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Audiokommunikation und -technologie M.Sc.

Self-Organizing Maps for Sound Corpus Organization

Master's Thesis

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Eidesstattliche Erklärung

Hiermit erkläre ich, dass ich die vorliegende Arbeit selbstständig und eigenhändig sowie ohne unerlaubte fremde Hilfe und ausschließlich unter Verwendung der aufgeführten Quellen und Hilfsmittel angefertigt habe.
Berlin, den February 8, 2019

. . . .
Jonas Margraf

Abstract An english abstract.

Zusammenfassung Die Zusammenfassung auch auf Deutsch.

Acknowledgements

This is where the thank yous go.

Contents

1 Introduction

This is the Introduction. Here's a citation about Self-Organizing Maps (SOMs)(Kohonen, 1990).

1.1 Motivation and Problem Description

1.2 Aims and Objectives

1.3 Previous Work

2 Background

This is the Background section.

2.1 Audio Feature Extraction

Make sure to quote Lerch (2012), Rawlinson et al. (2015), Rawlinson et al. (2019a), Mathieu et al. (2010) Mathieu et al. (2019).

2.1.1 Fundamentals

2.1.2 Audio Pre-Processing

2.1.3 Time-Domain Features

Define $x[n]$, n

2.1.3.1 Root Mean Square (RMS) measures the power of a signal (Lerch, 2012, p.73f). It describes sound intensity and is sometimes used as a simple measure for loudness (Rawlinson et al., 2019b) that does not take the nonlinearity of human hearing into account (Fletcher and Munson, 1933). It is calculated for an audio frame $x[n]$ consisting of n samples such that

$$v_{RMS} = \sqrt{\frac{\sum_{i=1}^{n} x(i)^2}{n}}. \tag{1}$$

2.1.3.2 Zero-Crossing Rate (ZCR) represents the rate of the number of sign changes in a signal. It can be used as a measure of the tonalness of a sound (Lykartsis, 2014) and as a simple pitch detection method for monophonic signals (de la Cuadra, 2019). It is defined as

$$v_{ZCR} = \frac{1}{2 \cdot n} \sum_{i=1}^{n} |sgn[x(i)] - sgn[x(i-1)]|. \tag{2}$$

2.1.4 Frequency-Domain Features

Define N_{FFT}, $X(k)$

2.1.4.1 Spectral Centroid is a measure of the center of gravity of a spectrum. A higher value indicates a brighter, sharper sound (Lerch, 2012). The spectral centroid is defined as

$$v_{SC} = \frac{\sum\limits_{k=0}^{N_{FFT}/2-1} k \cdot |X(k)|^2}{\sum\limits_{k=0}^{N_{FFT}/2-1} |X(k)|^2}. \tag{3}$$

2.1.4.2 Spectral Flatness is a measure for the tonality or noisiness of a signal, defined as the ratio of the geometric and arithmetic means of its magnitude spectrum. Higher values indicate a flatter (and therefore noisier) spectrum, whereas lower values point towards more tonal spectral content. It is defined as

$$v_{SFL} = \frac{\sqrt[N_{FFT}/2]{\prod\limits_{k=0}^{N_{FFT}/2-1} |X(k)|}}{(2/N_{FFT}) \cdot \sum\limits_{k=0}^{N_{FFT}/2-1} |X(k)|}. \tag{4}$$

2.1.4.3 Spectral Kurtosis indicates whether a given magnitude spectrum's distribution is similar to a Gaussian distribution. Negative values result from a flatter distribution, whereas positive values indicate a peakier distribution. A Gaussian distribution would result in a value of 0. Spectral Kurtosis is defined as

$$v_{SKU} = \frac{2 \sum\limits_{k=0}^{N_{FFT}/2-1} (|X(k)| - \mu_{|X|})^4}{N_{FFT} \cdot \sigma_{|X|}^4} - 3, \tag{5}$$

where $\mu_{|X|}$ represents the mean and $\sigma_{|X|}$ the standard deviation of the magnitude spectrum $|X|$.

2.1.4.4 Spectral Skewness assesses the symmetry of a magnitude spectrum distribution. It is defined as

$$v_{SSK} = \frac{2 \sum\limits_{k=0}^{N_{FFT}/2-1} (|X(k)| - \mu_{|X|})^3}{N_{FFT} \cdot \sigma_{|X|}^3}. \tag{6}$$

2.1.4.5 Spectral Slope represents a measure of how sloped or inclined a given spectral distribution is. The spectral slope is calculated using a linear regression of the magnitude spectrum such that

$$v_{SSL} = \frac{\sum\limits_{k=0}^{N_{FFT}/2-1} (k-\mu_k)(|X(k)| - \mu_{|X|})}{\sum\limits_{k=0}^{N_{FFT}/2-1} (k-\mu_k)^2}. \tag{7}$$

2.1.4.6 Spectral Spread is a descriptor of the concentration of a magnitude spectrum around the Spectral Centroid and assesses the corresponding signal's bandwidth. It is defined as

$$v_{SSP} = \frac{\sum\limits_{k=0}^{N_{FFT}/2-1} (k-v_{SC})^2 \cdot |X(k)|^2}{\sum\limits_{k=0}^{N_{FFT}/2-1} |X(k)|^2}. \tag{8}$$

2.1.4.7 Spectral Rolloff measures the bandwidth of a given signal by calculating that frequency bin below which lie κ percent of the sum of magnitudes of $X(k)$. Common values for κ are 0.85, 0.95 (Lerch, 2012) or 0.99 (Rawlinson et al., 2019b). It is defined as

$$v_{SR} = i \Big|_{\sum\limits_{k=0}^{i} |X(k)| = \kappa \cdot \sum\limits_{k=0}^{N_{FFT}/2-1} |X(k)|}. \tag{9}$$

2.1.5 Perceptual Features

2.1.5.1 Loudness (Peeters, 2004)

2.2 Self-Organzing Map

Something about SOMs and also neurons have IDs.

3 Implementation

This is the Implementation.

3.1 Groundwork: CataRT Extension

3.2 SOM Browser

4 Evaluation

This is the Evaluation.

4.1 Measuring SOM-Induced Quantization

4.2 Online Sound Similarity Survey

4.3 Semistructured User Interviews

5 Results

This is the Results section.

6 Discussion

This is the Discussion.

6.1 Outlook

7 References

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Appendices

A LaTeX Sources

The LaTeX sources for this work can be found in XXX.

B Thesis Bibliography

The references used in this work can be found in XXX.

Glossary

ID A name or number that identifies an object.

Acronyms

SOM Self-Organizing Map.

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Digital Resource

This page holds a data disk.