

Song Similarities via Homology of Chroma Features

{ Samuel Leventhal and Zahra Fahimfar

- Similarity of music found currently with **data-mining / machine learning** over common features and **co-occurrence** in user data.
- Common features studied via **matrix representations** of pitch, melodic similarity, rhythmic pattern similarity, ect...

Background

- Introduce a novel metric for similarity between songs.
- Provide a new perspective for studying musical compositions.
- Demonstrate topological tools for musical data analysis.
- Perform clustering of similar songs based on topological features.

Motivation

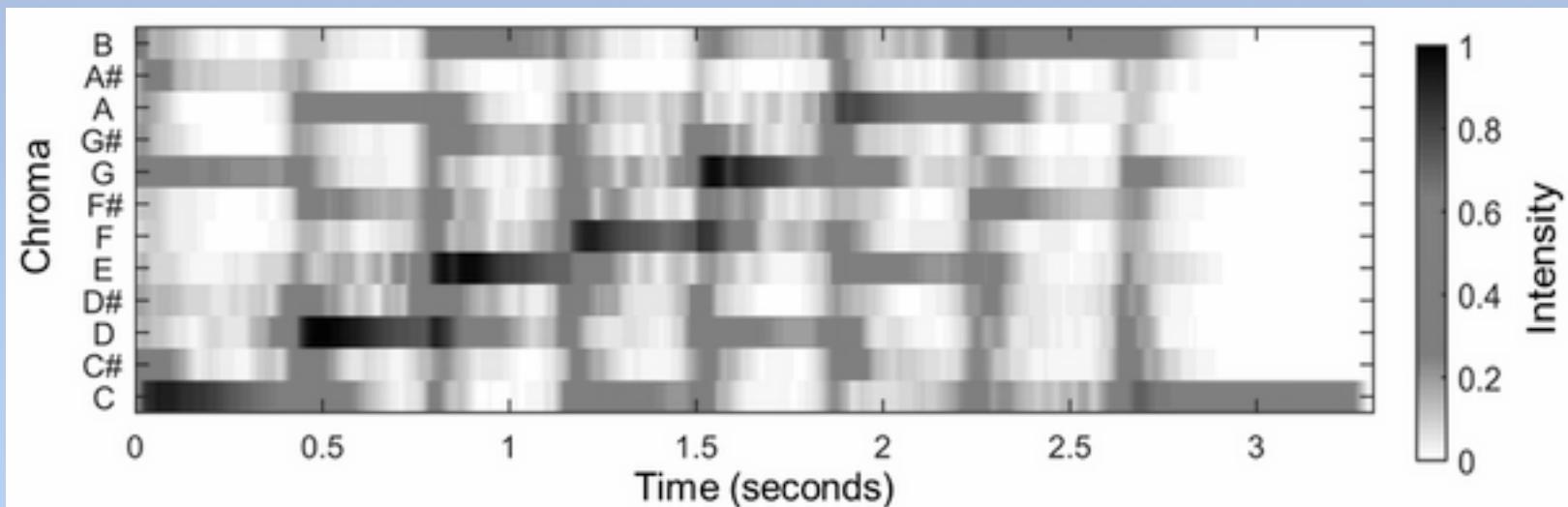
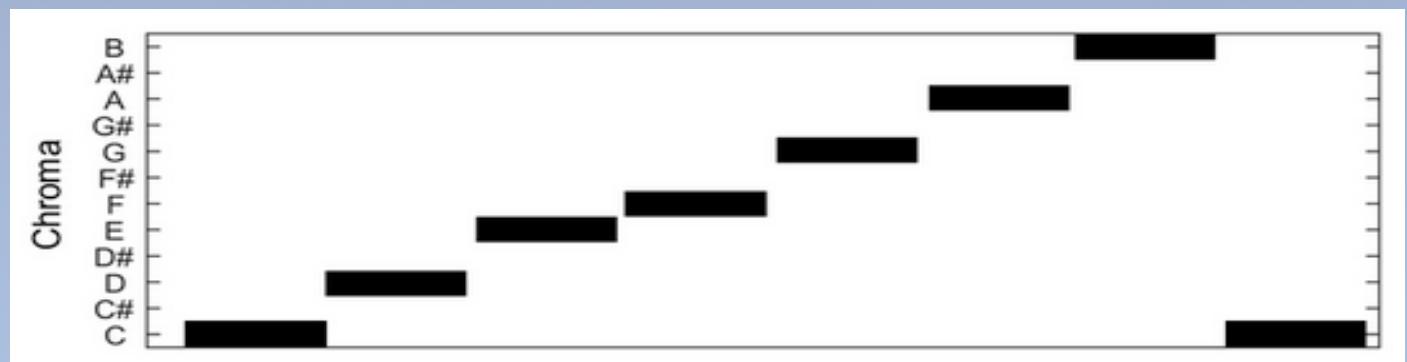
- View musical composition in terms of pitch, intensity, and time signatures.
- Relate homological features found from persistence over these terms between songs.

