Computational Music Analysis Workshop Introduction: First movement of Brahms' Op. 51 No. 1 and an Overview of the Proposed Approaches

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Outline

- Workshop: history and aims
- Computational music analysis
- Brahms' op. 51 no. 1
- Analyses by Lewin, Forte, Huron
- Comparison of Workshop's approaches

The workshop

- Motivation: Discussion and comparison of approaches to Computational Music Analysis **(CMA)**
- Workshop at MCM 2007
- Aims
  - Comparison on the meta-level of music analysis
  - Focusing on one piece (though possible intertextual comparisons)
  - Discussion session on methodologies, results, and general issues in CMA

Computational Music Analysis

- The structural analysis of the musical score using formal/computational means.
- Emphasis on knowledge representation
- Reductionist, paradigmatic, syntagmatic, harmonic, etc
- Paradigmatic: Pattern repetition in the musical surface. Capturing repetition, variation and transformation in music.
- Patterns can be motives, phrases, segments, and so on.
- Usually an analysis on the “neutral” level

Issues in CMA

- Various methodologies in Music Analysis
- Score representation
- Segmentation of the score
- One piece vs a small set vs corpus analysis
- Justification of approach
- Representation of repeating structures
- Musical interpretation of results

Brahms Op. 51 No. 1

- Why Op. 51 No. 1?
- An example of his most advanced writing
- Destroyed about 20 beforehand ...
- 1865 – 66, then again in 1873
- Papers on systematic analysis:
  - A. Forte, "Motivic design and structural levels in the first movement of Brahms's String Quartet in C minor", 1983.
  - D. Huron, "What is a musical feature? Forte's analysis of Brahms's opus 51 no 1, revisited", 2001.
  - D. Lewin, “Brahms, his past, and modes of music theory”, 1990.

Op.51 No.1: Form

- A general sonata form
- C minor
- Exposition (1 – 83): 2 contrasting subject groups, often heard together
- Development (84 – 132): using materials from exposition
- Recapitulation (133 – 260): 2 subject groups, Coda (224 – 260).

