USE OF ACOUSTIC SIMULATION AND VISUALIZATION FOR REVITALIZATION OF ANCIENT BUILDINGS

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Abstract: *In this paper, the new approach to reviving of ancient buildings is described. Photo realistic visualization is performed to create exact visual reproduction of the building. To make the virtual environment complete a 3D acoustical computer simulation is also performed. The results of acoustic simulation can be used to make an auralization of the building. This approach has been carried out on the atrium of "Knežev dvor", one of the most famous buildings in Dubrovnik.*

Key words: *sound, computer simulation, visualization, auralization*

1. INTRODUCTION

For some time the computers have been used as a valuable tool for revitalization of ancient buildings. Primary use of computers in this field is for the purpose of visualization. The visualization of ancient buildings that no longer exist is interesting for both archeologists and public. Archeologist can test their thesis by visual inspection of computer models of buildings they study, in order to find misconceptions that are not so easy to discover in 2D drawings. Public can benefit by exploring high-quality photo-realistic renderings of famous buildings that no longer exist. In addition, by the means of Virtual Reality (VR) technology, it can walk through them using the computer and VR equipment.

However, in most cases the use of computer technology stops here, even if the object of attention is some acoustically interesting building [1], like a theater, a church etc. In these cases, the simulation of acoustic properties would be of great help in the archeological research. It could give them additional data to reach better conclusions in case where acoustic plays an important role in the particular space. In addition, the results of acoustical simulation can be used for an auralization [2,3] – reproduction of the anechoic signal convolved with the impulse response of examined space. Thus, the VR experience of a visually reproduced building can be enhanced by adding sound either preprocessed or real-time.

In order to examine this technology a pilot project was carried out. If some destroyed building were chosen for the simulation, there would be impossible to check accuracy of visual and acoustical simulation. To be able to verify results the existing building was chosen – it was "Knežev dvor" in Dubrovnik.

2. VISUALIZATION

"Knežev dvor" ("Lord yard" in English) is a famous building, often used for concert purposes, and its architecture is exceptionally prized. The whole yard is built of stone, and

hard lime plaster. For the purpose of the simulation, the atrium of the building was selected. The structure of the atrium is very complex, with numerous vignettes such as columns of different dimensions, column capitols, stuccos etc. Also, the ceiling of the atrium is the sky, which imposes great demands on accurate reproduction of light. Such a complex structure was a good model for testing the possibilities of highly realistic visualization. If the photo-realistic impression can be achieved in this case, it could probably be achieved for most buildings that don't exist anymore.

Fig. 1. Plan and side-view of the atrium.

First step to ensure high realistic visualization was to get quality blueprints of the atrium. They were provided by the Department for Conservation - Ministry of Culture. These plans were in 1:25 and 1:50 measure, very detailed, and included the plan view and all four side views of the atrium (fig. 1). This plans, together with some recent photographs, ensured that accurate 3D computer model could be made. Great attention was given to details – every capitol and stucco decoration was modeled, and not only bump mapped (fig. 2).

Fig. 2. Decorations were modeled in great detail.

To make the stone and plaster look realistic, custom textures were made from photographs taken at the site. The model had about 1 million faces (triangles) and it took 4 months to finish. The computer modeling and rendering was carried out in program Discreet 3D Studio MAX. Several products were derived from this project – still pictures, video clips and simplified VRML model that can be used for walk-through Virtual Reality visualization. The results of the rendering are shown on figure 3, which shows that highly photo-realistic look was achieved.

Fig. 3. Left - photography, right - computer visualization.

3. SIMULATION OF ACOUSTIC PROPERTIES

For the purposes of the acoustic simulation a simplified 3D model was developed [4], which consisted of 325 triangles (fig 4.).

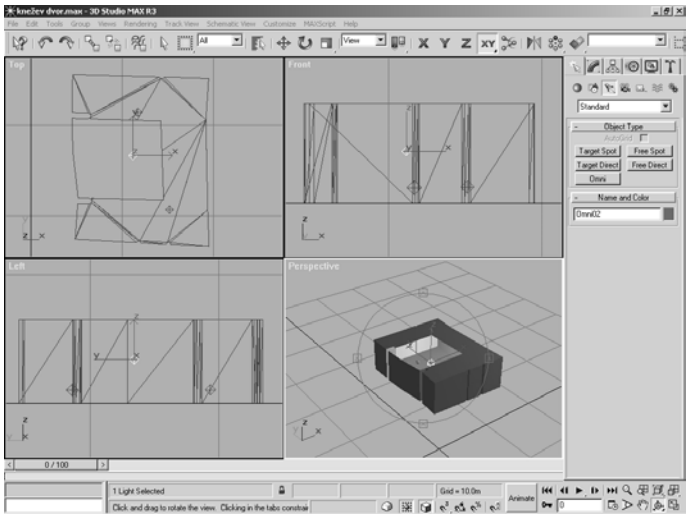

Fig. 4. Simplified model for acoustic simulation.

