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Noise auralisation challenges in web and augmented reality applications

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Auralisation of the machinery noise is becoming important with the development and availability of advanced noise modeling tools. With the auralisation, it is possible to enhance or replace the prototype or mock-up construction. For this purpose, we have developed real-time auralisation platforms for welding noise, engine noise and rock crushing station noise, among the others. The developed auralisation tools operate as stand-alone systems and also as web tools. Converting the stand-alone models to web applications is not a straightforward task, and several issues must be taken into an account. The other expansion path is to connect audible models to virtual or augmented reality environments. We simultaneously visualise and auralise 3D sound field of machinery noise with the combination of the audible model in a laptop computer and visualisation with a tablet PC. In this way we demonstrate the future of noise-related product prototyping and development.

1 Auralisation and an overview of the Audible Model Platform

Auralisation [1] of the machinery noise is becoming more and more important concurrently with the development and availability of advanced numeric noise modeling tools. With machinery noise auralisation the target is in the development of the machinery, and not so much in acoustics as with architectural applications of auralisation [2]. With the machinery noise auralisation, it is possible to enhance or even replace the prototype or mock-up construction and related measurements.

For such auralisation we use Audible Model Platform (AMP) [3]. AMP is dedicated for the real-time re-creation of various noise scenes. In that way it is different from the other, usually off-line audible noise modeling tools. Emphasis is on the real-time noise generation and modification. AMP consists of artificially re-created and recorded noise components. Individual noise components may be turned on and off to facilitate the evaluation of the psychoacoustic properties of the noise, and its individual components. Additionally, noise transfer paths are adjustable. Furthermore, the signals are also visualised in various ways. The schematic operating principle of AMP is shown in Figure 1.

AMP has been used for evaluating the sound quality in moving machinery cabin [4] and in vicinity of the wind turbines [5]. Similar work for wind turbines have been carried out also by other researchers [6]. Likewise, auralisation is possible for evaluating the welding noise [7] including the other related noise components at the metal workshop. This work is a continuation of the work with the simulated background noise of the workshops [8].

Metal workshop and engine noise applications are used here as examples of the developed tools. For the metal workshop noise a web model was developed and for the engine noise model the connection to a augmented reality platform.

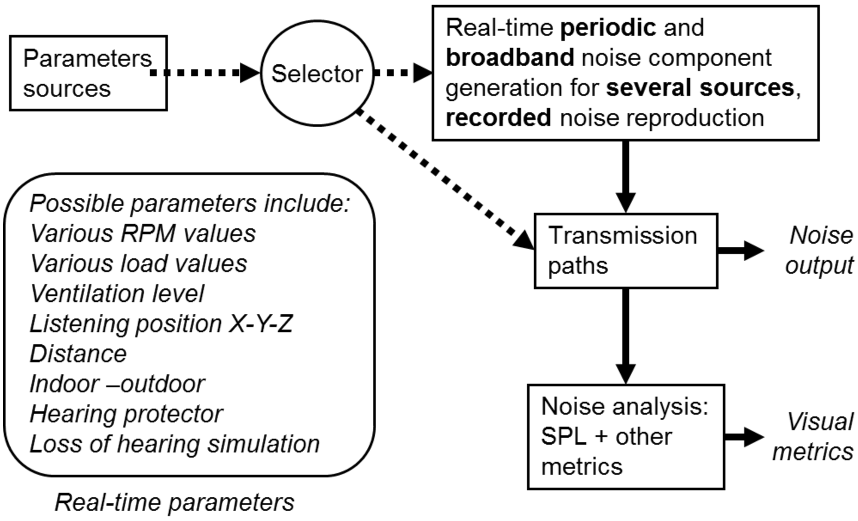

Figure 1. AMP operating principle.

2 Metal workshop noise model and conversion to a web model

In general, the noise at a metal workshop consists of welding, ventilation, hammering, grinding, and other ambient noise, such as music. Noise contributions of such machinery have been studied by Nejade [9] and Arata [10]. Another important noise sources to be monitored and taken in to account are the communication including speech, and warning signals, which must be always audible.

