DIGITAL SKETCHING: MEANS AND ENDS

A. KOUTAMANIS
Delft University of Technology, Faculty of Architecture,
Berlageweg 1, NL-2628 CR Delft, The Netherlands
Email address:a.koutamanis@tudelft.nl

Abstract. Sketching is one of the few analogue design practices that persist in the digital era. The transfer of architectural sketches and sketching to the computer presupposes a demarcation of applications and representations on the basis of specifications relating to the mechanical, paradigmatic and syntagmatic dimensions of drawing.

1. Sketching and computerization

Digital environments are replacing a wide variety of analogue design procedures and representations. Most drawings are produced with CAD systems, including perspective and axonometric projections as well as renderings, and even physical models are made with rapid prototyping techniques. Computerization is dominating both the production of conventional documents for specification or communication and the manner we conduct design processes either individually or in teams.

One of the few analogue areas that appear to resist computerization is sketching (Do, 2002). Doodles on a paper napkin or the back side of a beer mat remain popular in architectural lore. But even on boringly plain paper analogue sketches still have a significant place in early design. Equally significant is the use of sketching in our interaction with design documentation, for example by means of graphic annotation (e.g. markup). However, the persistence of sketching means little for the future (Asanowicz, 2002). Sketches can be seen as a throwback that must be tolerated purely for practical reasons. These include the scarcity of 3D systems for conceptual design, limitations of current 3D design interfaces, but also cognitive limitations of users who may be unable to handle such systems and interfaces successfully. It is often assumed that sketching does not ultimately compare to digital modeling in terms of richness or to generative formalisms with respect to rigor and transparency.
Consequently understanding and expanding sketching processes and products through computational means are seen as lesser issues. It is telling that most digital sketching tools are primary facsimiles of analogue media, e.g. “paint” programs that reproduce just the appearance of analogue sketching. One of the main reasons for the relative neglect of sketching is confusion between means and ends, something that can be observed in both architectural education and theory. The present paper is an attempt at a classification of means and ends in digital sketching. Its main ambition is to produce a transparent description of what and how we produce with digital sketches. This should lead to clear specifications for digital sketching products, processes and environments that enhance our design capabilities.

2. Applications and representations

A pragmatic starting point for the analysis of digital sketching is the demarcation of its applications and forms. The purpose of this process is to distinguish between different activities and representations that fall under the generic category of sketching, as well as to identify common aspects and elements that permit the development of a sound basis for computerization.

2.1. REGISTRATION

Using sketches to register information is a familiar design activity. It refers to two different forms of information that are captured in the same way:

- *Perceptual information*: This is an application with artistic origins and refers to the interpretation of a three-dimensional scene into a projection on paper. The interpretation often takes place on site, in a short period of time and involves observation and abstraction. These are widely credited with the added value of sketching in comparison to e.g. photographic registration (Cheng and McKelvey, 2005, Cheng, 2004b). Abstraction is frequently coupled to stylization, which permits greater fluency and imposes non-arbitrary rules to sketching representation.
Design information: The registration of actions, decisions, processes and products is frequently done with abstract and largely diagrammatic sketches. These comprise more 2D than 3D depictions and are generally associated with early design and design generation. Sketches registering design information are generally more complex than sketches of a viewed scene. This is largely due to the conditions under which the sketches are produced: multi-actor situations, complex communications, compact and hasty formulation of conclusions in a design session etc.
2.2. INTERACTION

Uses of sketching in interacting with design representations are comparatively poorly defined and explored:

- **Annotation** (including various forms of markup like redlining): Sketching is a common way of working with design information. Annotating is essentially similar to registering design information with the fundamental difference that its referential character makes it more elliptic and deictic: annotations are practically never self-sufficient, as even locally complete specifications may miss context, and frequently point out problems that have still to be resolved. A more prosaic difference is that annotations take a more important role as the design process progresses and the production of drawings and detailed specifications increase.

