Tonal Organization

Augusto Sarti

Computer Music Representations and Models

M.Sci. Music and Acoustic Engineering

References and readings

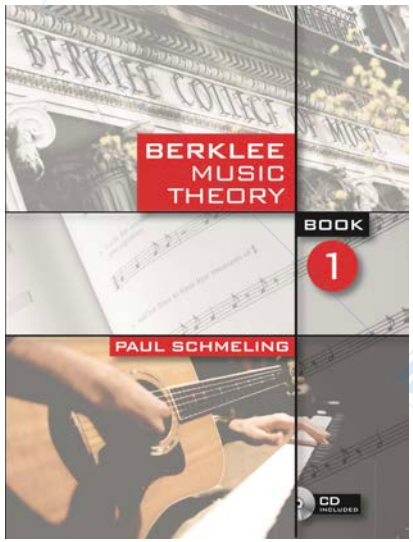
Music Notation and Basics

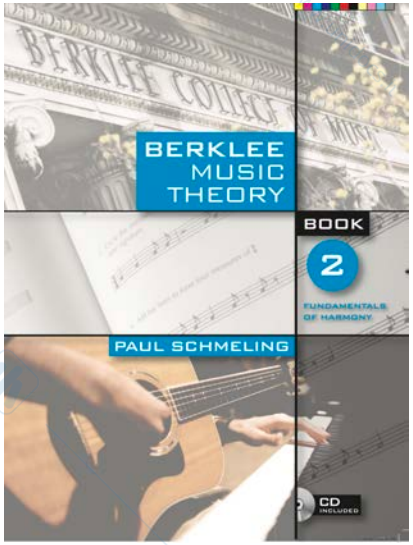
Both units of “Notes and Rhythm” and “Reading Music” are excellent primers for those who don’t have a solid music background

- https://www.khanacademy.org/humanities/music/music-basics2

General Music Overview

- Excellent resources (for those who want to know more of music theory) are
  - P. Schmeling “Berklee Music Theory”, Vol. 1 and 2. Berklee Press.





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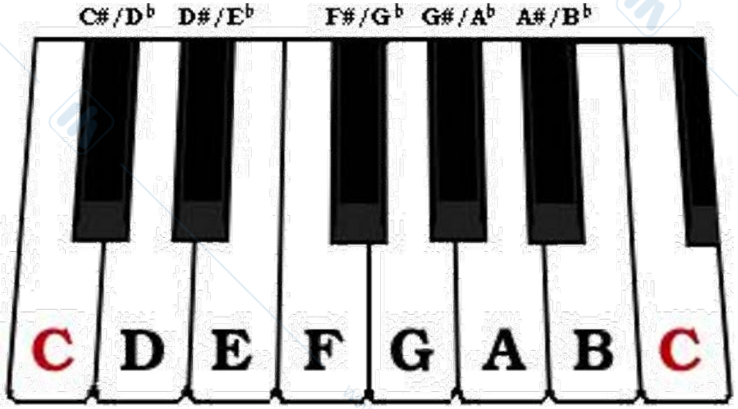
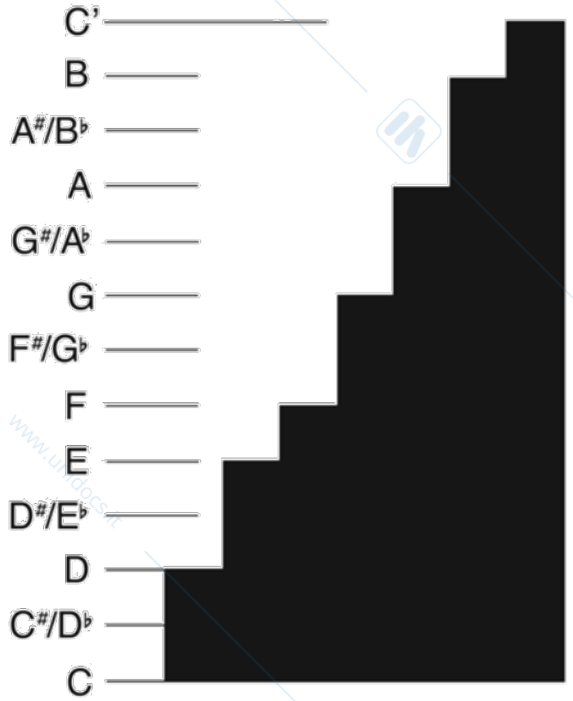
Why this structure?





Pitch progression staircase

Why not this one?

