Glasberg and Moore’s Model of Loudness Applicable to Time-Varying Sounds

Lasse Vetter

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Introduction

Model Explanation

Model Results

Why we Need Loudness Models

Overview

▶ Outer ear: Filters to detect direction of sound
▶ Middle ear: Mechanical system with transfer function
▶ Cochlea: Transform from time- into frequency domain

Anatomy of the Ear
Overview of the loudness model

- Apply frequency behavior of the ear
- Emulate the excitation pattern that stimulates neurons
- Generate STL and LTL, as the listener perceives loudness
Filter frequency response of the outer and middle ear

Fig. 1. Transfer function of finite impulse response digital filter used to simulate effects of outer and middle ear. Gain scaled to be 0 dB at 1000 Hz.

- sound coming from frontal direction implied (simplification)
- Different filter settings available, e.g. no outer ear filter for in ear headphones
- 4097 tap FIR filter used
Time Frequency Analysis

- Six hanning windowed time segments with different lengths
- Update FFT calculation every 1 ms, i.e., every 32 samples @ \( fs = 32 kHz \)
- Combine FFT outcomes into one
Cochlea Modeling

- Filter bank with ≈ 130 filters
- Filter bandwidths increase with increasing center frequency
- Filter bandwidths increase with increasing levels
Instantaneous Loudness

- Excitation pattern is transformed to specific loudness pattern
- Transformation is non linear, due to compression within the cochlea
- Integration of the specific loudness pattern gives the instantaneous loudness pattern
- Not available for conscious perception!
Short Term Loudness

- Average instantaneous loudness with attack and release time

Long Term Loudness

- Average short term loudness with attack and release time
Equal Loudness Contours

- Minimum Audible Field (MAF), corresponds to 2 phons
- Remind: Binaural listening in free field with frontal incidence
Loudness as a Function of Bandwidth

- Five different fixed noise levels
- Noise geometrically fixed at 1kHz
Response to a Tone Burst

- Gated tone burst (200ms 4kHz)
- LTL decay might refer to memory effect
Amplitude Modulated Sounds Compared with Pure Sinusoids

- Top: Linear modulation 100 percent modulated
- Bottom: 60dB (peak to valley) modulated on decibel scale
Any Questions?