

An Introduction to **Symbolic Music Processing** in Python with *partitura*

*Carlos Cancino-Chacón, Emmanouil Karystinaios,
Silvan David Peter, Francesco Foscari*

Tutorial Organization

- Introduction to symbolic music processing
 1. An introduction to the Partitura library
 2. Automatic alignment between performances and scores.
 3. Pitch spelling with Partitura.
 4. Transformer Based Beat Generator using Partitura.

Theoretical
presentation

Hands-on
tutorial

Symbolic Music

Symbolically encoded Music

(aka symbolic music)

The subset of **musical data types** that **explicitly represent**:

- Note pitches
- Note onsets and durations
- Voices
- Key signatures
- ...

Symbolically encoded Music

(aka symbolic music)

The subset of **musical data types** that **explicitly represent**:

- Note pitches
- Durations
- Onsets
- Voices
- Key signatures
- Metrical positions
- ...



Audio



Raster
Image

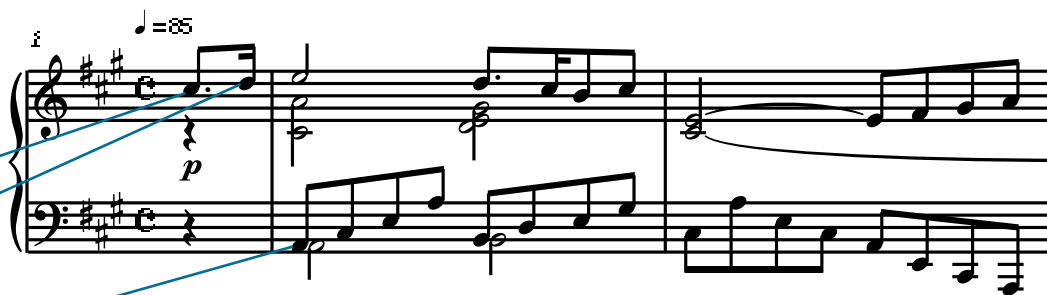
Musical Score

- Note pitches (pitch spelling)

- Durations
- Onsets
- Voices
- Key signatures
- Metrical positions
- ... C#

D

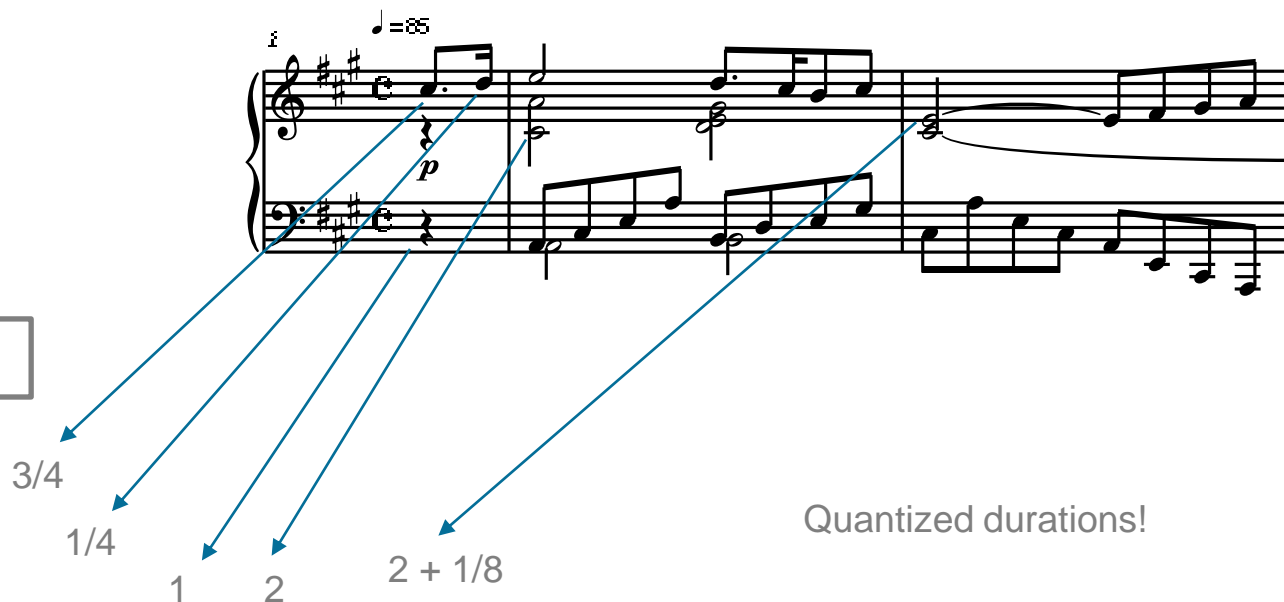
A



Musical Score

- Note pitches
- Durations
- Onsets
- Voices
- Key signatures
- Metrical positions
- ...

Musical units, e.g. 1 = 



The diagram shows a musical score for piano in D major (two sharps) and 3/4 time. The tempo is marked as ♩ = 85. The score consists of two staves. Blue arrows point from specific notes to duration labels below the staff:

- An arrow from the first quarter note in the right hand points to $3/4$.
- An arrow from the first quarter note in the left hand points to $1/4$.
- An arrow from the first eighth note in the right hand points to 1 .
- An arrow from the first eighth note in the left hand points to 2 .
- An arrow from the first quarter note in the right hand of the second measure points to $2 + 1/8$.

