MULTISENSORY EVALUATION TO SUPPORT URBAN DECISION MAKING

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ABSTRACT

Community noise measures are conventionally based on various indicators derived from sound pressure levels. However this approach usually encounters difficulties in evaluation of experienced quality of soundscapes. Furthermore, communication of the technical noise information through maps and numbers is far away of depicting complex sonic environments. Virtual Reality technology offers possible improvements in these issues introducing realistic experience of sound and its context. In this preliminary study it is aimed to demonstrate the potentiality of a multisensory (audio-visual) evaluation technique, involving the end users during the design process and administration. The multisensory evaluation technique has been applied to a case study in historic neighbourhood Triana of Seville (Spain). This initial study is concluded with a demonstrative virtual reality application and with insights on possible future directions including the experiment protocol that should be designed with objective and subjective psychological measures.

RESUMEN

Tradicionalmente los estudios sobre ruido se han basado en indicadores numéricos derivados de los cálculos de niveles de presión sonora. Sin embargo de esta manera resulta complicado evaluar de forma subjetiva la molestia que ocasiona el ruido. Las nuevas técnicas de realidad virtual ofrecen la posibilidad de mejorar este aspecto puesto que representan con mayor realismo un ambiente en todo su contexto. El objetivo de este estudio preliminar es el de demostrar la capacidad de una metodología de evaluación multisensorial que permite conocer la percepción ciudadana ante determinados entornos, muy útil en los procedimientos de información pública. Dicha metodología ha sido aplicada a un caso estudio en el barrio histórico de Triana (Sevilla) para obtener finalmente una aplicación en realidad virtual de la misma.

1. INTRODUCTION

Contemporary urban governance requires a multi-actor collaboration in decision making processes in order to achieve a more democratic governing practice. Traditional top-down practices in urban and environmental context are giving their place to negotiation, cooperation and co-production processes. Beside the governmental and private partners, the general public and its organizations should be involved in urban decision making process. Urban decision making requires a compromise and a good understanding between the actors so as to achieve successful resulting decisions. The involvement of general public in decision making process enables a better understanding of users' needs and expectations, and also helps to build trust, increase user satisfaction and facilitates acceptance of new interventions in urban area [1]. In

Europe the Aarhus Convention [2] is the underlying document that establishes rights of the public regarding environmental issues. The three basic rights of public pointed out in convention are; access to environmental information, public participation in environmental decision-making and access to justice.

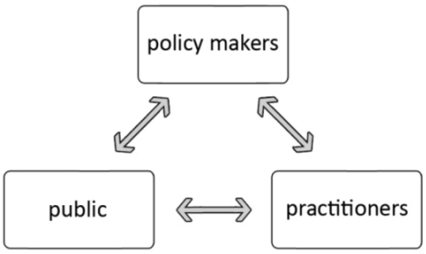

Figure 1. Actors of urban decision making.

In EU, environmental noise related issues are defined by 'Environmental noise Directive 2002/49/EC' putting emphasis, in accordance with Aarhus convention, on communicating environmental noise data to public. The presented noise information is required to be clear and comprehensible by general public. However, no definition of the public involvement process was specified. Noise maps and numerical data seem to be the tools pointed by the legislation for the public information. These tools are not easily understandable and do not give enough information to depict sonic environments for the non-technical users (general public).

Beside the legal necessity of public information and participation, it is getting more and more important to get consultancy of local experts (end users) in order to understand better the nature of human auditory perception and the reaction to the audio stimuli [3]. The generalized noise indicators of regulatory attempts do not consider the complex interactions that occur when people hear sounds. In our daily life we continuously sense sounds in our environment, these sensations recall our memories and previous experiences and trigger a multisensory processing that leads to identification and the recognition of environment. This process finally forms judgments as a function of the context in which the sound is heard. Standard regulatory processes can mislead the noise impact assessment when it is applied to different contexts, to different communities [4]. Therefore, an ecological assessment of environments should take into account the multisensory and interdependent nature of human perception.