- **Interface**: In a number of design environments associated with the concepts of virtual and augmented reality sketching has shown a potential in the manipulation of information. Such interfaces build on user familiarity with implements such as the pen to lower interaction thresholds through mostly symbolic structures (Woessner et al., 2004, Do, 2001, Achten et al., 2000). Even though the results of this interaction may not resemble conventional sketches, the manner of entering information has strong links with sketching procedures to a degree that justifies the categorization of such interfaces under sketching.
2.3. SKETCHING REPRESENTATIONS

Representations produced by sketching fall under two main categories:

- **Representational sketches** reproduce the appearance of objects in real life. Their legibility depends little on architectural training and only to an extent on cultural conventions such as drawing styles. Representational sketches are mostly 3D or 2½D projections.

- **Diagrammatic sketches** are highly symbolic and generally relate to specific conventions (often mixed). 2D projections such as sections and plans lend themselves to diagrammatic treatment arguably because of their aspirations to objectivity and overview.

Both categories involve multiple abstraction levels, which are applied selectively and opportunistically. More than other architectural representations sketches assume flexible compound forms by combining symbolic and pictorial elements. This permits a wider scope of expression, including making explicit relationships and references, especially if they indicate prominent features in the design or the discussion. The similarities between such compound forms and hypermedia / multimedia can be striking.
2.4. DRAWING DIMENSIONS

The distinction between different dimensions in a sketch follows a general semiotic framework for drawing and writing (Van Sommers, 1984):

- The *mechanical* dimension refers to the interaction between the sketcher’s anatomy, pen, paper or other drawing implements.
- The *paradigmatic* dimension considers the drawing as a collection of primitives (graphic or symbolic).
- The *syntagmatic* dimension describes the sequence by which these primitives (or their parts) are entered in the drawing.

Sketch analyses along the paradigmatic dimension are the most common, as they relate to the recognition of structure and meaning and consequently to the translation of sketches into architectural drawings. The syntagmatic dimension can be a focal point in studies of how a sketch develops, e.g. in teaching or protocol analysis. The mechanical dimension remains largely neglected despite its influence on syntagmatic and paradigmatic aspects.

2.5. CORRELATION

Diagrammatic sketches predominate in design uses where the verisimilitude of representational sketches may not suffice for the specification of products and processes. Annotations are primarily diagrammatic, while interfaces can use either representational or diagrammatic structures, generally depending on the representations they refer to.

<table>
<thead>
<tr>
<th>Application</th>
<th>Representational</th>
<th>Diagrammatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registration perceptual</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Registration design</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Annotation</td>
<td></td>
<td>++</td>
</tr>
<tr>
<td>Interface</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Dimensions relate more to the purpose and products of an application than to representations used. The sequence of drawing actions by which a visual scene is registered is less important than the legibility of the final sketch, with the obvious exception of learning activities where the process of sketching almost rivals its products. On the other hand, syntagmatic information is frequently essential for understanding the meaning of sketches produced during a design session: tracing the development of a design and distinguishing between different states of the representation can explain not only the form of a design but also the reasons behind it. The mechanical
dimension appears to be more closely linked to syntagmatic aspects, even though the form of primitives is also influenced by e.g. the position of the sketcher’s arm and handedness.

TABLE 2. Correlation applications-dimensions

<table>
<thead>
<tr>
<th>Application</th>
<th>Mechanical</th>
<th>Paradigmatic</th>
<th>Syntagmatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registration perceptual</td>
<td>+++</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Registration design</td>
<td>++</td>
<td>++</td>
<td></td>
</tr>
<tr>
<td>Annotation</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Interface</td>
<td>++</td>
<td>+++</td>
<td></td>
</tr>
<tr>
<td>Learning</td>
<td>++</td>
<td>+++</td>
<td>+</td>
</tr>
</tbody>
</table>

3. Sketch digitization

3.1. OPTICAL AND MANUAL DIGITIZATION

Images can be digitized in a number of alternative ways:

- **Optical digitization** (scanning) transfers analogue information to the computer as an array of points (pixels)
- **Manual (mechanical) digitization** registers pen movements on a (pressure-sensitive) surface and can produce vector images
- **Manual digitization on top of viewing devices**, as in a tablet PC or PDA, comes close to the cognitive ergonomics of analogue media by providing direct visual feedback
- **Digital pens** are another variation of manual digitization: they produce digital copies of the strokes made on paper

The performance of digitization is usually measured in terms of digital image quality and efficiency. With respect to sketches and sketching we should also take into account performance along each drawing dimension. The mechanical dimension reveals that manual digitizers try to be a facsimile of analogue processes, while optical digitization is not intended for capturing the mechanical subtleties of sketching processes. From our particular viewpoint optical digitization is primarily an efficient manner of transferring analogue images to the computer that allows the sketcher to make use of analogue skills but fails to capture the processes that involve these skills (with the possible exception of video capture).

