

Digital Musicology 2022
Tutorials

Assignment 1: Meter and time signatures

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Deliverables

- Due date: 23.03, 12h
- Deliverables:
 - **Code:** A Jupyter Notebook
 - **Report:** A short report (max. 2 pages) as a Word document or other text file
- Submission:
 - Each group should create a ****private**** GitHub repository (shared with the team members and the TAs) where data, code and report will be stored. Make sure your notebook is pushed with all output visible, i.e., in a form whereby we do not need to run the code.

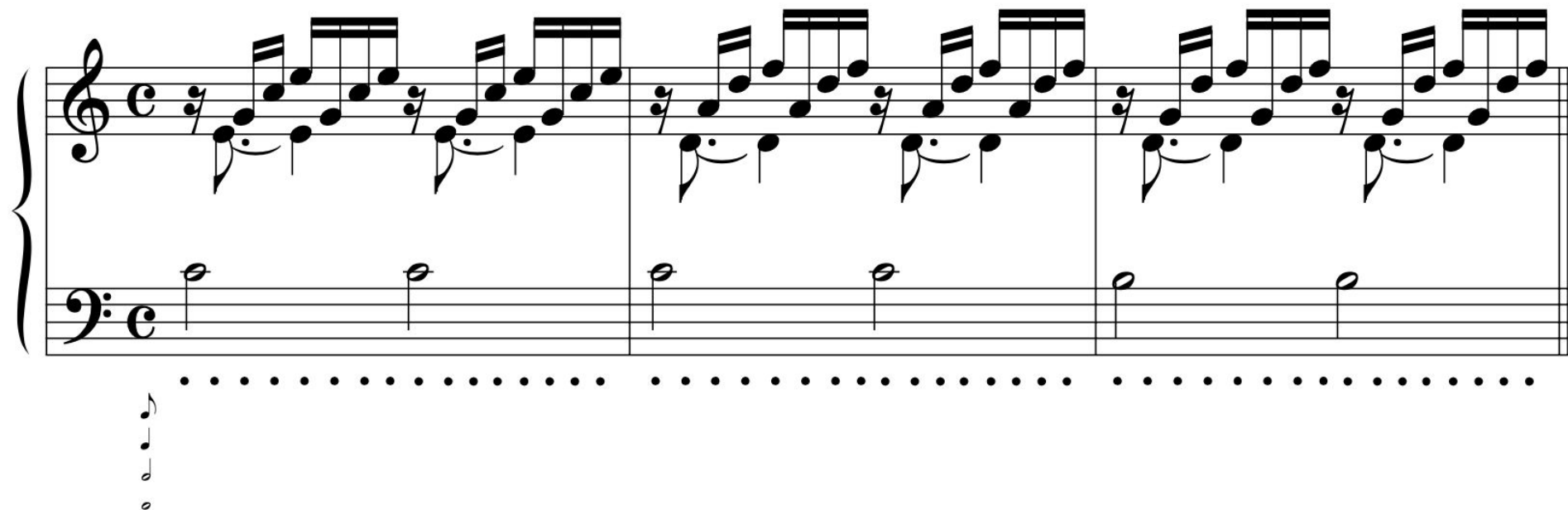
Since this is the first assignment, please make sure to share access to your repository with the TAs (GitHub handles: `GabrieleCecchetti` and `yrammos`) and to send the link by email (gabriele.cecchetti@epfl.ch) at any time before the deadline.

Task

The task for this assignment is to implement a data-driven approach to infer the time signatures from a dataset of symbolically-encoded music. Note that the ground-truth is included in the dataset and can be useful for implementing a supervised classification approach, as well as to evaluate the outcomes.

Try to quantify statistically the effectiveness of the classification. Is the classification equally confident with all pieces? In the report, try to motivate the approach you adopted, discuss why it resulted in the observed outcome (e.g., why did it fail on some specific pieces, or why did it work 100% of the time, or why did it work very poorly), and how it could be improved/generalized.