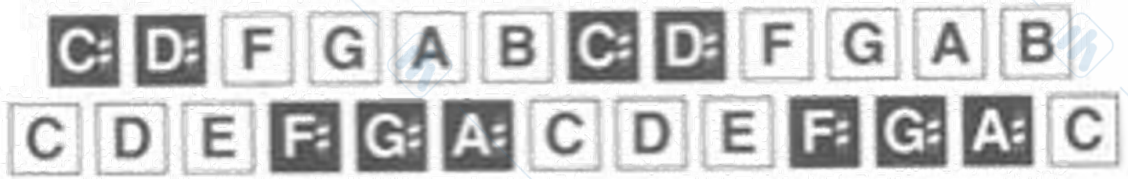
- Stradella button keyboard

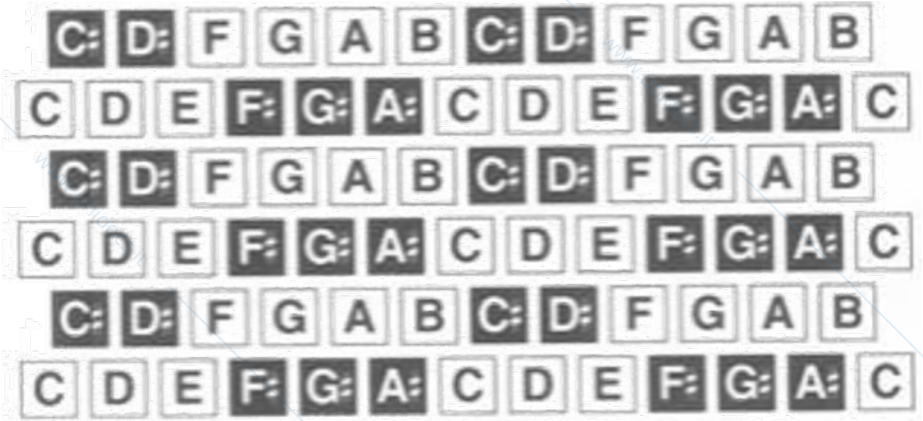
Stradella variations

- **Stradella bass system** (std bass): arranged in a circle of fifths and uses single buttons for bass notes and additional rows of single buttons for preset major, minor, dominant seventh, and diminished chords. The dominant seventh and diminished chords are three-note chord voicings that omit the fifths of the chords
- **Belgian bass system:** variation used in Belgian chromatic accordions. Also arranged in a circle of fifths but in reverse order. Three rows of basses, three rows of chord buttons allowing easier fingering for playing melodies, combined chords, better use of fingers one and five, and more space between the buttons. Rarely used outside of Belgium
- **Various free-bass systems** for greater access to playing melodies and complex basslines on the left-hand manual and to forming one's own chords note-by-note. These are often chosen for playing jazz and classical music. Some models can convert between free-bass and Stradella bass; this is called converter bass. The free-bass left hand notes are arranged chromatically in three rows with one additional duplicate row of buttons

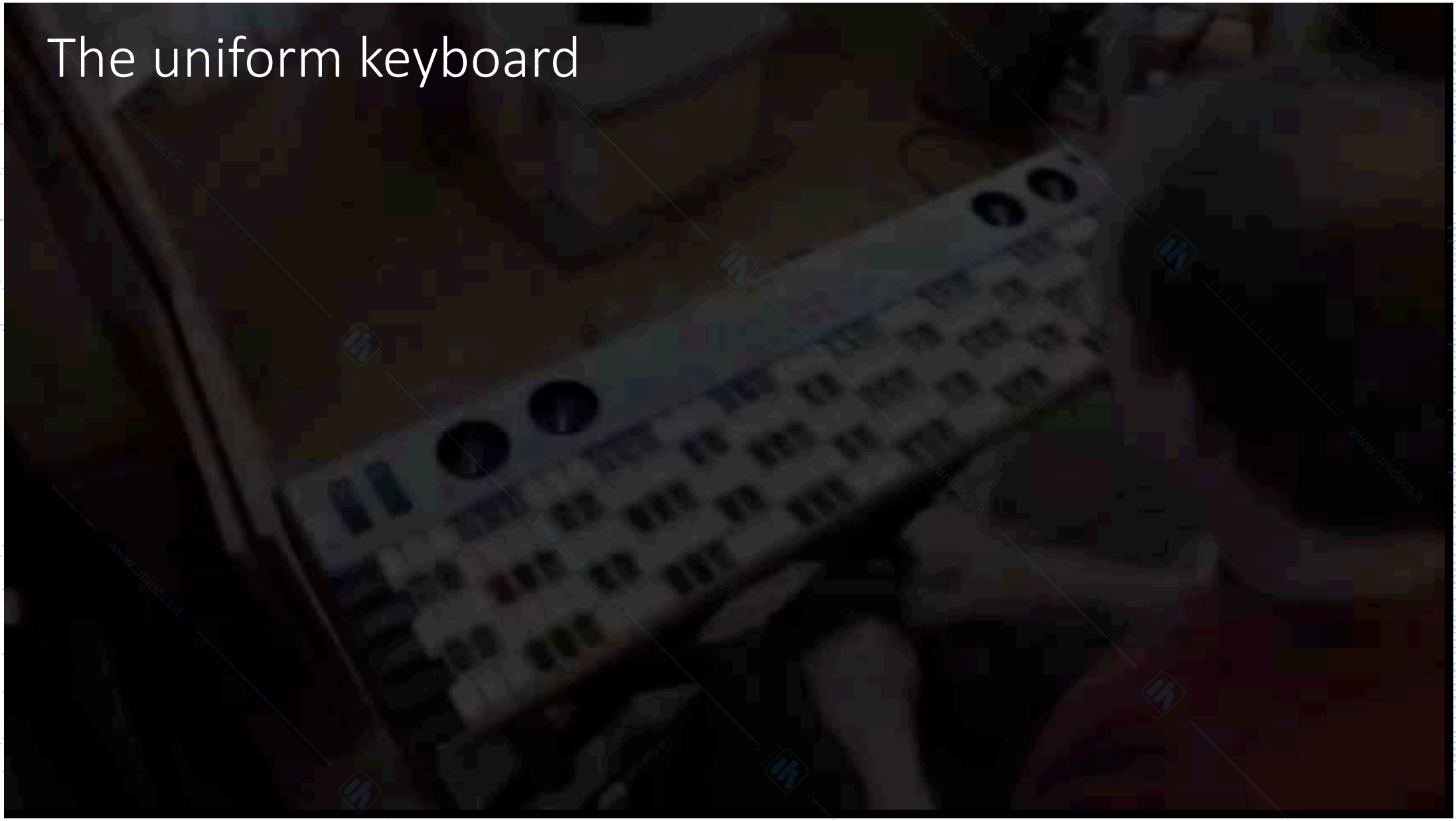
Why not this one?

