrong interpretation, and to make our database interpretable by the system proposed, we have decided to describe images in a semantic and unambiguous and structured language, "a thesaurus" (S.Kacher J-C bignon and G.Halin, 2003).

2.1 The proposed language:

This stage of the work is based on a database containing about 1000 images. It is important to remember that for more efficiency, the corpus of the selected images illustrates architectural works belonging to a particular domain of architecture which is the wood construction field. This limitation allows us to add another dimension to the description language (Cabré,M.T. 1999) which is the type of "material used". The vocabulary is structured in three hierarchical levels (Rosch, E. 1977) and is divided into 4 classes *(Figure N°1). :*

2.1.1 The architectural element :

Indicate every physical part of a whole architectural work which has an essential or a particular function (post, beam, window, ...).

2.1.2 The material :

Includes every wood material and its by-products (species, glued-laminated).

2.1.3 The products :

Include any component aimed at protecting and decorating wooden elements (fungicide, impregnation).

2.1.4 The type of architectural realisation :

Includes the name of the category to which the work element illustrated belongs (school, single-family dwelling).

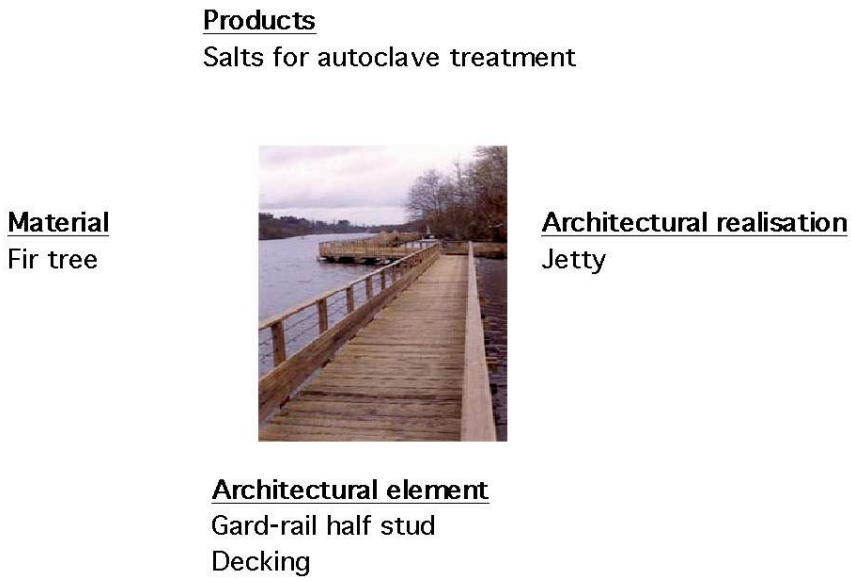


Figure N°1 : The proposed language

2.2 Defining weights for image indexing:

For each image in the database, a weight is associated to each thesaurus term. It's important to make clear that each term of the thesaurus corresponds to the "name" of the real architectural element, which is illustrated by an image. Weight values are given according to the importance of that illustration. This importance is evaluated depending on graphic criteria which correspond to the graphic features of the

representation of the element (Bignon, J.C., Halin, G.and Al, 2000) on each image and are defined as follows :

2.2.1 The area occupied on the image:

Depends on whether the illustration of the real architectural element occupies a large area in the image or not (*Table N°2)*. It is important to remember that images belonging to our database illustrate real objects put in situation. Then, we can say that the representation of the element is in prominent position if its occupies a larger visual area than the other elements which surround it. The visual area depends on the shot distance and on the size of the photographed element.

	In which of these images is the roof the most important?	

Table N°2 The area occupied

2.2.2 The likeness with its archetype:

Depends on the likeness of the illustration of the real architectural element to the ideal model shared by professionals belonging to the same domain. The fact is that if the representation of the element keeps the structural and spatial properties of the real objects so allowing the viewer to identify the element appearing in the image, the element will be easier to recognise (Reed, S. K 1999).

	Do these elements look like their archetypes ?	

Table N°3 The archetype likeness

2.2.3 The contrast with the image background:

Depends on the capacity of the illustration of the real architectural element to emerge from the rest of the image. The element will be in a conspicuous position if the representation of the element contrasts strongly with the rest of the image (colour, light, ...).

	Do these elements contrast with their image background ?	

Table N°4 The contrast

2.2.4 The focus:

Depends on the position of the illustration of the real architectural element in the image. If it occupies the centre of the image (diagonal junction), the element should be more obvious than the rest of the elements illustrated.

	Are the windows more obvious in the left image than in the right one ?	

Table N°5 The focus

2.2.5 The completeness:

Every representation or illustration of a real architectural element shows only a part of this element. This graphic criteria "completeness" depends on the fact that the part of the illustration of the real object represents the semantic features (Reed, S. K 1999) that allow a viewer to identify the represented element.

	Is the element more easily identifiable in the right image or in the left one ?	