There are several attempts to achieve better practices covering these gaps of standard procedures of noise impact assessment and public involvement. Three dimensional representations [5] [6] [7] [8] and virtual reality simulations [9] [10] [11] have shown promising results to overcome these issues. With the recent developments in VR technology and auralization techniques, it is much easier to communicate complex noise information making it audible and present it in its multisensory context [12]. Thus the general public can experience the urban environment with the changes in its aural and visual aspects in a realistic way and understand noise information without any prior knowledge of complex noise indicators.

In this preliminary study it is aimed to demonstrate the potentiality of a multisensory (audio-visual) evaluation technique which employs immersive virtual reality (IVR) simulations to involve the end users during the design process and administration. The multisensory evaluation technique has been applied to a case study in historic neighborhood Triana of Seville (Spain) in order to support technical understanding and awareness of regional legislation of Andalusia in terms of resources and possible solutions on noise and light pollution.

2. MULTISENSORY EVALUATION TECHNIQUE

Thanks to recent developments in virtual reality technology and audio-visual rendering techniques it's possible to experience new approaches for the assessment of urban sites [13]. The proposed methodology is based on objective and subjective assessments using an immersive virtual reality system. In order to assess the subjective reactions, regarding to the change of an existing scenario, the steps shown in Figure 2 should be executed comparing ante and post-operam situation at different locations.

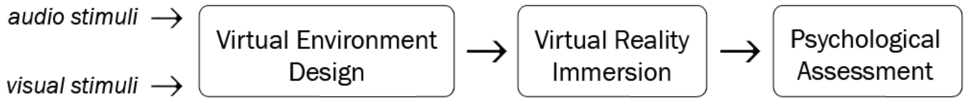

Figure 2. Scheme of IVR approach for multisensory assessment.

2.1 Audio Stimuli

In the design phase of the audio-visual scenarios, each chosen listener location is matched with two audio signals: in situ recording and auralized sound. They represent the ante/post-operam conditions. The in situ recordings are utilized as they are, considering the desired duration and representative time interval. On the other hand, for the post-operam conditions, the audio signals are obtained employing the auralization techniques. Each sound source contribution of the new project obtained according with the auralization tool in different listener location is merged with the in situ recordings of the appropriate position, to represent post-operam scenario (Figure 3).

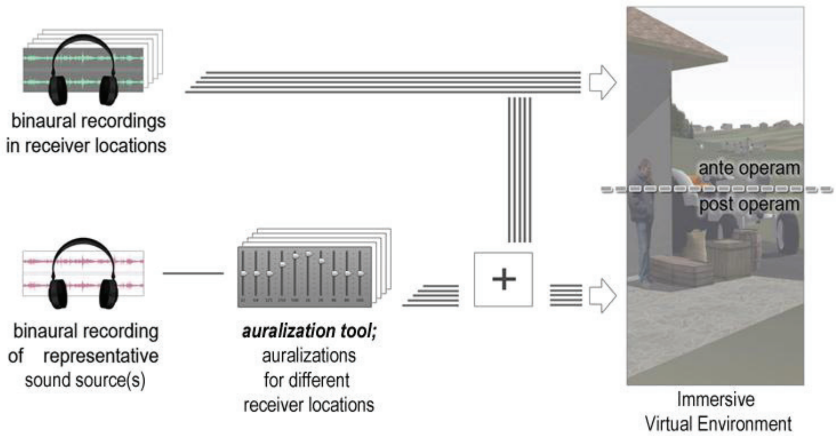

Figure 3. Scheme of the audio stimuli design.

2.2 Visual Stimuli

The visual stimuli are designed in three steps: 3D model by GIS data, texture mapping and IVR enhancement (Figure 4). In the first step a 3D model of the real environment, consisting of the built environment and of the ground, has been created by GIS data and satellite images. In the texture mapping step two series of images are used to be matched to the basic 3D model: in situ taken real photos and rendered images. The photos taken in the surroundings of the specified positions are utilized as they are, to represent the ante-operam conditions.

