3D Crossover

From 3D Scanning to Digital Modelling, Rapid Prototyping and Physical Depiction

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Crossing over a variety of digital and physical media, creation and representation of an architectural design process can influence perception, comprehension and conception of spatial volumes within both physical and virtual environments. These tools then transform and translate the design process from virtual to tangible portrayal of architectural design and vice versa. Artists and designers pushed media to new interpretations of the media themselves and with that of their artwork. Using these potentials and translate them by employing current technologies we embarked to new understanding and communication of architectural gestalt, form finding and design process. Interchanging and merging design environments from reality to virtuality to an extent that the boundaries of each one are dismantled, both realms can be used together in an overall process that leads to alternative form findings and resulting designs.

Keywords: Form generation; design translation; design interpretation; design manipulation; virtual environment.

Context

Intersecting media and domains, the artist Man Ray expressed and communicated ideas in pictograms he called Rayographs (Figure 1 left: De l’Ecotais in 2002). In these, Man Ray ‘drew’ directly on photographic paper using light sources. Similarly, the architect Jørg Utzon and the artist Asger Jorn used virtual and real media to convey spatial designs. Emulating a painting by Pablo Picasso, Asger Jorn used a ‘light pen’ and photography to re-present sketches by Utzon (Figure 1 right: Weston in 2002). In the design process, architects use both physical and digital forms. The design of the Guggenheim Museum in Bilbao, for example, employed physical models that were translated into digital form (Figure 2: Bruggen in 1999). With the re-representation from a virtual to a real three-dimensional (3D) model, shape and design are translated in such a way that they fit into the new media’s characteristic. Previous research suggests that spatial creations of architectural volumes are enhanced using virtual environments (Schnabel, 2003). It appears that interactions between conventional and digital media are
multifaceted combinations of characteristics and possibilities introduced by each of them. Yet, the quality of design and the depth of its form-finding are directly linked to its representation, communication and collaboration (Kvan, 2002). Consequently if such characteristics and possibilities influence the reinterpretations that generate design information, then media interactions amplify the designer’s opportunities (Herbert, 1995).

Inspired by Utzon’s and Jorn’s expressive methods to move freely between different domains, we conducted a simple spatial design exercise. Architectural students were asked to develop a scheme using physical together with digital means to develop their design ideas. They engaged in repetitive interactions and reinterpretations of their designs from real to virtual and back to real. This process introduced students to a new approach of design-creation and form-finding (Schnabel et al., 2004).

By this way we wanted to identify how designers translate spatial volumes and communicate design ideas by using both Virtual Environments (VE) and conventional methods of 3D depictions such as physical models. Using those outcomes, we investigated how tools for design influence perception, comprehension and creation of spatial 3D compositions within both virtual and physical environments. We compared those results with works by artists, designers and architects, who also employed movement to design spatial compositions, to intersect a variety of settings and to create re-representations during their design process.

**Design Cycle**

We engaged students in a creative process of an imaginary design task that allowed a free generation and interpretation of form and space within an architectural context. There were no limitations since an important part of the whole exercise was the freedom of possibilities of each step (Brady, 2000). They translated, explored and manipulated a conceptual idea within the setting of a design studio using physical and virtual tools. An idea was to be transformed from real to virtual 3D environments and back in repetitive cycles. The students started using an object or other inspiration of their choice for their initial expression. They used a 3D-Scanner to translate their initial intention into a digital 3D model by either scanning the object explicitly or by moving the scanner through the air in order to ‘sketch’ three-dimensionally in space (comparably to Jorn, Figure 1 right). In a next step, the scanned file was manipulated using a variety of modelling software, including a haptic feedback tool. The de-
Design rendered into physical 3D form using a Rapid Prototyping (RP) process for further manual transformation. The model then could be re-scanned and the cycle was repeated as students refined their designs until they reached a satisfactory outcome. Finally the students presented their designs using physical models and digital projections showing the final outcome as well as the process they undertook to arrive at their result. Figure 3 illustrates the design cycle and its steps. The design cycle is described in more detail in Schnabel et al. (2004) and the outcomes can be viewed online at: http://3d.arch.hku.hk

