Tools for Visual Simulation of Space and their Use by Students

Bob Martens
Vienna University of Technology
Institut für Raumgestaltung
Karlsplatz 13/256
A - 1040 Vienna
Austria

Summary

Most visual representations of architectural space are still done using drawings of ground plan, section and view. Yet, when experience is lacking – as with students or laypeople – these two-dimensional representations hardly show their correspondence to a three-dimensional reality. This article examines the various visual techniques for spatial simulation available today and their implementation by students involved with architectural projects.

Résumé

L'espace architectural est encore le plus souvent représenté visuellement par le biais de dessins le montrant en tant que plan, section et élévation. Et pourtant les personnes manquant d'expérience – comme les étudiants et les non-spécialistes – ne peuvent que difficilement traduire ces représentations bidimensionnelles en une réalité tridimensionnelle. Cet article examine les différentes techniques visuelles permettant actuellement d'élaborer des simulations spatiales, ainsi que leur utilisation par des étudiants travaillant à des projets architecturaux.

1. Learning about Tools for Visual Representation

In the course of the summer term of 1992 students taking part in a class on "Historical Aspects of The Art of Furniture" at the Vienna University of Technology were given an assignment on "The Architect's Portable Office". Helmut Wieser developed a "Roll-Off Writing Pad" (fig. 1) and described it as follows:

> "The architect often spends a lot of time in his office pondering on the sparking idea which will just not develop. And then (if at all) an idea comes to him in the precise moment when he is without anything to put it down, apart from a writing pad perhaps. In his office practice, however, the architect is used to developing his design work step by step and layer for layer on transparent paper."

The "Roll-Off Writing Pad" is designed to provide the architect with his costumary design tools. A paper-roll is improved by an integrated measuring tape, a pencil holder, a pencil sharpener and more. The plexiglas-pane that goes with it serves as a drawing pad.
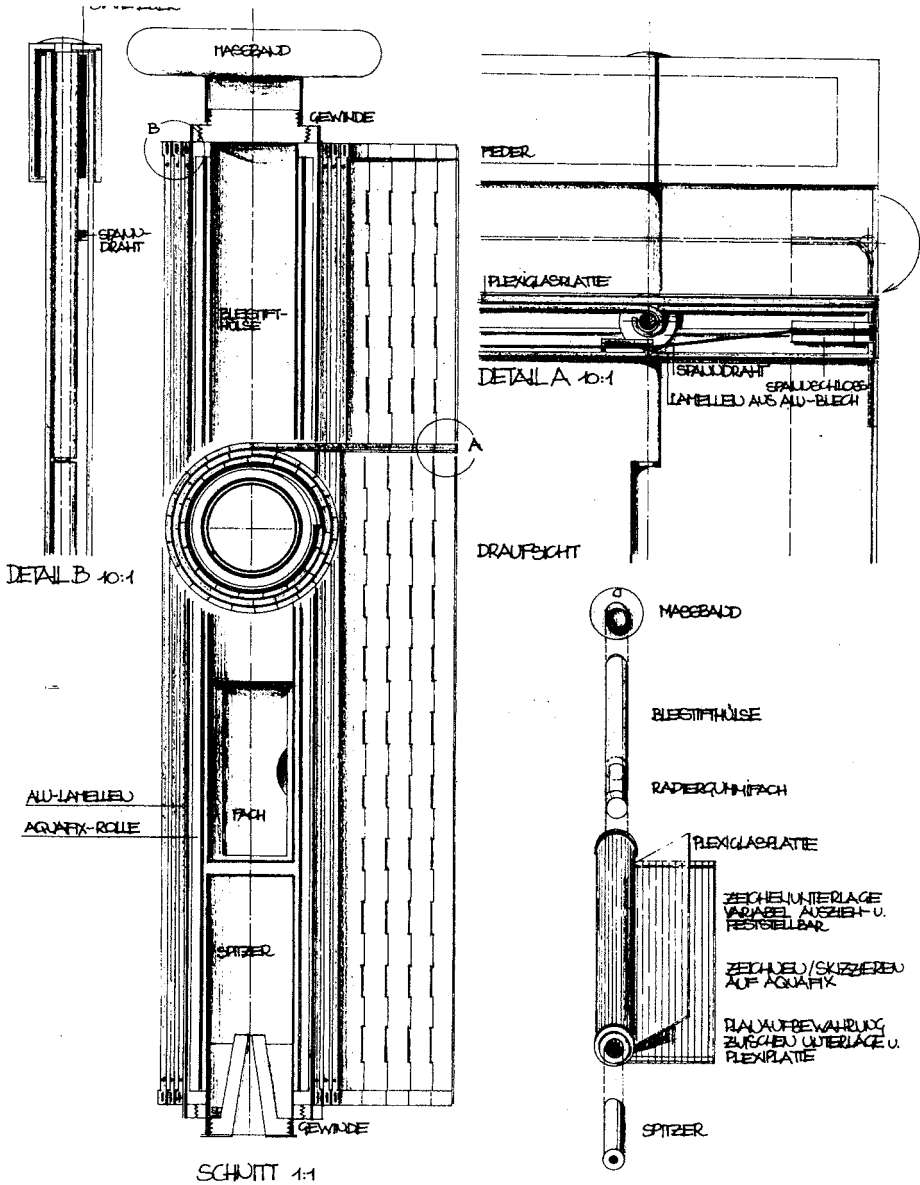
Fig. 1   The "Roll-Off Writing Pad" as an architect's tool by Helmut Wieser.
          Le "Roll-Off Writing Pad", un outil pour architecte de Helmut Wieser.

