A METHOD TO CODE SHIFTING SEMIOTIC STATES IN DESIGN

DARIN PHARE, NING GU, MICHAEL J. OSTWALD, AND TONY WILLIAMS
University of Newcastle, NSW, Australia
darin.phare@uon.edu.au
{ning.gu, michael.ostwald, tony.williams}@newcastle.edu.au

Abstract. As of Dec 2013 there were over 2.8 Billion internet users using, sharing and collaborating over the internet. The rapid developments of the web are enabling us to share increasingly richer forms of media in more inventive and immediate ways. Consequently there is growing interest centred on the relationship between the media rich content of the internet, its users and design. Drawing heavily from the study of both experienced designers and novice participants the frontline field of architecture has long provided a fertile resource for design research. However the methods of data capture traditionally associated with design research in this field are not suited to capturing the information flow within the newer web-based environments. As such there is a need for an effective method which both captures and allows us to understand the flow of design meaning. To gain a better understanding we look to semiotics. The paper presented describes a formal method for applying semiotics to code the flow of design meaning when it occurs within these media rich online environments.

Keywords. Design, semiotics, representation.

1. Introduction

With computer based communication technologies and the structure of the web 2.0, which is by design decentralised (Berners Lee, 2010), large numbers of people all over the planet now collaborate in ways that were never before possible (Malone, 2004). As a result, the role of Social networks and shared 3d virtual environments and their relationship with design is gaining research momentum. A key factor underpinning both design and the ever continuous flow of activity within the web is the reliance on, and the production of, media rich representations. Despite the emergence and increasing
adoption of web-based and social media environments in design there is a lack of effective method for capturing and understanding the use and the information flow of these media–rich representations in these environments. It has long been recognised that representations play a central role in the design process (Goldschmidt 1991, 1994, 2003; Schon 1983; Asimov 1986; Suwa and Taversky 1997). The representation is an important vehicle for generating and communicating design meaning. However many approaches to traditional design studies do not handle design related meaning. On the contrary semiotics provides method for understanding how meaning is generated. This paper offers a method for coding representational data within a design context using semiotics.

2. Background

The most direct definition of semiotics is that is the study of signs. Early in modern semiotics ‘signs’ include images, words, gestures and objects (Chandler 2002). These signs are not studied in isolation but as part of ‘sign systems’. Sign systems allow us to investigate how meaning is generated and how reality is represented through varying forms, and combinations of ‘text’ and ‘media’. The use of semiotics in the interpretation of design activity is an excellent tool for dissecting, explaining, and evaluating large amounts of visual information both in design and design in a web context. At its core semiotic theory is a framework in which three types of sign can be categorised, depending on how they allow for comprehension. These categories include icons, indexes, and symbols. The Icon, Index and Symbol provide a coordinated way of talking about how meaning is expressed via the relationship between Representamen (the form a sign takes), Object (entity to which the sign points), and Interpretant (qualities expressed by the representamen) (Everaert-Desmedt 2011; Chapman 2004; DeGrassi et al. 2008). Following is a description of the three types of sign.

**Icons** in a general context represent the ‘signified’ through the use of similarity and work by imitating the visual features of the object that it is representing. The icon closely resembles what is being represented. The icon is similar as much as the representation possesses some of the signified qualities: e.g. a photograph, portrait, and sound in movies (Chandler 2002). **Indexes** in a general context convey a relationship between the ‘signifier’ and the ‘signified’. Index is a mode of representation where the signifier is not arbitrary but directly connected in some way. Common examples are smoke and footprints (Chandler 2002). Although the actual subject is of the human is absent in the image, the presence of the footprint directly connects the image to the person which had to have created the print. **Symbols** do not
resemble the signifier. Any connection to what is being represented is purely conventional (Chandler 2002) in a general context operate, not by using visual or conceptual connections to the signified, but through a socially established convention (i.e. something that has to be learned before the meaning of the symbol can be understood) (Pierce 1982; Chapman 2004; Chandler 2005).

