SKETCH INTERPRETATION IN DESIGN COMMUNICATION

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1 Introduction

Designers need to communicate their ideas to others. But these ideas can be fluid, vague, provisional, and involve a mixture of degrees of detail and levels of abstraction. Expressing and interpreting imprecision and uncertainty is a challenge for human-computer interaction when designers use CAD systems. It is also a problem for communication between different members of design teams. Sketches are both a tool and a source of confusion for conveying provisionality and uncertainty. Freehand sketches are a fast and powerful medium for expressing design ideas; their inherent imprecision and ambiguity facilitates idea generation by allowing designers to see variations and re-interpret their own sketches. But misinterpretation of sketches is a major cause of communication failure in design teams. This paper presents an analysis of imprecision in sketch-based communication. It is intended as a foundation for technological and organisational approaches to improving communication in design teams.

2 An example of communicating by sketch

Knitwear designers communicate their designs to knitting machine technicians with a ‘technical sketch’ comprising a short verbal description, a set of measurements and a sketch. The measurements are often incomplete, inconsistent and inaccurate. Designers often don’t have the domain knowledge to specify shapes accurately; and they find it difficult to improve their specifications because they cannot unpack the effects of their specification from later changes made for technical reasons. In theory the sketch should clarify the specification. However the technicians, who do a lot of detail design in the course of creating knitting machine programs based on these specifications, tend to ignore the sketches and rely mainly on the verbal descriptions, which only give broad indications of categories [Eckert 1997].

Figure 1 illustrates how the sketch itself can be inconsistent: one sleeve is drawn straight, the other flaring. In this case the issue of the style of the sleeve can be resolved by the measurements, which ask for a flared sleeve. However some features cannot be communicated through measurements but only through a sketch. Even then the
technicians ignore the sketches, because they feel they cannot trust the designers to mean what they have drawn, at that degree of detail. In consequence different garments look much more similar than the designers intended. They might require costly re-sampling before they conform to the designers’ ideas. So why is the sketch ignored?

3 Sketching abstract and provisional designs

Engineering designers often think at a middle level of abstraction, about concretely imagined but nonetheless qualitative designs, in terms that cut across neat conceptual categories. Even when designs are formulated in abstract functional terms, many designers have mental images of designs embodying rough ideas of shapes, layouts and magnitudes, even when there is no need to make decisions about them. These designs lack details, or are uncertain about them. They embody decisions that are provisional: the designer is not committed to them. Some elements of the design might be worked out in concrete detail embodying firm decisions, while other parts of the design are vague or are merely categories. In expressing these designs, designers wish to convey a class of artefacts rather than an individual artefact. Knitwear designers are typically strong visualisers, who have vivid mental images of the garments they are designing. Often they have the subjective feeling of imagining, in exact detail, an individual garment that they want to create; although the image may be lacking some aspects or details of the finished garment, and may mutate as details are considered more closely. At other times designers know they want ‘one of those’: they imagine relatively exact designs, but the designs or elements of them merely serve as placeholders for much wider and more abstract categories. Sketches of conceptual designs express design ideas at very different levels of concreteness, detail, precision and commitment, and often in the same sketch.

But sketches that do not give clear depictions of precise design decisions cause problems when they are used to communicate designs. So why aren’t sketches drawn better? Drawing skill is a limiting factor, especially when complex three-dimensional objects are involved. But more importantly designers often need to communicate ideas when they haven’t made the detailed decisions about shapes and spatial relationships that would be embodied in more precise sketches. This can be because they need help to make those decisions, or because making them would restrict other design choices that should be made first. Drawing a sketch carefully may simply not be cost-effective (for instance for knitwear designers who need to produce many designs quickly). Investing effort in a sketch also interrupts design thinking and increases the designer’s emotional commitment to the design. Eckert [1997] also found that designers did not recognise that the ambiguity in their sketches led to the sketches being ignored.

4 Sketches as dense symbols

Most fundamentally a sketch is a series of marks on paper. These marks form dense symbols, whose interpretation depends on both category information and exact spatial form [Goel 1995]. Their meanings lie in the combination of symbolic and geometric mappings from the sketch elements to the referent objects the viewer interprets the sketch to depict.

