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Novel Objective and Subjective Metrics For The Assessment Of Sound Quality In Critical Listening Rooms

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1.- Problem:

- The current description of sound fields in small rooms borrows acoustic metrics based on diffuse field theory which is more appropriate for larger spaces
- There is a lack of objective measures that reliably describe the acoustic quality in partially diffuse and non diffuse spaces.

2.- Aims:

- To characterize the degree of diffusion in a room and its spatial distribution across time
- To measure intensity at a point and determine direction of reflections.
- To derive a metric that describes the sound perceived in a room that improves on the current *reverberation time*

3.- Outcomes:

- A novel room measurement method based on acoustic Intensity using 3D orthogonal signals
- Novel signal analysis techniques that extract the spatial distribution of energy during the sound decay in a room.
- An objective metric that provides a reliable indication of the acoustic quality in a critical listening space.

4.- Current Work:

- 3D orthogonal measurement system.
- Real time extraction of incoming signal direction.
- Real time extraction of 3D room impulse response.

5.- Commercial Viability/Application:

- Architectural acoustic measurement and design.
- Signal detection and localisation.

6.- Equations used:

$$w_{corrected}(n) = \sqrt{2}\left[w_{measured}(n)\right] \quad (1)$$

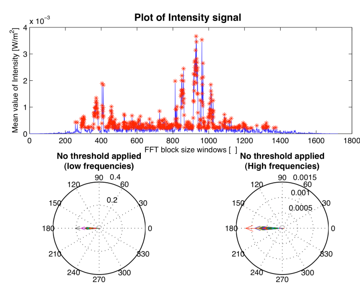
$$I_x(m,k) = \frac{1}{\rho_0 c\sqrt{2}}\mathrm{Re}\left\{\underbrace{W_{corrected}{}^{*}(m,k)}_{\text{Pressure}}\cdot\underbrace{\vec{X}(m,k)}_{\text{Particle velocity}}\right\} \quad (2)$$

$$I_y(m,k) = \frac{1}{\rho_0 c\sqrt{2}}\mathrm{Re}\left\{\underbrace{W_{corrected}{}^{*}(m,k)}_{\text{Presure}}\cdot\underbrace{\vec{Y}(m,k)}_{\text{particle velocity}}\right\} \quad (3)$$

$$\theta_{XY}(m,k) = \left(\frac{180^\circ}{\pi}\right)\tan^{-1}\left(\frac{-\vec{I}_y(m,k)}{-\vec{I}_x(m,k)}\right) \quad (4)$$

$$I_{XY}(m,k) = \left|\vec{I}_{XY}\right| = \sqrt{\left(\vec{I}_X\right)^2 + \left(\vec{I}_Y\right)^2} \quad (5)$$

$$\vec{I}_{XY}(m,k) = \left|\vec{I}_{XY}\right|\angle\theta_{XY} \quad (6)$$



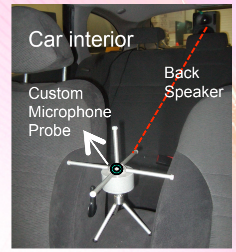
Peak detection of the mean value of the intensity and split of signal in low and high frequencies

The signals acquired in time are transformed to frequency by applying the Fast Fourier transform:

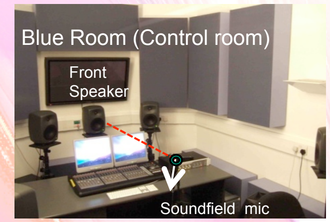
$$S(k) = FFT\left[s(n)\right]$$

The subindex 'm' is the FFT block index and the subindex 'k' is the discrete harmonic index of the FFT.

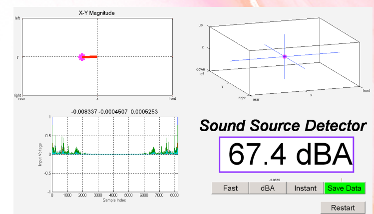
The asterisk (*) represents the complex conjugate of the pressure signal *W*.



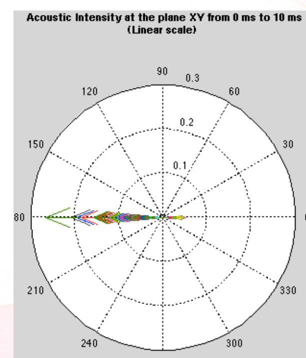
Custom made microphone probe inside the car



3D Acoustic Probe in Room



Real time display of the Acoustic Intensity



Intensity vectors from source at the back of the car

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