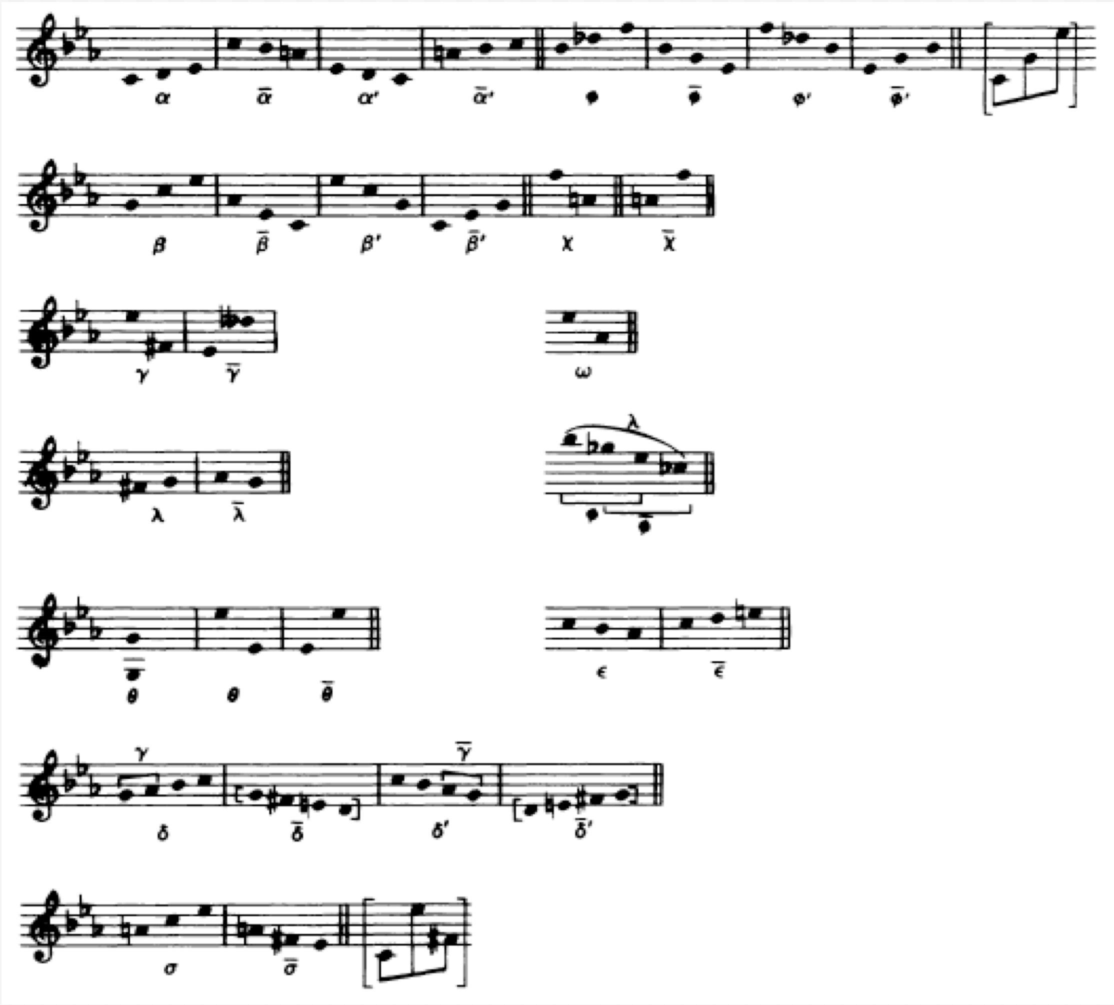
Lewin's analysis

- Discusses two subjects of exposition (bars 1-23)
- Two rhetoric modes
- One Beethoven like: motivic material stated, progressively developed, then liquidated, leading to cadence of V
- Here: modified – second subject comes early, large-scale elaboration of dominant in bars 7 - 24
- One lyrical, dominant prolongation, Mozart like
- The two different modes are put together in a Brahmsian way

Forte’s Analysis

- Importance of the motive
- Also using Schenkerian principles
- Inspiration from Pathétique Sonata
- Motives are pitch, PC-specific or PCI-specific
- Boundary interval feature of motive (alpha)
- Transformations: R, I, RI, minor-major, major-minor
- Leaves out rhythmic features
- Finds same motives in Schenkerian structure of middleground...
- Motives are related to each other in various ways

Forte’s Table of Motives



Huron's Analysis: A response to Forte

- What is a musical feature?
- How do we distinguish one piece from others within a corpus?
- Notion of presence, salience, distinctiveness, significance
- Analysis of quartet as an illustration of the theory
- Forte's alpha motive does not distinguish this quartet from others by Brahms.
- But: prime form of alpha, linked with rhythmic pattern (lsl) is distinctive.

Comparing Computational Analysis Approaches

- Type of analysis
- Scientific context
- Communication level
- Approach aim/strategy
- Programming language & computational limitations
- Musical texture for analysis
- Music representation for implementation
- Music Segmentation
- Analyzed musical objects, representations (approach & implementation) & identification
- Output representations

Type of Analysis – Connection to traditional music analysis approaches

	Metric & Rhythmic Analysis	Harmonic Analysis	Motivic Analysis	Structural Paradigmatic Pattern	Set Theory
Ahn		X	X		
Buteau			X		
Cathé		X			
Conklin			X		
Gualda	X		X	X	X
Lartillot			X		
Tenkanen		X		X	

Scientific Context

	Machine Learning	Mathematics	Statistics	Cognitive Science	Other (specify)
Ahn		X	X		
Buteau		X			
Cathé			X		Music Analysis & Music Theory
Conklin	X		X		
Gualda	X	X	X		
Lartillot		X		X	Pattern mining
Tenkanen		(X)			

Communication Level

	Poietic Level	Neutral Level	Aesthesic Level
Ahn		X	
Buteau		X	
Cathé		X	
Conklin		X	
Gualda		X	
Lartillot			X
Tenkanen		X	

Approach Aim/Strategy

- Ahn: **Applying Klumpenhouwer nets** to the Brahms'Quatuor with the different motives proposed by Forte, try **to construct a graphical representation of a significant motif**
- Buteau: **Construction of a motivic hierarchy** of a piece & **identification of germinal motives** (motives that are omnipresent in a piece through their repetitions and variations).
- Cathé: The theoretical background of the approach is the **theory of the Harmonic Vectors of Nicolas Meeùs**. It has been developed to take account of the nature of the chords, in addition to the root motions.
- Conklin: Goal of **discovering general patterns** that are **distinctive**: **occurring with significantly higher probability in an analysis corpus as compared to an anticorpus**. Patterns are discovered by an algorithm that explores a pattern specialization space using two refinement operators.

Approach Aim/Strategy (2)

- Gualda: **To identify large patterns** as well as **frequent small patterns, based on a few equivalence rules,** which can be chosen by the user.
- Lartillot: **Discovery of repeated motives** in symbolic music representations, **through a search for closed patterns in a multi-dimensional parametric space**. A modeling of cyclic pattern enables an adapted filtering of combinatorial redundancy caused by successive repetitions of patterns.
- Tenkanen: I am developing an analysis method called **comparison set analysis** (CSA). At its first stage CSA was **based on imbricated segments of pc-sets and similarity measures** like Lewin's REL. Now I'll test a distance function for **measuring 'tonal distances'** between pc-sets.

