Towards a framework to store and retrieve memories for creative architectural projects

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Abstract. Creative aspects of architectural and design thinking have been studied in recent research in connection to concepts of innovation and originality. In architecture novelty is intended as a "major criterion of creativity" and is related in the visual arts to the manipulation and transformation of images. Memories have a fundamental role in the implementation of creative and innovative architectural projects. We hypothesize that this creative process is strongly based on mechanisms that resemble metaphorical thinking on memories and propose an approach, whose first elements are outlined in this paper, to help architects to retrieve and re-contextualize their memories when captured via external supports, like photos and sketches, by mimicking the way metaphors are resolved in cognitive science.

Keywords. Architecture, Analogy, Metaphor, Creativity, Annotation, Pattern

1. Introduction

It is a widespread conviction that architects are endowed with the ability to imagine and to create; sometimes this ability is called fantasy, sometimes dream [1]. Hofstadter defines creativity (or the essence of creativity, or all-round creativity) as having a marked intuition for what is interesting, in using it recursively, applying it to the meta-level and modifying it accordingly [2]. Creativity has also been defined as the ability to restructure old ideas to produce new inventions [3] and to apply original thinking [4,5]. As design is a complex and weakly structured activity, the exploration of unfamiliar and unconventional design solutions requires creative skills [5,6,7,8].

Creative aspects of architectural and design thinking have been studied also in recent research in neuroscience, where creativity is often linked to the concepts of innovation and originality. In architecture, novelty is intended as a "major criterion of creativity" and is related in the visual arts to the manipulation and transformation of images [9] and mental images as well [10]. Architects in their writings express the awareness of how the

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insight for a new design arises already constrained [11]. This is about putting everything in relation to oneself and reflecting on the influence that the environment, where an agent (an architect) is located, exercises on his/her imagination with its dimension, shadow, light [1].

If we attempt to reduce this to the mere notion of knowledge already available to the architect, the emergence of new ideas cannot be explained. It seems that the generation of new ideas is based on further cognitive processes, like mental simulation, that act on the basis of the available knowledge [12]. Our hypothesis is that the creative process is strongly based on mechanisms that mimic analogical, or even metaphorical thinking. Literature reports that creative thought builds on, and goes beyond, memory [12] and we argue that an analysis of analogical and metaphorical mechanisms could be the basis for a tool to help architects in using memories and knowledge to generate novel ideas and insights.

2. Memory as a support for creativity

Memories have a fundamental role in the implementation of creative and innovative architectural projects. Remembrances of childhood, travel, and working experiences filtered by reflections and training paths–e.g., rules typical of a discipline or of a style (with its language protocols), embraced by an architectural school–all contribute to the development of new ideas as described in cognitive studies, interviews with architects, critical writings on architecture, etc. [13,14].

Architects have always gathered experiences of new places and of different buildings while traveling, and used such experiences to accumulate images, sketches and notes about inspirations these provide them with: “traveling and sketching” is thus a major factor in architectural training and remains the quintessential way to understand architecture even in a material and structural sense. This trait characterizes not only architects, but people at large [8].

Generally speaking, the collected experiences are not used by the architects in their original forms. They are elaborated, distorted and mixed to form innovative combinations that offer new ways to tackle architectural problems. Some studies explore the changes in design problem solving in relation to the availability of external stimuli that can enhance metaphor generation. Following this line of research, one could even attempt to explain the architects’ frequent use of metaphors as a rhetorical mechanism that helps them to develop and communicate their ideas in a coherent and efficient way [5].

3. Analogies and Metaphors through memories for new design insights

Analogies are extremely important in the development of the architectural design process. Making analogies is the heart of the perception and extrapolation of structures underlying the order of reality [2]. An example of the use of analogies can be the association of two sets of numbers which are similar in rhythm or alternation: “to create variations based on both single structures and on the similarities between these is a fundamental ingredient of the creative process” [2].

Analogy is also linked to the issue of variants: the basic idea is to move away from the original theme at a very superficial level, while remaining faithful at a level that

is deeper from a certain point of view. A similar mechanism can also be found in the analysis of the types in architecture and their respective possible variations [15,16].

All kinds of events in everyday life showing similarity and the related images are activated in different degrees, and mixed with other events experienced by the agent him/herself, forming a very complex structure, a shared essence [2].

Metaphors, on the other hand, can be seen as a cognitive tool to create unlimited possibilities for transforming and blending concepts, and can help identify unorthodox perspectives from which architectural problems can be approached. However, it is unclear how all these processes involving creativity and memory work. What can be said is that retrieving a design concept from a remote memory demands a practical and flexible attitude of the architect, who must adapt the concept to the design problem at hand [5]. Several studies have explored the changes in design problem solving in relation to the availability of external stimuli that can enhance a more effective design answer [17,18,19]. In this paper, we focus on the contribution of the designer's experiences and insights to his/her creativity, especially when these are recorded in external devices, from sketches on paper to digital images.

