CROSSING THE MEDIA: An Experiment in the Digital Analogue Borderland

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Abstract. An open-ended, diversified and critical approach of architectural design, using different form of ideas representation might offer best chances to gain new spatial solutions. Today's most forward architects and designers are aware of this and make full use of physical and digital media during the process of design. During the summer term 2004 the experiment 'Crossing the Media' took place at the Technical University of Braunschweig. The main goal of this practical oriented seminar has been the exploration of the interface between *analogue* and *digital* media within the design process. Both techniques, *analogue* and *digital*, were used in an experimental way and their interaction and adaptability in the field of architecture was analyzed.

The work examines the possibility of a consistent integration of digital and physical representation in a design process and the individual benefits of each. In order to achieve this, we made up a stringent line of digital-analogue and analogue-digital (DA-AD) technologies for our design experiment.

During the examination we focused especially on the creative potential of the techniques used, their interaction and adaptability in the field of architecture. Hence one of the goals of the occupation with the digital analogue interfaces was the examination of the emerging shift within the structure during the process, the imprints of technology

This paper describes the workflow and tools that were used, our practical experiences with analogue digital interface and the emerging questions and impulses to architect future work and theory. The discovered limitations and consequences of interfaces between the analogue and digital realm of design and their creative chances will be revealed. We share results which we think may be helpful to others, and we highlight areas where further research is necessary.

1. Background

Although the field of architecture, as late adopter of new technologies, established first digital workflows some 20 years ago, these are still not fully implemented in today's practice. This might defer of the size of buildings or not suitable tools—yet mostly existing traditional work processes have been transferred into digital

ones. Today most digital tools deal with the technical, representational and administrative part of architectural processes—not creative ones. This part of design and tools seems to be underemphasized. The creative implications of new tools and technologies, like the 3D surface-modeling software and Rapid Prototyping, are only partially used.

At the same time, improvements in rapid-prototyping and 3D-scanning technology pave the way for a better integration of analogues and digital design processes. The principles for a self dependent handling of this multitude of methods and technologies can only be taught within the architecture-formation. The experiment 'Crossing the Media' has to be seen as an approach.

2. Introduction

The experiment is based on the presumption that it is possible today to transport digital projects into physical models, edit them and transfer them back into editable digital data.

A linkage of the digital and analogue design processes seems obvious as each has explicit advantages, offering huge chances for the architectural design.

TABLE 1. Aspects of physical and digital representation of designs.

	digital representation	**physical representation**
pro	-Massive Transformations and Mutations in design are licit (Deformation, Parametric and programmed Design)	-Modifications can be executed instantly with familiar tools -Shifts in design are physically sensible
con	-Information is represented in abstract way -Shifts have to be done within complex Interfaces	-Massive shifts in design result in Destruction of model

As the transition between the medial representations was the main goal, interfaces linking the worlds were of highest importance. As former work has shown, these interfaces act in an ambivalent way. On one side, those links are not free from losses and problems as Ucelli et al., (2000) Petric showed in several publications, on the opposite side those can be interpreted and enhanced as creative chance, especially if forced to (Schnabel et al., 2004), to gain access to coincidence and intuition, naturally unusual in the domain of CAD. This knowledge might lead users to interact in a different, more creative way with IT-technology.

Crossing the Media tried to connect a great deal of transitions, to gain a significant density of transformations—the difficulties with interfaces were made to a point of special interest. The evolving complex problems should exceed the technical level and lead to a deeper understanding of terms and consequences for architectural concepts.

As appropriate, elements such as field trips and three lectures, dealing with the theoretical aspects of surface, volume and space in the field of computational architecture, have been positioned in the seminars course to support the textual architectural layer. This should allow a discourse and a comparison of knowledge, based on theoretical excurses, experiments and on practical experience.

2.1. SET UP OF EXPERIMENT

The experiment was undertaken in a seminar for students experienced in the field of CAAD. Thus the course could focus on aspects, referring to Digital Analogue Interfaces (DAAD). To enhance the students' understanding of this interplay, the underlying techniques and to enhance the students' motivation a playful approach was chosen, consisting of a continuous chain of DAAD transitions. In order to inhibit distraction by spatial and known architectural questions in the course action, the use of a spatial-based exercise was abandoned in favour of an object-based approach, which was new to most participants.

