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 23 and January 24;
- Python Programming Language;
- Approximately biweekly soft exercises;
- Comprehension exercises during lectures;
- Final Project - A composition based on techniques discussed during lectures.

Contents and Lectures

- Introduction to Music Theory
- Introduction to Machine Learning
- Tonnetz and Negative Harmony
- Deep Generation
- Formal Grammars for Symbolic Music Generation
- Agents and Reinforcement Learning
- Concert

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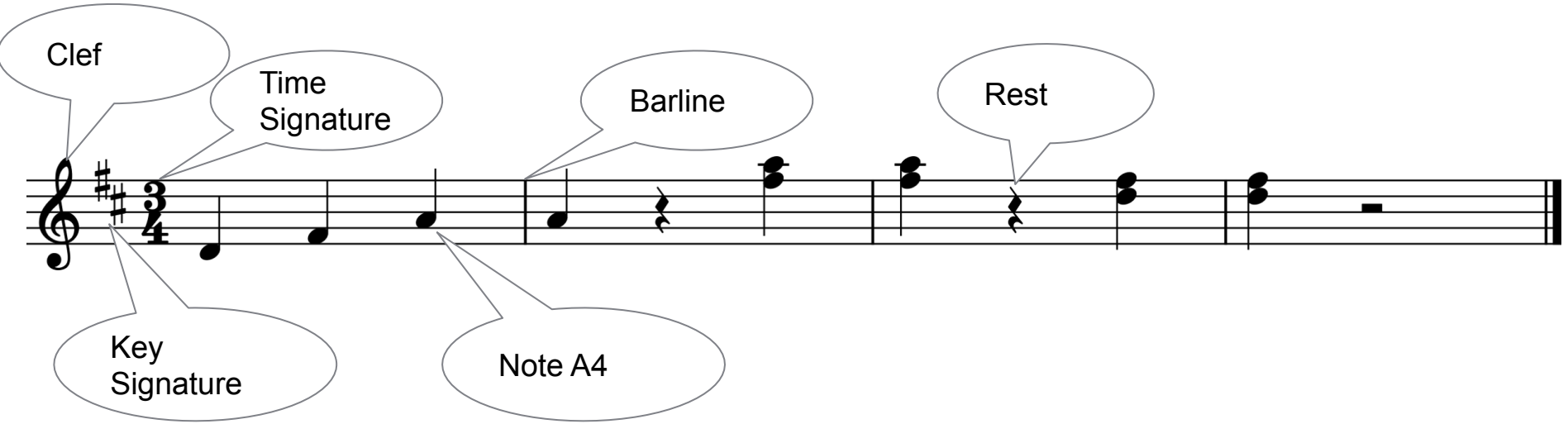
Introduction to Music Theory

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),
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    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=69, velocity=80, time=25),
