Neo-Riemannian cycle detection with weighted finite-state transducers

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Research goal

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

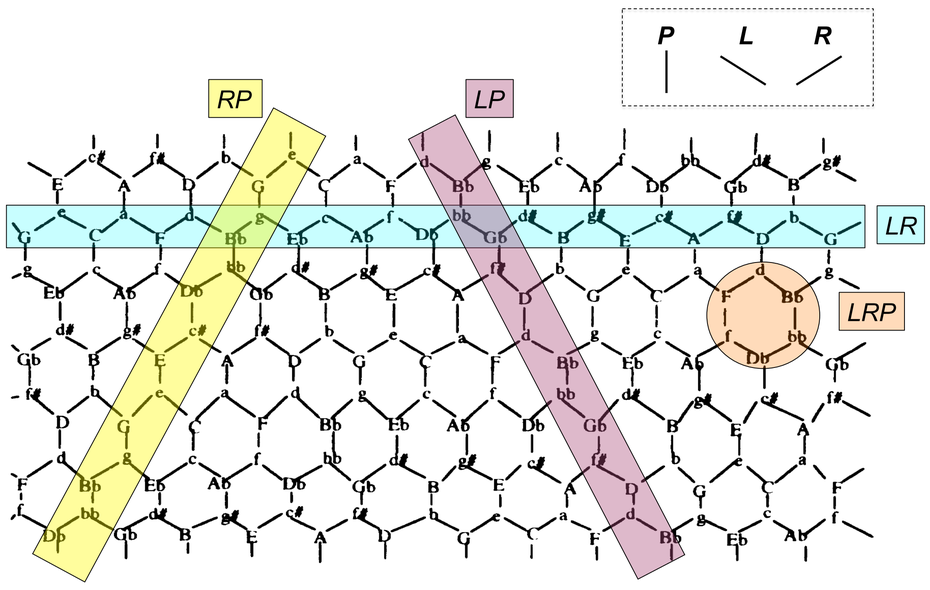
Motivations

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

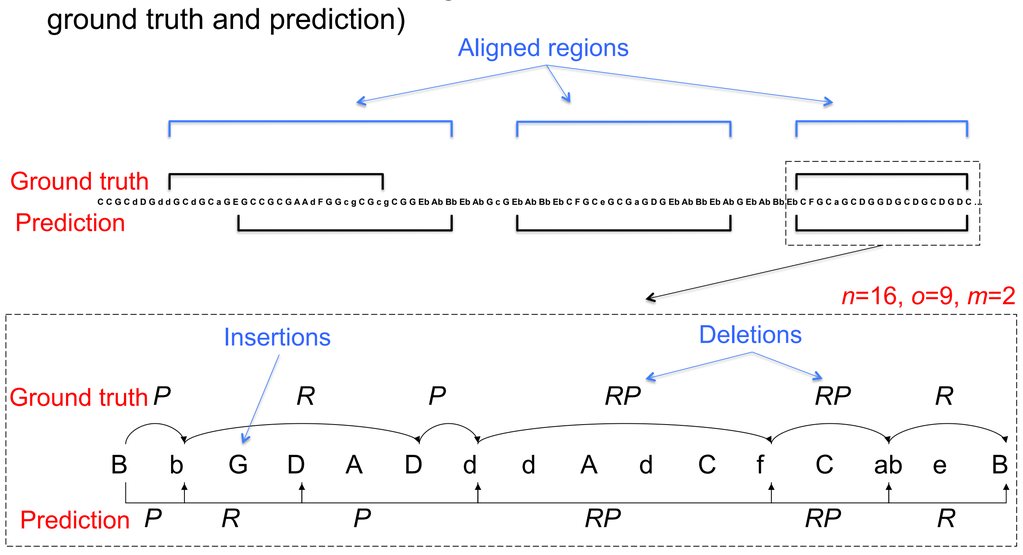
- Harmonies are related by transformations, rather than common tonic
- Basic transformations ***P*** (parallel), ***L*** (leading tone), ***R*** (relative)
- Repeated patterns of transformations generate cycles of harmonies



