A SEMANTIC INDEXATION METHOD TO ASSIST WITH THE ARCHITECTURAL DESIGN PROCESS BY IMAGES

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Abstract

A lot of research shown that designing an architectural solution requires introducing external references other than those existing in the design problem. In our case we choose photographic images to illustrate these references because an image illustrates the graphic part of an architectural concept. For this the information transmitted by photographic image is often easier to interpret by the designer. To assist the design process, we are working on the construction of a reference image database where the designer will find various solutions to his design problem. We have therefore proposed a method for indexing this image database. The following paper tackles the particular question of semantic meaning applied to architectural works. More precisely, we present the results obtained through an experiment following the Chi-square statistic rule, whose objective was to validate the weight associated with the architectural concepts illustrated according to their visual features in images.

Key words: *Reference image database, thesaurus, semantic image indexation, experiment.*

1. Introduction

To assist the design process, we are working on the construction of an image database that will constitute a semantic reference device with which designers could construct new semantic systems oriented toward their project. To help the designer to find solutions to his design problem, an interactive and progressive research system [2] by image was developed by the MAP-CRAI[1].. This system uses the "Engine SK"[2] tool. More specifically, our work consists of defining a "thesaurus" [1] to describe architectural elements illustrated by the image database. This vocabulary will be inserted into "Engine SK" in order to better meet to the user's needs. The distinctive features of this Engine are divided in two parts:

1. The first one concerns the assignation of a weighted value that will be assimilated to a rank for every thesaurus term used for indexing images.

2. The second one concerns a research process using images. For each image presented by the system and visualised by a user, he 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 vector-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. The proposed method for image indexing

To improve our database we propose a method in three steps:

2.1. Step (1): defining the vocabulary for image description

At the beginning, we defined the vocabulary depending on the knowledge shared by the professional in the domain [3]. It is important to remember that our images illustrate real architectural objects. The vocabulary created will have two functions:

1. It describes architectural elements illustrated on the images.

2. It describes "the wood construction" domain.

Thus, we defined four families of image describers:

- The architectural realisation family; includes the name of the category to which the architectural element illustrated belongs (school, single-family dwelling, …).

1 "MAP-CRAI" Architecture and landscape Modelling – Research Centre in Architecture and Engineering, Architecture School of Nancy. www.crai.archi.fr.
2 Engine SK is a search engine based on the Apple Reference Library "Search Kit" "version 1.0.1" for "MAC OS X". "http://developer.apple.com/".

- The built-works family; indicates every physical part of an architectural realisation which has a particular function (post, beam, window, ...).
- The material family; includes every wood material and its by-products (species, glued-laminated, …).
- The products family; includes any component aimed at protecting and decorating wooden elements (fungicide, impregnation, …).

2.2. Step (2): defining the hierarchy in the vocabulary

To better represent the described domain, we structured each family of image describers, following the E.Rosch [8] categorisation which structures in 3 hierarchical levels the real world objects. Thus, every identified family is structured in three levels [6]:

- The current level; called the “basic level” because it contains the name of the current concepts in the domain (post, beam, window, …)
- The superior level; more general than the current level (vertical structure system, opening system, …)
- The inferior level; used for image indexation and the terms of this level contain only one degree of extra specificity than those of the current level. This specificity is obtained by searching for the visual characteristics of the represented element such as ; shape, number, orientation, functional mechanism, constructive mechanism, empty-device mechanism (circular post, curved roof, …)

2.3. Step (3): organising the terms used for image indexation

Describing a built-work element illustrated by an image with a vocabulary term is not enough [figure N°1]. We can identify in these images that «post » in the first image does not possess visually the same importance as in the second.

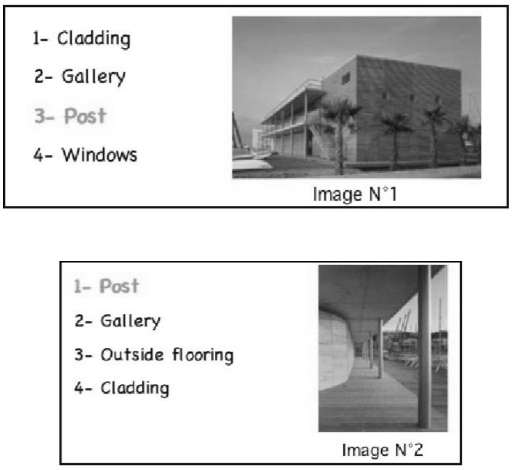

Figure 1: The organisation of the indexation terms.