Matthias Zykan a student, designed an "Architect's Portable Office" made up of an architect's chair to be carried on one's back and integrating various working tools (fig. 2). His intention was to enable the architect to perform all his design work – including building details and statics – *in situ*. While the architect is drawing ("Cursor-Shifting by Manual Movements"), his movements are visible on the monitor.

Wieser's and Zykan's conceptions both attempt to approach the architect's concrete activities. Wieser's proposal refers to existing tools such as paper, pencil and drawing board, these instruments being still effective at a low cost. Zykan is dreaming of a new tool. This demonstrates how difficult it is to answer the polemic question, "Can the quality of an architectural design be improved by the increased use of highly advanced simulation techniques implemented during the working process?".

In what follows I am simply going to present some present-day tools for visual representation of architectural space, such as they were used and experienced by a group of students in our school.

2. Spatial Simulation Techniques

By using three-dimensional simulation techniques a more or less effective Virtual Reality can be created. The appropriate use of spatial simulation techniques increases considerably the plasticity and the realistic content of a project; moreover, it may encourage experimentation and trial attempts.

A course on "Simulation of Architectural Space" was first added as an optional subject to the curriculum of architectural studies at the Vienna University of Technology in the Winter term of 1990/91. The students' interest was quite remarkable, even though a great deal of improvisation was often required. The exercise took place at two different laboratory sites, both of which were provisional: the faculty's EDP-Lab and the Full-Scale Laboratory of the Institut für Raumgestaltung of the Vienna University of Technology.

The course introduced students to the following simulation techniques:

- Firstly, *computer-aided spatial simulation,* where the computer is acting as a kind of "electronic drawing board". Objects are described by means of various two- and three dimensional geometrical shapes (lines, progressions, circles, triangles, extrusion specimens, etc.). Objects such as walls, floors and ceilings are thus defined in the X, Y, Z-system of coordinates (fig. 3). Once defined, objects can be changed, multiplied or shifted as desired; several representations from various points with different angles do not result in additional input work. Sophisticated programs produce pictures that are hardly to be distinguished from real photographs.

- Secondly, *stereoscopic spatial simulation.* This technique produces two exposures of an object (e.g. a room) that can then be viewed together. Two retina pictures are produced which merge to spatial vision.

