

Digital Musicology 2022
Tutorials

Assignment 3: Similarity

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Deliverables

- Due date: 04.05, 12h
- Deliverables:
 - **Code:** A Jupyter Notebook
 - **Report:** A short report (max. 2 pages) as a Word document or other text file
- Submission:
 - Store your data, code and report in your group's private GitHub repository (shared with the team members and the TAs). Make sure your notebook is pushed with all output visible, i.e., in a form whereby we do not need to run the code.

The corpus

- Symbolic encoding (.mscz) of 366 chorales by J. S. Bach (1685-1750)
- Files are numbered according to the Riemenschneider catalogue. Inside each file, you also find the corresponding Bach Werke Verzeichnis (BWV) numbering as well as the incipit of the text
- 4-part vocal writing
 - one staff per voice, ordered by register from top to bottom: Soprano, Alto, Tenor, Bass
- “Chorale melody” in the upper voice
- Roughly homorhythmic texture
- Segmentation marked by fermatas

The dataset

- Scores are parsed into a .csv list of notes
- For the purpose of the task, only consider the incipits of the chorales:
 - If the first fermata occurs before the 4th bar, consider until the second fermata
 - If the first fermata occurs in or after the 4th bar, consider until the first fermata
- The entire chorales are still available (e.g., for detecting statistical regularities in the style etc.)

Fermatas

Was betrübst du dich, mein Herze

The image shows a musical score for a piece titled "Was betrübst du dich, mein Herze". The score is written for four staves. The first staff (treble clef) has a fermata (a curved line with a dot) over a note, which is highlighted with a red rectangular box. The other staves (treble and bass clefs) show various musical notations including eighth and sixteenth notes, rests, and accidentals.

n	piece	mn	mn_onset	timesig	act_dur	staff	voice	duration	nominal_duration	scalar	tied	tpc	midi	gracenote	fermata
34	BachChorales/Chorale237	2	1/4	4/4	1	1	1	1/8	1/8	1	NaN	3	69	NaN	False
35	BachChorales/Chorale237	2	3/8	4/4	1	3	1	1/8	1/8	1	NaN	-2	58	NaN	False
36	BachChorales/Chorale237	2	3/8	4/4	1	1	1	1/8	1/8	1	NaN	1	67	NaN	False
37	BachChorales/Chorale237	2	1/2	4/4	1	4	1	1/4	1/4	1	NaN	2	50	NaN	False
38	BachChorales/Chorale237	2	1/2	4/4	1	3	1	1/4	1/4	1	NaN	3	57	NaN	False
39	BachChorales/Chorale237	2	1/2	4/4	1	2	1	1/4	1/4	1	NaN	2	62	NaN	False
40	BachChorales/Chorale237	2	1/2	4/4	1	1	1	1/4	1/4	1	NaN	6	66	NaN	False
41	BachChorales/Chorale237	2	3/4	4/4	1	4	1	1/4	1/4	1	NaN	2	38	NaN	True
42	BachChorales/Chorale237	2	3/4	4/4	1	3	1	1/4	1/4	1	NaN	6	54	NaN	True
43	BachChorales/Chorale237	2	3/4	4/4	1	2	1	1/4	1/4	1	NaN	3	57	NaN	True
44	BachChorales/Chorale237	2	3/4	4/4	1	1	1	1/4	1/4	1	NaN	2	62	NaN	True

Rhythm

Christ ist erstanden

This musical score is for the hymn 'Christ ist erstanden' in 4/4 time. It features four staves: two vocal staves (Soprano and Alto) and two piano accompaniment staves (Right and Left Hand). The key signature has one sharp (F#). The melody is primarily in the Soprano voice, with the piano accompaniment providing harmonic support. The lyrics are written above the vocal staves.

Meine Seel erhebt den Herren

This musical score is for the hymn 'Meine Seel erhebt den Herren' in 4/4 time. It features four staves: two vocal staves (Soprano and Alto) and two piano accompaniment staves (Right and Left Hand). The key signature has one sharp (F#). The melody is primarily in the Soprano voice, with the piano accompaniment providing harmonic support. The lyrics are written above the vocal staves.

Task

This assignment focuses on quantifying the similarity between musical excerpts: specifically, between the incipits of Bach chorales.

