Model Simulations in Urban Design Planning Processes

Comparisons of Analog and Digital Simulations
Tobias Niemann, J. Alexander Schmidt, Susanne Reiß
University of Essen, Germany

Summary
Urban design model simulations serve to let us envision the future environment. These models are important tools in planning processes and serve to democratize improve the comprehension of decision processes. Those affected and (often) laypeople help in the formulation of opinions. Not lastly, model simulations facilitate the evaluation of the quality of the future urban design spaces and allow for corrections in the optimization of designs. Model simulations can be created by the help of endoscopic techniques already well known to medicine. Nowadays, virtual simulations can, on the other hand, be entirely created on a computer through the use of suitable programs.

At the present time a comparative investigation into the performance capabilities of analog and digital technologies is still pending. In a two-group comparative study, static analog and digital simulations were compared by using categorical scales to answer questions on urban design layout and living space quality. The results demonstrated that analog and digital simulations lead to similar value judgments. However, layout and living space quality in the analog simulations were given somewhat higher rankings, on average. A conclusive statement about the performance capabilities of analog or digital simulations in urban design processes is still premature. Future studies should take this context into consideration.

Aside from the performance capabilities of a simulation, other aspects are also to be considered, such as the resource requirements for practical urban planning processes. At this time the use of analog simulations is often recommended. This is because the use of analog simulations brings similar results using fewer resources than digital simulations. To the observer, analog simulations retain a more

natural quality. Now as before, models are often constructed during the performance of urban design projects, reducing even further the resource demands of an analog model, which in the end is reflected in the costs.

1. Introduction

Urban design models and environmental simulations assist in the visualization of, for example, future residential surroundings. In contrast to two-dimensional abstract plans and three-dimensional models offering only bird's eye view perspectives, these models give insights into future residential establishments, in true to scale, eye level views (Bosselmann 1998). In decision processes they give the layperson, a future resident or a politician for example, the chance create for themselves a sound representation of the future residential surroundings or get a feeling for the qualities strived for in the urban design. Especially with consideration to the increasing significance of democratization within urban design decision-making processes, simulation technologies are a helpful tool for attaining transparency and understandability.

Various types of simulations for future urban design projects can be

generated.

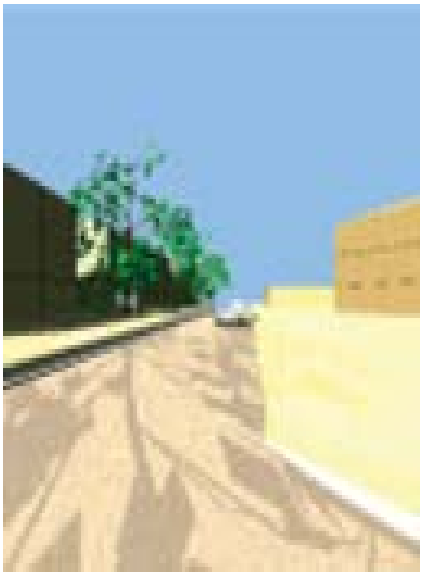
In analog model simulations, an endoscope commonly used within the field of medical optics is conveyed through an urban design or architectural model at a true to scale, eye level viewpoint. This technique, which has been renowned for a good 40 years, has been continually developing up to the present time. The course of development traces back to still pictures, then on to dynamic scenes employing a movable video camera fixed to the head of the endoscope, up to interactive digital visualization and computer-controlled, complex camera routings (see, for example, Niemann & Schmidt, 2001).

Following the developments in the field of Information Technology, simulations have, within this time frame, also been able to be generated digitally. To this purpose, CAD software specially

developed for architecture and having supplementary 3D functions, or software employing exclusively three-dimensional animation programs have come into being. With the help of virtual cameras, various locations in true to scale, eye level viewpoints can be observed or routings through the model can be programmed.