Motivation: Low Hanging Fruit.

- Initial ideas:
 - Graph Representation:
 - $V = \{pitch, (t_{start(pitch)}, t_{stop(pitch)})\}$
 - $E =$ Connecting Sequential pitches
 - $W =$ Edge weight proportional to number of times pitches follow one another within entire song.
 - Matrix Representation:
 - Rows/Columns correspond to pitches observed in a song in order which they appear. For $t_{i,j} \in T$
 - i.e. $(t_{start(i)}, t_{stop(j)})$ $i = pitch^{\text{"}i\text{"}} \& j = pitch^{\text{"}j\text{"}}$
 - Chroma Features...

Approach: Data

Data: Chroma Features.



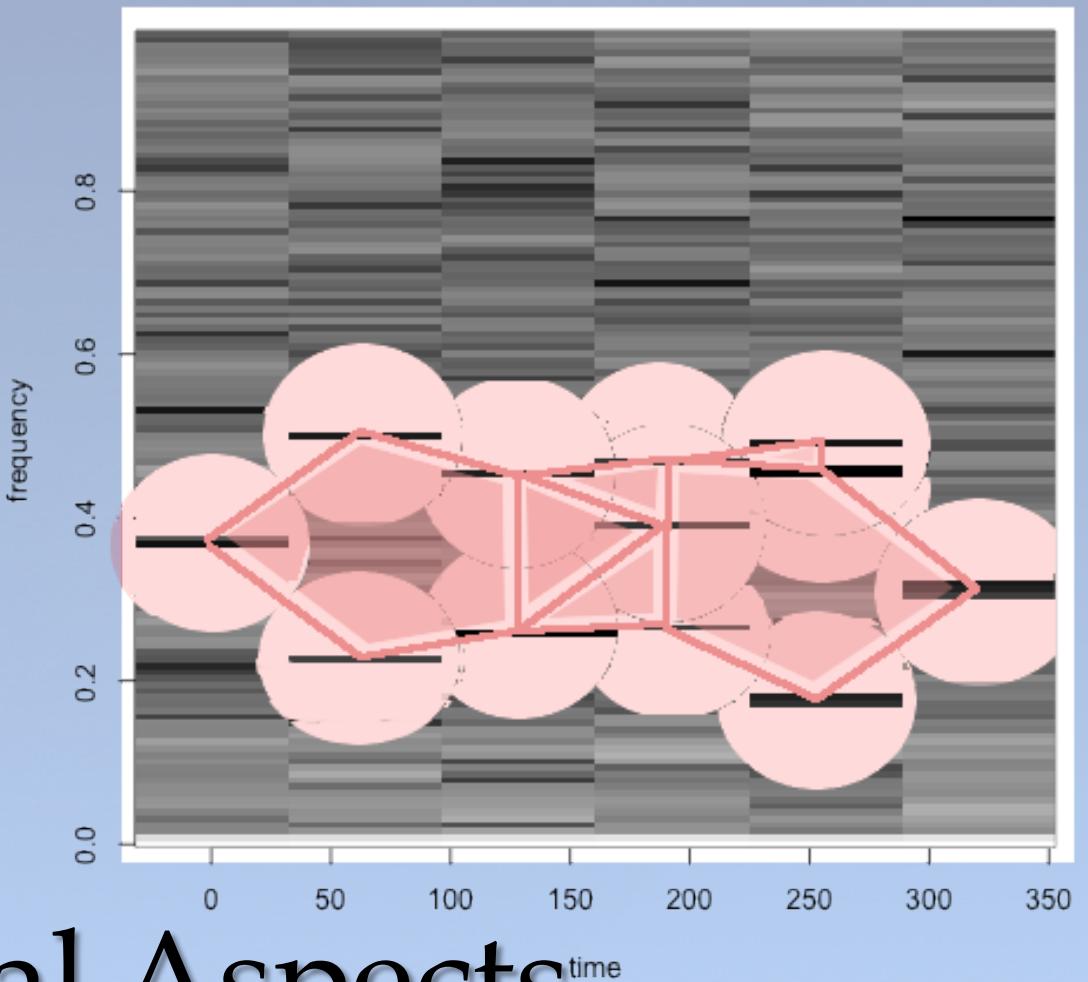
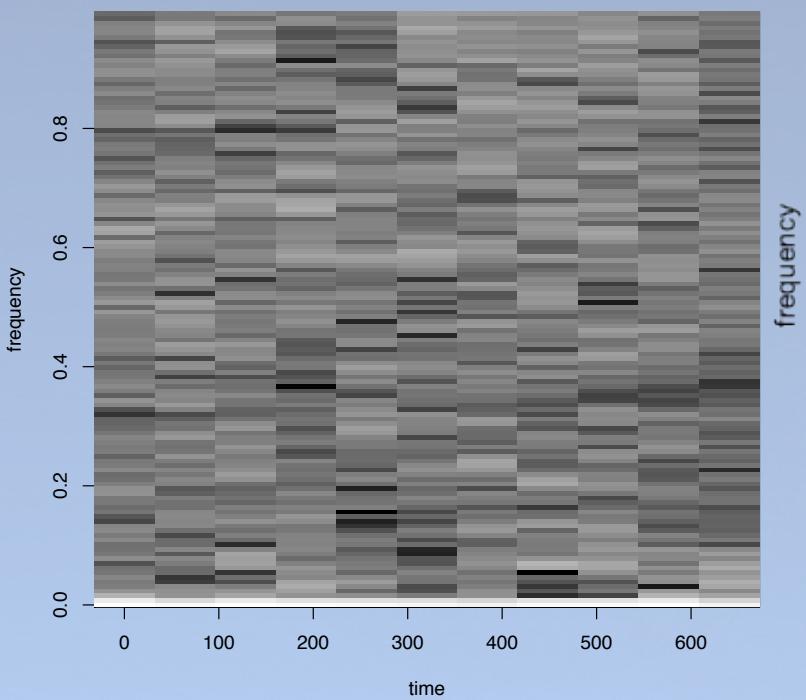
1. Data Mining: Obtain Chroma Features of Songs.
2. Compute homological features in chroma features via persistence.
3. Obtain pair-wise Bottleneck distances between persistence diagrams of songs.
4. Perform clustering based on pair-wise Bottleneck distances.
5. Perform dimension reduction for visualisation.
6. Assess success of found clusters.

