CONSTRUCTIVE INTERPRETATION WITH EXAMPLES FROM INTERPRETING FLOOR PLANS

Abstract. This paper describes the role that interpretation plays in facilitating situated design and presents an implementation that demonstrates a system interpreting floor plans. Designers often see more in what they produce than they intentionally put there. Cognitive studies suggest that this helps develop design ideas. Interpretation is described as the use of expectations to construct an internal representation of an external representation (such as a sketch). An implementation of this notion of interpretation is described. As an example of its capability the system, primed on floor plans, looks at a randomly generated image and can find a floor plan within it. The system produces different results with the same image if it has different expectations. This is used to discuss the notions of a space of possible designs and the two-way relationship between expectations informing interpretation and interpretation changing the expectations (design ideas) of a designer. Further work is suggested and the ideas are discussed.

Keywords. constructive interpretation, situation, floor plan, reinterpretation, push-pull

1. Introduction

Whenever designers bring something from the external world into their internal world, interpretation is occurring, such as when designers read a design brief, consider their own work whilst sketching or observe the behaviours of a model. In each of these cases, designers interpret by constructing from their expectations. Their interpretation is affected by their past experiences (the limits of their knowledge) as well as their current cognitive state (how their knowledge is being used).

The designer does not experience the world *tabula rasa* – there is pre-understanding, founded on experience, brought to the act of interpreting. What then is the relationship between the meaning that the designer constructs and the past experiences of the designer? Two computational models of interpretation applied to the domain of floor plans are described in this paper, demonstrating what interpretation as the 'construction of meaning' looks like as distinguished from interpretation as the 'processing of infor-

mation' (Bruner 1990). This work looks towards an understanding of the relationship between experience, expectation and interpretation in which: (i) interpretation is driven by expectations; (ii) expectations come from experience; and (iii) experiences occur through a sequence of interpretative acts.

1.1 INTERPRETATION IN DESIGN

It has been well recognised that the construction of interpretations is a part of design activity (Schön and Wiggins 1992, Suwa and Tversky 1997). The importance of these two studies on 'kinds of seeing' and 'what do architects and students perceive in their design sketches' is underscored by the fact that they are the two most cited papers within the *Design Studies* journal since 1990[1]. In sketching, designers work with elements and the relationships between them. When they look at what they have sketched, they are able to see things in the representation that they did not intentionally place there. Interpretation becomes a way in which designers change their own idea of what they are doing (Suwa et al 2000, Oxman 2002). This can be observed in the "seeing-moving-seeing" of the design conversation, where discoveries within a sketch from the basis for future design actions (Schön and Wiggins 1992). This work is based upon a perceived need to explain this conversation of design at a deeper, cognitive level, in the language of concept formation and use. It is grounded in three cognitive frameworks: (i) Perceptual Symbol Systems (Barsalou 1999, 2008); (ii) Conceptual Spaces (Gardenfors 2000) and (iii) Hierarchical Temporal Memories (Hawkins 2005).

An interpretation arises not just from the representation and the designer's knowledge about the world, but also from 'whereabouts' within this knowledge the designer is at when interpreting; their current cognitive state or the *situation* they are in when interpreting (Clancey 1997, Gero 2007). In the implementation described here a situation can be considered as the world view resulting from the use of a number of concepts where concepts affect the use of each other (after Gero 2007). There is a bi-directional relationship between interpretation and situation: the situation that the designer is in changes their interpretation, and the act of interpreting can change the situation. The contribution made by the work is to posit a possible method for modelling this bi-directional relationship that is observed in designers.

