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Digital & Analogue – Seamlessly Integrating Freehand-Sketching in a Digital Design Environment

1. Introduction

Architecture has always been closely bound with the possibilities and limitations of the technologies we use to realise it. Alongside a multitude of building materials, construction technologies and other boundary conditions, these include the aids employed in the design and conception of a building. These tools and media, as well as the methods we use when designing, can greatly influence the resulting outcome, as exemplified by the emergence of perspective in the Renaissance period. The design is therefore not solely the representation of a brilliant idea plucked from the head of the designer, but the result of an ongoing reciprocal process of working on what we are creating. As such, it is also always a product of the tools used while designing.

Today, the increasing digitalization of design tools has culminated in a universal “meta-tool”, the computer as a medium for design. One of the great advantages of using computers in design lies in the integration of many disparate aspects of design in a single medium: it provides both effective tools for data capture as well as tools for the virtual realization of a building. Extensive drawing and modelling tools enable one to design complex forms and can also realize them through computer-aided manufacturing. Exploration techniques, such as virtual walkthroughs, allow one to discuss all levels of a design in great detail. Analysis and simulation programmes can assist decision-making processes and generative design methods are currently opening up a whole new field of exploring the space of possibilities. In an ideal scenario, all these techniques are embedded in a consistent digital planning process that also allows different participants to contribute and communicate. While the advantages of this “digital chain” are undeniable, these developments also bring with them new risks that stem from the peculiarities and restrictions of digital tools. A case in point are component-oriented CAAD systems that prescribe a certain sequence of steps in the design of a building which may not correspond to a designer’s way of working and thinking (see also Bolte, 1998). The results achieved using such systems are at best limited and at worst deficient. This phenomenon can be illustrated by paraphrasing Sullivan’s famous slogan “form follows function” – when the tools used have a disproportionately large effect on the resulting design one can speak of “form follows software”!
The “creative phase” of a design forms the starting point for all subsequent stages of the planning process and has a decisive impact on functionality, appearance as well as the cost-effectiveness of the proposed building. At this stage decisions are made that shape the entire concept of an architectural solution and potentially the built environment for years to come. Nevertheless, according to the HOAI, the German Scale of Fees for Services by Architects and Engineers, the design stage represents only a small part of the overall architectural planning process. This “creative phase” is also marked as distinct from what follows by a change in the media of design when analogue tools are laid down in favour of entering the design into a CAAD system. To speak solely of planning from this moment on, however, would be to deny that one also designs in the later phases of the planning process. One must also take into account that it is still not as easy to develop ideas in digital systems as it is with analogue tools. If one does not want to subordinate oneself to the restrictions of the system, one has to ‘resort’ to “traditional” tools, although this is becoming increasingly difficult as more and more “all-round” tools purport to provide digital counterparts for these, and we in turn presume too much of them. A well-known software manufacturer, for example, advertises that their program “works the way an architect thinks”. Two aspects are needed to truly overcome the restrictions and dangers of a digital design process: on the one hand the user needs to have excellent media competencies and on the other, systems need to be improved to remove these difficulties.

To improve the usability of digital systems, it is in our view essential that they accommodate the specific aspects of designing, not just at the project inception but also throughout all phases of the planning process – from the large to the small scale, from the conceptual sketch to detailed working drawings. Only through a seamless dialogue between designer and computer will it be possible to fully exploit the potential computers offer to integrate a variety of disparate aspects and tools in a single medium and to enable networked working methods from spatially separate locations. To facilitate a more fluent dialogue, we are investigating the development of an ideal computer-aided design environment, both on a conceptual (Fig. 1) as well as on a technical level (Fig. 2). A core concept of this ideal framework is the seamless networking of various design tools and the interactive working methods this permits (Schneider and Petzold, 2009). This is the context for this paper which describes the
process of sketching as one example of an integral part of this ideal digital design environment.

2. Analogue vs. Digital

Designing can be understood as a process of inquiry in which knowledge is enriched through making things, experimentation and testing. The designer thinks through his or her actions which are in turn informed by perception and experience. These form the starting point for design thinking as well as for handling the tools used while designing. In the process, the specific qualities of the respective design tools play a central role, i.e. in how the artifacts are created and how they are perceived and processed.

