USER REQUIREMENTS FOR VIRTUAL ENVIRONMENTS USED TO MODEL BUILDINGS AT THE URBAN SCALE

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ABSTRACT

Urban renewal is a complex process involving numerous actors and data. In such a process, design and communication tools play an important role. Appropriate visual tools should be able to establish a common language between professionals and between professionals and citizens. However, there are indications that particular representations may also achieve the contrary by creating different perceptions according to the background of the actors. New emerging technologies offer a large variety of visualisation tools that may solve this problem and greatly enrich visualisation and communication possibilities. This paper discusses the specifics requirements for virtual environments to be used in the framework of urban building models and investigates how 3D geo-information technology can be used to support this task.

INTRODUCTION

Post-war neighbourhoods in the European Union often fall short of fulfilling current needs and are consequently being renovated on a large scale. Urban renewal is practically a complex decision-making process, which involves many actors, performing different tasks and having diverse points of view. In urban renewal projects such actors have often-conflicting expectations, background and foci. In the Netherlands, the urban renewal design consists mostly of six phases, which has as a result specific maps and plans:

- The Vision plan, which is the beginning in any urban planning process, decides on general development of a particular area.
- Land use & Zoning plans are the official long term plans for sustainable development of a municipality. They define the planned land use and the allowed future developments.
- The Master Plan is a large-scale plan that shows the future shaping of the area emphasizing the important spatial relationships. It is a sketch plan and usually altered in gradual steps. It also gives a social and economic character of the design.
- The Urban plan is the detailed plan for the development of an area. It is often a collection of sketches and description in a real scale plan, making distinctively clear what should happen in the area.
- The Specialization Urban plan indicates the functions and the detailed volumetric structure of the buildings.
- The Architectonic-quality plan shows architectural aspects and form and shape of the buildings. It represents the architectural aspiration of the project area as when implemented. Details such as window openings, doors, facades etc. are clearly represented.

Actors involved in those phases are quite different. While in the first three phases more urban planners and local authorities are involved, in the last three phases architects and citizens are more prominent. The actors in urban design and planning in the Netherlands can be subdivided in two large groups with respect to their involvement in the design process:

- Design Professionals: urban planners in municipalities, private architecture and urban design firms, technical experts on design quality and social housing agencies and related technical consultants (internal departments, construction firms, project developers, etc).
- Non-design Professionals: the municipality, politicians, citizens

Visual information is believed to help in discovery, understanding and analysis of design problems in order to propose and choose sustainable solutions. Traditionally, municipalities use 2D paper maps, CAD drawings, graphical images, textual/oral information and physical 3D models to present ideas and discuss alternatives to citizens. Most municipalities have websites for dissemination of spatial plans, but they are in 2D and in most cases static visualisation. Only recently large municipalities may employ systems allowing for presenting interactive digital maps for the public in Web Map Services (WMS) \cite{1}. In the last several years advances of
geo-information technology such as 3D virtual environments, 3D analytical visualisation and 3D formats for sharing of data offer large spectrum of new possibilities for communication of ideas and discussion of design alternatives. Virtual environments like Google Earth, Virtual Earth have made 3D visualisation known and accessible for everyone. Many municipalities and urban designers are in process of discovering these new functionalities. However, there are indications from practitioners that this visual information is not necessarily equally perceived. A given representation may be misunderstood by the receiver, due to wrong presented message or due to different concepts of the actors.

This paper presents our study on applicability of new visualisation tools and environments in the large-scale urban renewal process. These are estimated with respect to different actors and different phases in urban renewal process. Through interviews and questionnaires different possibilities were discussed with a selected group of actors in the urban renewal process.

VISUALISATION TECHNOLOGY OF INTEREST FOR URBAN RENEWAL

Visual materials
Visualisation can be very realistic or very abstract, which is much depending on the application and/or the purpose of the visualisation. Numerous classifications can be found in the literature defining levels of abstraction. To reflect the level of abstraction we have adopted the LOD subdivision as presented in CityGML (an open data model, XML based format for the storage and exchange of virtual 3D city models). LOD0 is considered as 2D model, the consequent levels are regarded as 3D models. CityGML was of particular interest due to last initiatives in using it as a bridge for integrating GIS and CAD/BIM models ([2], [3], [4]). Considering the levels of details several models (TUDelft campus and Potahof neighbourhood) were created, which were used to illustrate the idea of LOD during the interview (Figure 1). The models were created without using realistic images for texture to avoid confusion and keep the attention on the level of abstraction.