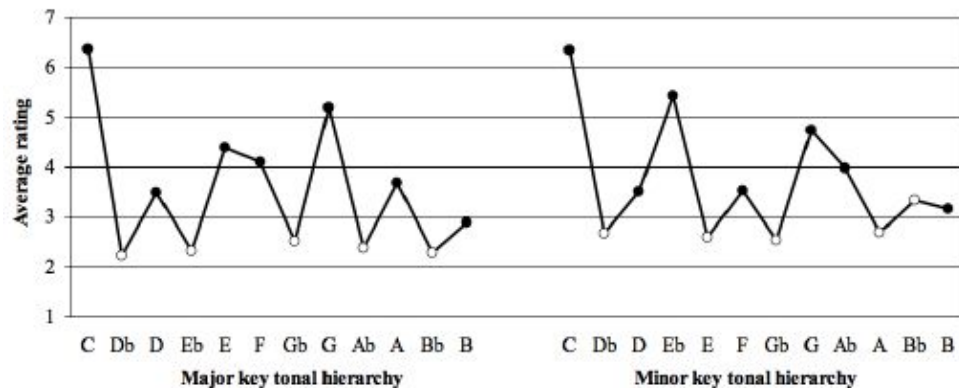
- (A) Start with a qualitative exploration of the data: e.g., listen to nn. 221, 300, 332 and try to identify salient similarities and differences
- (B) Implement a measure of musical similarity for each of the following parameters:
 - Melody and melodic contour
 - Rhythm
 - Harmonic content
 - ...

The proposed measures should aim at reflecting the similarity between two musical excerpts as it is subjectively experienced.

(C) Evaluate your proposed measures by giving examples of excerpts that are predicted to be similar/dissimilar, and explaining in what ways the measure does or does not match your subjective experience.

- Which one of these measure captures your hearing the best?
- Reflect on what is missing, and whether/how you could combine these measures to create a “compound” measure that reflects your intuition better

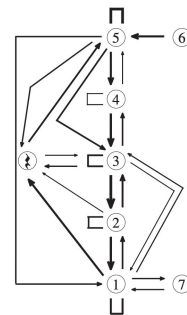
The role of temporality



“STATIC”

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
		C.E.G	D.G.B	C.F.A	C.E.A	D.F.A	D.F.G.B	D.F#.A	E.G.B	C.D.F#.A	E.G#.B	C.D.F.A	C.E.G.A	D.F.B	C#.E.A	C.D.G	
1	C.E.G	71	6.37	5.79	4.13	1.68	1.15	0.84	0.48	0.29	0.54	0.15	0.88	0.24	0.37	0.11	0.63
2	D.G.B	61	8.98	2.26	0.63	1.28	0.51	0.51	0.56	0.55	0.25	0.34	.	0.38	0.01	0.04	.
3	C.F.A	52	3.04	1.22	0.70	0.26	0.56	0.50	0.14	0.23	0.11	0.05	0.11	0.06	0.40	0.02	0.07
4	C.E.A	53	0.92	1.38	0.56	0.85	0.63	0.16	0.34	0.55	0.44	0.29	0.43	0.07	0.12	0.05	0.01
5	D.F.A	53	0.99	0.81	0.09	0.50	0.43	0.44	0.03	0.26	0.04	0.26	0.04	.	0.04	0.37	.
6	D.F.G.B	26	2.56	0.09	0.07	0.15	0.04	0.05	.	0.04	.	0.01	0.04	.	0.02	.	.
7	D.F#.A	22	0.11	1.69	.	0.04	.	0.04	0.08	0.04	0.11	0.06	.	.	0.01	0.01	.
8	E.G.B	28	0.35	0.18	0.63	0.42	0.11	0.09	0.04	0.11	0.02	0.03	0.01	0.33	0.09	0.02	.
9	C.D.F#.A	25	0.05	1.04	.	0.06	.	0.01	0.04	0.07	0.01	0.04	.	.	.	.	0.04
10	E.G#.B	18	0.02	.	0.20	1.06	0.03	.	.	0.02	.	0.09	.	0.01	.	0.04	.
11	C.D.F.A	18	0.11	1.12	0.02	0.01	0.04	0.04	.	0.02	.	0.05	.	.	0.01	.	0.04
12	C.E.G.A	19	0.04	0.09	0.08	0.03	0.12	0.04	0.47	.	0.09	.	.	0.01	0.04	.	0.04
13	D.F.B	23	0.80	0.02	0.03	0.04	0.01	0.05	.	0.04	.	0.02	.	.	.	.	.
14	C#.E.A	25	0.08	0.04	0.01	0.12	0.46	.	0.04	0.03	0.03	0.01	.	.	0.10	.	.
15	C.D.G	10	.	0.67	.	0.01	.	0.19	0.01	.	.	.	.	0.01	.	.	0.01

$$p(e_i | e_{i-1}) = \frac{\text{count}(e_{i-1}^i)}{\text{count}(e_{i-1})}$$



“DYNAMIC”

Melody

Transformations and invariances



EDIT DISTANCE (note-by-note): 10

EDIT DISTANCE (inversion): 4

?

