Digital Musicology 2022
Tutorials

Assignment 2: Pitch and keys

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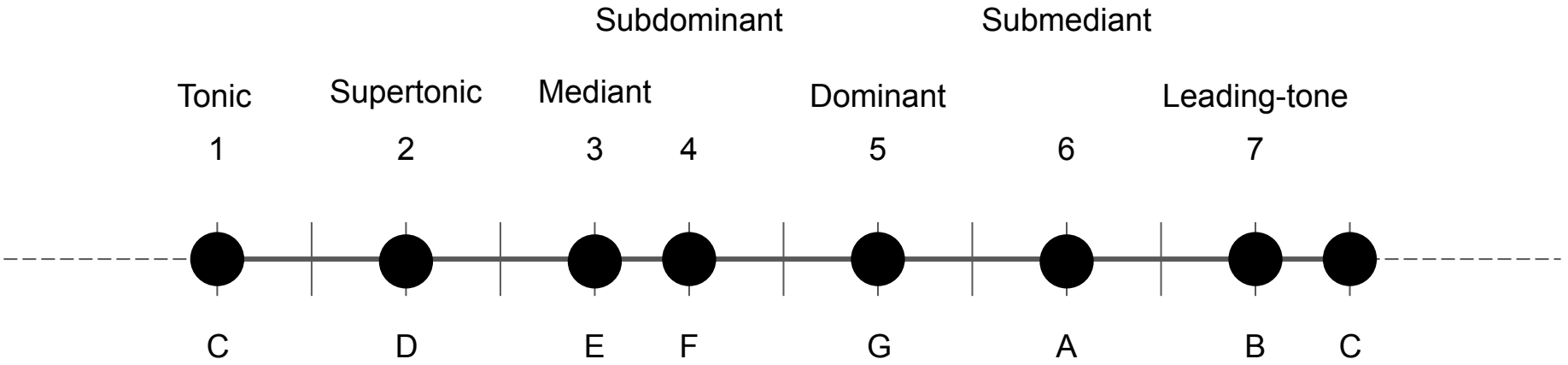
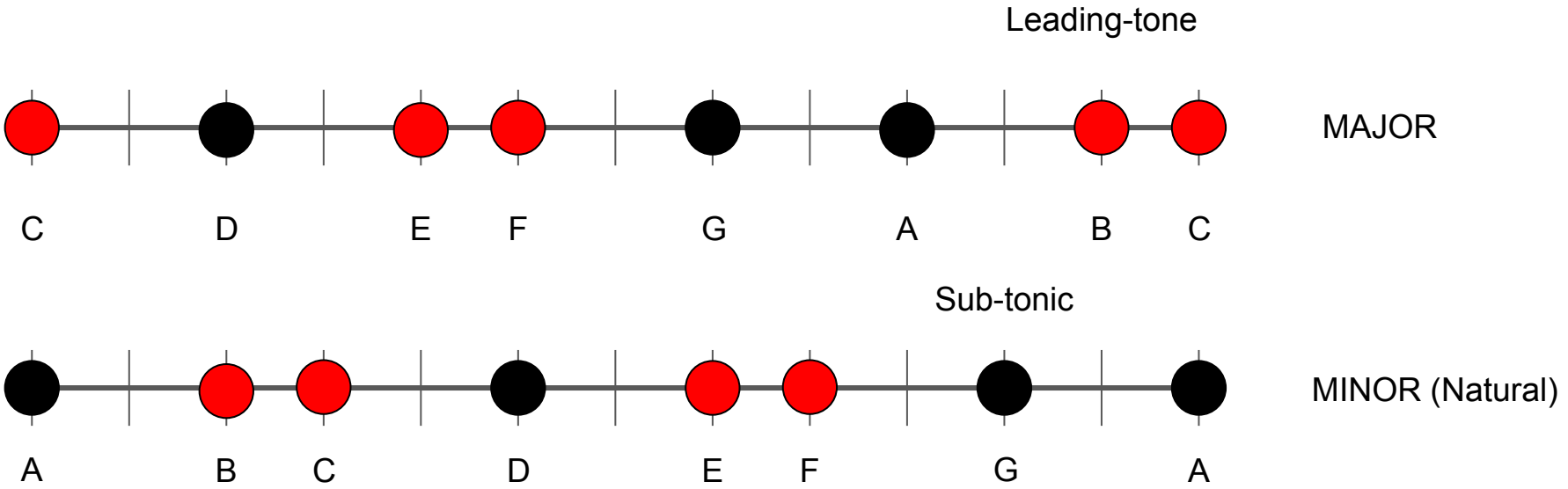
Deliverables

- Due date: 06.04, 12h
- Deliverables:
  - **Code:** A Jupyter Notebook
  - **Report:** A short report (max. 2 pages) as a Word document or other text file
- Submission:
  - Store your data, code and report in your group’s private GitHub repository (shared with the team members and the TAs). Make sure your notebook is pushed with all output visible, i.e., in a form whereby we do not need to run the code.