But what is a metaphor? We follow Lakoff and Johnson [20] in their claim that metaphor is what unifies reason and imagination. Reason, at the very least, involves categorization, entailment, and inference. According to Lakoff [21], metaphor essentially amounts to understanding and experiencing one kind of thing in terms of another. Lakoff and Johnson [20] see the human conceptual system as strongly based on metaphorical reasoning and understanding. New metaphors, but conventional metaphors as well, have the power to define and re-design the perceived reality.

Concerning how such cognitive mechanisms work, we could roughly say that analogical transfers do not require a huge creative effort; the latter is limited to the recontextualization of a pattern of properties in a new situation. Metaphorical transfers, on the other hand, are more creative processes, as they usually require a change in the kind of properties considered and can also go from temporal to spatial configurations. Clearly, such transfers can be more or less conservative and may include more 'destructive' transfers, in which the original and the obtained pattern have little left in common.

Imagination in one of its many aspects involves seeing one kind of thing in terms of another–and this is how we have defined metaphorical thought; metaphor can be thus seen as a form of imaginative rationality [20].

4. Analogies and Metaphors in architecture

We can imagine architects as moving around with their eyes (and mind) always wide open, ready to catch some 'genetic material' to transform in a creative design, in an interesting shape, in a comfortable and original atmosphere. As a first step in our reconstruction of the use of analogical or metaphorical thinking in architecture, we can start with the transfer of a structure, recovered from memory or from a device to store such memory traces, to a new target. An example of this mechanism of structure transfer inspired by analogical or metaphorical thinking is provided by spatial patterns.

Focusing on spatial patterns, we may associate and transfer aspects of remembered scenes (e.g., topological or geometrical structures that identify spatial distributions of features of objects) to imagined project solutions. The architect starts from a concrete instantiation of the pattern that she/he re-situates in a different concrete context.

A more creative ‘reuse’ of patterns consists in transferring them into different property systems. We can have an intra-sensorial level of pattern transferring: for instance, the alternation of empty and full spaces perceived while looking at the rows of a vineyard on a hill may be creatively transformed into a pattern of colours, thus, voids and filled spaces in the vineyard can become an alternation of colours on a façade, a pattern of textures, an alternation of voids and walls, or an alternation of different materials, and so on. But we can also have more complex examples of structure transfer, at an inter-sensorial level, as in the case of a musical rhythm (a sound pattern) that can be transformed into a visual pattern by improving a façade ‘rhythm’ (indeed) with the alternated presence of full and empty surfaces or shadow and light or different colours (cadenza).

In Figures 1–5 and 6–12, we report two iconographic examples. In both cases, the starting point is a picture of a natural anthropized environment, two images of landscapes. In both we see the progressive elicitation of ‘structural’ spatial patterns, till the sketch of a façade. The first image, Figure 1, is a vineyard on a hill, while the second, Figure 6, is an olive grove that emerges from a blanket of white snow. These examples have

Figure 1. Vineyard.

Figure 2. Highlighting horizontal lines.

Figure 3. Highlighting vertical lines.

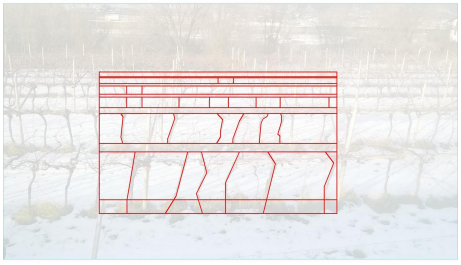

Figure 4. Merged lines closing a shape.

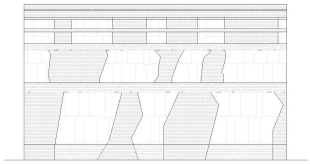

Figure 5. Sketch 1 for a façade.

been created by one of the authors to make explicit the steps of the process that (in our hypothesis) takes place in the mind of an architect.

Figure 6. Olive trees with snow.

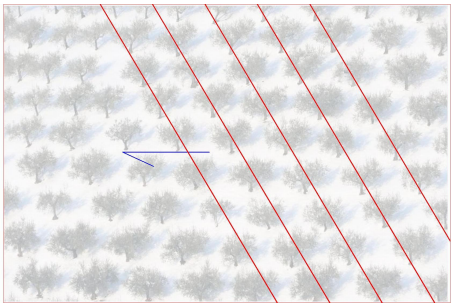

Figure 7. Highlighting diagonal lines.

