BINAURAL ROOM SIMULATION

H. Lehnert, J. Blauert, and W. Pompetzki
Ruhr Universitat Bochum
Bochum, FR GERMANY

In every-day listening the auditory event perceived by a listener is determined not only by the sound signal that a sound emits but also by a variety of environmental parameters. These parameters are the position, orientation and directional characteristics of the sound source, the listener's position and orientation, the geometrical and acoustical properties of surfaces which affect the sound field and the sound propagation properties of the surrounding fluid. A complete set of these parameters can be called an Acoustic Environment. If the auditory event perceived by a listener is manipulated in such a way that the listener is shifted acoustically into a different acoustic environment without moving himself physically, a Virtual Acoustic Environment has been created. Here, we deal with a special technique to set up nearly arbitrary Virtual Acoustic Environments, the Binaural Room Simulation. The purpose of the Binaural Room Simulation is to compute the binaural impulse response related to a virtual acoustic environment taking into account all parameters mentioned above.

One possible way to describe a Virtual Acoustic Environment is the concept of the virtual sound sources. Each of the virtual sources emits a certain signal which is correlated but not necessarily identical with the signal emitted by the direct sound source. If source and receiver are non moving, the acoustic environment becomes a linear time-invariant system. Then, the Binaural Impulse Response from the source to a listener's eardrums contains all relevant auditory information related to the Virtual Acoustic Environment. Listening into the simulated environment can easily be achieved by convolving the Binaural Impulse Response with dry signals and representing the results via headphones.

Our simulation system contains the following steps. First the parameters of the environment to be simulated are entered into the computer using a CAD program geometric data of the room and databases for acoustic data of the walls and the directional characteristics. Position and orientation of source and receiver are defined by local coordinate systems. Then, the positions and orientations of the virtual sound sources are computed by ray tracing or mirror imaging algorithms (refs. 1, 2, and 3). The signals of the virtual sources are derived by convoluting all impulse responses of the walls involved in the sound path of the virtual source. The binaural room impulse response is then computed by propagating the signal of each virtual source to the listener and convolving the result with the external-ear impulse response of the listener for the respective direction of incidence.

REFERENCES

1. J. Borish, "Extension of the image model to arbitrary polyhedra," *J. Acoust. Soc. Am.*, Vol 75(6), pp. 1827-1836, June 1984.

2. J. P. Vian et al., "Calculation of the room impulse response using a ray-tracing method," *12th ICA, Vancouver Symposium,* pp. 74-78, 1986.

3. M. Vorlander, "Ein Strahlverfolgungsverfahren zur Berechnung von Schallfeldern in Raumen (A ray-tracing program for the calculation of sound fields of rooms)," *Acustica,* Vol. 65, pp. 138-148, 1988 (in German).