Summary of Computational Methods

- Persistent Homology of chroma features.
 - **Homological features reflect common compositional structures** in songs.
 - **Birth and Death times** of homological features **reflect chord progression** and **root key** in musical compositions.
- Bottleneck distance between persistence diagrams of songs.
 - Allow a **measure of similarity between structure of song compositions**.

Topological Aspects

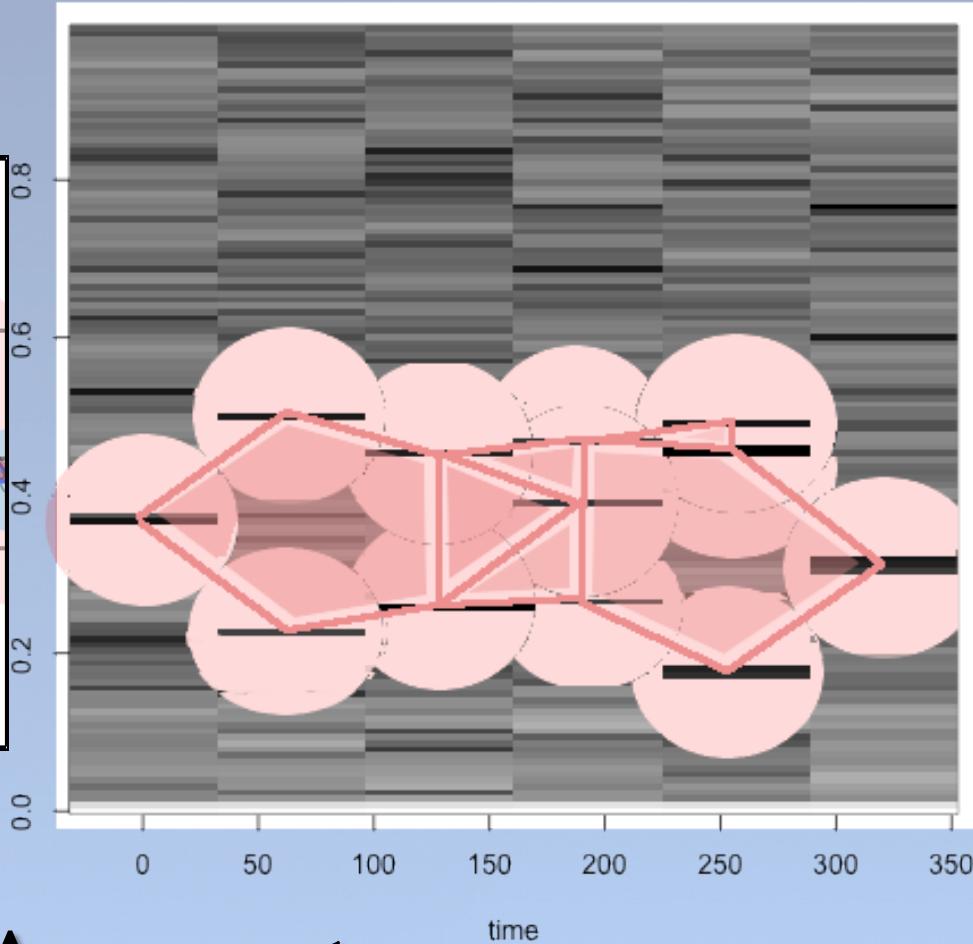
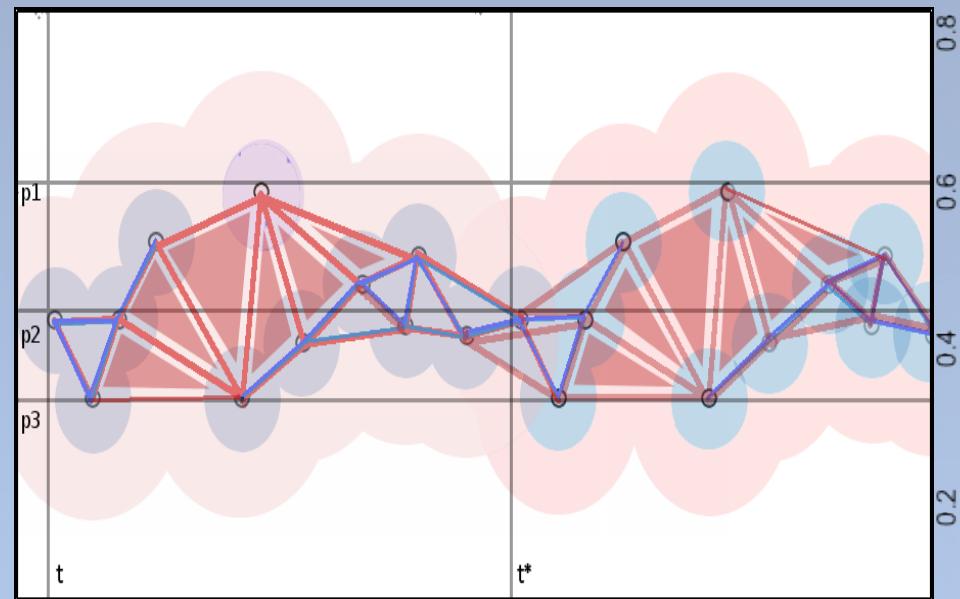
- Persistent Homology of chroma features.