Independent of the type of simulation, a fundamental question exists as to how valid or how capable the simulations are, meaning that given a simulation–based evaluation, to what extent can its implications be carried over to the real situation. Investigations carried out over the past few years dealing with this question have shown the tendency to support the validity of model simulations, depending on factors such as the experience of the situation, the quality of the model and the type of method, among others (see, for example, Fahle & Haefele 1983).

However, investigations on the issue of performance capability have only been carried out on analog model simulations. Results on the performance capability of digital model simulations or the direct



comparison between analog and digital model simulations are not available at this time. As an initial starting point, the present research discussed here should serve to address this issue. Are the performance capabilities of analog and digital model simulations comparable or are there differences? What affects these differences? Additionally, the time requirement for the generation of an analog or digital model needs to be considered. In the end, a differentiated picture could be brought into being, one which would indicate under which practical circumstances of urban design processes which model would be sensible and recommended. The investigation presented here will start with a comparison of static analog and digital simulations. Future studies could be widened to new and more complex issues, which could also stem from the results of the present study.

2. Method

2.1 Research Subject

The plan of a future residential area in Oberhausen-Ripshorst, Germany was used for the analog and digital model simulation. The

design for this residential area was developed within the framework of an interdisciplinary specialization seminar held at the Faculty of Civil Engineering at the University of Essen.

2.2 Simulation

For one segment of the research, the plan was transposed into a scaled model, structured on a 1:500 scale. Using the help of endoscopic visualization techniques (see Niemann & Schmidt 2001), eight viewpoints showing the important spatial relationships and perspectives within the future residential area were photographed and saved on DV materials (DigitalVideo). (For the example photographs see Figure 1, left column).

For the other part, the plan was transposed into a digital, three-dimensional model using an extended version of an urban design CAD program (VectorWorks). The level of detail in the digital transposition was kept to a similar level as that of the analog model. Using a virtual camera, corresponding views and perspectives to the analog simulation were rendered in digital format and were issued out in digital video format (for example photographs see Figure 1, right column).

The analog simulation required a total of 12 working days (10 working days for building the model, 2 working days for the production of the simulation). The creation of the digital simulation required 20 working days.

2.3 Experiments

The analog and digital simulations were fed into a digital video clip program on a computer, set up into two photo suites and were then saved on DV materials. Each photo suite consisted of four analog and four digital pictures, arranged in random order, whereby the sequence of corresponding analog and digital remained the same in the associated columns. The length of time for each picture on the video was 10s.

Judgments on the urban design layout and the living space quality

were collected by means of a questionnaire. The quantitative capture of subjective evaluations can be done through the use of categorical scales that are value-graded from 0-9 in aesthetic assessment (for example beautiful - ugly) or in a judgment about the environmental quality (for example, too few trees – enough trees). As an example, see the captions in Figures 2-4. In the experimental series, four questions regarding the urban design layout were asked about each of two analog and two digital simulations. A further four questions regarding the living space quality were asked about each of two analog and two digital simulations.

In total, 72 Town Planning and Landscape Architecture students at the University of Essen took part in the comparative two-group study. In groups of 18, the subjects participated in a series of experiments (photo suite 1 or photo suite 2). They were placed in a darkened room at approximately the same distance from a TV monitor with a closed-circuit video recorder. Before the start of the experiment a short introduction to the background of the experiment was given. During the experiment and following the simulation presentation, the research subjects were requested to record their value judgments in the corresponding questionnaire.

2.4 Evaluation

From the resulting scaled response judgments the mean and the standard deviation of the data were calculated and were tested for the no-difference condition. Value judgments from corresponding analog and digital simulations were subjected to a non-parametric statistical test (U-Test) to determine if there was a significant difference between the evaluations.

3. Results

The given value judgments were not equally distributed, meaning that the value judgments of the research subjects were, with a high probability, not arbitrary (Chi-Squared Test, P-0.01).

3.1 General Judgment of the Urban Design Layout and Living Space Quality

Next, it was investigated to what extent the simulation tended to trigger either positive or negative judgments, independent of the difference between corresponding analog and digital simulations.

