

**Jonathan Bragg**  
Harvard University

**Elaine Chew**  
Queen Mary, University of London

**Stuart Shieber**  
Harvard University

## Research goal

Automatically identify and label neo-Riemannian cycles in a score of music

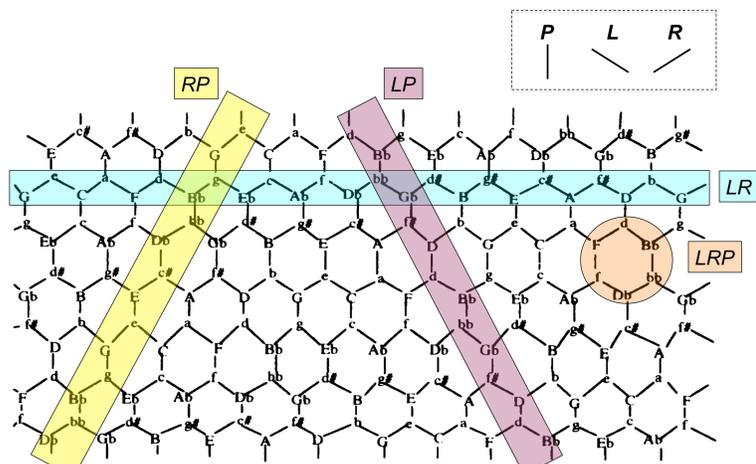
## Motivations

Why automate what music theorists already do?

- Formalize the task with a rigorous definition of what constitutes a cycle
- Understand musical judgments made during an analysis
- Facilitate a comprehensive study
- Facilitate a critique of neo-Riemannian theory

## Neo-Riemannian theory

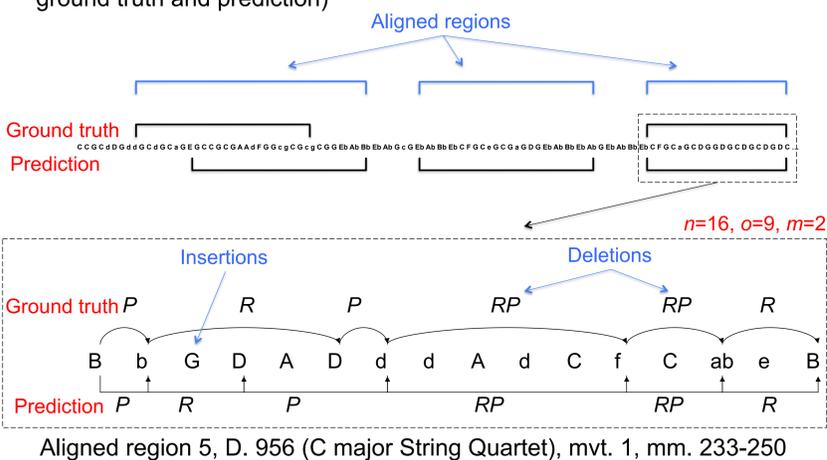
- Harmonies are related by transformations, rather than common tonic
- Basic transformations **P** (parallel), **L** (leading tone), **R** (relative)
- Repeated patterns of transformations generate cycles of harmonies



Neo-Riemannian cycles *LP*, *RP*, *LR*, and *LRP*, shown on the *Tonnetz*

## Experiment

- **Data** are analyses of four chamber pieces by Franz Schubert
- **Training** parameters set from system of linear inequalities (empirical)
  - $B + oD + mI < nX$  (privilege labeling over deletion of an observed cycle of  $n$  triads with  $o$  insertions and  $m$  deletions)
  - $D > X$  (prevent arbitrary cycle extension)
- **Evaluation** scores from global string alignment on each region (calculate edit distance between the strings of triads labeled with transformations in ground truth and prediction)