Manual digitizers can register and exploit mechanical aspects with variable results that remain within a rather small bandwidth. Their
performance with respect to paradigmatic aspects is even more uniform: they are capable of registering the graphic primitives denoted by single or sequential strokes but are yet incapable of recognizing more advanced graphic configurations and architectural symbols (Koutamanis, 2001, Achten and Jessurun, 2002). The ability to register syntagmatic information in manual digitization has long been acknowledged and put to use in sketch recognition and design education (Cheng, 2004a, Gross, 1995). As the same paradigmatic results can be achieved through different action sequences, the use of syntagmatic information is primarily restricted to explaining and disambiguating sketches (Koutamanis, 2005).

3.2. PIXELS AND VECTORS

The ability to produce vector images is an important step in the recognition of the paradigmatic content and structure of a sketch (segmentation). However, vectorization in mechanical digitizers is invariably restricted to the registration of strokes, which are translated into basic graphic primitives. Combination of these primitives into meaningful symbols is deferred to purpose-made, domain-dependent post-processing systems.

Vector images may permit more direct and meaningful manipulation of their parts but pixels have their uses too, for example in rendering but also in the identification of regions in an image. Systems that replicate analogue drawing capabilities as well as image processing systems tend towards hybrid environments that combine vectors and pixels. Such environments are well suited for mechanical digitization of sketches, provided that the sketcher uses different primitives consistently.

4. Means and ends: a discussion

4.1. REQUIREMENTS AND SPECIFICATIONS

The correlation of means and ends relies on usability constraints which determine general requirements for the flexible, adaptable, reliable and direct processing of architectural sketches. These constraints derive jointly from the capabilities of analogue sketching and possible improvements and enhancements through computerization.

- Mechanical
  - Large viewing facilities: for a profession used to A0 and A1 sheets no size limitations are acceptable. We may be getting used to the significantly lower resolution of computer monitors but lack of overview is a common complaint.
• *Correlation of viewing and sketching*, as in LCD tablets and tablet PCs but also with pen and paper

• **Paradigmatic**
  - *Multiple copies*: using multiple copies of the same document supports the parallel exploration and comparison of variations and alternatives, including fast backtracking.
  - *Free interaction* with all documents including overlaying of different documents, direct modification and markup of coherent and meaningful primitives, as well as allowing several actors to work together on one document.

• **Syntagmatic**
  - The ability to *distinguish between different actors and actions*: analysis of syntagmatic information (in relation to paradigmatic analysis) in order to record complex situations, untangle contributions, disambiguate forms and interpret intentions in a reliable and consistent manner. This is of particular importance in multi-actor situations.

4.2. **SUITABILITY AND USABILITY**

The registration of perceptual and design information, especially with representational drawings, has known progress in recent years –mostly technological but also domain-related (Richens, 1999). However, further development is hampered by lack of continuity between sketches and other design representations. Despite the current emphasis on building information models and interoperability, early design is poorly supported and interpretation of design representation tends to be deterministic.

Promising technical developments can be found in the still embryonic area of digital pens and paper. These concern a number of issues, such as the integration of digital information processing in the analogue world (including feedback to the computer), adequate registration of syntagmatic information and support for multi-actor processes and products.

Digital sketching has yet to support the diagrammatic, relational character of generative sketches and annotations. Despite the proliferation of multimedia and hypermedia, image processing and document recognition, sketching is limited to variations of basic “paint” software. This reduces the effectiveness and utility of mechanically interesting technologies that combine viewing and sketching (LCD tablets, tablet PCs, PDAs), even in redlining and other forms of markup on digital documents.

The main challenge is arguably the development of representations that cover the entire life cycle of a design and support abstract, elliptic thinking, incompleteness and uncertainty. These are cornerstones of design thinking as
well as sketching. While there is no perfect solution among the currently available technologies, their combined performance and capabilities seem sufficient for going beyond academic experimentation. However, this may require relaxation of many of the generative assumptions underlying CAAD.

References


