

Audio Source Separation: "De-mixing" for Production

De-mixing 'The Beatles at the Hollywood Bowl'
using Sound Source Separation

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Overview

- Historical Background
- Sound Source Separation
- Considerations for De-Mixing
- Source Separation Techniques
- Audio Examples

Historical Background

- The Beatles at the Hollywood Bowl
 - Beatlemania had just landed in the US
 - Previous attempt to record live performances blocked by musicians union in the US
 - 1964 tour, Capitol attempted to record concert
 - 15,000 screaming girls created a wall of sound



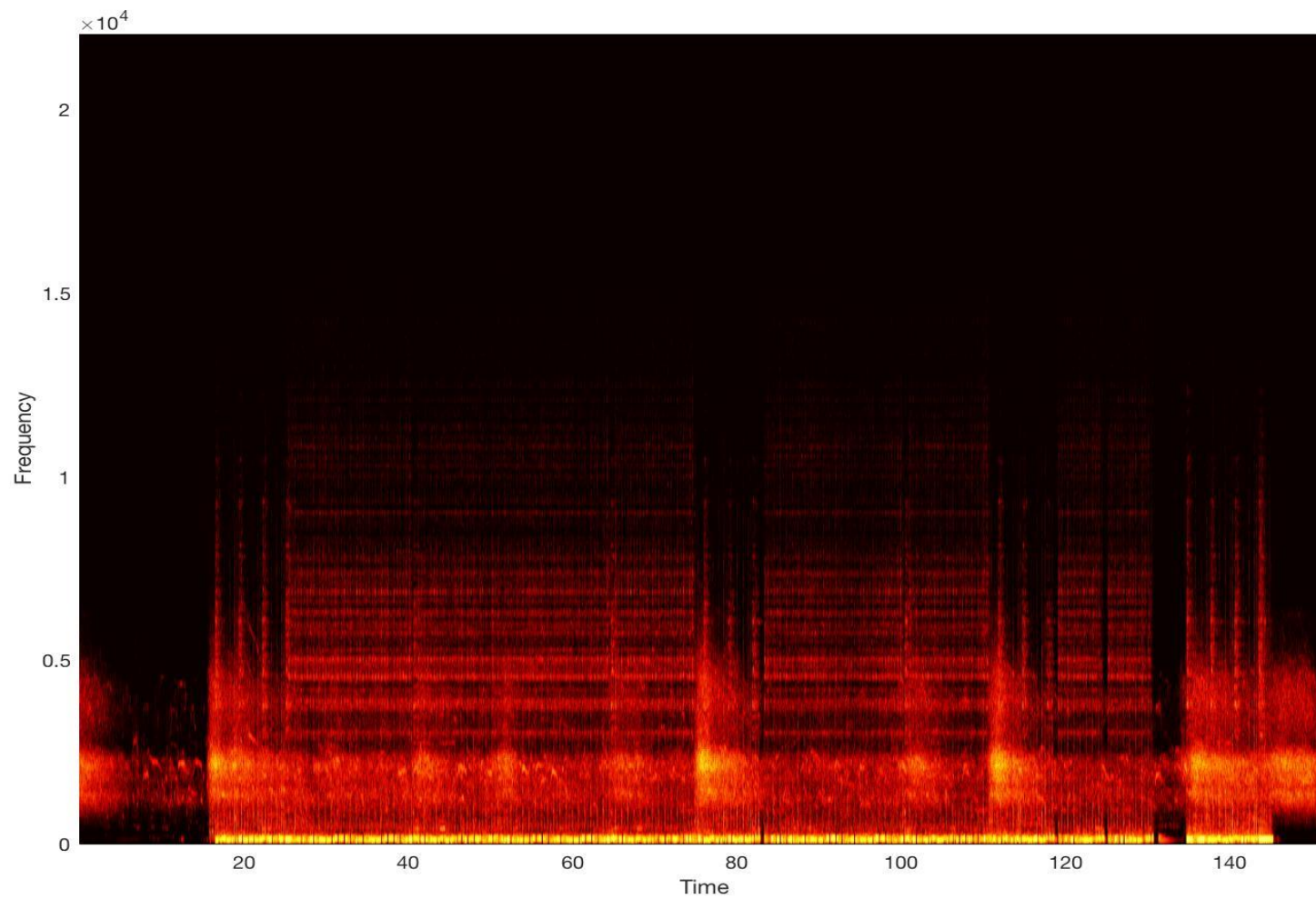
Historical Background



Historical Background

- Three Concerts 1964 and 1965
 - Recorded on Ampex 3-track machines
 - Vocals on 1 track
 - Instruments on remaining 2 tracks
 - Crowd mixed purposely into instrument tracks
