Sound and Music Computing

Silvan David Peter - Emmanouil Karystinaios

JOHANNES KEPLER
UNIVERSITY LINZ

Institute of
Computational
Perception

Who are We?

Silvan David Peter :

Researcher in Music Information Research at the Institute of Computational Perception at JKU. Lecturer at JKU, University of Applied Arts Vienna. Sound & media artist.

Emmanouil Karystinaios:

Researcher at the Institute of Computational Perception (JKU). Research Topics : Computational Musicology, Music Analysis, and Graph Neural Networks. Background in Musicology, Composition, and Mathematics.

Organization Details

- 7 lectures between October 22 and January 23;
- Python Programming Language;
- Approximately biweekly exercise projects;
- Comprehension exercises during lectures

Contents and Lectures

1. Introduction to Music Theory, Python, and Partitura
2. Introduction to Machine Learning
3. Tonnetz and Negative Harmony
4. Deep Generation
5. Formal Grammars for Symbolic Music Generation
6. Agents and Reinforcement Learning
7. Summary and Q/A

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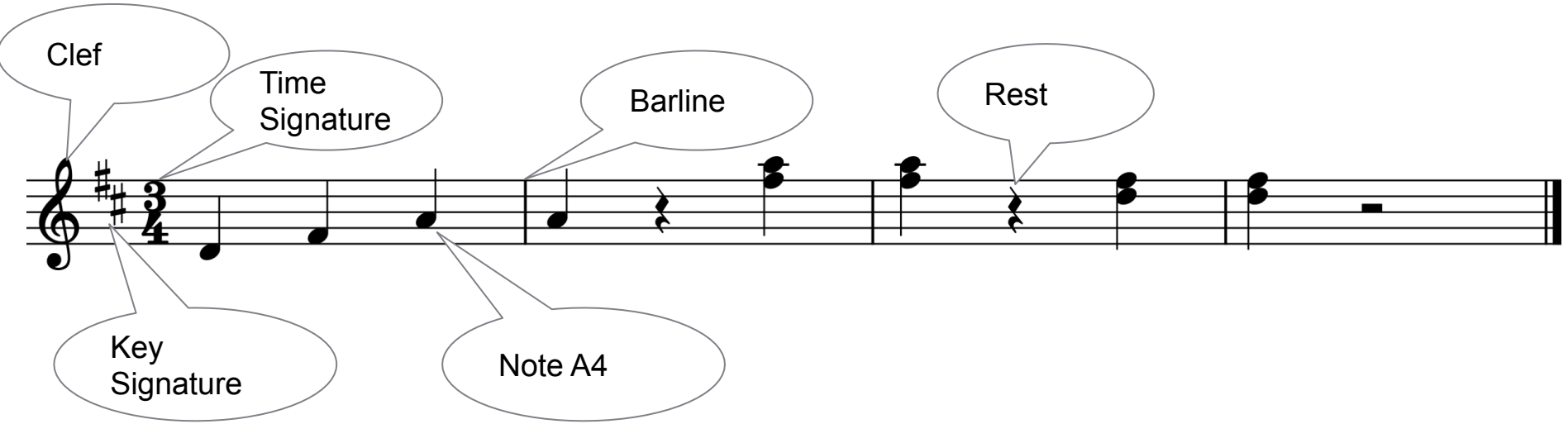
Introduction to Music Theory

In this section we will address:

- Notes / Pitch / Temperament
- Chords and Harmony
- Rhythm

From the point of view of musical representations and encoding.

