Where is the Sound

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PROBLEM

Members of the hard of hearing community often struggle with audio localization. Hearing Aids and Cochlear Implants restore hearing, but don't fully capture the magnitude and time delay differences between ears necessary for localization.

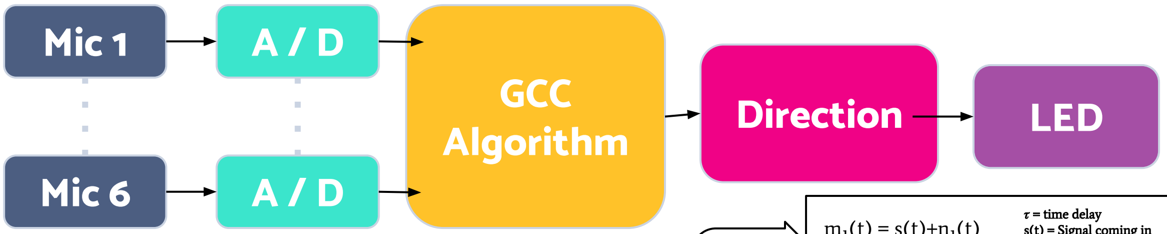
SOLUTION

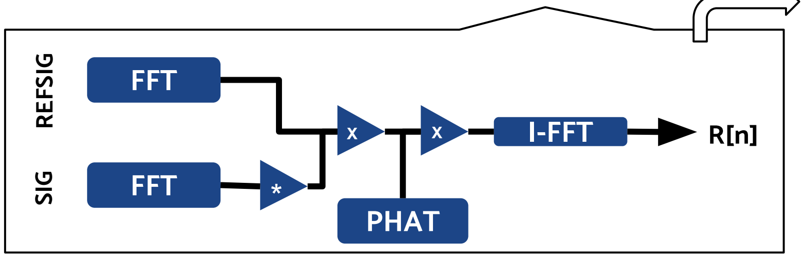
Compute the Angle of Arrival of audio signals using a 6-Mic Circular Array and display the estimation to the user via LEDs. Amplitude gives a good indication of which microphone is closest to a source, but is not robust against echos. Time Delay Estimation algorithms like GCC-PHAT are more robust to echoes and reverberations without being overly computationally complex.

TESTING

- Accurately reports Direction of Arrival from 10cm up 2.5m of range
- Using the GCC-PHAT algorithm, angles reported are within +/-15 degrees of the actual source
- Estimates are computed and displayed within 500ms +/- 100ms

SYSTEM BLOCK DIAGRAM





$m_1(t) = s(t)+n_1(t)$

$m_2(t) = s(t-\tau)+n_2(t)$

τ = time delay
s(t) = Signal coming in
n(t) = Noise

Broadside Angle:
L = Microphone distance
c = 343 m / s (speed of sound)

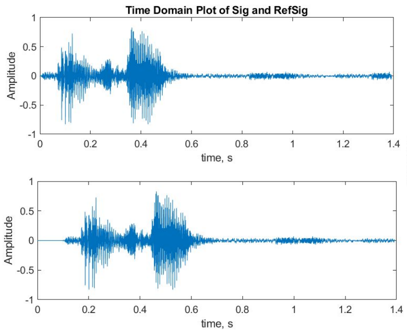
$\sin\beta = c\tau / L$

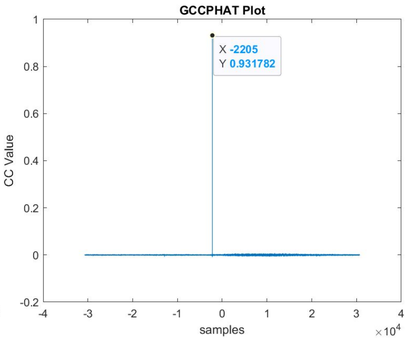
$M_1(\omega) = S(\omega)+N_1(\omega)$

$M_2(\omega) = S(\omega)\exp(j\omega\tau)+N_2(\omega)$

* = conjugate

$R(\omega) = M_1(\omega)M_2(\omega)^*$





NEXT STEPS

- Redesigning DSP around a multisource DoA algorithm
- Implement user controlled microphone passthrough and background noise suppression
- Apply noise level or voice activation preprocessing
- Implementing language processing algorithms to get real-time subtitles