Diatonic scale

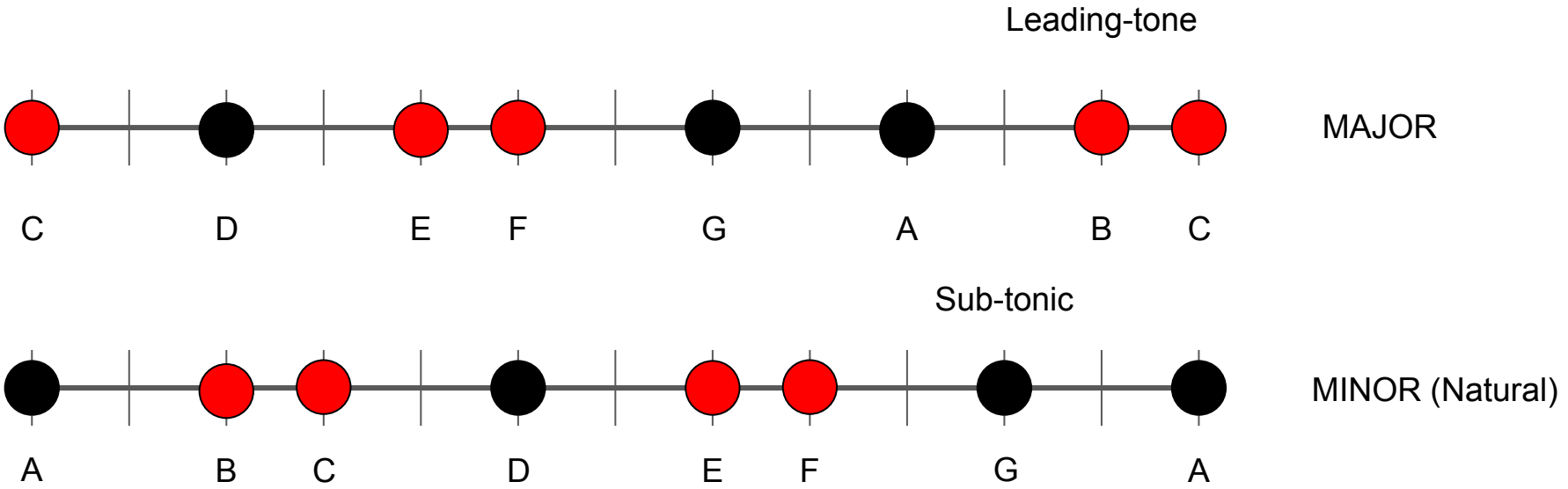


Major and minor modes



WWHWWWH vs. WHWWHWW

Major and minor modes



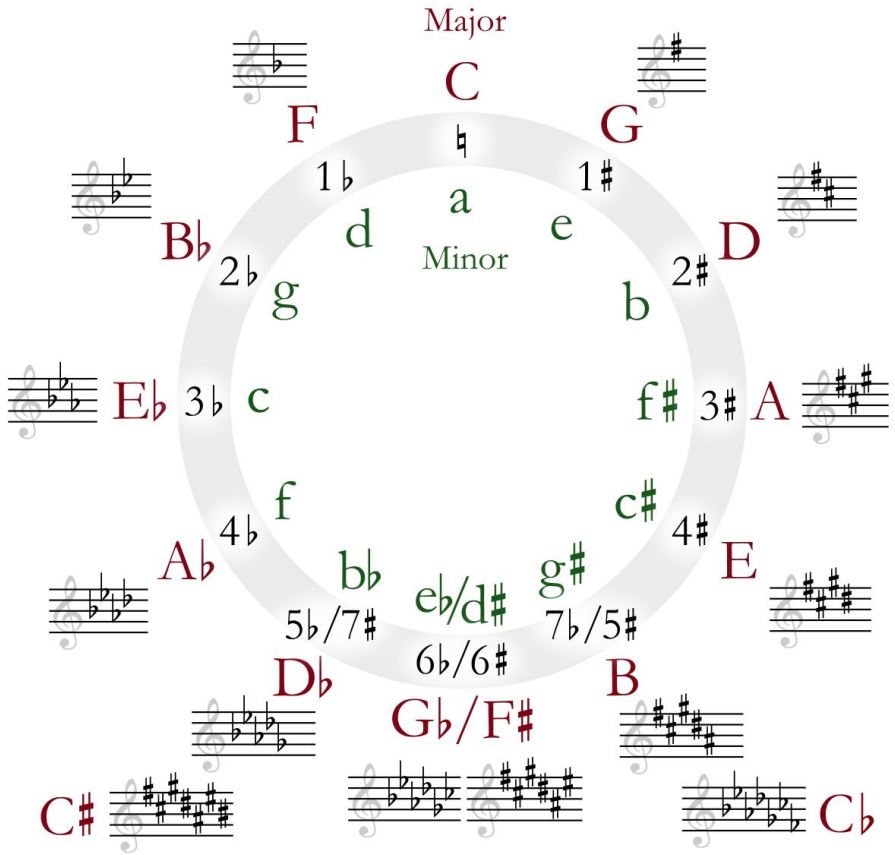
minor mode often comes with alterations:
e.g., #7 (harmonic), #6 & #7 (melodic)

Major and minor keys

- The two prototypes for major and minor modes can be transposed to different tonics → keys

- Each key is identified by:
  - tonic
  - major or minor

- The task requires to infer the tonic and whether the key is major or minor

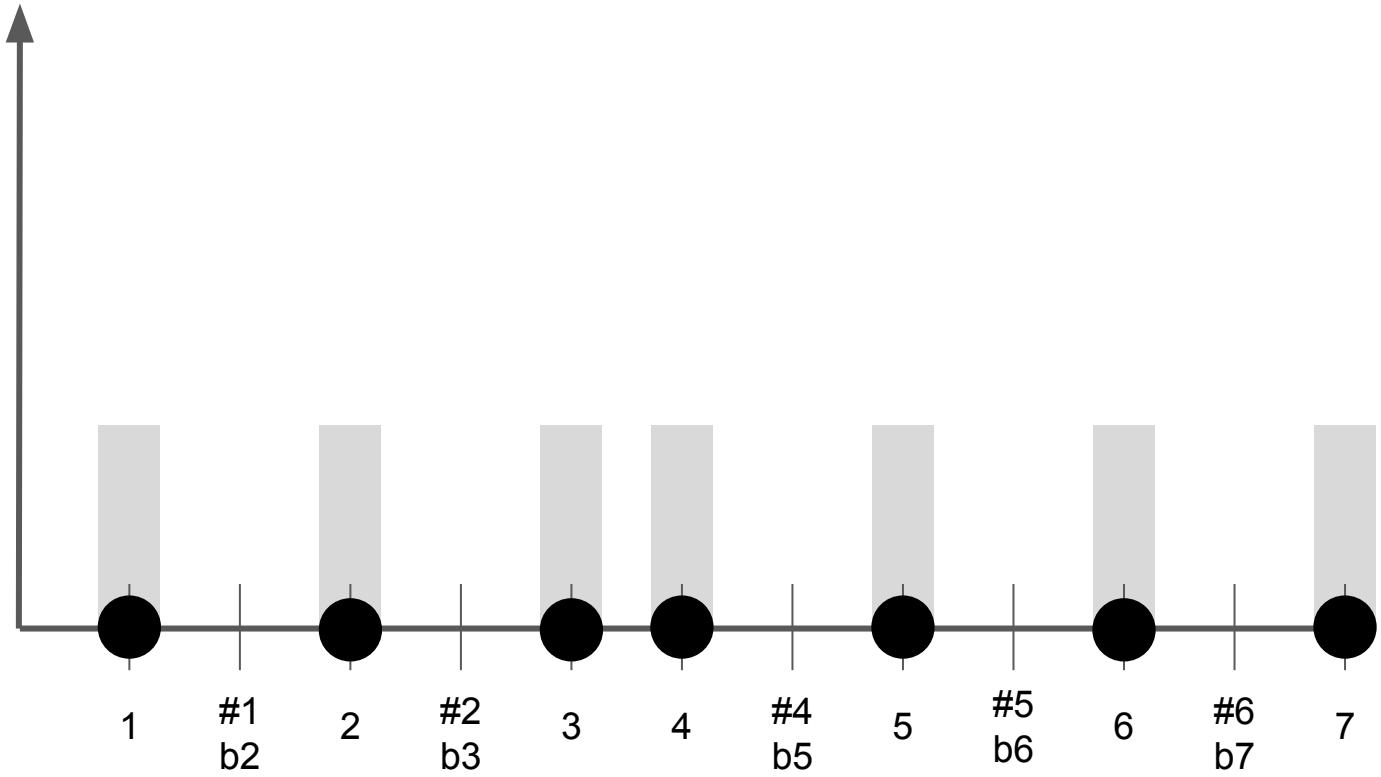


https://youtu.be/O43EBVnwNvo?t=299

Modes

- **Scale:** specifies an alphabet as an (ordered) set of pitch (classes)

Importance: notes of the scale

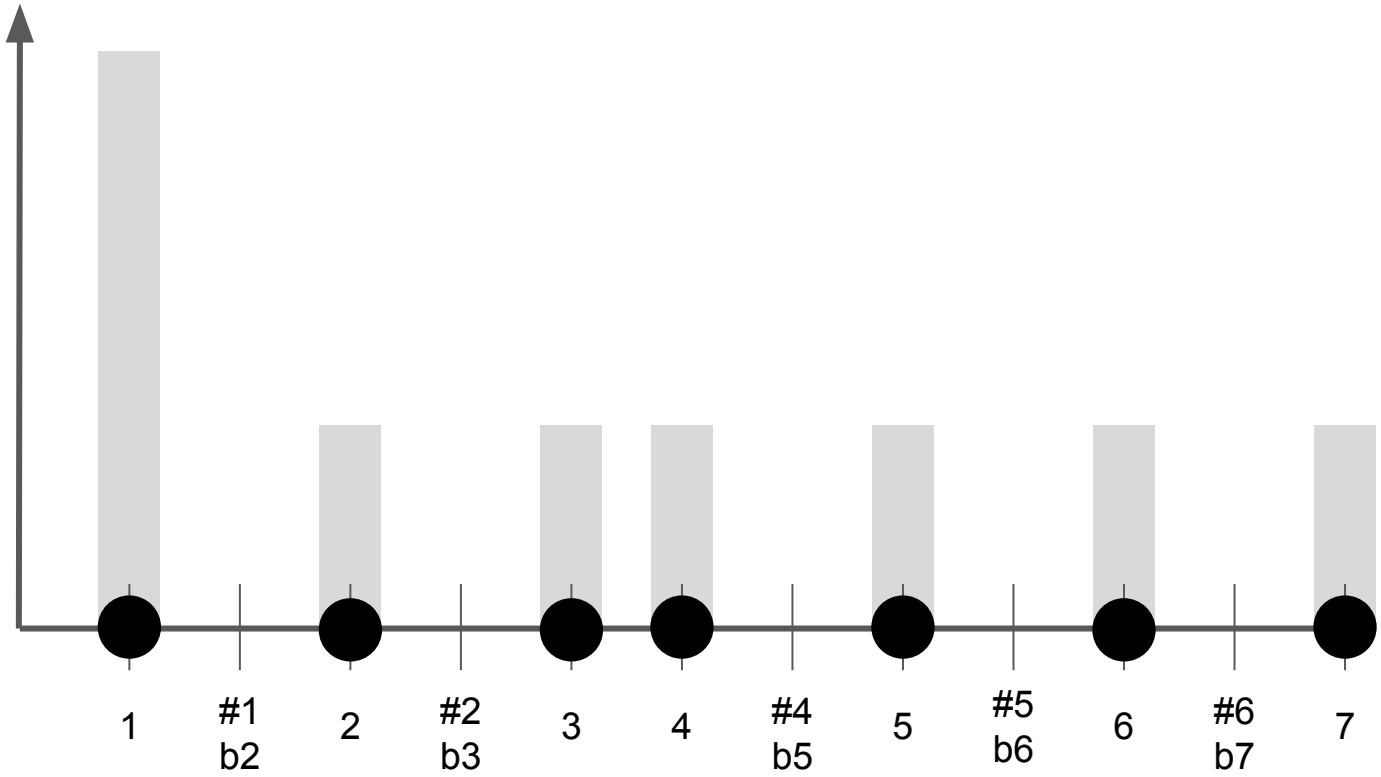


Modes

- **Scale:** specifies an alphabet as an (ordered) set of pitch (classes)

