Functional Harmony Annotation Database for Statistical Music Analysis

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(1) Abstract: We introduce our newly designed data of functional harmony analysis (chord and key modulation) of 50 classical music, discuss statistical findings from the data and show that functional harmony chord model can reduce the perplexity of HMM-based chord sequence model.

(2) Motivation: In short, functional harmony analysis is to identify the key (tonality) and describe the chords with Roman numerals representing the scale degree of the root of the chord. It is essential in statistical modeling of chord progressions.

(3) Notation: We designed a new chord encoding system referred to "KS notation" to represent chords with the ASCII character set in a concise and human-readable syntax allowing multiple possibilities of harmony analysis. Basically, alphabetical letters, Roman numerals and Arabic numerals represent absolute pitch (A–G), scale degree relative to the key, and note relative to the root, respectively. The basic notation of chord is in the form: **[duration] [borrowed key:] [root modifier] Roman numeral [fifth note modifier] [other note descriptor] [inversion] [/bass]** combined with modifiers **+**, **-** and **!** representing semitone higher, lower and omitted, respectively (See Fig. 1). There are also many other features.

(4) Data collection: Musicians and selected music students well-trained in harmony theory analyzed 50 titles in the RWC classical music database and converted labels into KS notation. The duration in the KS notation was found helpful in automatically "playing" the chord data to verify the annotation data by listening.

(5) Statistical analysis: With a syntax parser for the KS notation, statistical analysis on the KS notation database brought a number of interesting findings such as:
- Frequency in appearance of chords (in scale degree unigram): Most frequent chord is dominant(V), followed in frequency by tonic (I and i) and then by subdominant (IV and iv).
- Chord transitions (bigram): High probabilities are observed in dominant motions between II, V and I, and subdominant motions between IV, I and V. (See Fig. 2)
- Inversions: Root position is seen most often for all scale degrees especially for I and V.
- Key modulations: Modulations into subdominant and dominant keys are both almost 20% larger than other cases (subdominant slightly higher).
- Principal Component Analysis (PCA) of chord transitions: Principal components form clusters of composers corresponding the era.
- Chord progression modeling efficiency: Trigram model of chord sequence can reduce the model perplexity with functional harmony labels.

(6) Data availability: We plan to open the data at:

http://hil.t.u-tokyo.ac.jp/software/KSN/.
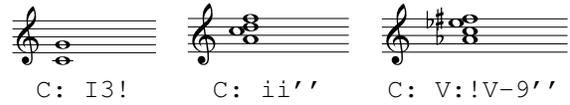
Figure 1: KS notation examples in C major – left: tonic chord with the third note omitted; center: supertonic chord with second inversion; right: dominant ninth chord borrowed from the dominant key, root omitted, fifth note lowered, second inversion.

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% RWC-MDB-C-2001 No.2
% Mozart: Symphony No.40 in g minor, 1st Movement
@K=g @M=2/2 % key=g-minor, meter=2/2
% bars 1- (theme I)
g:
||: i | i  | i | i | ii-7''' | ii-7''' | V7' |
V7 | i | !V9''' | i' | !V9''' | i' | {v: ii-7 |
!V-9'' | I! 1/2!V9'''' 1/2!V9''''/I |
I 1/2!V9'''' 1/2!V9'''' | I 1/2!V9'''' 1/2!V9'''' |
I !V9''''/I I !V9''''/I | I} V3!7'' | i V' |
i | i | iv7' | iv7={III: ii7 | V7 | V7 |
I | V' | IV' | I'' | ii' | I'={V: IV' |
V7 | V7 (!V9''') | V7 (V!9'''') | V7 |
I} V7 | i'' V:!V9''/I | V V7 |
i'' V:!V9''/I | V z V z | z |
% bars 44- (theme II)
3!I' V:V! | V7 | i!3! !2vi V:V7' | 2I'' 1!V' (1z) |
3IV! vi:V! | ii:V!7 V:V! V!7 I! | ii' V7 | I! |
3!I' V:V! | V7 | i!3! !2vi V:V7' | 2I'' 1!V' (1z) |
3ii' vi:V7 | ii:V!7 V:V7 V!7 IV:V7} |
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Figure 2: A KS-notation example from W. A. Mozart's Symphony No. 40, 1st movement.
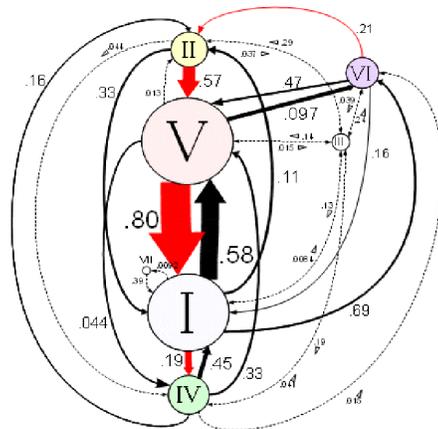

Figure 3: Chord bigram probabilities obtained from key-independent statistical analysis of chord progressions in 50 RWC classical music pieces. Areas of circles represent unigram (i.e., occurrence) probabilities of chords while arrow widths represent bigram (i.e., transition) probabilities between chords.