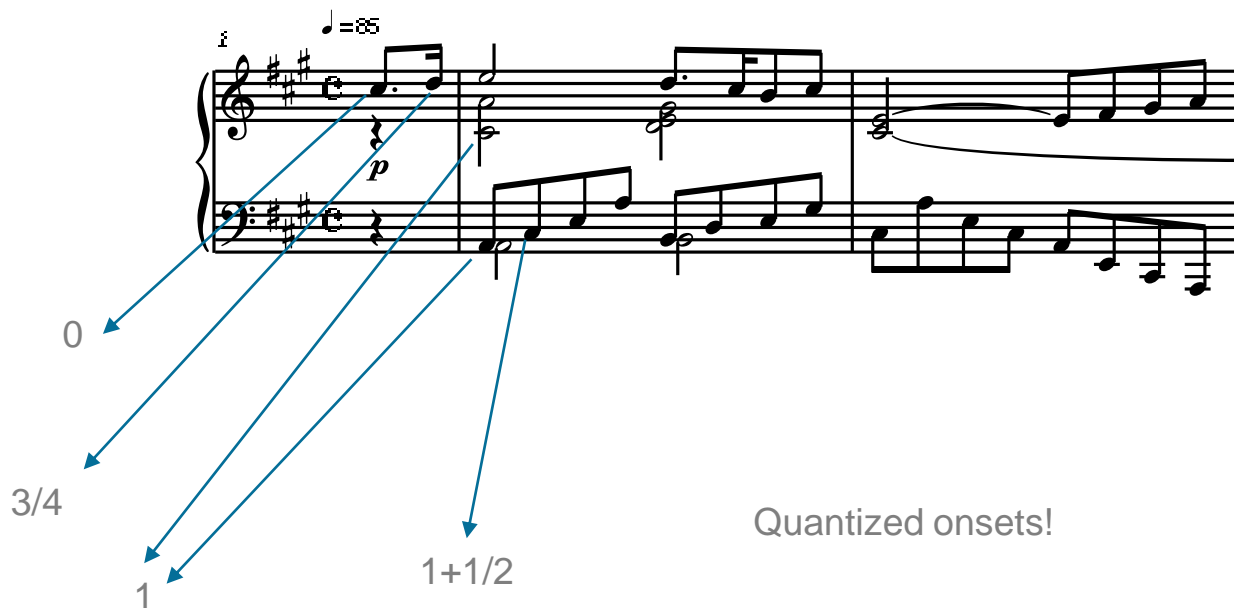
The text "Quantized durations!" is written to the right of the staff.

Musical Score

- Note pitches
- Durations
- Onsets
- Voices
- Key signatures
- Metrical positions
- ...

Musical units, e.g. 1 = 

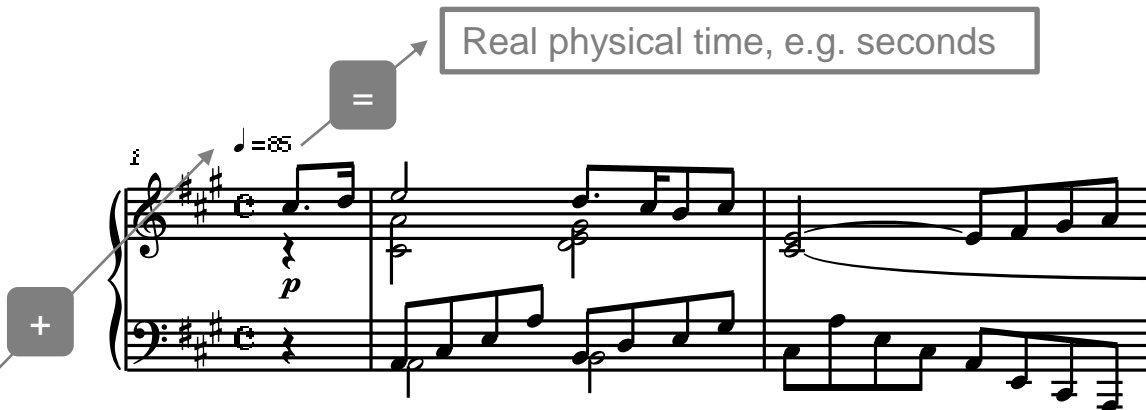
Cumulative duration of
previous events



Musical Score

- Note pitches
- Durations
- Onsets
- Voices
- Key signatures
- Metrical positions
- ...

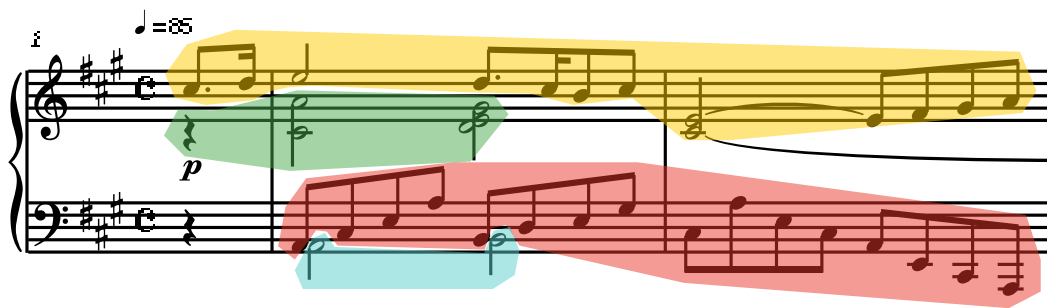
Musical units, e.g. 1 = ♩



Quantized temporal positions!

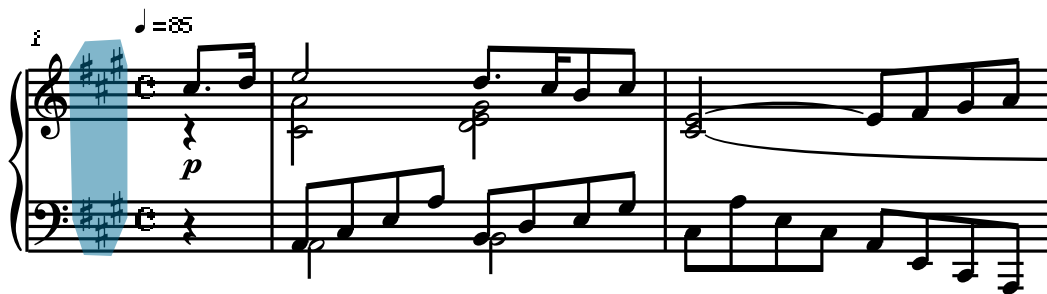
Musical Score

- Note pitches
- Durations
- Onsets
- **Voices**
- Key signatures
- Metrical positions
- ...



