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Structural analysis of the musical piece by GTTM which extended prolongational reduction

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In this paper, we describe the problems of the automatic analysis of structures and reductions in Generative Theory of Tonal Music(GTTM), and then propose methods to solve them.

There have been remarkable progresses in the ability of computer processing for the last several years, especially in calculation speed, and in the way of expression. This can be said also in the field of music processing. So it has become possible for us to play and edit music by computer processing. The progress of computer has brought computer scientists the following new viewpoint.

> " Is it possible for computers to imitate various human actions
> for music by modeling human recognition of music?"

If human recognition of music can be implemented on a computer, it would be possible for a computer to simulate various musical activity such as identification of a composer, information retrieval from music base, expressive performance and arrangements. These technique not only enable those with little music knowledge to support works which requires these knowledge but also treat music easily.

These perspectives can be considered to be an extension of natural language processing. Namely, these are considered to be an attempt to construct human musical process on a computer, as we process natural language. That is, analyzing music is clarifying musical structure using musical grammar which based on a certain music theory.

We think that human language activities are closely related to human musical activities. Human language seemed to begin to develop from the motivation of telling one's intention to others. Later, characters came to be used in order to record them. Similarly, music began from the way of communications in the beginning , and later scores came to be used in order to record them. Therefore, we think that it is appropriate to apply similar methods of natural language processing to the research in the analysis of music. So in this research, we would like to try structural analysis of a music piece as an first step of the recognition of music.

In this research Generative Theory of Tonal Music(GTTM) that Fred Lerdahl and Ray Jackendoff proposed in 1983 are used. GTTM based on structural analysis which based on the Ursatz concept of Schenkerian, and generative grammar theory of Chomsky. In GTTM, the musical piece was analyzed in groups and the layered structure of the strain-relaxation inside reduced time-spans is described in generative grammar.

This theory seems appropriate to be implemented on a computer because it consists of itemized rules. However, there are several problems from viewpoints of uniqueness and optimality because these rules are not rigorously formalized. Then in this research, voice leading, first voice progression and parallel computation are proposed to overcome these problems.

Voice leading gives a relation between notes which are independent on a score according to the concept of melody. Since each rule of GTTM is for finding the boundary of the structure, the rules that give relations between the notes are needed. Because voice leading can treat polyphonic music pieces, it can also use to separate multiple melodies.

The first voice progression extracts a melody. Though the sequence of notes of voice leading may be one of candidates that GTTM is applied, it is unsuitable to grasp whole the music piece because these are divided into too small parts. So the rules are applied to the melody throughout the musical piece in this system. Therefore, the first voice progression is

adopted as a simple melody extraction.

The attempt of parallel computing solves two problems. One is implementing a feedback function so that the rules of GTTM can refer to structures of higher concept. This is a system approach of adapting such rule that stabilize the next structure most. In this implementation, all possible solution candidates are considered, and then the most suitable one in the following stage are selected. The other one is to output multiple analyses. Generally, interpretation of music differ between individuals. So, it is unrealistic for the theory to produce one unique solution. Therefore, all possible solutions are taken into account in this research.

Each module was implemented focusing on the above extensions. We have clarified the reference relation with other modules, and have arranged the dependency of rules, when each module is implemented.

In the system which this research proposes, the effective result was obtained about two structures with such specifications. However, the subjective viewpoints remain about the reduction.

In this paper, the details of GTTM are explained and we clarified the problem of GTMT. Moreover, the solution of the problem in this research is explained, and an experiment shows the validity. At the end of the paper we discuss our future work.