For this, we have to organise the terms used to index each image according to the visual importance of the built-works illustrated. We therefore identified visual properties that will enable us to evaluate and quantify this importance.

We defined five image properties [6]:

- Occupied area:
  Depends on whether the illustration of the real architectural element occupies a large area in the image or not. Then, the representation of the element is in a prominent position if it occupies a larger visual area than the other elements, which surround it.
- Archetype likeness:
  Depends on the likeness of the illustration of the real architectural element to the ideal model shared by professionals belonging to the same domain. 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 [7].
- Contrast with the background:
  Depends on the capacity of the illustration of the real element to emerge from the rest of the image. The element will be in a conspicuous position if its representation contrasts strongly with the rest of the image (colour, light, ...).
- 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.
- Completeness:
  Every illustration of a real element shows only a part of it. This graphic-property depends on whether the illustration of the object represents the semantic features or not [7]. That allows a viewer to identify the represented element.

At the moment, all these image properties possess the same importance value. To check if the identified properties really possess the same importance we carried out an experiment.

3. The experiment to validate graphic-properties

An experiment was carried out to validate that:

- Our organisation of the terms used for image indexation according to visual properties corresponds to that proposed by the professional in the domain.
- All the graphic-properties identified do not possess the same importance visually.
- Every type of built-work object is linked to a certain graphic-property. This enables us to define semi-automatically the rank of a term depending on the type of built-work element described and its graphic-property checked in the image.

3.1. The subjects selected for the experiment

The subjects who participated in this experiment are divided in three groups: (1) professional Architects in the wood construction domain (2) architectural researchers and (3) architectural students.

3.2. The protocol of the experiment

The experiment was conducted in three stages [6].

- Stage (1): we presented to the subjects a series of images illustrating real architectural elements on sheets of paper. Below every image a table with 7 columns. One of these columns included the list of terms describing the built-work elements illustrated by images. This list was classified in alphabetical order.

- Stage (2): we asked the subjects to classify in decreasing order the list of terms according to what they considered important in each image. Then they associated rank “1" with the term describing the most important element in each image, “2” for the next most important and so on.
- Stage (3): we asked the subjects, for every term in the presented list, to tick the shared cell on the table if the graphic-property’s element was checked in the image [6].
- The results of the experiment:

The experiment allows us to obtain some untreated results.

- The more the subjects select graphic-properties, the more important is the rank associated with the term describing the built-work element.
- The most selected graphic-property is “archetype likeness” (34%).

Results treatment

After validating that the number of subjects for the experiment was statistically available, all the answers given by the subject were summarised in a table [table N°1]. To these answers we applied the Chi-square rule as a way of calculation [5]. This statistic rule aims to check if two variables are linked. In our case we would like to check if a relationship exists between:

- Rank associated to the terms and the graphic-properties.
- Built-work type and the graphic-properties.

Three types of built-work elements were defined [4]:

- Punctual elements: seen as a singular element in a group. They could be assimilated to a building product such as furnishing element or a junction point between two linear elements (chair, joint, ...).
- Linear elements: principally defined by a length, a direction and a position (post, beam, ...)
- Surface elements: all plane or surface elements (roof, floor, …)

Table results

The first table [Table N°1], groups the answers of the subjects to which the statistics rules will be applied. Example: the subject number ID=3 selected more often the contrast graphic-property for the rank “2”.

- The first line includes the subjects’ ID.
- The first column includes the number of the ranks from 1 to 5.
- The cells include the number of the graphic-properties selected by each subject.