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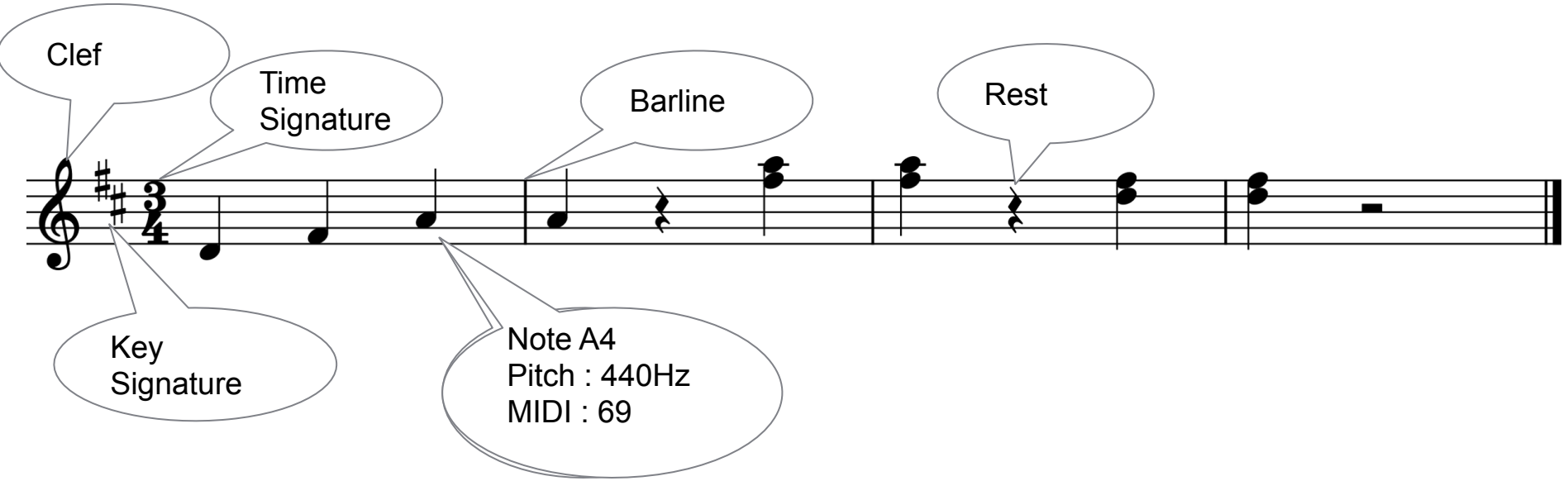
    Message('note_on', channel=0, note=78, velocity=0, time=455),
    Message('note_on', channel=0, note=81, velocity=0, time=0),
```

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

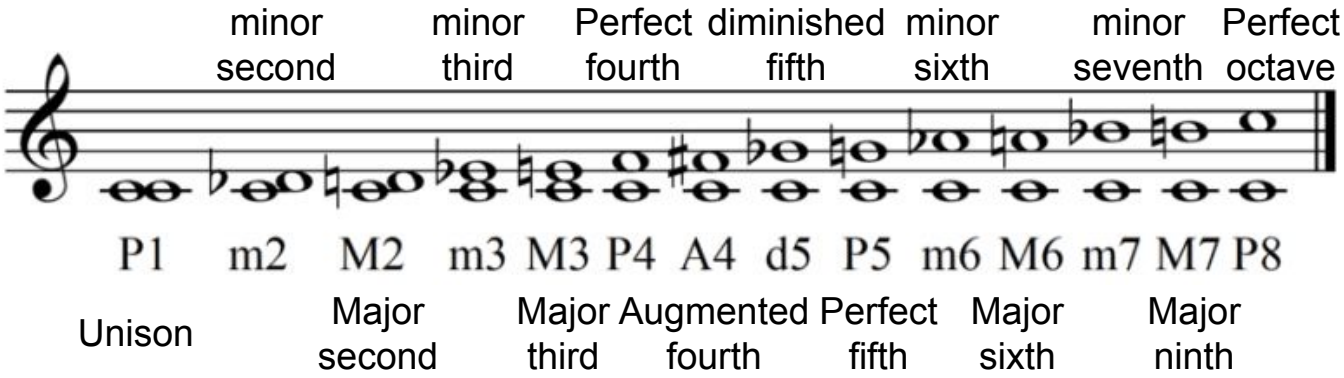
- What is a musical encoding?
  - Encoding is the conversion of Musical information into a specialized format for efficient transmission or storage. More generally from one communication protocol to another.
- Why do we need to encode?
  - To store information (save a score)
  - To communicate (from 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 a semitone
  - Double sharp (𝄪): Raise the notes two semitones
  - Flat (♭): Lower a note by a semitone
  - Double Flat (𝄫 ♭): Lower a note by a tone
  - 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.