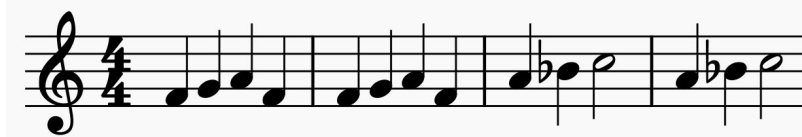
■



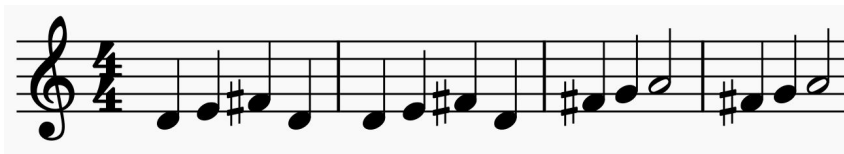
EDIT DISTANCE (note-by-note): 14

EDIT DISTANCE (intervals): 0

?



Transformations and invariances



EDIT DISTANCE (note-by-note): 10

EDIT DISTANCE (inversion): 4



EDIT DISTANCE (note-by-note): 14

EDIT DISTANCE (intervals): 0

?

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Steps vs. jumps

Warum betrübst du dich, mein Herz

300

Den Vater dort oben

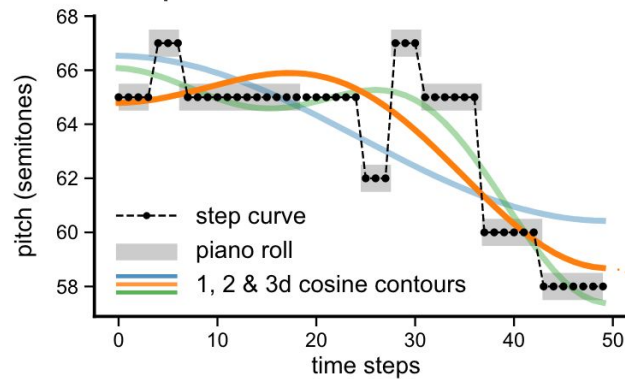
239

Contour

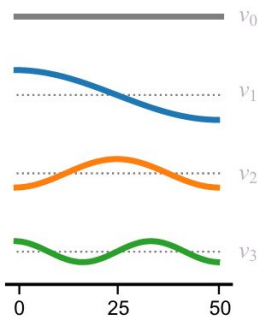
A. Melody



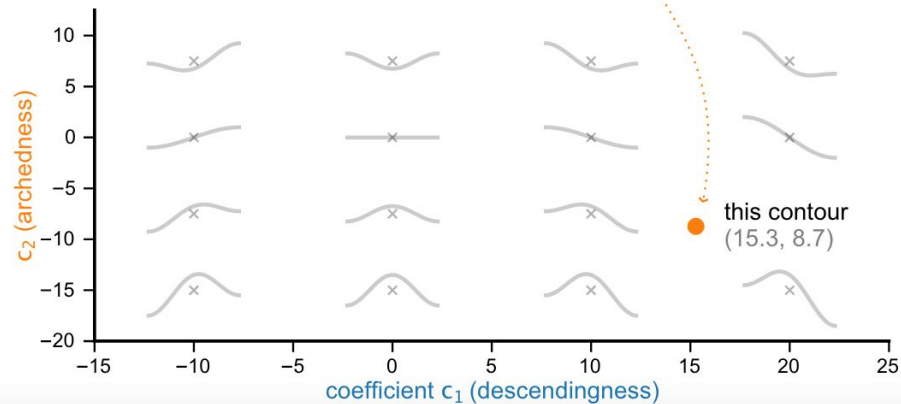
B. Step curve and cosine contours



C. Basis functions



D. Cosine contour space



Rhythm

Rhythm and texture

185

Nun freut euch, Gottes Kinder all

The image displays a musical score for the hymn "Nun freut euch, Gottes Kinder all". The score is written in 4/4 time and consists of four staves. The first two staves are vocal parts, and the last two are instrumental parts. The key signature is one sharp (F#), and the time signature is 4/4. The melody is simple and joyful, with a mix of quarter, eighth, and dotted notes. The instrumental parts provide a harmonic accompaniment, with the bass line featuring some eighth-note patterns. The score is presented in a clean, black-and-white format.