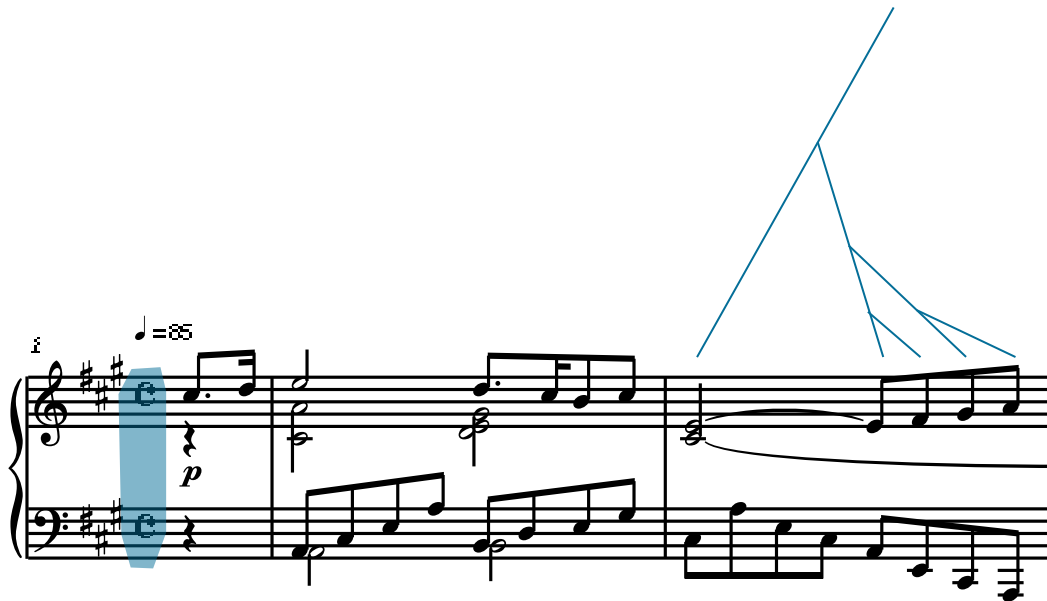
Musical Score

- Note pitches
- Durations
- Onsets
- Voices
- Key signatures
- Metrical positions
- ...



Musical Score

- Note pitches
- Durations
- Onsets
- Voices
- Key signatures
- Metrical positions
- ...



Musical Score

- Note pitches
- Durations
- Onsets
- Voices
- Key signatures
- Metrical positions
- ...

Sonate N°18.

The image displays a musical score for 'Sonate N°18' in 3/4 time, featuring two systems of staves. The score is annotated with various musical markings and colored highlights. The first system includes a tempo marking 'Allegro.' in an orange box above the treble staff, a dynamic marking 'p' in a blue box below the bass staff, and performance instructions 'ritard.' in a red box and 'cresc.' in a green box. The second system includes a tempo marking 'a tempo.' in a grey box above the treble staff, a dynamic marking 'p' in a blue box below the bass staff, and performance instructions 'ritard.' in a red box and 'cresc.' in a green box. The score is written in a key signature of two flats (B-flat and E-flat) and features various musical notations such as notes, rests, and accidentals. Colored highlights (yellow, blue, green, red, pink) are used to mark specific musical elements like note onsets, dynamics, and tempo changes.

Typically produced with a music notation software

Musical Score

- Note pitches
- Durations
- Onsets
- Voices
- Key signatures
- Metrical positions
- ...

The screenshot displays a music notation software interface. The main window shows a musical score for 'Sonate Nr. 13 in A Major #' by Schubert D. 664 Op. 120 (1825). The tempo is marked 'Allegro moderato' with a metronome marking of 85. The score is in A major (one sharp) and 3/4 time. The interface includes a menu bar (File, Edit, View, Add, Format, Tools, Plugins, Help), a toolbar with various notation tools, and a palette on the left with 'Clef' and 'Add Palettes' options. The score is displayed on a grand staff with piano and bass staves. The timeline at the bottom shows measures 1 through 60, with a vertical frame indicating the current position.

Musical performance

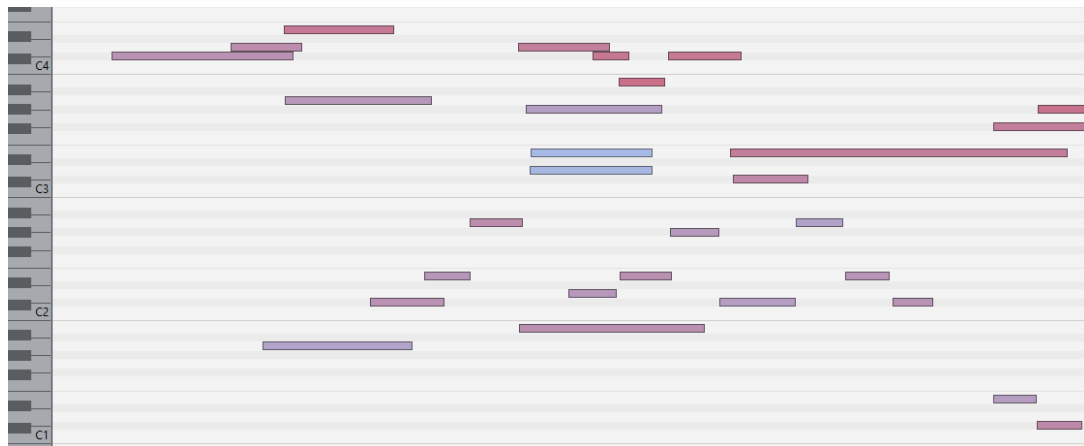
Typically produced performing an instrument