The simulations can be classified into three main groups:
Ý Simulations which triggered a more positive judgment, independent of the type of simulation (analog, digital)[4 simulations]
Ý Simulations which triggered a more negative judgment, independent of the type of simulation [2 simulations]
Ý Simulations which triggered contrary judgments, independent of the type of simulation [2 simulations]

Figure 1A shows and example picture of a positively judged simulation. For both the analog and the digital simulation, the valuation in response to the four questions lie extremely close together and are predominantly in the area interpreted as positive (> ø 4.5; more friendly, more new and so on)(Figure 2).

Figure 1C shows and example picture of a negatively judged simulation. For both the analog and the digital simulation, the valuation in response to the four questions lie predominantly in the area interpreted as negative (< ø 4.5; too many automobile emissions, not a good neighborhood and so on)(Figure 4).

Overall, no unifying picture in relation to the value judgments of the presented simulations was demonstrated. They triggered neither positive judgments without exceptions nor negative judgments without exceptions or else they triggered simultaneously positive and negative judgments.

3.2 Special Judgments on the Urban Design Layout and Living Space Quality

Furthermore, the differences in value judgments between analog and digital simulations and the response to individual questionnaires were investigated.

The simulations can hereby be classified into the following groups:
Ý Questionnaires in response to analog and digital simulations which resulted in significantly contrary judgments (for example, analog: positive, digital: negative) [in 8 questionnaires, 25.80%]
Ý Questionnaires in response to analog and digital simulations which resulted in contrary but non-significant judgments (for example, analog: positive, digital: negative) [in 3 questionnaires, 9.67%]
Ý Questionnaires which, in the case of both types of simulations, resulted in similar judgments but which demonstrated significant differences in the level of intensity (positive or negative) [in 3 questionnaires, 9.67%] (see for example Figure 4)
Ý Questionnaires which, in the case of both types of simulations, resulted in similar judgments but which demonstrated non-significant differences in the level of intensity (positive or negative) [in 17 questionnaires, 54.83%] (see for example Figure 2)

Figure 1B shows an example of a picture of a simulation generating predominantly contrary valuations. The valuations in three questionnaires were significantly different, in which the analog simulation was evaluated as positive (U-Test, P-0.01) (Figure 3).

Judgments were the same for both types of simulations in the predominant fraction of the questionnaires (more positive or more negative) [in 64.5 % of all questionnaires]. In the other questionnaires, contrary judgments in correlation to the type of simulation were in evidence. In 81.81% of these contrary judgments, it was shown that the analog simulation was valuated as being more positive whereas the digital simulations were judged to be more negative.

Finally, the mean valuation for all the questionnaires was cumulated, respectively for both analog and for digital simulations, in order to determine if analog simulations or digital simulations showed tendencies towards better or worse valuations. Table 1 shows the mean result of the analog and digital simulations for all the questionnaires. The analog simulations gave rise to an overall more positive valuation (> ø4.5) whereas the digital simulation to an overall more negative valuation (< ø4.5) (P-0.05, U-Test).

4. Discussion

The different valuations of the various simulation viewpoints (more positive, more negative or part positive and part negative) independent of the type of simulation leads to the conclusion that the research subjects gave individual judgments in response to each presentation. This observation means that with each new presentation the question about the urban design layout and the living space quality was newly posed, and not given categorically once the valuations of all the subsequent presentations had been made. Additionally, the results indicate that the research subjects really did consider the urban design layout and living space quality and that the valuations were not about judging the quality of the picture. Independent of the viewpoints and perspectives presented, picture quality was always the same for both the analog and the digital simulations, something which, had the valuations only been based on picture quality, would have necessarily resulted in consistent valuations of the simulation viewpoints.

4.2 Evaluation of analog and Digital Simulation

With consideration to the individual differences in the valuation of analog and digital simulations, some differences are in evidence. The predominant fraction of the questionnaires show similar valuations of both analog and digital simulations, meaning that when the analog simulation was judged more positively, so was the digital simulation. To follow, this result indicates an identical potential for usage for both analog and digital simulations. However, in a good third of the questionnaires, the type of simulation resulted in contrary valuations. These valuations can probably be attributed to, in part,

small differences in viewpoint details in the analog and digital simulations (so, for example, the judgment in Figure 1C of the tree grove is certainly based on the count of the trees depicted. In another case of a viewpoint not shown here, a question about building density, for example, would be under suspicion for the same reason). It would seem that an even more exact representation of this level of detail in the analog and digital simulation would be a point to consider in future comparison studies.