On the other hand, for the post-operam conditions, the images are obtained employing lighting simulation techniques. Each light source contribution of the new project considered to render post-operam scenario. In the third step, considering the sound sources recorded in situ, dynamic components like cars, people, animals, etc. have been added and programmed to act in line with the virtual reality.

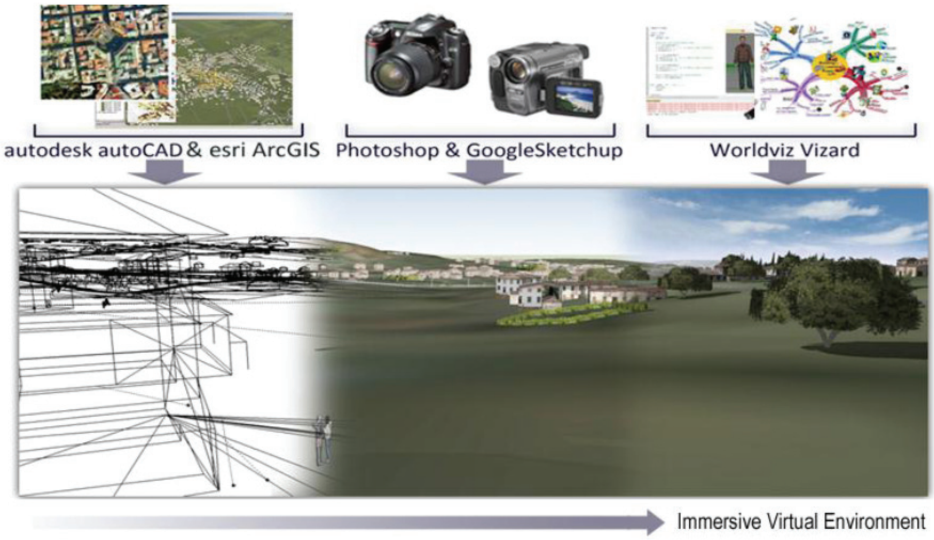

Figure 4. Organization of visual stimuli.

2.3 Virtual Reality Immersion Application

The reproduction of the prepared IVR scenarios can been carried out with an immersive virtual reality system that includes at least a work station linked to the 3-D Virtual Reality Toolkit . The 3D VR toolkit should be composed of the following devices: Head mounted display unit, two position trackers, equipped with high precision orientation sensors, one precise position tracker and earphones.

The audio reproduction system must be tested and calibrated with a dummy head, to get the accurate levels of audio stimuli.

Figure 5. Mobile IVR lab of Ri.A.S., Second University of Naples.(lab. in construction)

2.4 Psychological Assessment

In this phase according to the target of the study, the test subjects must be chosen in order to evaluate psychological reactions of general public. The subjects should well represent the variety of the local population.

Participants to test must perform a training session before the test starts. The degree of annoyance is evaluated with verbal and numerical rating scale. To analyze self-report ratings of annoyance, an ANOVA analysis is suggested [14].

Figure 6. Test phase of psychological assessment.

3. CASE STUDY: TRIANA – CALLE SAN JACINTO

Triana is a neighborhood in the city of Seville, Spain, across the river Guadalquivir from the center, and in fact the majority, of the city. The most common route of access to Triana, from the city center, is through the bridge of Isabel II. The bridge leads to the calle San Jacinto which is a vibrant street of the Triana neighborhood.

3.1 Analysis on Study Area

Several exploratory surveys have been carried out at different times of the day, in order to reveal the daily life dynamics as well as the built environment. During these surveys special attention paid to reveal pedestrian/traffic flow and identification of noise and light sources.