Musical performance (symbolic)

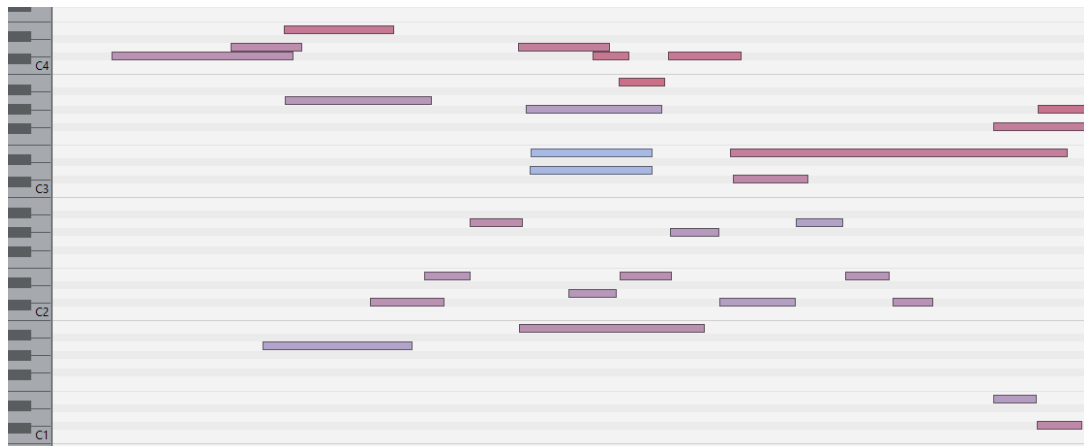


Instruments with MIDI sensors



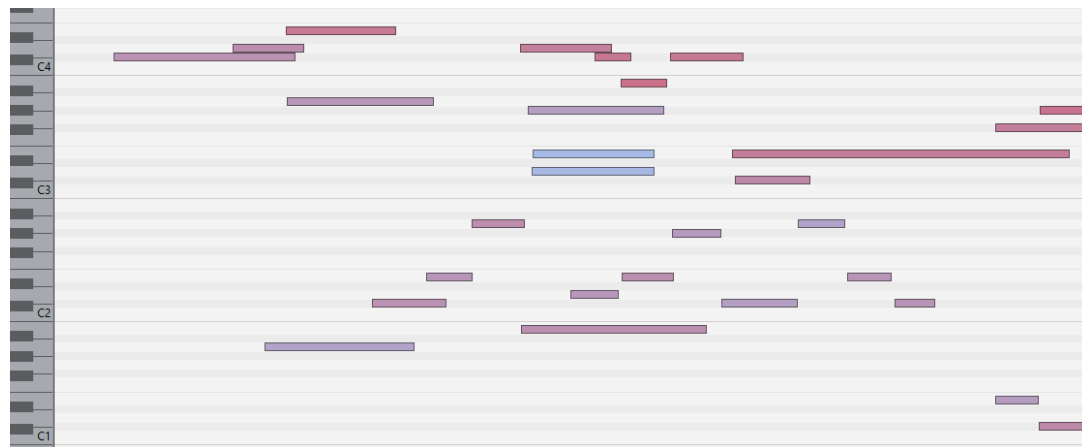
Musical performance

- Note pitches (no pitch spelling)
- Onsets
- Durations
- Velocity



Musical performance

- Note pitches (no pitch spelling)
- Onsets
- Durations
- Velocity

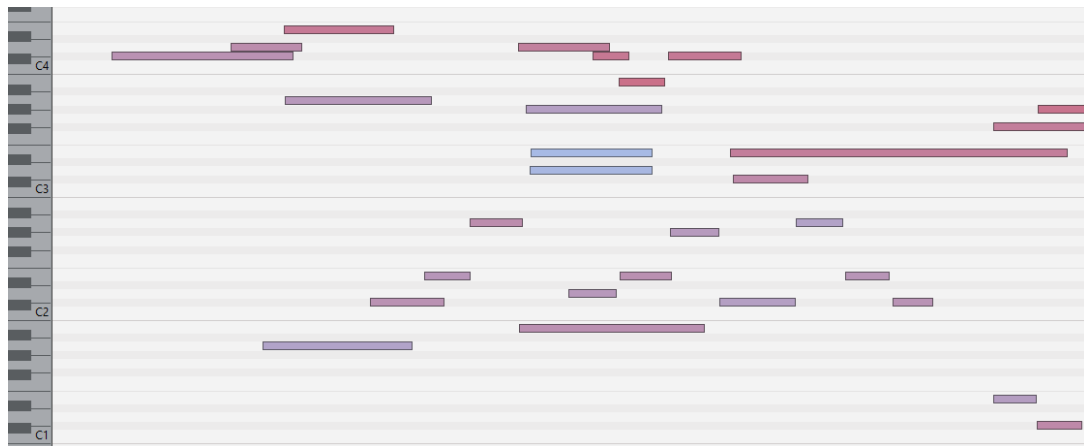


Which key is pressed?