Figure 1. Examples of Icon, Index and Symbol.

It must be noted that these categories are not mutually exclusive. “Icon,” “index,” and “symbol” are not so much different types of sign as they are different principles that serve to bind a certain signified to a given signifier. There can easily be two or even three of these principles used together in any sign. For example Google Earth is a mixture of representational forms and can be read as Indexical: satellite images. Iconic: road maps. Symbolic: nation-state boundaries (Helmerich 2011).

Figure 2. A Google map overlay will display all the semiotic classes combined.

An un-manipulated photograph (as a signifier) is frequently linked to its subject (the signified) both indexically and iconically at the same time. That is, a photograph of a man is an iconic sign of that man inasmuch as it resembles him. It is also an indexical sign of that man because the photograph was originally physically contiguous with him: the man had to be there, in front of the lens at the time the shutter was opened, to be captured on film (Cramer n.d).

2.1. SEMIOTICS IN DESIGN

As an activity, design is “bound to treat as real that which exists only in an imagined future and designers have to specify ways in which foreseen things
can be made to exist” (Jones 1980). To this end, the interaction with representations plays a central role in allowing the designer to abstractly reason on the ‘what could be’. Descriptive representations used to describe this ‘what could be’ often take the form of precedents or sketches to be recalled for comparative analysis (similar to the signified). These images can be relatively abstract in nature and easily disregarded in the design process in the search for more concrete functional diagrams or information (Wade 1977). Functional representations are based on defining structural characteristics (similar to the Signifier) and are more concrete in their nature. The signs that convey contextual meaning in design can be categorised differently according to how they function in order to convey meaning or act as a cue in initiating further investigation.

Icons in a design context still adhere to normal semiotic rules. They represent the ‘signified’ through the use of similarity and work by imitating the visual features of the object that it is representing. To qualify as an icon in design it must closely resemble what is being represented. As such what is being represented must exist. Indexes in a design context contain similar visual qualities as the icon however contrary to the Icon what is being represented does not yet exist. Although the actual signified object cannot be physically present the presence of the image directly connects the image to the design intention. In a design context the drawing or rendering which depicts a potential building, although possessing Iconic qualities, cannot be considered an Icon as per normal semiotic rules and only an index to what potentially can be. Symbols in a design context operate according to normal semiotic rules, i.e. they are understood having pre-learned a conventionalised set of rules (Pierce 1982; Mahin et al 2001; Chapman 2004; Chandler 2005). A symbol is a signifier which does not resemble the signified and is fundamentally arbitrary or conventional (Chandler 2002) For example: in design plans are heavily embedded with multiple conventional symbols that describe wall size, materials, and openings. But in reality these are an arbitrary relation to what is actually being signified.

Figure 2. Icon in design, Index in design and Symbol in design.
Semiotics is a method that is widely used for analysing signs in images and provides a formalised interpretive framework for disseminating the meaning they contain. Design and Semiotics share several procedures that are directly related to the function of design representations; they both rely on descriptive notational systems to provide functional and generative content—often in simultaneous combination (Nadin 1990). However there are differences in that general semiotics represents what exists, and design semiotics strictly represents that which does not yet exist. By identifying the semiotic characteristics of representation within a design context we now look to a method of coding semiotic data according to our general and design related contexts.

3. Design Process

As a process, the act of designing has been modelled at various levels of abstraction with Asimov (1962) offering one of the earliest examples of a design model (Gero 1998). Asimov divided design into three classes: Analysis, Synthesis and Evaluation (ASE). Operating at a higher level of abstraction John Gero’s (1987, 1990, 1998) Function, Behaviour, Structure framework (FBS) incorporated the ASE model and included ‘Formulation’ as a precursor to Analysis and Reformulation as an account of the recurring nature of the interaction between ASE phases. Gero further added to the existing ASE framework by including Documentation, which is the formal output of ASE (Gero 1999; 1998).