Music Representations



Music Representations - MUSICXML

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<time>
    <beats>3</beats>
    <beat-type>4</beat-type>
    </time>
<clef>
    <sign>G</sign>
    <line>2</line>
    </clef>
</attributes>
<note default-x="110.48" default-y="-45.00">
<pitch>
    <step>D</step>
    <octave>4</octave>
    </pitch>
<duration>1</duration>
<voice>1</voice>
<type>quarter</type>
<stem>up</stem>
</note>

```

Music Representations - Pianoroll

Music Representations - MIDI File

```
MidiFile(type=1, ticks_per_beat=480, tracks=[
  MidiTrack([
    MetaMessage('track_name', name='Piano\x00', time=0),
    MetaMessage('time_signature', numerator=3, denominator=4, clocks_per_click=24, notated_32nd_notes_per_beat=8, time=0),
    MetaMessage('key_signature', key='D', time=0),
    MetaMessage('set_tempo', tempo=500000, time=0),
    Message('control_change', channel=0, control=121, value=0, time=0),
    Message('program_change', channel=0, program=0, time=0),
    Message('control_change', channel=0, control=7, value=100, time=0),
    Message('control_change', channel=0, control=10, value=64, time=0),
    Message('control_change', channel=0, control=91, value=0, time=0),
    Message('control_change', channel=0, control=93, value=0, time=0),
    MetaMessage('midi_port', port=0, time=0),
    Message('note_on', channel=0, note=62, velocity=80, time=0),
    Message('note_on', channel=0, note=62, velocity=0, time=455),
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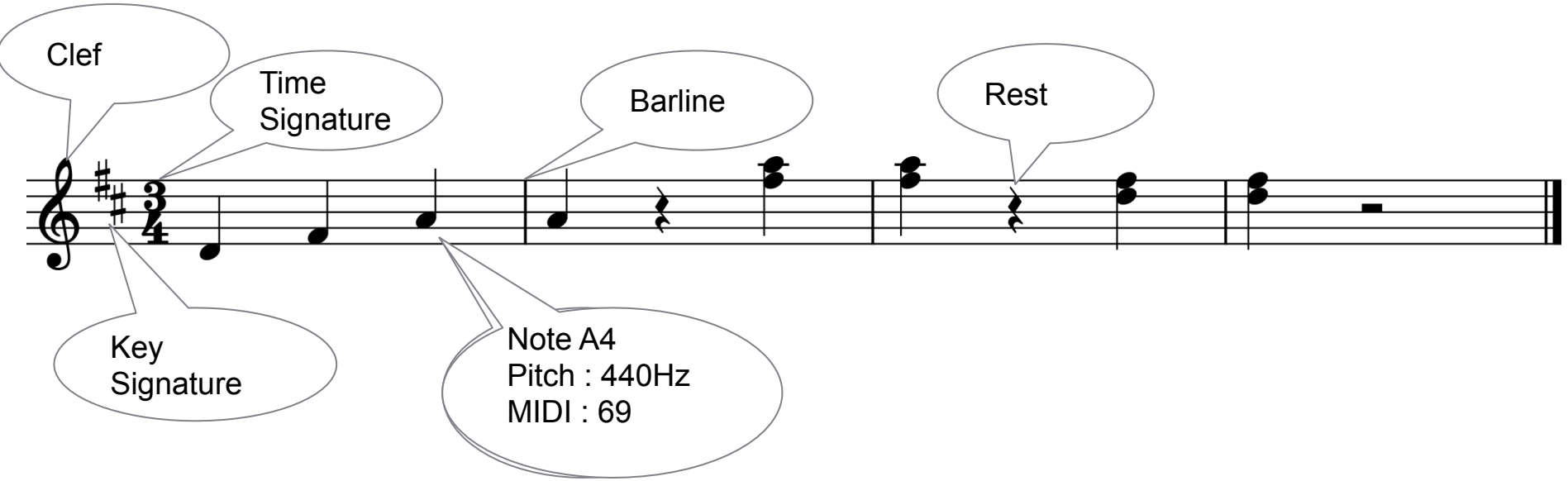
    Message('note_on', channel=0, note=78, velocity=0, time=455),
    Message('note_on', channel=0, note=81, velocity=0, time=0),
```

Music Representations - Note Array

id	onset_beat	duration_beat	onset_quarter	duration_quarter	onset_div	duration_div	pitch	voice	divs_pq
p0n0	0	1	0	1	0	1	62	1	1
p0n1	1	1	1	1	1	1	66	1	1
p0n2	2	1	2	1	2	1	69	1	1
p0n3	3	1	3	1	3	1	69	1	1
p0n5	5	1	5	1	5	1	78	1	1
p0n6	5	1	5	1	5	1	81	1	1
p0n7	6	1	6	1	6	1	78	1	1
p0n8	6	1	6	1	6	1	81	1	1
p0n10	8	1	8	1	8	1	74	1	1
p0n11	8	1	8	1	8	1	78	1	1

Music Representations



Exercise on Music Representation

What would you need to represent a music Element i.e.:

