SOUND DESIGN TO ENHANCE PRESENCE IN PHOTOREALISTIC VIRTUAL REALITY

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ABSTRACT

The role of soundscape design to enhance the sense of presence in virtual reality is discussed and tested. Preliminary results which compare real versus virtual soundscapes are reported.

1. INTRODUCTION

Although it is well known that sound enhances the sense of presence, i.e., the sense of being in a specific place, quantitative results on sound quality and quantity and specific sound design patterns for virtual reality and immersion are not yet available.

Presence research is a topic which is increasing its popularity in the virtual reality community. Several results are appearing in the literature concerning the interaction between different modalities such as vision and audition to achieve a higher sense of presence, or on the role of reproduction quality which allows the user to enhance its perception of immersion [1, 2]. For a survey of presence research applied to virtual reality, see [3].

Recently, some attention has also specifically been given to sound content. In [4], it is suggested that a minimalistic number of sound objects and events need to be reproduced. This idea is based on the ecological approach to auditory perception [5], which states that people hear sound events. It is also claimed that expectation plays an important role in enhancing sense of place.

In this paper preliminary results are reported which are related to sound design issues for the Benogo project [1], i.e., an European consortium whose goal is to develop and explore new recording and visualization technologies enabling people to experience presence at real and possibly known places. The experience is based on true-to-life visual and auditorial sensorial information presented in real-time. While the goal of the project is to recreate photorealistic spaces, from the auditory point of view it is not evident that realistic soundscapes produce the higher sense of place.

An empirical study related to the same project was reported in [6]. By recording the soundscape of a computer cluster and reproducing it in a multi-channel setup, it was shown how by only using auditory information it is possible to recreate a sense of place.

In the following section sound design principles common to the entertainment industry are described. Such principles are a useful starting point concerning sound design for the Benogo project.

[1] www.benogo.dk

2. SOUND DESIGN IN THE ENTERTAINMENT INDUSTRY

Sound design concepts and ideas for virtual reality simulations can be borrowed from the entertainment industry, which has long recognized the importance of sound to add presence and immersion to film and videogames. As a result, the film industry has devoted many of its resources to develop techniques for producing sound effects and ambience sounds that evoke emotional responses and allow the viewer to be immersed.

However, there is an obvious fundamental difference between sound in film and sound in interactive virtual worlds. While designers of film sound can create a soundtrack with a specific duration which correspond to the length of the visuals, in an interactive virtual world, the characteristics of the environment vary in real time according to the input of the user. This interactivity allows the user to enhance attention and interest on the environment. Therefore, a dynamic soundscape must be created that can respond appropriately to any change caused by the user of the environment itself.

When planning the soundscape for a virtual environment, it is necessary to distinguish among ambient sounds and sound events, which are also known as Foley effects. Sound events include both predictable and user triggered sounds such as doors opening and footsteps. Ambient sounds are background sounds that are used to create a sense of atmosphere [7]. Examples of ambient sounds are wind blowing, street noises and so on. In movies, sound effects exaggerate reality to create an immersive experience. Virtual environments are created to immerse users in order that they may experience a so-called *suspension of disbelief*.

3. SOUND DESIGN FOR BENOGO

The same principles described in the previous section are useful also to the Benogo project. One challenge of this project concerning sound design is the fact that the photorealistic landscape is rather static. Moving objects cannot be physically present when pictures are taken, but need to be added to the virtual place by use of augmentation. This limitation requires more creativity for the sound designers. The most suitable locations to ensure image quality for the project, infact, are indoor places were the physical soundscape is almost silence. This is an additional challenge to the sound designer, who needs to use sounds to lively up the static scene reproduced by the landscape.

An example of one of the demonstrations for this project was the photorealistic reproduction of an empty office. In this case, ambient sounds such as hypothetical street noises coming from outside the window were used. The soundscape was also enhanced by sound events such as the ring bell of a phone or the sound of a coffee machine.

To enhance sense of place, the following design issues are taken into consideration:

- Sound delivery method: according to [8] a soundscape reproduced in a multichannel system enhances the sense of presence. However, results described in [2], say that presence and audio/visual quality are enhanced by enhancing low frequency content or increasing the volume, but the addition of more channels does not enhance presence.
- Motion: it is assumed that moving sound sources allow to increase the dynamicity of the environment and make it more interesting for the user. Effects tied to moving objects should be spatialized depending on the capabilities of the playback platform.
- Interactivity: using an head tracker it is possible to let the user interact with the sonic environment. This means that the soundscape needs to take into account the position of the user in order to be more realistic. In this case sound models can be effective and more realistic than sounds samples, especially for those situations in which the user can truly interact and affect the sounds of the environment. In particular, friction models for rubbed surfaces [9] allow to reproduce different sonorities existing in a specific environment. In this case, the parameters of the models vary in real-time, according to the contact time and the force and velocity of the contact. Other parameters control the properties of the materials of the objects in contact.
- Variety: loops and repetitions in the soundscape are likely to be detected and perceived as unrealistic. It is necessary to create a soundscape which does not repeat at a rate perceived by the user. This can be achieved, for example, by collecting a database of sound events and ambience sound, and playing them at a random rate. Also soundscapes based on artificial intelligence systems can increase the level of realism.
- Exaggeration: in the movie industry, sound effects are exaggerated to capture the user s attention. It is likely that also in virtual reality enhanced sound events will increase the sense of immersion.
- Quantity: it is well known that sound is important to recreate a sense of place. However, it is not known how much information delivered by sound should be added to the environment. For example, objects which are seen and are likely to make a sound, should be sonified. In the Benogo project, however, the scene is static so no particular sound events need to be there a priori. The only sounds which are expected are ambient sounds. Moreover, the sound of other moving objects which are not seen in the scene might distract the user and decrease its sense of presence. In one of the preliminary demonstrations of this project, in which a botanical garden was recreated, the sound of birds was artificially positioned on top of the head of the users. This created some confusion, since users were looking for birds which were not present.