The uniform keyboard

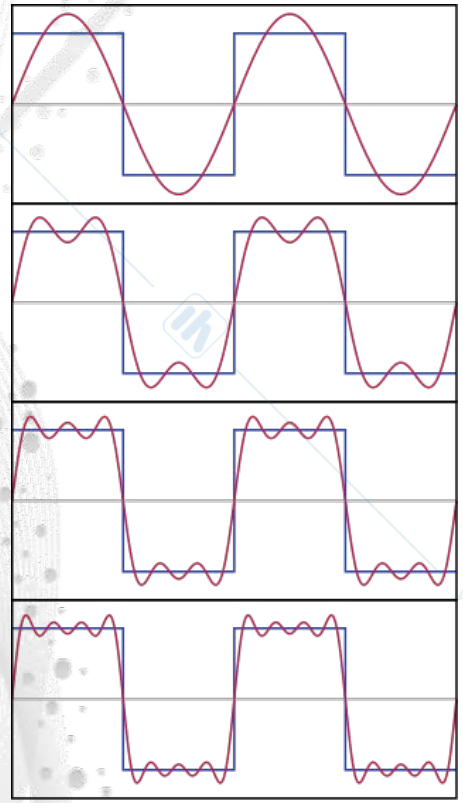




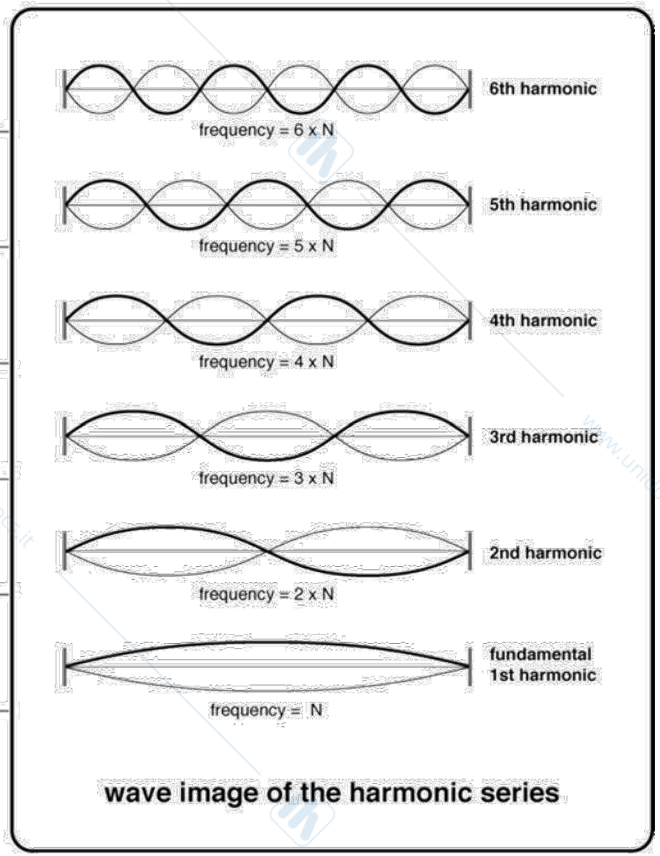
The uniform keyboard



Tonal progression of partials

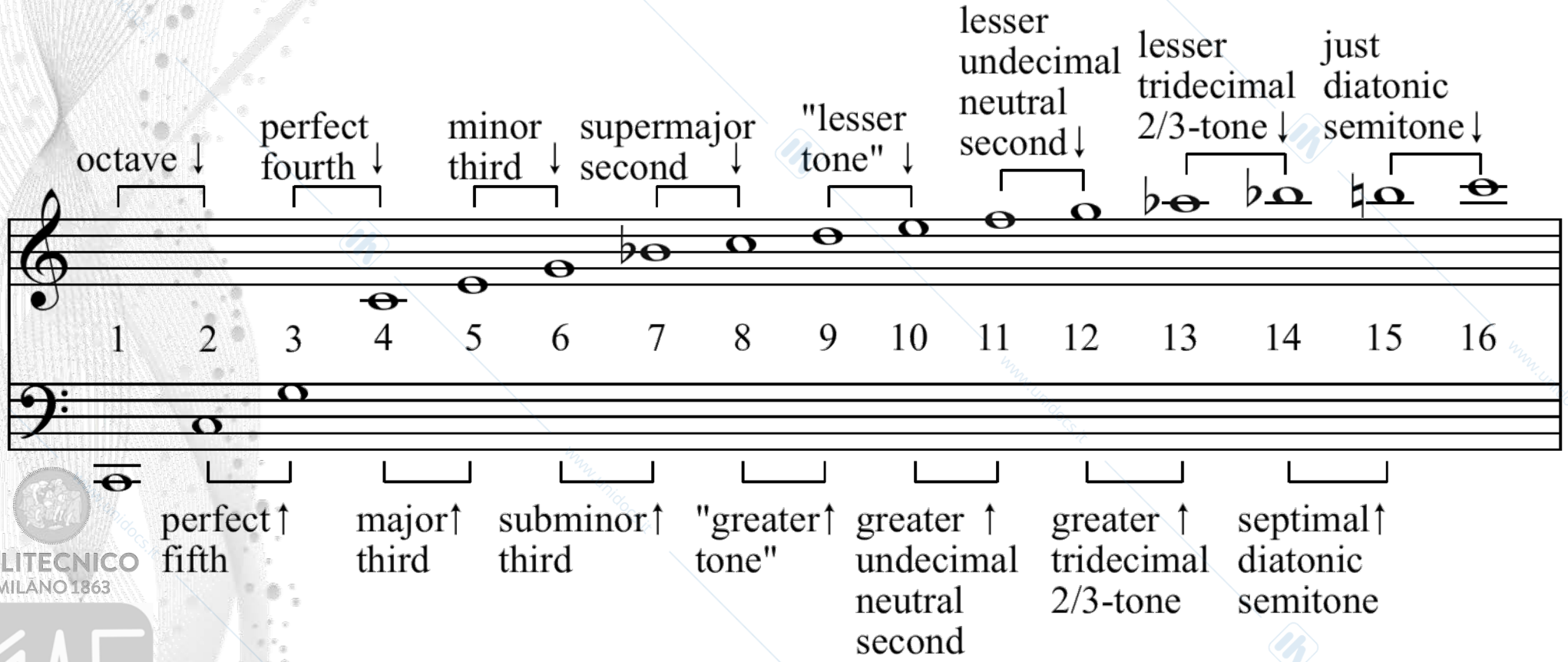


Interval	Tone	Frequency
2nd Perfect Fifth	G_1	1536
Major Third	E	1280
2nd Octave	C_2	1024
Perfect Fifth	G	768
1st Octave	C_1	512
Fundamental	C	256