Interaction with the model
As described in the first section, urban renewal involves many non-design users, who have difficulties distinguishing between the wide number of interaction possibilities. Moreover we have limited ourselves in this research to the use of desktop systems without elaborated hardware equipment. Therefore after thorough analysis of several taxonomies, we have defined the following five levels of interaction: animation/video, interaction (navigate, zoom, manipulate), query (explore), feedback and change (edit). These types could be easily explained to all approached users:

1. Animation is a dynamic visualisation of walk-through (fly-over) existing or design area. Animation can be created from a sequence of images or directly from a 3D digital model. Although visually 'dynamic', the user cannot change the sequence of visualised materials. He can only observe.
2. The second more advanced level is navigation. The user is provided with tools to change his position in the 3D model and adapt his/ her field of view (distance and angle to a particular object). The user still cannot change anything in the model or in the scene, be he/she can decide freely where to go. Typical tools provided for desktop systems are ‘walk through’, ‘fly over’ and ‘examine’.
3. Next level of interaction is possibilities to query objects. The user has the opportunity to obtain more information about the object (not only what is visible). Some software packages are able to provide such information automatically on ‘mouse click’ and ‘mouse-over’ (e.g. Google Earth).
4. Feedback is yet another level allowing users to express their opinion. Opinions will be recorded for later analysis and evaluation, and replies could be sent back.
5. Change (edit) is the highest level of interaction, when the user is allowed to invoke changes in the shape or attributes in the 3D model. This usually requires specific editing tools most often performed with the mouse (click and drag) or combinations of mouse and keyboard. The editing could be temporal or permanent.
RESULTS

The six types of visual materials defined in Figure 1 and the five levels of interaction defined here above were investigated during a workshop with 30 participants from 13 cities. The investigation was carried out among design professional (urban planners, housing companies and architects) and non-design professionals (municipality). Citizens were not directly interviewed but the municipalities were requested to give an opinion on level of interaction appropriate for citizens. Additionally, several very experienced urban planners (called here experts) from large municipalities and housing agencies, involved heavily with renewal projects were interviewed separately. The two major questions in this research were:

- Which digital visual materials are most suitable in the renewal phases?
- Which functionality have to be provided to be able to best understand and evaluate the proposed design alternatives?

Two questionnaires were prepared one for each research question and where organised as statements, which the users have to evaluate using six-level scale (absolutely necessary, necessary, desirable, don’t know, not necessary and absolutely not necessary). The results from the questionnaire were prioritised using the MoSCoW method [5] into must, should, could, and won’t (but could be in the future) be available in a system for urban renewal. A statement is classified as must be available when above 75% of the interviewed have agreed (absolutely necessary, necessary and desirable) with that statement. The results between 50% and 75% are classified as should, 50% and 25% is could have and below 25% is won’t (but could be in the future).
Visual materials (see figure 1)

Static images (photos and snapshots)
Reference pictures (snapshots from 3D architectural models) have been widely used though the entire renewal process. The photos are especially important in the beginning when the social situation is discussed. The study has shown that 60% (in average) of the interviewed has found static visual material appropriate for presenting ideas in all the phases. The discussions with the group of experts have revealed interesting observations regarding reference images. Reference images are provided at later stage when the Urban plan has to be presented. Although it is often believed that reference pictures can help in the design phase, it appears from the interviews that people often focus the discussion on unimportant features. For instance the materials used for the buildings will be discussed whereas the volumes are important. Misunderstandings have been noticed between professional as well when using too soon detailed pictures. However, reference pictures are of importance later in the design process, when discussion starts on this materialisation.

LOD0 (Maps)
Design professionals prefer two-dimensional maps with provisional plans at the beginning of the process because they do not fix any detailed solution and allow for an extended discussion. At the same time they doubt whether these two-dimensional plots are really understood by citizens. Using them in combination with physical models is a preferred option. LOD0 is found mostly appropriate for the Master (70%-80%) and Urban plan (50%-70%). Specialisation Urban plan could be also represented as a map (56%) but without many realistic details (36%). This is a clear indication that the plans might be confusing when more detailed maps are presented within information about vertical space orientation. Although few argue for map visualisation (32%) in the last very detailed phase, it is obvious that 3D visualisation is then preferable.

LOD1 (block model)
Block models have been widely used for creating a volumetric perception and presenting new design within existing situation. Those models however have been mostly physical (created in one specific scale). As discussed with the experts, block models give good overview on existing situation, without concentrating on details. Design alternatives have been also discussed applying physical block models with citizens. The digital block models seem less attractive. The discussions have revealed that the good possibility for overview is somehow lost when looking at the computer screen. The interviewed could agree (72%) having LOD1 for an early stage (Master plan), but their use in Urban Plan (60%) and Specialisation Urban Plan (56%) is estimated as could be used. Clearly, the participants selected LOD1 as the most appropriate type of presentation of Specialised urban plans, although without convincing majority (64%).