1.2 INTERPRETATIONS ARE CONSTRUCTED

A well-known children's game can be used to demonstrate interpretation as a constructive activity. In this game, one player scribbles some lines on a page such as that seen in Figure 1. The second player then has to draw a picture using the lines in the scribble. In order to do this they interpret the lines in

the scribble 'as' something. For the scribble in Figure 1, as with any representation, there are many possible interpretations. In Figure 1, a drawing could be made using the lines of the scribble in which the circle becomes the wheel of a car, the eye of a bison or a hole in a cliff face – in each case the player has seen the drawing in such a way that an action is suggested. There are no limits to possible interpretations within the representation, only within the mind of the viewer. The example demonstrates that the meaning lies not in the representation itself but rather is constructed by the player looking at the scribble – and a different player will likely construct something different from the lines. In doing this the player is making use of their knowledge from experience in the world to construct an interpretation. In other words, "it's not what you look at that matters, it's what you see" (Thoreau 1851).
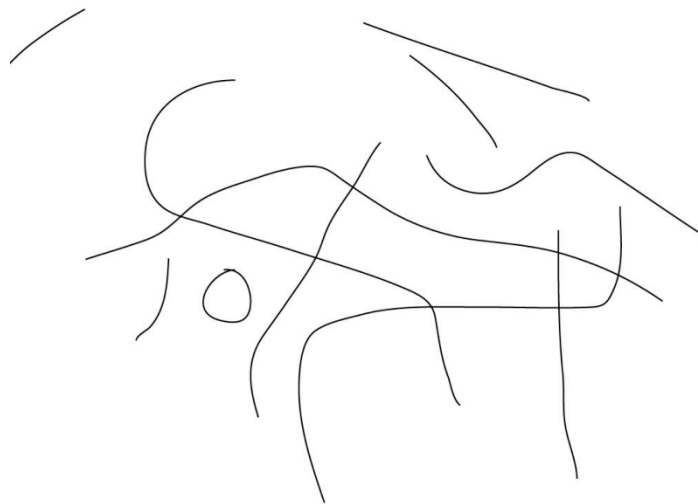
Figure 1. Lines on a page from which an interpretation can be constructed.

2. A computational example of construction

The same effect has been implemented in a constructive interpretation system. The system demonstrates that: (i) a randomly constructed representation is given meaning by a system through construction from expectations founded on experience; and (ii) the same system with the same source and the same knowledge produces different interpretations depending upon the situation it is in when interpreting.

The system is primed through experience of a number of floor plans, a sample of which is shown in Figure 2. The system uses a self-organising

map (Kohonen 1989) to learn the different representations. It then scans the external representation, which is this case is a randomly generated set of marks upon a page, such as that seen in Figure 3(a), and constructs an interpretation using its expectations. In doing this the system constructs an interpretation that is both relevant to where it is at cognitively, its situation, and the source that is interacting with visually.

The development of situations is supervised in that floor plans are labelled with the architect responsible for them. Prior to interpreting the source, the system holds expectations from the situation. For example, if it is expecting a Palladio floor plan then it holds conceptual expectations related to this.
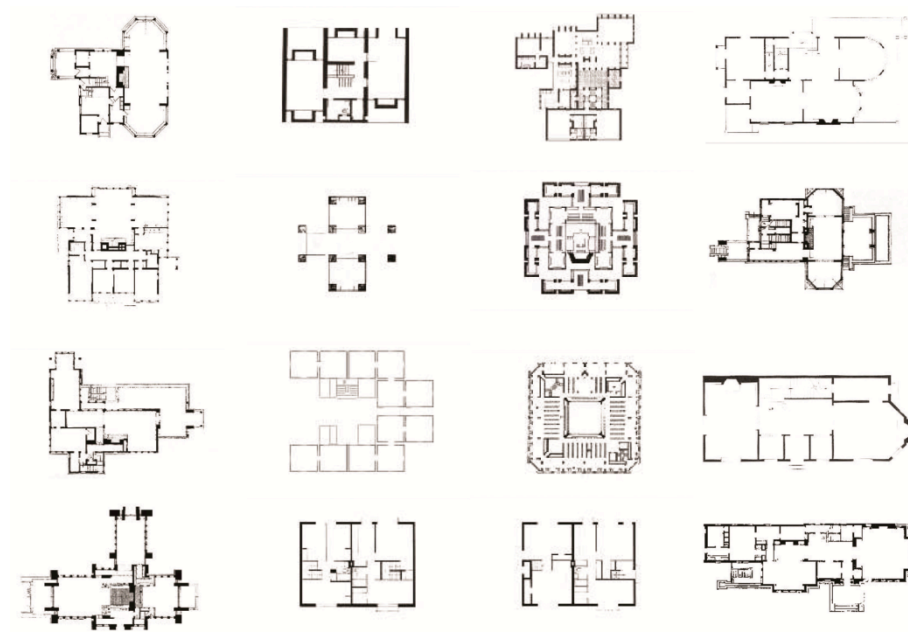

