INTERNATIONAL AUDIO LABORATORIES ERLANGEN — AUDIO LABS

Meisterklasse HfM Karlsruhe

Music Information Retrieval

Classification & Clustering

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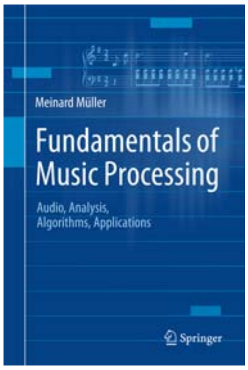
Book: Fundamentals of Music Processing



Meinard Müller
Fundamentals of Music Processing
Audio, Analysis, Algorithms, Applications
483 p., 249 illus., hardcover
ISBN: 978-3-319-21944-8
Springer, 2015

Accompanying website:
www.music-processing.de

Book: Fundamentals of Music Processing

Chapter	Music Processing Scenario
1	Music Representations
2	Fourier Analysis of Signals
3	Music Synchronization
4	Music Structure Analysis
5	Chord Recognition
6	Tempo and Beat Tracking
7	Content-Based Audio Retrieval
8	Musically Informed Audio Decomposition

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Dissertation: Tonality-Based Style Analysis

Christof Weiß
Computational Methods for Tonality-Based Style Analysis of Classical Music Audio Recordings
Dissertation, Technical University of Ilmenau 2017
to appear

Chapter 7: Clustering and Analysis of Musical Styles
Chapter 8: Subgenre Classification for Western Classical Music

Music Genre Classification

J. S. Bach, Brandenburg Concerto No. 2 in F major, I. Allegro, Cologne Chamber Orch.

L. van Beethoven, *Fidelio*, Overture, Slovak Philharm.

R. Schumann, Sonata No. 2 op. 22, II. Andantino, B. Glemser, Piano

A. Webern, Variations for Orchestra op. 30, Ulster Orchestra

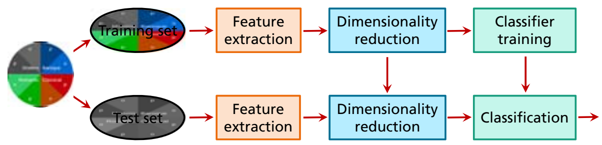
Music Genre Classification

Music Genre Classification

- Standard approach (*content-based*)
  - Supervised machine learning
  - Based on spectral / timbral features
- In classical music → Instrumentation
- Better categories?
  - *Musical style*
  - Independent from instrumentation
  - → **Tonality / Harmony**

Music Genre Classification

- Typical approach: Supervised machine learning

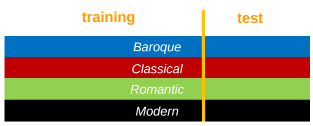


Music Genre Classification

- Experimental design: Evaluation with Cross Validation (CV)
- Separate data into different parts (*folds*)

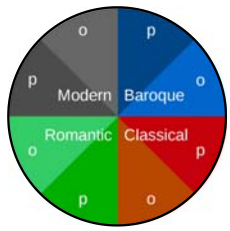
	Fold 1	*Fold 2*	*Fold 3*
Round 1	Training fold	Training fold	Test fold
Round 2	Training fold	Test fold	Training fold
Round 3	Test fold	Training fold	Training fold

- Distribution of classes balanced for all folds

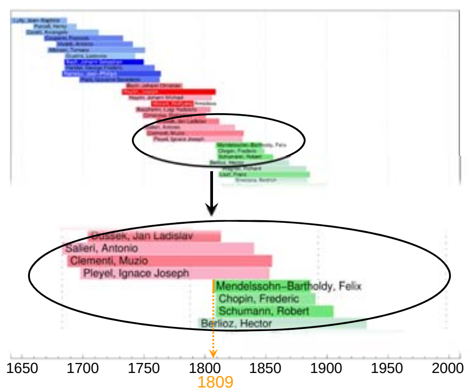


Classification Scenario

- Dataset: *CrossEraDB* (Historical Periods)
  - Balanced Piano (p) – Orchestra (o)
  - Each 200 pieces → 1600 in total



Classification Scenario

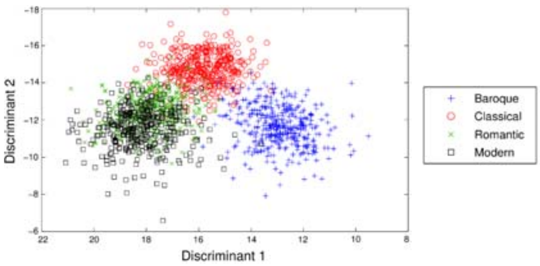


Classification Features

Standard	Dim.	Tonal	Dim.
MFCC	16	Interval cat.	6 x 4
OSC	14	Triad types	4 x 4
ZCR	1	Complexity	7 x 4
ASE	16	Chord progr.	11 x 5
SFM	16		
SCF	16		
SC	16		
LogLoud	12		
NormLoud	12		
Sum	119	Sum	123
Mean & Std	x 2	Mean & Std	x 2
Total	**238**	**Total**	**246**

