Beamforming for Far-field Voice Capture using a Microphone Array

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A central task in the field of acoustics and speech signal processing is to extract or enhance some signal of interest, while suppressing noise. To address this task, beamforming techniques, based on spatial filtering utilizing a microphone array, is used. In this thesis we investigate far-field voice capture and noise suppression using these methods.

Introduction

Imagine talking to someone on a mobile phone, the wind blowing in the background. It is almost impossible to understand the person at the other end. If people are in the same noisy environment, talking face to face, the brain can easily adjust to the conversation while ignoring the noise. Not being in the same room will leave the brain with less information to process and therefore make it a harder task to separate source from noise. This warrants an adaptive method which takes parameters, such as noise, into consideration in order to improve speech intelligibility. To successfully solve this problem we make use of acoustic beamforming.

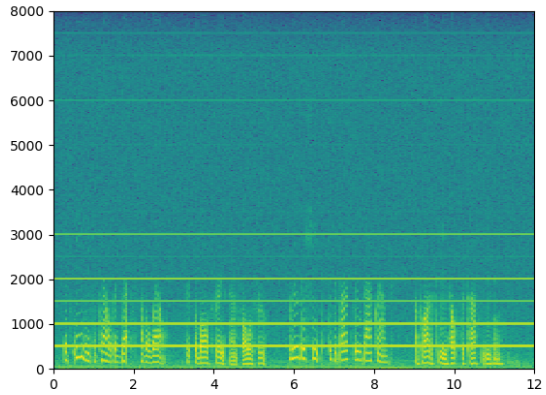
Beamforming

The goal of a beamformer is to simply attenuate the surrounding signals while leaving the desired source signal untouched. In this thesis *delay-and-sum* (DS) and *minimum-variance-distortionless-response* (MVDR) beamformers are implemented.

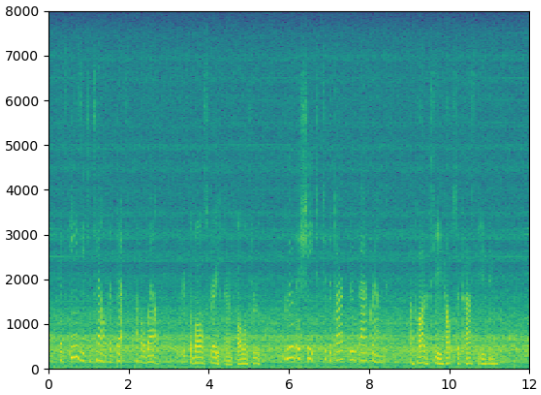
The signal is captured with a microphone array which is a set of microphones operating in tandem. Once the signal reaches the microphone array processing can begin. For DS, each channel is simply delayed and summed to its produced output, whilst for MVDR, a more sophisticated method, adapts to the current acoustic environment. For a signal degraded by noise e.g. sine tones of different frequencies, the result would be suppression of the sine tones. This effect is seen in the spectrograms where the frequency components are plotted as a function of time. The solid lines are the unwanted noise signals, each from directions different than the signal of interest. The extracted signal shows how the tones are suppressed due to beamforming.

Direction of Arrival

To be able to steer an acoustic beam it is required to estimate the direction of arrival (DOA) of the signal of interest. Together with beamforming it can be used as a blind signal separator.



Incoming signal



Extracted signal

Blind Signal Separation

Blind signal separation (BSS) is a method for separating a set of mixed signals with no or little information about the sources or about how they were mixed. This is generally done in one step and not via DOA and beamforming which gives a very flexible solution for the noise suppression problem. Finally you can hear your friend with a noisy background over the phone. You can also listen to private conversations in a crowded room - use it with caution!