Harmony

Harmonic content

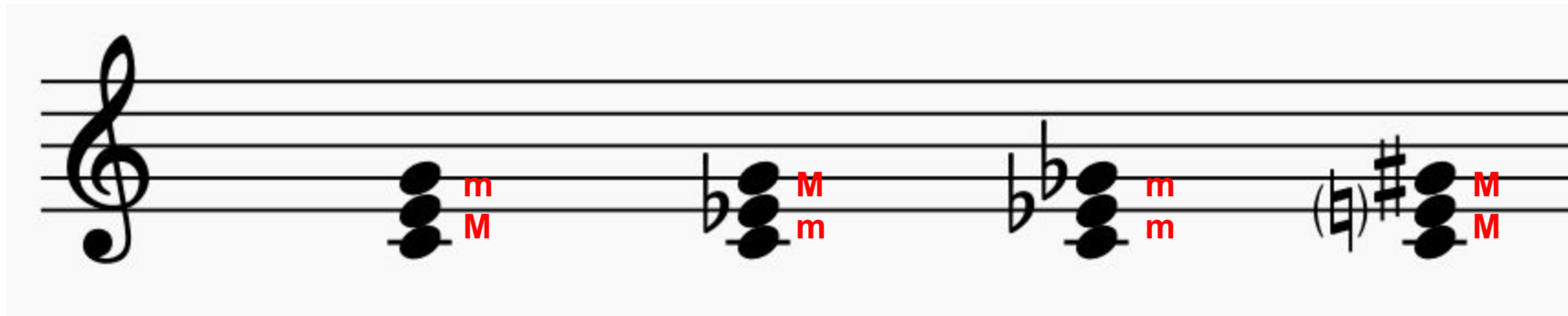


Chords

- The prototype of a chord in Western tonality is the (root-position) triad:
 - Stacked (major or minor) thirds above a root
 - 4 types (M, m, +, o) x 12 roots = 48 root position triads

Triads

<http://musictheory.pugetsound.edu/mt21c/TriadsIntroduction.html>



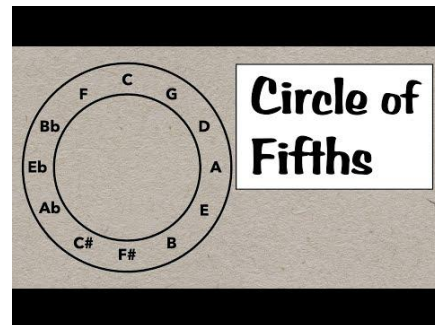
Major (M)

minor (m)

diminished (o)

Augmented (+)

Chords



- The prototype of a chord in Western tonality is the (root-position) triad:
 - Stacked (major or minor) thirds above a root
 - 4 types (M, m, +, o) x 12 roots = 48 root position triads
 - Music is creative/messy: chords may contain additional (e.g., sevenths) and/or extraneous notes!
- “Distance” between chords:
 - Distance between the roots (in fifths)
 - Number of common tones
 - “Voice-leading” distance: total distance required to match the second chord by moving the notes of the first chord by the minimal amount of semitones
 - ...
- Consonance/Dissonance

Consonance/Dissonance

Consonances

Perfect

- Unison and octave
- Fifth (ratio of 3:2)
- **Fourth**

Imperfect

- Third (major and minor)
- Sixth (major and minor)

Dissonances

- Second (major and minor)
- Seventh (major and minor)

- The tritone (ratio of 45:32!)
 - Augmented fourth or diminished fifth
 - *Diabolus in musica* (!)

Chords as interval vectors

The image illustrates the concept of chords as interval vectors. On the left, a musical score in 4/4 time shows a D minor chord (D-F-A) across four staves. The first two staves (treble clef) contain the notes D4 and F4, and the last two staves (bass clef) contain the notes D3 and A3. To the right of the score, a series of vertical brackets represent the intervals between the notes, ordered from smallest to largest: P5 (between D3 and A3), P8/P1 (between D3 and D4), m3 (between D4 and F4), P4 (between F4 and A3), m6 (between A3 and D4), and m3 (between A3 and F4).

Interval Vector: P5, P8/P1, m3, P4, m6, m3

Interval vs. interval class

Smallest interval between PC a and PC b (irrespective of direction)

$$IC(a,b) = \min\{I(a,b), I(b,a)\}$$

P1/P8 → 0

m2/M7 → 1

M2/m7 → 2

m3/M6 → 3

M3/m6 → 4

P4/P5 → 5

4+/5° → 6



IC	1	2	3	4	5	6
#	0	0	2	1	2	0

Pitch-class sets

- Chords as sets of pitch-classes
- Reduce redundancy: ignore repeated notes, reduce to “normal form”
- <https://musictheory.pugetsound.edu/mt21c/IntervalVector.html>