- a Note,
- a Key Signature,
- a Time Signature
- a Dynamics' Element

Musical Encoding

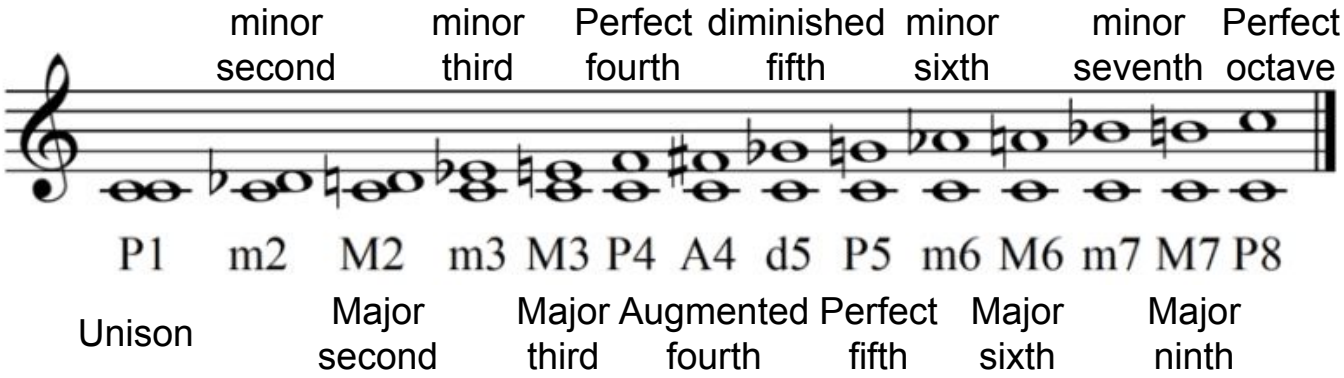
- What is a musical encoding?
  - Encoding is the conversion of Musical information into a specialized format for efficient transmission or storage. More generally from one communication protocol to another.
- Why do we need to encode?
  - To store information (save a score)
  - To communicate (from one musical language to another from score to tablature, pianoroll, etc.)
  - To formalize (create formal systems and prove properties)
  - To use intelligent systems (convert human readable score to numerical function for ML)

Note Naming Conventions

- Accidentals (♯,𝄪,♮, ♭).
  - Sharp (♯): Raise a note by half a semitone
  - Double sharp (𝄪): Raise the notes two semitones
  - Flat (♭): Lower a note by half a semitone (double flat)
  - Natural (♮, it is usually implicit): resets the previous accidentals
- Pitch Classes: 12 of them:
  - B♯/C, C♯/D ♭ , D, D♯/E ♭ , E/F ♭ , E♯/F, F♯/G ♭ , G, G♯/A ♭ , A, A♯/B ♭ , B/C ♭
- Pitch Spelling: “musical orthography”
