Offline Automatic Harmonic Accompaniment With Externally Generated Onset Signatures

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Abstract

This paper introduces a method for automatic accompaniment track generation for solo pieces. Using a dataset of manually annotated lead sheets, multiple systems are trained to predict best-fitting chords for unaccompanied melodies. Once chords are predicted, a rhythm is generated to back the track of this song by taking an existing song's onsets as a beat "signature", stretching these to match the detected beat measures of the solo performance. The hypothesis of this is that using onset data from existing songs will result in a similar "strum pattern" of the songs in these pieces, and thus a less canned sound to the accompaniment by the introduction of this stochasticity. We also review different approaches towards chord estimation, and their performance when applied to the task of predicting the best-fitting chord sequence for monophonic audio. Additionally, we introduce a new heuristic for evaluating the performance of chord estimation algorithms.

Relevant Work

Band-In-A-Box
- RealTracks profiles for accompaniment patterns
- Different Patterns Per Genre

MySong
- HMM based automatic harmonization
- Chroma collected at a set interval

Cyber-Joao
- Rhythmic pattern deduction

Hypothesis

- Use beat synchronous chroma in probabilistic chord prediction to prevent lag
- Generate onset signatures externally to add musicality to the generated output
- Experiment with multiple probabilistic systems for chord prediction

Dataset (RS200)

- Annotated form of about 200 songs from the Rolling Stone's *Top 500 Songs of All Time*
- Contains notes, keys, scale degrees, chord progressions
- Extracted note usage, synchronized notes and chords

Onset Pattern Creation

- Segment song per beat
- Collect onsets from each segment
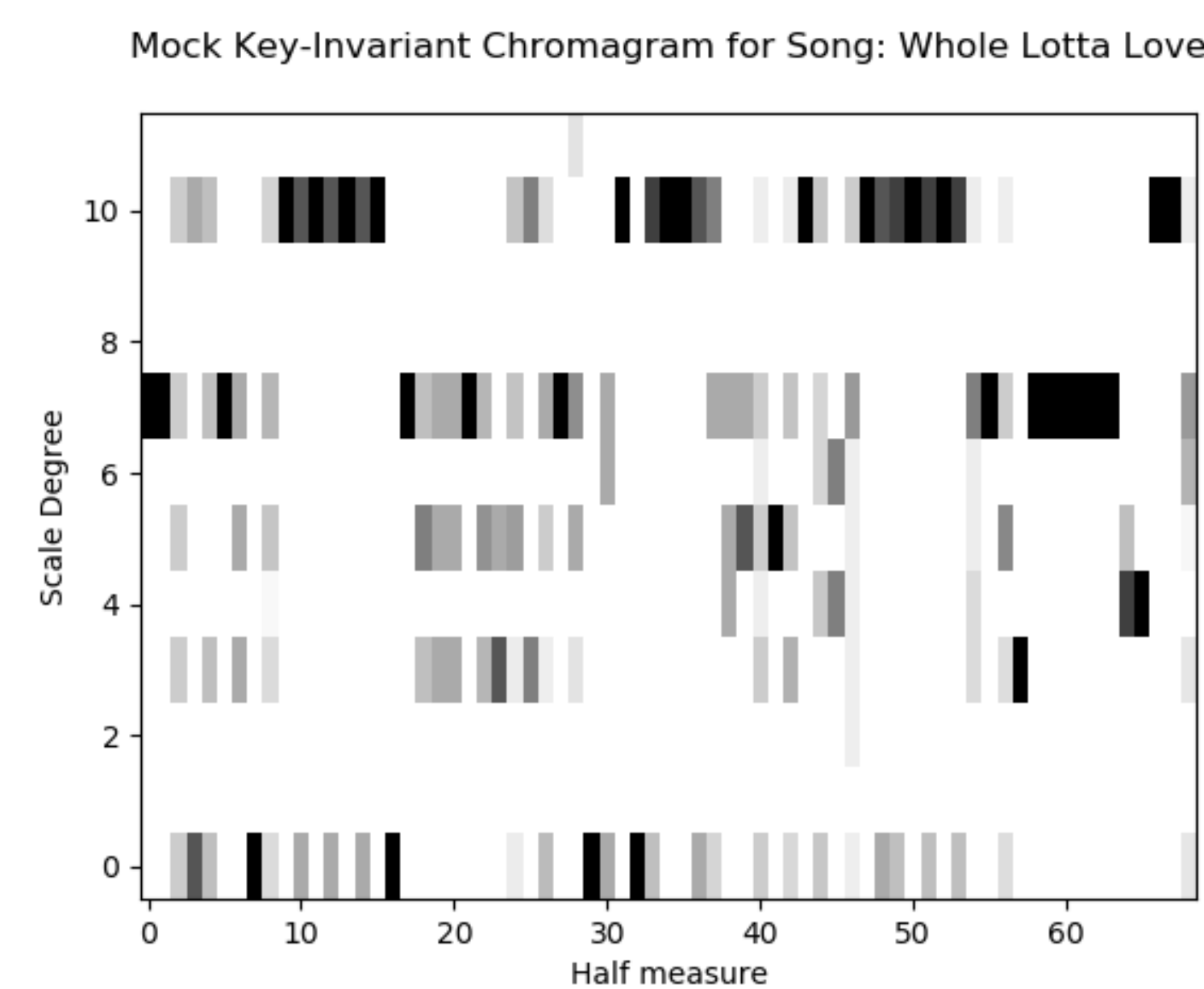- Normalize to a 1000 point sparse vector, creating an onset pattern signature

