A Study Of Intonation In Three-part Singing Using The Automatic Music Performance Analysis And Comparison Toolkit (AMPACT)

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AMPACT

Overview of AMPACT

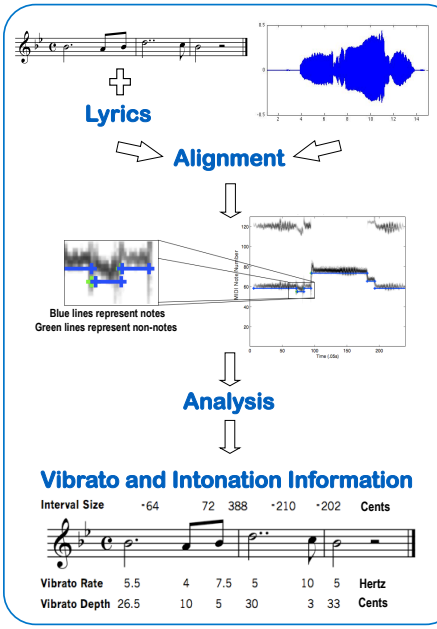
- Automatically extracts performance data from monophonic/quasi-polyphonic recordings for which a score is available
- Written in MATLAB
- Available in beta release for download at www.ampact.org
- Code repository is also available at github.com/jcdevaney/AMPACT

Alignment Algorithm

- Provides estimates of note onsets and offsets for tones with non-percussive onsets (e.g., vocalists) that are more robust than existing blind onset detection or alignment algorithms
- Refines the results of an existing dynamic time warping approach with a hidden Markov model
- observed variables: periodicity, signal power, and F0 estimates for each frame (obtained from YIN)
  - states: silence, transient, and steady state
  - for recordings of singing, the state sequence is modified by the lyrics in the score

Analysis

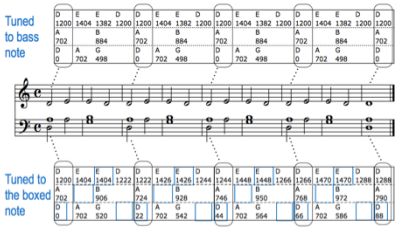
- The analysis portion of the toolkit allows for the extraction of various performance parameters:
  1. inter-onset intervals between notes
  2. tempo information
  3. relative dynamic level between notes
     - using Glasberg and Moore's model for estimating loudness in time-varying sounds
  4. mean frequency for each note and interval size in cents
     - using a weighted mean based on the F0's rate of change, frames where the F0 has a lower rate of change are assigned a higher weighting
  5. vibrato rate and depth
- The statistical tools allow comparisons of different performances of the same musical material or piece
  - tools include ANOVA and linear regression



Intonation Experiment

Experimental Material

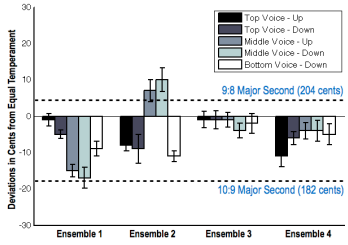
- Three-part chord progression written by Bendedetti designed to show that singers do not tune in Just Intonation with the current sustained note
  - strict adherence to Just Intonation would result in a significant upward pitch drift
- The numbers in the tables at the top and bottom of the figure indicate the theoretical Just Intonation tunings tuning in relation to the starting pitch in the bass (top) and the sustained note (bottom)



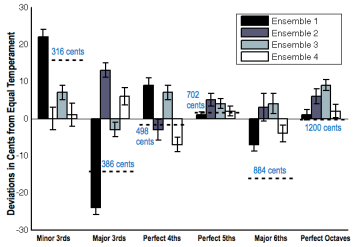
Subjects

- Ensemble 1 (lab): semi-professional alto, tenor, and bass singers who performed without a conductor
- Ensemble 2 (lab): professional alto, tenor, and bass singers who performed with a conductor
- Ensemble 3 (church): professional soprano, alto, and tenor singers who performed with a conductor
- Ensemble 4 (church) professional alto, tenor, and bass singers who performed with a conductor

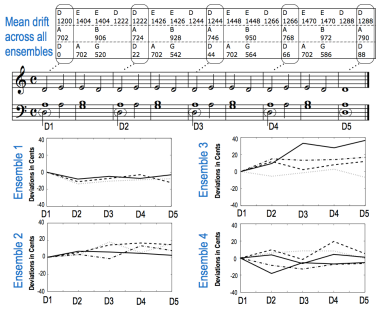
Results



- ANOVA on melodic major second data
  - no significant effect for direction in any of the ensembles
  - ensembles 1 and 2 had significant effects for singer
  - ensemble 1 was significantly smaller than the others
- Did not conform to either the 10:9 (204 cent) or 9:8 (182 cents) Just Intonation tunings but were generally closer to equal temperament



- ANOVAs were run on each vertical interval to test for group effects
  - ensemble 1's m3 intervals were significantly larger
  - ensemble 1's M3 intervals were significantly smaller
  - ensembles 1 and 3's P4 intervals were significantly larger
  - there were no significant effects for P5, M6, or P8
- Generally closer to equal temperament than Just Intonation



- Table at the top of the figure shows the means and standard deviations for each note across all of the ensembles
- There was a drift upwards of 8 cents in the lower voice, 10 cents in the middle voice, and 13 cents in the upper voice
- Suggests that singers tuned to the bass
  - this conforms to Benedetti's prediction that tuning to the sustained note is unlikely due to the drift it would create

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