**Crosstalk Cancellation Implementation with two loudspeakers: Derivation of Matrix Inversion**

---implementation notes referring to works done by a lot of researchers

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描述已自动生成**

To describe a setup of crosstalk cancellation system using two loudspeakers as shown (typically, l, θ and Δr are measurable), the transmitted sound pressure fluctuation at the two points of the listener’s ears in frequency domain,

For each of , the deterministic differences between the two summed terms are: , and . describes the vibration motion of the sources, and thus represents the difference in the audio output and the loudspeakers (usually the two loudspeakers are the same so q is purely based on audio). The relationship between and can be derived as,

The relationship between and is simply,

Thus,

Thus, we define,

Understandably, in time domain, is a term affected by transmission delay affected by the direct transmission distance . Thus, in time domain, this is a time delay. And now,

Hence if we represent the terms using,

We can represent the system using matrix

is named transfer matrix, basically transferring terms that are related to into terms that are related to . describes the strength of sources, in this case, the final output of loudspeakers.

Since our goal is to cancel the crosstalk between two sources at and , must be filtered from the original output.

For the original two-channel binaural input we define,

is named the ‘filter matrix’. And overall,

The cross product is introduced as the performance matrix where,

Let’s recall that, our aims is to let the listener’s left ear hear the audio from left channel only, and right ear hear the audio from right channel only (referred to as ‘ipsilateral’ or ‘contralateral’, ~~nothing different but to leave a impression of paper-publishing-ready professionalism to people whose mother tongues are not English~~), and this gives us the fundamental aim of CTC,

In frequency domain,

This gives the theoretical crosstalk cancellation operation, and it is clear to this step that the nature of crosstalk cancellation is fundamentally related to matrix inversion.

In reality, lots of implementation constraints and fundamental trade-offs exist. is pretty much impossible to reach the unity matrix, and that’s pretty much why it’s called the ‘performance matrix’ – its spectrum can be used to judge the performance.

As stated before, for any 2-channel input , the outputs at two loudspeakers has the relationship with in frequency domain as,