PURPOSE COMPLIANT VISUAL SIMULATION

towards effective and selective methods and techniques of visualisation and simulation

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ABSTRACT

Visualisation, simulation and communication were always intimately interconnected. Visualisations and simulations impersonate existing or virtual realities. Without those tools it is arduous to communicate mental depictions about virtual objects and events. A communication model is presented to contribute to a better theoretical foundation of the meaning and relevance of simulations of different types.

Introduction

Some centuries ago the relevance of visualisation was (so the legend says) experienced by tsar Peter the Great, who wanted to master as fast as possible the prominent Dutch shipbuilders' craftmanship in those days in order to create his own contemporary Russian shipbuilding industry. For various reasons, the Dutch craftsmen used little draughting to communicate the shipmakers' knowledge. The English shipbuilding industry used drawings to store knowledge and experience, and scaled models for simulations. It was only by this English approach that the tsar could obtain the needed transferable knowledge and experience to send home for implementation.

Visualisations do more than to communicate factual knowledge. Visualisations are also used as a means of expression and persuasion by the designers. And as a device of identification and participation by the client and others, like users or inhabitants, they also help to elicit other people's reactions about perceptions, experiences and significations supposedly corresponding to the reactions to the original, existing or yet to be realized.

The question is whether simulations lead to correct decisions: they do so only if the behaviour shown in interaction with the simulation corresponds to real user behaviour once the design is built. This is far from evident and needs to be proven. Stimulation of the imagination about a not-yet-built environment is not sufficient for correct decisions. A seemingly realistic simulation can even lead to results which are irrelevant to the purpose pursued. The visualisation of shapes and materials should activate the knowledge and experience of designers and decision makers about the expected functioning and operation of the visualised real or virtual original.

The need for further theoretical development

Due to the improved technical developments of display dynamics and virtual reality, the use of simulation and simulators is growing beyond the traditional application areas of environmental simulation. However, the theoretical and conceptual development does not keep up with the enlarged technical possibilities.

What all means of visualisation and simulation have in common, is that they are used to acquire an understanding of the effects of the intended situations and to communicate them. In order to compare, interprete and evaluate the means of visualisation and simulation on all relevant aspects, the needed theoretical development should be directed to connecting purposes, operational models and devices. In this paper we suggest to take a communication model as a run-up to a possible basis and scope for such a theory and a research program inferred out of it to visualise and simulate in a purpose compliant valid and applicable way.

A tentative communication model

The proposed communication model is derived from the linguistic concepts of Roman Jakobson (1963) about the functions of linguistic communication. Jakobson makes six distinctions: (1) the emitter, (2) the recipient, (3) the context, (4) the channel, (5) the code and (6) the message. Six functions correspond to these distinctions: (1) the emotive or expressive one for the emitter, (2) the attention and direction one for the recipient, (3) the reference and denotation one for the context, (4) the keeping up of the communication one for the channel, (5) the metalinguistic function one for the code and (6) the poetic and esthetic function one about the style and substance of the message.

If we apply this model to visual communication about the built environment, visualisation is the combination of channel, code and message. Its reference to the architectural building (context) occupies the central role. It is related directly to to the emitter wanting to express her or himself by way of the visualisation. It is connected to the recipient as an attention calling message from the emitter to influence the behaviour of the observer, for example to direct him/her towards a certain point. The visualisation as a reference to an existing or future reality as the original building or piece of architecture to be realised should also reflect the performance of the building. Moreover on a meta-semiotic level, a scale model for example consists of spatial elements which are intended to refer to other spatial elements. Last but not least, a visualisation has qualities of its own: the same medium can be stylish or be designed in an uninspired way. Jakobson's model is a good starting point. However, it does not help us enough when we see visualisations as reference and reflection of the performance of buildings: we will come back to the complexities of visualisations as models in the following.