Programming Language/Software

- Ahn: LISP - **OpenMusic**
- Buteau: **JAVA** (computations), **OpenMusic**/Common Lisp and **Maple** (for visualization of output)
- Conklin: **Perl** Objects, with some code in **C** (for efficiency)
- Gualda: **C++**
- Lartillot: Common Lisp, integrated in **OpenMusic**
- Tenkanen: **R** (see website ref)

Computational Limitations

- Buteau: Possible large number of gestalts, 2 additional programs for output visualization (**tediou**s), first-stage **manual segmentation**
- Cathé: The **software is a help**, and nothing more.
- Conklin: The pattern space is very rich (pattern components are sets/conjunctions of features) and therefore **search heuristics are used** to find a solution in cases where there are very large search spaces (large analysis corpus and/or many viewpoints used for the analysis).
- Gualda: **64-bit integers** – for compatibility with 32-bit processors (128-bit integers would be ideal)
- Lartillot: **Slow** (not optimized at all). Many **bugs**. **Results** represented as list of numbers, **difficult to read**. The results still contain redundancy that **needs to be filtered out** manually for the moment.

Musical Texture for Analysis

	Monophonic Music	Homophonic Music	Polyphonic Music
Ahn			X
Buteau	X	X	X
Cathé		X	X
Conklin	X	X (must be 'sliced')	X (must be 'sliced')
Gualda	X	X	X
Lartillot	X	(each voice separately)	
Tenkanen			X

Music Representation for Implementation (input)

	MIDI file	Humdrum	(hand-written) Score	Other
Ahn	X			OM score
Buteau	X		X	
Cathé			X	Chords list
Conklin	X	X		
Gualda	X			SonicEvents
Lartillot	X	(in progress)	X	
Tenkanen	X			

Music Segmentation

	No segmentation	Automatic segmentation - score specific; e.g. contiguous melodies until a rest	Automatic segmentation - computational criteria; e.g. melodies within a bar window	Semi-Automatic - e.g. a hand-segmentation followed by its segments' automatic segmentation	Hand-segmentation
Ahn	X				
Buteau			X	X	
Cathé					X
Conklin	X				(X)
Gualda			X	X	X
Lartillot	X				
Tenkanen		X			

Analyzed Musical Objects

- Ahn: **motives**
- Buteau: **motives** (of any size)
- Cathé: all **successions of (classified) chords**
- Conklin: The method analyzes **sequences**: these sequences **may contain notes, segments or slices**.
- Gualda: **melodic lines, motives**, and **large sections**.
- Lartillot: **motives of any size** (from cell to whole themes)
- Tenkanen: **Imbricated pitch-class sets**

Representations of Musical Objects

- Buteau: a motive is a finite set of notes that are represented by: **COM-matrix**, **strings of pitch intervals**, *(elastic shapes), ...*
- Conklin:Notes: (pitch spelling, onset, duration) & **Patterns: sequences of feature sets,** where a single feature is a name:value pair (e.g., int:2).
- Gualda: **strings of pitches** and **of pitch profiles**
- Lartillot: a **motive is a graph of state**, where each state is a note and each transition an interval. Each state and transition can be associated to **various musical dimensions**. The whole **set of motives form a prefix tree**.
- Tenkanen: **Pitch-class vectors**

Musical Objects in Implementation

	Contiguous objects	Also some non-contiguous according to some rules	Also non-contiguous objects
Ahn	X		
Buteau			X
Cathé	X		X
Conklin		X	
Gualda		X	
Lartillot		X	
Tenkanen	X		

Identification of Musical Objects

	Strict (string) Identification	Combination of sub-strings (or representations) Identification	Similarity of strings (please write similarity measure name(s))
Ahn	X		
Buteau	X		Relative Euclidean, CSIM, Absolute value
Conklin		X	
Gualda	X	X	X
Lartillot		X	
Tenkanen			tondist, distance function developed by undersigned

Resulting Analysis & Musical Object Representations

	One analysis possibly considering many representations	Many analyses each considering one representation
Ahn	X	
Buteau		X
Conklin	X	
Gualda	X	X
Lartillot	X	
Tenkanen		X

Output Representations with your Implementation

	Numerical Output	Graphic Representations	Visualization in Score	(Automatic) Tabular Representations	Other (specify)
Ahn		X	X		
Buteau	X	X	X	X (dynamic)	
Cathé	X	X			
Conklin	X			X	
Gualda		X		X	(‘Piano roll’) (‘Interactive’)
Lartillot	X				
Tenkanen		X			

In preparation for the discussion

- Reference to Forte and Huron's papers
- Approach aspects
- Comparison of results
- More generally: Issues in computational music analysis & its contribution to the general field of music analysis
- Do results require further musical interpretation?
- Does statistical significance mean musical significance?
- Does computation add rigor to music analysis, or is it restrictive?