2.1 Stand-alone noise model

The complete simulation model for the metal workshop is shown in Figure 2. The stand-alone version is created with Simulink. Each noise component may be switched on and off separately. The welding noise, the hammer noise, and background music are sample-based, and the grinder noise components are synthesized. There are 2 different welding types with different audio signatures (DC and pulse welding), and welding may also be switched completely off. The audible welding noise model can be used to analyse the effect of the hearing protection. There are 6 different hearing protector models, both earmuff and earplug types, and a setting without any hearing protectors. Also the effective Sound Pressure Level (SPL) is monitored.

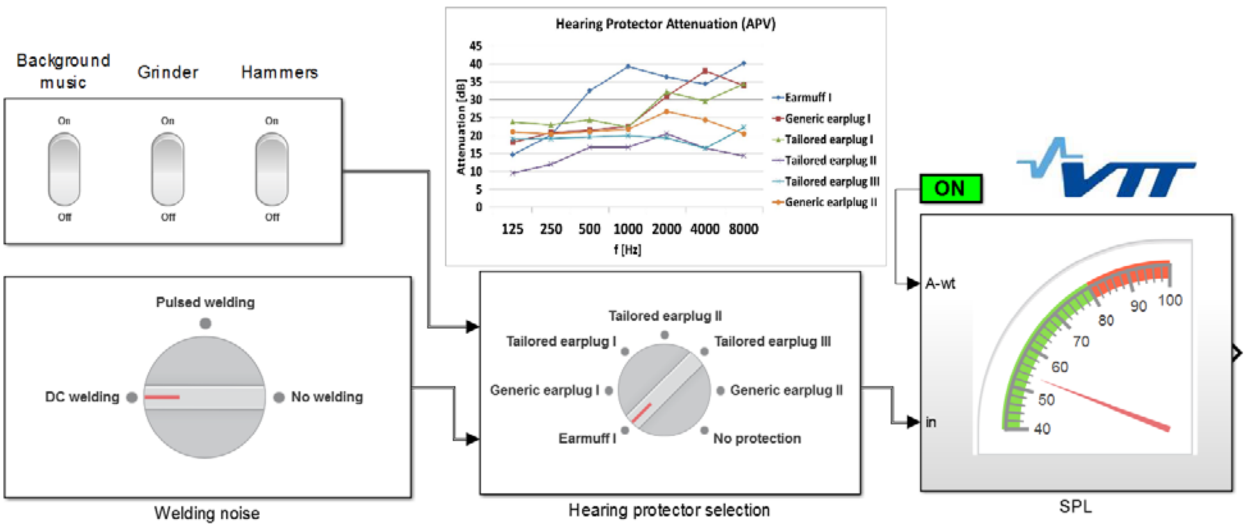

Figure 2. AMP applied for metal workshop audible welding noise synthesis.

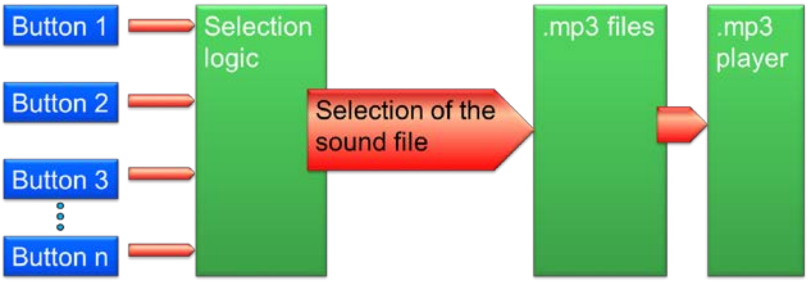

Figure 3. Operating principle of the web model.