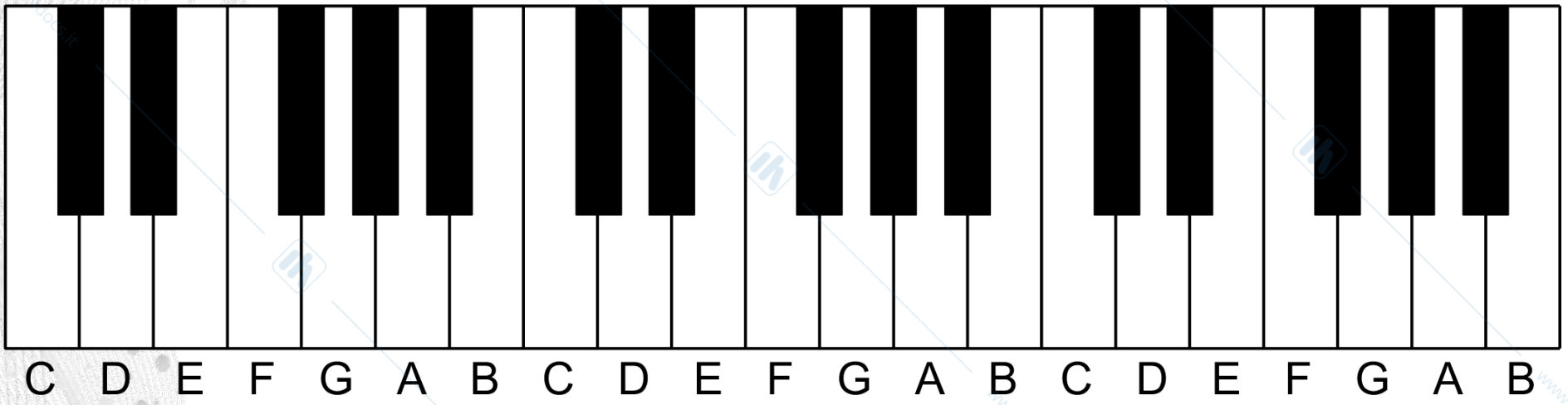


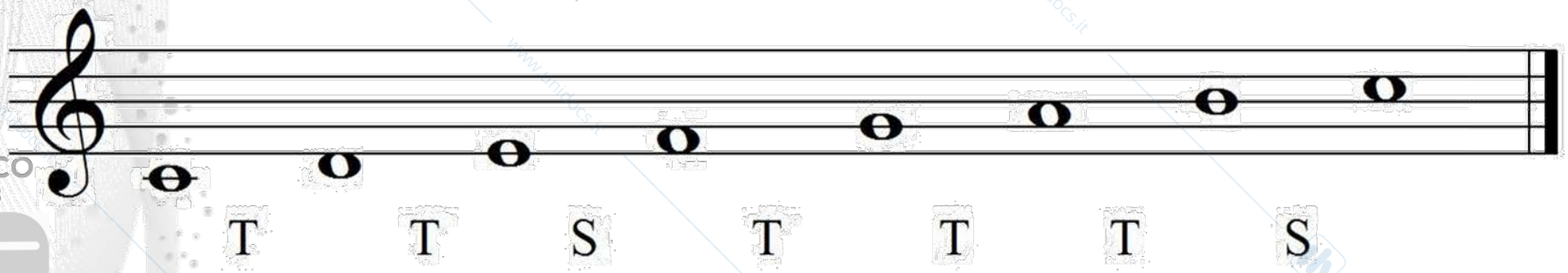
wave image of the harmonic series

Tonal progression of partials



Ionian keyboard – in order of relevance

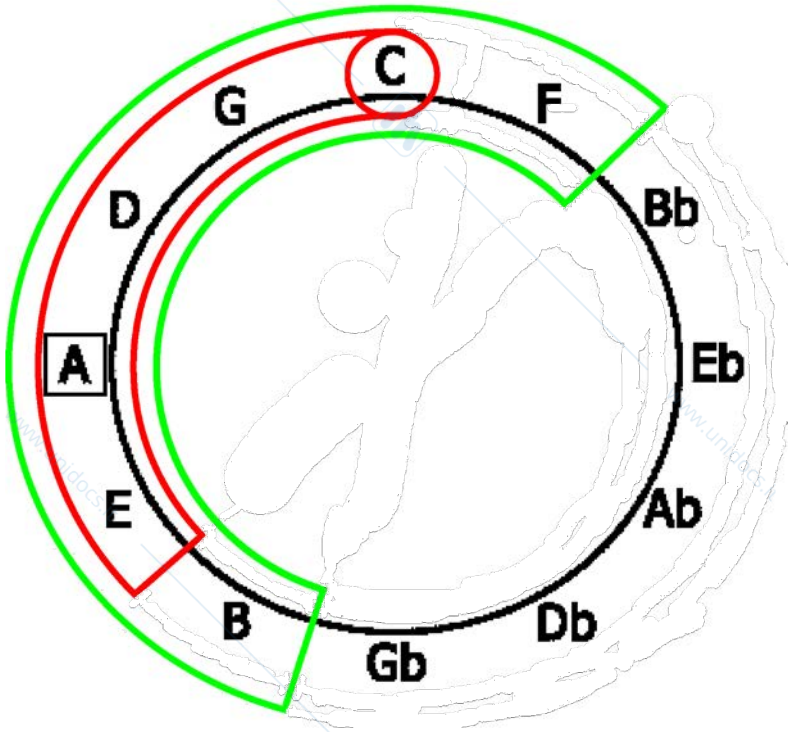




Ionian scale

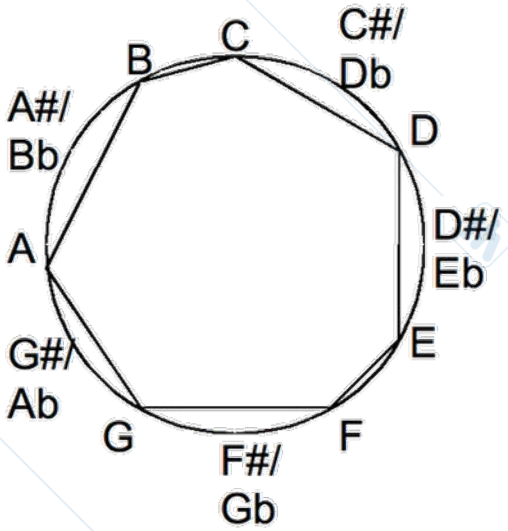
Ionian keyboard

- A different interpretation of white notes choice: the seven pitches of a diatonic (ionian) scale are obtained by using a chain of six perfect fifths
  - The seven natural pitches that form the C-major (ionian) scale can be obtained from a stack of perfect fifths starting from F