Musical performance

- Note pitches (no pitch spelling)
- Onsets
- Durations
- Velocity

Real physical time, e.g. seconds

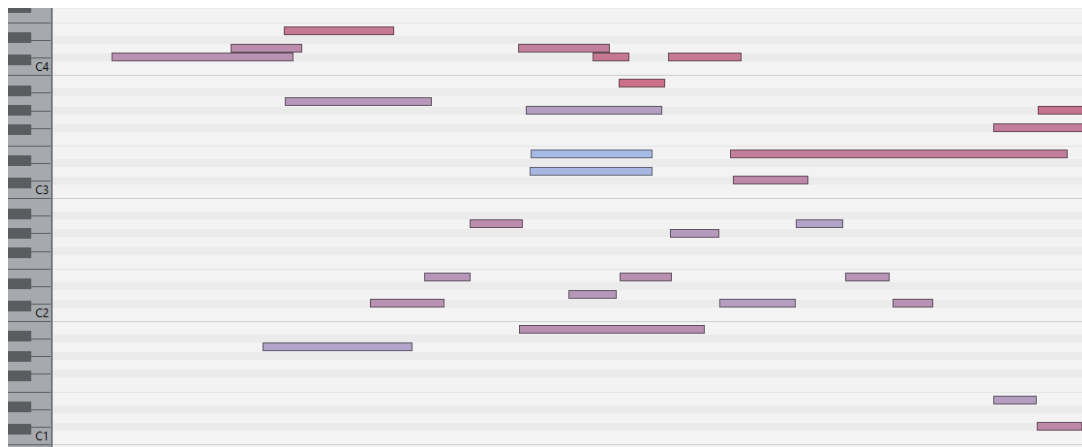


Unquantized temporal positions!

