Sound Field Control for Outdoor Concerts

Franz M. Heuchel[1,*] and Diego Caviedes-Nozal[1,+]

[1]Acoustic Technology Group, Department of Electrical Engineering, Technical Universtity of Denmark, 2800 Lyngby
[*]fmheu@elektro.dtu.dk
[+]dicano@elektro.dtu.dk

Relevance and identification

The number of outdoor concerts and festivals happening per year in Europe are raising steadily. At the same time, policy makers around the world are increasingly aware of the impact of environmental noise on the health of their citizens. In 2011, the World Health Organization estimated that one million healthy life years are lost due to noise exposure every year in the western part of Europe[1]. As a consequence, organizers of open air concerts and festivals are facing the challenge to deliver their guests an exciting and loud audio experience while having to comply with local regulations that restrict the noise emissions to the surrounding area in order to protect the well-being of nearby citizens.

The purpose of this research project is to determine how such noise can be reduced with methods of active sound field control. Today, such technology is commercially applied to ventilation systems, headphones, and car, aircraft and helicopter cabins. In most of these applications, the control area is a volume in an enclosed space or an enclosed space itself. However, the active control of sound has only seen little application outdoors. One might identify two main reasons for this. First, the sound creation process of many outdoor noise sources like traffic noise or noise from construction sites is complex, random and spread over large areas. This makes it extremely difficult to estimate the primary sound field created by these sources in an extended area. Yet, this estimation is essential for creating a corresponding cancelling secondary sound field. Secondly, controlling sound over a large area is expensive. It requires a considerable amount of technology in terms of sensors for sound field characterization in the control area, in terms of signal processing and communication for the computation and distribution of appropriate secondary source signals and in terms of secondary loudspeakers that create the secondary sound fields.

The problem of noise emission from outdoor concerts is a special case, because the noise creation process is determined by the music signal fed to the loudspeaker system. Apart from variations in the transmission path due to atmospheric changes, the primary sound field from outdoor concerts is deterministic and can thus be estimated. Regarding the cost of controlling extended areas, we are showing with our work that the amount of sensors needed for the sound field characterization can be considerably reduced with the help of sound propagation models.

Impact and consequences

The overall hypothesis of this research project is that active sound field control is a useful technology for reducing the noise exposure of sensitive areas in vicinity of outdoor concerts. We have proposed a sound field control technique for this purpose[2] and experimentally verified and demonstrated it in small scale lab experiments, large scale outdoor experiments and real outdoor concerts[3,4]. We showed that atmospheric conditions can play a crucial role on the performance of such systems[5] and that even with lot of weather sensors and data, it seems difficult to adapt open-loop control systems to such changes[6]. We have come up with a modelling technique that considerably decreases the amount of measurements needed in the control area[7,8] and are planning to publish experiments that show that this technique also works in large scale (see figure 1).

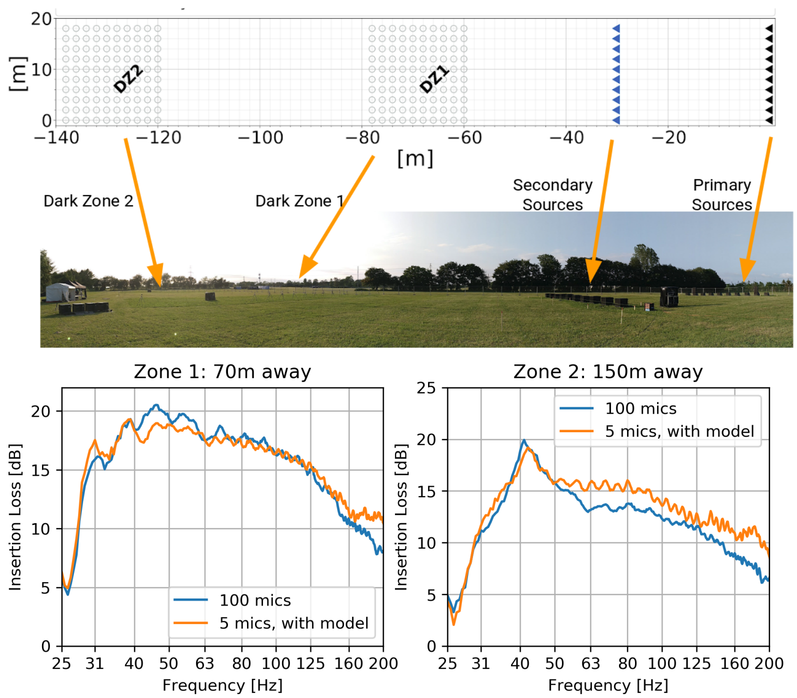

Figure 1. Top: Last large scale experimental setup. The primary sources mimic a subwoofer array of an outdoor concert. The secondary sources behind the audience cancel the concert sound in either of the two control areas. Bottom: average reduction of sound pressure level in two control zones of size 10x10m 70m and 150m away from the primary sources. In the blue lines, the control areas were densely sampled with 100 microphone positions. The orange lines show the archived insertion loss with only 5 microphone positions and our proposed model.

References

1. WHO Regional Office for Europe. Burden of disease from environmental noise - Quantification of healthy life years lost in Europe. Tech. Rep. (2011).
2. Heuchel, F. M., Caviedes Nozal, D., Brunskog, J., Fernandez Grande, E. & Agerkvist, F. T. An Adaptive, Data Driven Sound Field Control Strategy for Outdoor Concerts. In *Audio Engineering Society Conference: 2017 AES International Conference on Sound Reinforcement – Open Air Venues* (Struer, 2017).
3. Heuchel, F. M., Caviedes Nozal, D., Agerkvist, F. T. & Brunskog, J. Sound field control for reduction of noise from outdoor concerts. In *145nd Audio Engineering Society International Convention 2018*, 1–8 (New York City, 2018).
4. Brunskog, J., Heuchel, F. M., Caviedes-Nozal, D., Agerkvist, F. T. & Fernandez-Grande, E. Full scale outdoor concert adaptive sound field control. In *International Conference of Acoustics 2019* (Aachen, 2019).
5. Cavides Nozal, Diego, Heuchel, Franz M., Agerkvist, Finn T. & Brunskog, Jonas. The effect of atmospheric conditions on sound propagation and its impact on outdoor sound field control. In *Internoise* (Madrid, 2019).
6. Heuchel, F. M., Caviedes-Nozal, D., Fernandez-Grande, E., Brunskog, J. & Agerkvist, F. T. Adapting transfer functions to changes in atmospheric conditions for outdoor sound eld control. In *International Conference of Acoustics 2019* (Aachen, 2019).
7. Caviedes Nozal, D., Heuchel, F. M., Fernandez Grande, E. & Brunskog, J. A bayesian spherical harmonics source radiation model for sound field control. *J. Acoust. Soc. Am.* (Accepted, 2019).
8. Caviedes Nozal, D. & Brunskog, J. Parameter optimization of forward sound propagation models using bayesian inference for sound field control purposes. In *Euronoise 2018 Proceedings* (Crete, 2018).