The FBS model (shown in figure 8) contains three classes of variables: Function (F), Behaviour (B) and Structure (S). Function (F) represents the design intentions or purposes; Behaviour (B) represents the object derived (Bs) or expected from the structure (Be); and structure (S) represents the components that make up an artefact and their relationships. The model is strengthened by two external design issues: requirements (R) and descriptions (D). The first of these represents requirements from outside design and the second, description, means the documentation of the design. Listed
against figure 8 are eight design processes - Formulation, Analysis, Evaluation, Documentation, Synthesis, and Reformulation I, II and III. Among these design processes, the three types of reformulation process are suggested to be the processes which potentially capture the creative aspects of designing and is said to be where the introduction of new variables occur (Kan and Gero 2009). This paper adopts the FBS model to contextualise how representations are applied, adopted and reapplied in the generation and flow of design meaning.


In design as well as semiotics the main objective of generating representational ‘signs’ is to encode meaningful information. We categorise this meaningful information according to two contexts: Semiotics in a general context ($S_g$) and semiotics in a design context ($S_d$). In a general context the semiotics of the representation pertains to its subject only prior to being used for design. In a design context the ‘signs’ used in the design process signify information that conveys conventionalised design meaning. Regardless of the context the generation of meaning is constructed through varying combinations of the icon, index or symbol ($S_g$(Icon, Index, Symbol)) ($S_d$(Icon, Index, Symbol)) (Figure 9).

Example:

$S_g(x)$ General Semiotics (Icon, Index, Symbol)
$S_d(x)$ Design Semiotics (Icon, Index, Symbol)

When the meaning in any given image is changed through contextualisation a shift will occur from what the icon, index or symbol originally signified to a new or an additional signified meaning. Changes in meaning can be identified as a transition ($Tr$). We identify two types of $Tr$: Firstly ($S_g(x)$) to an identified context (design) which can be described as ($S_g(x)$→$S_d(x)$). This handles the introduction of previously unrelated imagery when it is applied to a design conversation. Secondly once contextualized, a second type of transition meaning can occurs, and may continue to occur, between evolving design meanings. This can be described as: ($S_d(x)$→$S_d^1(x)$→$S_d^2(x)$) (Figure 10).
The two types of transition \( (Tr) \) in meaning can both be determined by reviewing the descriptive combination of text and image. The transition from a general to design is a once only transition \( Sg \rightarrow Sd \). And the transition \( Sd \rightarrow Sd \) is recurring \( (Sd \rightarrow Sd^{(1)} \rightarrow Sd^{(2)} \rightarrow Sd^{(3)} \rightarrow \ldots) \). We are interested in capturing the flow of design meaning when imagery is introduced in both the ‘one off’ \( Sg(x) \rightarrow Sd(x) \) \( Tr \), and throughout the design process \( (Sd(x) \rightarrow Sd^{(n)}(x)) \). The combinations of \( Tr \) are outlined in Table 1.

### Table 1. Possible combinations of Semiotic transitions.

<table>
<thead>
<tr>
<th>Transition 1 (Tr1)</th>
<th>Transition 2 (Tr2)</th>
<th>Transition 3 (Tr3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Icon → Icon</td>
<td>1. Index → Index</td>
<td>1. Symbol → Symbol</td>
</tr>
<tr>
<td>2. Icon → Index</td>
<td>2. Index → Icon</td>
<td>2. Symbol → Icon</td>
</tr>
<tr>
<td>3. Icon → Symbol</td>
<td>3. Index → Symbol</td>
<td>3. Symbol → Index</td>
</tr>
<tr>
<td>4. Icon → Icon + Index</td>
<td>4. Index → Index + Icon</td>
<td>4. Symbol → Symbol + Icon</td>
</tr>
<tr>
<td>5. Icon → Index + Symbol</td>
<td>5. Index → Icon + Symbol</td>
<td>5. Symbol → Icon + Index</td>
</tr>
<tr>
<td>6. Icon → Icon + Index + Symbol</td>
<td>6. Index → Icon + Index + Symbol</td>
<td>6. Symbol → Icon + Index + Symbol</td>
</tr>
</tbody>
</table>