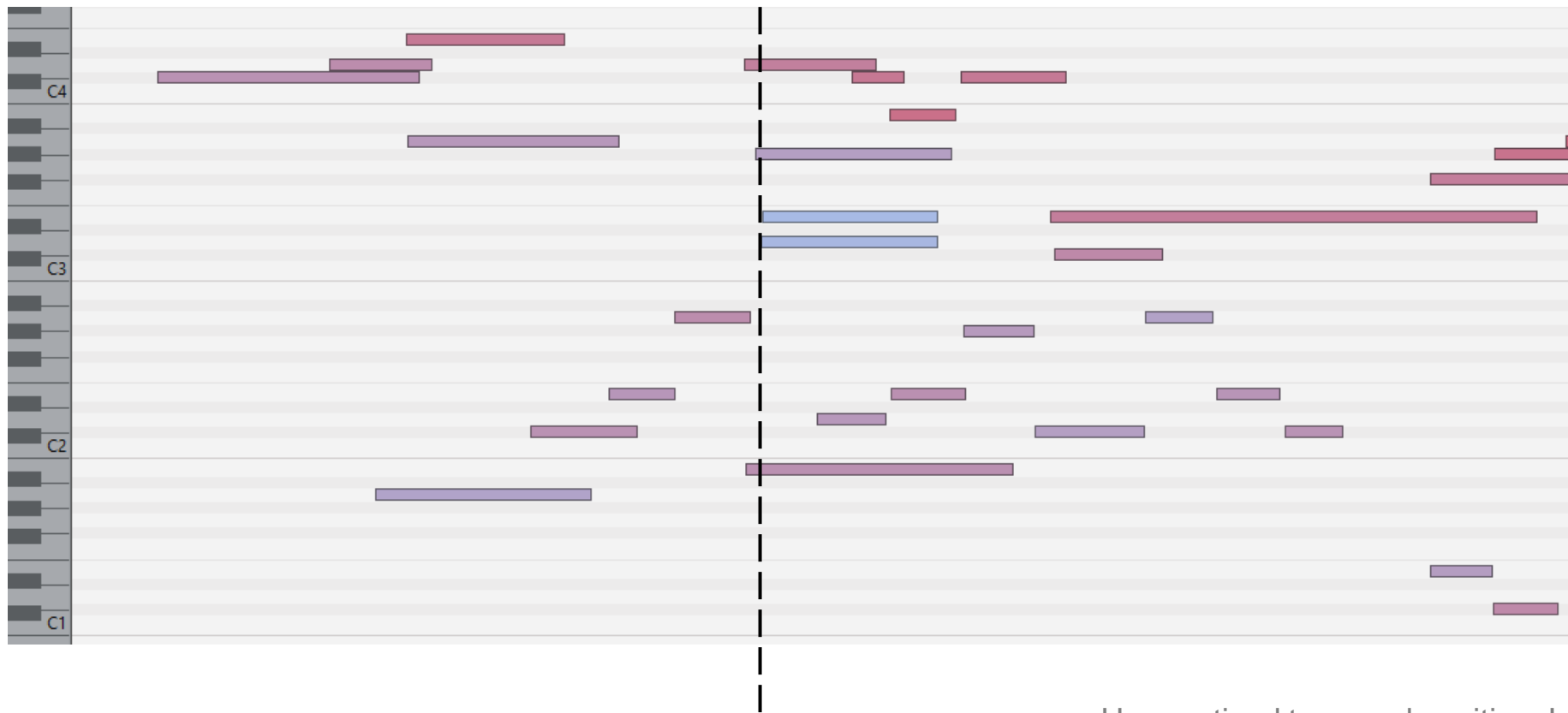
Musical performance

- Note pitches (no pitch spelling)
- Onsets
- Durations
- Velocity

Real physical time, e.g. seconds



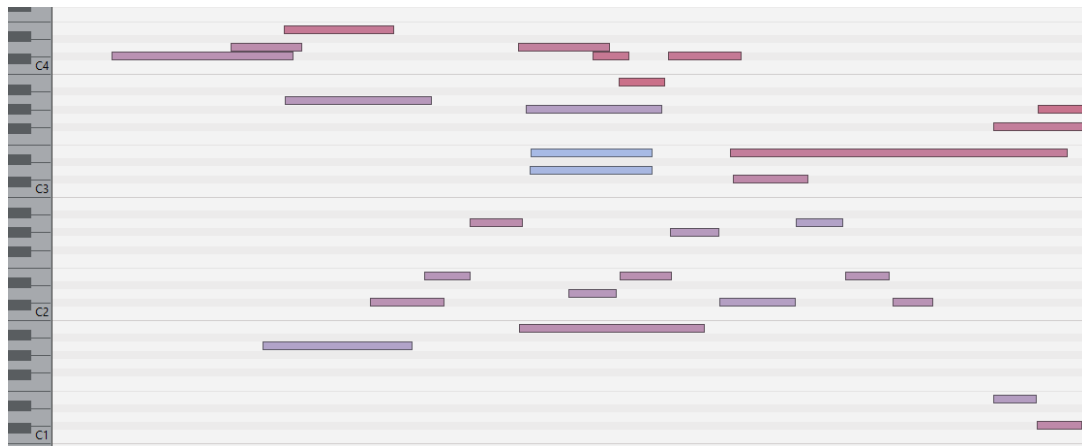
Unquantized temporal positions!



Unquantized temporal positions!

Musical performance

- Note pitches (no pitch spelling)
- Onsets
- Durations
- Velocity



How fast is the key pressed

Encoding Formats - musical score

The screenshot shows a music notation software interface. The title bar includes 'File', 'Edit', 'View', 'Add', 'Format', 'Tools', 'Plugins', and 'Help'. The main window displays a musical score for 'Sonate Nr. 13 in A Major'. The score is in A major (one sharp) and 4/4 time. The tempo is marked 'Allegro moderato' with a metronome marking of 85. The score is written for piano (p) and features a single melodic line on a grand staff. The interface includes a palette on the left with various musical symbols and a timeline at the bottom.

```

43      </clef>
44      </attributes>
45      <note>
46        <pitch>
47          <step>E</step>
48          <octave>4</octave>
49        </pitch>
50        <duration>1</duration>
51        <voice>1</voice>
52        <type>quarter</type>
53        <stem>up</stem>
54        <staff>1</staff>
55      </note>
56      <note>
57        <pitch>
58          <step>D</step>
59          <octave>4</octave>
60        </pitch>
61        <duration>1</duration>
62        <voice>1</voice>
63        <type>quarter</type>
64        <stem>up</stem>
65        <staff>1</staff>
66      </note>
67      <note>
68        <pitch>
69          <step>C</step>
70          <octave>4</octave>
71        </pitch>
72        <duration>1</duration>
73        <voice>1</voice>

```

```

<staffGrp xml:id="s1uvhv9"
  <staffDef xml:id="p1" b
  <instrDef xml:id="i1
  <staffDef xml:id="s1
  <clef xml:id="c10
  <keySig xml:id="k
  <meterSig xml:id=
  </staffDef>
  <staffDef xml:id="s1
  <clef xml:id="cql
  <keySig xml:id="k1ze1gun mode="major" sig="35" />
  <meterSig xml:id="m1589vdf" count="4" sym="common" unit="4" />
  </staffDef>
  <grpSym xml:id="gxqo0lp" symbol="brace" />
  </staffGrp>
</scoreDef>
<section xml:id="s14cxhpk">
  <pb xml:id="p184jxzx" />
  <measure xml:id="m1n3jhen" n="1">
    <staff xml:id="slsk790" n="1">
      <layer xml:id="l14u141l" n="1">
        <beam xml:id="b1r7ub6h">
          <note xml:id="n5m2zh1" dots="1" dur.ppq="9" dur="8" oct="5" pname="c" stem.dir="up">
            <note xml:id="ngyz76c" dur.ppq="3" dur="16" oct="5" pname="d" stem.dir="up" />
          </beam>
        </layer>
        <layer xml:id="l5i0pcp" n="2">
          <rest xml:id="rv1jq09" dur.ppq="12" dur="4" />
        </layer>
      </staff>
    <staff xml:id="srdjrxw" n="2">

```

38	16En	16aaL	.	.
39	16G#JJ	16gg#JJ	.	.
40	16D#LL	16ff#LL	.	.
41	16G#	16gg#	.	.
42	16BB#	16ff#	[8dd#	.
43	16G#JJ	16gg#JJ	.	.
44	16C#LL	16ee#LL	8dd#L]	f
45	16D#	16gg#	.	.
46	16E	16een	8cc#	.
47	16F#JJ	16gg#JJ	.	.
48	16G#LL	16dd#LL	8b#	.
49	16A#	16gg#	.	.
50	16Bn	16ddn	8bnJ	.
51	16E#JJ	16gg#JJ	.	.
52	=3	=3	=3	=3
53	16F#LL	16cc#LL	8a#L	.
54	16G#	16gg#	.	.
55	16An	16b#	8anJ	.
56	16D#JJ	16ff#JJ	.	.
57	16EnLL	16b#LL	4g#	.

Encoding Formats – symbolic performance

Midi

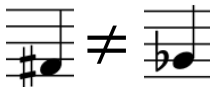
Delta-Time (decimal)	Event-Code (hex)	Other Bytes (decimal)
0	FF 58	04 04 02 24 08
0	FF 51	03 500000
0	C0	5
0	C1	46
0	C2	70
0	92	48 96
0	92	60 96
96	91	67 64
96	90	76 32
192	82	48 64
0	82	60 64
0	81	67 64
0	80	76 64
0	FF 2F	00

Scores vs. Performances

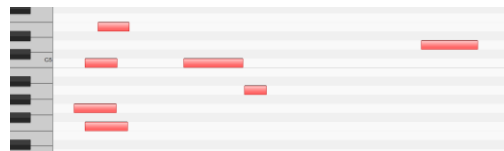
(in symbolic music)

Musical scores



- “Musical” time units, quantized
- Hierarchical time representation
- Pitch spelling  \neq
- High-level musical information
 - Key/time signature
 - Voices
 - ...

