



Introduction to **Audio Content Analysis**

module 7.2: representation of pitch in music

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introduction

overview

corresponding textbook section

section 7.2

■ lecture content

- pitch-related music terminology: interval, mode, tonic, chord

■ learning objectives

- name musical intervals and notate them in score notation
- explain pitch distance
- discuss whether a chord is a harmony



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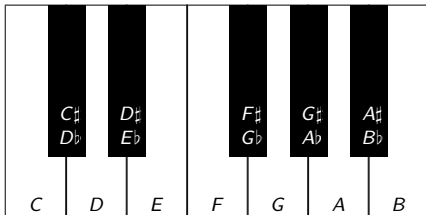
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musical pitch

notation and names

each octave (freq factor 2) is split into 12 pitch classes



0	1	2	3	4	5	6	7	8	9	10	11
C	C \sharp /D \flat	D	D \sharp /E \flat	E	F	F \sharp /G \flat	G	G \sharp /A \flat	A	A \sharp /B \flat	B

musical pitch

intervals

Interval	Enharmonic Equivalent	Δ ST	
Unison	Diminished Second	0	
Minor Second	Augmented Unison	1	
(Major) Second	Diminished Third	2	
Minor Third	Augmented Second	3	
Major Third	Diminished Fourth	4	
(Perfect) Fourth	Augmented Third	5	
Augmented Fourth	Diminished Fifth/Tritone	6	
(Perfect) Fifth	Diminished Sixth	7	
Minor Sixth	Augmented Fifth	8	
Major Sixth	Diminished Seventh	9	
Minor Seventh	Augmented Sixth	10	
Major Seventh	Diminished Octave	11	
(Perfect) Octave	Augmented Seventh	12	

musical pitch

MIDI pitch

$$p(f) = 69 + 12 \cdot \log_2 \left(\frac{f}{f_{A4}} \right)$$

$$f(p) = f_{A4} \cdot 2^{\frac{p-69}{12}}$$

MIDI pitch mapping to *pitch class*

$$PC(p) = \text{mod}(p, 12)$$

musical pitch

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musical pitch

(MIDI) pitch distance

cent: pitch distance between two frequencies

$$\begin{aligned}\Delta C(f_1, f_2) &= 100 \cdot (p(f_1) - p(f_2)) \\ &= 100 \cdot \left(\left(69 + 12 \cdot \log_2 \left(\frac{f_1}{f_{A4}} \right) \right) - \left(69 + 12 \cdot \log_2 \left(\frac{f_2}{f_{A4}} \right) \right) \right) \\ &= 1200 \cdot \log_2 \left(\frac{f_1}{f_2} \right)\end{aligned}$$

\Rightarrow 100 cents span one semitone

musical pitch

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musical pitch

temperament

■ equally tempered scale:

- octave split into 12 equidistant notes (on log scale)
- not key dependent, any modulation possible
- enharmonic equivalence: $C\sharp = D\flat$
- typical scale for keyboard instruments

$$\frac{f_1}{f_2} = 2^{N/12}$$

- ### ■ other scales can sound purer for specific keys but are less commonly used

musical pitch

intonation & vibrato

- **expressive intonation:** deviation of pitch frequency from temperament depending on musical context

- leading tones
- “pure” intervals

- **vibrato**

- periodic modulation around mean pitch
- frequency: app. 4–10 Hz, range: app. 20–300 cents

- applies only to instruments with

- continuous frequency scales (e.g., string instruments, human voice)
- other possibilities to adjust frequency (e.g., wind instruments, fretted string instruments)

musical pitch

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 - continuous frequency scales: vocals, string instruments, trombone, ...
 - other possibilities to adjust frequency: guitar, wind instruments, ...

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summary

lecture content

■ pitch

- each octave split into 12 pitches
- *pitch class* is an octave-independent representation of pitch

■ intervals

- distance between two pitches

■ cent

- metric for pitch distance

