DESIGN MEDIUM - DESIGN OBJECT

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The impact of computing on architecture receives little reflective judgment, its role either being negated or over-emphasized. To one group of architects, it is not desirable that the machine should influence the object. Another, mostly younger group, takes the impact for granted, without much reflection on its underlying reasons. The smallest group - mostly in academia - is interested in actively defining the impact of computing on design and in defining a new kind of architecture. The paper will explore the relation between computer and architecture on three levels, in which the machine has the role of an instrument, a medium, and a partner. It will demonstrate a serious deficit in education regarding the new roles of computing in design.

1. Status Quo

At the end of the first phase of computerization - employing computers as tools - we find office automation and CAD software in each and every architecture office. The second phase of computerization and networking - employing the computer as a medium - is about to begin. One is surprised to find so little hard data showing the effects on architecture caused by the most capital intensive investment since design offices exist. Contradictory statements such as „The machine has a tremendous impact“, „Computers have no impact on my thinking or design“, „We tried computers, it did not work, so we went back“, are well known. In spite of architects working with computers at various stages of the design, it seems that they have - with few exceptions - little or not changed the design object to date.

To measure the impact of computing on architecture, at least two criteria are of interest. The first criterion is the visible influence on the built environment. It could be measured by comparing projects and built structures before and after the use of computers, based on buildings of similar size and purpose by the same design office.

The second criterion is the impact of the medium on design education. This can be observed - albeit incompletely - by studying yearbooks and studio reports of architecture schools. Most of the schools produce the documents digitally, but in spite of massive increases in the use of the computer in the studio, they contain only little final work produced with CAD (Rowe, 1996). It might be that the computer contributes during the
design process and that CAD output is not used in the final presentations due to time pressure or graphic presentation standards, but it is certainly astonishing, how little inroads computer presentations have made in education.

2. Computer Evolution: Tool, Medium, Partner

One reason for the lack of observed impact of computers on architecture is that, opposite to the intentions of many CAAD pioneers, computerization has taken a much more brutal course than originally anticipated. Certain terms make this clear: office automation instead of office work support, and drafting automation instead of intelligent drafting support (see the software name AutoCAD, for example). Computerization followed the lines of automation earlier this century. Computers today are used as tools, replacing mental work as machines replaced physical work. This era of replacement is coming to an end because of the high degree of automation achieved already in post-industrial society. The era of the computer as a medium is beginning and will be followed by that of computers as partners.

For simplification, the term computer will be used for the entire working environment, consisting of hardware, software, and network. In most languages, the computer is treated as a living being rather than a lifeless object: a work horse, an enemy, a friend, and many meanings in between. If common language is an indicator, the computer is already considered as a medium and will be accepted as a partner soon. This is an expression of hope, given the quality of today’s design software and hardware. Whereas the next evolutionary steps of computer environments seem to be clear for research and parts of practice, education has recently concentrated on teaching mainly the tool aspects of computers. Widely abandoned or forgotten are the previous attempts to use the machine as a medium by supplying it with design strategies, ranging from shape grammars to case-based reasoning (Schmitt, 1993). This is where architectural design education should place more emphasis.

3. The computer as a tool or instrument

The computer as a tool or instrument has been most successful in terms of efficiency. One reason is that a clear paradigm or Leitbild exists for this purpose. Yet the definition of the computer as a mere tool does not take into account that it not only emulates office instruments, but that it also simulates new design instruments unthinkable without the computer. This instrument can quickly turn into a self-generating and self-referential system.

Werner Oechslin in his essay *Computus et Historia* describes the close relation between instrument and architecture, in particular between computing devices and design thinking (Oechslin, 1993). One can observe that today’s technically highly developed physical
and intellectual instruments have gradually replaced the philosophical instruments and measuring devices in classical antiquity. But similar to antiquity, control over the instrumentarium is restricted to a small percentage of the population. A few understand and develop, the others apply and execute.