LOD2 (detailed roof)
LOD2 is much better appreciated compared to block models. Apparently roof (or façade) information helps in understanding the ideas. For Urban plans most of the survey population (72%) argued for the use of LOD2 (without texture). The texture, which gives more information on facades is seen dangerous at this stage. Our interviews have revealed an interesting observation, i.e. the level of visual detail is understood by the actors as having a relationship with the stage of the project. Abstract forms and hand drawings are tools for the beginning of the project. More details and clear computer drawn lines depict a finished design. Style of drawing may have an implicit message, but this implicit message is not necessarily understood the same way by professional and non-professional actors. Therefore the interviewed also refused the use of this LOD for Master plan (13%) and could accept (36%) such possibility for the Specialisation urban plan. It is not surprising that textured with realistic images LOD2 models becoming very attractive for Architectural-quality models (76%).

LOD3 (architectural)
According to our investigation, LOD3 is the abstraction needed during presenting and discussing the Architectural-quality plan (88%). This is the stage when all the finalizing details should come at stage. The presented ideas should present as better as possible. This is practically the only phase when such a realistic visualization is required. Despite some people considered such visualization for other phases, from the discussions the benefit did not become apparent. The group of the experts did warned, that three-dimensional representations may also be confusing if the viewpoint is not the one of the inhabitant walking in the street. A view taken from an observer above the building for instance may be very nice for a marketing aim, but most inhabitants will probably not be able to draw conclusions about how it will be experienced from the street. Combining 3D models (or reference images of them) with realistic elements of the present situation appears to help citizens a lot in understanding the design. The experts did agree that the interaction (see below) will also play an important role. For example, a computer animation in which an existing tram was integrated tends to give the non-professional actors more grip on the design (municipality Delft).
**LOD4 (indoor)**

As it could be expected, this abstraction is only appropriate for the last phase and even some of the urban designers do not consider it important for urban renewal. Interiors of buildings may be designed for public buildings like shops, cinema's, restaurants, but hardly this is done for individual houses. Citizens generally perceive better floor plans, giving dimensions of rooms. This opinion however can easily be changed if more 3D indoor models become available. None of our models has designed indoor spaces and therefore it is unrealistic to derive a strong conclusion.

The urban renewal process runs from abstract to details and therefore the visual information should support this and yet provide every actor with as much information as necessary to make it intelligible. While architects are more comfortable with 3D models, urban planners and municipalities prefer images, animations and plans. Our study tends to refute the assumptions of Al-Kodmany in [6] that, for a good communication between actors, realism should be preferred to the expression of design uncertainties. A logical outcome of our interviews is that there should be more research on intelligible ways to represent design uncertainties. Combinations of several LOD in 3D scene is an option to emphasize on different parts of the design. Most of the population agreed that a comparison between existing situation and designed situation should be also possible (75%).

**Interaction and other functionalities**

The participants in the questionnaire had to consider that a visual system will be available to all the actors in the renewal process and had to define which functionality would be appropriate for the different actors. Every phase may require animations, navigations, query, sending feedback or editing. In this study for simplicity we have grouped the users in three groups: housing agencies, municipalities and fictive ‘citizens’. In our study, the municipality provided information (based on their experience with citizens) on the kind of functionality that would be appropriate for them.

**Animation**

Animation is one of the best-accepted tool for presenting a particular design to a group of people. As more advance the phase gets the more and better animations are expected. Since good animations could be very time consuming, they are mostly prepared for the discussions with the citizens. The experts group confirmed that animations are the best tools for presenting projects to citizens. Video recordings are made mostly for the beginning of the renewal project to show to design specialist existing problems. A very interesting finding was that the system should be able to animate and simulate a scenario (72%). Movies in mp4, avi etc are the most preferred animation formats. The simulation needs a well-designed algorithm to convey a good and convincing message. Animations could show development of green areas, traffic, sun movement, noise distribution, etc. Animations may be also 2D, e.g. to illustrate the grow of a city in the last five years.