- **Tonic:** specifies one of the notes of the scale as the reference note

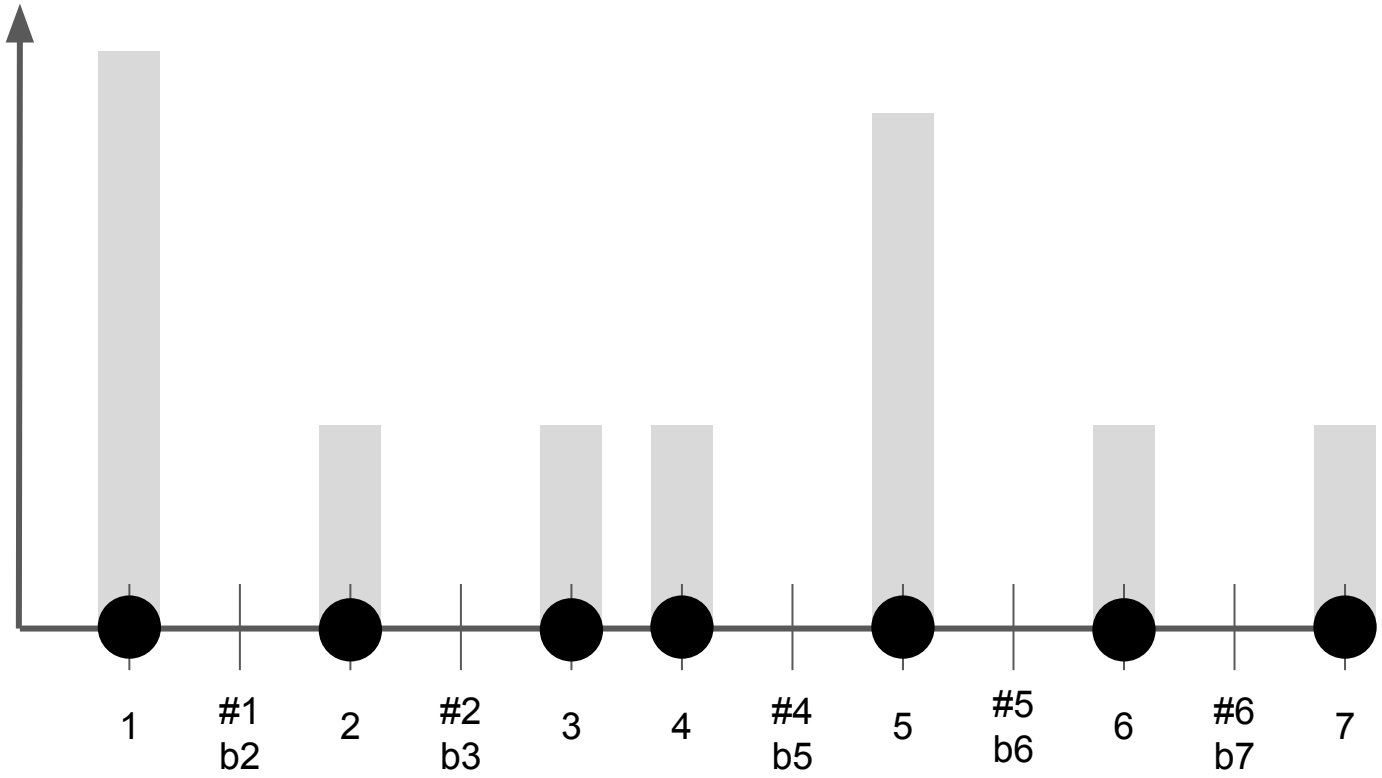
Importance: tonic



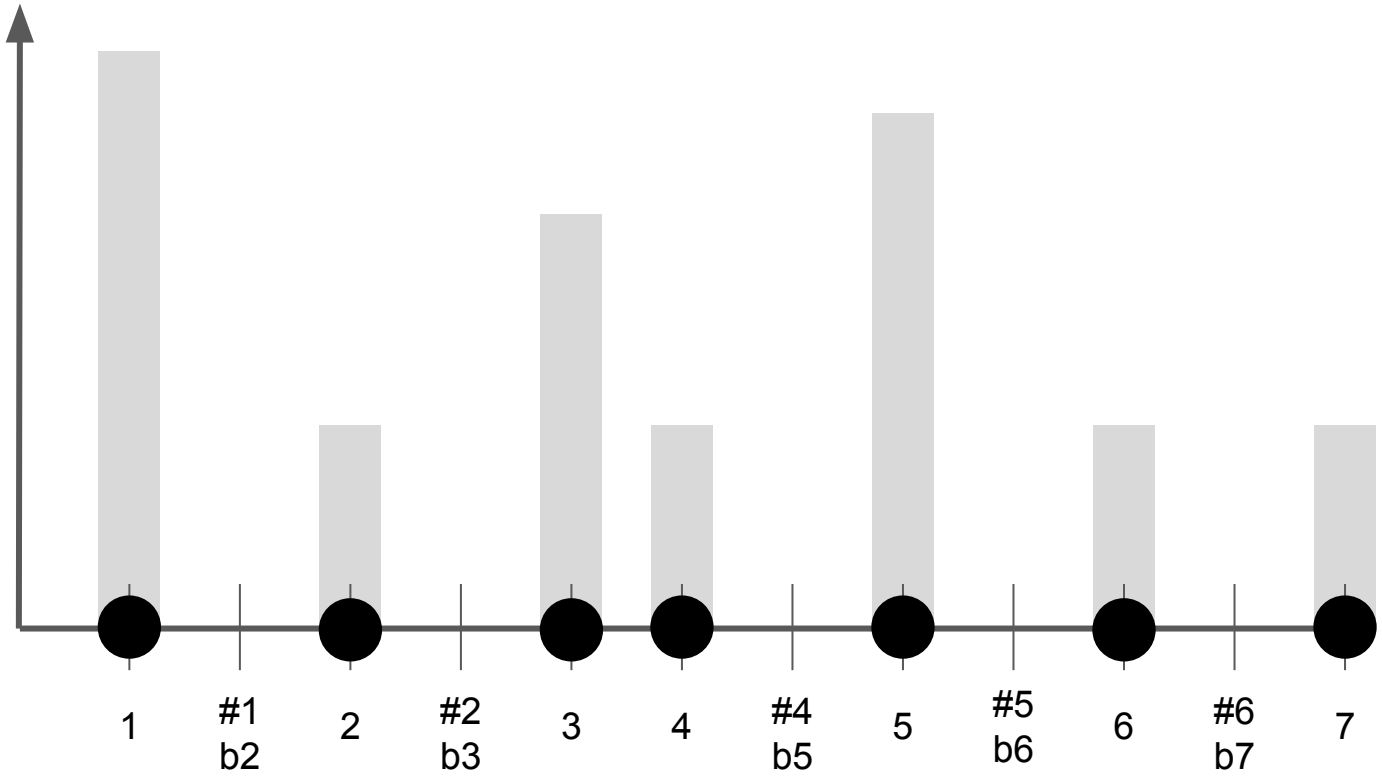
Modes

- **Scale:** specifies an alphabet as an (ordered) set of pitch (classes)
- **Tonic:** specifies one of the notes of the scale as the reference note
- **Hierarchy:** notes of the scale have different degrees of stability or importance