The setup of the transitions chain was based on three principles:

1. **Establishment of a design cycle**
   The creative use of technology was the experiment's main focus, significant creative input has to evolve out of each transitional step. Thus a significant and creative change of data could be achieved by the interface itself, the handling of data, arising from the interface (e.g. polygon reduction after 3D-scanning) or an intermediary step of transformation in the physical or digital realm. For example oversized amounts of data were reduced with different technologies or insufficient data enriched with new information to access a new level of evolution.

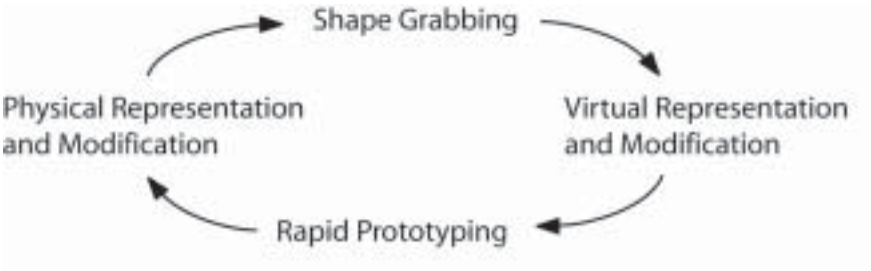


Figure 1. Design Cycle (Advancement of Design Cycle by Petric and Maver, 2003).

2. **Didactic proceeding**
   Basic technologies where introduced at first, giving a fundamental understanding of methods, which could be seen in the technical mature processes in the later part of the seminar.

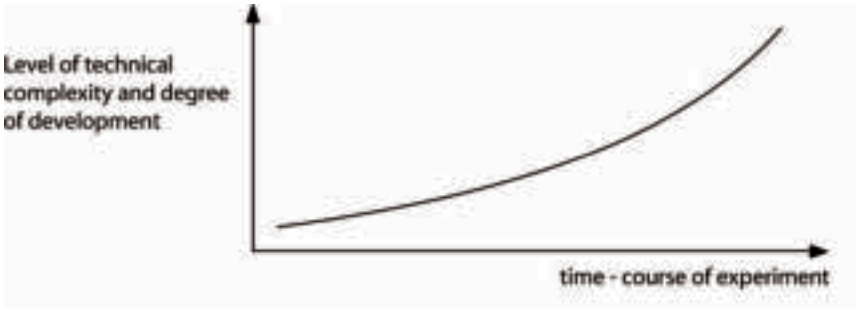


Figure 2. Didactic proceeding of experiment.

3. **Flexibility**
   As the correct functioning and course of the different DAAD processes could not be pre-emphasized, the course of the seminar was planned in an open way, to react to possible setbacks.

3. Process

According to the aforementioned principles, a course was set up. The start into the sequence of DAAD transitions was made by an exercise, which can be considered as example of the addressed interplay.

At the ETH Basic course Design 1+2 of Angélil et al. (2002), two movies of dance sequences where handed out. The characteristic, dynamic course of motions had to be analyzed und reinterpreted three-dimensionally. Each student had to present a gypsum sculpture, done by cast, the belonging formwork and formwork drawing.

Figure 3. Clip from presented movie and samples of objects created in step 1.

Two different approaches emerged in this step:

- A part of the students developed the sculpture via CAD or 3D-modelling software. Afterwards the object was sectioned to create a layered formwork. If the limitations of this production process were kept in mind, the object was similar to the virtual archetype.
- Others created the sculpture in an intuitive and experimental way. This led

to greater variety in terms of configuration and formal expression. An approach to the final form was made via mock-ups. The demanded documentations of this complex forms could hardly be made afterwards.

In this exercise it became clear how easily complexities were achieved, which exceeded the possibilities of classic ways of representation.

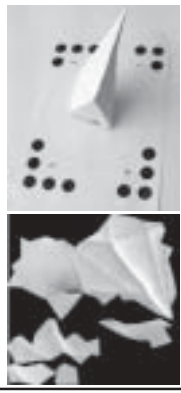
Alternative ways of representation and treatment were presented in the following course of the experiment :

TABLE 2. Steps and insights of the experiment.