Pitch Estimation Vs Chroma

Pitch Estimation
- No noise from harmonics
- Potentially incorrect reads

Chromagram
- Some harmonic noise, but less room for error
- Easy to keep beat related, can convert RS200 to match collected data

Mock Key-Invariant Chromagram for Song: Whole Lotta Love

Chord Prediction – Hidden Markov Model

- States (chords) are hidden
- Chroma are observations
- Model the chance of being in a state, and the chance of transitioning from one state to another

Chord transitions for Song: Me and Bobby McGee
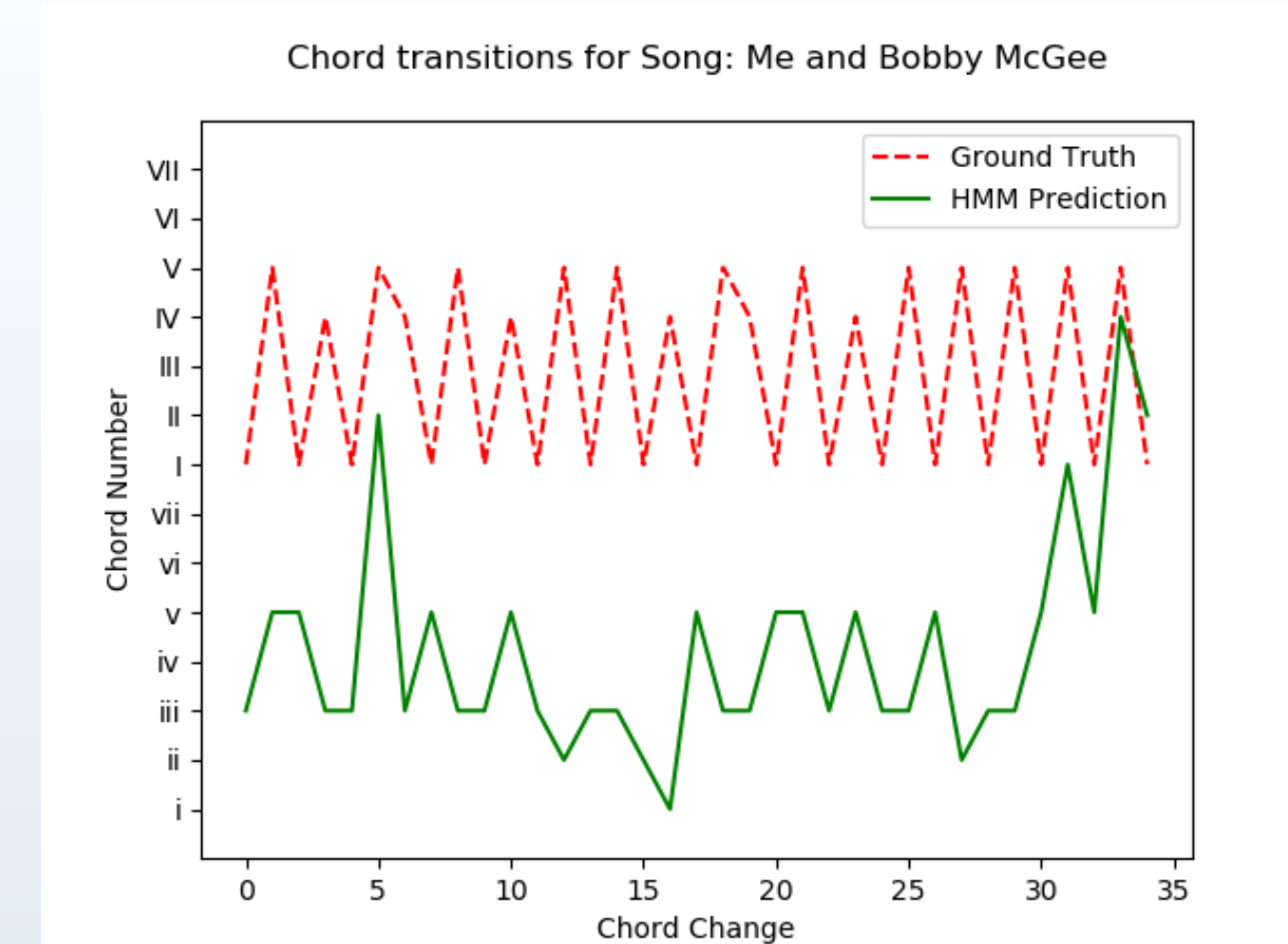
Chord Prediction – Conditional Random Field