  On the other end, in another demonstration in which an empty staircase was virtually reproduced, the sound of a breaking mirror captured the attention of the users and allowed them to feel immersed in a certain scenario where something was happening. Without that sound the scene would have appeared pretty quickly static and uninteresting.

4. A CASE STUDY: A PANORAMIC VIEWPOINT

As part of the Benogo project, the sense of place in a panoramic viewpoint in Prague shown in Fig. 1 was investigated. After visiting the viewpoint, 38 subjects of age between 18 to 70 were asked to report the sounds they remembered having heard. While filling the questionnaire, people were physically present in the place, although they were not facing the view but positioned at about 100 meters from it. People interviewed might have reported the sounds that they were still hearing, instead of the ones they remembered having heard. Moreover, the soundscape of the viewpoint significantly varied at different times of the day. However, some interesting observations can noneless be made by looking at the results, which are summarized in Fig. 2.

Figure 1: *The panoramic viewpoint in Prague used for the experiments.*

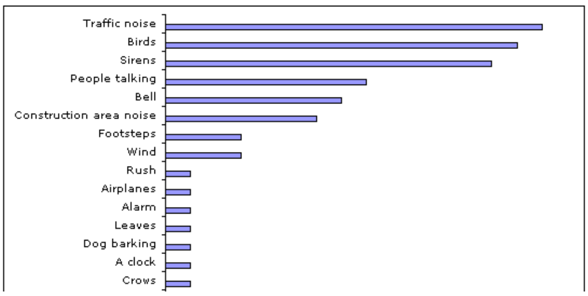

Figure 2: *List of the sounds heard by the visitors at the panoramic viewpoint.*

An interesting characteristic of the viewpoint is the fact that sounds are clearly positioned in space. While the visitor faces the view, typical noises of a busy city are heard in front and coming from far away. Such sounds are those identified as city noises and sirens. Moreover, the churches (such as the cathedral which can be seen on the left of the picture) are noticeably heard every half an hour by the sound of their bells. On the other end, closer to the visitors and on the back side the characteristic sounds of nature, such as birds and the sound of the wind hitting leaves, are heard. The sounds of a construction area placed on the back of the people facing the viewpoint was also strongly heard. A sound map of the main characteristics of the auditory scene is shown in figure 3. Inside the dotted line it is found the space which can be seen by the visitor while he or she is facing the view. All these sounds create a

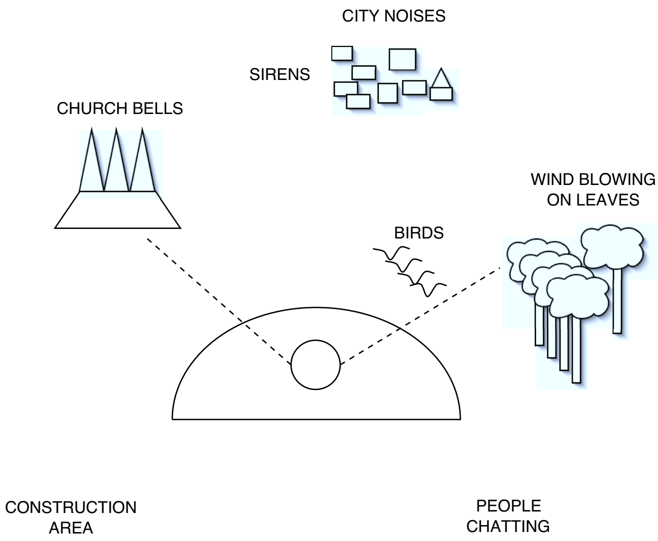

Figure 3: *Locations of the main sound events of the viewpoint.*

very interesting and characteristic soundscape. Other sounds heard from the visitors were people chatting, walking, cellular phones ringing. From Fig. 2 it is clearly noticeable how the sounds that are heard more often are the *ambient sounds*, i.e. those sounds which can be considered as background of the environment, and also the ones that most likely create a sense of place. The other sounds can be identify as sound events, and can help to capture the attention of the user when transported to the virtual environment.