- Thirdly, *holographic spatial simulation.* This technique enables the storing of spatial pictures while maintaining their three-dimensional quality. Holograms offer perspectives when the angle of view is changed and back parts of the picture can more or less be seen. The actual color- and material effect, however, is lost.
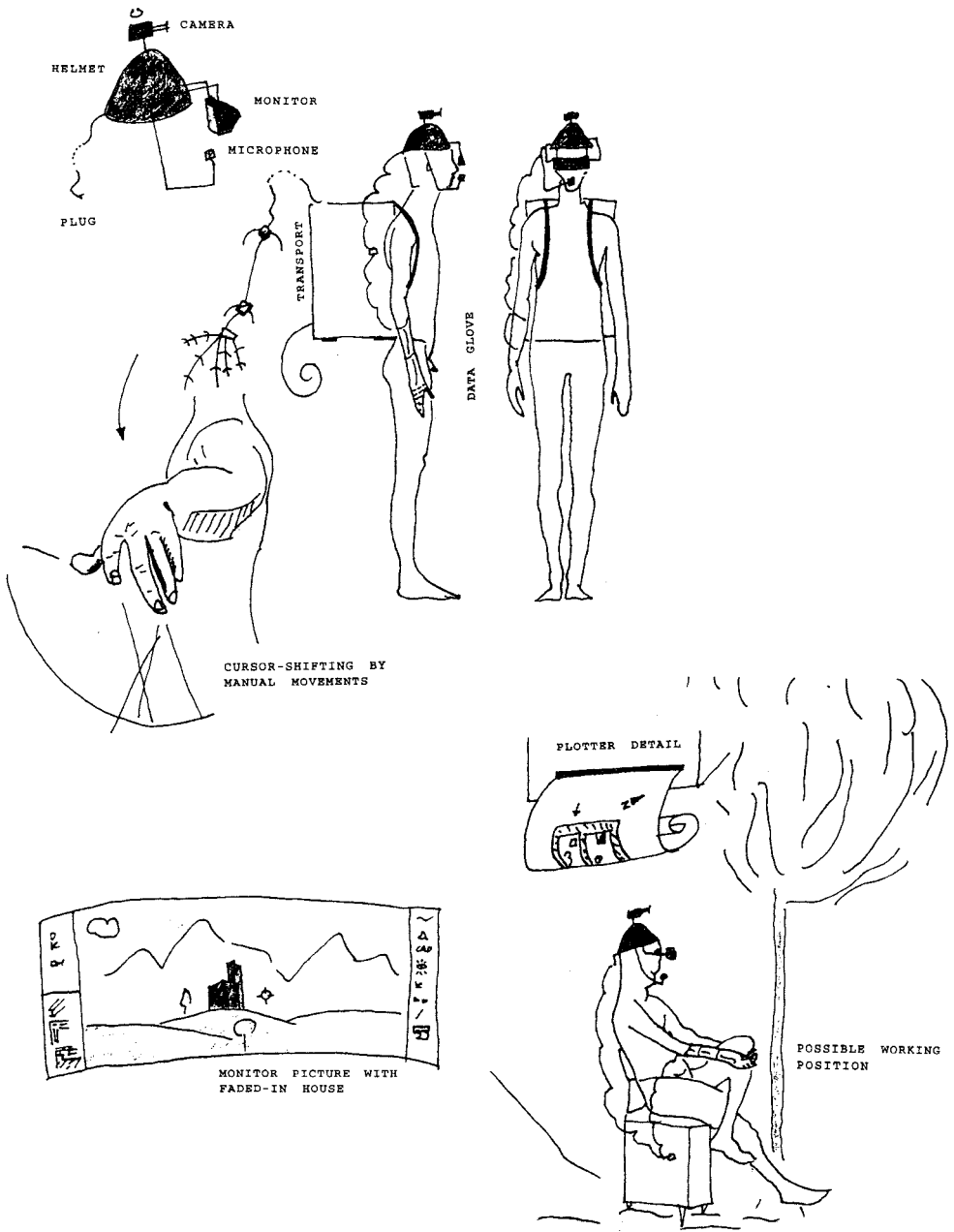
Fig. 2   A vision by Matthias Zykan for the architect's portable office. Possible working position / monitor picture
          with faded-in house, seat, protection cover for EDP.

          Une vision d'un bureau portable pour architectes présentée par Matthias Zykan. Position de travail
          possible / image moniteur avec maison surajoutée, siège, couverture de protection.

- Fourthly, *(video-)endoscopic spatial simulation.* By means of an endoscope scaled-down models can be viewed in such a way that one sees from a pedestrian's perspective. The endoscope can also be connected via an adapter to a CCD-video-camera, providing picture sequences in addition to still pictures.

- Fifthly, *full-scale modelling. In situ* experiments are designed to produce a full-scale (part-)model and to study its effect in its future surroundings. Even though it is difficult to use full-scale models to study future surroundings to the full, the 1:1 model gives an impression of elements such as (interactive) effects of light, colour, material and surface in architectural space.