Meter is about periodicities



Meter is about periodicities

The image displays a musical score on a grand staff (treble and bass clefs) in common time (C). The melody in the treble clef consists of eighth-note patterns, while the bass clef provides a simple harmonic accompaniment with quarter notes. Below the staff, a series of dots represents the temporal positions of the notes, illustrating the periodic nature of the meter. A vertical line of dots on the left side of the staff indicates the starting point of the first measure.

The musical score is written on a grand staff with a treble clef and a bass clef. The time signature is common time (C). The melody in the treble clef consists of eighth-note patterns, while the bass clef provides a simple harmonic accompaniment with quarter notes. Below the staff, a series of dots represents the temporal positions of the notes, illustrating the periodic nature of the meter. A vertical line of dots on the left side of the staff indicates the starting point of the first measure.

Meter is about periodicities

The image displays a musical score and a corresponding dot grid illustrating the concept of meter as periodicity.

Top Staff (Treble Clef): The music is in common time (C). It features a repeating rhythmic pattern of eighth notes, with some measures containing beamed eighth notes. The melody is divided into three measures by vertical bar lines.

Bottom Staff (Bass Clef): The music is in common time (C). It features a simple harmonic accompaniment consisting of quarter notes, also divided into three measures by vertical bar lines.

Dot Grid: Below the staves is a grid of dots representing a timeline. The grid is organized into three measures, each containing 16 dots. The first measure has a musical note (a quarter note) at the first dot. The second and third measures also have musical notes at the first dot. The dots are arranged in a way that highlights the periodicity of the meter, with vertical bar lines separating the measures.

Meter is about periodicities

The image displays a musical score and a corresponding rhythmic diagram. The musical score is written for piano, featuring a treble and bass staff. The time signature is common time (C). The treble staff contains a complex melody with eighth and sixteenth notes, while the bass staff provides a simple harmonic accompaniment with quarter notes. The score is divided into three measures. Below the musical notation, a rhythmic diagram uses a series of dots to represent the timing of the notes. The dots are arranged in a grid-like pattern, with vertical lines indicating the onset of notes. The diagram illustrates the periodic nature of the meter, showing how the timing of notes repeats across measures.

Meter is about periodicities

The image displays a musical score and its corresponding Braille representation, illustrating the concept of meter as periodicity.

Top Staff (Treble Clef): The melody consists of eighth and sixteenth notes, grouped in measures of three. The first measure contains two eighth notes followed by a sixteenth note. The second measure contains a quarter note followed by two eighth notes. The third measure contains a quarter note followed by two eighth notes. This pattern repeats across the staff.

Bottom Staff (Bass Clef): The bass line consists of quarter notes, one per measure, representing the harmonic foundation.

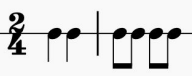

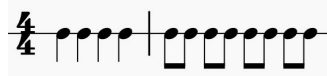
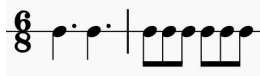
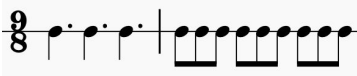
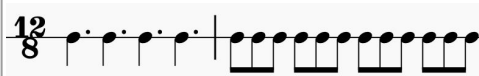
Braille Representation: Below the staves, the musical notation is represented in Braille. The first staff of Braille shows the treble clef and the melody, while the second staff shows the bass clef and the bass line. The Braille notation uses standard musical symbols (clefs, notes, rests) to represent the musical score.

Meter is about (hierarchically nested) periodicities

- The beat is a periodic pattern
- The bar is a repeating group of beats (duple/triple/quadruple):
 - ⇒ The bar is a periodic structure whose period is a multiple of the period of the beat
- The periodicity of the beat can be subdivided in two (simple) or three (compound) parts:
 - ⇒ The subdivision of the beat is also a periodic structure, whose period is a sub-multiple of the period of the beat
- Bars can also be grouped into groups of bars (hypermeter)
 - ⇒ Repeating groups of bar are also a periodic structure, whose period is a multiple of the period of the bar

Types of meter

- Type of beat: are beats subdivided in two (simple) or three (compound) parts?
⇒ ! Bars can also contain both types of beats: these are called “odd meters” (e.g., 5/8) !
- Quantity of beats: how many beats per bar? (duple/triple/quadruple)