The visual communication model and theory related purposes

There is no universal visualisation which can represents all the aspects of a built environment, or it would be the built environment itself, like in a story (by Borges) where the map becomes the country and vice versa. And even reality is not good enough a model of itself: as a predictive model, it excludes 'what-if' manipulations and exercises. Therefore we must make a choice, and to make a choice, we need theory. Such a theory should connect the types of purposes which we aim for when making a visualisation, the types of operational models and the kinds of media we use. The visual communication model as an ordering device might be a step towards a theory connecting purposes, operational models and visual means. From the model at least three architectural purposes can be discerned from the position of both the emitter and the recipient.

(1) The first type of purpose has to do with functions, its usage and workings of the built environment. The model should tell us something about how a building performs as an environment for its inhabitants and how it stands as a technical object submitted to wear and tear. Usages are specified in words like 'school' or 'classroom' and the way a building works is stated by performance specifications about for instance the permeability of the building for heat and cold or for sound or noise.

(2) The second type of purpose is related to form. It has to do with establishing a relationship between the visualiser and the recipient via the visualisation. A visualisation is not neutral. It carries with it some of the values and choices of the visualiser. The recipient will judge the visualisation according to his of her own system of values as a meaning worth to accept or to reject and replace for a meaning of their own and independent of the intended one. Meanings are given by the geometric shape, position and surfaces of

the building, material and constructional surfaces varying in their size, as well as in their value and color, their transparency and ornament and their texture, orientation and articulation; all these formal qualities act as metaphors, as signs and symbols. It is studied by semiotic analyses, by art criticism and the use of iconographic techniques. If the configuration of those formal qualities conforms to a coherent whole, we call it a style.

(3) The third type of purpose has to do with making the deeper structure of a building tangible by expressing its topological circulation structure. Thomas Markus has illustrated the deeper structure as the driving force to experience a building as a social system of distributed controls and power and of bonds and friendships (Markus, 1993). Markus uses tree diagrams to express spatial dependency. The deeper a tree structure is, the more dependency is felt by the user and the less legible it is. And in reverse to arrive at legible buildings, one ought to allow the user control over his own circulation. To enhance bonds and friendships, shallow spaces and rings are needed instead of deep trees.

For each type of purpose there will be a more or less adequate kind of model and a more or less adequate method for communication.

Degrees of manipulation

Traditional scale models and projections are descriptive models of reality. They are easy to understand but difficult to manipulate in order to determine the effect of changes on the original. On the other hand a computer simulation makes such a manipulation easier to perform. The same holds for the presentation of the model to the recipient: this is a matter of the properties of the visualisation as such. The degree to which visual simulations might be manipulated differs to a great extent. They might be distinguished as: (1) passive (2) in interactive (3) controlled and (4) generative types.

1. All photographic and predescribed (video)film productions like endoscopic and virtual reality presentations are passive simulations, because the observer is confined to looking at what someone else has composed for him of her.
2. With life shots filmed or video taped by the user or observer him/herself, it is possible to

interact directly with the endoscopic equipment or the Virtual Reality system used, in order to look from every position to the still immovable 3D model and surrounding environment.

3. In controlled simulations the (2D or 3D) model itself is made movable in a fixed environment, like training telecontrolled robots for inspection in harsh environments.
4. In generative simulations the object itself is made either changeable or mutable: changeable by physical or electronical combinatorial elements for building alternative designs, or mutable by breeding genetically coded shapes within a morphogenetic computer program (Daru & Snijder, 1997).

Comparisons have already be made between some of these types of simulations. The first type, passive simulation by means of an optical endoscope, is compared with simulations of the second type by digital means by Stellingwerff and Breen (1995). Ohno, on the other hand, uses interactive simulation (Ohno & Hata, 1993; Ohno et al., 1995). When interpreting the conclusions of such research we should take into account the purpose to which each simulation can be used. A nice example of the generative type using a classical endoscope is given by Breen & Dijk (1997).

The possibilities for manipulating the model and the environment are different per simulation type. With passive simulations (1), one needs shots of for example (video)films of different models in order to vary the visualisation. In the case of an interactive simulation (2), the presentation (but not the model) is changed by the user of the system. In a controlled simulation (3) the behaviour of the model is changeable within the visualisation (for example the airplane model in a flight simulator). Last but not least in generative simulation (4) the model itself is changeable, allowing to study its behaviour and perfomances directly integrated with design interventions.