Design tools exist in analogue as well as digital form. Each of them has different qualities, are used and perceived differently and accordingly support different mental and working processes. The advantages and disadvantages of both kinds of tools have been discussed at length and quite differently in various publications. In his book "analog und digital", Otl Aicher (1991) takes an almost philosophical approach. Given that it was written at a time when digital technology was first becoming more widespread and influential, he adopts a quite critical standpoint. He argues for “analogue thinking”, which he describes as visual and comparative, contrasting it to “digital thinking” which he describes as verbal, strictly logical and exactingly numerical. In his opinion, ambiguous, comparative working methods are more appropriate for understanding and assessing complex problems than the exacting rationality of digital processes. Gänshirt (2007) refers in his study of design tools to this differentiation and classifies them according to their mode of perception in visual (analogue) and verbal tools (digital). This differentiation can be traced to research into the function of the brain, according to which the different hemispheres cater for different ways of thinking: the left hemisphere controls the analytic, logical-linguistic thinking and operates linearly, i.e. in successive mental steps, while the right hemisphere prefers a visual-spatial, synthesizing and comprehensive thinking which takes place in concurrent mental steps. This division into distinct functions for the left and right halves of the brain is today regarded as an outdated. While modern brain research still presumes that certain brain regions fulfill certain functions, current research suggests that the two cerebral hemispheres interact in a more network-like, concerted manner (Squire et al., 2009). Both, the visual-
analogue and the verbal-logical depend on one another. It is therefore questionable how useful this separation is, aside from for classification purposes. It may be that we have to accept a consciously ambiguous distinction, not least in order to combine the different technologies, network-like with one another. In 2005, Parthenios therefore posed the question “Analogue vs. Digital – Why bother?” and sees the concurrent use of analogue and digital media and agile switching between the two as a synergetic process. However, it has to be noted that, on account of the increasing digitization of nearly all design tools, it becomes more and more difficult to actively sustain this practice of switching between the two, and not to succumb to a kind of “digital lethargy”, and with it the restrictions of the programmes. Attempts to create a computer-aided design environment should therefore aim not to separate analogue and digital, but to facilitate their interaction in a network-like coupling of digital and analogue technologies.

3. Variety and simultaneity in the design process

According to Donald Schön (1983), designing should be understood as a continuous dialogue between the designer and the respective situation. Schön describes this process evocatively as a reflective conversation between the designer and the virtual products (artifacts) of his work, and therefore an interactive process of feedback between designer and tool (Fig. 3). To allow the designer to continue his or her train of thought and mental activity, it is important that this dialogue is not interrupted unnecessarily. In addition, these processes often take place simultaneously at different levels of abstraction and scale. One moves freely between different levels of detail, parts of the design and the overall view. One cannot identify where analysis, synthesis and evaluation start and finish (Lawson, 2006) and, similarly, there is no clear separation between imagining, presentation and testing as these are all held together by the cognitive ability and empirical knowledge of the designer (Fig. 4). According to the authors, a tool or medium for designing will be more effective in externalizing invisible design thoughts if it can avoid creating breaks between these phases and activities and allows diverse aspects to be dealt with at the same time.

The computer has the potential to bring together very different aspects of designing in one single medium, to concentrate...
information, relate these to one another and visualize them from detail to the whole. A whole variety of different programmes can be used to create, for example, exact virtual building models, to carry out light simulations, to include the context in photomontages and to generate atmospheres as well as for many other things. However, the individual programs are in each case differently well suited for particular purposes, which is why it is necessary to use different systems. The use of many heterogeneous tools, however, implies a linear working process conditioned by the unavoidable need to import and export data. Changes in the three-dimensional model, for example, have no effect on the photomontage – the data has to be re-exported and the photomontage created anew. Although the actual content of the programs is closely related (Fig. 5), the individual artifacts are edited independently of one another, and culminate in each case in separate end products, each with their own file format.

Despite the fact that they exist in one and the same media, the different contents of the individual representations remain separate and are seldom related directly to one another. The ability to overlap information, however, helps us to quickly visualize complex relationships, to keep an eye on the overall relationships, and to experiment by overlapping different kinds of content. It is only partially important that there is a consistent semantic link between the different contents, as facilitated by Building Information Modelling Systems (BIM), as the logical combination of information takes place primarily in the designer’s head. By combining different relevant design and visualization technologies this process can be made easier, bringing about a playful, almost experimental interaction of different types of information from which new ideas can emerge. It is this seamless connection between different programs and types of content that we have attempted to facilitate with our experimental design platform (Fig. 2). In the following section we will examine sketching more closely as a design tool to be used in combination with others.