Many architects, made nervous by the emergence of the new computing environment, found solace in the hope that the computer was *just* an instrument. In the early days of transition from the industrial to the information society, this may have been correct. But this view of a computer can correspond to a regressive *Leitbild*, associated with a large number of problems: A computer tool under a regressive *Leitbild* must prove itself in eliminating previously human activities with less cost and higher quality. While this might be a goal for short term gains, it is a dangerous development in the long term. If one considers the computer as an instrument only, it must pay for itself in that it perfectly replaces activities that were previously difficult or boring or expensive to achieve. Examples are word processors, when seen as replacing secretaries; spread sheets, when seen as replacing calculators; CAD programs, when seen as electronic pencils; office automation programs, when seen as a collection of desktop activities; rendering programs, when seen as a way to impress clients. Those instruments pose the problem that they directly aim at eliminating expensive human labor. Even worse from an intellectual standpoint is that human skills are directly transported to the computer which is then „personalized“ or „humanized“. The computer becomes the repository of activities that were once human. Because machines cannot yet reason about, improve or question their own activities, it also implies, that these activities are then frozen in their present state. With this, the computer could become a retarding, regressive instrument that hinders progress.

4. Example: Useful in the Office, Useless for Design?

There are positive examples of using the computer as an instrument, supporting and strengthening a particular design method: A design method being the overall problem solving strategy, and the instruments, in a subordinate role, supporting that method (Schmitt, 1993).

Jim Glymph, principal with Frank O. Gehry & Associates, reported on the past, present and future use of computers in the office (Glymph, 1997). Frank Gehry’s office is a positive example of using the computer as an instrument to strengthen a particular, already existing design philosophy. As Glymph pointed out, the earlier, small scale work of Frank Gehry showed many of the characteristics of his later buildings, but it was the intelligent use of the computer that enabled the actual physical construction of these designs on a large scale. The machine contributed to the constructability by acting as a communication and translation instrument between architect and contractors, and as a CAD/CAM instrument for the material producers. Glymph countered the repeated questions concerning the dependency of the office on a particular solid modeler with the
statement that the software was only selected after the fields in which it could be helpful were decided on, and that the software could be changed in the future. He also used the expression of computers as electronic pencils and remarked that they were useless for design at present - a statement that is logical and correct if computers are seen as an instrument only.

Hans Kollhoff has employed the computer as an instrument for visualization and communication for several years. The machine has influenced the presentation and delivery of his work. He used telephone lines early on to transfer files between Berlin and Zürich and employed artists from other fields to produce computer generated videos of his designs. But, as in Frank Gehry's case, he uses the machine to strengthen his particular design philosophy and position, rather than being influenced by it. For him, the machine is just another tool.

5. The computer as a medium

A medium is more than a tool or a method. It is an interactive counterpart, not necessarily an intelligent being, but something that has to offer knowledge and capabilities in the area we are interested in. A computer aided architectural design environment, equipped with the necessary components and in cooperation with a competent designer, can achieve the status of a design medium already today. In this case, we can enter a discourse on the level of a medium that will not take away work from us, but that will allow us to deal with the important questions of future architecture more competently.

Architectural design must be more than playful interaction with geometric forms, supported by increasingly more attractive computer tools. Architecture must use all available technology on the best possible level during its creation. Architecture today does not suffer from too much technology, but from the inappropriate application of it. It cannot be the Leitbild for the computer to design the most complex artifacts of our civilization with drafting programs under the electronic pencil paradigm. The missing competence in realizing and controlling certain actions and relations in the building process must not serve as an excuse for retreating to a position of decorating. Should architects keep and improve their role in the building process in the future, the computer must achieve the role of a medium that supports designers in areas were they do not have sufficient knowledge or competence themselves. The most obvious application for the computer as a medium is simulation. More advanced applications are computer supported methods (Schmitt, 1993) and agents (Schmitt, 1996). This is where university education in architecture should place more emphasis.
6. Example: Phase X

Phase X is the first design course at ETH Zürich using the computer as a medium. It is the newest in a series of network-based teaching experiments which involved more than 600 students since 1993. Its purpose it to pose and explore fundamental questions concerning design, modeling and authorship. Phase X expands the idea of the paperless studio by building more-dimensional computer models, by networking the designs and by focusing on abstract concepts such as Types & Instances (Madrazo, 1996). Adding new modeling instruments such as Sculptor (Kurmann, 1996) offered students additional opportunities to explore different design approaches, based on playful interaction with design objects. The complete description of the results can be found under http://caad.arch.ethz.ch/teaching.