Figure 2. Samples from the set of floor plans used in the example.

A source is randomly generated as a set of pixels on a canvas, Figure 3(a), and the system saccades across the canvas, interpreting as it perceives, Figure 3(b).
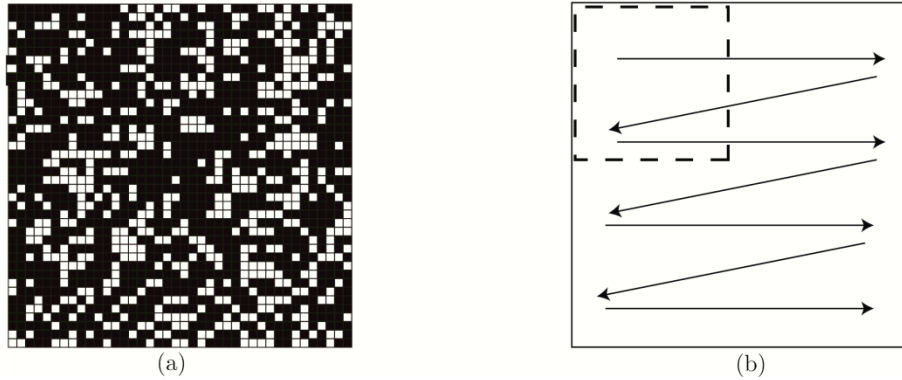
Figure 3. (a) A randomly generated source, (b) is perceived by saccading across the image in a pattern from left to right, with the system only ever perceiving 16x16 squares at a time.

The system attempts to construct from the available source data as it saccades, using its expectations. Figure 4 shows two examples of where a construction has occurred in two different runs of the experiment. In Figure 4(a) the system is expecting to find a Frank Lloyd Wright floor plan and in Figure 4(b) it is expecting to find an Andrea Palladio floor plan. The two runs have the same source and the same knowledge, but the situation that the system is in is different in the two runs. As a result, the constructed interpretation is very different - not only is the system constructing something different, but it is using a different part of the representation for construction.
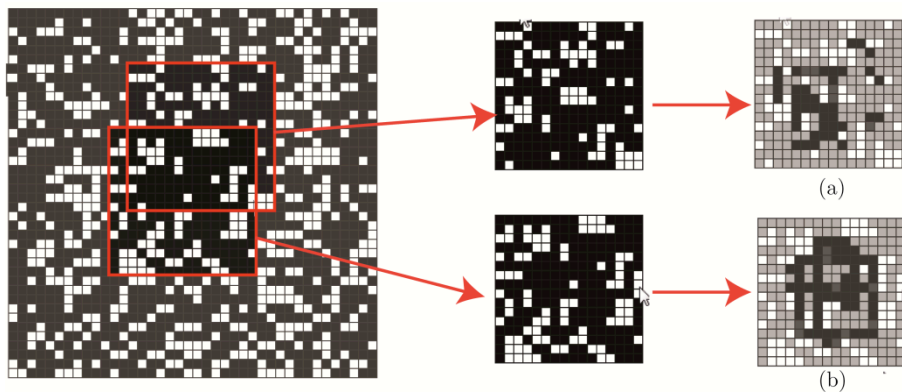

Figure 4 Two different constructions from the same source have resulted from two runs of the system with different expectations: (a) expecting a Frank Lloyd Wright; and (b) expecting an Andrea Palladio. The squares are black where construction from expectation has occurred.