SIMPLE	2 	3 	4 
	6 	9 	12 
COMPOUND			
	DUPLE	TRIPLE	QUADRUPLE

Time signatures and metrical grid: 3/4

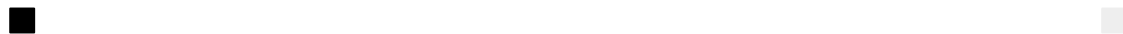
SUBDIVISION OF
THE BEAT



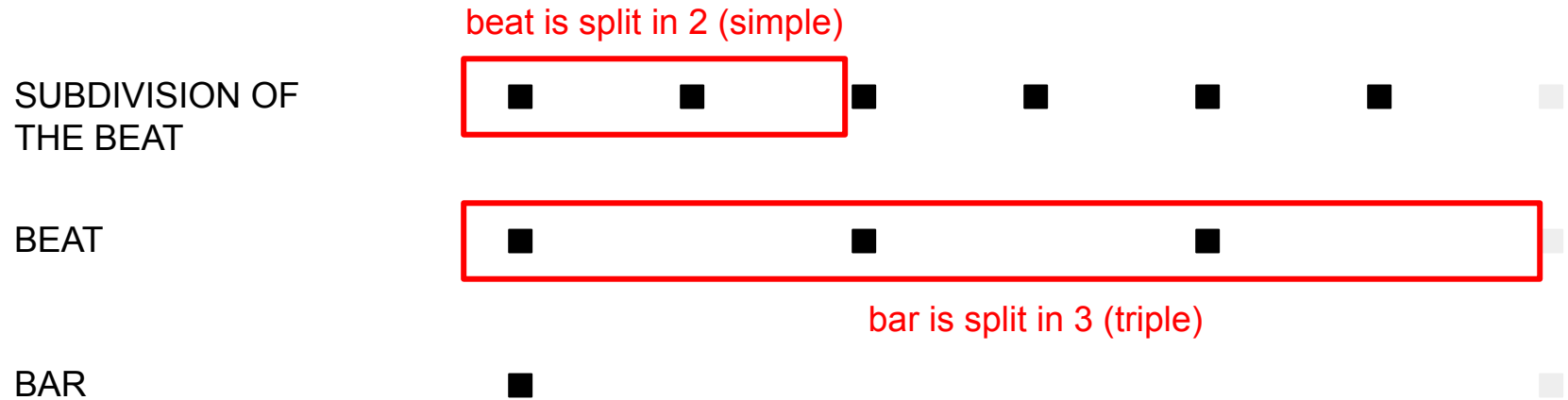
BEAT



BAR



Time signatures and metrical grid: 3/4



Time signatures and metrical grid: 6/8

SUBDIVISION OF
THE BEAT



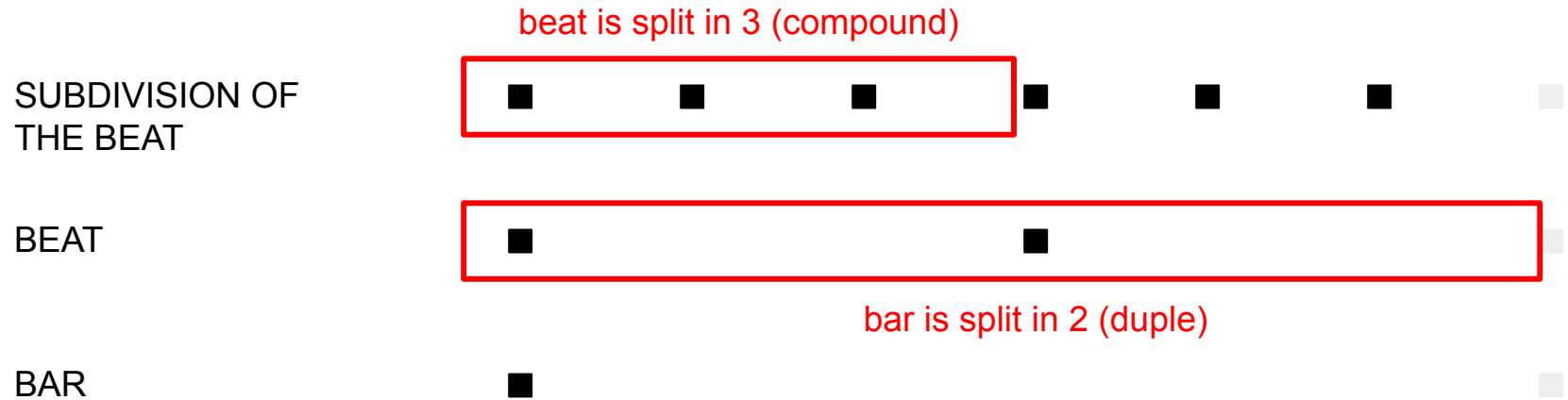
BEAT



BAR



Time signatures and metrical grid: 6/8



Time signatures and metrical grid: 4/4

SUBDIVISION OF
THE BEAT



BEAT



BAR



Time signatures and metrical grid: 4/4

SUBDIVISION OF
THE BEAT



BEAT

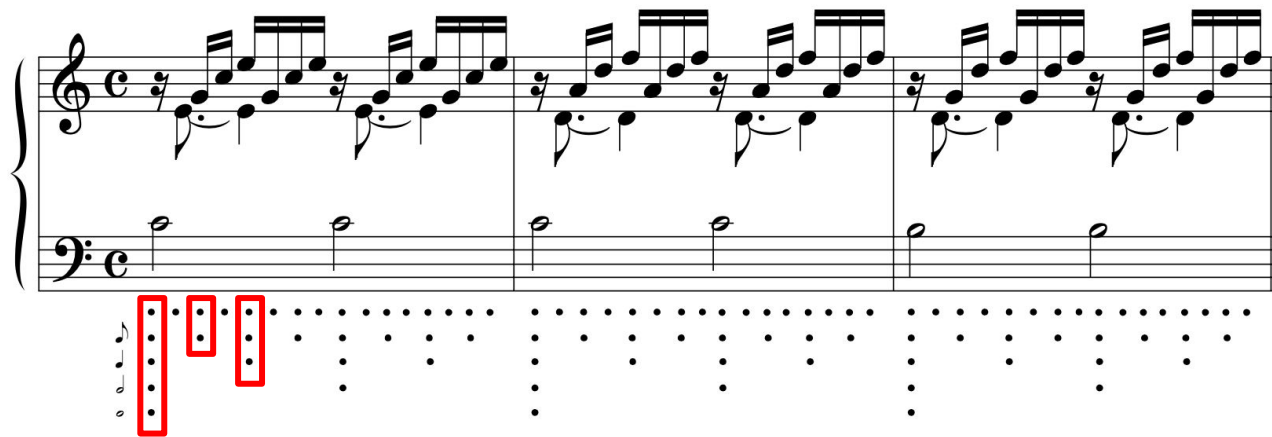


BAR



Meter is about weight (accent)

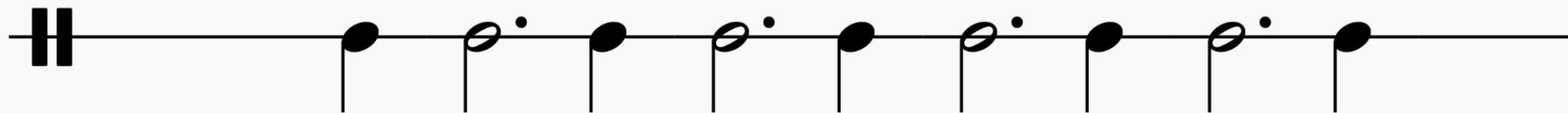
- Points in time where many periodicities overlap have stronger **metrical weight** (accent)



Meter is about weight (accent)

- Points in time where many periodicities overlap have stronger **metrical weight** (accent)
- This weight is construed by the mind of the listener or introduced explicitly in the performance...
- however, traces of the metrical weight can often be recognized in the score

Meter is about weight



Meter is about weight

- Longer IOIs/durations are more likely to be associated with stronger metrical beats

$$w(t) \sim \sum_{n | onset(n)=t} d(n)$$

- Different metrical grids might favour certain patterns of IOI/durations

(Some) possible approaches

- Extract particularly common rhythmic patterns and consider the distribution across different time signatures
 - ⇒ Are some rhythmic patterns particularly distinctive of a certain time signature?
- Estimate the metrical grid (e.g., through the sum/average durations for each onset) and compare the metrical grid among pieces
 - ⇒ (Unsupervised) clustering: which pieces have more similar metrical grids? Do the clusters correspond to the ground-truth?
- Estimate the metrical grid and “extract” the most salient periodicities (e.g., through autocorrelation or DFT)
 - ⇒ (Supervised) classification: what periodicities are more informative to infer the time signatures?