Topological Aspects

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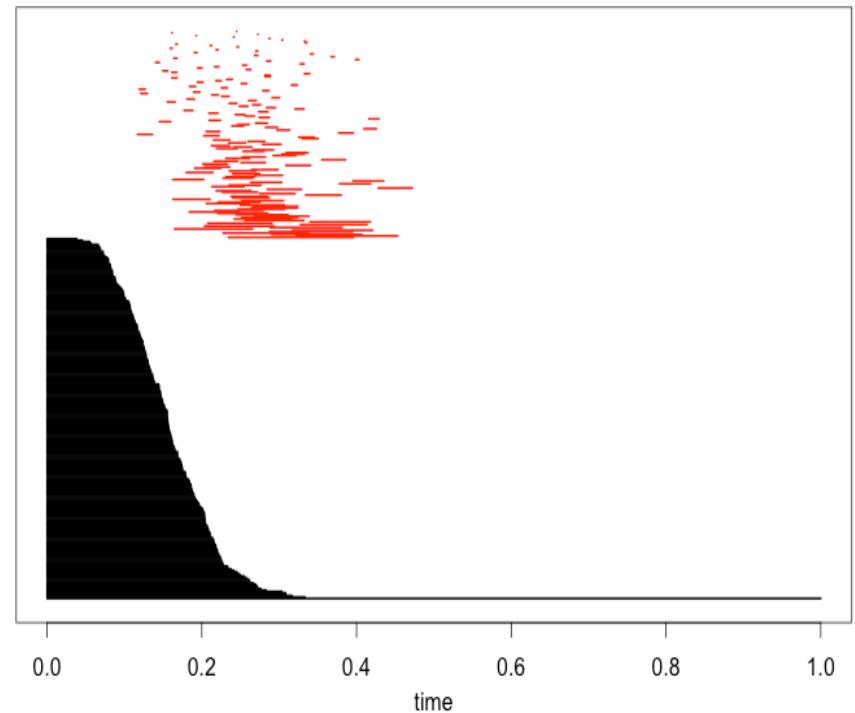
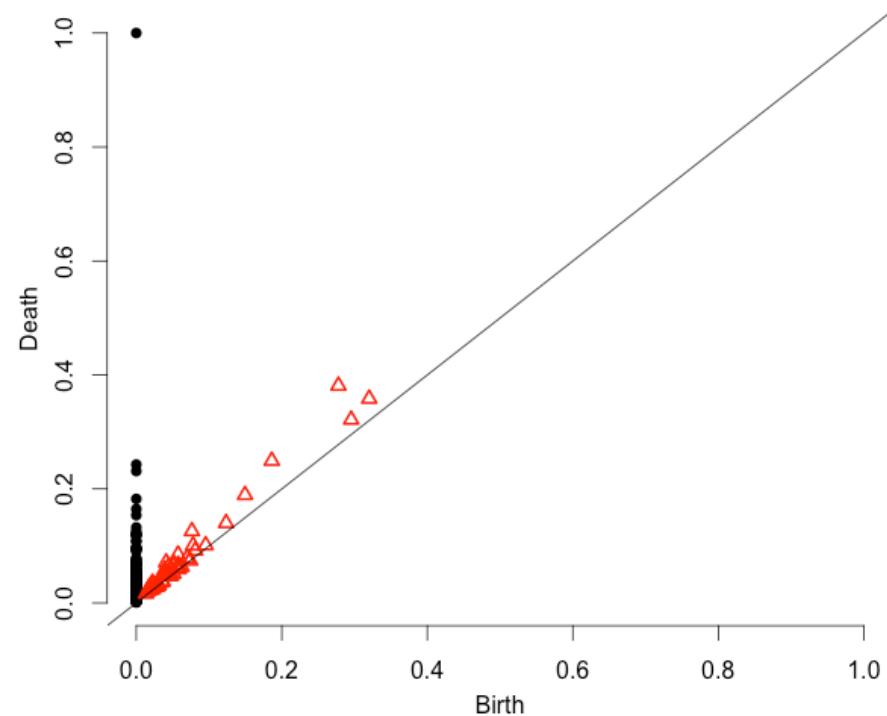
- Persistent Homology of chroma features.