The constructed representations are canonical representations of the initial floor plans that the agent was primed with through its experience. Figure 5(a) and Figure 5(b) show what the system has 'seen' within a randomly generated source when expecting a Lloyd Wright and a Palladio floor plan respectively. In each case it has constructed as interpretation of something in the source as a floor plan from what is available. It has made this construction because of the expectations that it held. At this point in the saccade there was sufficient similarity for the system to be able to construct an interpretation from what it was expecting.

interpreting as a Lloyd Wright

(a)

interpreting as a Palladio

(b)   (c)   (d)
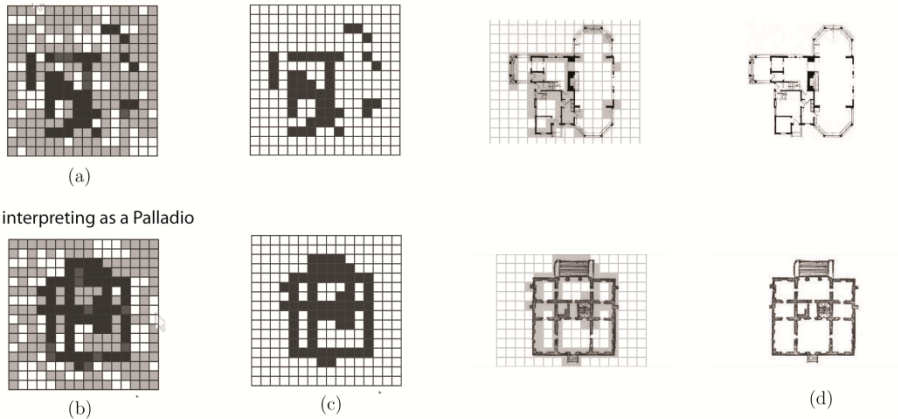
Figure 5 The two constructed representations are compared to the original representations that were part of the training set from: (a) a Frank Lloyd Wright; and (b) an Andrea Palladio. The images labelled (c) are representations of the concepts within the system that have been constructed. The images labelled (d) are the original representations used in the training set that goes to make up the viewer's knowledge about plans.

Two different interpretations are produced by runs in the system, but neither the knowledge held by the system nor the source has changed. The reason why the interpretation is different is that the system is within a different situation. This demonstrates that the expectations that the system holds are important in constructing an interpretation.

The source being interpreted is a randomly generated bitstring. Because the system knows about floor plans, it is trying to construct what it is seeing as a floor plan. Often it is not able to construct anything meaningful.

3.2 A SPACE OF POSSIBLE INTERPRETATIONS

One way to describe what is occurring in the model is to introduce the notion of a space of possible interpretations. We can describe three spaces of possible interpretation based upon how they expectations are used referring to notions of push and pull (Gero and Kannengeisser 2004):

- **Push-only interpretation.** In push-only interpretation, expectations are not utilised in producing an interpretation. The system uses everything that it knows about producing a representation from a source in the interpretation. In push-only interpretation the same knowledge (in the system) with the same source will produce the same interpretation. For example, a CAD system will represent the same file in the same way. Figure 6(a) shows this as a single space of possible interpretations bounded by the knowledge that the agent holds.

- **Pull-only interpretation.** In pull-only interpretation the expectations of a system are the basis for producing an internal representation. In pull-only interpretation every source is constructed from the expectations held by the system, regardless of how good a fit for the source these expectations are. Figure 6(b) shows this as a reduced space of possible interpretations. This space will be located in a different place in a different situation, meaning that the same source can produce a different representation.