  - F—C—G—D—A—E—B

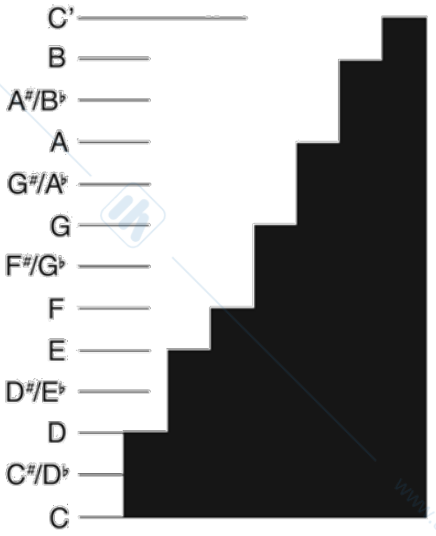


Counting the steps (on the log-frequency axis)

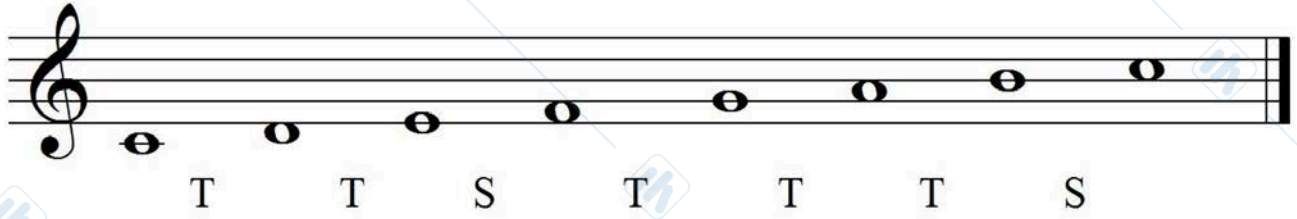
An irregular polygon in the chromatic circle



An irregular staircase

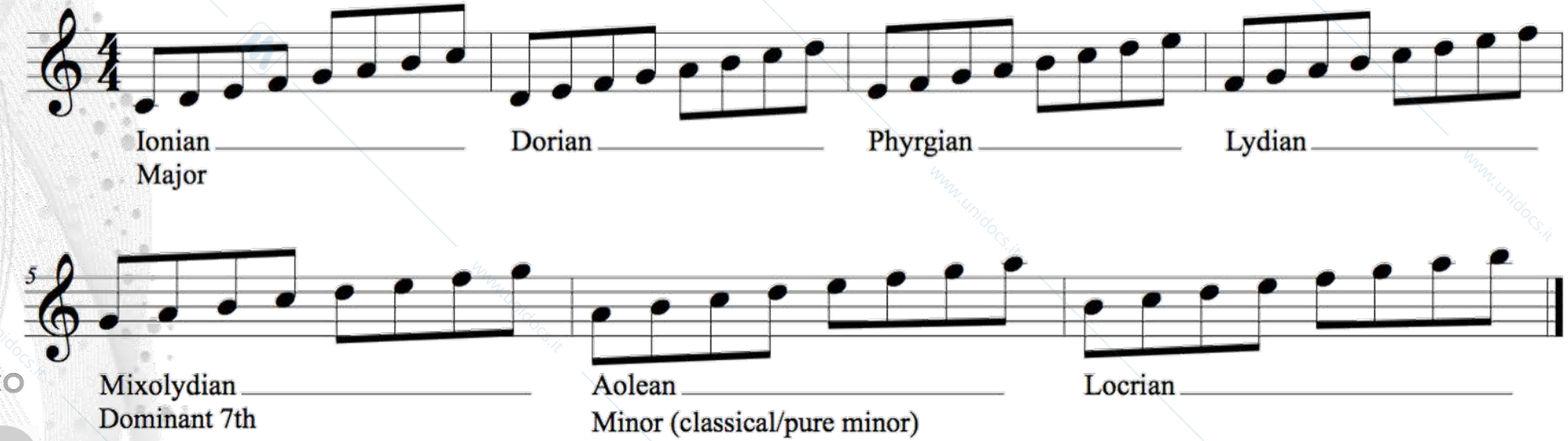


	0	1	2	3	4	5	6	7	8	9	10	11	
Ionian	1	0	1	0	1	1	0	1	0	1	0	1	Major



Translational transformations within the ionian scale

If play the ionian scale starting every time from a different note we obtain «Church» Modes (modal scales), which are characterized by different distributions of irregular intervals