The model included only the basement of the atrium, because upper portions do not alter the acoustic situation in the parterre. The simulation was carried in HEAD 3D acoustic simulation software that works as a plug-in for the Discreet 3D Studio MAX. This simulation

software uses the virtual sources method for calculation of the distribution of the sound pressure level and the impulse response of the room. The parameters of the simulation were: absorption in air 0.02 dB/m, reflection coefficient for stone 0.9989, speed of sound 343 m/s. The source was situated beneath the main porch, at the height of 1m, and referent sound pressure was set at 0 dB at 1 m distance. Simulation, which included direct sound and first reflections, was carried out for raster of 100x100 points (fig. 5.). The results of the simulation show that sound pressure level was biggest under the porch (because of reflections from the porch ceiling), and that the lowest values of SPL occur in the entrance hall.

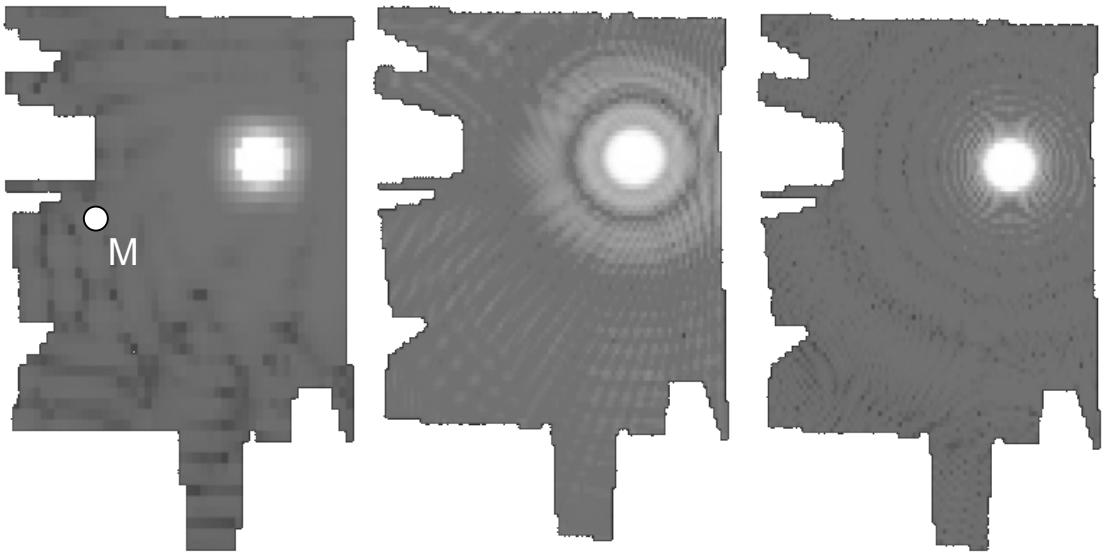

Fig. 5. SPL distribution for frequencies: 250, 1000 and 4000 Hz

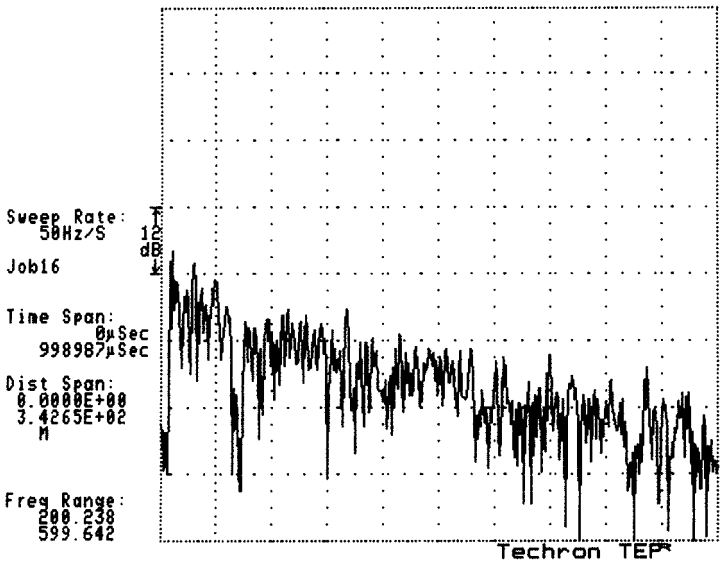

Fig. 6. ETC of measuring spot M, time span is 1s, frequency range 200-600 Hz.

The simulation results match well with measurements made in the Knežev dvor, [5]. For example, fig.6 shows an ETC curve measured on spot "M" indicated in fig.5. The source position for the measurement was at same place as in the simulation. Many strong reflections

can be seen after the direct sound from stone walls and floor. This coincides with the irregular pattern of sound pressure distribution shown in the simulation.

4. CONCLUSION

The visualization and acoustical simulation has been carried out for the "Knežev dvor" in Dubrovnik in order to test the abilities of software tools for revitalization of ancient buildings. This particular building has been chosen because of its complexity both in the mean of visual decoration and acoustical behavior. If it can be simulated, the reliability of this method is suitable for use in case of ancient building that no longer exists. The results of the visualization here presented can be of great use both to archeologists – as an additional tool in their studies, and to general public that is now accustomed to modern ways of presentation. The experience can be enhanced if models presented here would be used for real-time Virtual Reality visualization and auralization using the computed impulse response.

Next step in this project will be to use this method for an ancient building, which no longer exits. The first building that would be treated this way would be *Basilica Urbana* in Salona (today Solin near Split), one of the biggest churches of that time.

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