Topological Aspects

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- Persistent Homology of Chroma Features.
 - Example: Preachin' by Son House



Topological Aspects

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- Based on **pair-wise Bottleneck distance matrix**.
- Cluster with **kMeans** and **kMedoid**.
- Visualisation via **multi-dimensional scaling**.

Classification via Clustering

"8 nearest songs to Government Fleet Blues song by Son House"

Track_id	Duration	Artist_name	Song_title
TRYCIVS12903C95AB5'	411.55873	'Son House'	'Government Fleet Blues'
TRAEEH128E0795DFE'	241.162	'Chris Rea'	'Driving Home For Christmas'
TRAAXPA128F92FC706'	215.35302	'Carlos Nu\xc3\xb1ez'	'Quiero Ir Ao Mar'
TRAASSO12903CDD2FF'	303.04608	'Ultraviolence'	'Murder Academy'
TRTMBEM128F427E66C'	224.70485	'Son House'	"Never Mind People Grinnin' In Your Face"
TRAABDL12903CAABBA'	226.35057	'Andy Andy'	'La Culpa'
TRAAPLS12903CB2D40'	243.1473	'Pascal Sangla'	'Une petite pause'
TRAACPE128F421C1B9'	342.56934	'Terry Callier'	'Do You Finally Need A Friend'
TRAUUMZ12903CA97DC'	158.56281	'Carl Doy with NZSO'	'The First Noel'

Results:
Nearest in Bottleneck Distance

"8 nearest songs to Government Fleet Blues song by Son House"			
Track_id	Duration	Artist_name	Song_title
'TRYCIVS12903C95ABS'	411.55873	'Son House'	'Government Fleet Blues'
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'TRAABDL12903CAABBA'	226.35057	'Andy Andy'	'La Culpa'
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'TRAAMUZ12903CA97DC'	158.56281	'Carl Doy with NZSO'	'The First Noel'