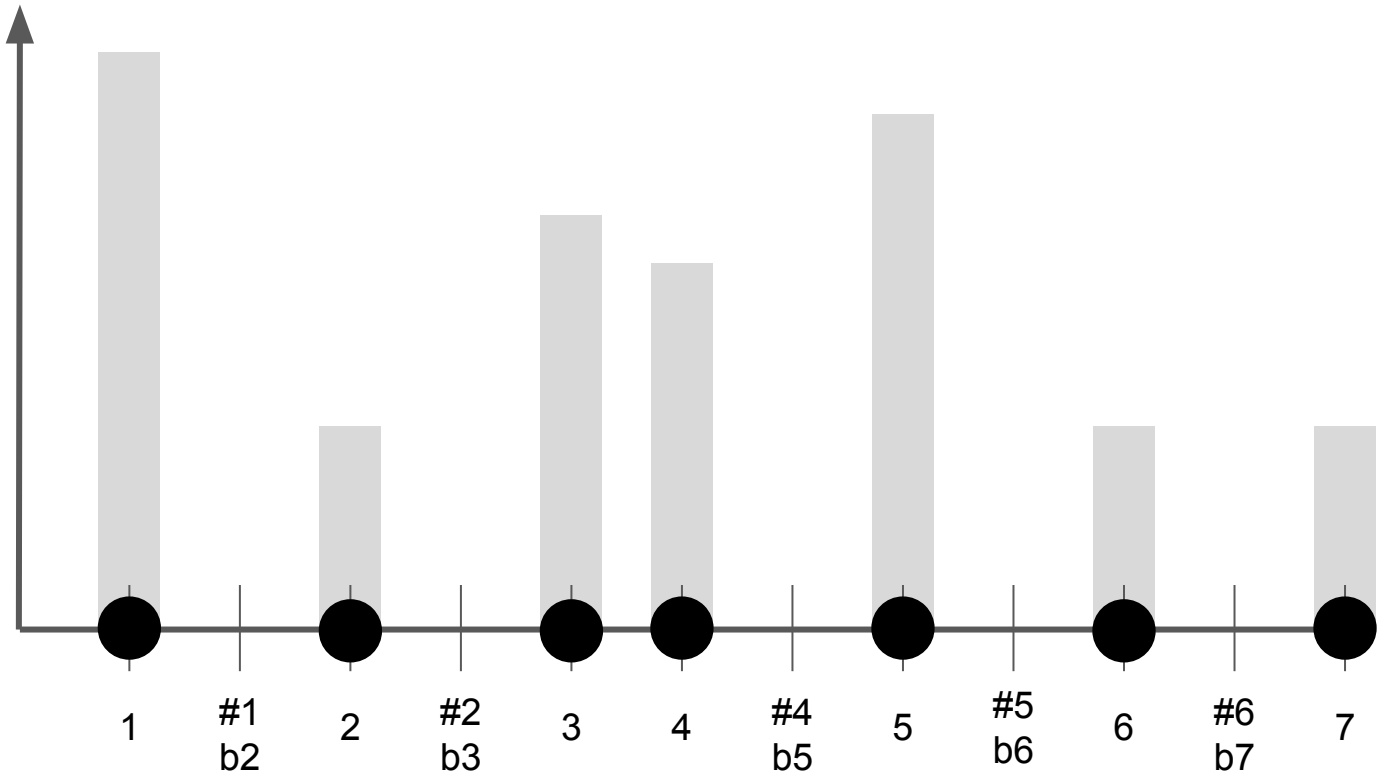
Importance: dominant



Importance: mediant (major)



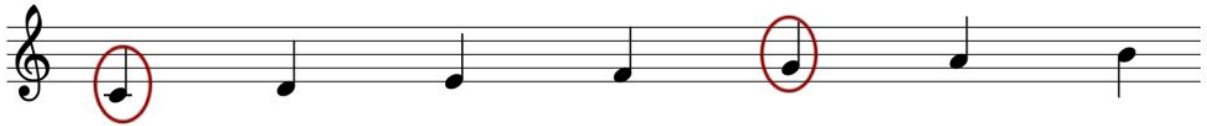
Importance: subdominant



Hierarchy of importance

A mode is associated with a distribution of importance over pitches/pitch-classes

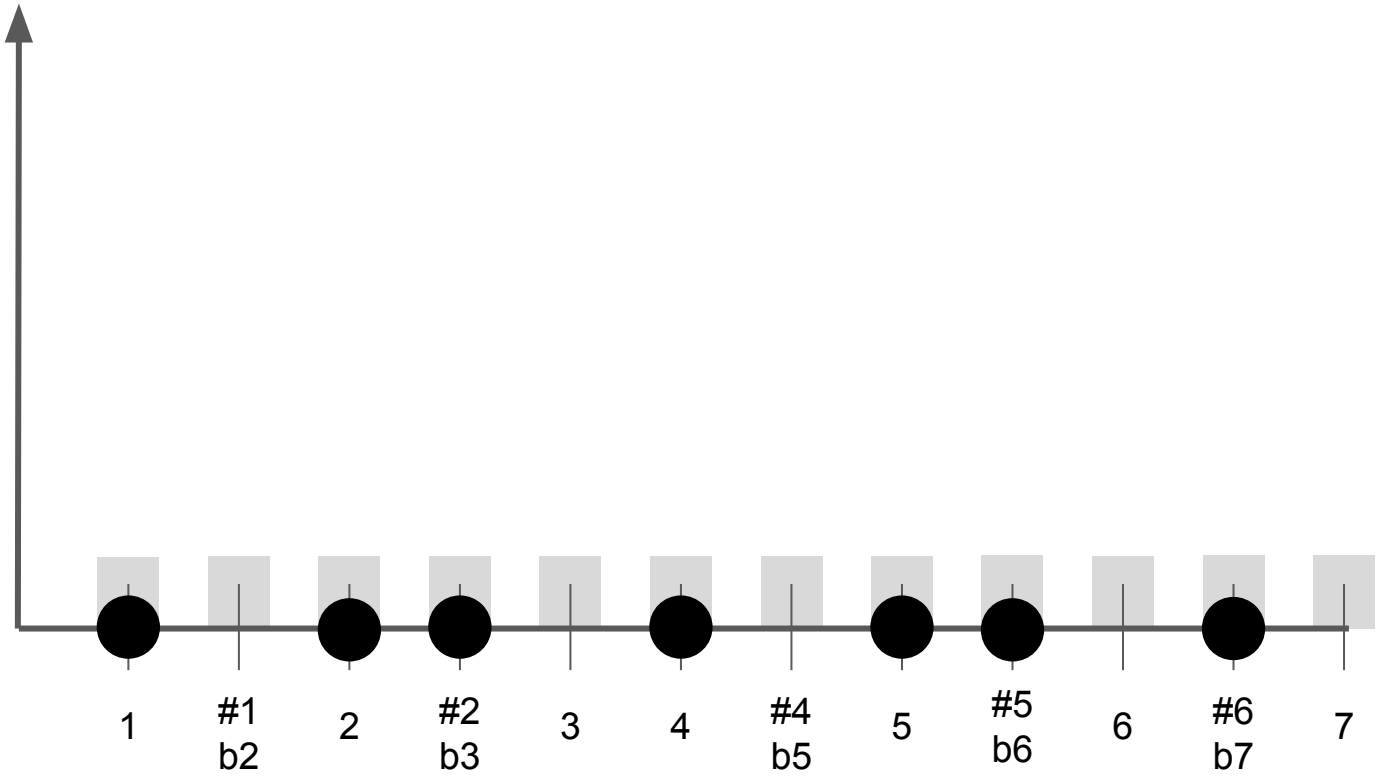
Level a	(tonic):	1											
Level b	(dominant):	1							5				
Level c	(tonic triad):	1				3			5				
Level d	(diatonic):	1		2		3		4	5		6		7
Level e	(chromatic):	1	#1	2	#2	3		4	#4	5	#5	6	b7	7



Common naming conventions for the diatonic scale degrees:

tonic, supertonic, mediant, subdominant, dominant, submediant, leading tone

Hierarchy (minor)



