Virtual reality, especially in a CAVE environment can be used in different ways. In architecture up to now it is mainly used to visualize planned or ancient buildings. Based on the information approach, on the approach that VR can be used not only to show the visual appearance of things but also information, which might be invisible in real world, seven rules are set up. The rules have been applied in university courses as testbed and verified in commercial projects.

**Keywords:** Virtual reality; information; cognition; space; collaboration.

Visualizing the future or the past, visualizing planned or ancient buildings, up to now is one of the main applications of virtual reality (VR) in architecture. Especially in a CAVE (Cave Automatic Virtual Environment) virtual reality has certain advantages compared to other conventional presentation techniques like drawings, models or video.

The advantages mainly arise from the fact that users are standing physically in and experiencing an original sized virtual model. Real world communication can be combined with virtual representation. The transition between the two worlds is fluent. Whereas this architectural area of application becomes quite common and turns out to provide additional benefit, it just covers a part of the possibilities that VR can offer. And due to the limited number of VR environments in the world only a small number of institutions is working on other scenarios for VR (e.g. Donath and Regenbrecht, 1999) in architecture.

Searching for new possibilities in using VR with an architectural background is one of the approaches in the combined design- and seminar course “digital year for architects” held since several years at the institutes IGP/IDG1 at Stuttgart University. This course is for graduate students and students about to take their diploma. The course ranges from technical over theoretical to formal education, this means from web-design, graphics, animation, video, cad, modelling over seminar papers to formal exercises, video- and design projects. Starting after four and again after seven months the use of VR becomes an integral part in the mostly experimental design projects.

VR resources are provided by the high-performance computing-center Stuttgart (HLRS) with a semi immersive workbench, 1.7 x 1.3 meters and one fully immersive CAVE‘ like system (Cruz-Neira et al., 1993), the “CUBE”; and a team of VR-specialists developing the VR software COVISE/COVER (Rantzau et al., 1998) and running the environment.

Based on the experience of the educational testbed as well as the realization of commercial projects, this paper describes in “seven rules”, how VR in (but not limited to) architecture should be used to work with the potential of the medium. The rules are all based on the assumption, that VR is a tool to show more than we see in reality, a tool to visualize
different information, invisible information. Elements in VR become information carrier (see fig. 1) and can take on multiple shapes to show the information, which is invisible in real world.

**Rule 1: Forget reality paradigms**

Hardly anything in VR is like in reality, however VR can be used to project a certain part of reality. Forces, gravity or scaleability are limitations in reality, not virtuality. Limitations are only the speed of hard- and software and – the user’s thoughts. If reality paradigms are applied like e.g. in the reconstruction of ancient buildings, these paradigms should be applied on purpose. Every design step should be rethought, if it is appropriate for the virtual and not only a transferred limitation from the real world.

**Rule 2: Show what you think**

In architecture mainly final results of ideas (concepts) - drawings, models or buildings are basis for a communication between the involved. But, how could we show our ideas and not only final results? (fig 3).

Semiotics, the science of signs, describes the relation between “concept”, the idea in our mind, “object”, the physically existing and “symbol or language”, the notation representing the idea and the
physically existing (see fig. 3). Symbols can be described as further symbols, still meaning the same object (shown in the horizontal array of triangles). Similar to that, ideas (concepts) can be described by other concepts (vertical array of triangles).

By “shifting up” the level of representation, that means not representing the visual appearance of an object but using a notation of a higher level concept, a clearer basis for communication can be achieved. Even environments with mixed levels of concept showed to work out fine (fig 4).

**Rule 3: Show properties not appearance**

Similar to the mental “concept”, most properties of things can’t be perceived visually in reality. VR offers a chance to develop a visual representation of properties. They can be mapped into a visual representation (Lang, 1999). It is a method of working, which is well known in other disciplines like physics or hydrodynamics (fig 5).

Scientific visualization utilizes this phenomenon. Attributes like tension in a material or the speed of wind can be represented by different colours. Time as fourth dimension in realtime simulations gives an even better understanding of how something e.g. reacts and not only how it looks, that means it shows other properties than visual properties. By fading the visual appearance of objects with additional information, a comprehensible basis for discussions is prepared and assists interdisciplinary teams in communicating and developing projects.