![Figure 1. Snapshot of the Phase X InWorld interface. Parent design from the previous phase on the left and children designs on the right of the object. F. Wenz, F. Gramazio, U. Hirschberg, C. Besomi, B. Tunçer, 1996.](image)

Phase X treats authorship in a way that is only possible in a networked, cooperative design environment. After each phase, students do not proceed with their own design but continue with one produced by their colleagues. In Phase 1, they choose from three
different designs as a starting point. After saving the results they designed based on those examples into a data base, they are made public to all other students. In Phase 2 and in all following phases, students can choose freely from the examples in the data base. They check out a design and continue to work on it. Students progressively refine the objects in the following design stages. The end result are complex objects with shared authorship that can be traced back to the contributing authors and co-authors. As a result, two important views of the process and the products developed: InWorld and OutWorld.

![Figure 2. Left: View on a two-dimensional presentation of OutWorld. Each horizontal bar stands for an individual design. Diagonal lines depict the path that students chose from phase to phase. Right: Three-dimensional view of the same data base. F. Wenz, F. Gramazio, U. Hirschberg, C. Besomi, B. Tunçer, 1996.]

InWorld describes the perspective of the participant from within the structure of the experiment. The Interface supporting the creation of memes placed the observer and designer into an introverted position. He can only see what is directly before or after his design: its parent and its children. He is caught in the system in a genetic tree structure, without horizon or perspective. Only navigation from one branch to the next sheds some light on the system structure. The relations between objects, although rigidly maintained by the data base, remain subjectively connected only through the memories of individual images and models. InWorld is the plane on which design ideas were developed and stored. Phase X objectively keeps the memory of the individual designs and makes them available in real time. Out of this develops the OutWorld.

OutWorld is the name for the presentations that develop from the entire data set. Based on these overviews, cross comparisons emerge, assumptions and theses can be studied. The OutWorld replaces the sequential view of the InWorld with a parallel view. The interface produces the presentation - consisting of lines and surfaces in three-dimensional space - in real time. The different overview presentations give partial objectivity to the OutWorld. The observer influences the views by choosing parameters (see figure 2). More than 700 student works from one semester form a large quarry of design data. Together, InWorld and OutWorld form an environment that could not be created or exist
without the computer. They are therefore an example for the use of the computer as a medium.

7. The computer as a partner

Architecture in the information territory is a radical alternative to existing, physical architecture. In this territory, information is the raw material and the only reality is virtual reality. The computer is at the same time instrument, infrastructure and design environment. It has received a role as a partner that is able to accept responsibility and is able to execute certain tasks independently.

Design in the information territory will rely on similar methods and instruments as traditional computer aided architectural design. Methods are in particular abstraction, generation of models, and simulation (Schmitt, 1996). The instruments made for the information territory include more abstract capabilities than those for traditional CAAD. But contrary to using a computer in traditional design, the creation of physical structures is not the highest goal. Rather, the goal is to overcome the typical shortcomings of physical architecture. Results could be the elimination of the energy consumed to build and maintain physical buildings, and the reduction of transportation energy. At the same time, the advantages of personal meetings between people and of physical architectural environments must not be lost.

Design with the computer as partner is a mental activity in which computing offers methods and instruments absolutely necessary in the information territory. In this mental modeling territory - a human invention - the designer meets computer based modeling instruments that are also human inventions. In this abstract world of ideas, man and machine can achieve a high degree of compatibility. This can lead to drastic improvements of the design process and ultimately to better design. Working in the information territory must not involve a humanization of the machine or a computerization of humans. Rather, it is a neutral, abstract territory to which both man and machine have access. In this environment the computer is a natural, intellectual instrument. Without it, certain tasks are as impossible to achieve as an eye surgeon could work without a laser instrument. Although the eye surgeon has neither built the machine nor can service it, he has to rely on it.

8. Example: TRACE City

The design and construction of a new city in the information territory is certainly an occasion where humans and machine must interact as partners. The opportunity for this experiment came with the exhibition The Archeology of the Future City that opened in July 1996 in the Museum of Contemporary Art in Tokyo (Tokyo, 1996). Florian Wenz and Fabio Gramazio developed TRACE, an interactive computer installation. There was
different ways. TRACE is not a simulation, although it uses methods and instruments of simulation. It is, in the sense of Jean Baudrillard, a substitution of the real (Baudrillard 85).