- Fit a system to model the probability of certain sequences of states given an inherently multivariate observation

CRF Chord Prediction for Song You Really Got Me
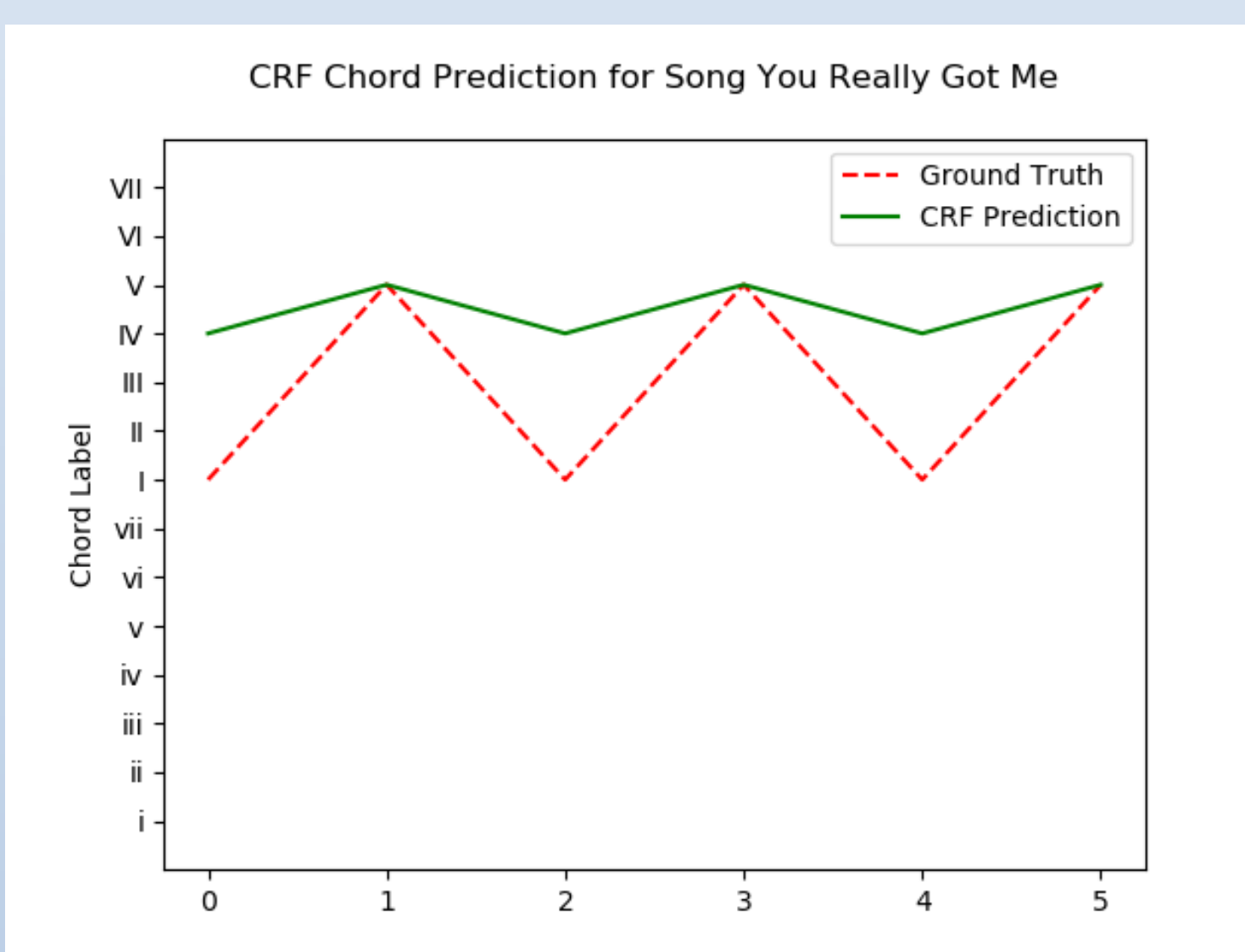
Chord Fit Heuristic