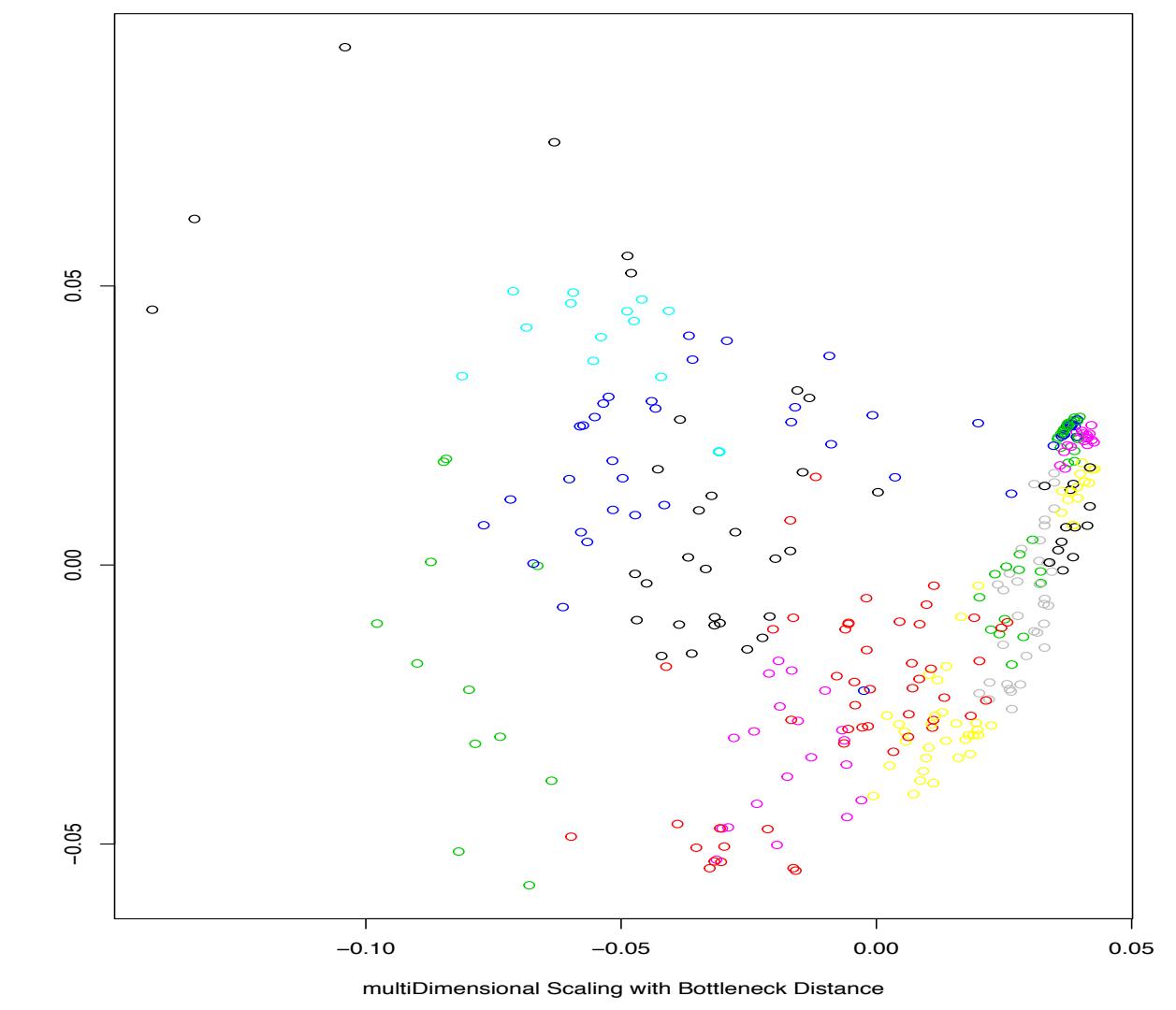
"13 nearest songs to Preachin' The Blues song by Son House"			
Track_id	Duration	Artist_name	Song_title
'TRYUOOZ128F427E839'	299.17995	'Son House'	"Preachin' The Blues"
'TRAAIRG128F93265E8'	184.31955	'DJ X-Change featuring DJ Joey A'	'Come Over'
'TRAAQPS128F429161D'	397.26975	'Bongzilla'	'Witch Weed (Live)'
'TRAAQIH128F428BDEA'	192.1824	'Busdriver'	'(Bloody Paw On The) Kill Floor'
'TRAAVIT128F92E657C'	301.06077	'Nightwish'	'Escapist'
'TRAAWGY128F4298A09'	182.09914	'Led Zeppelin'	'Poor Tom (Album Version)'
'TRYZZOJ128F1466CB7'	239.38567	'Son House'	'Death Letter Blues (Live)'
'TRAIAIE128F42AC53D'	261.95546	'Martina McBride'	"I Can't Stop Loving You"
'TRAASYO128F4263883'	315.27138	'Sir Neville Marriner'	'4 Sea Interludes Op. 33a: Storm'
'TRAAGKF128F932D5A2'	233.27302	'Smartbomb'	'Complicate It'
'TRAAVAH128F4284D7C'	234.65751	'RUN-DMC'	'Hard Times'
'TRAAAFD128F92F423A'	209.60608	'Gob'	'Face the Ashes'
'TRTOAOZ128F42760C0'	237.5571	'Son House'	"It's So Hard"
'TRAABNV128F425CEE1'	228.5971	'Richard Souther'	'High Tide'

Results:

Nearest in Bottleneck Distance

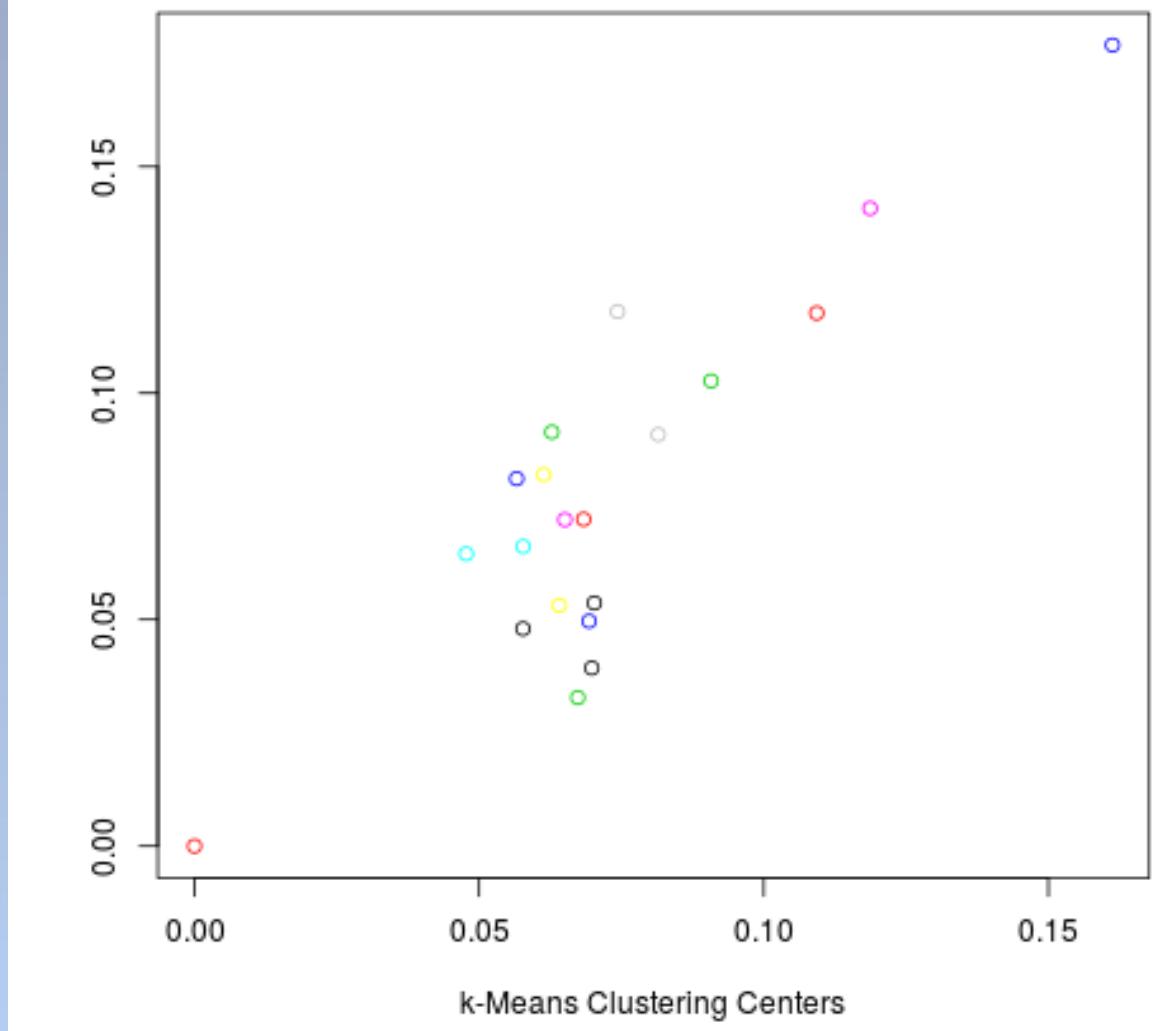
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Results: Multi-Dimensional Scaling and kMeans Clustering



Results: kMeans Clustering Centers

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"6 nearest songs within a Kmean cluster"			
Track_id	Duration	Artist_name	Song_title
'TRAAGXN128F92DE52C'	206.75873	'The Dirty Skirts'	'Wake'
'TRAALHD12903D0BD6A'	230.00771	'Eddie'	'No Control'
'TRAAIAN12903cff16d'	176.27383	'Horace Andy'	'Thank You Lord'
'TRAAIFG12903CB0BCB'	171.49342	'Richard Burton'	'I See The Boys Of Summer'
'TRAACHN128F1489601'	225.09669	'Five Bolt Main'	'Made Like This (Live)'
'TRAANLO128F422AE37'	321.35791	'Cradle Of Filth'	'Summer Dying Fast'

- Issues:
 - Results similar genre but potentially coincidince.
 - Cluster centers change every time clustering performed.
- Solution:
 - kMedoid Clustering- more robust outliers.

Results:

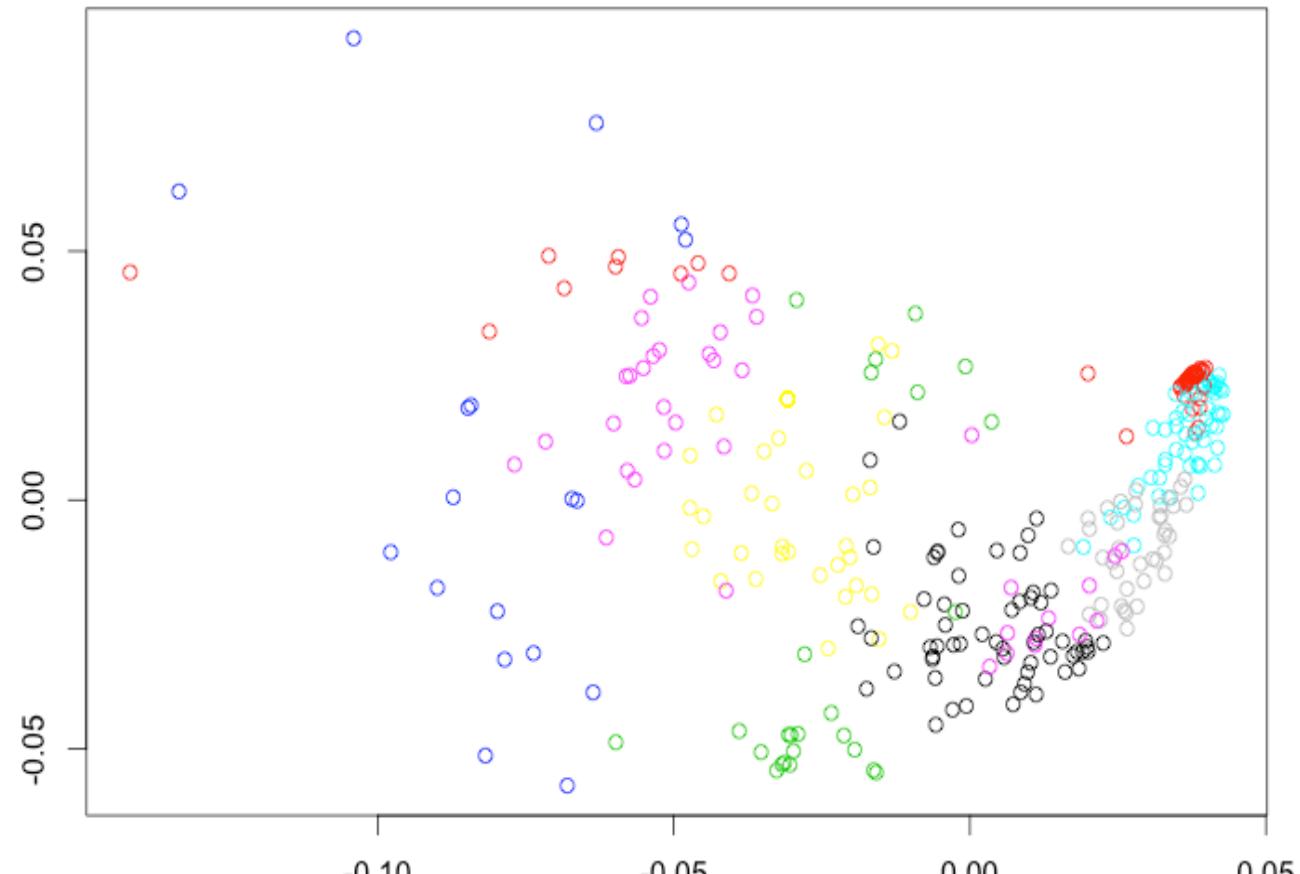
kMeans cluster example

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Results

Multi-Dimensional Scaling and kMedoid Clustering

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"6 nearest songs within a kmedoid cluster"

Track_id	Duration	Artist_name	Song_title
'TRAABRB128F9306DD5'	599.24853	'Faiz Ali Faiz'	'Sohna Nee Sohna Data'
'TRAAYPG128F933C941'	465.60608	'JDS'	'Nine Ways'
'TRAALEO128F42A7AEA'	570.90567	'Sven Tasnadi'	'2190 Dias Contigo'
'TRAAKVD12903CE8474'	525.16526	'Dolce; Oscar G.'	'Fire (Oscar G Space Vocal Mix)'
'TRAAORY128F934984F'	557.26975	'Sven Tasnadi'	'Charisma'
'TRAADHS12903CE70A9'	456.30649	'Jacob Young'	'In A Subtle Way'

- Identified songs by same artist despite songs having been randomly chosen from 1,000,000 songs.
- Let's listen.

Results

Multi-Dimensional Scaling and kMedoid Clustering

- **Apply p-Wasserstein Metric:**
 - kMedoid showed sensitivity to outliers, maybe P-Wasserstein better since sensitive to details of bijection between corresponding points of persistence diagram.
- Introduce **cut off for intesity** with chroma features.
- Use **true pitch composition** instead of chroma features since in order to **capture inversion**.
- **Train** on fundamental chords, chord progressions, time signatures, and introduce timbre.

Future Directions

- “Thierry Bertin-Mahieux, Daniel P.W. Ellis, Brian Whitman, and Paul Lamere. The Million Song Dataset. In Proceedings of the 12th International Society for Music Information Retrieval Conference (ISMIR 2011), 2011.”
- Edelsbrunner, Herbert, and John Harer. *Computational topology: an introduction*. American Mathematical Soc., 2010.

References

Questions

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