  - Pitch class + (alteration) + octave
  - Central C is C4

Intervals

- **Intervals**: Relation between notes (Pairwise distance)
- **Relative pitch:** We (humans) recognize a musical context (e.g., melody) by the relationships of its notes (i.e., the intervals) rather than the notes themselves
- Names of Intervals



Consonant and Dissonant Intervals

- **Consonant** vs. **Dissonant** Intervals
  - Consonant:
    - Unison, Octave, Perfect fifth (Perfect);
    - Fourths, thirds, sixths (Imperfect).
  - Dissonant everything else!

Equal Temperament

Temperament refers to the division of the octave into tones, semitones, microtones, etc.

The most commonly used Since the WTC by J.S. Bach is the **Equal Temperament** dividing the octave in 12 semitones.

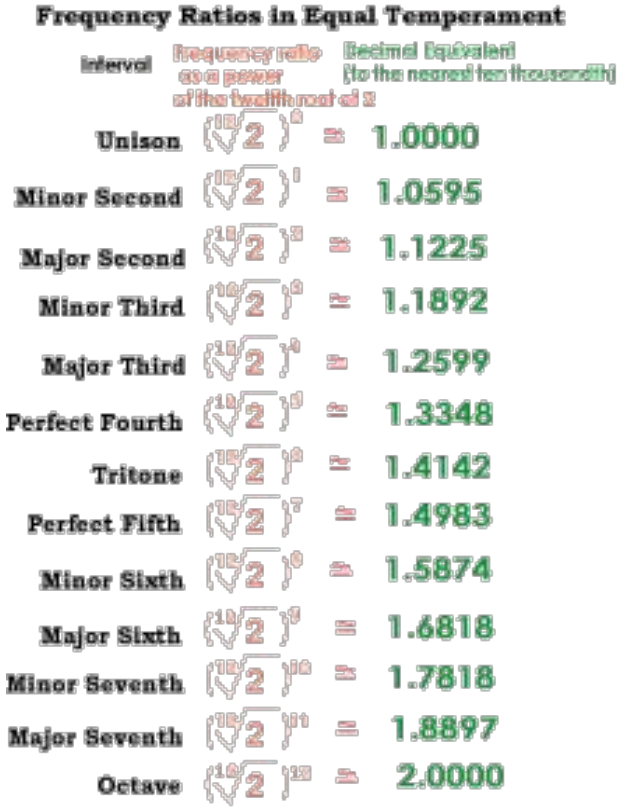
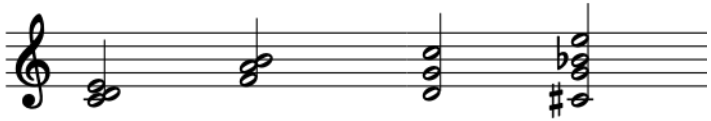


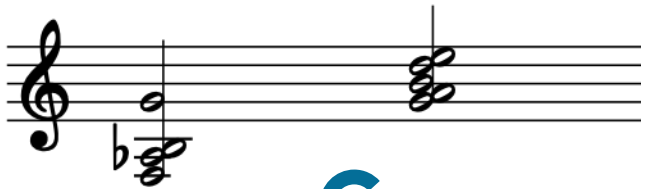
Image from cnx.org

Chords

- Chord: a collection of **notes** that are heard as if sounding **simultaneously**

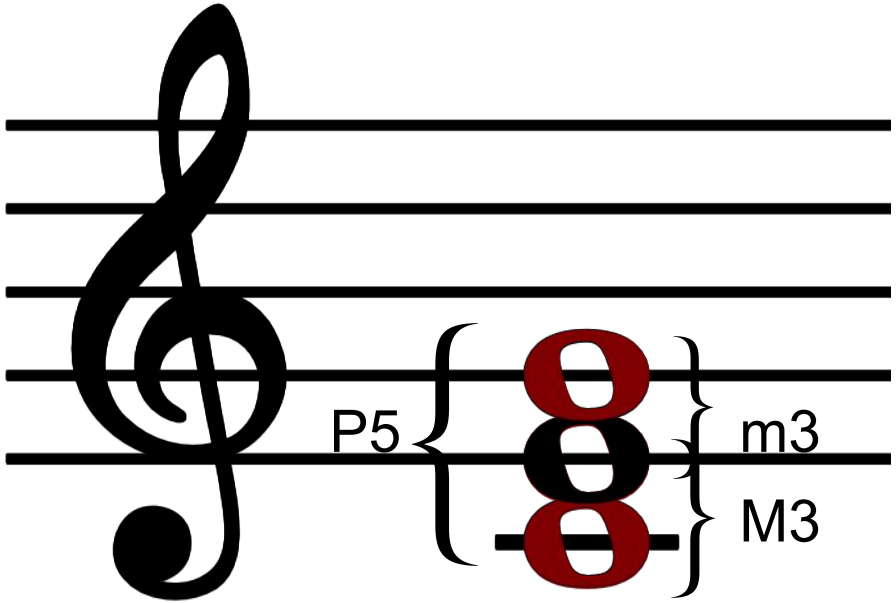