Two further examples are taken from real architectonic artefacts. The first example, Figure 13, is by Jorn Utzon, a danish architect. Here, it is interesting to follow the architect's reflections about his project for a church in Bagsvaerd [1] by reading an excerpt from his own words:

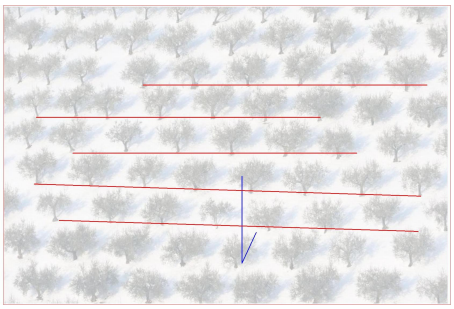

Figure 8. Highlighting horizontal lines.

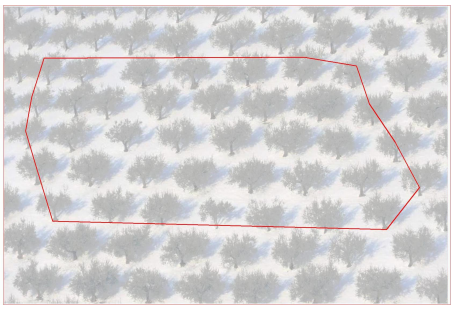

Figure 9. Highlighting circles – A closed shape.

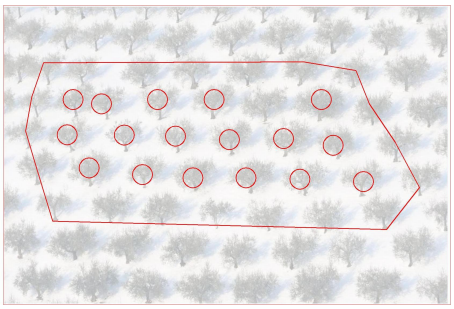

Figure 10. Highlighting cones on the shadows.

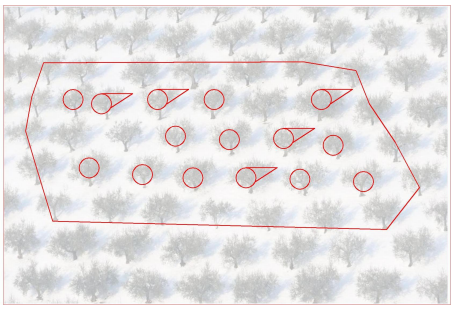

Figure 11. Highlighting circles – A closed shape.

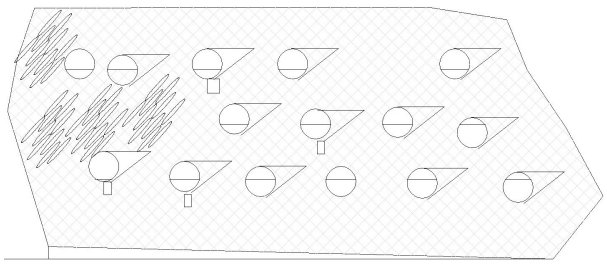

Figure 12. Sketch 2 for a façade.

> It is just like it happened with the church of Bagsvaerd (1968-1976). I started by asking how a church should be. Then I stopped thinking about the building [...] One night in Hawaii (at that time I lived there) I was thinking how far was the seaside where I was, and I became thoughtful [...]. There the wind always blows in the same direction, with the clouds arranged in a totally uniform way [...], the waves are large and break in parallel rows, according to a grandiose order [...]. I looked at the clouds and I discovered that these could be the roof of my church, and passing through them the light could penetrate inside the church. [1].

This stream of thought led him to draw the shape of the roof of the church, but firstly these reflections were fixed in some sketches.

A more abstract example is the reference to the japanese concept of *ma* by Carlo Scarpa. The *ma* symbol means room, distance. We find a sort of translation of this con-

Figure 13. Church in Bagsvaerd (Denmark), interior (photo credit www.flickr.com/photos/seier/5958688179).

cept in the research of composing elements in the garden of the Italian Pavillion at Biennale in Venice, Figure 14. Distance becomes the visual effect of suspension that the concrete slab offers. But such distance, which seems to bear the physical effort of supporting and keeping raised the concrete slab, is made of matter, and has a shape: it is a sphere. A very little object made in brass between the columns and the slab. The translation of a concept (*ma*) here becomes a visual effect and a shape.