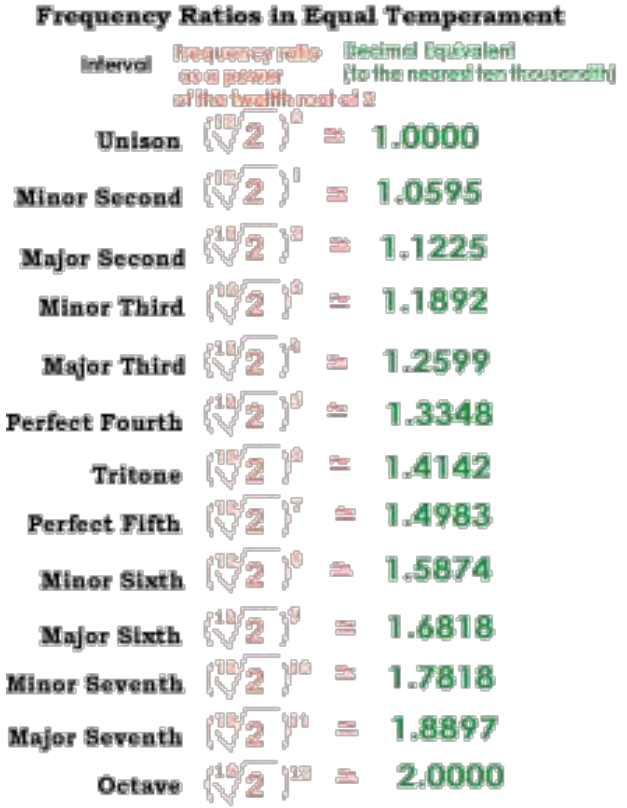
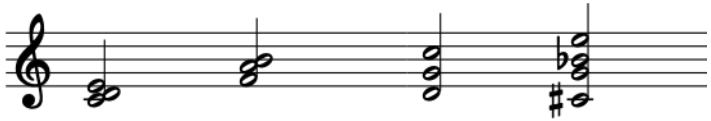


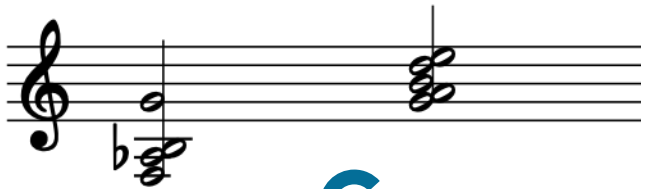
Image from cnx.org

Chords

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

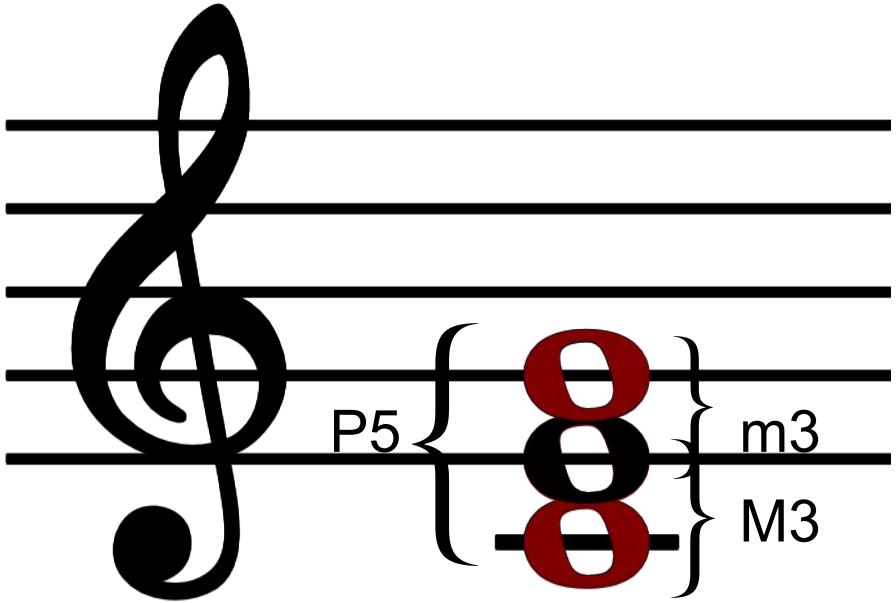


- In Western tonal music, the most common/important chords are conventional **triads**, which consist of **3 notes:**
  - Root + third and fifth “above” the root
  - The 4 basic triads are Major, Minor, Augmented and Diminished
  - The chords are named after the root (e.g., C major is the major chord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

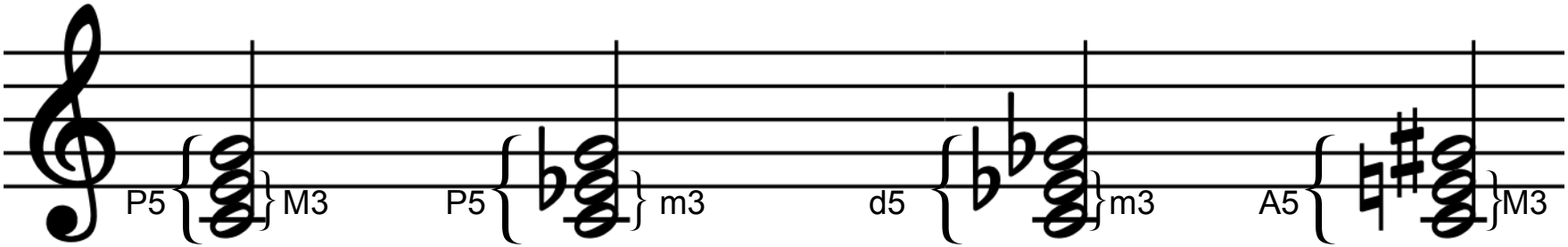


