International Journal of Research (IJR) Vol-1, Issue-10 November 2014 **ISSN 2348-6848**

HRTF (Head-Related Transfer Function)

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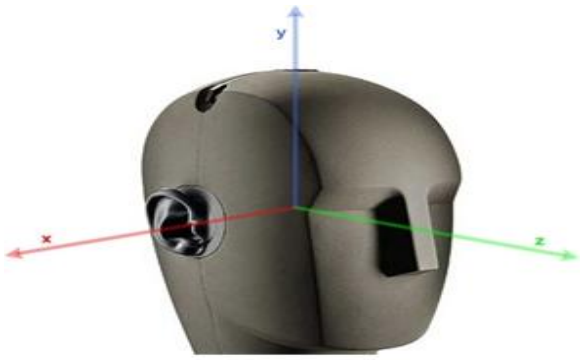
Abstract:

The HEAD RELATED TRANSFER FUNCTION (HRTF) is a type of response which tells us that how an human ear receives a sound from a point in space, when used in pairs, these HRTFs can help to synthesize binaural sound that appears to be coming from a particular point in space. The HRTFs vary from person to person. These functions are dependent on four basic principles: frequency, distance, elevation and azimuth. These factors are used by HRTFs to generate best possible outputs in any sound system converting monaural sound to binaural sound.

Introduction

Humans have tendency to locate the sound in 3 directional axes i.e. in range front and rear (the distance from ears), in up down direction and in left right direction. Our brain, inner ear and outer ear (pinna) work together to make decisions about the location of the sound in 3-dimensional structure. It is evolved in humans as a necessity because of inability to view in all directions at any instance. As our eyes can only see some part of the world (in front of our eyes) that also can be hampered by the poor visibility. But sound can be located in all the directions by our ears, regardless of any light dependency. Humans determine or estimate the location of sound source by taking cues (signals) from both the ears and comparing the difference between the two. The cues derived from one ear is called monaural cue while the cue derived from two ears is called binaural cue. Monaural cue is obtained by the interaction between source of sound and human anatomy (where original sound is modified before it enters the ears). These modifications encode the source signal and may be captured via an impulse response which relates the source location and ear location. The impulse response is termed as HEAD RELATED IMPULSE RESPONSE. The HRTF is the Fourier transform of HRIR. HRTF is also known as Analytical Transfer Function (ATF). HRTF for left and right ear basically describe the filtering of a sound source X (t) before it is perceived at left and right ear. The HRTF also can be delineating because the modifications to a sound from a direction in free air to the sound because it arrives at the tympanum. These modifications embrace the form of the listener's external organ, the form of the listener's head and body, the natural

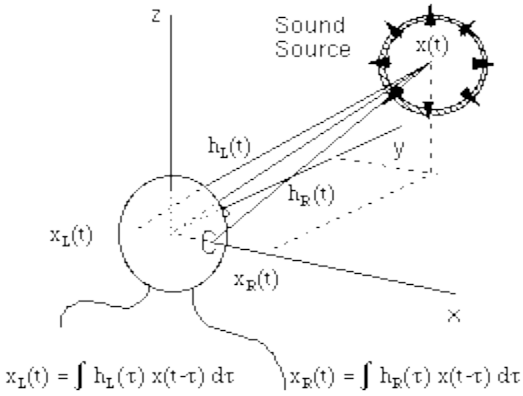
philosophy characteristics of the house within which the sound is contend, and so on. These characteristics can influence however (or whether) a perceiver will accurately tell what direction a sound is coming back from.



3D Audio Coordinate System

WORKING OF HRTF

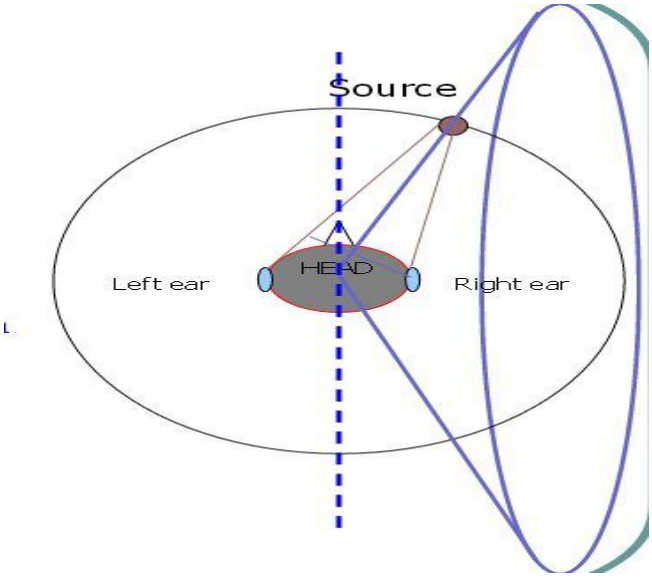
The associated mechanism varies between people, as their head and ear shapes dissent.



HRTF describes however a given acoustic wave input (parameterized as frequency and supply location) is filtered by the optical phenomenon and reflection properties of the pinnacle, pinna, and torso, before the sound reaches the transduction machinery of the tympanum and sense organ . Biologically, the supply-location-specific pre filtering effects of those external structures aid within the neural determination of source location, notably the determination of the source's elevation. Linear analytic thinking defines the transfer perform because the advanced magnitude relation between the sign spectrum and also the signaling spectrum as a perform of frequency. Blauert (1974; cited in Blauert, 1981) ab initio outlined the transfer perform because the free-field transfer perform (FFTF). Alternative terms embrace free-field to myringa transfer perform and also the pressure transformation from the free-field to the myringa. Less specific descriptions embrace the pinna transfer perform, the external organ transfer function, the pinna response, or directional transfer perform (DTF).

The transfer performs H (f) of any linear time-invariant system at frequency f is:

H (f) = Output (f) / Input (f)



One technique accustomed get the HRTF from a given supply location is thus to live the head-related impulse response (HRIR), h(t), at the ear drum for the impulse Δ(t)

placed at the supply. The HRTF H(f) is that the Fourier rework of the HRIR h(t).

Even once measured for a "dummy head" of idealized pure mathematics, HRTF square measure sophisticated functions of frequency and also the 3 spatial variables. For distances greater than 1 m from the pinnacle, however, the HRTF are often aforementioned to attenuate reciprocally with vary. It's this far field HRTF, H (f, θ, and φ), that has most frequently been measured. At closer range, the distinction in level determined between the ears will grow quite massive, even within the low-frequency region within which negligible level differences are observed within the far field.

Measurement of HRTF's

A common technique went to thorough empirical observation for right and left ear HRTF's is to insert probe tube microphones partially into a subject's ears, and then to perform a straightforward kind of system identification by enjoying a known spectrum stimulant through a electro-acoustic transducer placed at a fixed AZ θ, elevation φ , and distance from the subject's head. In follow, the stimulant could also be a straightforward click, pseudo-random binary sequences, or complementary Golay codes. parts of the measured transfer functions as a result of the measuring equipment, such as the electro-acoustic transducer and speaker transfer functions, beside parts of the measured transfer functions that area unit the same for all locations, area unit known as the common transfer operate (CTF), and are far away from the raw measurements. The final result's the directional transfer operate (DTF) at AZ θ and elevation φ. The DTF is that the quantity which contains spectral cues answerable for spatial hearing, and is commonly informally called the HRTF in much literature.

CONCLUSIONS

This paper introduced HRTF's and mentioned their role in the synthesis of spatial audio over headphones. The need for spectral cues / HRTF's was motivated by an inability of duplex theory to resolve spatial locations uniquely from ITD's and IID alone.

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