City Simulator

A Multi-dimensional VR-Simulation Environment

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Whether in splendid rural isolation or in an urban area, settlement and building structures always are exposed to the public. Questions as to the future design of our vital space basically always concern the public and thus call for a great deal of discussion. Launching a well-balanced debate between all those involved in the planning and design process requires clear exemplification of urban-spatial visions by means of simulation. A simulation device - called "City Simulator" - suited to conveying the multitude of spatial relations within the urban configuration and for developing urban-spatial ideas would fulfil such expectations. The complexity of the information required in this context can be coped with effectively by means of computer-aided simulation techniques focusing on digital city models. Thus the implementation of a "City Simulator" may be regarded as a decisive tool for the purpose. As those involved in the process normally consider themselves absolute novices within the context of complex planning processes, the simulator will to some extent act as a "translation machine". This paper is based on a project proposal which has been submitted by the authors aimed at the acquisition of a "City Simulator" at Vienna University of Technology in the near future.

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1. Introduction and Background

Spatial simulation methods and techniques are required at all levels of planning, in particular wherever it is necessary to prepare, take and put across three-dimensional decisions. Applications for (urban-)spatial simulation include not only the simulation space but also processes, i.e. their (future-related) "projection" or (past and present-related) "duplication". Spatial simulation can therefore be a great help in creating (or replicating) spatial realities of different concrete spatial forms. It should be pointed out here that simulation processes are based on models taken from reality. One type of simulation which has the lowest degree of abstraction – or deviation from reality – is called isomorphic. At the other end of the spectrum are simulation processes known as homomorphic or laboratory simulation. This latter

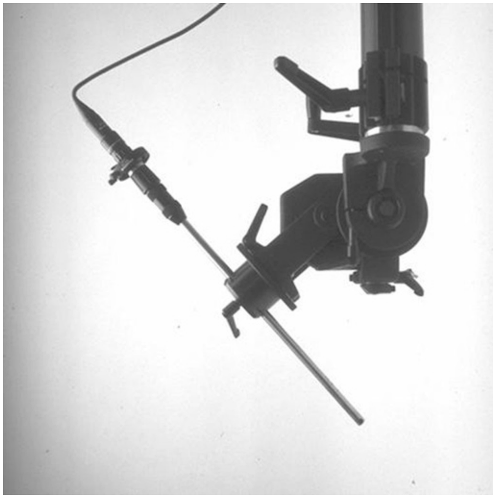

Figure 1
Example of an endoscope

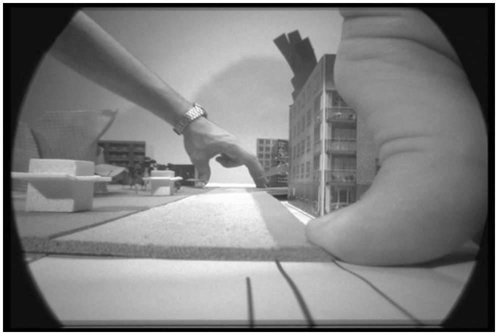

Figure 2
Example of an endoscopic representation (UT Vienna)

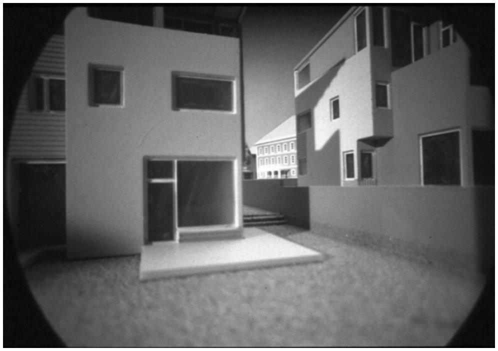

Figure 3
Example of an endoscopic representation (UT Vienna)

simulation provides a graphic basis for discussion within the communication and decision processes of independent and community planning [Hirche, kind of simulation attempts to express the essential features, elements and elemental relationships of spatial structures filtered according to specific criteria. Here too, there are different degrees of abstraction. The level of abstraction consequently determines the choice of simulation techniques and their combination. After all what matters is finding the simulation process that can best convey specific information. As the next stage we should be envisaging discussions about simulation technique networks within which complex facts and connections can be conveyed.

Section two of this paper will focus on the working context of CAVE Simulator environments, taking into account developments in the field of optical and digital endoscopy as well as computer-aided VR-environments. The definition of objectives in section three can be regarded as a kind of "check-list" for the acquisition of a "City Simulator". Section four will elaborate on a VR-Simulation Environment called "ARS Box", which was developed by the "ARS Electronica Futurelab" in Linz, Austria and is likely to be purchased by Vienna University of Technology, and that is followed by concluding remarks in section five.