- Problems
 - Engineered by the Hollywood Bowl and not Capitol
 - No monitoring on the 3-track
 - Capitol had no influence on actual recording
 - Excess crowd levels not discovered until playback in studio

Spectral Sources



- Solution – Create new stereo re-mixes using Sound Source Separation technology
- Sound Source Separation - Given a recording of a mixture of sound sources, attempt to recover the original sound sources in isolation.
- Problem: There are usually many more sources than signals, it is a difficult task, but still possible.
- Why use sound source separation?
 - Filtering by EQ affects all recorded signals as discovered by Martin and Emerick in 1977. We can now attempt to isolate crowd directly

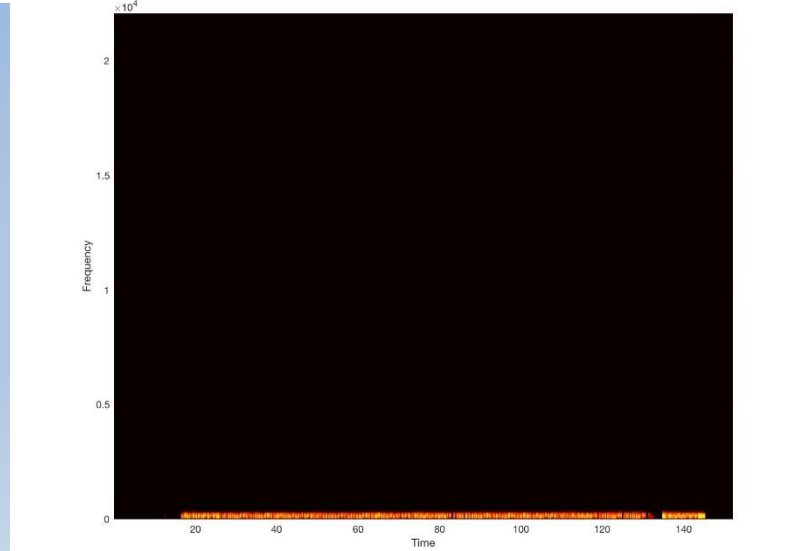
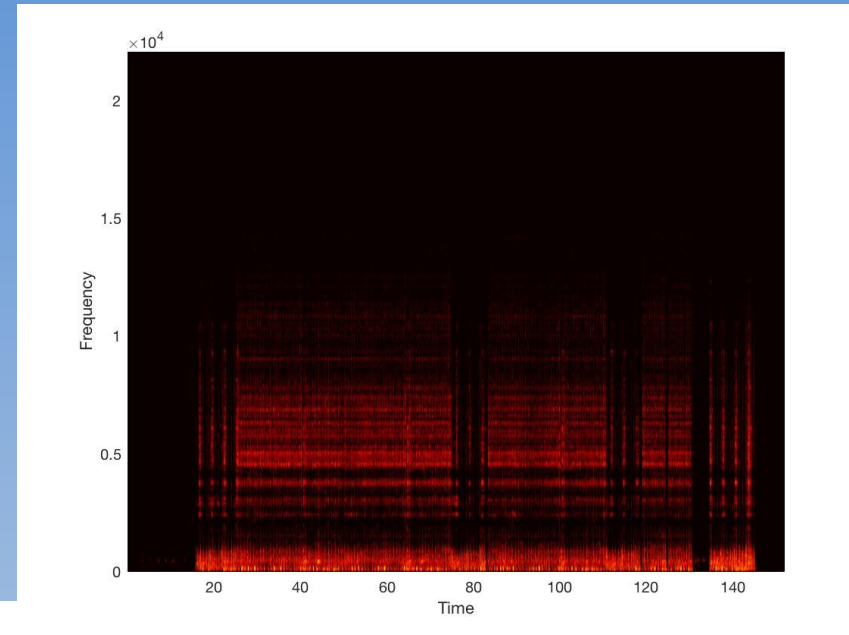
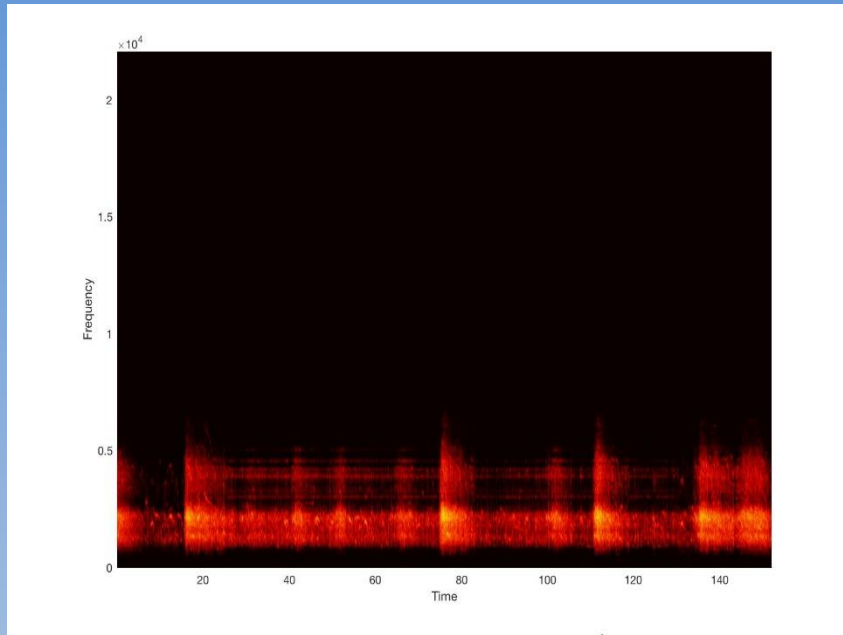
Project Timeline