Sketch elements have symbolic meanings, defined by notational conventions and mediated by the recognition of abstract category memberships, mapping categories of mark-combinations to categories of objects or concepts. Sketch elements may be icons, or have shapes directly corresponding to the shapes of the object categories they represent. McFadzean et al [1999]
found that designers use a personal recurring set of graphical symbols to express abstract attributes of a design. These personal notations are based on the standard drawing conventions of the domain, but include idiosyncratic extensions and variations. Designers have recurring, idiosyncratic procedures for constructing symbols, that influence their final form. For example they would use the same curve to denote an arch, when they do not know the form of the arch.

Sketch elements often also have geometric meanings, mapping the exact forms of the marks and the spatial relationships between them, to the shapes and spatial relationships of the depicted objects. This geometric mapping is perceptual and non-symbolic, although interpreting pictures is to some extent a learned skill. The graphic notations for many spatial concepts embody direct mappings from their conventional shapes, so they convey geometric meaning even when only a category identifier is intended. Making geometric mappings involves recognising and exploiting drawing conventions. Recognising drawing conventions is especially important in understanding sketches of three-dimensional objects.

Viewers understand sketches by perceiving both the symbolic categories and the shapes of design elements – but shape perception depends on what symbols are seen. A sketch is ambiguous, as opposed to vague, when alternative ascriptions of symbols to sketch elements are possible.

For each viewer, a design sketch has a perceptual interpretation space: its meaning is the range of designs that it perceptually affords (see figure 2). Beyond this, it has a deductive interpretation space: this is the range of designs that the viewer reasons that it can cover. As sketched lines have definite shapes and sizes, they suggest proportions and magnitudes, so interpretation spaces typically have centres – the interpretation that is most strongly suggested - and fuzzy boundaries. The greater the appearance of roughness the wider and more qualitative is the perceptual interpretation space.

5 Imprecision and ambiguity

Designers typically sketch imprecise ideas, embodying tentative decisions and with purely qualitative elements, covering a space of possible designs. Such a design space is difficult to express in a pictorial form. Designers often draw a typical instance or a range of instances, which can either be typical or mark the edges of the design space that they represent. This strategy for indicating spaces can be applied equally to rough sketches and precise representations [Eckert and Stacey 1999]. Figure 3 might represent the relative location of two houses. Any range between the two extremes would be acceptable, but typically only the middle instance would be sketched. As design sketches are necessarily imprecise, they introduce ambiguity and inaccuracy into the transmission of meaning. Designers draw their mental concepts with varying degrees of accuracy according to their own conventions, but the sketches are interpreted
according to the viewer’s conventions as a different space of possible designs (see figure 4). Different people have different conceptions of central or typical category members; this is important when design element categories can vary over time, as in knitwear design.

A sketch may be ambiguous; that is, it affords alternative symbolic interpretations. This can happen when a sketch element can be interpreted as: a roughly drawn instance of one symbol or a more precisely drawn instance of another (such as a flared sleeve); or is on a fuzzy boundary between two category symbols (for instance, a slightly flared sleeve); or when marks can be grouped into symbols in different ways; or when the sketch is self-contradictory (for instance, a sweater with two different sleeves); or when alternative notational conventions are in conflict (a common problem in interpreting sketches of three-dimensional objects). A sketch element can be quantitatively ambiguous when it is unclear whether it is purely a category symbol or has a meaningful shapes, or how wide the range of its geometric meaning should be. The degree of apparent roughness is a powerful signal of how wide the interpretation space should be, but the recipients cannot easily distinguish between intentional roughness and poor drawing. Roughness biases interpretation (for better or worse) towards simple shapes.