Musical performance



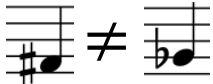
- Time expressed in seconds
- Sequential representation
- MIDI notes
- Precise timing and velocity of each note

Scores vs. Performances

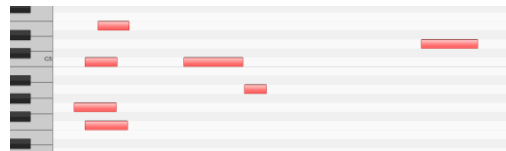
(in symbolic music)

Musical scores



- “Musical” time units, quantized
- Hierarchical time representation
- Pitch spelling 
- High-level musical information
 - Key/time signature
 - Voices
 - ...

Musical performance



- Time expressed in seconds
- Sequential representation
- MIDI notes
- Precise timing and velocity of each note

File formats:

musicxml, mei, kern

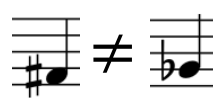
midi

Scores vs. Performances

(in symbolic music)

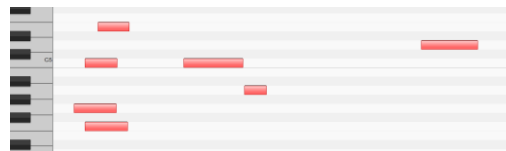
Musical scores



- “Musical” time units, quantized
- Hierarchical time representation
- ~~Pitch spelling~~ 
- High-level musical information
 - Key/time signature
 - Voices ?

~~musicxml, mei, kern, (midi)~~

Musical performance



- Time expressed in seconds
- Sequential representation
- MIDI notes
- Precise timing and velocity of each note

midi

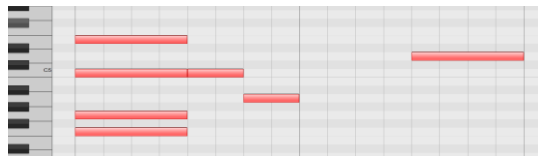
MIDI Scores?

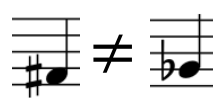

File formats:

Scores vs. Performances

(in symbolic music)

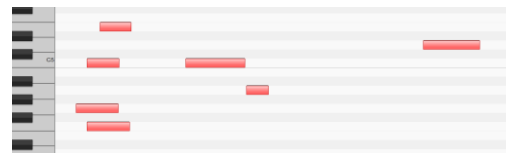
Musical scores



- “Musical” time units, quantized
- Hierarchical time representation
- ~~Pitch spelling~~  \neq 
- High-level musical information
 - Key/time signature
 - Voices ?

~~musicxml, mei, kern, (midi)~~

Musical performance



- Time expressed in seconds
- Sequential representation
- MIDI notes
- Precise timing and velocity of each note

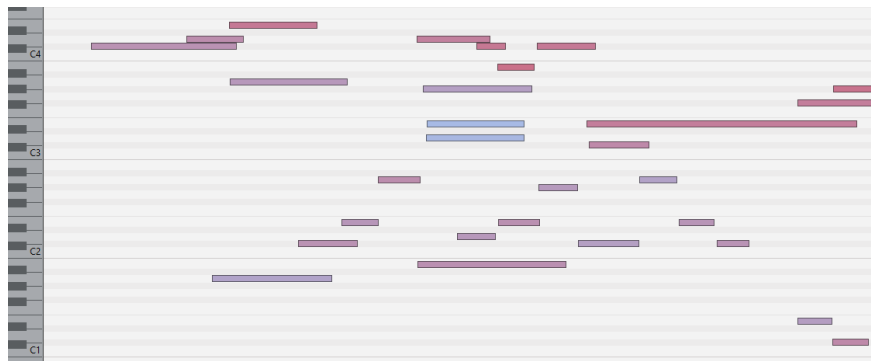
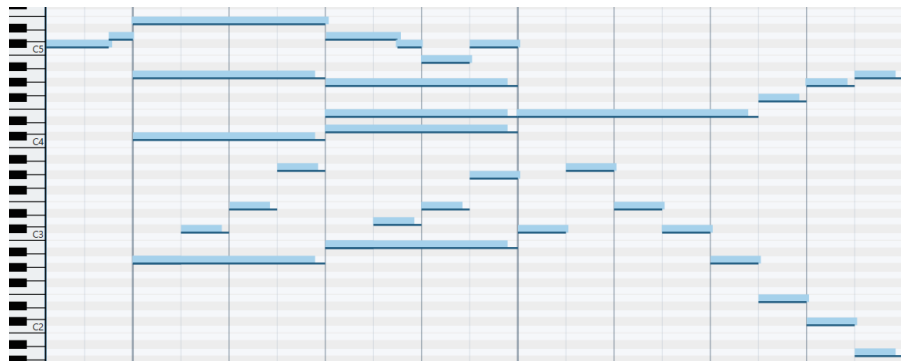
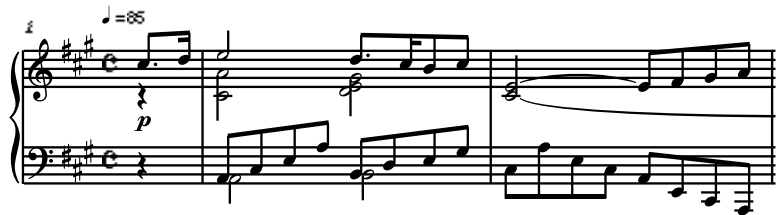
midi

MIDI Scores?

File formats:

Scores vs. Performances

MIDI Scores?