3. Didactic Aspects

Even though our course on "Simulation of Architectural Space" focusses on computer-aided spatial simulation, the other simulation techniques described above are also used. Combinations of the individual techniques are also explored. We consider this to be the first didactic aspect. Thus a stereoscopic pair of pictures can easily be generated with the computer and then examined stereoscopically. Drawing programs can process the pictures further and manipulate video-endoscopic spatial pictures.

Working on a small design project represents a second didactic aspect. Participants are grouped into small teams that design a spatial unit for a specific person or activity. Ideas as to formal developments of the concept, including the effects of colour, light and material, are then elaborated by the group. To begin with, work is performed with a 1:100 scale model. At a later stage, ground plans, sections, etc., are generated from the 3D-computer model. Object size is limited, as the design is to be the means and not the aim of this work. After the working model has been built, simulation techniques are applied. This procedure is used on the assumption that students will then be able to accept the limits and possibilities of an individual simulation technique. Participants were requested to report their experience at the end of project work. I try to account for their comments in the following sections.

4. Computer-Aided Spatial Simulations: Hard- and Software

The majority of participants in the class had practically no previous computer experience. However, the Apple MacIntosh graphic user's surface made it possible to acquaint architecture students with the main system functions within one morning session. After that, independent working - with assistance at regular intervals - became possible.

The software "Zoom" (Abvent, France) was succesfully used for our teaching purposes. In this "user-optimized" programme, up to four working windows can be activated simultaneously. "Zoom" allows a description in four different modes: top view, elevation, side view and axonometric view. Thus interactions between ground plan, side and front view are possible. If the input is a square, it can simultaneously be recorded and altered in all four windows. Up to 128 sources of light and structured surfaces can be described.

The modelled descriptions can be retouched or improved by means of an additional programme. However, photo-realistic pictures calculated with shadow-

casting and "antialiasing" (i.e. smoothing the outlines of an object) take a calculation time of several hours depending on their complexity, data file and the size of the picture.
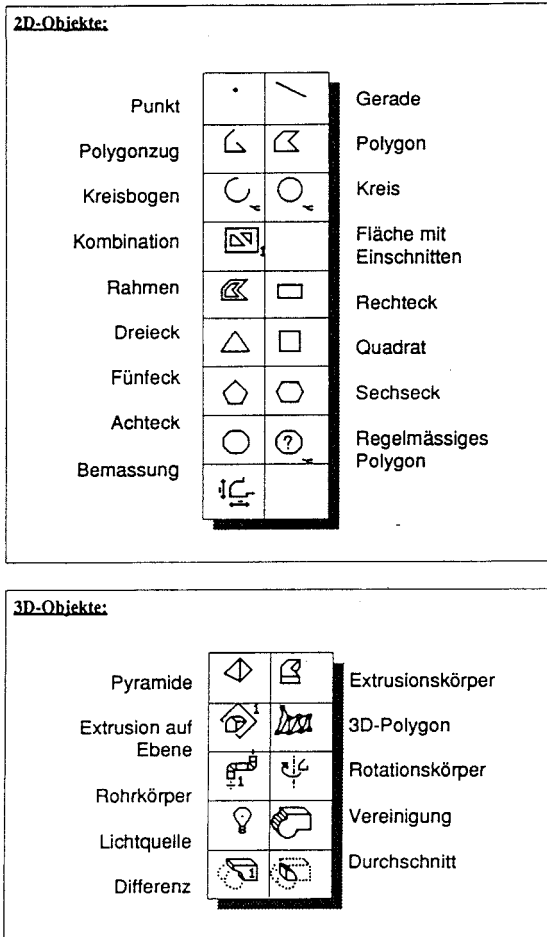

2D-Objekte:

Punkt	·	╲	Gerade
Polygonzug			Polygon
Kreisbogen			Kreis
Kombination			Fläche mit Einschnitten
Rahmen		▢	Rechteck
Dreieck	△	▢	Quadrat
Fünfeck	⬠	⬡	Sechseck
Achteck	◯	⑦	Regelmässiges Polygon
Bemassung			

3D-Objekte:

Pyramide			Extrusionskörper
Extrusion auf Ebene			3D-Polygon
Rohrkörper			Rotationskörper
Lichtquelle			Vereinigung
Differenz			Durchschnitt

Fig. 3   Geometrical tools in the modelling programme *Zoom.*
Outils géométriques dans le programme *Zoom.*

For not too complex geometrical objects an Archicad-programme (Graphisoft, Hungary) was used. The manner of definition of objects (walls, doors, windows, ceilings, roofs, etc.) and the object library supplied make it a typical programme for architects. Projects may be described in the 3D-section of the programme but input is done in the 2D-ground-plan format and it must be precise.