5. TESTING THE VIRTUAL PLACE

In order to create a virtual reconstruction of the physical place, different issues need to be taken into consideration. First of all it is necessary to distinguish among those sounds that recreate the sense of place and those which are more likely to be random sound events.

To understand the relationship between a place and the sounds associated with it, another questionnaire was prepared and proposed to people who had never visited the place. Four different virtual soundscapes were created, obtained by editing the sounds recorded at the viewpoint. Since the goal was to judge actual sound content instead of sound delivery methods, the sounds were played back using headphones. Thirty subjects of age between 18 and 70 were interviewed. A snapshot of 30 seconds from the soundscape was played first, and the subjects were asked to list everything they remembered having heard. This question was the same as the one asked in the real place, with the only difference that the sounds were delivered in a shorter amount of time and the users had no visual feedback concerning the place. In the virtual place, the sounds which hit mostly the attention of the subjects were the bells sounds (64 %) and the birds sounds (93 %). 53 % among the 64 % declared of having heard church bells.

In the same question, subjects were asked to associate the sounds heard to a specific place, without giving any hint concerning the place. Most of the people recognized the place as outdoor. Some of them felt to be by the sea, but they were confused by the bells sounds. Some subjects (20 %) felt to be in the countryside. Others (20 %) felt to be in a square next to the city hall, due to the bells sound.

In the second question a list of 6 specific places was spelled in random order, and subjects were asked to rate in a scale from 1 to 5 the relationship between the sounds heard and the place listed, where 1 is no relationship and 5 is strong relationship. The results are shown in Fig. 4. Notice how panoramic viewpoint and a park had a statistically significant higher rank.

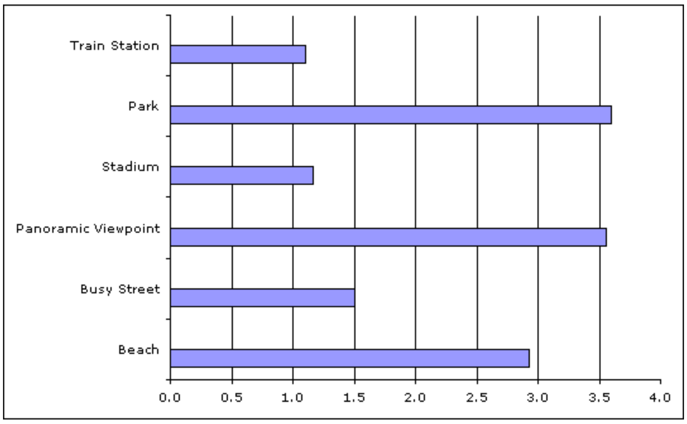

Figure 4: *List of the places which the subjects associated to the soundscape.*

In the third question Fig. 1 was shown, and two different soundscapes were played to the subjects, both related to that picture, randomly chosen among four. Two soundscapes were mere playback of the original recordings through headphones, while the other two were strongly augmented by enhancing the amplitude of the low frequencies and creating more frequent sound events. The subjects were given 11 hypothetical coins, and were asked to divide such coins according to which soundscape gave a stronger feeling of being in the place displayed. Users did not feel more engaged in augmented and exaggerated soundscapes. This means that the commonly used technique of the film industry to engage the audience did not work in this situation. One of the reasons might be the fact that the place is better connected to quite and peaceful sounds.

As a last question, a set of sounds taken randomly from the ones shown in Table 2 was randomly listed, and augmented by other sounds not present in the recordings. Subjects were asked to rate in a scale from 1 to 4 how often such sounds were expected to be heard in the environment shown by the picture. Results are shown in Table 5.

6. CONCLUSION

We reported an investigation of soundscape design to increase sense of place in virtual reality. Results show that sounds can create a sense of place, although people are not able to precisely recognize a place by only listening to the soundscape.

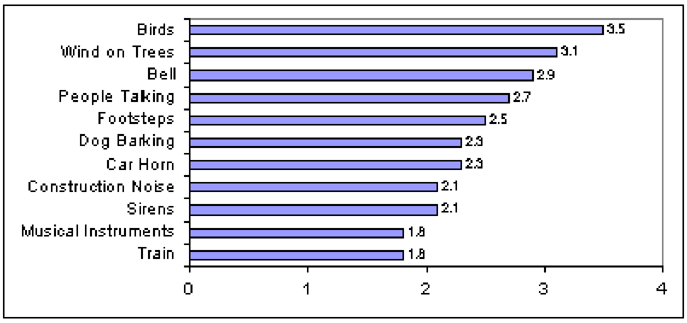

Figure 5: *List of the sounds which people expect to hear in the place of Fig. 1.*

So far no quantitative results are available to help designers to build soundscapes which allow the user to feel fully immersed. The results which provided by this paper are a step forward toward this direction.

The possibility to produce soundscape design patterns is currently investigated, inspired by the patterns proposed for sonification design in [10].

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