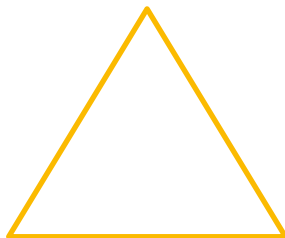


Scores vs. Performances

Babbitt's Representation
Domains of Music (1965)



Performance:
the produced musical experience



Score:
written musical experience



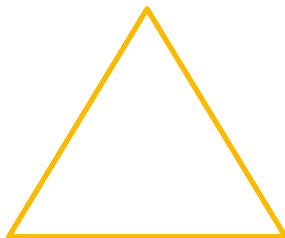
Auditory:
received musical experience

Scores vs. Performances

Babbitt's Representation
Domains of Music (1965)



Performance:
the produced musical experience



Score:
written musical experience

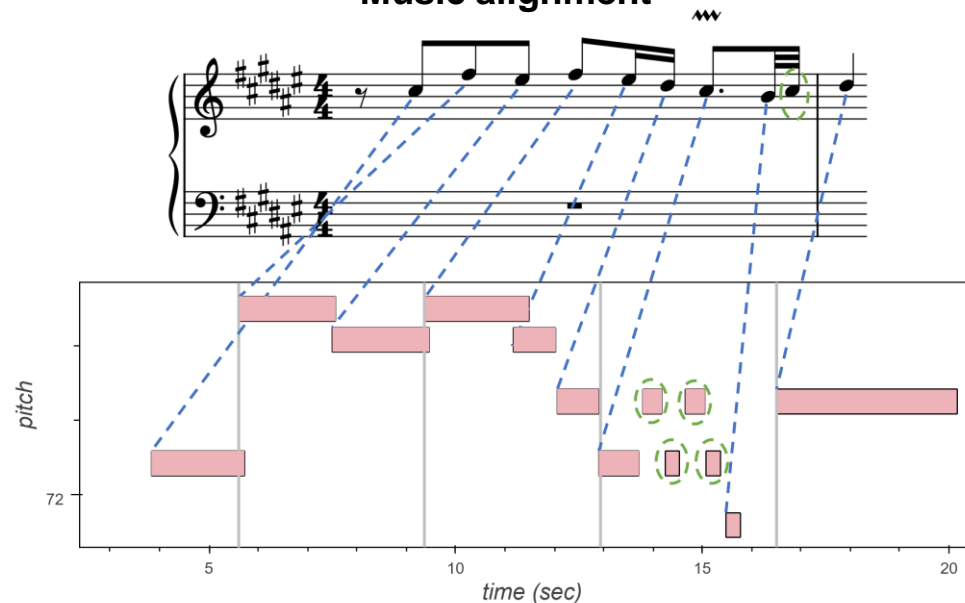


Auditory:
received musical experience

Score-to-performance alignments

Another symbolic data type

Music alignment



File formats:

Matchfile

Why using symbolic music

- “Less noisy” representation of musical content
- Better interpretation
- Can point to groups of explicitly encoded events (audio is “vertically mixed”)
- Usage as ground truth for high-level musical element prediction

Why scores over MIDI

- Higher level musical features available
- Readable by humans

MIR with symbolic music

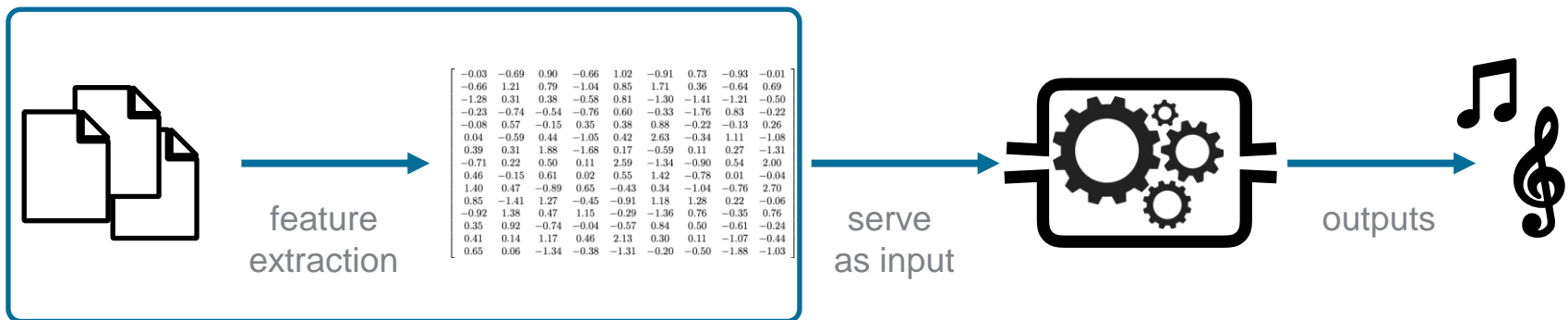
A Common MIR Pipeline

input symbolic
music files

features

machine learning
model

musical concept to
model/predict/generate



Focus of Partitura

Symbolic Music Processing Packages in Python

PrettyMIDI

- Focus on fast extraction of information from MIDI files
- No real distinction between performance and score
- Very easy to use for people without musical background

Raffel and Ellis

Partitura

- Simple, yet complete representation of scores
- Handling scores, performances and alignments
- Focus on lightweight extraction of MIR features

Music21

- Complete and hierarchical representation of scores
- Focus on computational musicology
- Very powerful but has a steep learning curve

Cuthbert & Ariza

Datasets

Name	Scores	Performances	Note-alignments
Vienna 4x22	4	88	43,450
Extended ASAP	222	1062	7,275,074

The Partitura Development Team

Current



Carlos
Cancino-Chacón



Silvan
Peter



Francesco
Foscari



Emmanouil
Karystinaios



Patricia
Hu

Tutorial presenters

Former



Thassilo
Gadermaier



Nimrod
Varga



**Benevolent
Dictator
for Life**
Maarten
Grachten

https://cpjku.github.io/partitura_tutorial/