1. Occupied area
2. Archetype likeness
3. Contrast
4. Focus
5. Completeness

Subjects ID
The ranks
Table Nº 1: Subjects answers

	1	2	3
RK1	3,	4,	2,
RK2	2,3	2,	3,
RK3	5,	5,	3
RK4	3,	2,3,	4
RK5	1,2,5,	1,2,	1,2,3,4,5

The Chi-square table: represents the application of the chi-square rule to check if a relationship exists between the type of built-work and the graphic-properties [Table N° 2]:

- O: Observed values (answers given by subjects).
- E: Hoped for values (answers obtained by statistic calculations)
- Y: Participation in the chi-square value (value obtained with the chi-square calculation)

This Chi-square table for built-work/graphic-properties [tableN°2]: allows us to ascertain the graphic-property most often selected for:

- Planar built-works is the occupied area.
- Linear built-works is the focus.
- Punctual built-works is the occupied area.

Table N° 2: Chi-square table for built-works type and graphic-properties

		Area	Archetype	Contrast	Focus	Completeness	Sum
Planar	O	33	18	12	13	14	55
	E	19,45	23,91	14,18	18,64	13,78	55
	Y	9,42	1,46	0,33	1,71	0,003	20,00258
		72,82%	11,32%	2,61%	13,22%	0,03%	100,00%
Linear	O	5	13	6	18	5	47
	E	10,16	12,49	7,40	9,73	7,19	47
	Y	2,62	0,02	0,26	7,00	0,67	10,5905
		24,76%	0,20%	2,53%	**66,17%**	6,34%	100,00%
Punctual	O	10	28	17	15	15	85
	E	18,378	22,59	13,40	17,61	13,01	85
	Y	3,81	1,29	0,96	0,38	0,30	6,77
		56,41%	19,13%	14,28%	5,72%	4,46%	100,00%
	Sum	48	59	35	46	34	222

The Chi-square table for ranks/graphic-properties. [Table N°3]: allows us to identify that the graphic-property most often selected for:

- Rank 1 is “archetype likeness”.
- Rank 2 is “completeness” followed by “archetype likeness”…

Table N°3: Chi-square table for ranks and graphic-properties

		Area	Archetype	Contrast	Focus	Completeness	Sum
Rk1	O	18	3	9	11	13	54
	E	10,53	15,80	9,21	8,56	9,87	54
	Y	5,28	10,37	0,00	0,69	0,98	17,34
		30,47%	**59,80%**	0,03%	4,01%	5,69%	100,00%
Rk2	O	9	18	7	6	3	43
	E	8,390	12,58	7,34	6,81	7,86	43
	Y	0,04	2,32	0,01	0,09	3,01	5,49
		0,81%	42,37%	0,29%	1,78%	**54,75%**	100,00%
Rk3	O	8	11	4	8	10	41
	E	8	12	7	6,5	7,5	41
	Y	0	0,083	1,28	0,34	0,83	2,54
		0,00%	3,27%	**50,45%**	13,58%	32,70%	100,00%
Rk4	O	4	14	10	6	7	41
	E	8	12	7	6,5	7,5	41
	Y	2	0,33	1,28	0,03	0,033	3,69
		54,19%	9,03%	34,84%	1,04%	0,90%	100,00%
Rk5	O	9	26	12	8	12	67
	E	13,07	19,60	11,43	10,62	12,25	67
	Y	1,26	2,082	0,02	0,64	0,005	4,03
		31,48%	**51,65%**	0,68%	16,05%	0,13%	100,00%
	Sum	48	72	42	39	45	246

Following the results obtained from the experiment, we decided to take into account the 3 most important values, because the two others were statistically insignificant.

4. The proposed method

The following method aims to facilitate the indexer's task when he associates a rank with every term used for the semantic indexation of images, and is in three steps:

1. Firstly, the indexer must identify the element represented by the image that will be described.

2. Secondly, for each selected element, its representation will be compared to the experiment results. This will enable the system to propose rates to classify the indexed terms.

3. Thirdly, the indexer will decide if she/he will validate or refuse the ranks proposed by the system during the indexation process.

5. Conclusion

In this article, we have presented an experiment from which the results obtained will be implemented and integrated into "Engine SK", in order to better index images. The objective is to build a database in which a designer will search for and find relevant solutions to his design problem. The experiment's results showed which graphic-properties are related to each geometric family of elements. Following these results, the system will propose a classification of terms for image indexation, to reduce image interpretation confusions. 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 reference elements.

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