4.1. MAPPING TRANSITIONS TO THE FBS ONTOLOGY.

Once taken from a non-design context and applied to carry design meaning it is contextualised within the current design context. The \( Tr \) from \( Sg \rightarrow Sd \) involves images introduced and annotated. This annotation contributes to the meaning embedded in the image regarding a particular design issue (Design issue (I) as described in the FBS model Table 2). This \( Tr \) is written as \( Sg(x) \rightarrow Sd(x)I \).

Once contextualised within a design discussion \( (Sd(x)I) \) we are now able to use the design issue to determine the design meaning prior to its transformation. If picked up and annotated by another participant the image may now be embedded with a different meaning. This change in meaning can now reflect a related design process \( (P) \) in the FBS model. The entire \( Tr \) can be written as \( Sd(x)I \rightarrow Sd^{(n)}(x)P \). (Figure 11).
Table 2. The FBS Design Issue - Process ontology.

<table>
<thead>
<tr>
<th>Design Issue (I)</th>
<th>Process (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirement (R)</td>
<td>(F)ormulation</td>
</tr>
<tr>
<td>Behaviour derived from structure (Bs)</td>
<td>(S)ynthesis</td>
</tr>
<tr>
<td>Behaviour derived from structure (Bs)</td>
<td>(A)alysis</td>
</tr>
<tr>
<td>Behaviour derived from structure (Bs)</td>
<td>(E)valuation</td>
</tr>
<tr>
<td>Design description (D)</td>
<td>(D)ocumentation</td>
</tr>
<tr>
<td>Behaviour derived from structure (Bs)</td>
<td>(R)eformulation I</td>
</tr>
<tr>
<td>Function (F)</td>
<td>(R)eformulation II</td>
</tr>
<tr>
<td>Expected behaviour (Be)</td>
<td>(R)eformulation III</td>
</tr>
</tbody>
</table>

Figure 5 Mapping Semiotic transitions to the design process.

We can now describe both types of transition (Tr) as:

1. General semiotic to a design context
   \[ S_{g(x)} \rightarrow S_{d(x)} I \in \text{Tr} \ (1,2,3) \]

2. Design semiotics to design semiotics
   \[ S_{d(x)} I \rightarrow S_{d^{(n)} x} P \in \text{Tr} \ (1,2,3) \]

4.2 TRANSITION TYPE 1 - SG TO SD

The representation in table 3 is a safety mat. In its original state it is a general semiotic icon (Sg). An annotation with the image indicated a derived behaviour (Bs) by denoting ‘clicking’ style connectors that join living modules together. By representing a design idea the semiotics of the image changed from Sg to Sd. As the mechanism does not exist the original Icon functions as an index and a symbol. The image now indexically represents an idea with the image symbolic of a connection method. As there is a generation of information we can then place the image against a design process, and that is Synthesis (S).
Using our combined semiotic and design coding scheme we can transcribe the example transition in Table 3 as:

$$S_{g(Icon)} \rightarrow S_{d(Index, Symbol)} B_{s} \in Tr(1)$$

### 4.3 TRANSITION TYPE 2 - SD\( (X) \) TO SD\( ^{1} (X) \).

SD → Sd is the second transition type which will allow us to track the flow of semiotic meaning once the image is contextualised within a design conversation. The stack of shipping containers (Table 4) is used as a precedent with an annotation regarding their ‘stacking’ capability (Sd\( _{(icon)} B_{s} \)). This image was then annotated by another participant whose focus was interlocking units that ‘piggyback’ an in situ infrastructure. The Sd\( _{(icon)} B_{s} \) has now undergone its first contextualised transition to Sd\( ^{1} (index) \) and functions in an indexical capacity Sd\( ^{1} (index) \) and begins to synthesise (S) a potential solution.