**Impressions**

Architects explore their designs digitally and physically, using CAAD software, VE and employing physical media, such as clay, paper, cardboard, cutters and glue. Typically, these realms are treated separately as individual entities rather than integrated into a continuous process. We wished however, to link directly between these domains. One stage of the design cycle described above built upon the preceding step and opened up to the next following. Each translation offered students the opportunity to investigate further and recreate the design, each medium facilitating different acts of interpretation or transformation, which again were elaborated within the next phase. At every stage students moved beyond their initial forms of the previous phase and developed new concepts achieving new articulation of their design. The virtual representation of their work allowed them to study spatial compositions in a way, which they could not imagine of after choosing their object in the first phase and transforming it in each following phase.

This studio successfully dismantled the boundaries between real and virtual environments to an extent that both merged into each other. VE can be an environment for design distinguishable to and facilitating reality. Both domains were used and needed to achieve an overall conclusive design. A significant feature of this studio was the focus on multiple rather than single interactions that are always within three dimensions. Digital and analogue media introduce new aspects to the design and are neither neutral nor transparent. Interactions in different media confront the designer with unique objects that arise from scanning and model manipulation. These artefacts force the designer to return to previous interpretations of volume and space, and thus become sources for new forms.

Scanning, and the subsequent triangulation of the form, translated the physical model into an altered design. As Panepinto (2001) points out, similar to transformations from digital to physical realms accuracies and settings of the scanning process offer a variety of new design elements, which were not possible as such using other means: liquid conversions, faceted surfaces as well as manipulation of surface complexity or error generation are methods to reshape the physical model.

Previous research suggested, that spatial creations of architectural volumes are enhanced using VE

![Figure 3](image-url)
Consequently we asked students to transform their design using VE and its supporting software. In this way the design proposals could be examined in an inclusive, real scale and three-dimensional fashion. Thus the preliminary proposals could be re-represented and altered according to the intention of the designers.

Gibson et al (2001) advocate that RP plays a significant role in the design process that involves VE and that produce physical representations on demand. This translation can contribute to the communication and exploration of form and space within an architectural context. Yet, as Kvan and Thilakaratne (2003) noted: “RP models do not lend themselves to conversation as they are fixed in form and fragile in material”. In fact, the students could not modify their RP models following traditional techniques of model-building. Similar to the other earlier phases the students had to creatively adapt to the characteristics of this phase. Nevertheless, the physical models acted as the tool for communication and abstraction of the overall process of design.

Each of the phases is an essential part of the overall design creation and addresses only certain aspects of it. This enables a holistic dialogue about design, form, function and architectonics, which is significant not only within the architectural education, but also in all other dialogues involving spatial representations. It is surprising which creativity and spatial exploration of architectural forms and space these 3D transformations of our design studio generated. The quasi trivialness of the starting point of the design development turned very quickly into a serious dialogue of space, form and ‘gestalt’ (Arnheim, 1969).

**Crossing over**

There is a distance between the imagination of a design and its representation, communication and realisation: architects use a variety of tools to bridge this gap.

Most tools of VE are only used for presentation or simulation. Designing within VE, moving back and forth from and to reality, may minimise this divergence. This empowers designers to express, explore and convey their imagination with fewer differences. Unlike the digitisation of Frank Gehry’s models that are translated as a facsimile copy without any further design development within the new media (Figure 2 middle), the design cycle described above develops the design at each stage. It explored the opportunities offered in the transformation from one realm to another. The designers therefore could explore different possibilities of their designs that were unique to each phase. Each medium was investigated according its own strengths and weaknesses. The process of translation, such as scanning, became itself a creative act.