- Chords themselves have similarities to each other.
- Example: A I chord and an iii chord have two notes in common.
- A new heuristic had to be made to note not only the accuracy of the chord prediction, but how many notes in common it had.

Overall System
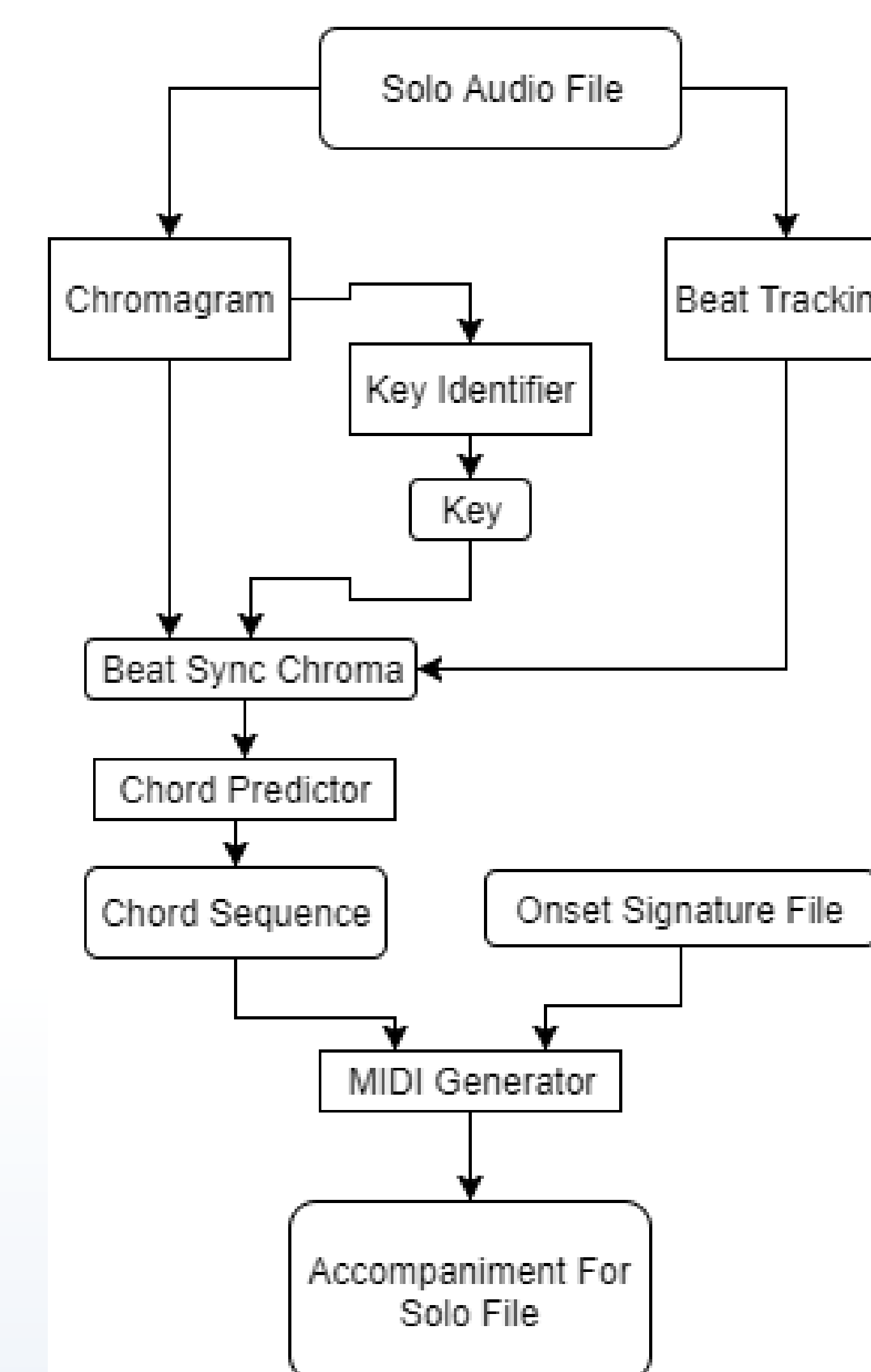
System Architecture: Chord Selection Decision