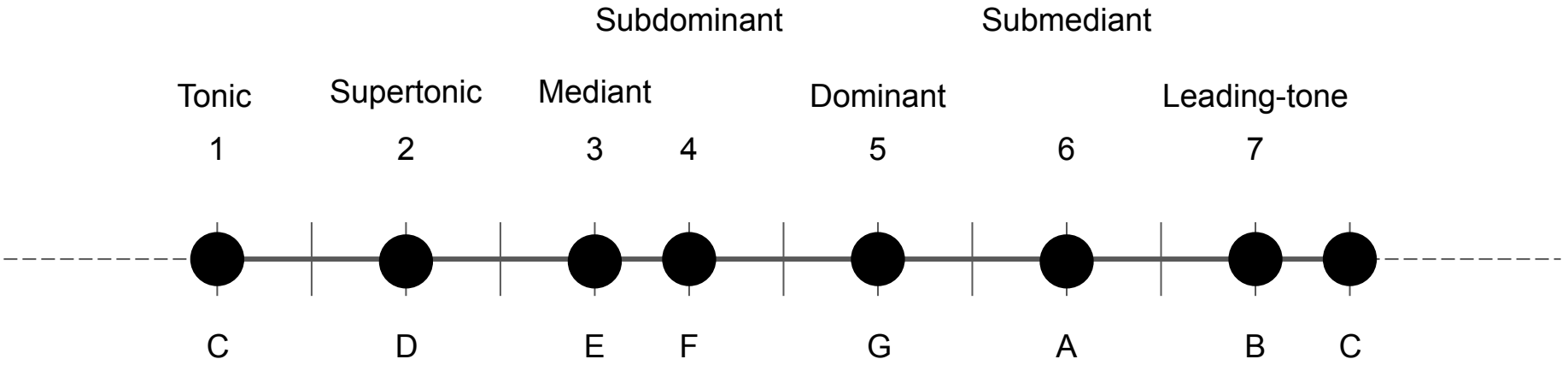
Modes

- **Scale:** specifies an alphabet as an (ordered) set of pitch (classes)
- **Tonic:** specifies one of the notes of the scale as the reference note
- **Hierarchy:** notes of the scale have different degrees of stability or importance

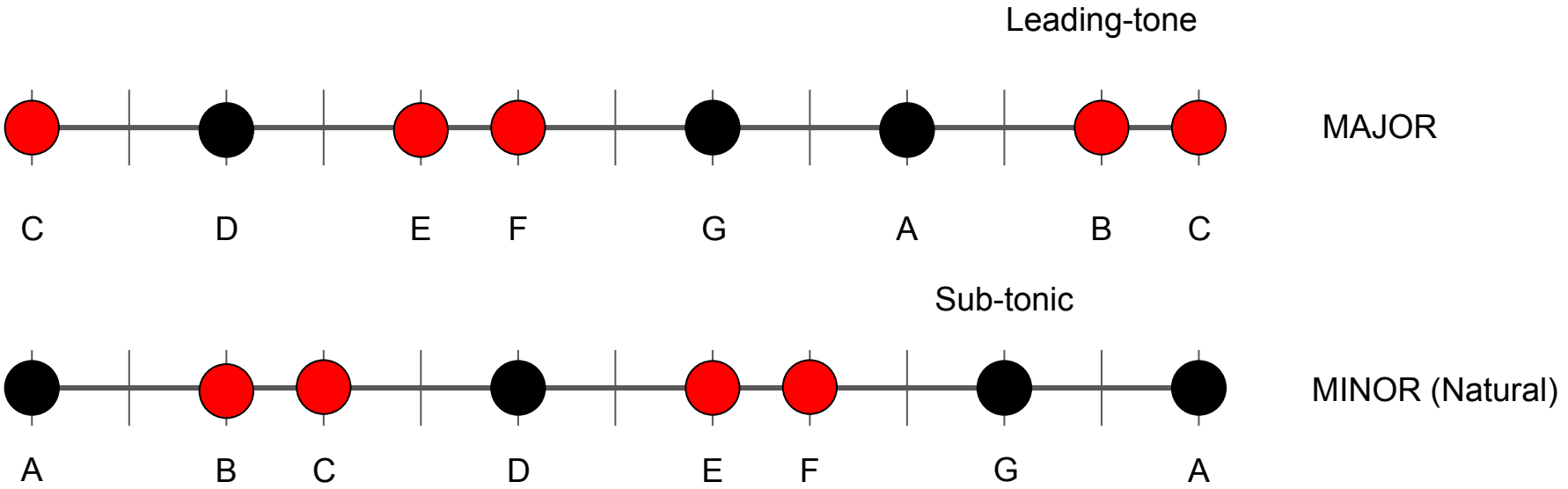
- **Preferred melodic motions:** some pitches are more likely than others to move to certain other pitches

Keys in the Western musical system

Diatonic scale



Major and minor modes



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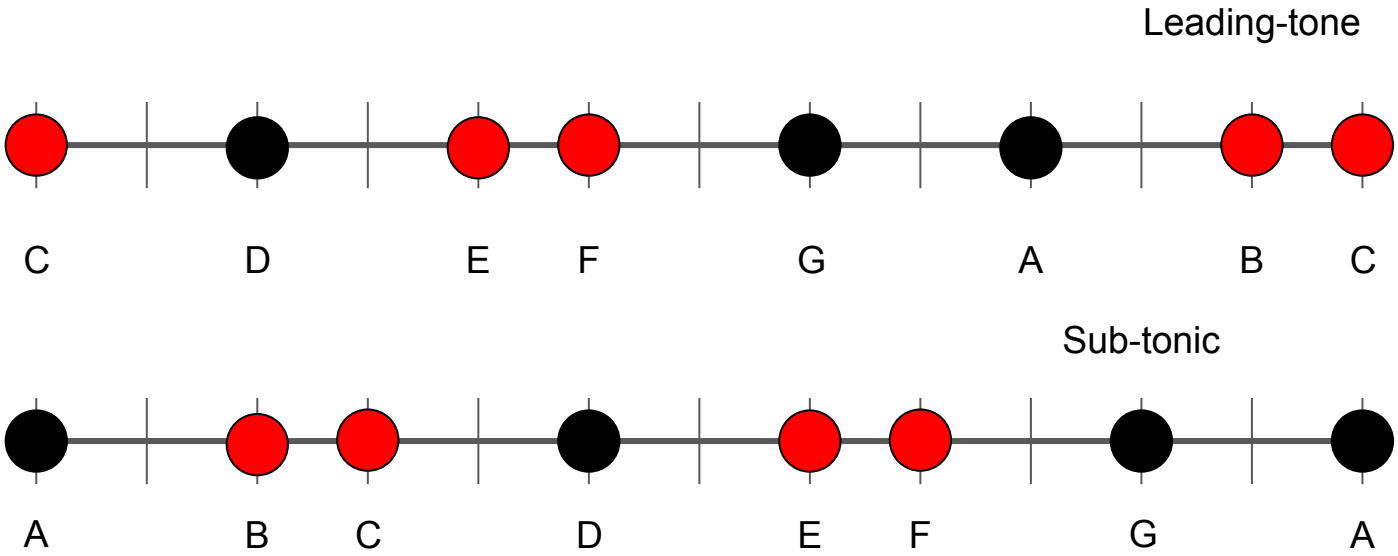

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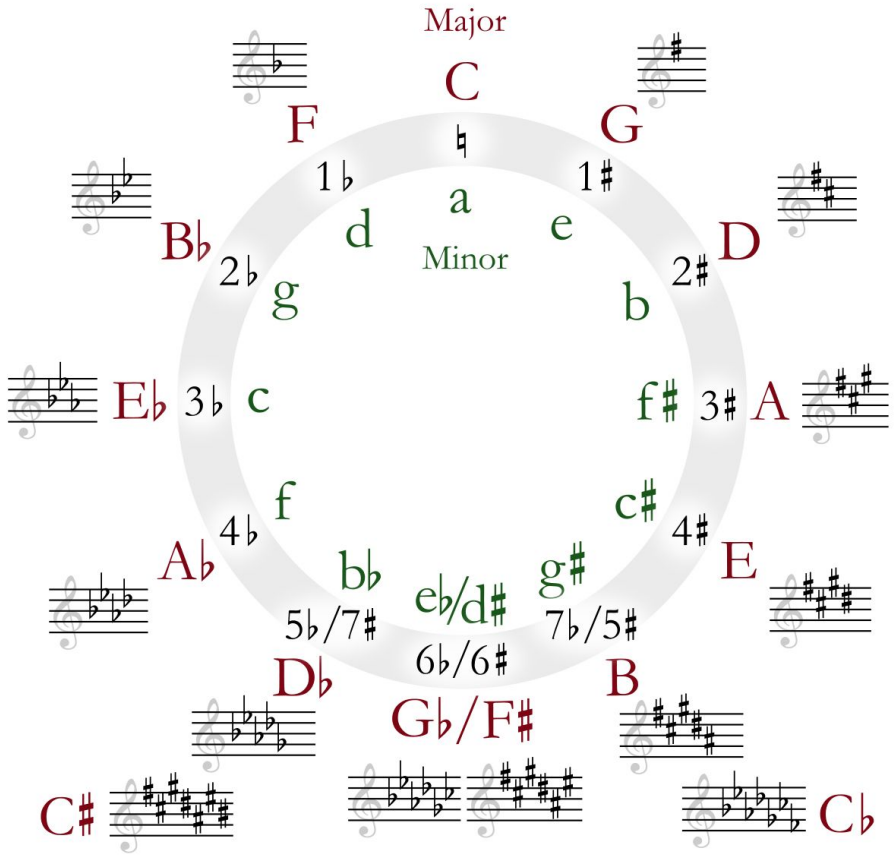