- How are you going to deal with ties and gracenotes?
- Are you going to bin the onsets or use them as they occur in the music?
- Are you dealing with staves and voices jointly or separately?

From the score
to the dataset

The score

Agogic

Adagio

A musical score for piano, consisting of a grand staff with a treble and bass clef. The key signature is B-flat major (two flats) and the time signature is 3/4. The tempo marking "Adagio" is written in a red box above the treble staff, with a red arrow pointing to it from the word "Agogic" written in red above the staff. The score is divided into three measures. The first measure begins with a forte dynamic marking (*f*). The melody in the treble staff features eighth and sixteenth notes with slurs, while the bass staff provides a harmonic accompaniment with chords and single notes. The second measure continues the melodic and harmonic development. The third measure concludes with a trill (tr) on a note in the treble staff. The overall mood is slow and expressive, characteristic of the Adagio tempo.

The score

Adagio

The image shows a musical score for piano. The tempo is marked 'Adagio'. The time signature is 3/4, which is highlighted by a red box and a red arrow pointing to it with the label 'Time signature'. The score consists of two staves, treble and bass clef. The key signature has three flats (B-flat, E-flat, A-flat). The first measure of the treble staff starts with a forte dynamic 'f'. The piece ends with a trill 'tr' on the final note of the treble staff.

Time signature

The score



Clefs

The score

Adagio

A musical score for piano, marked 'Adagio'. The score is written for two staves: a treble staff and a bass staff. The key signature is E-flat major, indicated by two flat symbols (B-flat and E-flat) at the beginning of each staff. The time signature is common time (C). The tempo 'Adagio' is written above the treble staff. The first measure of the treble staff is highlighted with a red box, and a red arrow points from the text 'Key signature' below to this box. The first measure of the bass staff is also highlighted with a red box. The score consists of four measures. The first measure of the treble staff starts with a forte dynamic 'f'. The first measure of the bass staff starts with a piano dynamic 'p'. The score ends with a trill (tr) in the final measure of the treble staff.

Key signature

The score

Adagio

The image displays a musical score for piano, marked 'Adagio'. It consists of two staves: a treble staff and a bass staff. The treble staff begins with a treble clef, a key signature of two flats (B-flat and E-flat), and a common time signature (C). The bass staff begins with a bass clef, the same key signature, and a common time signature. The music is written in a flowing, melodic style with many slurs and ties. A red box highlights a specific note in the bass staff, which is a B-flat. A red arrow points from the word 'Accidental' to this box. The word 'tr' is visible at the end of the treble staff, indicating a trill.

Accidental

The score

Adagio

The image shows a musical score for piano, marked 'Adagio'. The score is written for two staves: a treble staff (right hand) and a bass staff (left hand). The key signature is three flats (B-flat, E-flat, A-flat), and the time signature is common time (C). The left hand begins with a forte (*f*) dynamic marking, which is highlighted by a red box and a red arrow pointing to it from the word 'Dynamics'. The right hand features a melodic line with slurs and a trill ('tr') at the end. The left hand provides a harmonic accompaniment with chords and single notes.

f ← Dynamics

The score

Adagio

Slur

The image displays a musical score for piano, marked 'Adagio'. The score is written for two staves: a treble staff and a bass staff. The key signature is three flats (B-flat, E-flat, A-flat), and the time signature is common time (C). The tempo 'Adagio' is indicated above the treble staff. A red box highlights a slur over a group of notes in the treble staff, with a red arrow pointing to it from the word 'Slur'. The first measure of the treble staff begins with a forte dynamic marking 'f'. The score consists of four measures. The first measure shows a melodic line in the treble staff and a supporting bass line in the bass staff. The second measure continues the melodic line. The third measure features a trill (tr) in the treble staff. The fourth measure concludes the phrase. The bass staff provides harmonic support throughout, with some notes beamed together.

