Harmony Analysis in HPSG

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In this paper, we propose a harmony analysis based on cadence analysis (chord sequence analysis) by HPSG (Head-driven Phrase Structure Grammar), and verify its feasibility.

Many approaches that analyze music have been studied by today. These studies are important for realization of arrangement, accompaniment, etc. by the computers. In order to realize these applications, it is necessary to analyze the harmony structure from a musical piece automatically by computers.

In the formal theory of music, the harmony structure is constituted by tonality, chords, and cadences. The tonality means a set of a sequence of notes, such as "C, D, E, F, G, A, B", and so on. Basically, a musical piece is composed by using these notes which belong to a tonality. A chord is regularly constructed by notes obtained from tonality. It dominates the kind of notes in a certain time of a musical piece. A cadence means a sequence of chords which are generated from tonality, and is equivalent to a comfortable phrase when a man hears it. A musical piece is a sequence of some cadences.

In the existing harmony analysis, first, tonality and chords are analyzed. Next, cadences are analyzed from the result of these analyses. Because the harmony analysis consists of some difficult problems, it is one of the most retarded fields. The greatest problem of the harmony analysis is the

accuracy of each components. When tonality or chords are analyzed by these approaches, there occurs some mistakes and ambiguities. For this reason, the accuracy of the cadence analysis is also deteriorated, and the result of the harmony analysis becomes low. The most effective approach to raise the accuracy of each analysis is referring to the result of these analyses each other. For example, by referring to the result of cadence analysis, ambiguities which occur at tonality analysis and chord analysis will be improved.

However, an order of analyses becomes a problem in such case, because the cadence analysis can not be started without the result of the tonality analysis and the chord analysis. Thus, a framework which can solve this problem has to be constructed.

Another problem is that there are few approaches that can represent any musical knowledge flexibly, and most of them are specific to each musical piece. Because styles of tonality, chords, and cadences differ in each music piece, a harmony analysis system should be able to represent many musical knowledge flexibly, and select these knowledge according to each piece to be analyzed.

In order to solve these problems, we propose an approach of cadence analysis by grammar rules of HPSG, and try to analyze harmony structure from music comprehensively.

In our approach, paying attention to the similarity of music and natural language, we make chords correspond to words, cadences to sentences, and rules of the cadence to grammar. For these comparison, we will be able to analyze a cadence from a chord sequence as a sentence of natural language.

Because HPSG is a grammar theory that based on constraints, it requires fewer rules for analysis than other grammar theories. In this theory, words and sentences are represented by attribute-value-matrix called a feature structure. This representation is also effective to represent several musical knowledge. Thus, we can construct the system that can represent musical knowledge flexibly. In addition, the concept of the grammatical head plays an important role in the analysis of cadence structure from a chord sequence.

By using our cadence analysis, tonality and cadences can be analyzed at the same time. Because tonality is determined by a sequence of the chords,

it is effective to analyze it from chord sequences. Furthermore, analyzing tonality from each chord sequence which constitutes a cadence, it will be possible to recognize the modulation that is a tonality change.

Comparing a chord sequence and cadence rules, our cadence analysis system can specify ambiguities that occur at a chord analysis, because it is not possible to analyze a cadence from a wrong chord sequence. So, to test this function, we prepared two simple systems that can analyze chords from a MIDI file. The first one needs information which shows chord change points, and analyze chords from each chord range. The next one divides notes into every quarter note level or eighth note level, analyzes chords from each segments, and integrates chords which come to a sequence of the same chords in recognized chords.

In order to experiment the system, we used the formal theory of music as knowledge to analyze music, defined the notion of the head in music, represented chords, chord sequences, and cadences by the feature structures, registered information of 600 chords represented by the feature structure into the lexical entry. In addition, we used the same ID-schemata and principles as an analysis of natural language in HPSG. Our HPSG parser system that can also analyzes natural language was implemented by JAVA.

We chose the beginnings of 1st and 2nd movement of Mozart, Piano Sonata in C, K545., Beethoven, Piano Sonata, Op.49, No2., and Beethoven, Piano Sonata, Op.49, No1. as experimented pieces. They have 203 chords and 88 cadences. In that experiment, we analyzed cadences and tonality from right chord sequences by experts and ambiguous chord sequences by our chord analysis system, and compared these results. We evaluated the result of our cadence analysis by the recall rate of cadences which the system outputs, and by which the accuracy of chord analysis improved after the cadence analysis. To evaluate the result of our tonality analysis , we substituted the recall rate of cadences because the rightness of recognized tonality is guaranteed with the rightness of recognized cadences. Further, we evaluated the result of our chord analysis system by the precision of outputted chords. The correct answer of chord sequences was provided by a graduate of a music university.

The result of our experiment showed that the function to recognize cadences and tonality by our cadence analysis system is effective, and we

found that the function to specify ambiguities that occur at chord analysis is useful.