Integrating evaluation into visualisations

To simulate we should make a visualisation changeable. Every change will have some effects on values one is interested in, like aesthetic sensations, associated meanings, functions of all kinds, costs or technical performances. In scientific parlance the changes in the visualisation might be thought of as the independent variables and the values influenced by them as the dependent variables operationalised in some measurement procedures. Independent variables are the explaining variables under direct control of the experimenter.

The dependent ones are the variables to be explained, the behaviour or response we seek to measure, because we suppose that they are determined in some way by the independent variables.
Without a computer, calculating effects and making comparisons is a tedious job. Which is why it is generally left out. Once the calculation of effects is integrated in the visualisation software in the form of evaluation functions, using visualisation as experimental instruments is quite feasible. It is one of the most important conditions to produce reliable data.

Social objectives for visualisations and simulations

To govern is to foresee, to design is to foresee and to decide is to foresee. In all cases, we need reliable data. If visualisations and simulations will perform well to predict future reactions of users, owners and clients, they should resemble the real environment in their most essential characteristics as related to the purpose intended. Epidermic realism is not always asked for. If sightlines are more important, they should be modelled carefully with the body sizes of the user in mind and without a lot of effort wasted in the rendering of the walls. Extreme or even exaggerated realism is not only wasteful in many situations, in some cases it can be irresponsible. When the presentation becomes overpowering, it can frustrate sensible decisions and make people take choices against their own interest.

Scientific objectives for visualisations and simulations

What is the value of data about the way buildings are used, the feelings, attitudes and meanings they elicit when they are obtained by having people look at visualisations and simulations instead of the real thing? To give an answer comparative research is needed. After all, even the presence of some instrument is already enough to influence the behaviour of a subject and consequently to bias the results obtained. But working with visualisations and simulations we should not only take into account the purpose dependent essential characteristics of the environment to be translated in the imitation. Every imitation of reality simplifies a number of characteristics, and at the same time adds others which are not present in the reality it refers to. For instance with VR there is in principle a lack of gravitation and physical substance, allowing everybody to glide through, over, under and astride interior and exterior spaces and to traverse walls and floors. This can of course to some extent be programmed out.
We cannot expect to make good predictions based upon the reaction of people to simulated

or visualised environments, if we don't know exactly what the difference is between the simulation and reality, and which characteristics must be present or can be absent in the model.

Using technical possibilities beyond epidermic realism

Some of these problems might be overcome by taking into account user characteristics (such as body dimensions, weight, sight and movement restrictions). Even aesthetic and other preferences and attitudes could be added to simulate the reactions of special types of users within a visualisation on screen. Such user dependent conditions might be accomplished by:

- built-in special user interface constraints (limiting the user interaction of the interactive type of visual simulation) or
- avatars as representatives of one or more users and made observable on screen (limiting the avatar behaviour of the control type of visual simulation).

Avatars are beings arrived from the world of gaming, but they can be very useful in simulated environments as well (see for example Holtzman, 1997). Unlike avatars, constraints are working mainly in the background. They are only experienced if they prevent actions the user of the software is not supposed to be allowed. In such a case the average user for instance cannot traverse walls. In the case of a disabled person, the user interface should be adjusted to the constraints. This could mean for example that a staircase on the screen would not be accessible.

In the absence of real users from the intended population, the user interface constraints and avatars will act as virtual test subjects enabling the designer to evaluate and eventually to correct his or her design.

An avatar as an agent of the user on screen has the added advantage that it might be observed within the scene to be studied. Each user might even have several avatars, with specialized behaviour to test different aspects of the environment.

Efforts should therefore not only be invested in ever more sophisticated (epidermic) realism of the visualisations. Attempts should also be directed towards the possibilities of simulation of special user types by either imposing restrictions on the handling of the user interface or even better by applying avatars.