Chord structure: Major chord

Major chord



Chord structure: Triads

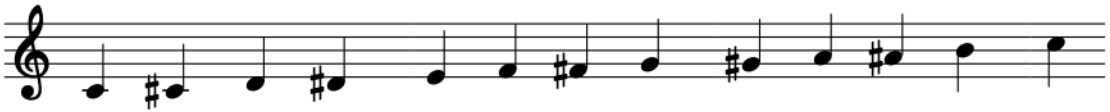


Major Minor Diminished Augmented

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

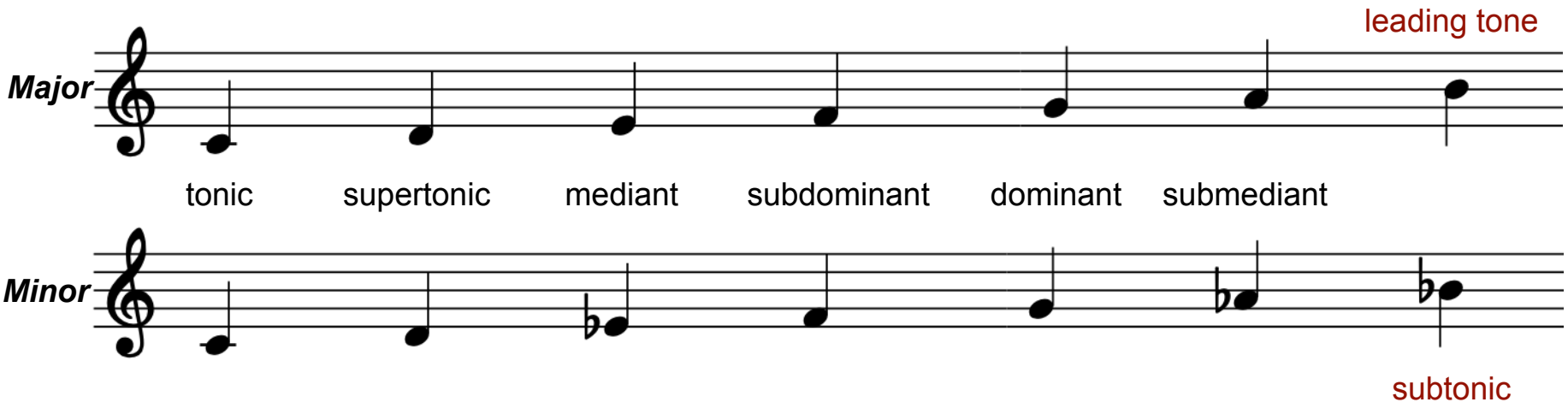
- **Tonality** refers to a **hierarchy** of notes/chords by relations of **stability/instability**, **attraction** and **directionality**
  - In tonal music, there is a note/chord (the **tonic**) that serves as the ***center of gravity*** of the other pitches in the scale
- The **key** of a piece/song 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

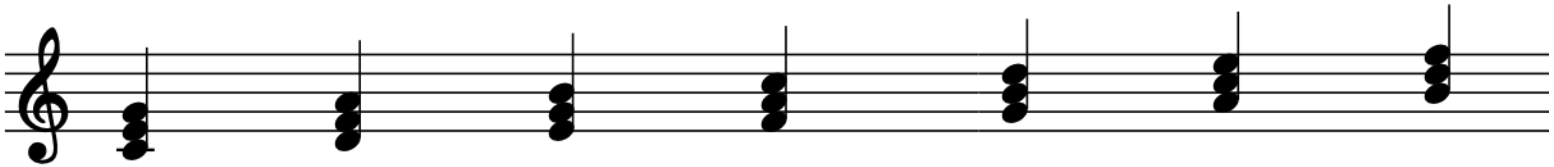