https://youtu.be/O43EBVnwNvo?t=299

Task

The task for this assignment is to implement a data-driven approach to infer the key of musical passages from a dataset of symbolically-encoded music.

(A) Infer the global key for each piece in the corpus
(B) Identify the modulations (changes in the local key within each piece)

The ground-truth for 80% of the pieces is included in the dataset and can be useful for implementing a supervised classification approach, as well as to evaluate the outcomes.

(C) Predict global key and local keys (modulations) for the remaining 20% of the pieces, and specify what accuracy you expect to achieve.

In the report, try to motivate the approach you adopted, discuss why it resulted in the observed outcomes, and whether/how it could be improved/generalized.

A

- Each piece in tonal music is composed with the purpose of establishing one key: its **global key**
- The task, then, is to infer the **tonic** and the **mode** (major/minor) of the global key, given a dataset of symbolically-encoded notes from a corpus of pieces
- Trained (and untrained) listeners *feel* that a piece is in a certain key: human brains can do the task based on (~) the same data! (As long as there has been prior exposure)
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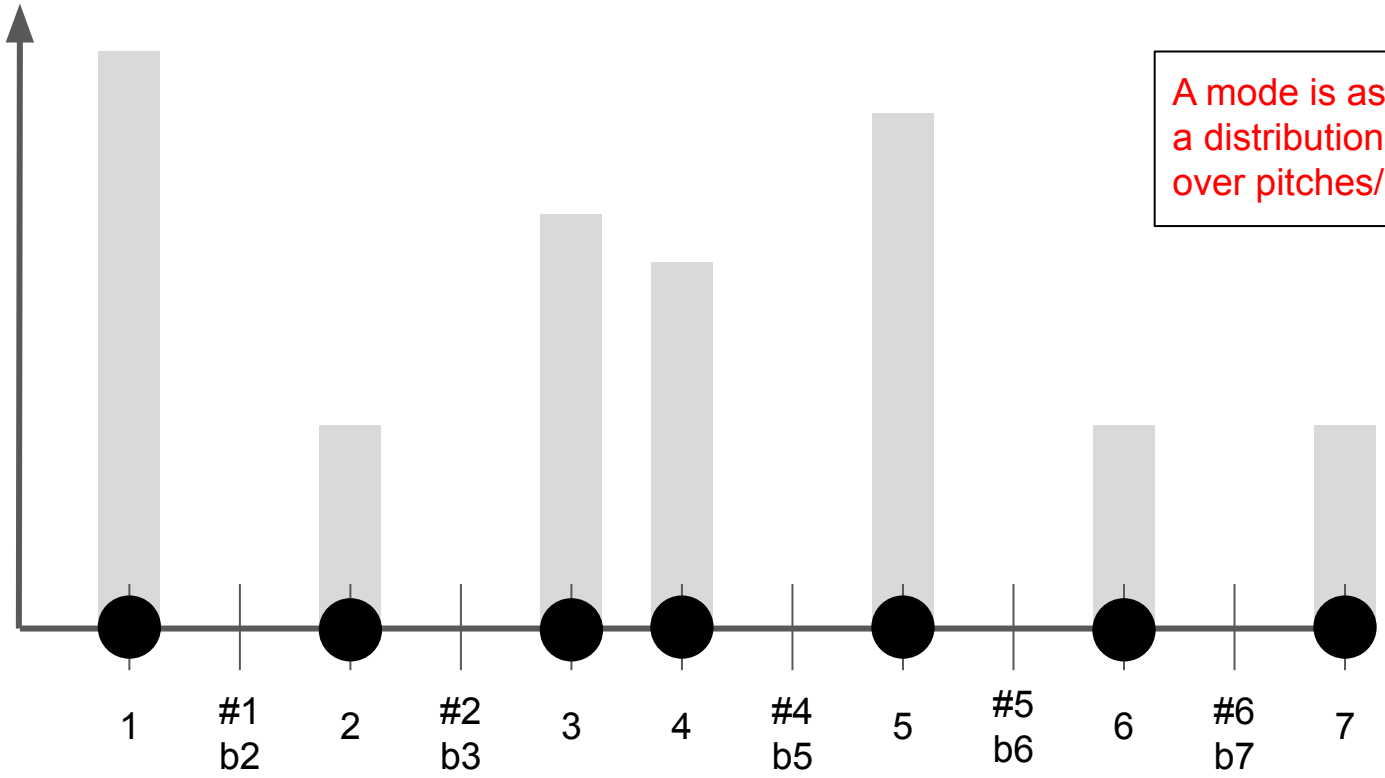
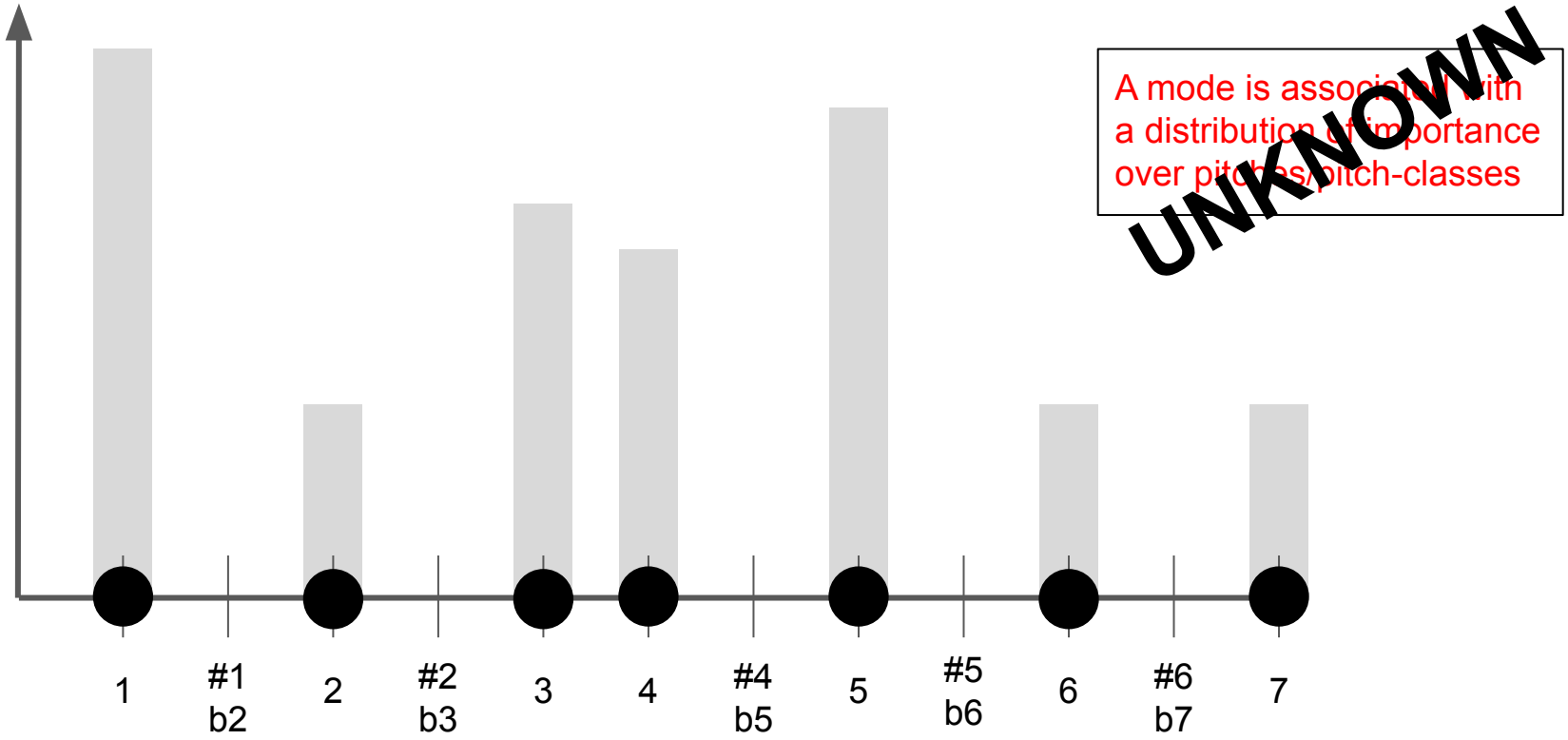
- This means that the way notes are used highlights the sense of key: e.g.,
  - Scale tones are more likely to be used than non-scale tones
  - The tonic is emphasized, in particular at crucial points (e.g., beginnings, ends)
  - More important notes are more likely to be emphasized in various ways and to be used more frequently, for longer durations, and in stronger metrical positions than less important notes
  - …