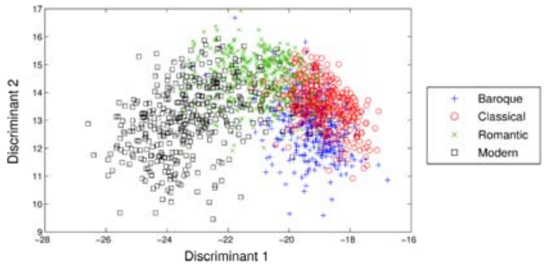
Dimensionality Reduction

- Reduce feature space to few dimensions
- Maximize separation of classes with **Linear Discriminant Analysis (LDA)**
- Using **standard features** (MFCC, spectral envelope, …)



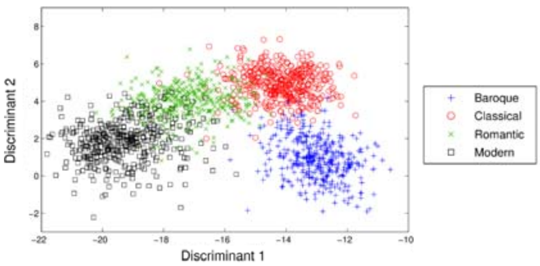
Dimensionality Reduction

- Reduce feature space to few dimensions
- Maximize separation of classes with **Linear Discriminant Analysis (LDA)**
- Using **tonal features** (interval, triad types, tonal complexity, … 4 time scales)



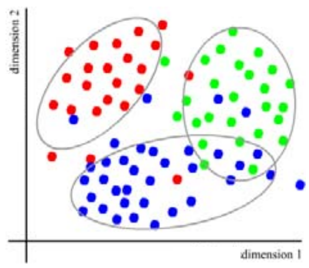
Dimensionality Reduction

- Reduce feature space to few dimensions
- Maximize separation of classes with **Linear Discriminant Analysis (LDA)**
- Using **tonal & standard features**



Classifier

- Train Machine Learning Classifier
- **Gaussian Mixture Model (GMM)**
- Using Gaussian distributions to model data points in feature space



Classification Results

- Gaussian Mixture Model (GMM) classifier, LDA reduction, 3-fold cross validation

	Full Dataset	Piano	Orchestra
Standard features	87 %	88 %	85 %
Tonal features	84 %	84 %	86 %
Combined	**92 %**	**86 %**	**80 %**

Weiss / Mauch / Dixon, *Timbre-Invariant Audio Features for Style Analysis of Classical Music*, ICMC / SMC 2014

Classification Results

- GMM classifier, LDA reduction, 3-fold cross validation

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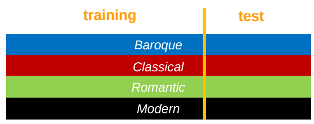


Flexer, *A Closer Look on Artist Filters for Musical Genre Classification*, ISMIR 2007

Classification Results

- GMM classifier, LDA reduction, 3-fold cross validation
- **No composer filter**

	Full Dataset	Piano	Orchestra
Standard features	87 %	88 %	85 %
Tonal features	84 %	84 %	86 %
Combined	**92 %**	**86 %**	**80 %**

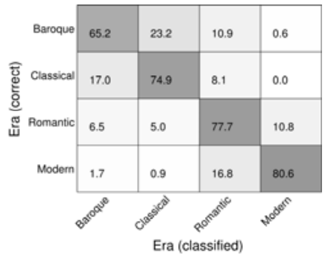
- **Using composer filter**

	Full Dataset	Piano	Orchestra
Standard features	54 %	36 %	70 %
Tonal features	73 %	70 %	78 %
Combined	**68 %**	**44 %**	**68 %**

Weiss / Müller, *Tonal Complexity Features for Style Classification of Classical Music*, ICASSP 2015

Classification Results – Confusion Matrix

- 80 tonal features, GMM with 1 Gaussian, LDA, composer filtering
- **Full** dataset
- Mean accuracy: **75 %**
- Inter-class standard deviation: **6.7 %**



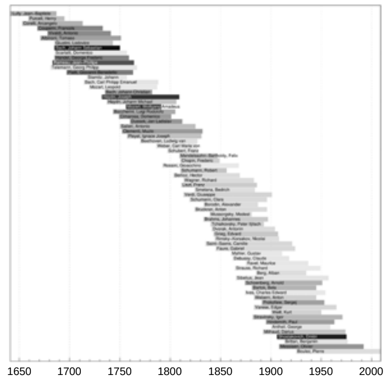
Classification Results – Summary

- Different types of tonal features
- Combination of time scales
- Classifiers (SVM, Random Forest)
- State-of-the-art
  - Few studies on audio
  - Good separation of tonal-vs.-atonal (**91 %**):