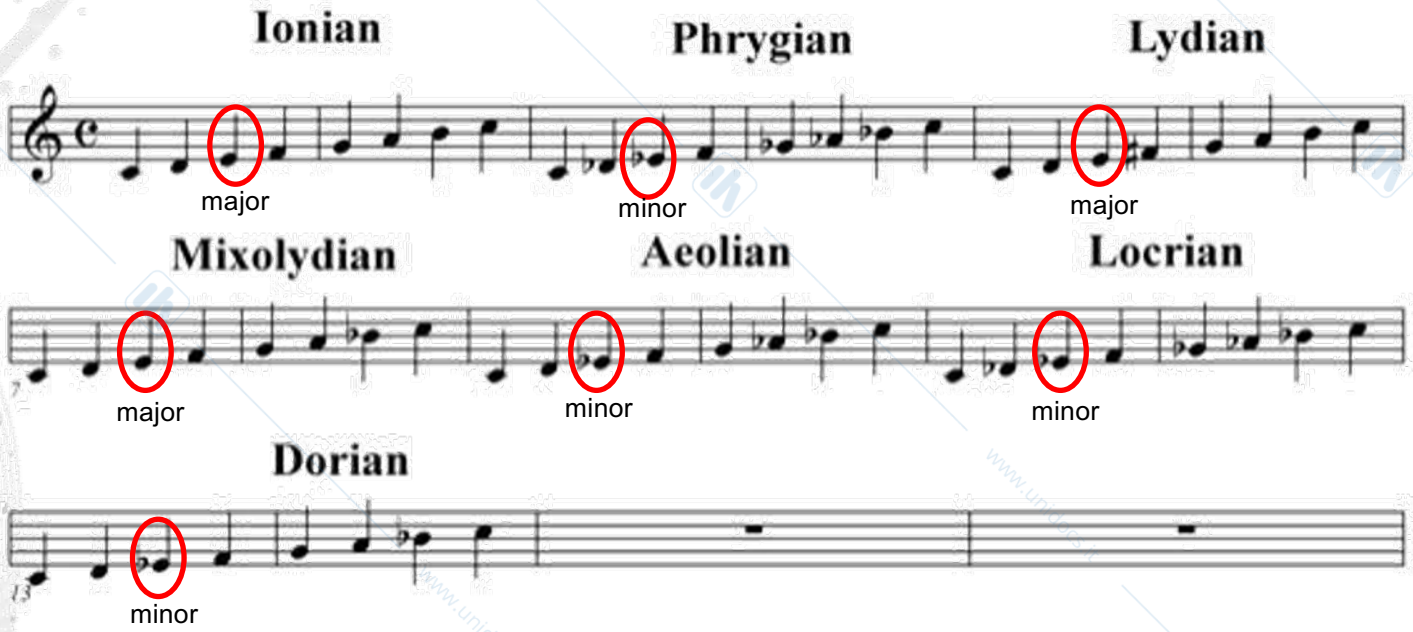


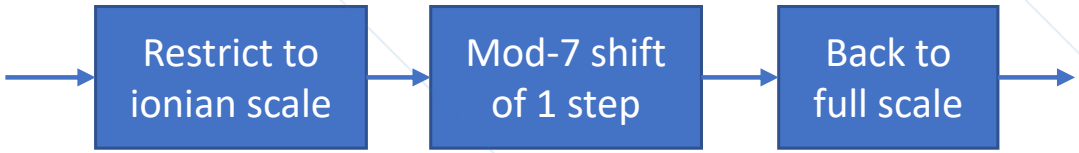
Translational transformations seen as bit rotations

	0	1	2	3	4	5	6	7	8	9	10	11	
Ionian	1	0	1	0	1	1	0	1	0	1	0	1	Major
Dorian	1	0	1	1	0	1	0	1	0	1	1	0	Minor
Phrygian	1	1	0	1	0	1	0	1	1	0	1	0	Minor
Lydian	1	0	1	0	1	0	1	1	0	1	0	1	Major
Myxolydian	1	0	1	0	1	1	0	1	0	1	1	0	Major
Aeolian	1	0	1	1	0	1	0	1	1	0	1	0	Minor
Locrian	1	1	0	1	0	1	1	0	1	0	1	0	Minor
Ionian	1	0	1	0	1	1	0	1	0	1	0	1	Major

What decides whether it is minor or major?

Shift back to tonal reference





Reordered from brightest to darkest

	0	1	2	3	4	5	6	7	8	9	10	11	
Lydian	1	0	1	0	1	0	1	1	0	1	0	1	Major
Ionian	1	0	1	0	1	1	0	1	0	1	0	1	Major
Myxolydian	1	0	1	0	1	1	0	1	0	1	1	0	Major
Dorian	1	0	1	1	0	1	0	1	0	1	1	0	Minor
Aeolian	1	0	1	1	0	1	0	1	1	0	1	0	Minor
Phrygian	1	1	0	1	0	1	0	1	1	0	1	0	Minor
Locrian	1	1	0	1	0	1	1	0	1	0	1	0	Minor

Hamming distance = 2 from one scale to next
(move location of 1 note)

Take every other note in a 7-note scale…

	0	1	2	3	4	5	6	7	8	9	10	11	
Lydian	**1**	0	1	0	**1**	0	1	**1**	0	1	0	**1**	Major
Ionian	**1**	0	1	0	**1**	1	0	**1**	0	1	0	**1**	Major
Maj	**1**	0	0	0	**1**	0	0	**1**	0	0	0	**1**	Major
Dorian	**1**	0	1	**1**	0	1	0	**1**	0	1	**1**	0	Minor
Phrygian	**1**	1	0	**1**	0	1	0	**1**	1	0	**1**	0	Minor
min7	**1**	0	0	**1**	0	0	0	**1**	0	0	**1**	0	Minor

…and you get chords

one chord may fit several scales

Other scales (not necessarily of 7 notes)

	0	1	2	3	4	5	6	7	8	9	10	11	
Chromatic	1	1	1	1	1	1	1	1	1	1	1	1	-
Pentatonic	1	0	1	0	1	0	0	1	0	1	0	0	Major
Blues	1	0	0	0	1	0	1	1	1	0	1	0	Major
Exatonic	1	0	1	0	1	0	1	0	1	0	1	0	-

4096 different scales!

