Automatic extraction of tonal metadata from polyphonic audio recordings

Tonality is a relevant aspect of music perception, and then a main axis for music description. We need to represent this aspect of music using a set of features computed from an audio recording. These features can be used for content-based retrieval and navigation through digital music collections.

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Tonal Metadata

Description scheme:

(1) Temporal validity:
- Instantaneous descriptors: valid for a time point.
- Segment descriptors: defined within an audio segment.
- Global: representative of the whole excerpt or piece.

(2) Level of abstraction:
- Low-level: computed directly from the audio signal or from other low-level descriptors.
- High-level: it requires an inductive inference procedure.


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    <SpectrumD>
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0.193451 0.122316 0.0948005 0.135353 0.212854 0.249327 0.194157 0.0857733 0.0301739 0.0720872 0.148929 0.182718
0.148403 0.0870518 0.0684743 0.13653 0.231203 0.270169 0.277118 0.293294 0.294509 0.217129 0.102392 0.0568156
0.124401 0.237221</HPCP>
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  <Melody>
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      <Note>G</Note>
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0.0029442 0.00282956 0.00301471 0.0176575 0.0898968 0.17107 0.207165 0.260252 0.350629 0.389508 0.28104 0.110348
0.0282654 0.0776006 0.173812</HPCP>
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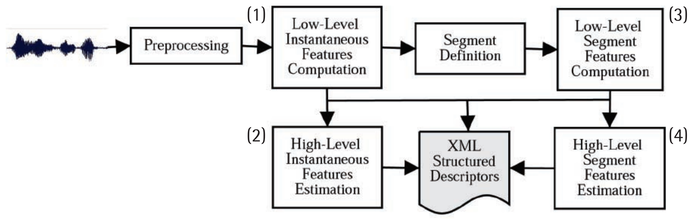
    ....
  </ChildrenD>
</AudioSegmentD>
```


Name	Temporal Validity	Level of Abstraction	Data Type
HPCP	Instantaneous	Low	Float vector
Chord	Instantaneous	High	Textual label
Chord Strength	Segment/Global	High	Float value
Global HPCP	Segment/Global	Low	Float vector
Key	Segment/Global	High	Textual label
Key Strength	Segment/Global	High	Float value

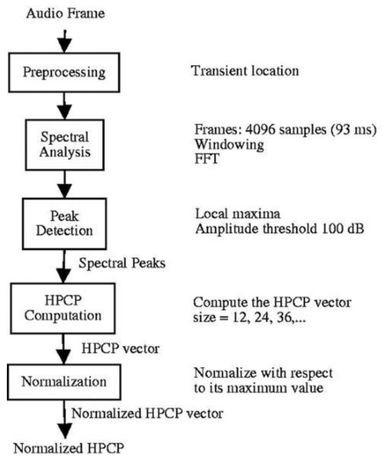
List of Descriptors

Feature Extraction

Block diagram for feature extraction:

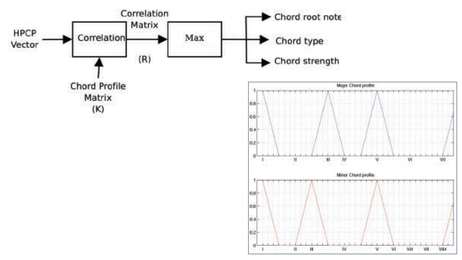


(1) Low-level Instantaneous feature computation: HPCP (*Harmonic Pitch Class Profile*). It represents the intensity of each pitch class mapped to an octave.

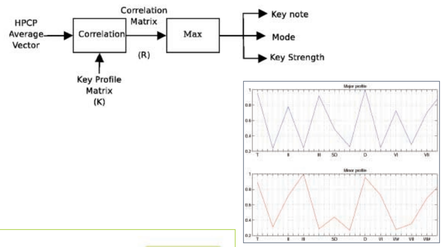


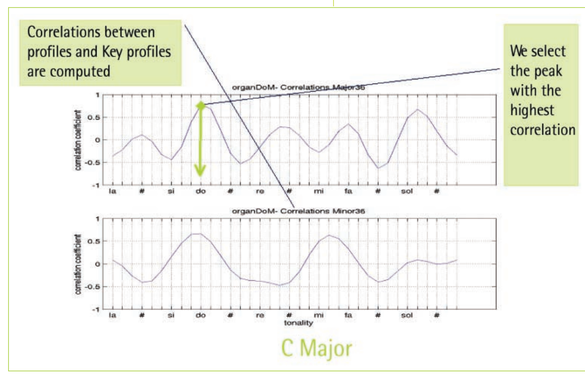
$$HPCP(n) = \sum_i^{nPeaks} w(n, f_i) \cdot ||a_i||^2 \quad n = 1...size \quad i = 1...nPeaks$$

(2) High-level Instantaneous feature computation: Chord, Chord Strength



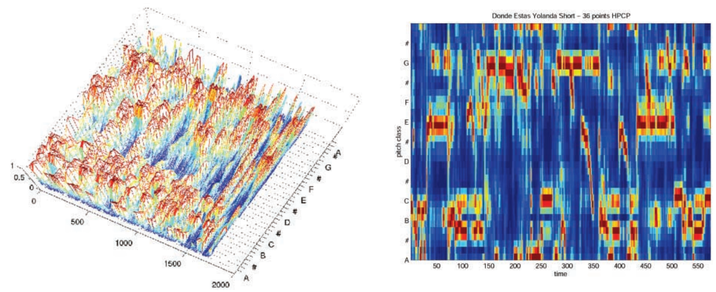
(3) Low-level Segment/Global descriptors computation: Average HPCP
(4) High-level Segment/Global descriptors computation: Key, Key Strength



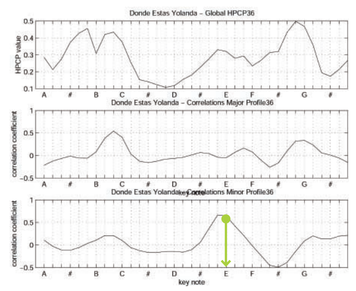


Results

Instantaneous HPCP for a 10 seconds excerpt of a song:



HPCP Global values and correlation for Major/Minor tonalities:



E Minor

Key Estimation Evaluation:

Small test database with different styles, key, mode. Labeled by hand (35 sounds).

Correct key note	65,5 %
Correct mode	83,24 %
Correct key	64,2 %

Database of 525 classical pieces labeled by their title.

Correct key	70 %
Mode error	3 %
Tuning error	6 %

References:
- *Fujishima, T. 1999. "Realtime chord recognition of musical sound: a system using Common Lisp Music". ICMC.*
- *Krumhansl, C.L. 1990. "Cognitive Foundations of Musical Pitch". Oxford University Press, New York.*
- *Sheh, A. and Ellis, D. 2003. "Chord Segmentation and Recognition using EM-Trained Hidden Markov Models ". ISMIR.*