4. Sketching in the digital age

To begin with, one would be forgiven for asking why one still draws by hand at all. The computer can already generate images that closely resemble reality within a short space of time and if one is to believe recent discourse on generative design, architects
in the “age of the digital reproduction” (Kuhnert and Ngo, 2008) will soon be programming their buildings rather than drawing them (Fritz, 2002). But if we recall Schön’s “reflective conversation with the situation”, we see that when we use digital tools, this natural conversation is still hampered more than it is facilitated by various internal restrictions in the digital tools. Inappropriate hardware interfaces block direct manipulation, complicated software interfaces force one to follow certain sequences of actions to use them, and switching between different tools or media is complicated by the unavoidable need to import and export. As such, designing with the computer blocks the free flow of thought. When sketching, however, the hand, eye and idea are in a state of flow, mutually forming and informing one another. “The lines originate from the movements of the hand and between seeing and continuing with the drawing an entire cycle of action has taken place.” By contrast, “(...) computer-aided design breaks this loop and disassembles it into linear instructions – one’s hands are not agile but discreet: they give orders which allow a machine (algorithms), to emulate forms.” (Petruchat, 2001)

Thus sketches are and probably remain the most important and most commonly used tool in designing. They are used in nearly all design phases, whereby different thoughts and levels of detail can be present superimposed in a single sketch. On account of the widespread availability of the tools needed for sketching and its ease of use, sketching is best suited to visualizing and recording internal images which would be forgotten again after few minutes (Gänshirt, 2007). In addition, sketches mediate between depictive (visual) and descriptive (verbal) modes of representation, stimulating the perception and bringing to light unconsciously remembered knowledge (Fish, 2004). The vagueness of a sketch makes room for flexibility, allowing one to make certain decisions later on in the design progress without losing sight of the whole. Furthermore, a sketch may not only describes a single solution but can reveal whole areas of the solution space, something that is effectively impeded by the highly-detailed virtual models resulting from component-oriented CAAD-systems.

5. Integrating sketching in a digital design environment

The use of pencil inputs for controlling computers is not an innovation of our time as Ivan Sutherland’s first CAD program
“Sketchpad”, made in 1963, testifies to (Sutherland, 1963). In the last few years, however, this way of operating digital equipment has spread so rapidly that nowadays every mobile phone is equipped with such interfaces. In view of our habitual exposure to this kind of interface, it will only be a matter of time before every display is equipped with touch- or pen-based interaction technology. The success of these displays lies in the provision of a tangible interface and the more natural human-computer interaction it facilitates. So, Tablet PCs or graphical tablets also make it possible to sketch freehand on screen, dematerializing the medium. How, then, should this pre-digital design tool be integrated into a digital design environment?

In the field of information technology, research is being conducted into the interpretation of hand sketches so that these may be transferred automatically into models that the computer can evaluate. One crucial problem arises here in conjunction with designing, which is that sketches themselves serve as a means and media of interpretation. The potential of sketches lies not only in their clarity but in their high level of interpretability. If this is left to an algorithm, exactly one interpretation will be chosen – the one that best corresponds to the algorithm. The ambiguity of the sketch vanishes. Misinterpretations may lead to frustration, or to new dependencies: for example, a designer may learn over time to habitually draw in such a way that his drawing is properly recognized. This hinders the natural way in which thoughts are formulated and developed with pen and paper. While sketch interpretation may result in another, perhaps more effective means of input, it has not much in common with freehand sketching as a design tool.

As such, modelling via sketch interpretation only creates new dependencies. In addition, it generates only one exact variant from the multiplicity of meanings embodied in the drawing. As a result, we have chosen to pursue an approach that connects the old with the new as easily as possible, honouring the qualities of both while creating a connection between the digital and the analogue. In contrast to the value accorded to vague, analogous information during the design process, their incorporation into digital building models has been all but non-existent despite the fact that they are often faster and easier to produce, and very often also easier to read than precise digital data. In our concept, sketches should serve the function of a mediator, an intermediary stage prior to further editing stages. That means the role of...
sketching and the resulting sketch are maintained in their original form and stored in the digital building model in a purely visual relationship. The designer interprets and responds to the sketch as he or she will. These approximate, initial graphic statements can be transformed afterwards by hand (using other tools) into models. For example, a designer can quickly explore spatial configurations and record this for editing later or conversion into more precise geometry. The digital model becomes a sketch pad and the sketches in turn serve as a reference for the dimension-containing model. The analogue and the digital are combined into a single hybrid data structure.