Table N°6 The completeness

3. THE EXPERIMENT

This experiment concerns the validation of the weights associated with the elements recognised. Weights assigned to the indexation terms according to these criteria will be used by the system as a basis of calculation for the relevance feedback. In order to validate our hypotheses, an experiment has been carried out.

- The first hypotheses concerns the fact that a relation exists between the rank and the value associated to each criterion.
- The second hypotheses concerns the fact that a relationship exists between the rank associated with each term and the kind of the architectural element to which belong the term.

At the moment, all these criteria are at the same level of importance. The second hypothesis concerns the fact that all the criteria do not have the same value.

3.1 The subjects selected for the experiment

The subjects who participated to this experiment are divided in two groups: (1) Architects in the wood construction domain (2) architects researchers.

3.2 The protocol of the experiment

The experiment was performed in several stages aiming to fill in the table illustrating in the (*figure N°2)*:

Stage (1)

This first step is performed by presenting to the subjects a series of images illustrating concrete architectural elements on sheets of paper. Below every image a table with 7 columns. One of these columns includes the list of terms describing the architectural elements illustrated by images. This list is classified in alphabetical order.

Stage (2)

This second step is performed by asking subjects to classify in decreasing order the list of terms according to what they consider important in each image or not. Then they associate the rank "1" with the term describing the most important architectural element in each image.

Stage (3)

This third step is also the last one. It was performed by asking the subjects, for every term in the presented list, to tick the shared cell on the table only if the graphic criterion is filled in by the representation of the element in the image. For example in the figure N°2, a subject classify the “cladding” term at the rank N°2 and selects the occupied area, the archetype likeness and the focus criteria with this term.

Image

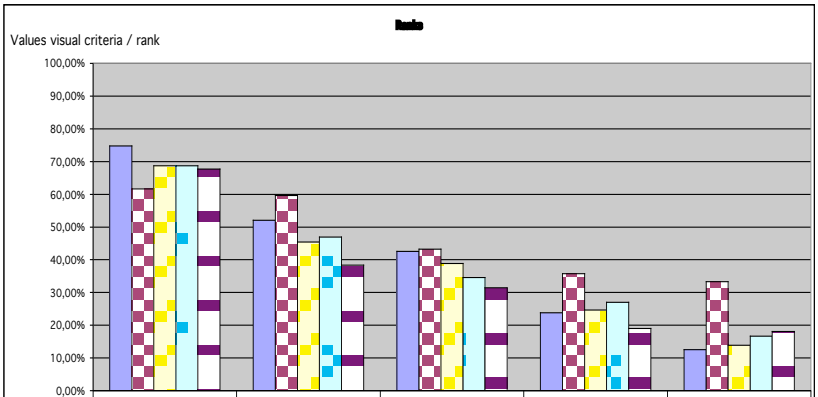
Rank	Element	The occupied area	The archetype likeness	The contrast	The focus	The completeness
2	Cladding	x	x		x	x
5	Outside flooring	x	x	x		
1	Outside shutter	x	x		x	
4	Outside terrace	x	x			
3	Window		x	x	x	x
Stage (2)	Stage (1)	Stage (3)				

figure N°2 the experiment protocol

3.3 The results

This experiment showed that the subjects put in relation the number of the selected criterion with the importance of the rank. In the figure N°3, we showed the rates associated by the subjects of the experiment to every visual criterion according to the rank. The results allow us to point the most important visual criterion for each rank. Then, for the first rank the subjects selected more often the "occupied area" criterion. For

the other ranks the most important visual criteria which have been selected is the "archetype likeness".



	Rank N°1	Rank N°2	Rank N°3	Rank N°4	Rank N°5
Surface	74,75%	52,02%	42,59%	23,81%	12,50%
Archétype	61,62%	59,60%	43,21%	35,71%	33,33%
Contrast	68,69%	45,45%	38,89%	24,60%	13,89%
Focus	68,69%	46,97%	34,57%	26,98%	16,67%
completeness	67,68%	38,38%	31,48%	19,05%	18,06%

Figure N°3 : rates of graphic criteria with ranks

The subjects also had the opportunity to criticise or to add missing terms or missing graphic criteria. For some of them, they asked to be added as graphic criterion, " the repetitiveness of the element ". Actually, they considered that when an illustrated element was repeated it became important in the image even if it did not necessarily fill all other criteria.