- Reduce state space of chords to 14 choices (major and minor for each 8 tone scale degree, ignoring the octave)
- Train separate HMMs and CRFs for subsets of the RS200: all songs, major moded songs, minor moded songs
- Cross validate these models using the similarity heuristic to choose which model to use.
- Results: Have the user select the mode, and use the corresponding CRF.

System	Major Songs	Minor Songs	All Data
CRF All Data	0.69	0.53	0.66
CRF Major	0.69	0.49	0.66
CRF Minor	0.50	0.58	0.51
HMM All Data	0.62	0.51	0.60
HMM Major	0.50	0.49	0.5
HMM Minor	0.66	0.45	0.63

System Architecture: Workflow

First, the chromagram for the piece is created using librosa. Next, the key is optionally identified based on the normalized sum of this chromagram. We can then roll the chromagram, and group by beats, to generate a scale degree beat synchronous chromagram. This can be fed into the CRF to come up with a chord structure, the triads for which are rolled based on the key to come up with notes. Finally, the onset signature is stretched per beat to create an onset pattern for the chords, then synchronized with the chord progression to create a MIDI output.

Results

Key Identification would sometimes fail, selecting a member of the true key's triad and throwing off chord prediction.
- Solution: make selecting the key an optional parameter

Onset Patterns, while at times fitting, would be cluttered
- Solution: add a time signature parameter to join beats together to spread out the signature further.
- However, this solution affects the chord progression creation.

Libraries for MIDI synthesis are hard to come by for Windows platforms
- Solution- dynamically identify the platform, and use either PrettyMIDI's fluidsynth library if on a Mac, or sine wave based synthesis if on a PC

CRF Based Chord Prediction would often come up with repeated patterns.

Discussion

Summary
- Introduced an objective heuristic for judging the harmonicity of a chord progression
- Showed that CRF's have some promise in the field of automatic harmonization
- Initial work towards meaningful onset pattern generation for rhythm in the accompaniment

Future Work
- We can extend the dataset to songs outside of the RS200 by locating the lead sheets used for MySong
- Onset signatures could be selected based on their fit in the melody, like Cyber-Joao
- Deep learning approach to automatic harmonization
- Expand the chord label space to nonstandard chords
- Mode identification – can we automatically select which mode to use
- Structural segmentation of solo recording before chord prediction

Contact Information

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All code for this project is found at:
www.github.com/hkmogul/Chord_Accompanist