- In Western tonal music, the most common/important chords are conventional **triads**, which consist of **3 notes:**
  - Root + third and fifth “above” the root
  - The 4 basic triads are Major, Minor, Augmented and Diminished
  - The chords are named after the root (e.g., C major is the major chord with root C)
- Chords with more notes exist, and are extensively used in many genres (e.g., jazz)
  - F9 ♭ 5, Gsus2add6

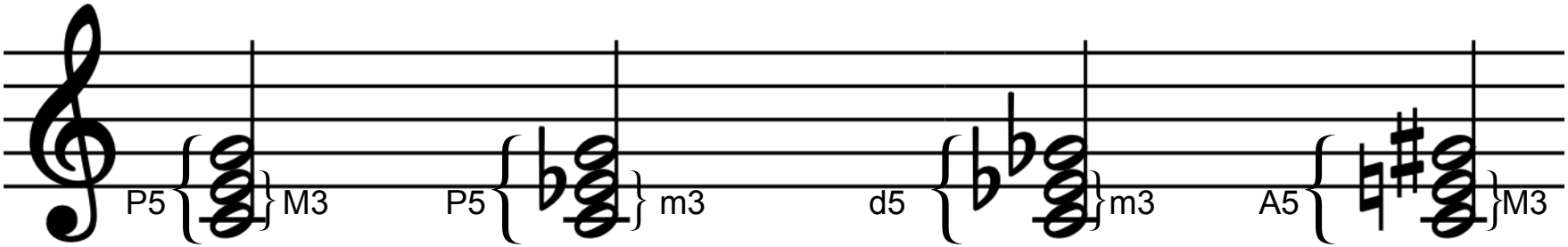


Chord structure: Major chord

Major chord



Chord structure: Triads

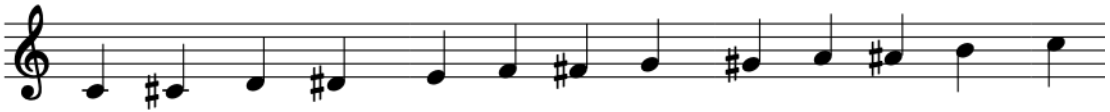


Major Minor Diminished Augmented

What would you need to encode a chord?

Scales

- 12 pitches: The Chromatic Scale



- Subsequences: The Major / Minor Scales
- (but there are dozens of others…)
- **Why scales?** -> Collection of notes that create relatively harmonious sounding intervals/triads
- **Why pitch spelling**? Scales are defined in intervals relative to a tonic note (no absolute reference!)

Tonality

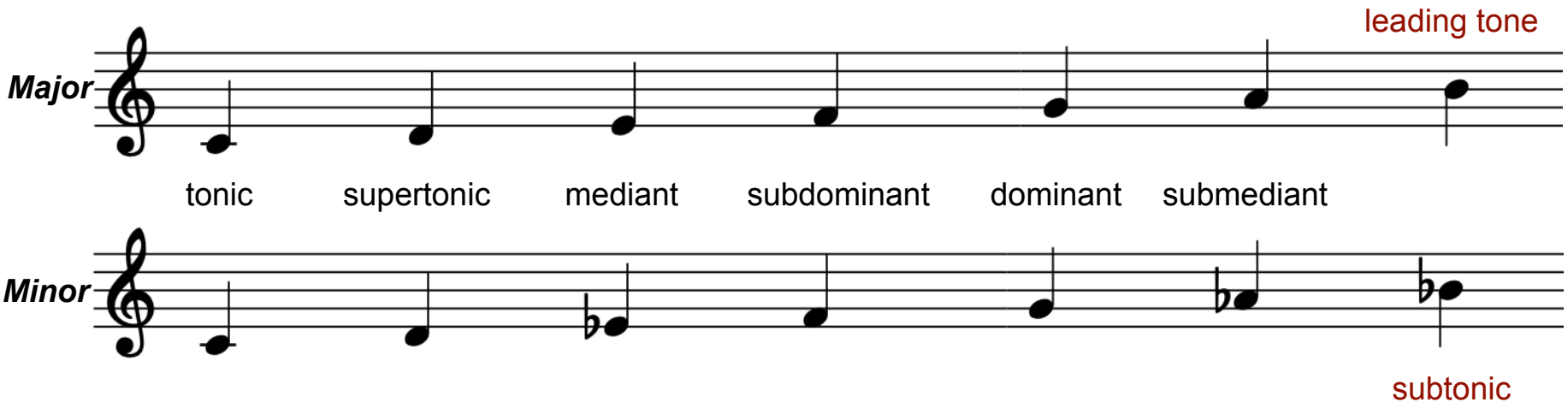
- **Tonality** refers to a **hierarchy** of notes/chords by relations of **stability/instability**, **attraction** and **directionality**