Design is an activity that is greatly complex, but influenced by numerous factors. The process may follow rules or established proceedings and traditions. Alternatively, the designer may choose to freely explore without need to conventions. In all instances the medium in which the exploration takes place will affect to some degree the act of designing (correspondingly to Jorn, Figure 1 right). For this reason the very different nature of each design environment allows architects to create objects that make use of the properties of the design environment that the other does not offer. For example the group OCEAN North dismantled those boundaries of each realm and employed a similar method as our design cycle exercise by exploring different media to achieve a design. In their design for the New York Times time-capsule a drift the group demonstrated how layers of digital movement around given physical objects determine the capsule’s unique gestalt (Figure 4 left: Hensel et al. in 2002). By using various media the final form is refined and produced with the help of RP (Figure 4 right: Hensel et al. in 2002).

Another recent example is the Paramorph Gateway proposal by dECOi Architects (Goulthorpe and dECOi Architects, 2003). The architects started with the existing base void of the site and then distorted the form not just parametrically but paramorphically.
in order to achieve a gestalt of patterns and rhythms of movement of the site (Figure 5 left). They treated virtual and real components of their design not separately, but as a whole. This resulted in a design that does not purely fit function, as demonstrated for example in Alvar Aalto’s Paimio Sanatorium (Figure 5 middle: Weston and Aalto in 1995), or gestalt, as mentioned in Gehry’s design (Figure 2).

Similar design methods are also used in other creative processes. Issey Miyake Design Studio uses digital animation to overlap material properties of a fabric with the movement of the human body. In the A-POC line of garments Pascal Roulin (2000) employed with his transformations both real and virtual tools to create clothing that lie outside of conventional fashion design (Figure 5 right). The design method included heat-cutting and chemical shrinking of synthetic fabrics, positioning of buttons employing digital animation and morphing of the cloth both virtually and real around the body. Each step was created in a separate domain and design phase, but building upon each other to reach the final design stage of a person wearing the outfits.

Design cycles and crossing over media or domains are methods regularly reinterpreted and applied by artists. Such as Herbert Matter created a short film over half a century ago on the artwork of the Artist Alexander Calder (Figure 6 left: Calder in 1974), based on cinematic techniques he merged movements of Calder’s mobiles with sound elements using John Cage’s interpretation of music (Figure 6 middle: Migayrou in 2003). Applying those understanding of crossing over realms (shape, sound and animation) John Maeda (2004) translated 2D shapes within his experimental Parametervision. Here digital representations of figures constructed by a 2D parametric system can be viewed in a single image plane and at the same time understood spatially (Figure 6 right).

Correspondingly to our design experiment these samples illustrate how non-linear design processes and re-representation of an idea can lead to new designs and expressions. The exploration of the gestalt within both environments enhanced the understanding of spatial issues and led to meaningful and new architectural results. Despite the fact that 2D representation of 3D space is the pre-dominant medium to understand and communicate spatial arrangements, the designers’ comprehension of complex volumes is enhanced by the re-representation of a 3D medium.
Conclusion

Exchanging 3D tools and elements of physical and virtual environments in an experimental design studio proved to be successful. Students created, transformed and re-interpreted complex spatial designs by manipulating them within 3D space. A series of solutions of both environments generated together understandable and rich spatial designs. We learned from our experiment that boundaries between the physical and the virtual can be dismantled and that these environments do not need to be treated separately as individual entities. The crossover between both realms allows a different approach towards design creation, exploration and communication.

Our method is not totally new. Artists and designers always pushed media to new definition of both the media themselves and with that of their artwork. As Man Ray (Figure 7 left: De l’Ecotais in 2002) explored with his photographic method the boundaries of a medium, he arrived at new techniques that allow a different understanding of movement and space. Also Frank Lloyd Wright’s Guggenheim Museum (Figure 7 middle) demonstrates how architectural design is not limited to a certain way how we understand and perceive buildings in design, gestalt and function. Using these potentials and translate them by employing current technologies we embarked to new understanding and communication of architectural gestalt, form finding and design process (Figure 7 right). For example in our case, the 3D Scanner became a sculpting and sketching device, rather that a copy or explicit translation tool. Reality was expanded into a new dimension without being duplicated, while virtuality became its own reality that compliments physical realms in its own rights.

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