5. Sketching a Model of Analogies and Metaphors

As said, our general hypothesis is that the creative process of architects can be grounded, at least in part, on the re-contextualization of spatial patterns of properties present in their memories via analogical or metaphorical mechanisms. In this section, we provide a more detailed analysis of the notion of pattern and of how we intend the analogical and metaphorical transfers of patterns. Our long term goal is to develop a general architecture for an information system supporting pattern-annotations of images, i.e., allowing to associate with each image a set of patterns that the architect considers relevant. Over time this generates a database of annotated images (represented by means of labeled graphs)

Figure 14. Italian Pavillion's Garden by Carlo Scarpa, Biennale, Venezia.

that can be queried: given a new architectural project, one can search for patterns that match the given requirements. The retrieved patterns can then be creatively transferred in the context of the architectural project.

Roughly speaking, *pattern* here means a specification of how some given properties distribute across space. Thus, the information system we envision should be suitable to specify kinds of properties and distributions. This result can be achieved by combining theoretical and formal elements as described below.

We take a *property system* to be a set of uniform properties together with a set of *structural relations* defined on them. For instance, colours may be structured by a qualitative metric relation (e.g., orange is closer to red than to blue), a topological relation (e.g., orange is connected to red), or an order relation (e.g., orange is lighter than red); weights and volumes by an order relation; lengths by a concatenation operator, etc. A *spatial system* is like a property system but with *locations* substituted for properties. Locations are structured by geometrical or topological relations.

A *configuration* of a property system is a set of structural constraints across properties in the system. For instance, one can consider a configuration of two colours, where the first colour must be a shade of red and the second a darker colour. Another example is a spatial configuration of two locations, one connected with the other.

Configurations are very abstract constructs that apply to all kinds of properties. For properties that locate in space—the great majority of properties considered in architectural projects—it is important to specify how they distribute across space, i.e., to constrain the geometrical or topological relations between their spatial locations.

To do that, we introduce *patterns*. Basically, they integrate a series of property configurations with a spatial configuration. For instance, the previous two examples of configurations can be integrated into a pattern specifying that the location of the red colour must be connected with the one where the darker colour is located. Other examples are the shape-patterns in Figures 3 and 11.

Patterns may be 'instantiated' by specific spatial regions or objects: a pattern that constrains two locations to be connected can be instantiated by (the spatial regions occupied by) Italy and France, by France and Spain and in general by any two entities that are spatially connected. In Figures 3 and 11, the original pattern 'moves' from one place to another: from vineyards and fields of olive trees to façades. This is a natural form of reuse of pattern, a sort of *analogical reuse mechanism*. It consists in instantiating the pattern in regions (or objects) different from the original situation.

A more sophisticated mechanism is the *metaphorical reuse mechanism*. This is more complex and consists in transferring a pattern from one property system to another. In such a case the structural relations in the original property system must map to those in the target system. A first possibility is to assume that (some of) the structural relations make sense in the other system as well. For instance, identity and connection, as well as orders and similarities, can be seen as 'universal' relations, relations structuring all (or at least several) properties systems. Configurations involving these relations are easily transferable. For instance, a configuration constraining two colours to be similar or connected can be transferred into a configuration where two shapes are similar or connected. More generally, one could introduce an explicit correspondence between structural relations in different systems. For instance, one could map the relation of 'being darker than' defined between colours to the relation 'being rougher than' defined between textures. In this case, the configuration of two colours, one darker than the other, is mapped into the configuration of two textures, one rougher than the other. With another abstraction step, one can map spatial configurations into temporal ones. In this latter case, a temporal rhythm of tastes or sounds, for instance, can map into a spatial rhythm of colours, textures, shapes, etc. (and vice versa).

While analogical transfers are limited to the instantiation of a given pattern in a different situation or context, metaphorical transfers presuppose a creative re-interpretation of the properties and the structural relations in the original pattern. As already pointed out, some transfers are more conservative, others more 'destructive', with few traits in common with the original pattern.

6. Conclusions and future work

Our overall aim is to help architects to retrieve and re-contextualize their memories when captured via external supports, like photos and sketches, by mimicking the way metaphors are resolved in cognitive science [21], i.e. by transferring a pattern, a set of structural relationships, identified in a specific quality domain into a new one. In architecture, this often translates in transferring geometrical relations (i.e., from a texture identified in a picture of a landscape to the texture of a façade). However, patterns abstract from specific quality domains, from specific property systems, their "meaning is disembodied" [20], therefore visual patterns could be generated by more complex memories involving sound, taste, smell, touch, etc.

As a first step, our framework should support architects in annotating pictures and sketches with (primarily spatial) patterns, by tracing a sort of path of the insight, of the inspiration that triggered imagination and creativity, thus helping them to retrieve and reinterpret these patterns for the development of novel project solutions.

Our long-term goal is to build an ontology-based tool to retrieve memories encoded in some graphical support to enhance the architects' creative process. Our idea is to use techniques of applied ontology to analyse the formal notions required to encode suitable schemas, as well as their application to specific kinds of object features (as, for instance, the architectural project) [22].

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