analog digital realm	step	Perception	Output
	Dance Scene Abstracting of a dance scene into a gypsum model	Different approaches emerged in this step, see above. Easily complexities were achieved, which exceeded the possibilities of classic ways of representation.	
	Contour scanning 3D-Scan via experimental assembly of contour scanning technique (Institute for Computer Graphics TU-Braunschweig)	Changes in the scanned geometry, caused by the experimental assembly, occurred. In relation to the original sculpture and its complexity these shifts were perceived as abstraction or mutation	
	Folding Out of the contiguous polygonal shell, created before, a sheet blank of the body was created using Form Z and polygon reduction tools, in 3D-max, cinema 4D or specialized software like rational reducer	Complex bodies led to inscrutable sheet blanks. An obvious solution was the reduction of polygons, to gain manageable structures. Just bodies, which were simple from the beginning, could be reproduced exactly with this technique. Normally the reduction implicated even the loss of the raw three-dimensional contour. Anyhow it was fascinating to reduce the objects to a kind of essence and imply with this kind of abstraction something like coincidence into the three-dimensional code	 
Lecture: Surface in the computational realm			
	3D-scan The UZR-3 software can retrieve nearly every object three-dimensional with	The result of the UZR-software were quite good. Massive shifts, resulting from the scan process, have not been noticed. In consequence of the	

common digital cameras. Besides 3D-meshes the object's material is transported by the calculation of UVW-Textures

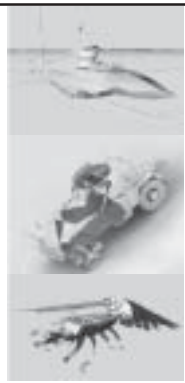
technological approach UZR encounters problems with the coverage of undercuts and interior spaces. Solely the reproduction of the originals surface via a texture makes the scanned object look very realistic. It could be very interesting to create a three-dimensional mix by sampling objects during the process of scanning.
Anyhow, during the last steps most of the object's initial information was lost.



Lecture: Volume in virtuality?

Virtual Input Boolean
In order to show a computer immanent transformation the 3D-models were merged with more detailed ones in a process of Hybridization using Boolean operations.

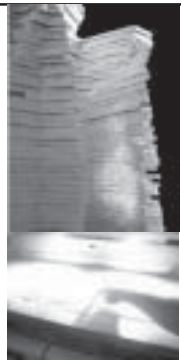
This first step of Transformation in the digital realm proved good and gave an understanding of digital tool's possibilities. The hybrid models showed a very high complexity.
Concepts, like the volume shadow models of Ernst j. Fuch's "Data Field" Zirl (1998) or Hendrik Mauler's work "Kontaktschmelze" (2002), present a new understanding of volume in the 3D-space of computers and inspired this step.



Guest Lecture: Nic Drews- Volkswagen AG - State of the art Design Workflows

Slice Modelling
Meant as an introduction to the concept of today's Rapid-Prototyping technologies, a technique using stacked sections of the 3-models was introduced (material Styrofoam)

The 3D-programm's form-z, rhino and 3D-max performed well, as these applications can apply sections freely to 3D-objects.
Accurate models were made, if a fine division was chosen. As the amount of work for those was quite high, most of the students chose a low resolution with strongly stepped surfaces. This led to aesthetic results. Undercuts and complex surfaces could be build.
Associated professional techniques, as Laser sinter, stereo lithography or other 3D-plot techniques have been seen during an following field-trip.



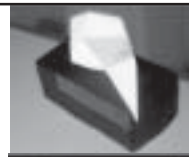
Displacement Mapping
Based on digital photography of the models, 3D-

As shown by groups like DECOi (1998) this technique can be very impressive when using dynamic or

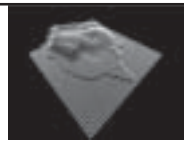
reliefs were made and exported as dxf file (software: cinema 4D, 3D max)	parametrized elements as basis for the deformation. The step of converting the displacement maps, which are usually just calculated while rendering pictures, worked out well using plugIns for 3D max or the relief object in cinema 4D.	
Milling Having introduced the folding of surfaces and the additive assembly of objects, the subtractive method- as third approach was introduced+ using a 3axis cnc milling machine.	The analysis of the milled foam material showed the high shares of craftsmanship within milling techniques. The final result is influenced by material, milling-strategy, size and speed of the milling cutter and several other parameters. Complex models with undercuts or hollow bodies can only be produced by more complex machines and processes. Anyhow this technique is able to produce stable models of nearly any material, which is not possible with any other method used in the experiment.	 

Field Trip: State of the art Rapid Prototyping (rpm)

Field Trip: State of the art 3D-Scanning and Industrial Design Processes (ipm)

Surface Scanning A 3D-scan technique called Single-Stripe-Pattern-Illumination-Method was used. A pattern of lines is projected, from the curvature of lines a software calculates the object's surface.	The advantages of this contact-free technique are the shape grabbing speed of 50Hz /second and the. Disadvantages are the inability to recognize some curved surfaces and sudden surface changes. High resolution scans have been made. For evaluation reasons, those scans were superimposed with the relief's source data. As only minor differences appeared, the established workflow from digital to analogue and back was a success in this field (Remondino, 2003).	 