2. Related Work and Best Practice

In the search for suitable simulation processes, the one that stands out in an urban space context is sensor-based environment simulation [coined by Markelin, 1979]. It encompasses a range of mapping procedures and techniques that create the necessary conditions for simulating human perception, human experience and action in existing or planned situations. This kind of simulation process is important for the following aspects: empirical research into human action, the mechanisms of human perceptive processes and the verification of planning visions. Sensor-based environment

1986]. The possibilities of sensory simulation therefore have to be viewed with the intention of reliably predicting user reactions and in an endeavour to initiate individual and/or group-specific “environmental learning processes”.

2.1 Digital Endoscopy

Simulators primarily focusing on endoscopic investigation [Patzner, 1989] have been around since the 1970s. They are scientific laboratory instruments which not usually accessible to the public [Thomas, 1987]. Moreover the set-up of the equipment is basically unsuitable for use by the layman.

“Endoscopy” stands for “inner view” having been used for decades exclusively as medical instruments for inspecting “human voids” prior to its specific implementation in other fields of science. Even though special endoscopes are now available for viewing (physical) architectural and urban models the picture quality produced often proves unsatisfactory. Endoscopic model rendering calls for profound photographic knowledge as both inconvenient light conditions and longer exposure times have to be compensated. Focusing - focus control - can also prove problematic. In other words, they do not produce needle-sharp renderings comparable to snapshots of a model. As far as animated endo-pictures are concerned, it took way into the eighties until satisfactory results were produced by means of CCD camera technology. The computer-assisted simulation applications (CAAD) now widely available surpassed the endoscopic rendering technique. They are based on viewing physical models using optical instruments. “Exoscopic” viewing angles (bird’s eye perspective, etc.) were popular then, but nowadays fewer scale-architecture models are being built. Viewing by optical endoscope relies on the existence of a (physical) model that supports an “interior” view without any further manipulation or training necessary.

What we are basically interested in is not the development or the immediate handling of the instrument “endoscope” as such, but rather the idea of endoscopy, i.e. obtaining “true to reality” insights into model situations. The slim design of optical endoscopes allows us destruction-free viewing of physical models, whereas computer modelings can be taken apart wherever required. The differentiation between “optical” and “digital” endoscopy has already been outlined in detail by Stellingwerff and Breen [1995] predominantly dealing with the set of instruments implemented for endoscopic model viewing. The fact that a sequence of images produced by an optical endoscope also lends itself to further processing activities might lead to linguistic confusion. The term digital endoscopy as used for our purposes comprises computer-assisted processing and revision, and also applies to the production of a sequence of pictures from the CAD model.

2.2 CAVE - Automatic Virtual Environment

The CAVE (http://www.evl.uic.edu/pape/CAVE/) is a walk-in cubic room whose walls, ceiling and floor can have images projected on them by video projectors. The images represent 3D real-time renderings from a virtual model from the viewing point of an observer who is in the room. The observer’s position is transmitted to the computer by tracking sensors. New images are continuously being computed so that users have the impression that they are moving around in the virtual model themselves. A 3D joystick allows users to interact with the surrounding scene. CAVEs have the advantage that several people can see the same picture (or perspective) at the same time and so can discuss it. Each position can be selected interactively (by navigation) and scaled to any size (e.g. from a view of a complete city model to walking through a microscopic element). Observers have the impression they are standing in the model.

3. Objectives and Basic Conditions for a “City Simulator”

Dealing with the subject “City” by covering past,

Figure 4
CAVE– example (www.aec.at), Concept: Dan Sandin, 1996))

Figure 5
CAVE - example (www.aec.at) The following objectives and basic conditions for a "City Simulator" have been formulated based on the outlined work environments.

present and future aspects will result in the programmatic approach. Equipped with that, the urban space of tomorrow will be tackled experimentally and the spatial impact of concrete projects can be clearly visualized. In particular, the following objectives will be taken into account:

- The major conceptual tasks for the City Simulator will be furnishing the required instruments and processes for simulating urban-spatial „realities", thus making for design of urban space based on digital city models as well as lending itself to experiencing urban space not (yet) built-up.
- A perceptual and environment-oriented psychological validation [Keul, 1996] of the simulation environment in question relating to improved usability for different user groups (expert, politician, citizen) is to be considered an essential basic condition for the implementation of a City Simulator.
- A vast variety of navigation and interaction possibilities (manipulation tools) should be made available. Questions relating to urban space experimentation are amongst the core research subjects. Some of the topics covered are: the examination of spatial impact and experience gained, the arrangement, shaping and structuring of volume (spatial organization and concentration, variants of mass distribution, grouping, scaling, texturing, etc.); layout and distribution of building volume in defined terms (urban-constructional parameters, site-related factors); urban-constructional particulars, (city furnishing, surface design, temporary space installations);
- Complex information structures are to be put at the user's disposal involving no complicated handling. That applies both to quantitative data (e.g. urban-constructional parameters) as well as to qualitative ones (e.g. visual information); scientific visualizations of digital city models are to be provided.
- Models are to be scalable, i.e. a variety of quality levels (Levels of Detail, LODs) are to be available. Models delivering a minimum degree of abstraction with significant information content are to become standard in order to meet the requirements for a meaningful City Simulator.
- System development is to be provided on the basis of a multiple-use simulation environment, as a presentation environment (video) and as an interaction workbench (authoring system). In this VR simulation environment, concrete experiments are to be performed involving reasonable effort – in relation to the benefits. The added value of immersive simulation environments can thus be studied by means of a greater number of concrete applications.

Further issues to be covered deal with the following topics:

- „Dimensions“ of digital cities: space and time (changes of space throughout time call for a dynamic space conception), variants and versions (in reality always only one present condition exists, in planning there are usually several variants); „Level-Of-Object Presentation“ (taking into consideration distance of viewer to object – depending on proximity of representation the objects are subdivided into several subobjects, i.e. the “scene” is scale-dependent);
- Techniques (description of scenes, rendering, clipping); integration of “City Simulator” in “Urban Space Related Content Management Systems” (SCMS);
- Questions as to benefits of the digital city models (optimal basic data set – multiple usage, synergy effects, relation: effort – benefits); user interests, user-oriented digital city models (models “on demand”).

As part of the quest for a suitable, affordable work environment for a City Simulator, the “ARS Box” is described below which permits the interactive real-time visualization of highly complex graphic datasets.

4. City Simulator based on the “ARS Box”

The VR simulation environment considered for purchase is the “ARS Box” system, an independent development of “ARS Electronica Futurelab” (Linz, Austria - http://www.aec.at/). The graphic representation is by means of back wall projection, or as an alternative, stereoscopic projection. Pairs of video projectors have to be fitted with polarization filters for the purpose. The observer uses polarization spectacles to receive the stereoscopic impression. With the graphic output that is available it is possible to process data in real-time under the interactive control of the user and represent it on the projection screens. In addition to creating graphic views, a PC-based computer network also takes care of the audio material and the interactive user control via the connected input devices. If required, different graphics sources can be seamlessly integrated (live video, video playback, stereo projection, slide shows, etc.).
A Palmist is used to control the respective information offered by the “ARS Box”. That applies not only to the choice of application and sequence (i.e. start, pause, close), but also to the interaction and navigation because necessary tracker software is integrated thus allowing the user to change the light situation in the model representation, for example, or to manipulate objects and change characteristics (e.g. colour, material, etc.).

A) The basic equipment is a complete system containing all the components necessary for operating the VR simulation environment, including a high-performance Linux PC workstation, monitor, hardware for stereoscopic observation (transmitter and shutter spectacles), a palmist interaction interface, the requisite network technology and an orientation tracker. The package also contains a VR library, a higher level graphic API, the VR Authoring System (VRA) and the PalmistSDK.
B) The stereoscopic one-wall projection system consists of a (standard size) projection screen, two projectors, filters and projector calibration system.
C) The database system is customized and used for scene management and dialogue with graphics.

Figure 6
ARS Electronica Center (Linz, Austria – www.aec.at)

The “ARS Box” is therefore a PC-based version of CAVE with various software products ported (CAVElib, Performer, etc.). Standard hardware components were used, such as NVIDIA graphic cards. In a direct comparison, CAVE is the more complex and expensive variant, especially since an SGI workstation is the central operating computer. In view of the high initial investment and follow-up costs, this simulation environment has in many cases not yet served a wide range of users. SGI's monopoly has been significantly curtailed by the growth in performance of PC-based computer networks. In addition, developments in the computer games industry has resulted in an ongoing reduction of costs for powerful 3D graphics components.

5. Conclusions

Spatial simulations use models with different levels of abstraction and scales - models that convey one or more specific aspects of a built reality. Since spaces always have to be viewed in conjunction with utilization processes, such manifold processes also need to be simulated, in other words the simulation of a changeable environment around the “rigid” architectural structure. The question as to which simulation techniques are suitable for intelligibly presenting and analysing planning projects with all their content, is necessarily central to the considerations regarding the conception of a City Simulator. The main focus of a City Simulator aims at the representation of urban visions in this context.
During the course of the desired information transfer of reality-based facts, the objectification capability of the simulation techniques used should be also be examined. The potential to be found in the “readability” of ambiguous information needs to be investigated in this context. The suitability of simulation techniques therefore needs to be evaluated and analysed.

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