2.2 Conversion to a web model

The developed auralisation tool for metal workshop noise operate well as a stand-alone system with a computer, using Audible Model Platform. However, there is also a need to distribute the auralisation models to a wider public. For example, the users of the Personal Protection Devices (hearing protectors in this case) want also evaluate the properties of the protectors themselves. For a wider distribution of the interactive models, the web is an ideal media. Yet, converting the stand-alone models to web applications is not a straightforward task, and several adjustments must have been done, including the re-arranging of the model operating logic.

The most important change was to replace the noise generators and filters in the original model with respective samples of different combinations of them, as shown in Figure 2. This was done because it is not straightforward to implement noise generators and filters in html5 [11] protocol, but auxiliary audio toolkits should have been used. Because the solution was intended to be as portable as possible the usage of such toolkits was avoided. A major challenge was to make the server compatible with such html5 - javascript combination, as well as ensure the compatibility with various browsers. Some browsers required certain magic strings in the code that they behaved as expected and reproduced the sound properly.

The converted audible model is publicly available at www.vttresearch.com/wndemo/wnd_en.html [12]. The screen capture of the web tool is in Figure 3. The user may select the welding type, one or several background noise types and various hearing protector devices, and compare how they sound like against each other. The audible model does not attempt to exactly model the real situation but to make it possible to compare how the selections differ from each other.

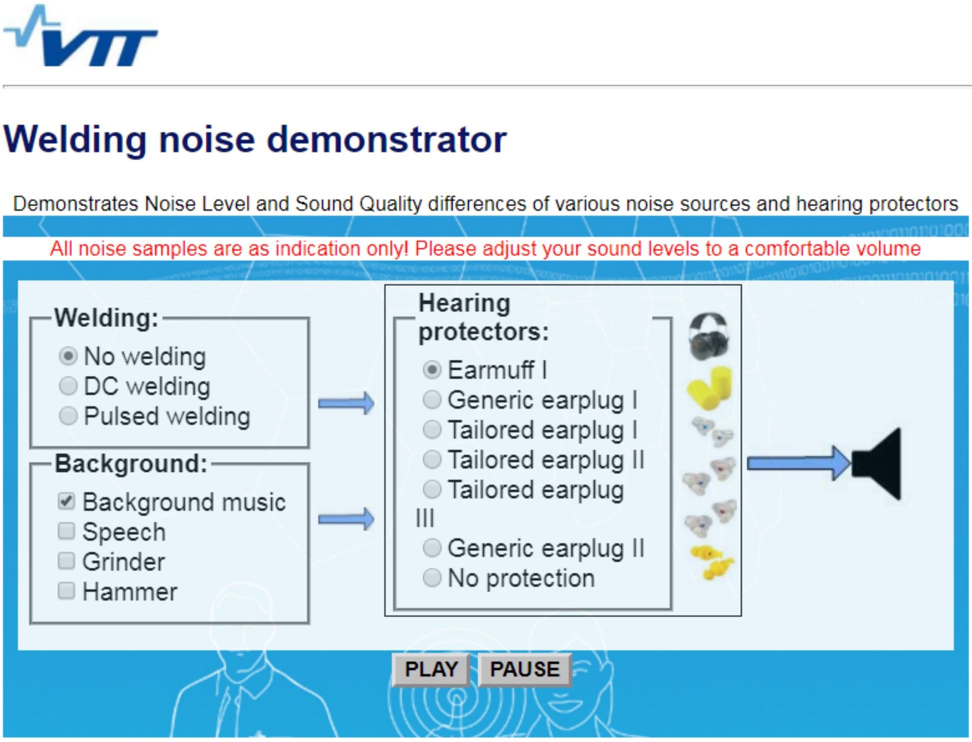

Figure 4. Web version of an audible welding noise model.

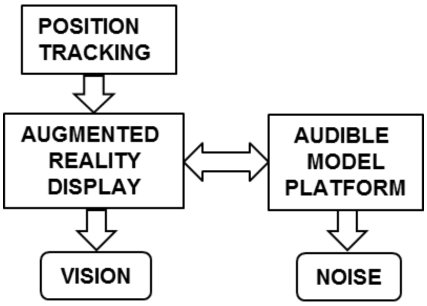

Figure 5. The connection of AMP and augmented reality visualisation.