### Table 4. Example Sd to Sd.

<table>
<thead>
<tr>
<th>Transition type 2</th>
<th>Behaviour derived from structure (Bs)</th>
<th>Synthesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Icon</td>
<td>Bs</td>
<td>Index</td>
</tr>
</tbody>
</table>

$$S_{d(Icon) Bs} \rightarrow S_{d^{1}(Index) S} \in Tr(1)$$

Coding the semiotics as described above will allow us to track the changes in meaning as they change over time and will easily handle the iterative time based nature of the design process (Figure 1). We have described a coding scheme that handles semiotics in a general and a design context and captures the transitions which indicate the shift in meaning. The coding scheme
presented in this paper will allow us not only to categorise the meaning communicated by the imagery involved, but it will allow us to track the shifts in semiotic meaning over any time based duration. Our next step is to test the validity of this coding scheme using the data collected from our main, online based, design experiment.

5. Discussion and Conclusion

There is no design activity without representation (Goldschmidt and Smol-kov 2004). In a representation rich discipline such as design, protocol studies have demonstrated that expert designers use representations to explore ideas and share meaning via commonly understood visual and linguistic conventions embedded in these representations (Ashwin 1984). It is these shared visual conventions that manage ambiguity in the overall design/engineering process (Hartmann and Vossebeld 2013). There is much in the literature which focuses on the expert and the interaction with representational media such as sketching (Ullman et al. 1990; Fish 2004; Suwa and Taversky 1997). However despite the considerable research in design there is little in the way of literature that concentrates on the mechanics of how visual meaning is generated in design. The protocol analysis, as a method of understanding designers in action, plays an important role in design research. However protocol analysis is typically obtained through observation or video recordings. This in turn comes with the additional caveat that in order to capture the data from these groups, the groups must be relatively small. Furthermore protocol analysis does not handle the meaning embedded in the representations when they applied to design purposes. To review how meaning is generated in design this paper presents a method for coding Semiotic information. The coding scheme presented in this paper can be applied to a design task undertaken in any environmental condition and any group size which are the current limitations found with typical video recorded sessions as a data collection method for a protocol analysis.

The semiotics described in this paper operates in two contexts: a general semiotic context and a design semiotic context. In the general context the representation carries nothing but its own meaning prior to being used in a design context. Once contextualised by a design brief the semiotic context becomes design related and it becomes possible to track the semiotic shifts in meaningful information over time. This is particularly advantageous for a time based activity such as design.

At present we use Geros FBS framework to position semiotics in a design context however a limitation of this approach is that the FBS model is typically geared toward understanding the behavioural activity of the expert de-
signer. As a standalone model for the design processes the FBS ontology does not provide for a differentiation between expert and novice design behaviour. By formalizing the criteria for evaluating how meaning generation occurs we might potentially facilitate a behavioural comparison between Experts and Novices based on understanding how meaning is constructed. This may be achieved through identifying the patterns that occur through both expert and novice groups. Furthermore with our semiotic coding scheme there are implications that the ambiguity of representational interpretation can be managed, to a degree through the larger issue of contextualisation.

The method presented in this paper will accommodate a review of both similarities and differences and it will also allow us to identify patterns of meaning based design related behaviour. With metrics for these we now have a common ground for evaluating how design meaning is generated and flows within the web environment, we have also alluded to larger issue of how representations are used by non-experts, without a shared set of conventions for communicating design, when tasked with generating and communicating design meaning within a web based design system.

Our next steps are to evaluate our method for coding semiotics, which will involve two rounds of coding the data gathered from our main experiment. We will measure how representations transition in meaning from a general context to a design context, and how the meaning shifts within a design context. We will compare how meaning is generated between an expert and a novice group. In addition we will need to elaborate on some smaller, but important issues, such as categorising and cataloguing of the imagery used and the abstract nature of design representations. Lastly we will need to review the issue of image redundancy. However we are ultimately interested in how the transitions in semiotic meaning occur over time in a large group when compared with expert designers when presented with the same design task and environment.

6. References

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