




# Discovering Musical Patterns through Perceptive Heuristics


By Oliver Lartillot

Presentation by Ananda Jacobs




## The dimensions of music


- Melody: the “tune,” or a succession of notes usually in the top voice
- Rhythm: the beat or pulse
- Meter (metric): global vision of temporal structures, usually dependent on style
- Harmony: the chords, subject to “grammatical” rules of progression



- Form: the overall structure, such as binary, ternary, sonata, rondo...




## Musical Pattern Discovery focuses on...




## Motives

- **Motive:** a melodic fragment or a short collection of notes that serves as a core idea for a musical piece.




## Motives can be transformed

- **Imitation** is a texture in which a motive is presented in one voice and then restated in another voice. A strict type of imitation is called a **canon**.
- **Inversion** is a technique that turns the motive upside down using the same intervals only reversing their direction.
- **Retrograde inversion** is a motive upside down and backward.




## Motives can be transformed

- **Augmentation** is the motive expanded into longer time values.
- **Diminution** is the motive compressed into shorter time values.



## Musical Pattern Discovery


- Goal of MPD is to provide automated motivic analyses of musical scores.



## Previous work on MPD


- Self-similarity matrix
  - Music is decomposed into local segments, and similarity distance is measured between all possible pairs of segments.
  - Can then pick out lines similar to first diagonal

*Weakness: cannot identify transformed patterns*




- “Multiple levels of abstraction”:
  - Transformed patterns may be detected by expressing parameters relative to a reference point.
  - Refer to pitch intervals rather than absolute pitch.

*Weakness: cannot handle local distortion inside patterns*



- Contour:
  - Describes direction of interval motion between successive notes: down, up, or constant.


*Weakness: produces irrelevant false positive results*




## Ways to chop up music



- Style-base groupings: based on meter and harmony, using stylistic norms to determine pattern length
- Local boundaries: melodic contour, dynamics, accents, or instrumentation changes, can signify a local segment.
- Repetition: a motive is detected through repeated occurrences throughout the score.




- Current study focuses on **repetition repetition repetition** of motive, as this is a common occurrence and is more theoretically developed than the local boundaries concept.
- Note that repetition can only be detected if it has been pre-segmented by local boundaries. That is, the pattern has to contrast with its surroundings.




## Terminology

- Pattern: an approximately repeated succession of notes
- Pattern class: multiple repetitions of a pattern belong to one PC
- Pattern occurrence: a set of notes with a similar succession to the one defined in the PC




## Temporal perception

- Patterns are conceptually inferred during the listening process.
- For each new note, the set of current inferences makes up a context, which in turn induces constraints upon the candidates for new inferences.
- *...irrelevant references are thus avoided*




## Memory

- Short-term memory: used in contour description (Dowling and Harwood, 1986)
- Long-term memory: used in pitch interval description




- Current study focuses on LTM.
  - Influences pattern discovery
    - Patterns are more expected if they have just been repeated several times
    - Patterns can be recalled even before they are explicitly discovered
    - May be only necessary to query a prefix, not the whole pattern



**Warning! Inherent problem:**


Cognitive model of induction is parallel, whereas computer architecture is sequential

To cope with this, make very careful orderings of operations...



For each new note, each possible PO concluded by previous note is a candidate for three operations:

- 1) **Pattern Occurrence extension**
  - current new note may be associated to continuation of already-identified PC.
  - candidates are considered by decreasing order of similarity
  - negligible candidates discarded



For each new note, each possible PO concluded by previous note is a candidate for three operations:

- 2) **Pattern Class Extension**
  - If previous condition does not occur, check eventual extension of PO with current note.
  - Extension should not already be inferred.
  - Negligible candidates discarded.

For each new note, each possible PO concluded by previous note is a candidate for three operations:

- 3) Pattern Class Initiation
  - New patterns are identified
  - These should not already be deduced by previous POs.

## Pattern association discovery

- Since pattern association may induce pattern expectation, include a rule for expectation
  - Every time a new PO of an associated PC is discovered, possible associated PCs are also expected
    - Example, sub-patterns. (Fig. 8)


## Results and Implementation

- Bach's *Prelude in C, BWV 846*
  - Algorithm generates all occurrences of the 8-note motivic pattern
  - Generates some irrelevant patterns
  - Not entirely robust, but serves as prototype

## Results and Implementation

Structures correspond to basic patterns of human perception

*OpenMusic*: graphical programming language for computing symbolic representations of music.



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