Physical-ergonomic avatars, simulating body dimensions, weight, sight and movement restrictions might be implemented in the software relatively easily as they are based on formalisable hard rules. On the contrary aesthetic and other preferences and attitudes will obey to more implicit and fuzzy rules. But if those rules are used in a consistent way, they might be captured effectively by neural networks. These networks, implemented in the software, can emit visual or acoustic signals and comments within the user interface or avatar. They ought to be programmed as to adapt themselves to the changing behaviour of the user.

Behavioural research and morphogenetic design

With user interface restrictions and/or avatars implemented in the simulation system, a variety of alternatives for the designed and modelled environments might be evaluated in a relatively easy, understandable and efficient way. But in order to define the interface restrictions or avatars, behavioural research should first be undertaken with real subjects in real environments and/or simulations with the most essential purpose-dependent characteristics implemented in the software.

To enable flexibility in producing new alternatives it is necessary to restrict the work in designing them. Morphogenetic design systems (Daru & Snijder, 1997) might be a solution for this type of problem. In addition it is then possible to combine designing and evaluation in a simultaneous process.

Examples in the field of wayfinding and spatial cognition

To test wayfinding properties of an environment the traditional endoscopic techniques are problematic. To our experience, comparing real environments with endoscopic presentations, subjects showed differences in their performance. Even when in a real environment subjects find their way easily and are able to make an accurate cognitive map, the endoscopic presentation of the same environment did bewilder a comparable group of subjects. Within a few turns of the endoscopic tube the user was already confused about the direction he or she is directed to. Moreover, building up a spatial map based only on the eye-level endoscopic visualisation is difficult te accomplish (Stellingwerff & Breen, 1995).
The endoscopic interaction method used by Ohno et al. (1995) is producing useful results, allowing for user initiated perception. This is a shift from the passive to the interactive simulation type, according to the notions of Gibson's ecological perception. User initiated viewing was found to be crucial also for tele-operation (Smets, 1995). However the literature

is not very clear about the requirements of simulation in the field of wayfinding, as fundamental work in perception, cognition and learning showed the importance of movements and bodily kinestetics, which are not available in mouse and joystick controlled interaction. To include movement and kinestetics in simulation we can allow the subjects to move physically around in the simulated environment. This is the most direct interaction possible for the interactive type of visual simulation. This requires a body-size simulation, e. g. with a real scale model.

Such a body-size environment can be abstract or more realistic, depending on the purpose of the assessment. For wayfinding research it is important to control the interference of mental maps. As for mental maps the literature distinguishes between the spatial cognition and environmental cognition (Kitchin, 1994), and it is important to consider this difference in the simulation. Whereas in environmental cognition the subjective interpretations and preferences of the subjects are an important aspect of behaviour, the simulation should have photographic realism when assessing this aspect. However where spatial cognition would be muddled by appreciation of textures and such, we should use neutral surfaces. In this neutral environment it is possible to include only the cues and landmarks which are needed for the study. For the urban environment Ohno et al. (1995) have applied such a neutral environment with addition of some cues. On the scale of buildings Passini found useful results on wayfinding in a body-size labyrinth built-up with identical door sized panels (Passini and Proulx, 1988; Passini et al. 1990). So there is already some experience about the use of models but it is scattered. We hope that in the future it will be possible to come to a coherent body of knowledge which will make attractive visualisations also really useful and efficient.

Concluding remarks

At the moment one buys or programs a visualisation technique assuming that it is appropriate to one's intentions. Or the administrator will burden the user with one or other technique, because it is cheaper than others, or on the contrary because it is technically more advanced and expensive and therefore it is more prestigious to have it at one's disposal. If visualisations and simulations are to help us, we must be in the theoretical and practical position to judge them according to the purpose we want to deploy them for. In order to get there, we should try to contribute to the development of a theory step by step to direct us in

our choices. Available visualisations and simulations should not define our research, our research should define them.
We still have a long way to go to make visualisations and simulations into models which fit our purposes, but we can make it happen.

By the way, we wonder what tsar Peter the Great of Russia would have said about the '97-MIR? A good predictive model wouldn't have been wasted there.

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