A scale degree is the role that each note “plays” in a key



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

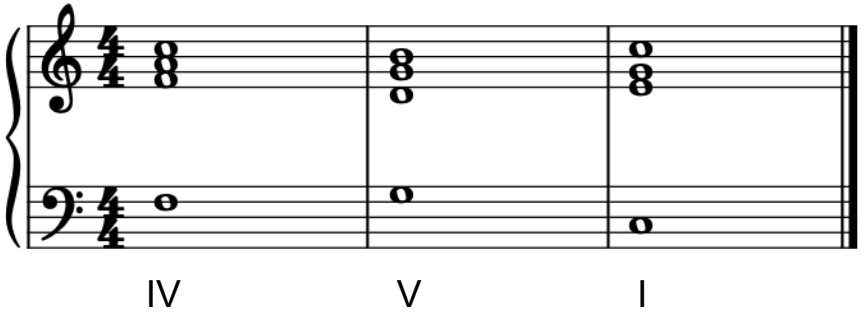


I	II	III	IV	V	VI	VII
tonic	supertonic	mediant	subdominant	dominant	submediant	leading tone
C Maj	D min	E min	F Maj	G Maj	A min	B dim

Cadences

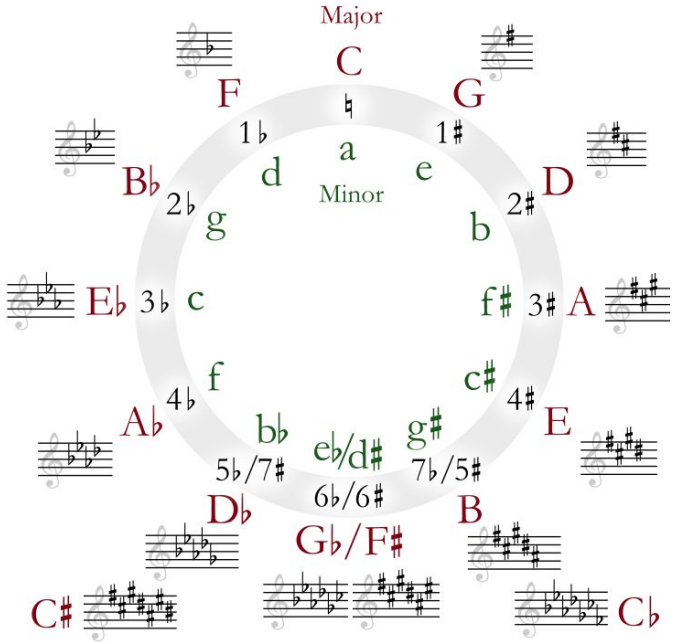
A cadence is particular combinations of Melodic (Voice Leading) and Harmonic progressions.

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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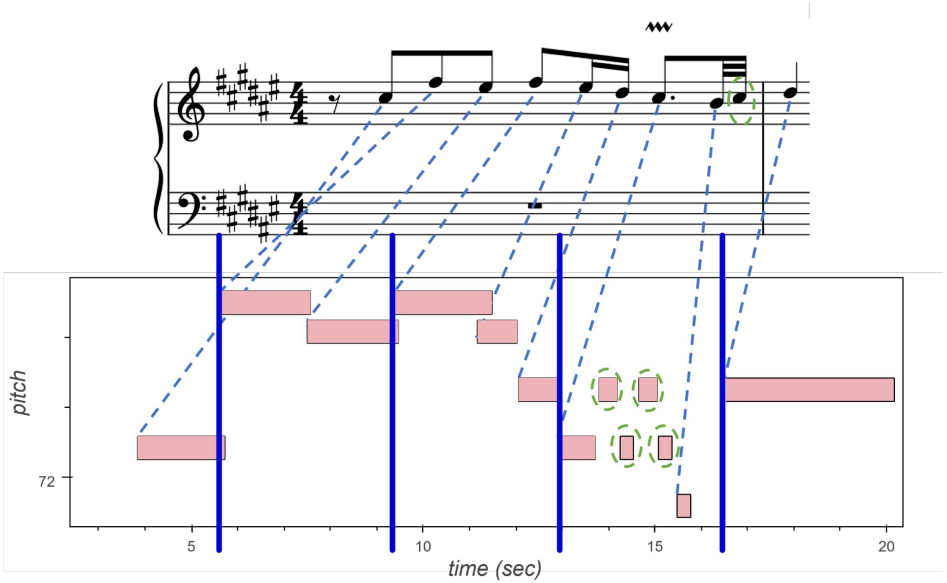
Rhythm

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?