- **Push-pull interpretation**. In push-pull interpretation an internal representation is constructed from expectations (as with pull-only) but push can occur where the expectations are not a good fit with the source. Figure 6(c) shows this as a reduced space of possible interpretations that can shift to another reduced space during interpretation.
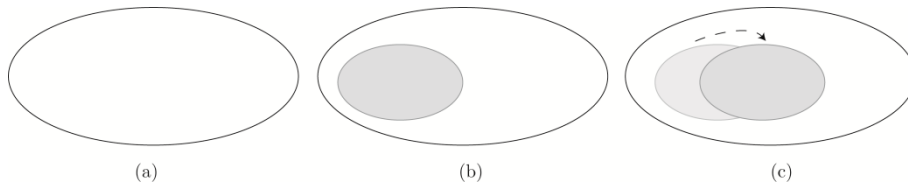

Figure 6 Three spaces of possible interpretations given: (a) push-only interpretation; (b) pull-only interpretation; and (c) push-pull interpretation.

3. Interpretation in the design conversation

In this first implementation the system was finding within a representation what it expected to find – an example of pull-only interpretation. In the design conversation, cognitive studies suggest that designers see using their expectations but also have their expectations changed by what they see (Suwa et al 2000).

A second implementation was developed in a similar environment to model a design conversation in which the design agent begins with one notion of what it is doing which changes over time as it plays with ideas and interprets the external representation. Figure 7 shows a script typical of this implementation as the interaction between three worlds (Gero and Kannengiesser 2004).
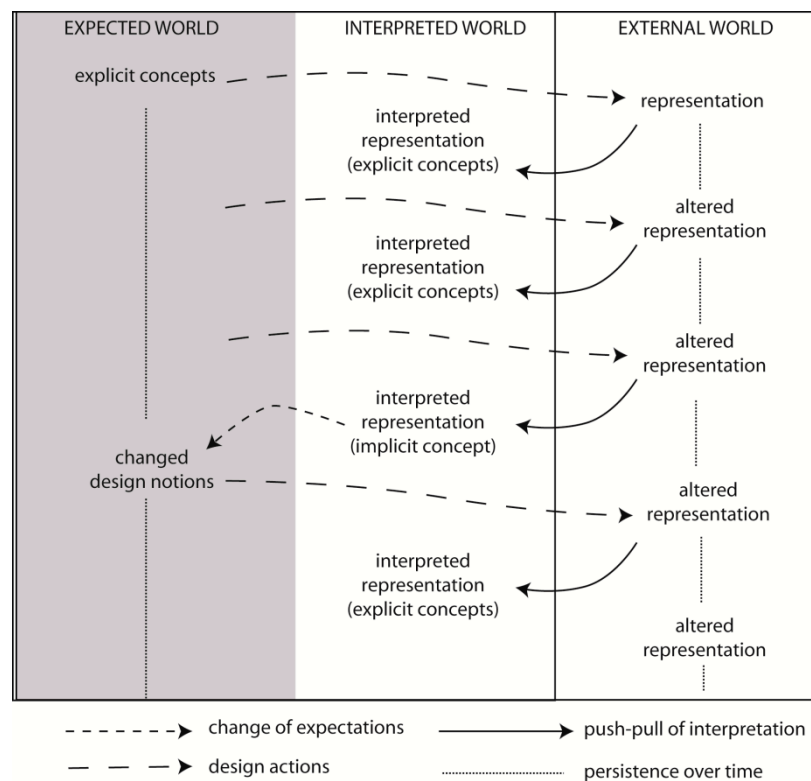

Figure 7 A design conversation as the interaction between three worlds, the internal, expected and external.

The agent begins with a set of explicit concepts and uses these in creating an external representation. For example, laying out a design using a grammar

of shapes from Louis Khan floor plans. When it looks at the resulting layout it constructs an interpretation, which can lead it to bring concepts outside the situation into the situation. An example of this is a shape from a Frank Lloyd Wright floor plan being seen suggesting other similar shapes that could be useful for the design.