We also analysed the relation between each kind of architectural elements and the visual criteria. For this, we classified all the terms describing images in the experiment according to their geometric features. For example we classified floors and walls as "planar elements" and posts or beams as "linear elements (Ching, F.D.K, 1996). Then we defined 4 families :

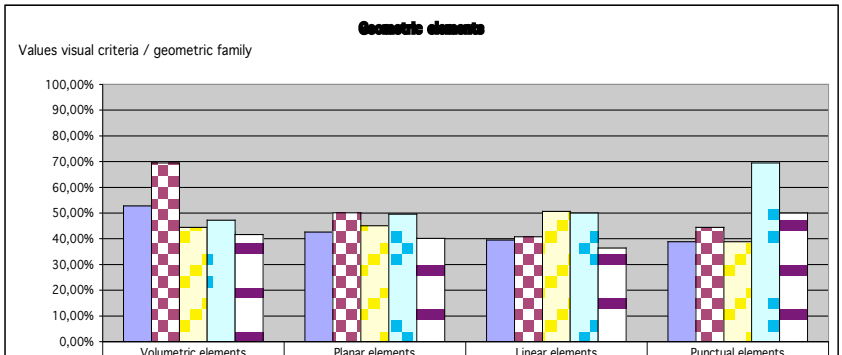
- Punctual elements : are seen as a singular element in a group. They could be assimilated to a building product such a furnishing element or a junction point between two linear elements (table, chair, spigot joint, ...).
- Linear elements : are principally defined by a length, a direction and a position, these include post, beam, ...
- Planar elements : are defined principally by an area (length and width) and also an orientation and a position. We can identify 3 kinds of planar elements related to their position in space. The

first one is the "overhead plane" which form the upper enclosing surface of a space. The second one is called the "wall planes", they possess principally a vertical orientation and they are also used to shape and enclose architectural space. The third one is called the " base planes" which constitute the ground plane that serves as the lower enclosing surface of an architectural space.

- Volumetric elements : all volumes can be analysed as the sum of point elements, line or edge elements, and plane or surface elements. All these elements and more specifically the surface elements, define the limits of a volume.

The experiment allows us to identify the visual criteria which are strongly related to each family. As a result we obtained figure N°4 :

- For volumetric elements, the visual criterion which have been selected very often is the archetype likeness.
- For planar elements, the visual criteria which have been selected very often are the archetype likeness mixed with the focus criteria.
- For linear elements, the visual criteria which have been selected very often are contrast mixed with focus.
- For punctual elements, the visual criterion which has been selected very often is the focus.



	Volumetric elements	Planar elements	Linear elements	Punctual elements
Surface	0,527777778	0,42650463	0,395061728	0,388888889
Archetype	0,694444444	0,501446759	0,407407407	0,444444444
Contrast	0,444444444	0,450810185	0,50617284	0,388888889
Focus	0,472222222	0,49537037	0,5	0,694444444
Completeness	0,416666667	0,40162037	0,364197531	0,5

Figure N°4 : rates of geometric elements with visual criteria

3.3.1 The results analyse

The results obtained by this experiment allow us to validate some hypotheses such as the fact that the more an important rank is associated with a describing term, more subjects select a greatest number of visual criteria. As another result, we can conclude that, for the subjects of the experiment the most important criteria are the occupied area in the image and the archetype likeness. This means that if an illustrated element is recognise because it looks like the ideal model of the viewer and if it also occupies a large area, it's will be more important than the rest of the illustrated elements.

We also obtained with this experiment other results related to the geometric features of the elements. It appears that for volumetric elements the most important visual criterion is the archetype likeness. This means that if a volumetric element looks like the viewer's archetype, the volumetric element becomes very important to him.

For the planar elements we obtained the best rates also for the archetype likeness. For the linear elements we obtained the best rates for the contrast and the focus criteria. This means that because of their lack of surface, the linear elements needed to be in contrast and in focus to be visually important to a viewer. And finally, for punctual elements the most important criteria is the focus. Then, if a punctual element is situated in the image centre, it will be more obvious than the rest of the elements illustrated by the image.

4. CONCLUSION

In this article, we have presented an experiment from which the results obtained will be defined as indexation rules to improve image indexing in our database. These results will be implemented and integrated with the research system tool by image, in order to better index images. The objective is to build a useful database in which a designer will search for and find the relevant solution to his design problem.

At first, the achieved results allow us to identify the most important graphic criteria to index images. The fact was that, before the test they were 5 criteria to each of which we associated the same weight and the sum of their weights was associated with the term used for the image indexation. In a second way this experiment allows us to carried out the future indexation with a new graphic criterion, which is " the repetitiveness of the element ". In a third way, the experiment

showed which visual criteria are related to each geometric family of elements.

Consequently, this experiment allows us to propose an indexation method to further image indexing:

- Firstly we must identify the element represented by the image that will be described.
- Secondly for each selected element, its representation will be compared to the results obtained by this experiment. According to the results obtained though this experiment, the system proposes rates to weight the indexed terms. For example, if an image illustrates a floor and if the illustration fill in the contrast criterion, the value associated to the term will be "0,45".
- Thirdly, the person who will index the images will decide if she/he will validate or refuse the rates proposed by the system during the indexation process.

At the moment, the statistical conditions were satisfied, more subjects have been tested. Finally, another experiment will be undertaken with professional people to validate the fact that design activity could be assisted significantly thanks to images illustrating wooden references elements.

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