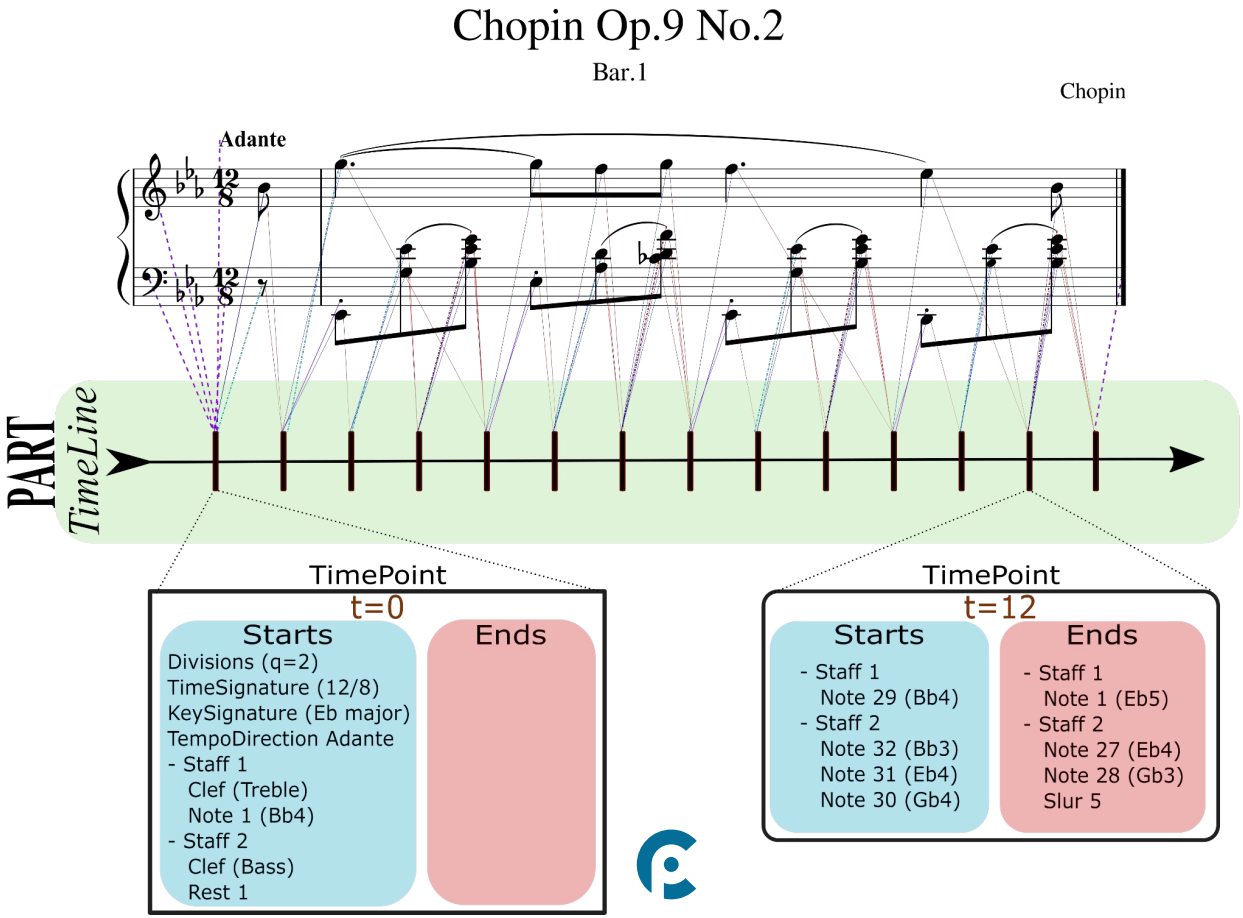
Examples of onset and duration units.

- 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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