Implementing a design conversation with push-pull interpretation produces some phenomena observed in conceptual design activity. This can be described using the notions of situations and a changing space of possible designs (Coyne et al 1990). Within a situation a limited number of designs are possible, Figure 8.
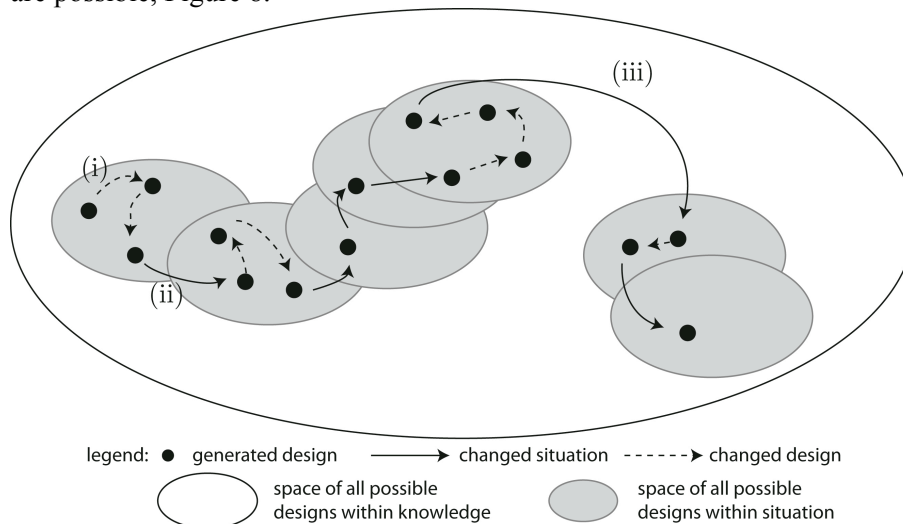

Figure 8 The changing space of possible designs in which interpretation can lead to: (i) new designs within the existing space; (ii) a shift to a changed space; and (iii) a shift to a new space of designs

Figure 8(i) shows the movement to new designs within a situation. While this occurs, interpretation is able to occur through pull from expectation. When expectations cannot be met, the situation can change in one of two ways, Figure 8(ii) through a change to the situation, or Figure 8(iii), through a change to an entirely new situation. These are the cases in which the designer has seen something within their work that they were not expecting. The model demonstrates one way in which this balance between pull from what is expected and push from the implicit expectations of a situation can be implemented.

Discussion

Interpretation pertains to the way that designers see things within their own work. The situation that a designer is in when they look at a representation affects the interpretation that they produce. The meaning of a representation is constructed by the viewer. Designers engaged in a design task see things within their work and the world around them that help them develop ideas. For example, a designer looks at a sketch, points to an element and makes a judgement about it. Where did this judgement come from?

This work suggests a model of interpretation through pull from expectations and push to a new situation when pull does not work. In this way a designer maintains a balance between a stable world (seeing what they expect to see) and a changing world (bringing concepts from outside the situation into the design conversation). In this paper two implementations have been discussed. In one a randomly generated representation is interpreted 'as' something. Different expectations of the system led to different interpretations. In the second system the initial design ideas are developed by using the ideas in creating an external representation and then interpreting the result. This leads to concepts being brought into the design task that were not previously being considered by the designer, providing a possible explanation for the observation of this phenomena in designers. The work starts with the observation that designers construct an interpretation from their expectations and considers the way that this affects the design conversation. This can be seen as a contribution towards understanding the relationships in the loop seen in Figure 9, trying to get at this overarching question: how do designers see?
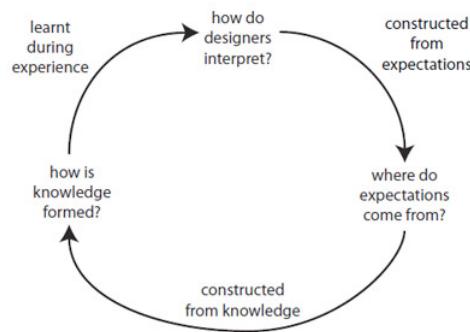

Figure 9 Research into constructive interpretation is a part of understanding how designers see, a loop involving the formation of knowledge through experience and development of expectations

Endnotes

1. Google Scholar as at 11/09/2010

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