The majority of students found the data-input very time-costly, as an exact input is necessary from the very beginning. What makes the programme attractive is that changes can be simulated very easily and the angle can be changed to meet any situation. A perspective view on objects is thus easily achieved. Students thought this allows design problems to be detected at an earlier stage than with conventional working procedures.

5. Stereoscopic Spatial Simulations

Presently stereo exposures are taken with a reflex camera. After taking the left exposure the camera is shifted on a special rail to take the right exposure. Analogously, stereo-pictures can be generated from the 3D-computer model. The biggest shortcoming of working with one camera is that recording must be done without moving features (such as people).

The students agreed upon the fact that, compared with "monophotography" stereo-photography makes for an increase of spatial effect. Plastic reproduction of spatial objects thus photographed turned out to be very satisfactory with a remarkably good depth effect. Stereoscopy appeared particularly well-suited for the documentation and description of buildings. It did not appear to be an aid in an "interactive" design process.

6. Holographic Spatial Simulations

This spatial simulation technique seems to be still surrounded by a halo of mysticism. This is not justified, though conditions for taking holographic pictures are completely different from those governing conventional photographic procedures.

Apart from the helium-neon laser, a camera consists of the required optic elements such as beamsplitter, mirrors and lenses. One of the most important prerequisites for successful holographic pictures is to create conditions free from vibrations.

The experience of taking holographic pictures and developing holographic plates in the dark room did not turn out to be very spectacular. As to the results, according to students' opinion, a hologram could act as a "model in one's portfolio": it is an economical way of storage with considerable information content. Even though looking at a hologram makes it possible to achieve a different view when changing the angle of view, it appeared that a single picture was not sufficient to get an impression of the object in its entirety. Doubtlessly, very impressing effects can be achieved using holography, such as creating a representation of spatial objects that seem optically to be leaving the focal plane. In this context, however, the question of the meaningfulness of such effects arises. Can this technique be used as an architect's tool in the course of design work?

Analogously to stereoscopic simulation, a certain basic knowledge has to be acquired in order to succeed in taking holographs. The light source is to be as focused as possible in order to make for ideal conditions for looking at a white light hologram. Considering the fact that picture information cannot be changed (e.g. loss of color- and material effect) or retouched, this tool seems to be of questionable use for architects in the process of designing their project.

7. Endoscopic Spatial Simulations

As opposed to computer-aided spatial simulation a video-endoscopic model picture is relatively easily arrived at. Practically no initial training is required from students before presentable results are achieved. Almost all small-scale models can be subjected to endoscopy without much effort. The "eye" of the camera is moved around in the model and used as a lense for taking pictures or filming. Even with models on an urban planning scale (1:500), practically "authentic" views may be obtained. Experiences with endoscopy were already made in the sixties and seventies. Their missing popularity may be due to the mediocre picture quality resulting from picture transmission by the peripheral equipment. The CCD-camera technology developed in the eighties has done away with such problems. Video cameras with much more light-sensitivity and less sensitivity to sudden lightchanges are now on the market.

Endoscopic pictures match the built reality more precisely than photographic pictures taken by wide angle or fisheye lenses. An endoscope (without peripheral equipment) proves sufficient for individual viewing. The possibility to "stroll through a project" is fascinating. In order to be able to simulate a correct speed, technical supplies would be required, that make it possible to drive the endoscope through the model at the "in scale" speed.

8. Concluding Remarks

Students, such as those taking part in this course will make up the future generation of architects. Therefore it seems meaningful that architectural curricula include courses on spatial simulation techniques. They should familiarize the students with the techniques but will also let students reflect on the uses of such techniques within an "interactive" project design. Moreover I do hope that colleagues specialized in different simulation techniques will be given increasing possibilities to share their experiences.