THE ANDREW & ERNA VITERBI FACULTY OF ELECTRICAL ENGINEERING

SIPL
Signal and Image Processing Lab

TECHNION Israel Institute of Technology

Binaural Graphic Analyzer

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In collaboration with WAVES

Introduction

- Binaural recording is a method of recording sound that uses two microphones, arranged with the intentto create a 3-D stereo sound sensation for the listener of actually being in the room with the performers or instruments
- Such recording can be obtaind phisically, by mounitng the microphones on a dummy head simulating the head and torso response; Or by a simulated dummy head recording, where the signal is sent through a complex mathematical algorithm that tries to simulate the binaural effect.

Dummy Head

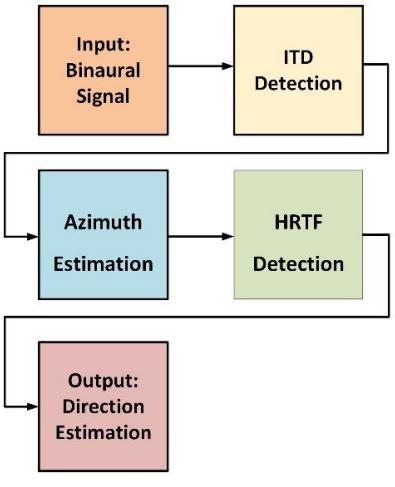
Goals

- Given a binaural recording consisted of multiple sources, we would like to determine (for each source)
  - Direction: azimuth and elevation
  - Main spectral content
  - Power
- Present and visualize that information on a GUI

Challenges

- Generation method is unknown: Signal could be generated by phisical recording or by simulation
- Spectral ques vary from different generation methods

Direction Estimation



ITD Detection

- A possible option for direction estimation is based on internal time difference - ITD
- The ITD was calculated by calculating the maximal cross correlation between the two channels

Azimuth Estimation

- A possible option for direction estimation is based on internal time difference - ITD
- We used an estimated formula by Brown & Duda to calculate the azimuth from the ITD
- Pros:
  - Easy and fast to calculate
  - Differ slightly between different techniques of binaural audio synthesis
- Cons:
  - Can't solve front back ambiguity
  - Can't indicate elevation
- We used this block to lower degrees of freedom in the next levels

What is HRTF

- The change inflicted on the signal as it propagates from the source to each ear is represented as a Head related transfer function - HRTF
- It's possible to record HRTFs in a studio
- We used the MIT database for our project

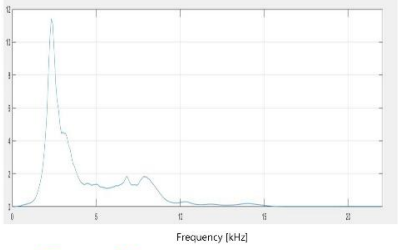
HRTF Detection

- It is common to use HRTF bank based algorithms to solve sound localization problems
- A solution reported to be succesful is the Cross Convolution (CC) Algorithm
- Direction Estimation according to CC is the solution to the following optimazation problem:

$$\min_{\hat{\theta},\hat{\varphi}} \sum \left\| R_{Left} * H_{Right}^{(\hat{\theta},\hat{\varphi})} - R_{Right} * H_{Left}^{(\hat{\theta},\hat{\varphi})} \right\|^2$$

- Azimuth estimation was used to lower degrees of freedom (otherwise have to check all directions)
- HRTF heuristic was combined in the algorithm to give extra weight to informative frequency bands
- Those bands are bands in which the variance of the HRTFs is highest:

Variance of HRTFs Along frquency bins



Results

- Successful Azimuth detection (not considering front back ambiguity)
- Azimuth RMSE: 64.5 degrees
- Elevation RMSE: 53.8 degrees