The score

Dot/Stroke
(staccato)

Adagio

The image displays a musical score for piano, marked 'Adagio'. The score is written for two staves: the upper staff in treble clef and the lower staff in bass clef. The key signature is three flats (B-flat, E-flat, A-flat), and the time signature is common time (C). The upper staff begins with a forte dynamic marking 'f'. A red box highlights a vertical stroke on a note in the upper staff, with a red arrow pointing to it from the text 'Dot/Stroke (staccato)'. The lower staff features a series of chords and single notes, some with accidentals. The score is divided into measures by vertical bar lines. The final note of the upper staff is marked with a trill 'tr'.

The score

Trill
(embellishment)

Adagio

The image shows a musical score for piano, marked 'Adagio'. The score is written for two staves: a right-hand staff (treble clef) and a left-hand staff (bass clef). The key signature is three flats (B-flat, E-flat, A-flat), and the time signature is common time (C). The right-hand staff begins with a forte dynamic marking 'f'. The melody in the right hand consists of eighth and sixteenth notes, some beamed together. In the final measure of the right-hand staff, there is a trill, indicated by the letters 'tr' in a red box. A red arrow points from the text 'Trill (embellishment)' to this box. The left-hand staff provides harmonic support with chords and single notes, including a half note in the final measure.

The score



Grace note

Adagio

A musical score for piano, marked 'Adagio'. The score is written on two staves: a treble staff and a bass staff. The key signature has two flats (B-flat and E-flat), and the time signature is common time (C). The treble staff begins with a forte dynamic marking 'f'. A red box highlights a grace note (a small eighth note) on the treble staff, with a red arrow pointing to it from the text 'Grace note'. The bass staff contains several chords and single notes, including a B-flat in the second measure. The score concludes with a trill marked 'tr' on the treble staff.

The score



Adagio

The image shows a musical score for piano, consisting of two staves. The top staff is in treble clef and the bottom staff is in bass clef. The key signature has two flats (B-flat and E-flat), and the time signature is common time (C). The tempo marking "Adagio" is written above the first measure of the top staff. The first measure of the top staff begins with a forte dynamic marking "f". The score is divided into measures by vertical bar lines. In the third measure of the bottom staff, a red rectangular box highlights a tie symbol (a horizontal line with a semi-circle) connecting two notes. A red arrow points from the word "Tie" to this box. The word "tr" is written above the final note of the top staff.

Tie

The score

Adagio

The image shows a musical score for piano, marked 'Adagio'. It consists of two staves. The upper staff is in treble clef and the lower staff is in bass clef. Both staves are in 3/4 time and have a key signature of two flats (B-flat and E-flat). The upper staff begins with a forte dynamic marking 'f'. The lower staff has a red line drawn across it, connecting the first four measures, indicating that these measures contain two voices in the same staff. The red line starts at the first measure, goes up to the second measure, down to the third measure, and up to the fourth measure. The notation includes various note values, rests, and a trill (tr) in the final measure of the upper staff.

two voices in the same
staff

From score to XML

Adagio .Eb.I{ V6 vi viio6/V

mp

```
<Chord>
  <dots>1</dots>
  <durationType>eighth</durationType>
  <Spanner type="Slur">
    <Slur>
      </Slur>
    <next>
      <location>
        <fractions>3/16</fractions>
      </location>
    </next>
  </Spanner>
  <Note>
    <pitch>70</pitch>
    <tpc>12</tpc>
  </Note>
</Chord>
<Chord>
  <durationType>16th</durationType>
  <Spanner type="Slur">
    <prev>
      <location>
        <fractions>-3/16</fractions>
      </location>
    </prev>
  </Spanner>
  <Note>
    <pitch>72</pitch>
    <tpc>14</tpc>
  </Note>
</Chord>
```

<https://github.com/DCMLab/DM2022Assignments>