Importance



A mode is associated with a distribution of importance over pitches/pitch-classes

Importance


A mode is associated with
a distribution of importance
over pitches/pitch-classes
UNKNOWN
1
#1
b2
2
#2
b3
3
4
#4
b5
5
#5
b6
6
#6
b7
7

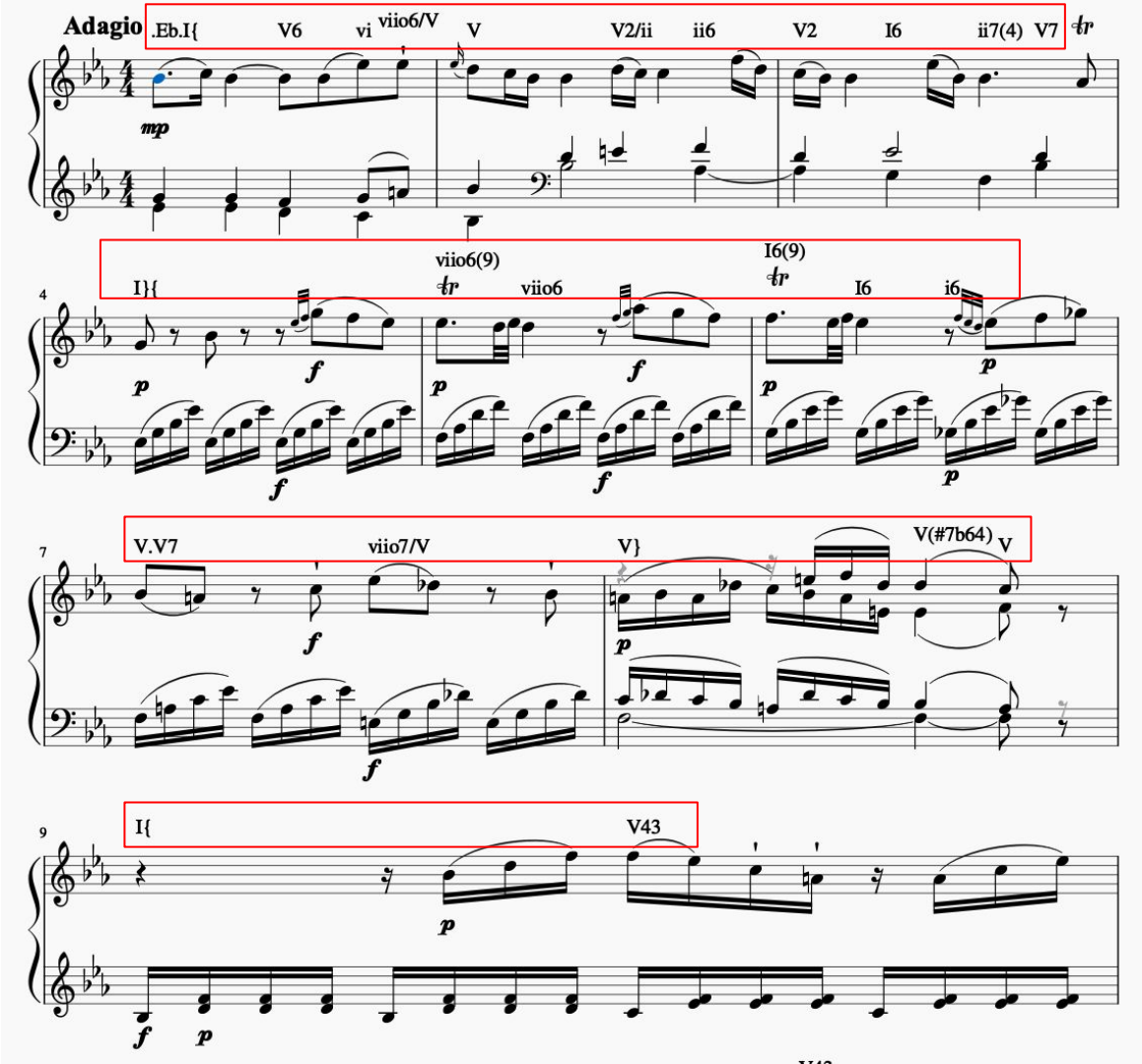
A possible approach

- Come up with an estimator of the “importance” of notes
- Infer from training data a prototype of the hierarchical importance of different pitch-classes (one prototype for major and one for minor, to be transposed to all 12 different tonics)
- Estimate which one of the 24 prototypes has the best agreement with the estimated importance of the notes in the test piece

B

- The key can change within a piece: i.e., different segments of a piece can (locally) highlight a different tonic and a different (major/minor) mode. The key that applies locally in a certain region of the piece is called the **local key**, and changes in local key are called **modulations**
- There is typically some ambiguity/uncertainty involved: has the key really changed, or is the music still in the same key, just ‘hinting at’ a different tonic?
- The ground-truth is based on human expert-knowledge, as encoded in annotations to the score
- Evaluating against the ground-truth means assessing how well the approach captures the annotator’s expert knowledge, but different annotators may disagree (do not expect 100% accuracy!)