Other scales (not necessarily of 7 notes)

Scales are often described according to the number of different pitch classes they contain:

- **Chromatic**, or dodecatonic (12 notes per octave)
- **Octatonic** (8 notes per octave): used in jazz and modern classical music
- **Heptatonic** (7 notes per octave): the most common modern Western scale
- **Hexatonic** (6 notes per octave): common in Western folk music
- **Pentatonic** (5 notes per octave): the anhemitonic form (lacking semitones) is common in folk music, especially in Asian music; also known as the "black note" scale
- **Tetratonic** (4 notes), **Tritonic** (3 notes), and **Ditonic** (2 notes): generally limited to primitive music

Scales in western music

- They generally consist of seven notes
- They are most often separated by whole-step and half-step intervals
  - The harmonic minor scale includes a three-semitone step;
  - the anhemitonic pentatonic includes two of those and no semitones.
- Western music in the Medieval and Renaissance periods (1100–1600) tends to use the white-note diatonic scale C–D–E–F–G–A–B
  - The seventh note (B) is used less often
  - Accidentals are rare, and somewhat unsystematically used, often to avoid the tritone

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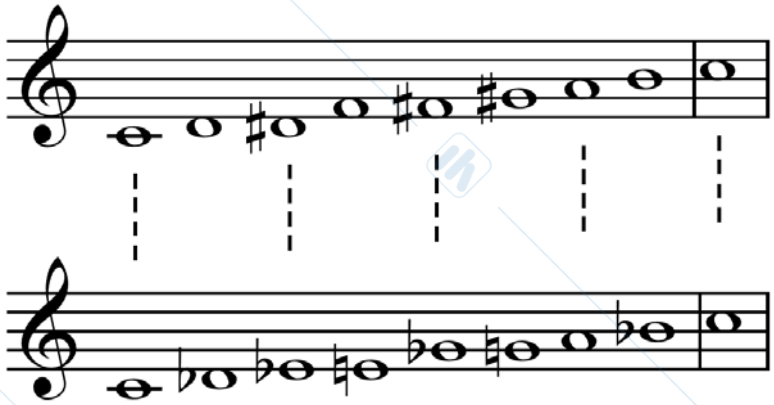
Examples of octatonic scale

- The scale most often meant by this term is one in which the notes ascend in **alternating intervals of a whole step and a half step**, creating a symmetric scale
- In classical theory, in contradistinction to jazz theory, this scale is commonly simply called the octatonic scale (or octatonic collection), although there are in total forty-two non-enharmonically equivalent, non-transpositionally equivalent eight-tone sets possible



Change scale… change mood…

from ionian…

…to aeolian

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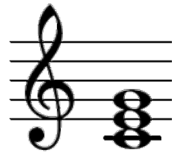
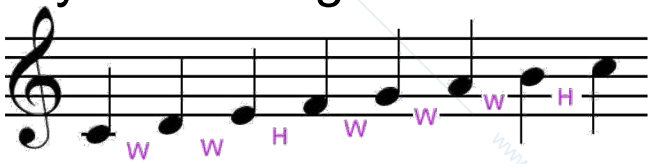
An aerial view

1. Chord: group of notes usually played at the same time



Major Minor Major7 Minor7 Dominant7 Semidiminished Diminished

2. Scale: monotonically increasing or decreasing tonal sequence of musical notes



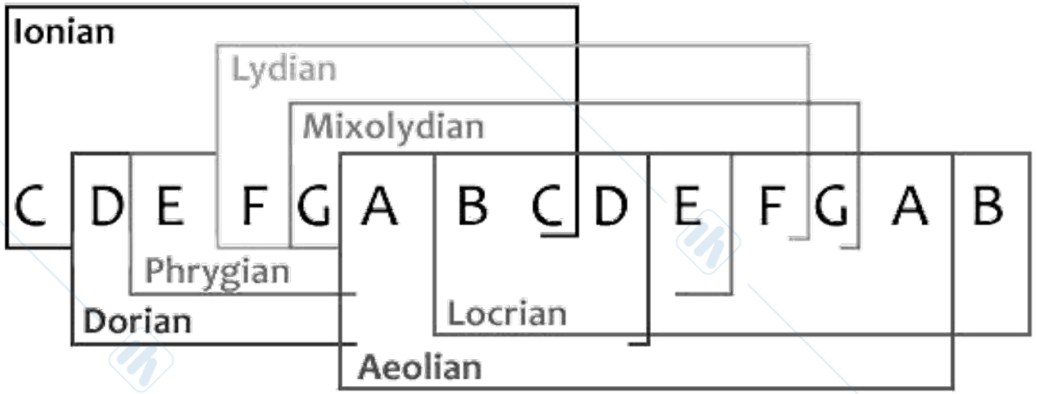
3. Modal scale: a scale generated from a “mother scale” by selecting a different starting point

Examples

Ionian

Dorian

Phrigian



An aerial view

4. Harmonic progression:

- sequence of chords.
  One of the fundamental structural pillars of musical forms