  - In tonal music, there is a note/chord (the **tonic**) that serves as the ***center of gravity*** of the other pitches in the scale
- The **key** of a piece/song indicates which chord is the tonal center:
  - Examples: Beethoven's Fifth Symphony in **C minor**
- **Cadences**: chord sequences leading towards this center

Key Signature

- The key signature indicates the key (tonality) of a piece of music in the score
- Human Composers are lazy by nature! Imagine having to write all of the alterations by hand!

Scale Degrees

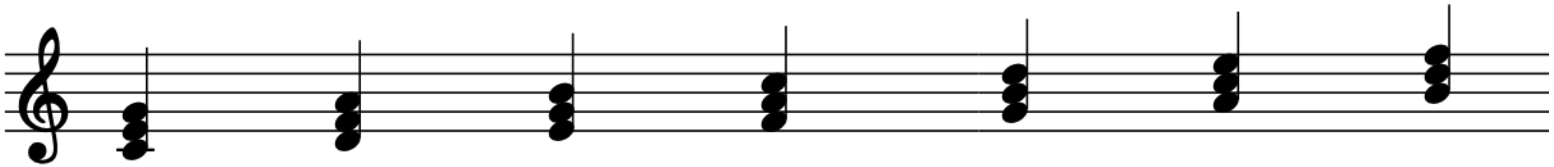
A scale degree is the role that each note “plays” in a key



Scale Degrees and Roman Numeral

Roman Numeral representation: Abstracts the **function** of each chord within a key:

We can express chord progressions independently of the key

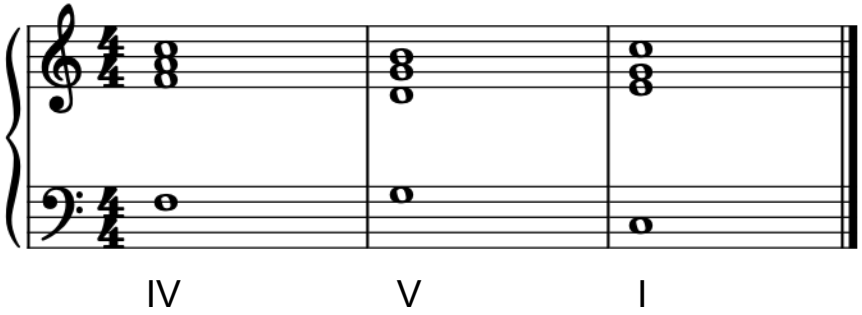


I	II	III	IV	V	VI	VII
tonic	supertonic	mediant	subdominant	dominant	submediant	leading tone
C Maj	D min	E min	F Maj	G Maj	A min	B dim

Cadences

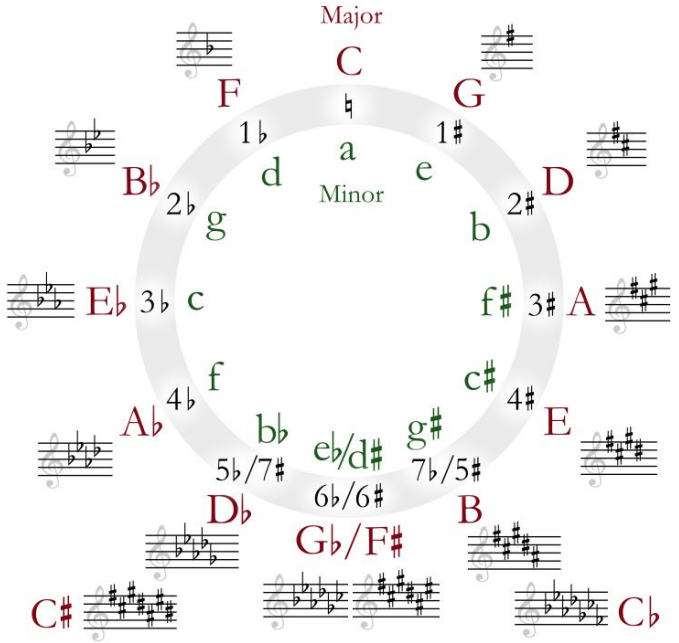