6 The role of ambiguity in individual design

Sketches play a vital role in many types of design activity as an externalisation of thought – they enable designers to communicate with themselves. Designers exploit the potential for differing interpretations of their own sketches to stimulate their own idea generation [Schön 1983; Goel 1995; see Purcell and Gero 1998 for a review]. In one of the first empirical studies of the relation of sketches to rational thought, Goldschmidt [1991] asked “what kind of reasoning does sketching represent?” She found that design reasoning is characterised by the designers’ oscillation between two modes of thought: ‘seeing as’ which deals with figural arrangements, and ‘seeing that’ there are non-figural issues that need to be resolved. McFadzean et al [1999] conclude that dissatisfaction with an aspect of the design drives the emergence of new designs through the re-interpretation of structural and conceptual properties of sketches, by finding alternative mappings from existing marks on paper to new graphical symbols. Emergence was found to evolve from the use and perception of the graphical notation used in the sketch. Designers related it to re-representation (redrawing a previously drawn visual element), and re-structuring (drawing over existing graphical elements indicating important features of the design) of the sketches. This activity creates ambiguity in the structure of the sketch and enables designers to make transitions from one shape to the emergence of a new shape, space or concept. Thus sketching allows ambiguity in the representation of the design, and thus facilitates the acquisition of new information through the analysis and synthesis of the perceived visual properties of the sketch.

7 Ambiguity in design communication
Sketches used for communication differ from sketches used within individual design activities in two important ways: the viewer does not know the creator’s intentions; and the viewer does not viewer does not share the creator’s context.

The recipients may get nothing more than marks on paper. But understanding the purpose of a sketch element is often essential for resolving ambiguity. Is a sketch element purely symbolic, or is its geometric meaning intended to be taken seriously? The recipients often cannot distinguish between purely symbolic representations of abstract design concepts, and sketches showing intended shapes, proportions and relationships, because the graphic notations for both produce very similar marks on paper. How precisely is the shape or spatial relationship drawn? Understanding the designer’s commitment to a design element is essential: Is the sketch element a specification for a particular design, or a placeholder that illustrates a class of possibilities? How important is the design element? Does the design element represent a firm decision or one that is tentative and provisional? Eckert [1997; Eckert et al in press] has found that misunderstandings of intention are a major practical problem in knitwear design. Here problems are caused by mismatches between notational conventions both between sketches and within sketches. Some sketch elements are intended as relatively exact depictions of important features, while others are merely placeholders for categories of design elements with approximate dimensions. But the knitwear technicians are unable to recognise what to take seriously. So they ignore sketches or change features central to the designer’s conception.

Working out what a sketch drawn to communicate a design ‘must mean’ involves using contextual knowledge to create a deductive interpretation space from a perceptual interpretation space. Sketch interpretation depends on the recipient’s understanding of the personal notational style of the designer, and of the design elements available to the designer and their canonical forms. When the range of design elements and their standard forms change with time, as in fashion and knitwear design, understanding depends on awareness of these changes. Eckert [1997] has found that sketches drawn by knitwear designers, using the design elements about to appear in coming fashion, are interpreted by knitwear technicians in terms of the elements of previously manufactured designs. Thus the garment designs the technicians program end up far more conservative than the designers intend [see Eckert and Stacey 1999].

The most important part of overcoming the problems involved in sketch-based communication without complete and unambiguous notations is recognising the problems. Then solutions can be negotiated between the participants in the process. Just doing this would make a major difference to the efficiency of the knitwear design process in industry (though Eckert et al [in press] propose using automatic design techniques for ensuring completeness and consistency in designers’ technical sketches). Developing solutions could be facilitated by meta-notational conventions for annotating sketches to indicate (1) importance; (2) the degree of provisionality or commitment; (3) exact specification or placeholder example or category symbol; (4) the intended regularity of lines and angles; and (5) the boundaries and asymmetries of quantitative interpretation spaces. The significance of communicating designers’ intentions in engineering design is recognised by Stevenson et al [1999], who propose notational conventions for signalling the space of possible interpretations of shapes and relative sizes, within a sketching interface for a solid modelling CAD system that handles imprecise specifications.
8 Conclusion

While the ambiguity inherent in design sketches can facilitate creative thinking, it can seriously hinder communication between designers. Misunderstandings of design intentions are a major reason for communication failure, for instance in knitwear design. Graphical depictions of seriously intended shapes and spatial relationships are hard to distinguish from more-or-less purely symbolic indications of categories. Sketch elements with radically different degrees of intended precision and commitment can coexist in the same sketch. No notational conventions for signalling precision and commitment are in common use. Design communication would be enhanced by the development of appropriate meta-notations.

References


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