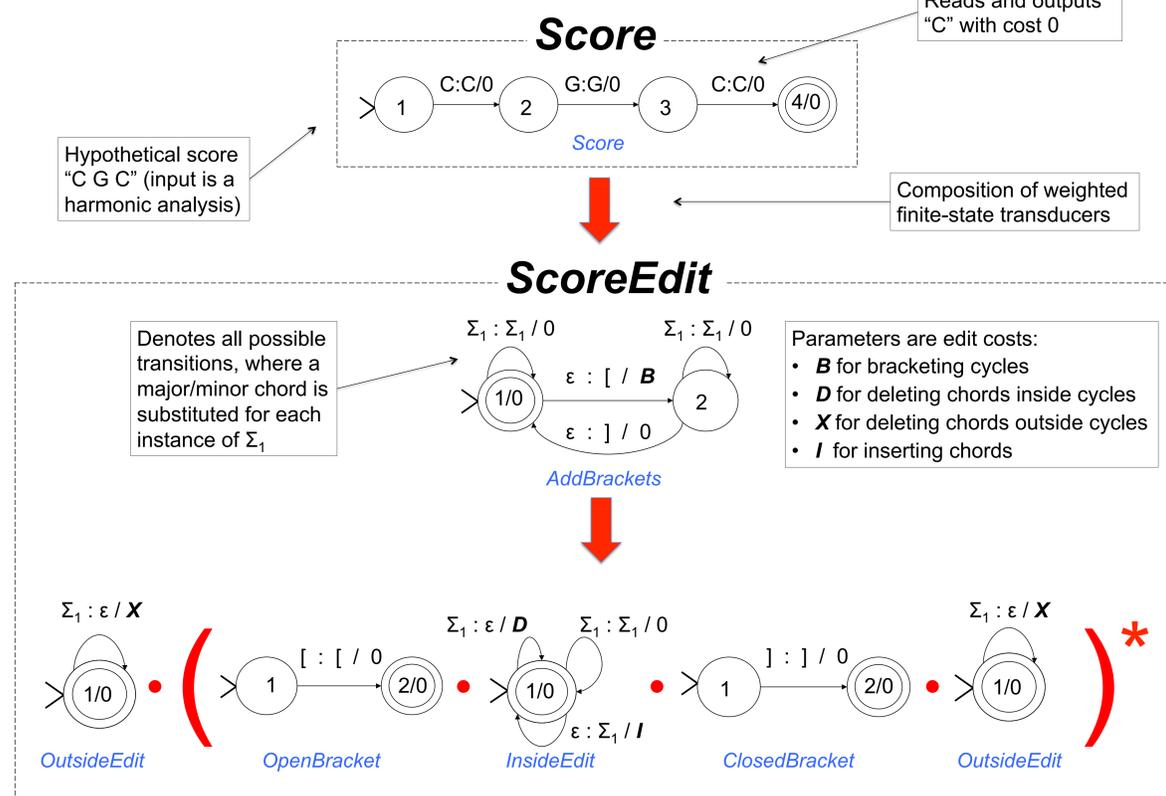
## Results

- Precision = 0.18, Recall = 1.0, where successful cycle retrieval is prediction of cycle in same aligned region as ground truth
- Precision score lowered by “false-positives” (cycles not in ground truth)
- Average cycle length 6.4 and alignment score 3.2
- Handled cycles with many insertions better than many deletions

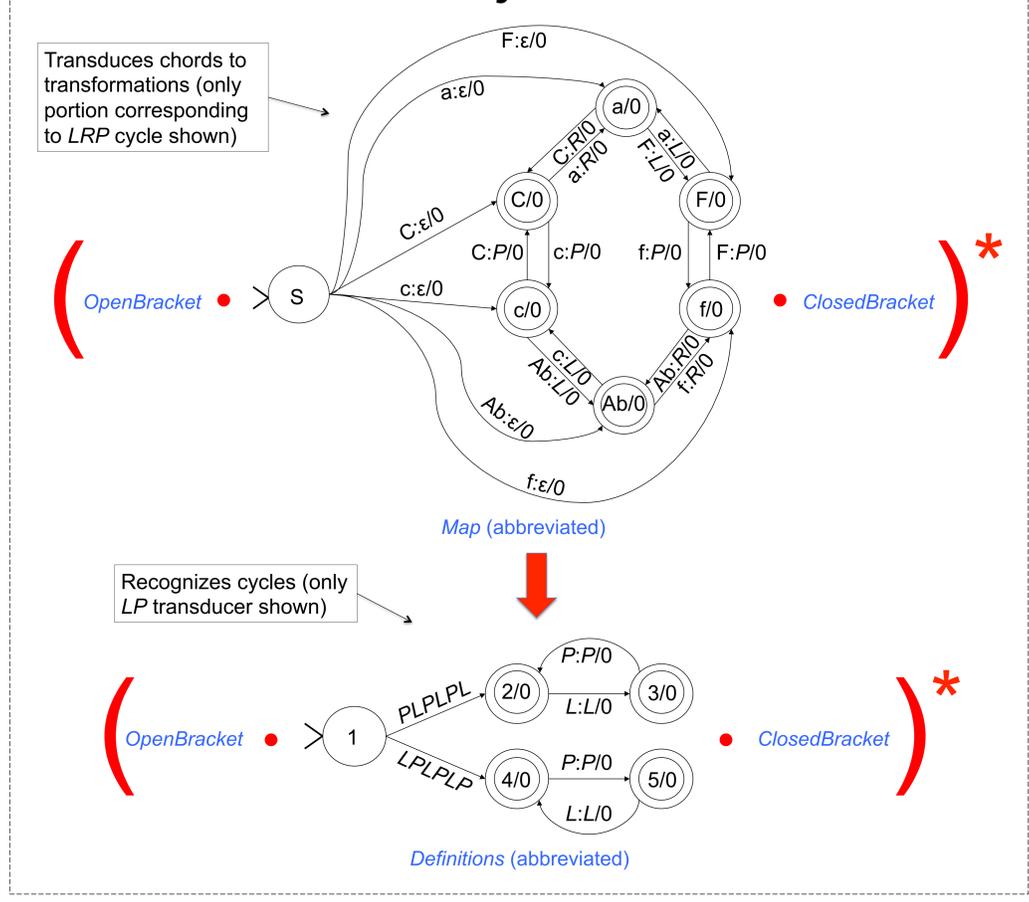
Piece	1	2	3	4	5	6	7	8	9	10	11	$S_n$	$S_p$	$S_t$
D. 959	5	<b>4</b>	6	<b>0</b>	5							4	16	20
D. 894	8	<b>10</b>	6	8								10	22	32
D. 956	6	5	9	7	<b>0</b>	7	6	5				0	45	45
D. 929	6	5	6	7	8	7	7	8	4	7	<b>2</b>	2	65	67

Alignment costs by region

## Noisy channel model



## Cycles



## Conclusion

- Performance**
- Good performance with little feature data
  - Retrieved all cycles in ground truth (some with very high accuracy)
  - “False-positives” are potentially viable cycles
  - Useful to music theorists in current form
- Future work**
- More harmonic analysis data will enable more extensive testing
  - Generalizable to other music features such as rhythm, and patterns other than cycles

## Related work

- Natural language processing**
- Mohri (1997) - Finite-state transducers in language and speech processing
  - Nelken & Shieber (2005) - Arabic diacritization using weighted finite-state transducers
- Neo-Riemannian music theory**
- Siciliano (2002) - Neo-Riemannian transformations and the harmony of Franz Schubert

For more details, please visit <http://www.jonathanbragg.com/ismir2011>

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