

Music Structure Analysis by Finding Repeated Parts

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Introduction

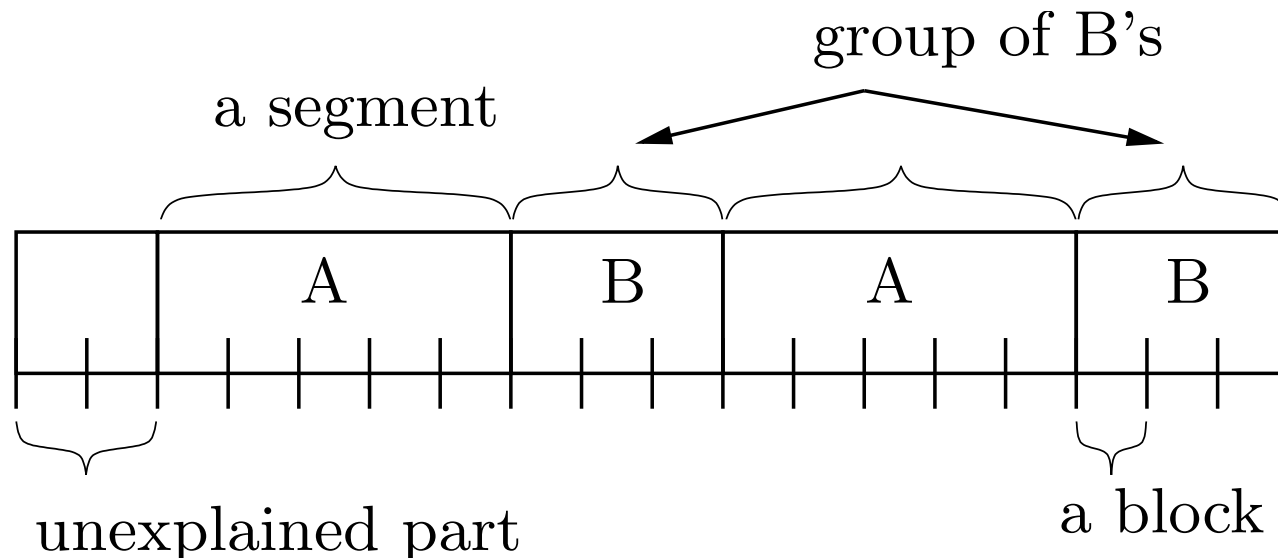
- Analysis of the structure of musical pieces.
 - Divide piece into distinguishable parts.
- Especially in pop music, structure relies on repetitions.
 - E.g., “intro, verse, chorus, verse, chorus, chorus”.
- Proposed method aims to locate the repeated parts.
 - Resulting description may not cover whole piece.
- Applications include
 - smart playback,
 - thumbnailing, and
 - musicological tools.





Definitions

- Musical piece presented as a sequence of *blocks* b_1, b_2, \dots, b_N .
- One or more consecutive blocks form a *segment* $s_k = b_i, b_{i+1}, \dots, b_j$.
 - An occurrence of a part.
- A group of non-overlapping segments, g_i .





Definitions, cont'd

- Segment groups have the properties
 - within-group dissimilarity, d_i , and
 - occurrences of a part should be similar
 - coverage, c_i .
 - the occurrences of a part cover some duration of the piece
- All segment groups form a set of *segment group candidates* $G = \{g_1, g_2, \dots, g_M\}$.
- Structural *explanation* $E \subset G$, such that the included groups do not overlap temporally.
- Select the best subset of the candidate groups.





A “good” explanation?

- Requirements
 - Segments in a group should resemble each others.
 - As much of the piece should be explained as possible.
 - The explanation should be as simple as possible.
- Calculating a cost for an explanation

$$C = \text{dissimilarity} + \alpha \text{ unexplained} + \beta \text{ complexity}, \quad (1)$$

with $\alpha, \beta \geq 0$.

- Evaluate above as

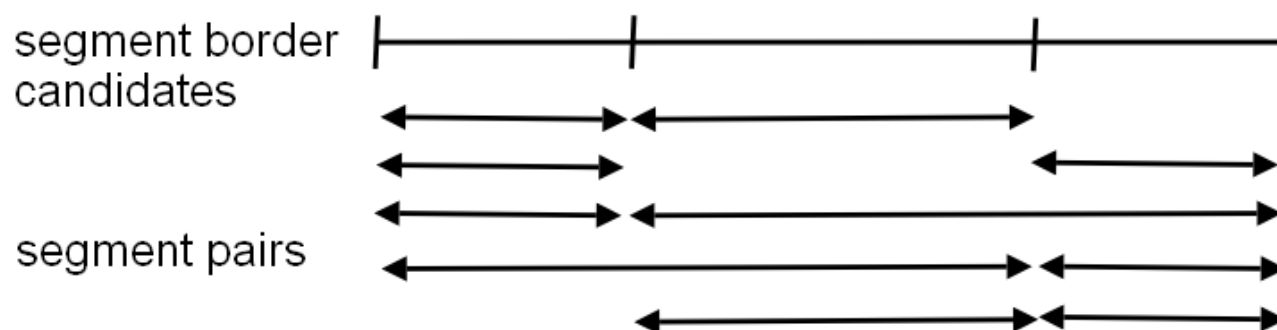
$$C(E) = \sum_{g_i \in E} d_i c_i + \alpha \left(1 - \sum_{g_i \in E} c_i\right) + \beta \log(1 + |E|). \quad (2)$$





From signal to segments

- Block division?
 - Utilise meter estimation. Block division from measure borders.
- Where a segment may start or end?
 - Given N locations, $O(N^4)$ non-overlapping segment pairs.
 - Not feasible to use all measure borders.
 - Create possible locations with novelty in general timbre.
- Create all non-overlapping segment pairs.





