Auralisation methods as tools for urban traffic noise assessment

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ABSTRACT

Assessment of sound environments for urban areas under development can be achieved by auralising them. This paper discusses auralisation tools needed for evaluating traffic noise. Depending on their usage, the tools could be developed either by simplified or physically detailed models. Simplified but perceptually valid models would suffice for spatially extensive areas. Such a model is outlined targeting distant background traffic noise in flat city scenarios. A more detailed modeling procedure is required for local urban events such as traffic within close range to a receiver, also when obscured by structures. While auralisation methods constantly evolve, their relevance for assessment of environments depends on the perceived acoustic field. A study of a soundwalk is described, where both recordings and data form survey questionnaires are available. The link between the two different forms of data and its use in auralisation tools is discussed.

Keywords: urban sound planning, auralisation, traffic noise synthesis, soundwalk

1. INTRODUCTION

Urban sound planning requires the evaluation of urban environments. These environments can be approached as systems that not only include several noise sources and different propagation paths. Their sound character is also dynamic in time and frequency, and can vary a lot from one case to another even if they have many similarities. These systems are composed of both physical layouts and personal and environmental factors that effect their perceived sound environment. Thus, simulating such environments using one single approach, can result in omitting many of its aspects. For a plausible auralisation of urban areas, the modeling procedure can be split according to the properties of its elements and how they do contribute overall to the sound environment.

Modeling local traffic sounds for example would require a more detailed description of the noise sources i.e. the cars. As urban environments always consist of significantly large structures to affect the sound character, a model should be developed for sound propagation, to predict for example propagation in street canyons. More distant events might not be necessary to model explicitly, but it could be enough to construct a model that is perceptually acceptable but not physically correct. Distant highway traffic noise is considered a distant sound event.

Another way to assess an urban environment is through surveys, both for urban planers and for citizens of an area. The comparison between these surveys and recordings on site can be used to further determine what is most essential to model in an auralisation model. The work described in this paper has been conducted under the EU commissioned project SONORUS.

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2. METHODS

Local car pass-by

For auralising local traffic scenarios, a detailed approach is required. The LISTEN project (1) developed a model where auralisation of car pass-bys is achieved by re-constructing them using parameters for the source and physical models for propagation, but with the expense of computational power and the lack of dynamic situations of accelerating or decelerating vehicles. To overcome this, a synchronous granular synthesis model has been developed, where a few grains of the a car engine sound are sampled and distributed in time to incorporate acceleration of any wanted rate. As the recordings were performed with a stationary vehicle, rolling noise from road-tyre interaction is omitted and needs to be included. The grains that are used for the synthesis are detected using an in-house adaptive algorithm that runs along a single run of the car's engine from its lowest to the highest speed. Additional recordings were acquired to account for the directivity patterns of the car both in the horizontal and vertical planes. This idea might be further developed in which the individual grains are created through additive synthesis. Recordings would then not be needed, and the synthesis could be parametrised to change between different car types.

Propagation path

Even in situation where a car is located close to a receiver, modelling just the sound radiating from it is not enough. Nearby structures, buildings, barriers, layouts like street canyons and atmospheric effects, contribute to the experience of the source. Reflected, diffracted and diffuse fields need to be considered for a realistic auralisation. CNOSSOS-EU is a standard for noise assesment that includes methods for calculating propagation effects (2). Using propagation models from CNOSSOS-EU and building a path finder algorithm, will provide a tool to determine the propagation effect in octave bands. To account for sounds accumulated at the same receiving point through different propagation paths, the time of arrival should be considered and compensating for phase differences. CNOSSOS-EU can then be easier tested through auralisations to determine if it is sufficient to be considered for predicting indicators despite working in octave bands.

Background traffic noise

For auralising background traffic noise, a simplified method has been proposed and passed through preliminary listening tests. This method uses as an input, power profiles of car pass-bys provided by the LISTEN demonstrator (1). The profiles filter pink noise to form the characteristics of a traffic scenario of a given speed, while the signal received on the right and left ear of a listener is non-correlated by randomising its phase components, in order to achieve a wide spatial auditory stereo image. Calculations are then performed in frequency domain to include ground effect, and atmospheric turbulence and absorption. For simulating single pass-bys, modulation transfer functions (MTF) are used (3). MTFs are sinusoidal ripples that travel along both the frequency and time domain. The neural auditory system tracks modulations like these in sounds in order to detect characteristics and enhance intelligibility. The characteristics of the MTFs are linked to physical and geometrical characteristics of the simulated scenarios. Assessment of this model showed that it is acceptable for describing background traffic noise of 70 kmph to 90 kmph, when the receiver is located more than 300 m away from the traffic. The developed model can run and change the parameters defining a scenario in real time. Further tests and improvements are needed in order to consider the model valid for distant traffic auralisations.

Soundwalks / surveys

During collaboration with the environmental office of the municipality of Gothenburg in Sweden, surveys targeted to urban planners have been designed. The surveys have been optimised through 2 revisions, and thereafter they were tested with both urban planning and acoustics students. Moreover, questionnaires targeted to children around 11-13 years old were designed and used on some sites in Gothenburg on soundwalks. These data, alongside with recordings acquired at the sites during the surveys and soundwalks, can be used to determine whether there are some parts of a perceived sound field in an urban environment that are essential to model in detail, and others that can be auralised with non-physically correct models.

3. CONCLUSION

Auralisations can be useful as a tool to urban planning processes as they can used to predict the sound field an urban environment. To be able though to do this efficiently, the auralisation process should be approached differently for different parts of the wanted area. During the SONORUS EU Marie Curie project, auralisation methods for this have been developed. For local traffic events, synchronous granular synthesis is used to auralise nearby car pass-bys. Propagation effects due to the physical layout of the area can be predicted using path tracing in combination with the CNOSSOS propagation models. Distant background traffic noise is auralised using a simplified model which is not physically correct but perceptually acceptable. Furthermore, questionaires for citisens and surveys for urban planners, as well as complementary recordings, can contribute on the development of more robust and efficient dynamic auralisation tools that can be used on real or user interaction time.

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