- 2009 started research into source separation
- 2011 Capitol discover original 3-track recordings and send to Abbey Road
- Approached by Giles Martin to see if I could do anything to improve the audio
- Source Separation succeeds by assuming crowd is signal and not noise
- Early 2012, re-mixes approved by "the board"
- 2016, 'Live at the Hollywood Bowl' Album released, coinciding with the release of the film *The Beatles: Eight Days a Week*

Sound Source Separation

- 3 Main types of Sources
 - Vocals
 - Pitched Instruments
 - Percussion/Drums
 - No one algorithm is optimal for all these sources - use different techniques
 - Prior knowledge of the sources should be used where possible (some multitracks are available)

Results



Considerations for re-mixing

- Use filters where the separated sources sum back to give the original signal – No information lost
- Any artefacts due to separation will then be masked – our brains re-integrate the parts
- Separation does not have to be perfect, just good enough to impart directionality.

Considerations for re-mixing

- However, if panned too far re-integration can break down.
- No phase problems between channels due to the type of filters used
- Source drift due to incorrect separation can be a problem – ameliorate by choice of pan position – Sources placed in original positions





Source Separation Techniques

- Drums/Percussion
 - Highly localised in time, broadband spectra and repetitive
 - Many approaches – Decomposition into parts (NMF), dictionary based methods, heuristics-based (drums –vertical lines, pitched instruments horizontal)
- Vocals/Lead Instruments
 - Decomposition into parts (NMF), melody tracking and filtering, heuristics-based (backing track is more repetitive than the main melody)
- Pitched Instruments
 - Again NMF, Additive Synthesis based decompositions, Source-Filter models
- User Assisted Algorithms
 - Use prior information to aid the separation process (Knowledge of melody, existence of backing tracks, chord progressions and so on)

Source Separation Techniques

- Different methods work better on different types of material, it varies from song to song
- Pick the techniques based on the song
- Order of separation can make a big difference in some cases
- **Whatever sounds best**

Audio Examples

- SLY – Original Stereo 
- SLY – Original Track 1 
- SLY – Extracted Drums 
- SLY – Extracted Bass 
- SLY – Extracted Crowd 