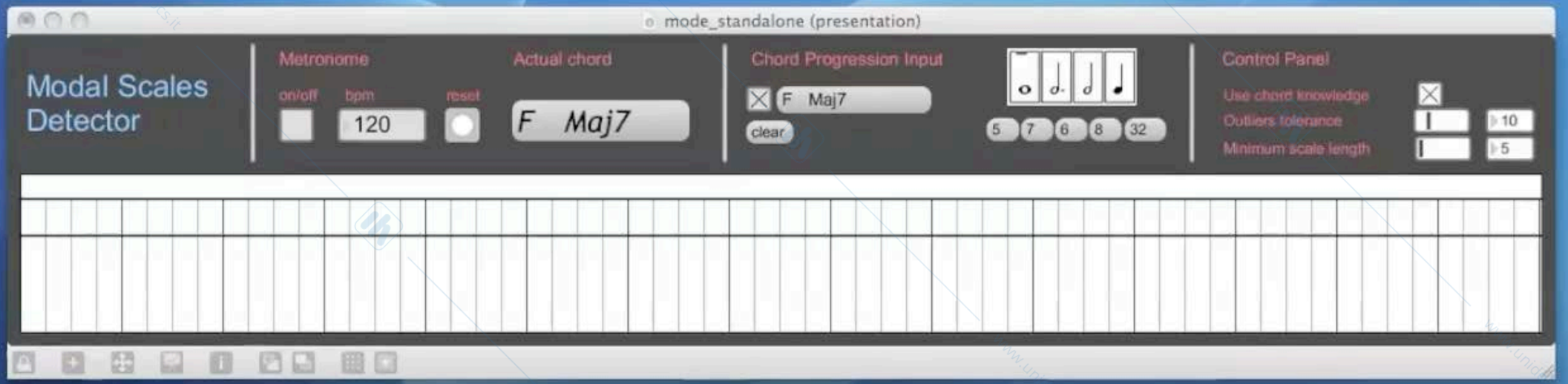
5. Relation btw chords and scales

- chords are obtained through 2:1 subsampling of modal scales or other scales whose intervals are do not exceed 2 H-T
- Different scales can be subsampled to the same chords

Maj7	**Min7**	**Dom7**
Ionian	Dorian	Mixolydian
Lydian	Eolian	Lydian b7
Pentatonic	Phrigian	Superlocrian
. . .	. . .	. . .

Scale adaptation

https://www.dropbox.com/s/clzwbjhg0716qw1/scale_adaptation.mov?dl=0



Modes and patterns

Melodic lines and patterns are often developed on a sequence of scales

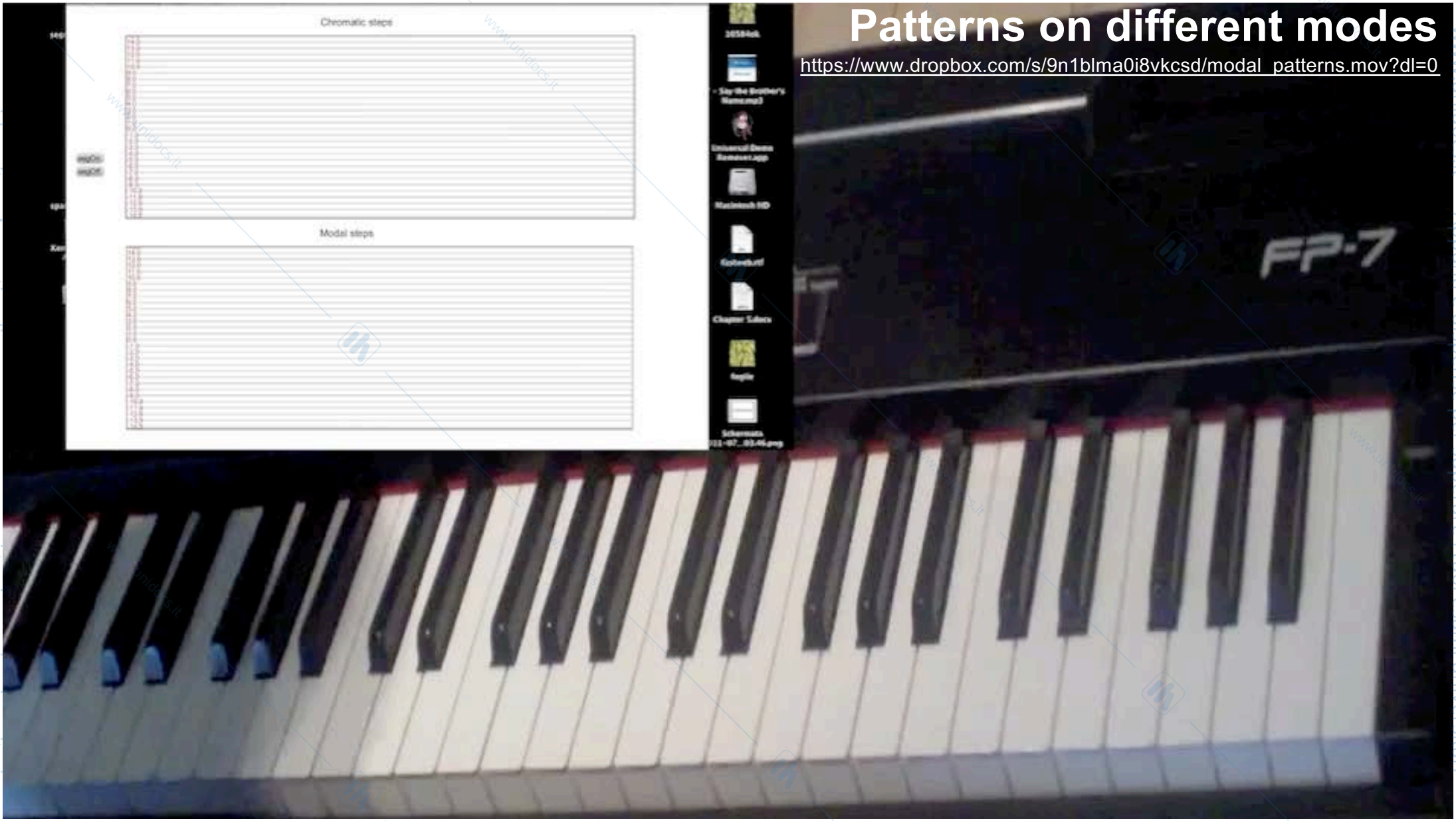
Example **Cm7:** *C Eb D F Eb G F A G Bb A C Bb D C*

Sequence of interval distances in half-tones:

+3, -1, +3, -2, +4, -2, +4, -2, +3, -1, +3, -2, +4, -2

Sequence of interval distances in **C Dorian** scale

+2, -1, +2, -1, +2, -1, +2, -1, +2, -1, +2, -1, +2, -1



Patterns on different modes

https://www.dropbox.com/s/9n1blma0i8vkcsd/modal_patterns.mov?dl=0