Segment groups

- Within-group dissimilarity?
 - Match two segments with DTW, using chroma (tonal descriptor) feature.
 - Average distance between all segment pairs in the group.
- Create candidate groups iteratively based on segment pairs.
 - Start from a pair, add non-overlapping segments one by one.
 - Heuristic rules to limit the number of groups (lengths of segments in a group, within-group dissimilarity, maximum number of segments in a group).





From groups to explanation

- Creating the best explanation is a combinatorial problem.
- Idea of the search algorithm:
 - Start from empty explanation,
 - iteratively, add one more group to explanation, and
 - evaluate the cost.
- Search space can be limited.
 - Estimate minimum cost that can be obtained by extending current explanation.
 - If the minimum is worse than best so far, no point to continue to that direction.





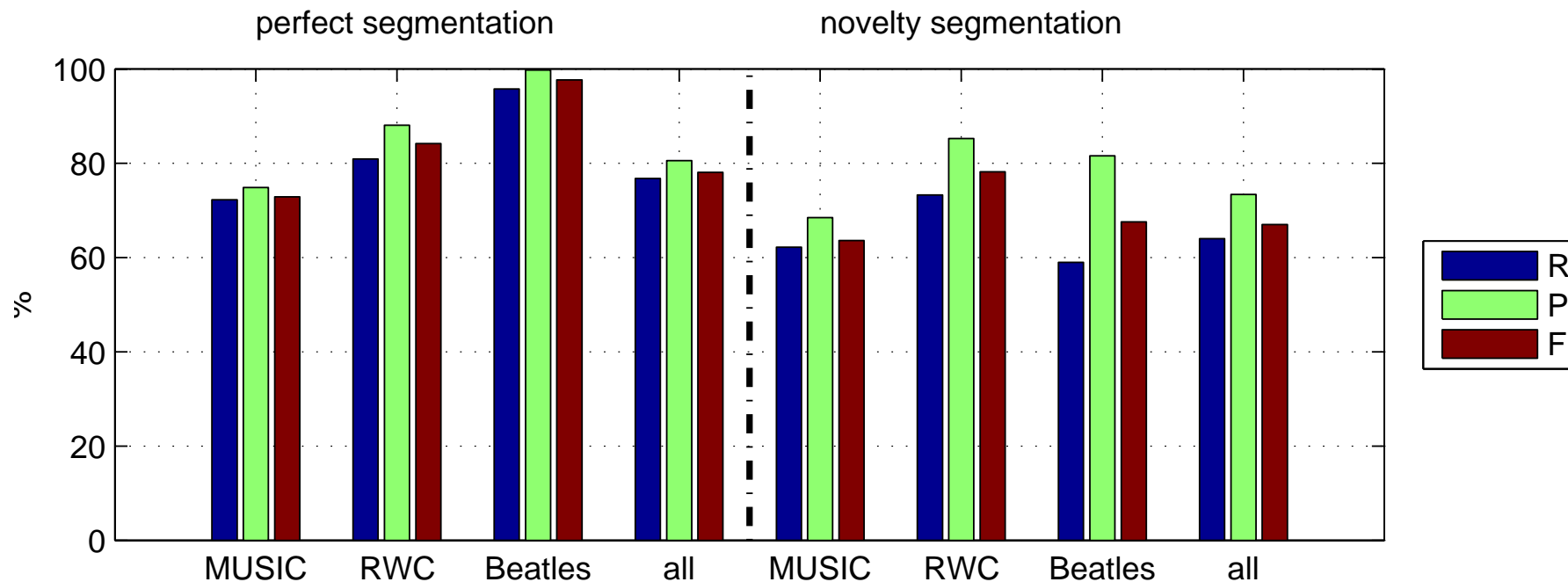
Material

- 50 popular music pieces, from 3 different collections
 - MUSIC
 - RWC-Pop
 - The Beatles
- Manual annotations of clear structural parts.
 - Main focus on repeated parts, but also solo etc. handled.
 - Some parts of the pieces may be left un-annotated.
- 3-fold cross-validation





Results



- R = recall rate, amount of annotated parts found
- P = precision rate, amount of found parts annotated
- F = harmonic F-measure from R and P





Summary

- Music structure analysis problem formulated in terms of parametric cost function.
- Proposed method relies on the repetitions of musical parts.
- Analysis system performance evaluated with real music pieces.
- Segmentation has quite large effect on performance.
- Difficult to find global values for parameters α and β so that method works for all music types.

