Content-based Organization of Musical Performers using Self Organized Maps

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Introduction

• Most of the people can recognize artists, what are the features that makes it possible?
• How can we organize artists based on sound?
Possible Applications

• Musicology research
• Create dynamic playlists suitable with the user’s musical preferences
High Level Design

Music Library

Feature Extraction → Training → Mapping and Classification

Musical map
### Music Genres

- Each song divided into 3 segments of 30 seconds

<table>
<thead>
<tr>
<th>ROCK</th>
<th>POP</th>
<th>JAZZ</th>
<th>RAP/ HIP-HOP</th>
<th>CLASSIC</th>
<th>ELECTRONIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metallica</td>
<td>Red Hot</td>
<td>Britney</td>
<td>OutKast</td>
<td>Bach</td>
<td>Infected</td>
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<tr>
<td></td>
<td>Chili Peppers</td>
<td>Spears</td>
<td></td>
<td></td>
<td>Mushroom</td>
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<tr>
<td>Jimi Hendrix</td>
<td>The Doors</td>
<td>Madonna</td>
<td>Frank Sinatra</td>
<td>The Black Eyed Peas</td>
<td>Vivaldi</td>
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<tr>
<td>LTE</td>
<td>Dream Theater</td>
<td>Spice Girls</td>
<td>Sarah Vaughan</td>
<td>Snoop Dogg</td>
<td>Beethoven</td>
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<tr>
<td>Queen</td>
<td>Symphony X</td>
<td>Shakira</td>
<td>50 Cent</td>
<td>Chopin</td>
<td>Prodigy</td>
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<tr>
<td>Coldplay</td>
<td>Guns N Roses</td>
<td></td>
<td>Eminem</td>
<td></td>
<td>Pendulum</td>
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<tr>
<td>Pink Floyd</td>
<td>Nirvana</td>
<td></td>
<td>Jamiroquai</td>
<td></td>
<td>David Guetta</td>
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<tr>
<td>Leonard Cohen</td>
<td>Pearl Jam</td>
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<td></td>
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<tr>
<td>Aerosmith</td>
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</tr>
</tbody>
</table>
Feature Extraction

- Features represent Timbre, Genre and Mood
  - MFCC
  - Spectral analysis
  - Tempo
- Extracted using MIR Toolbox
Mel-Freq Cepstral Coeff

- Common tool in MIR and speech recognition
- Approximates the human auditory system
Spectral Features

- First 3 moments of the spectrum
- Spectral Roll-off frequency
- Spectral Flatness – noisiness of the spectrum
PCA

• Represent the data in an orthogonal basis in which the variance is maximized
• Better separation and computability improvement
• Finds the best separating features
  - MFCC, Flatness, 3$^{rd}$ Moment
High Level Design

Music Library ➔ Feature Extraction ➔ Training ➔ Mapping and Classification ➔ Musical map
Self Organized Map

- 2-Dimensional node grid
- Unsupervised training process
- Useful for high dimensional input visualization
- Preserves topological properties
Training

- Choose a segment randomly
- Winner determination

\[ dist(\bar{x}, \bar{m}_i) = \sum_{j=1}^{d} (x_j - m_{ij})^2 \sqrt{\lambda_j} \]
Self Organized Map

- Closest node and neighborhood adaptation

\[
\bar{m}_i(t + 1) = \bar{m}_i(t) + h_{ci}(t)\left[\bar{x}(t) - \bar{m}_i(t)\right]
\]
Learning rate

- Starting with a large learning rate, gradually decreased to facilitate convergence

\[ h_{ci} = \alpha(t) \exp \left( - \frac{|r_c - r_i|^2}{2\sigma^2(t)} \right) \]
High Level Design

1. Feature Extraction
2. Training
3. Mapping and Classification

Music Library ➔ Feature Extraction ➔ Training ➔ Mapping and Classification ➔ Musical map
Mapping

- Histogram maps for each artist

Eminem  
Chopin  
Guns N Roses  
Ella Fitzgerald
Classification

• New (untrained) song from each album
• Find best matching node in the map
• Classification based on artist’s histograms
Performance Analysis

Artist Classification rate as a function of the number of artists

- 50x50 Map
- 20x20 Map

Classification rate (%) vs. Number of Artists

47%
38.6%
Classification

• Classifying unknown artists:

  *Mozart*
  *Billy Holiday*
  *Beatles*
  *Kanye West*
  *2Pac*
  *Pantera*
  *Alice in Chains*
  *Astral Projection*
Classifying Unknown Artists

Classical
- Bach
- Chopin
- Beethoven
- Mozart

Pop/Electronic
- Pink Floyd
- Coldplay
- The Beatles
- Billie Holiday

Rock
- Frank Sinatra
- The Doors
- Jimi Hendrix
- Metallica
- Alice in Chains

Hip-Hop
- 2Pac
- OutKast
- The Black Eyed Peas
- Snoop Dogg

Rap
- Kanye West

Astral Projection
- Pendulum
- Liquid Tension Experiment

Pop/Electronic
- Madonna
- DJ Tiesto
- Armin Van Buuren
- Aerosmith

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Conclusions

- PCA + SOM for representing music similarities
- We manage to implement approach for music organization
- 50.7% artist classification rate
- 78.5% genre classification rate
Future Work

- Further study for features selection
- Automatic playlist creation
- Similar artists suggestions
- Adapting the algorithm to other fields
  i.e. painter classification
Thank You