Lecture: Objects and Interaction in virtual Space

Intelligent particles The surfaces of the last 3D-scan were used as the starting point for particle transformations. The paths of particles movements were frozen into new 3D-objects.	Via particle simulations new spatial constellations could be created. Depending on the choice and configuration of parameters manifold manifestations and little similarity with the starting object emerged. The 'misusage' of computer technology turned out to be of higher	

	creative, than the purpose the software was made for originally (physical simulation or panic simulations in buildings) (Bandini et al., 2004; Robertson, 2004).	
DAVE The conclusion of the seminar was held in a 4sided active stereo virtual environment showing VRML models of the last step. (Fellner et al., 2003)	Even though not all the students managed the visualization in the dynamic-simulation of the DAVE, it was impressive to spatially perceive and walk through the 3D-models. Nevertheless problems with the VR interface, display quality and movement showed that VR technology is not technically mature, altogether a medium offering high chances to communicate spatial design.	

4. Evaluation

4.1. METHODOLOGY

The approach to teach the contents in a linear way of directly interdependent seminar-units turned out to be right. The unit's haptic approach eased the understanding of the partially very complex and theoretical contents. The alternation of practical and theoretical parts enhanced the participants' attention.

Inconsistency occurred within the linear conception of the seminar units because a direct reference could hardly be archived in some parts (e.g. before the step displacement mapping). Furthermore, the topic of digital and analog interfaces in the third stage of the experiment seemed a little far stretched—nearly the same insights were made in different technologies.

A further technical problem arose in the beginning from the chosen experimental technologies. Though the underlying principles of shape grabbing and RP-

Figure 4. Paper Shop by experiment's participant F. Sudfeld (Sheet Blank Technology).

Technology could be placed impressively, a lot of the original objects details were lost. It took the step of hybridization to make the objects detailed again.

In the long run the main goal of the seminar was that the students discover potentials for innovation and self-dependent ongoing work. This was achieved to an impressive degree.

Students working at the same time in a design class at the institute used the new techniques for their designs.

4.2. TECHNOLOGY

The concept of using many different programs to accomplish an objective stood the test. Basic functions of up-to-date software are easy to use. The course concept reflected today's demand for special abilities in the control of interfaces; favouring the opening of working communication Channels instead of the perfect control of few fields of activity or programs.

Although it would have been beneficial to broaden the used technologies (e.g. with Laser Sintering, 3D-Plot, Stereo Lithography, Stereometry, Form Grabbing using manual scanners), according to the author's experience, the experiments insights might be generalized.

TABLE 3. Insights to Shape Grabbing and TP-Technology.

Shape Grabbing	• Lack of ability to scan inner spaces, makes advance use for architectural design difficult. • Scan process tends to pile up large amounts of unorganized polygons, impeding reasonable use of data for further design.
Rapid Prototyping	• Large-scale models, which are necessary for design evaluation, are still far too expensive for use in design everyday environment. • Uniformity of material and lack of physical appearance lowers model's intuitive statement. • Techniques like unfolding force the use of a kind of economic design, which might reduce late cost. Other RP technologie's ability of minute but somehow dull representation of digital models, further an academic and abstract view on design.

5. Future Prospects

Evaluating the possibilities not only opened up a whole new world to the participants, but new and exciting insights and perspectives unfolded for the future work at the department.

Today's computational tools are only used to a small degree for the creative part of design. The sampling of different software and plug-ins makes the potential of innovation accessible. Activating these potentials requires either a very naïve

acquaintance or an undisguised professional view, consisting of a high level of knowledge and coexistent critical distance. In the future this could be systematically developed.

With some efforts it is possible to gain exact reproduction of geometries using 3D-scanning and rapid prototyping devices. These technologies will be enhanced in the future, giving less space for creative interaction.

As the technology improves, the workflows and dependencies of interfaces are still to be identified properly. The implementation of virtual techniques, as the DAVE, scan and RP-technologies offer new and intuitive workflows of high creative potential.

As the seminars experiment with the creative potential of mistakes and fuzziness, might be eliminated by future developments. The source for further inventions lies in the field of computerized 3D-manipulation. By creative usage, sampling, arbitrary interference, accidence, the use of parameterisation or analyses of new ideas and concepts arises. Great potentials are about to unfold to develop and give new relevance to architecture.

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