A BINAURAL MODEL WITH HEAD MOTION TO RESOLVE FRONT-BACK CONFUSIONS

By

John T. Strong

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Approved:

Jonas Braasch, Thesis Adviser

Ning Xiang, Thesis Adviser

Rensselaer Polytechnic Institute
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ABSTRACT

Binaural models have been developed over the span of many decades in order to simulate the human auditory system and its processing of acoustic signals. Many of these that have been designed to simulate localization tasks have been based on a cross-correlation analysis of signals arriving at both ears to determine the interaural time difference (ITD). This method can discern a source's azimuth, but due to near-symmetries of the human head, these models as well as human subjects can suffer from an inability to distinguish whether a source in the horizontal place is in the front or rear hemisphere of the listener's head. Listening tests have shown that subjects are able to resolve these front-back confusions with the use of head motion. Consequently, a model is proposed here to simulate the effect of head motion. While the model follows classical concepts by simulating the auditory system in sequential signal processing stages and analyzing ITDs with a cross-correlation, it incorporates simulated rotation to resolve front-back confusions. The confusions are resolved by tracking the virtual motion of the head and shifting the degree-based interaural cross-correlation function, which can only be determined relative to the head's position, to match the amount of rotation. This shifting causes the correct source location to remain constant over time while the unavoidable cross-correlation peak for front-back reversed location shifts. If averaged over time, the correct location prevails and the confusion is smoothed out.

The model is used to simulate an experiment by Perrett and Noble (*Perception & Psychophysics*, 1997) and reproduce their results showing that head motion reduces the occurrence of confusions to nearly 0° of the time. Two methods are used: the addition of calibrated levels of Gaussian noise to the remapping process, and the usage of multiple HRTF catalogs for batch testing. Head motion is shown to reliably reduce errors in both cases, but varying characteristics of HRTF catalogs prevent the reduction of errors to 0% for some azimuths. The model is then used to analyze simulated binaural room impulse responses in order to test its ability to discriminate the correct azimuth of individual reflections using only two discrete

head positions. This method is found to be able to discriminate properly, but more processing is necessary to make plots of the reflections easier to interpret and more visually meaningful.