A cadence is particular combinations of Melodic (Voice Leading) and Harmonic progressions.

Perfect Augmented Cadence



Circle of Fifths

- How close are different keys?
  - How many notes are different between the keys?
- Neighbor tonality:
  - ±1 fifth (1 alteration different)
  - Relative Minor (a minor third descending
- Parallel Minor/Major:
  - Same root but different mode
  - They are not very close



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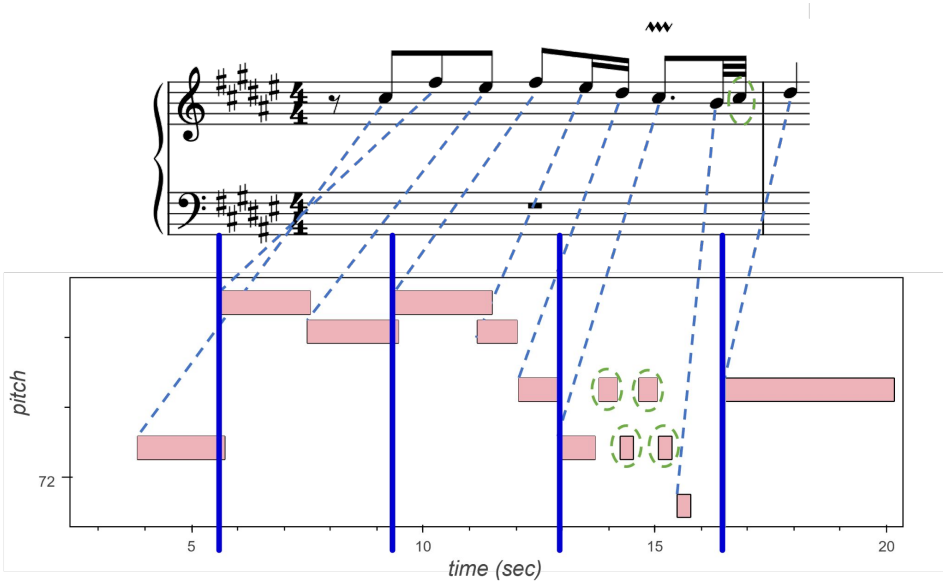
Rhythm

Note durations

Notation,
Onset (score position) vs. duration

Articulation: (staccato, legato)



Exercise

- **Think of different ways you could encode onset and duration.** (Hint MIDI)
- What about articulation?

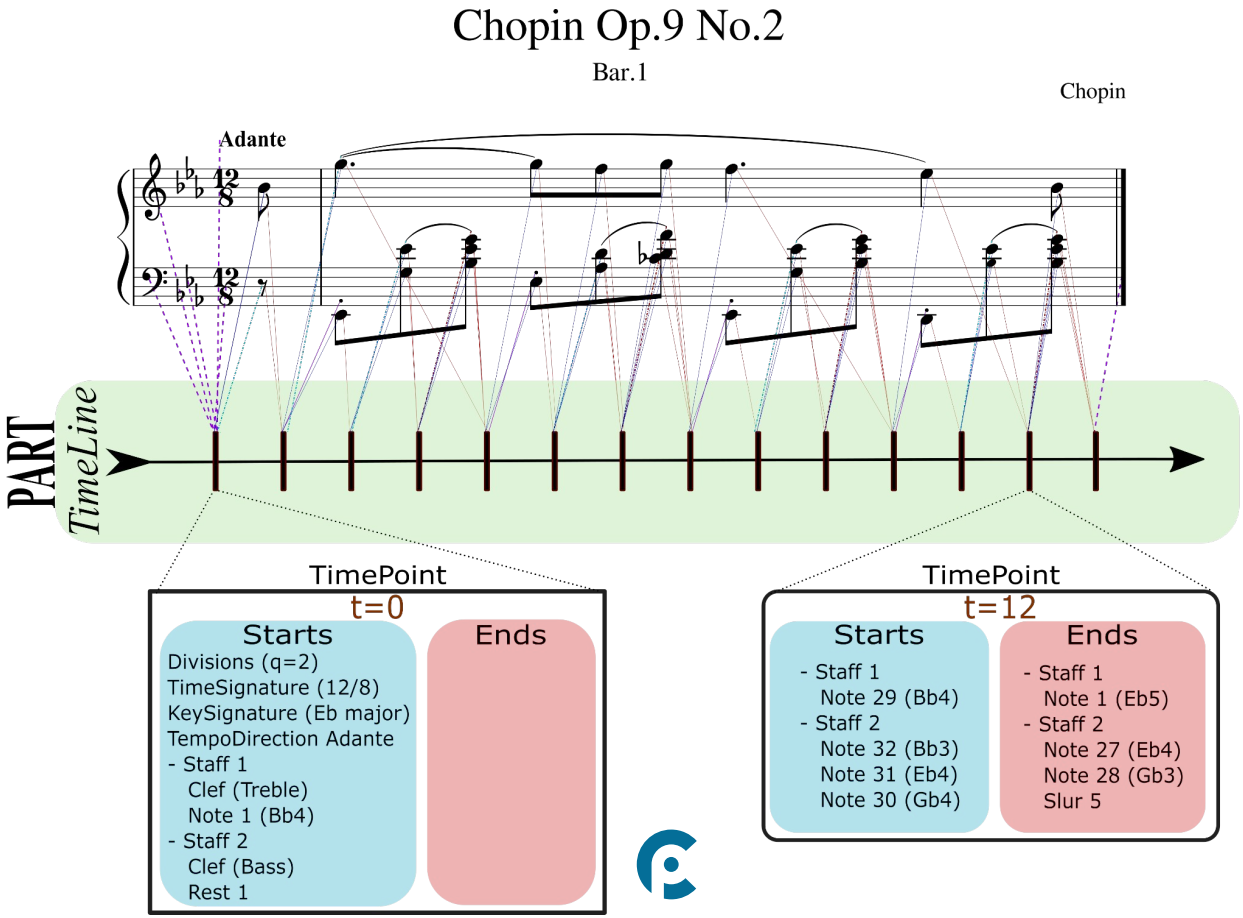
Examples of onset and duration units.

- Divisions (used in MIDI file encoding)
- Fractions of Beat
- Musical Duration encoding

Some Onset and Duration Encodings

- Divisions (used in MIDI file encoding)
- Fractions of Beat
- Musical Duration encoding

Encoding of a Score *(partitura)*



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