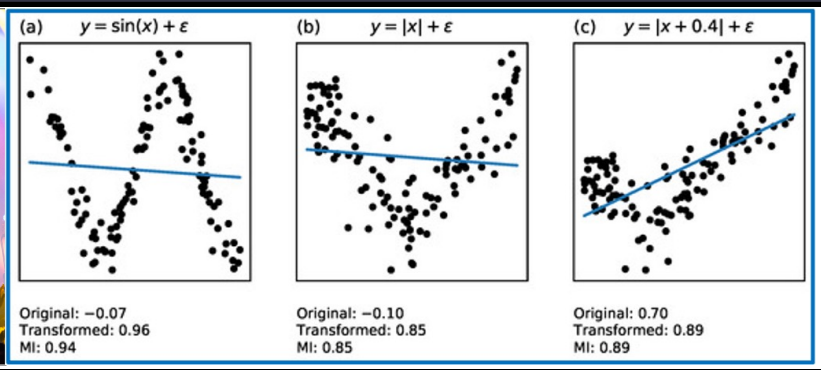
Master Project: Music Similarity Based on Multivariate Correlation

University of Zurich[UZH]



Introduction

This project aims to develop a framework for measuring music similarity based on multivariate correlation analysis of audio features. The core idea is to represent each song through a set of extracted low-level audio features (such as timbre, rhythm, and spectral characteristics) as a multivariate time series, and to compute pairwise correlations across these features to quantify the degree of similarity between songs. Feature extraction will be performed using Essentia, an open-source audio analysis library.

Potential correlation methods could be Mutual Information [1] and Earth Mover's Distance. Since the features we extract from audio can be of very high dimensionality, multivariate mutual information can be estimated either by KDE [2] or KSG [3]. To further improve estimation performance and computational efficiency, dimensionality reduction methods such as UMAP or t-SNE may be applied as a preprocessing step.

The main goal of the project is to evaluate how well correlation-based similarity metrics capture perceptually meaningful relationships between songs. The resulting similarity measures will be compared with those obtained from state-of-the-art neural network-based embedding models commonly used for music similarity and tagging tasks (e.g., [4]).

The evaluation will be conducted on benchmark datasets that include ground-truth similarity information, such as MagnaTagATune [5], to assess how effectively the correlation-based methods align with human perception and machine-learned representations of musical similarity.

Multivariate correlation analysis.

Assignment

The following tasks will be part of the project:

- Feature Extraction: Use Essentia to extract a comprehensive set of low-level and mid-level audio features, including timbre, rhythm, spectral, and tonal descriptors. Represent each song as a multivariate time series and store them in a structured format suitable for a database and for pairwise comparison.
- Similarity Computation: Implement correlation-based similarity measures, including Mutual Information (MI) and Earth Mover's Distance (EMD). Experiment with dimensionality reduction techniques (UMAP, t-SNE) to improve computational efficiency and accuracy.
- Evaluation: Evaluate the similarity measures against trained networks as well as ground-truth labels.

Project Type

Master Project

Requirements

Experience in programming with Python

Supervision

Prof. Dr. Renato Pajarola
Xiao Tan (Assistant)

Workload

- 30% Theory
- 50% Implementation
- 20% Testing and evaluation

Contact

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References

[1] Brian C Ross. Mutual information between discrete and continuous data sets. *PloS one*, 9(2):e87357, 2014.

[2] Young-Il Moon, Balaji Rajagopalan, and Upmanu Lall. Estimation of mutual information using kernel density estimators. *Physical Review E*, 52(3):2318, 1995.

[3] Alexander Kraskov, Harald Stögbauer, and Peter Grassberger. Estimating mutual information. *Physical Review E—Statistical, Nonlinear, and Soft Matter Physics*, 69(6):066138, 2004.

[4] Janne Spijkervet and John Ashley Burgoyne. Contrastive learning of musical representations. *arXiv preprint arXiv:2103.09410*, 2021.

[5] Edith Law, Kris West, Michael I Mandel, Mert Bay, and J Stephen Downie. Evaluation of algorithms using games: The case of music tagging. In *ISMIR*, pages 387–392, 2009.

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