To build-up the simulation, several soundwalks carried out in study area. Binaural audio signals (16 bit/44.1 kHz) were recorded with a portable two-channel device "M-Audio Microtrack 24/96" and with binaural headphones “Sennheiser Noise Gard HDC 451”. Photo and video acquisition were carried out in situ at the same time.

Figure 7. Scenes from calle San Jacinto.

After the exploratory surveys a representative part of the street was chosen to be studied. The chosen part is a 150 meters long pedestrian area.

3.2 Elaborating and Determining Future Scenarios for the Area

With the increasing public awareness on environment and sustainability of cities, governmental bodies are much more concerned about improving legal regulations to reduce pollutants and increase quality of life. Recently the General Directorate of Climate Change and Urban Environment, Andalusia, studied on noise and light pollution to introduce new regulations

[15][16][17]. Due to these efforts and new regulations, in near future it is expected to have better practices in urban environments.

In this study it is aimed to present possible changes in urban environment in accordance with new regulations to the public via IVR simulations and get their appraisal. In this way public information can be carried a step forward at which the public can proactively experience and evaluate the regulatory measures. Moreover the involved population can provide assistance to the administration with their appraisal on these measures experienced and be closely involved in improvement process of urban decisions.

For this purpose the future scenarios are prepared focusing on lighting design, lamp and luminaire types in accordance with the new decree 357/2010 on night-sky protection and also soundscape charactheristics that meet regulatory measures. Two different types of light; LED and sodium-vapor, and a generic modern street lamp type with plane diffusor were chosen to simulate possible future scenarios with corresponding binaural audio stimuli. It is aimed to get public appraisal on the urban environment after the implementation of LED light which emits a white light with a certain wavelength unfavourable for the environment and people’s health, compared to a sodium vapor lamp recommended by the new legislation.

The final simulation is decided to include 3 scenarios; daylight, sodium-vapor lighting and LED lighting, all accompanied with corresponding binaural soundwalk recordings.

3.3 Preparation of the Audio Visual Simulation

The audio stimuli are prepared extracting representative tracks from the soundwalk recordings. For the daylight scenario a 2 minute long audio stimuli is extracted from the soundwalk 18 February 2011, 14:00. The sodium-vapor lighting scenario has the audio stimuli extracted from the soundwalk 7 March 2011, 21:00. The LED lighting scenario has the audio stimuli extracted from the soundwalk 25 February 2011, 21:00.

The three dimensional model of the study area is prepared and the images acquired in situ are mapped on the 3D model in order to depict existing daylight situation. Other two scenarios with LED and sodium-vapor lighting are simulated with appropriate lighting simulation software and resulting textures are mapped on the 3D model in order to present in final virtual reality simulation. The chosen sodium-vapor light has 70 W power and 100 lm/W efficacy whilst LED light has 42 W power and 80 lm/W luminous efficacy. After that, the prepared visual stimuli are merged with corresponding audio stimuli in virtual reality application and dynamic components (people and cars) are added and programmed to act in a realistic way.

Figure 8. Snapshots of three prepared scenarios.

4. CONCLUSIONS AND FUTURE DIRECTIONS

The prepared simulation demonstrates the possible changes in urban environment due to the new regional regulation on an interactive virtual reality platform. This preliminary study is concluded with a virtual reality simulation which is not a high precision application of the innovative multidimensional assessment approach. Nevertheless it gives a qualitative insight and it is promising for further studies that support public and technical understanding and awareness of regional legislation of Andalusia in terms of resources and possible solutions on noise and light pollution.

The General Directorate of Climate Change and Urban Environment of Andalusia has been one of the first governmental bodies that consider such an innovative approach to evaluate urban environments that facilitates public information and participation obtaining public opinion to improve regulatory and decision making processes. The preliminary study should be improved in order to obtain greater precision and realism in virtual reality simulations so it can be a very useful tool for local administrations to involve public in urban decision making processes.

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