**Rule 4: Speak to several senses**

There are several different theories, doctrines (equivalent information, analogous quality, corresponding psychophysic properties), of how the senses work together or supplement one another (Guski, 2000a). However it can be said in general, that an event might be perceived by all senses and only a combination of the senses is giving a full impression of the event.

VR up to now is mainly limited to the visual sense, acoustic information is hardly implemented in architecture representation. Some applications like

![Figure 4. Representation of information and structure in a project.](image)

![Figure 5. Simulation of the current of air in an urban / skyscraper situation – different representations of the same property.](image)
e.g. a vibrating floor (imk.gmd.de/index_laboratories.html: May 2001) can supply further information. In projects it has been proven, that by adding sound to architecture, e.g. by playing helicopter-sound for flights, street noise outside buildings or driving sounds for elevators, there was a much more intense immersion of the users. Even if redundant information is supplied, the users do not perceive it as unpleasant, since human perception is based on redundancy. A similar effect is known from language (Lindsay and Norman, 1981).

**Rule 5: Provide interaction**

To become part of a scene, one has to interact with the scene. VR as a form of presentation might be impressive, but to immerse into a scene, one has to have the chance of interacting with the objects in the scene (Kalawski, 1991). Grasping (to take hold of) and grasping (to understand) have a strong correlation.

On the one hand, the interaction man – object is important, on the other hand the interaction man – man in coupled virtual environments. To support collaborative work, in general a sense of presence has to be established as well as clues for several aspects of awareness - location awareness, attention awareness and action awareness. Sense of presence in virtual environments often stands for the degree of

immersion created by the virtual environment, the user gets a feeling of “being there”. In shared virtual environments however, presence is also “being there”, but more in the sense of letting other people know that you are there. To support this kind of presence, in COVER partners are represented as avatars (fig 6).

The position of the avatar directly shows the location of that person, while the scale of the world is represented by the size of the avatar. The avatar is a minimalistic representation of the user, consisting only of a pair of glasses, one hand and feet. (Leigh et al., 1998) and our own experience showed, that this limited set of features gives enough clues to work together efficiently.

**Rule 6: Use animation**

Man is mainly perceiving information, if it contains a change of a state (Guski, 2000b). It is a property of human senses to become insensitive to unchanging stimulation, so the amount of data which has to be mentally processed can be reduced. By using this human characteristic, animation is a good way to specifically offer information that should be perceived by users, that means focusing the attention.

Furthermore design processes like e.g. the architectural “putting shapes together” or “subtracting them”, can be much better understood, if the process is shown that caused the final shape. This is due to the fact, that understanding is a process that takes time and knowledge does not come all of a sudden.

**Rule 7: Work in a team**

Only the combination of a team, the ability to get an understanding of the other’s work makes VR a powerful tool. It is the platform, where different professions can work together and share their knowledge (fig 7).

Working in a team in shared virtual environments brings up the question of how the virtual worlds are linked together. Therefore three modes in COVER have been implemented:
• tight coupling – the viewpoints and model scale of all partners are synchronised.
• master/slave – the master controls both viewpoints and model scale of all slaves.
• loose coupling – neither viewpoint, model scale nor any interaction is synchronised, only the state of the virtual world is shared.

Tight coupling mode fits best for engineering applications and master/slave mode for presentations, whereas loose coupling mode turned out to fit best for architectural applications.

Discussion and outlook
The seven rules provide an outline, of how the architects traditional notations are extended by VR, not replaced. By mapping “the invisible” into the visible, by transferring invisible properties into a visual representation, a better understanding for complex correlations can be achieved. On the one hand it supports the author of a system to better comprehend it, on the other hand it helps to communicate a system, its properties and the intentions of the author.

VR is not a standalone tool but has to be integrated into the design process. Since the technology of VR is quite new and allows notations far beyond the ones known from the real world, it is still a field hardly explored.

One of the greatest advantages of VR is best described in the words of the British philosopher and mathematician Alfred North Whitehead: “By relieving the brain of all unnecessary work, a good notation sets it free to concentrate on more advanced problems, and in effect increases the mental power of the race. ... Civilization advances by extending the number of important operations which we can perform without thinking about them.” (Sowa, 2000b).

References


Spence, Robert: 2001, Information Visualization, Harlow, Addison-Wesley