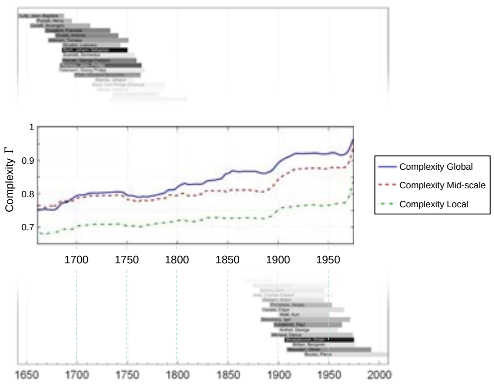
    Izmirli, *Tonal-Atonal Classification of Music Audio Using Diffusion Maps*, ISMIR 2009
- Composer Identification
  - Up to **78 %** for 11 composers

    Hamel, *Pooled Features Classification*, MIREX 2011
  - Dataset balanced?

Musical Style Analysis

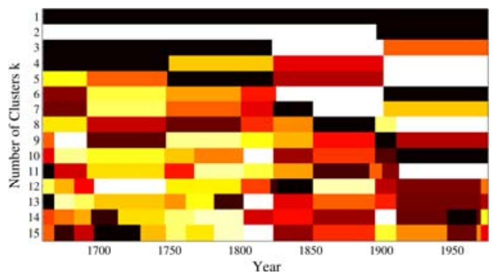


Musical Style Analysis – Complexity



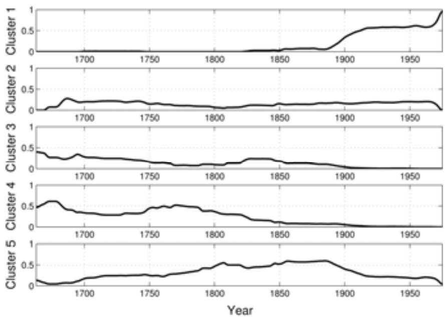
Clustering: Years

- Features: Interval, complexity, chord progressions
- Dimensional reduction with **Principal Component Analysis (PCA)**
- *k*-means clustering with different number of clusters *k*

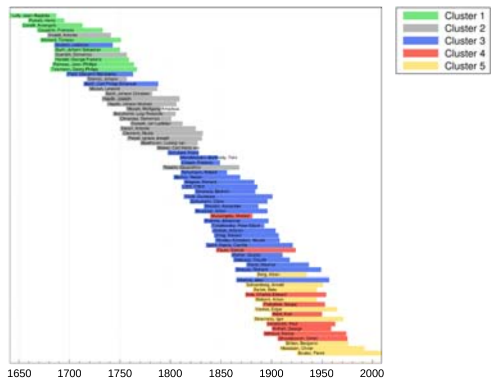


Clustering: Pieces

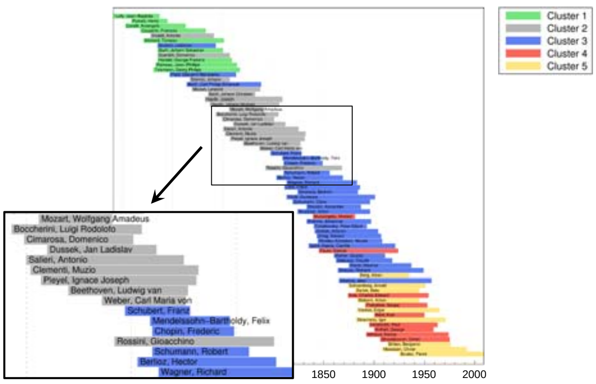
- *k*-means clustering with *k* = *5* clusters



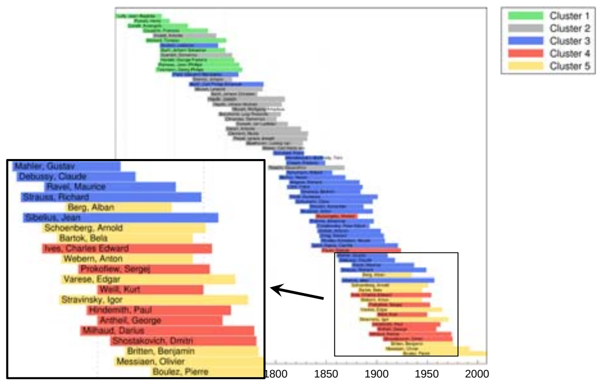
Clustering: Composers



Clustering: Composers



Clustering: Composers



Clustering: Composers