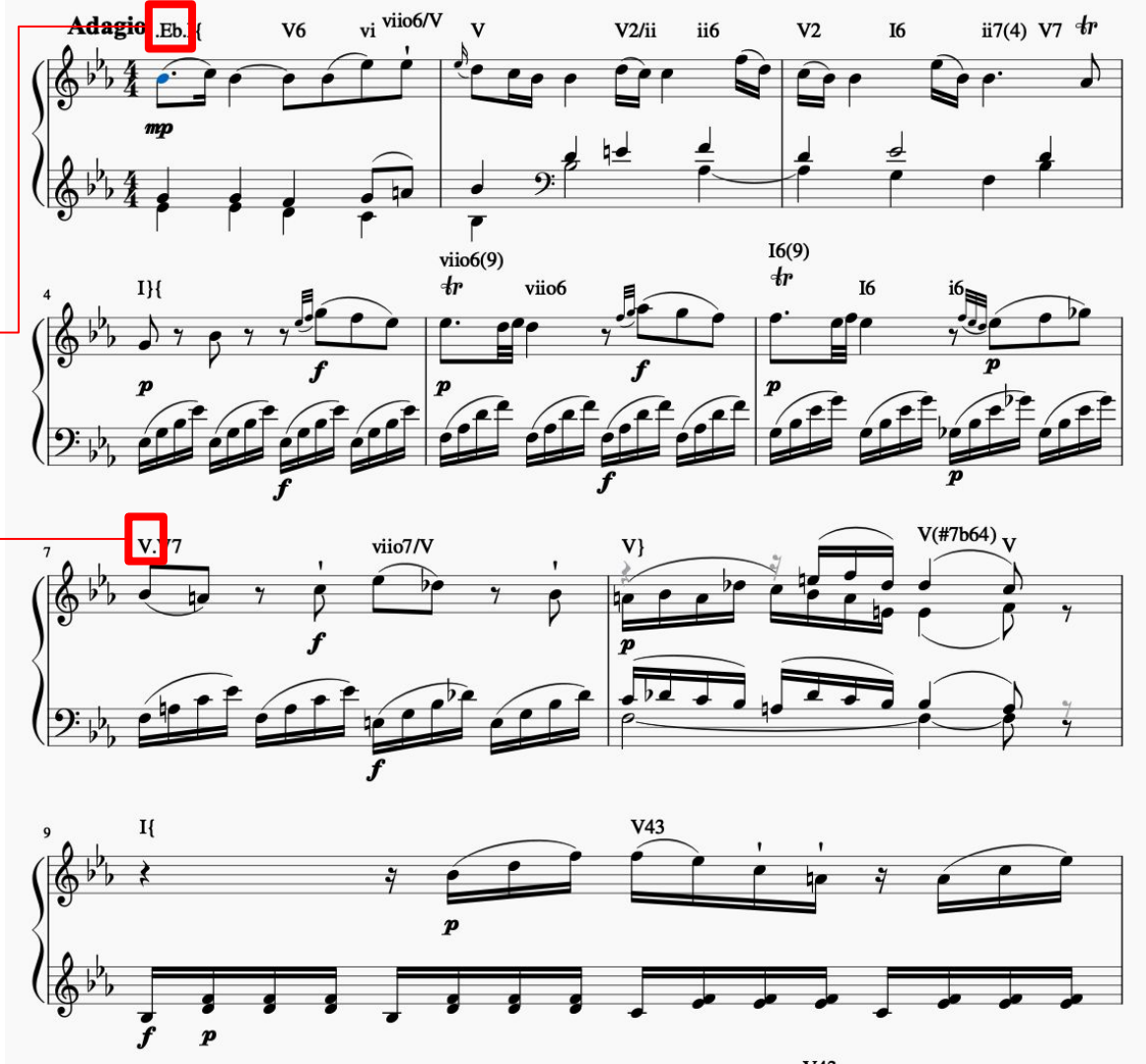
Annotations



Annotations

GLOBAL KEY

LOCAL KEY



B

- Take into account the uncertainty/ambiguity of the global-key inference throughout the piece: are there passages within a piece where the global-key attribution is particularly uncertain, or where alternative keys would be more likely?
- Identify regions that (locally) belong to a different key (Note: identifying the boundaries of a modulation *exactly* as encoded in the groundtruth may well be impossible)
- Quantify the accuracy for local keys and test whether it improves over approximating all local keys with the global key
- Give examples where the approach does or does not work

C

- 20% of the pieces in the corpus (“test set”) have no ground-truth for global keys and local keys
- Predict the global key and local keys for these pieces
- Specify in your report what accuracy you expect to achieve on these “unseen” data, based on the performance on the training data

Representing pitch and pitch-class

Representations of pitch and of pitch-class

- MIDI
  - represents absolute pitch height (i.e., C4 != C5): there are (virtually) infinite distinct values
  - does not distinguish enharmonic equivalence (i.e., F# = Gb): there are 12 distinct values per octave (but virtually infinitely many octaves)

- Tonal pitch-class (tpc)
  - represents note names (C4 = C5), i.e. pitch-class and not pitch height
  - distinguishes enharmonic equivalence (F# != Gb), i.e., there are (virtually) infinite distinct values

- ‘Chromatic’ pitch-class
  - represents note names (C4 = C5), i.e., pitch-class and not pitch height
  - does NOT distinguish enharmonic equivalence (F# = Gb), i.e., there are only 12 distinct values

Representation of pitch

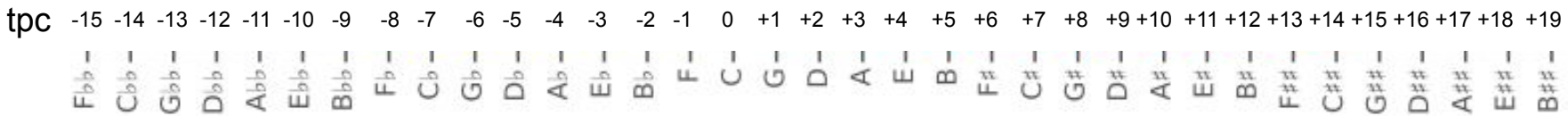
MIDI:

- Integer scale
- C4 is 60
- +/-1 means moving by a semitone up/down
- Enharmonically equivalent notes (e.g., C# and Db) have the same MIDI value

Representation of pitch-class

Tonal pitch class (tpc):

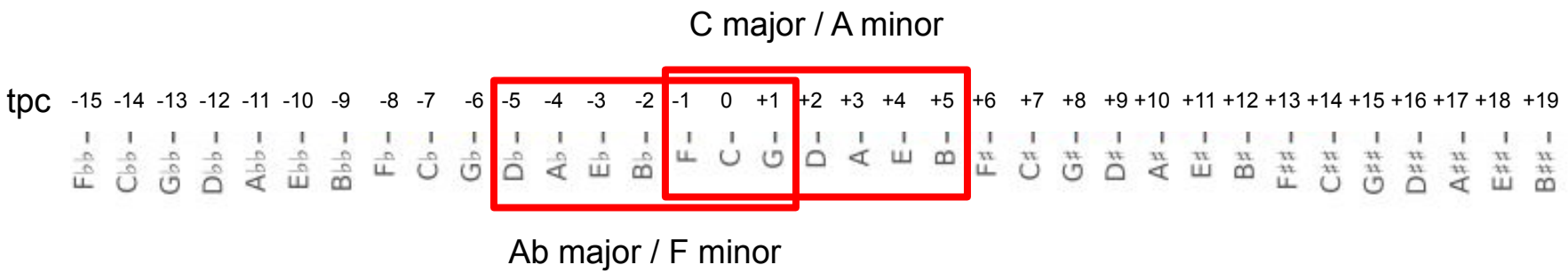
- Integer scale
- C is 0
- +/-1 means moving by a fifth up/down (i.e., one step on the **line of fifths**)



- Enharmonically equivalent notes have different tpc values

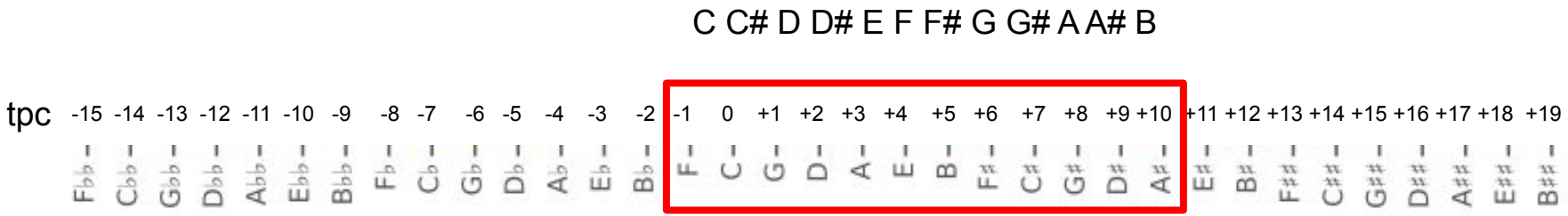
Diatonic scales on the line of fifths

- A diatonic scale comprises a contiguous segment of 7 steps on the line of fifths
- Relative keys have the same pitch classes in their scale (yet different tonic)
- The tonic of a major diatonic scale is the second element of the segment, the tonic of the relative minor scale is the fifth element of the (same) segment



The chromatic tones on the line of fifths

- Any segment of 12 consecutive items on the line of fifths contains each one of the 12 chromatic tones exactly once (i.e., with no enharmonic equivalents)



Chromatic pitch-class

- Ordering by semitones:

cpc = MIDI mod 12

C	C#/Db	D	D#/Eb	E	F	F#/Gb	G	G#/Ab	A	A#/Bb	B
0	1	2	3	4	5	6	7	8	9	10	11

- Ordering by fifths:

cpc = tpc mod 12

C	G	D	A	E	B	F#/Gb	C#/Db	G#/Ab	D#/Eb	A#/Bb	F
0	1	2	3	4	5	6	7	8	9	10	11

Notebook

https://github.com/DCMLab/DM2022Assignments/blob/main/DM%202022%20Assignment%202%20%5BNotebook%5D.ipynb