Overall, the analog simulation tended to show better valuations. It is possible that a qualitative difference exists between analog and digital simulations, one that should be taken into consideration when employing simulations. Viewed subjectively, analog simulations seem to be “more natural” because of the differentiated material representations, balanced light modulation and/or better renderings of reflections (see Figure 1). As regards to these points, the circumstances behind the insufficient picture quality in digital simulations are due to either the fact that the technical possibilities of the CAD program (VectorWorks) are inadequate or that the technology is available but was not exploited due to time limitations. In this case, a further study using more sophisticated digital simulations should be considered. For this purpose, special 3D animation programs having high-performance features for Ray-Tracing and rendering would be needed. In light of past experience, the more resource-intensive digital simulation implies higher technical needs. Already in the present study, an additional expenditure of time was required for the generation of the digital model in comparison with the analog simulation. The convergence of digital simulations to a more “natural” appearance would further widen the time discrepancy between the generation of an analog and a digital simulation.

4.3 Further Research

A conclusive statement regarding the performance capabilities of analog and digital simulations in urban design planning processes can, at the present time, only be made with certain reservations. This first experimental usage has shown the complexity of this

subject, which can only be tackled in small steps.

Therefore, further research to be considered would involve the use of varying digital simulation quality in order to determine whether the tendency towards better valuations in analog simulations can be attributed to the possible lower quality of the digital simulations or whether a fundamental difference in valuation can be correlated to the type of simulation.

Furthermore, something to consider for future research is to choose an already existing residential area, which could be transposed back into analog and digital simulations. In this way the value judgments given by the research subjects could also be given for the real residential area. The comparison of these valuations with those given for the analog or digital simulations would allow conclusions to be drawn regarding the more effective performance capabilities of analog or digital simulations (see also Fahle & Haefele 1983).

Above and beyond this point, the extension of experimental approaches from purely static simulations to dynamic and/or interactive simulations for the use in comparative studies would then be thinkable. An additional quality in the simulation can lead to other, and for analog and digital simulations, different evaluations of the performance capabilities of each. Additionally, the extension of the parameters to be investigated which could include, for example, questions pertaining to the cognitive spatial representation within both types of simulations could improve the evaluation of the performance capabilities of an analog and a digital simulation.

Lastly, when it comes to creating a differentiated picture of the advantages and disadvantages of both analog and digital simulations, a conclusive judgment of the advantageousness of using one or the other simulation, other aspects such as the work requirements for the generation of a simulation must also be taken into consideration. At this point in time, the generation of a digital simulation takes considerably more time than for an analog simulation. Now as in previous times scaled model representations of urban design projects

are constructed, not insignificantly, for their haptic qualities and also for their particular demonstrative aspect for the lay public. Along these lines, the time requirements for the generation of an analog simulation would be further reduced when the necessary model is already available.

For the design of trade fair stands and theatre stages, the use of scaled analog models will continue as before or will even be intensified. These models are more flexible in day-to-day use and leave more room for discussion in projects still in the planning stage. In contrast, digital three-dimensional transpositions require additional expenditure and appear less natural in the transposition (see also Page 11/99, p. 21).

4.4 Epilogue

In the usage of simulations in practice, for genuine urban design projects for example, it seems as though analog simulations show advantages over digital simulations. For the time being analog and digital simulations do show clear and distinctive differences not subject to exceptions in the valuation of urban design quality. At this time the performance capabilities of both simulation technologies can be viewed as similar. The appearance of an analog simulation continues to seem more natural, as in the past. In line with experience, the time requirements for the generation of an analog simulation are lower, especially when a scaled model is already available, which is further reflected in lower costs.

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