One enters TRACE through one of many possible variations of public_out.world (see figure 3, right). The navigation space consists of a deformable, closed volume (blob), generated by a single nurbs surface, that in its ideal state has the shape of a perfect sphere. The actual form of the blob is defined by a fluid balance between pulling and pushing forces, which press as symbolized Internet sides on the control points of the surface. The visitor moves on the surface similar to the movement on an artificial landscape, without having to understand the actual form of the blob. This illustrates two basic properties of information space: as three-dimensional coordinate space, the system is scaleable, but in contrast to this general feature, it is formulated differently in certain areas. Because it always leads back to itself, it has no noticeable external limitations such as a beginning or an end.

In contrary to public_out.world as complex superpositions, private_in.world is specific and seemingly simple. Here, the geometry generator translates traces of previous visitors in a network of containers with connecting corridors. Containers hold one unit of media (image, sound, model or text), while the connections contain a specific pattern of movement (straight, zigzag, up and down, curved). The user is caught in this labyrinth and navigates through it by moving continuously forward and by choosing in each container one of four options: straight ahead, back, right or left. If he moves back, the system will stop the generation cycle and will produce a new public_out.world which now contains its previously created traces. A more complete description of the TRACE environment can be found under http://caad.arch.ethz.ch/trace.

9. Tool - Craft, Medium - Abstraction?

Analogies exist between the products originating from the computer used as a tool and the products of craft, and so do analogies between the products of the computer used as a medium and the products of abstraction. The interdependencies are complex and not causal. Malcolm McCullough in his book Abstracting Craft (McCullough, 1996) treats in-depth the fascinating relations between hands, eyes, and tools in the human context; between symbols, interfaces and constructions in the technological context; and between medium, play and practice in the personal context. What clearly emerges is the role of digital craft as an entirely new field which could elevate the architectural discourse to a higher level of abstraction than ever before.

With the computer increasingly assuming a role as a medium, several terms important to architecture must be expanded or re-defined, in particular material, structure and firmitas. The conclusion of a discussion on firmitas in November 1996 between Mario Botta, Roger Diener, Frank Gehry, Jacques Herzog and Jean Nouvel at ETH Zürich was
- not unexpected - that firmitas is not a function of the physical building material, its thickness or weight, but rather a conceptual and structural property. As the essence and quality of architecture depends on its structure and material, an expansion of the definition of both terms is needed. The definition of material must include information, the definition of structure must include organizations possible only in computer networks, and the definition of firmitas must include stability and character in the emerging information space.

10. Conclusions

Computers used as instruments act as amplifiers: They help to perfect known tasks, they enable to expand on existing theories, and they support strong personal architectural and design philosophies. On the negative side, modern software overpowers weak philosophies with default assumptions not generated by architects but by developers with other agendas. Computers used as tools tend to eventually replace all activities and tasks that can be automated.

Computers used as a medium create the unexpected in cooperation with human designers. Genuinely new findings may develop from this, as the Phase X experiment has demonstrated. Here, the entire design object has become much more than the sum of its parts. Employed as a medium, the machine can influence the architectural product to a degree that the question of ownership must be re-defined. Because of the combined competence of program and designer, it can lead to better architecture.

Computers as partners are the least explored area but it is safe to assume that this constellation will make most sense in the information space. Here, machines and humans can interact meaningfully, and the design objects will have a higher information content than physical structures. In the information space, the influence of design medium on the product will be strongest.

As long as computers do not influence the architectural design process, their impact on built architecture will be minimal. As soon as a partnership between architects and computers develops, the impact will become visible and result in an improvement of the built environment. Increasingly, a digital architecture emerges that can only exist in the information territory. Whether we like it or not, this architecture will not be designed by architects, unless we rapidly begin to educate architecture students for this task. This implies that architectural education should less concentrate on teaching computers as tools, but rather research, teach and thus influence the way the computer will be used as an instrument and partner.
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http://caad.arch.ethz.ch/projects/acm/.