In commercial systems, such sketching and annotation functionality is currently offered in the form of Design Review Systems, although these are conceived as independent tools which are not integrated seamlessly into the overall digital chain. Here again a division is drawn between presentation, design and evaluation which does not correspond to the continuous cyclic process of designing. This may explain why such tools are only rarely used.

6. Digital sketch book – a software prototype

To demonstrate and explore the potential of the theoretical elaborations discussed here, we implemented a software-prototype with the described requirements. Unlike commercial solutions, in our design environment sketching is integrated seamlessly alongside other tools in an overall digital building model. This means that the process of sketching is not obstructed by a “time-lag”, but that sketching can done directly and at any time in the digital model (Fig. 8). The integration of sketches into the virtual building model is achieved by linking two-dimensional content with the respective camera position. The stored data is purely 2D which, as discussed earlier, allows them to be edited more freely and offers more room for interpretation. As a kind of visual note, they serve as an intermediate stage for later development (Fig. 9), as well as a means for actively “appropriating“ the “lifeless“ geometry shown on screen. Ideas can be noted immediately wherever they occur, in other words directly on the “artifact” on-screen (Fig. 10). In addition, they are available to all persons involved in the digital design process.

The resulting sketches are stored in a “digital sketch book” that enables one to go back to previous drawings and edit them again. The drawings can be made transparent, layers can be added and
removed. Clicking on a “small-scale” sketch takes the viewer to the respective position in the model where the sketch fades in, superimposed over the model (Fig. 11). The designer can therefore navigate quickly between different views and their associated remarks and sketches. Using a personal linked image library, the designer can drag an image from elsewhere onto the sketch, much in the manner of working with layers in Photoshop (Fig. 12). As a result, photos of the surroundings or images of building references can be incorporated into the sketch and the model wherever they are relevant. These images are added as layers to the existing sketch and can be edited further with the usual image-editing tools.

This deliberately “vague layer”, which lies superimposed over the digital model like a sheet of tracing paper, makes it easier and faster on the one hand to try out ideas and thoughts without having to consider the complexities of software tools, and on the other, facilitates communication between the different persons involved in the project, because this information is more readily understood and more rapidly editable than the pure 3D-model.

7. Conclusion and outlook

The concept put forward in this paper of mixing analogue means of freehand sketching with the advantages of digital design systems leads to further questions. What emerges from this combination and what influence does this “ambiguous” layer have on the editing of precise digital data? Do new synergies result from it? Could it potentially mark a new relationship between the individual act of creating and the rational digital artifact? At the same time we also need to ask: What can digital sketching not achieve? Is the drawing or the sketch still a relevant medium for designing with computers or will new, generative, parametrical methods of modelling result in a totally different approach to designing in which the personal “signature” is replaced by programming and algorithms?

Figure 11: Camera path between different positions constructed from sketches
To sum up, we can state that the integration of freehand sketches into a digital design environment allows one to effect an immediate coupling of different technologies. On the one hand, this coupling makes editing more efficient by overcoming barriers between media, and on the other it improves the level of interactivity. Instead of passively observing what is shown on screen, designers are encouraged, through the ability to sketch, to actively engage with and to “take possession” and personalize the virtual products. This breaks down the authority of perfect digital representations and makes it easier to try out different thoughts and ideas. Working on a virtual model acquires some of the qualities and directness of working with traditional tools, with the added benefit of the possibilities of digital media. In this scenario, the digitization of the sketch makes it immaterial and the multimediality of the system makes designing transportable, supporting spatially distributed collaborative work patterns.

In future research work, we will focus on the interplay of sketches with other digital design tools. The intention is that digital sketching will be used as a clear, visual language that facilitates collaborative work in an open design process, and that can become a constituent part of generative tools for generating floor plans.
References