3 The engine noise model and connection to augmented reality environment

The other expansion dimension is to connect audible models to virtual or augmented reality environments. We simultaneously visualise and auralise 3D sound field of a diesel engine noise with the combination of the audible model in a laptop computer and visualisation with a tablet PC, as shown in principle in Figure 4 and in practice in Figure 5. This requires wireless data and parameter transfer between them. Such real-time transfer is sometimes challenging due to the network congestions, delays and buffering issues.

To create an audible engine model, the engine sound was first recorded at 10 points around a diesel engine. The recordings were carried out during a run-up in order to detect the variation of the sound at different RPMs. The most audible engine orders were then determined and their amplitudes and phase angles were extracted as a function of location. An optimisation algorithm were used for finding the most representing engine orders at all RPMs and locations. The computational power of a laptop computer had to be taken into account, limiting the number of orders and restricting the authenticity of the reproduced engine sound.

The audible model running on a PC is then used with the visualization platform running on a tablet PC. The position tracking runs on the tablet PC and is programmed to detect a marker (e.g. a figure or photo) and visualize the engine at top of the marker on the screen. The user can also change the RPM of the engine on the tablet PC. The position and the RPM are sent to the audible model which produces the engine sound at the specific position. The user can thus move around the marker and hear the engine sound alter just like with the real engine.

Challenges are caused by UDP connection delays and reliability of the tracking algorithm if the user is far from the marker. The wireless data transfer between the visualisation platform (usually a tablet PC) and Audible Model Platform may sometimes be tricky to set up. The amount of data which is transferred via UDP (User Datagram Protocol) is not large. Nevertheless, the wireless data transfer suffers often from the data congestion and delay issues, especially when the system is running in a place with a lot of wireless traffic. Such places include trade fairs and other crowded, public places. Sometimes it is possible to set up only one-way wireless traffic without the return channel for no apparent reason. Also the UDP buffering in some PC operating systems is unreliable and may cause unexpected delays and lagging from time to time, which is of course detrimental to the model operation and convincing audio experience.

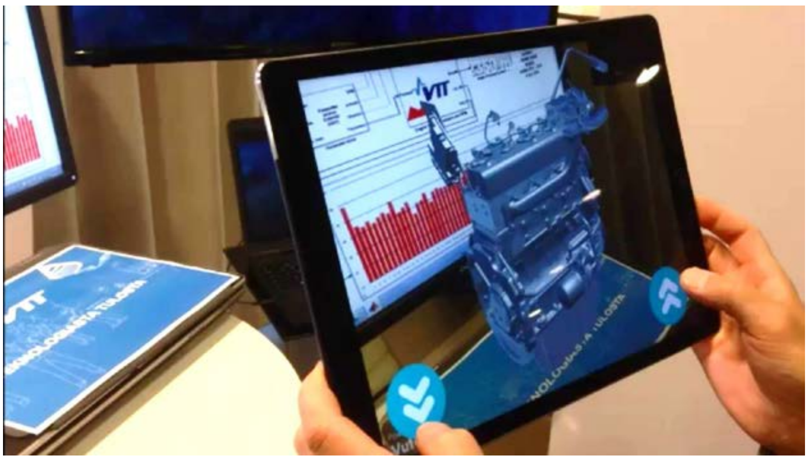

Figure 6. The engine application running in the tablet PC.

4 Conclusions and future work

Even though the technology is not yet fully mature, we are able to demonstrate the future of product prototyping and development. This relates especially to noise properties of the products, and their interactive improvements, and it will be booming in the near future. The most important technology development steps still needed are related to the mobile and web application conversion especially with audio objects, data transfer, audio processing capacity, and augmented reality position tracking.

5 Acknowledgements

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