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

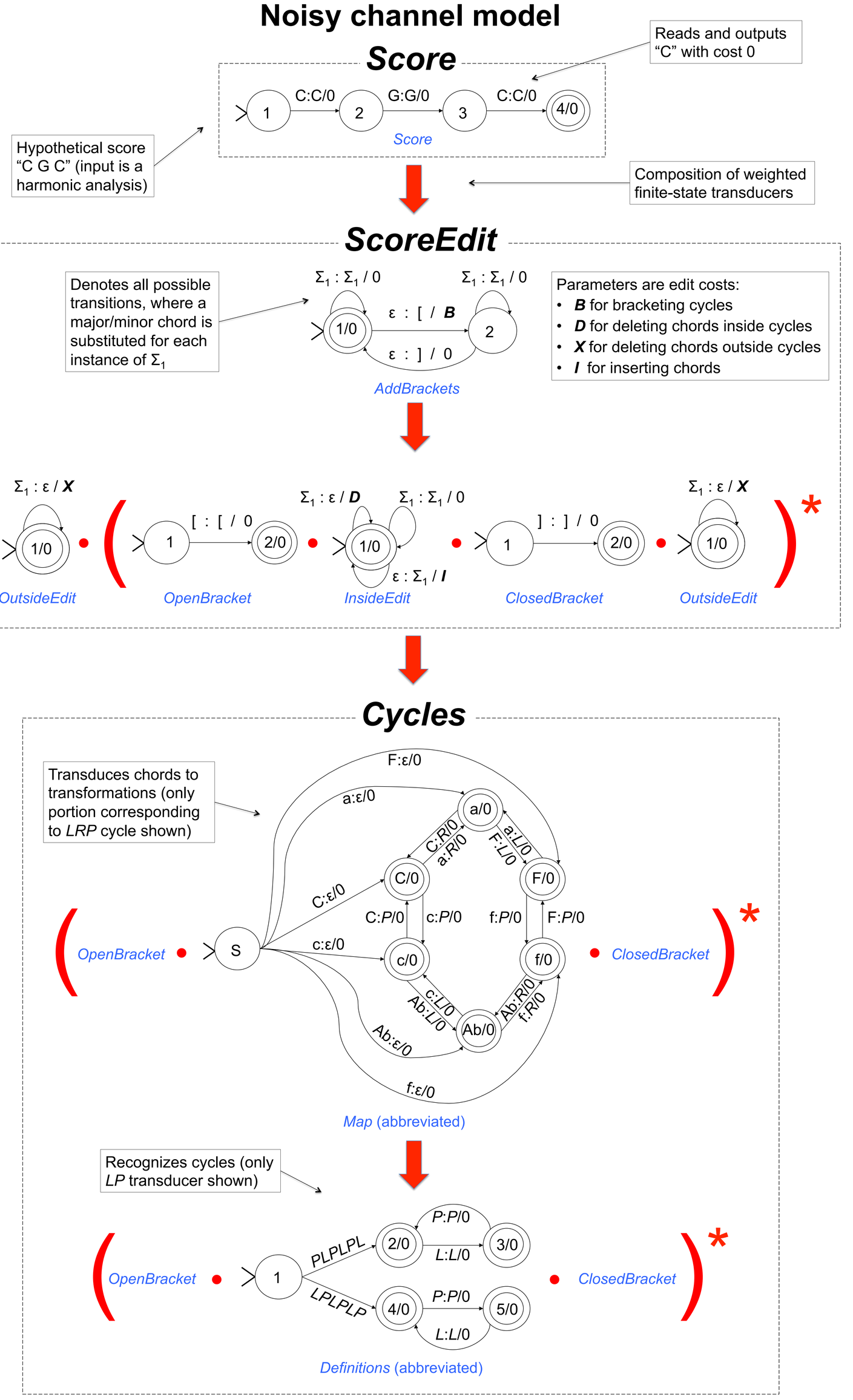
Experiment

- **Data** are analyses of four chamber pieces by Franz Schubert
- **Training** parameters set from system of linear inequalities (empirical)
  - ***B*** + *o****D*** + *m****I*** < *n****X*** (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)



Aligned region 5, D. 956 (C major String Quartet), mvt. 1, mm. 233-250

Noisy channel model



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	**4**	6	**0**	5							4	16	20
D. 894	8	**10**	6	8								10	22	32
D. 956	6	5	9	7	**0**	7	6	5				0	45	45
D. 929	6	5	6	7	8	7	7	8	4	7	**2**	2	65	67

Alignment costs by region

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***

This work was supported in part by the Harvard College Program for Research in Science and Engineering and NSF Grant No. 0347988. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors, and do not necessarily reflect those of Harvard University or NSF.