**Navigation**

All the participants has easily accepted that the desktop navigation possibilities walk-through, fly-over and examine should be available. Most of them have worked with visualization environments as Google Earth or Virtual reality browsers. They classified this level of interaction as compulsory for all the actors when 3D digital models are used. Almost the whole survey population agreed that the system should have multiple linked windows visualizing co-coordinated views where different data of different dimensionality is viewed (80%). If necessary, the user should have the possibility of turn off the coordinated windows and only the 3D scene and/or the 2D map/plan will pop up. As the urban renewal is about comparing existing and new situation, the participants in the study have agreed the system should be able to visualize designs and existing situations and designs in different representation for specialists. However, the people in the municipalities disagree about sharing information of different design phases with the citizens. Some urban planners in municipalities do not see added value of the idea that the citizens should be consulted in every phases of design and therefore they do not see need of multiple representations. According to them the citizens may get confused. While the majority of people in the municipalities are interested in letting housing agencies add 3D models in the system (53%) (assuming that the system is managed by the municipalities) only a minority (33%) of the housing agencies and data providers are interested in sharing their 3D data with the municipality. They prefer to provide their data via services. In both cases the municipality (67%) and the housing agencies (83%) strongly disagree to let their data to be copied and saved. Both groups demanded strongly that they should have the functionality to hide and filter information (80%).
**Query/Exploration**

The specialists do not consider query of the model a compulsory characteristic. The system should allow the users to click and select the 3D models. The discussions during the workshop have revealed that further questioning and information request is important, but the direct user manipulation with the 3D scene is not vital. In GE, BitManagement X3D plug-in or VirtuoCity one can click and select the ‘pin points’ but not the 3D objects. This functionality is better accepted for citizens. CityGML viewers like LandXplorer or Aristotle lets the user click and select 3D objects are more appropriate for specialists. Through the CityGML is created with reach semantics, it can be used to get overview on construction parts or materials. The participants have agreed that the system should have dynamic spatial query to find street, areas, postcode etc. similar to Google Earth possibilities (76%). In a way, this is a kind of model exploration and it results in must have functionality. The same is valid for elaboration of 3D models through hyperlinks and linked windows. All the professionals see this functionality as ‘must have’ (80%). The general impression was that the municipalities were open to provide a large set of exploration possibilities for the design specialist and municipality and a bit less information to the citizens.

**Feedback**

Feedback is considered important, especially during discussions and presenting plans to citizens, but they prefer either real-time discussions or collection of opinions and off-line analysis. Many officials at the municipalities and housing agencies think that tools as interactive chatting are a very low priority (12%). Although tools as interactive chatting, videoconferencing, etc. increases collaboration and design interaction, which is the main task of such system, this option is still not accepted. In free discussions, the specialists pointed out various reasons like ‘chatting is relatively slow’ (better talk via phone), or ‘videoconferencing might be unreliable’ (better discuss face-to-face), or the good video-conferencing system is expensive. But almost everyone agreed that the system should have functionalities for email feedback or let the voters vote electronically, etc (‘must have’).

**Editing**

The editing of provided information might be allowed only for design-specialists (67%). The system should not allow the citizens to move and delete 2D/3D objects and their attributes (80% of municipalities). But the system can have functionalities to modify views, colors and transparency, which occur temporary on the local computer of the user that don’t change the data in the database. This functionality lets the citizens interactively and intuitively design solutions for urban development projects. The municipalities could not imagine how a system can be designed that can simulate citizen’s design similar to block physical models.

In general the few of housing agencies and municipality does not differ much in their opinion about needed functionality. The system should be more elaborated for design specialist and providing basic navigation, and exploration tools to the citizens. The sharing of data is a very sensitive issue for design-professionals: they do not want to share all their design models with the municipality, though they understand the benefit of comparing and sharing.

**CONCLUSIONS AND RECOMMENDATIONS**

In this paper, we have reported our investigations on the use of visualisation tools and functionality in the urban renewal design process. The way visual information is presented to the various actors is of critical importance for the correct communication of ideas and discussion of alternatives. In this respect, we believe that many of the discussed misunderstandings can be avoided by using multiple computer generated representations, which can be adapted with respect to the needs/expectations of the users. The concept of LOD is a very promising approach to agreeing on abstractions and representations in the different renewal phases. The discussions did not revealed lack of digital possibilities for visualisation. Several times was discussed that attention should be paid how to visualise the proposed alternatives.

The second aspect of our study, interactivity, has revealed that the municipalities are convinced that the citizens should not go further than giving feedback. Animations, navigations and possibilities to explore the design proposal via additional information provided via web links are the best tools. The municipalities are open to think for much higher functional and interaction possibilities for design specialists. A system that can comprise all the data allowing multi-view visualisations and even editing is not a strange idea. Systems like GIS/CAD/DBMS would is able to provide such functionality.
REFERENCES


