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Cadential Retention in GTTM Based on Revised TPS

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As computer science has been developing, there is a growing interest in musical information science. It is expected that it will be applied to industrial purposes; e.g. automatic or computer-aided musical composition and arrangement, or music recommendation based on similarity among musical pieces. These application require automatic musical analysis which should be based on musical theory and knowledge. Traditional musical theory is the accumulation of human empirical rules. Therefore, it is too subjective and ambiguous for a computer to understand. Researches on computational musicology have been trying to restructure musical knowledge mathematically to implement them on a computer.

A Generative Theory of Tonal Music (GTTM), proposed by Lerdahl and Jackendoff, is considered as one of the most promising computational musical theory. It focuses on Western classical tonal music. In this theory, one is able to analyze a musical piece as hierarchical structures. This approach is based on the reduction hypothesis, that a listener attempts to organize all pitch events (notes or chords) in a piece into a hierarchical structure of relative importance, advocated by Schenker. GTTM consists of four sub-theories; grouping analysis, metrical analysis, time-span reduction, and prolongational reduction. Each of them represents a musical piece as a hierarchical structure. Among them, results of time-span reduction and prolongational reduction are given as tree structure. It meets the concept of the reduction hypothesis, and is easy to understand for a computer.

Each of sub-theories in GTTM has mainly some well-formedness rules (WFRs) and preference rules (PRs). WFRs define a strict form of the hierarchical structure, and PRs describe how to construct the hierarchy based on actual contents of a piece. The latter, PRs are permitted to conflict with other ones. If more than one PRs are not able to be applied simultaneously, which one will be adopted is up to a human decision. Furthermore, some of rules related to harmony, symmetry, parallelism, and stability are still ambiguous. Although GTTM is rule-based, it is hard to implement this as it is because of these ambiguities.

This paper focuses on the third sub-theory, time-span reduction in GTTM. In this process, an analyst compares pitch events within a time-span and select one as a head. This comparison is based on the structural importance of each event. PRs in the time-span reduction suggest which one is more likely to be a head. Since time-spans are hierarchical, heads in some time-spans are compared in the immediately higher-level time-span like a tournament.

Hamanaka et al. mathematically redefined GTTM and proposed it as exGTTM. It is implemented as Automatic Time-span Tree Analyzer (ATTA). A user is able to obtain resulting time-span tree just by tweaking priorities of involved PRs. However, exGTTM is limited in monophony, that is, a musical piece consisting of only a single melody. Some of PRs regarding harmony have not implemented yet and therefore the prolongational reduction is completely untouched. The reason of this limitation is difficulty with harmony analysis. Among these non-monophonic PRs, Cadential Retention is the most important one. It is a rule that gives higher structural importance to a cadence, which plays the role of a punctuation in a harmonic progression. In GTTM, there are three types of cadence; an authentic cadence V→I, a deceptive cadence V→vi, and a half cadence V. Besides difficulty with harmony analysis, there is another problem to handle a two-element cadence as one unit in implementing Cadential Retention.

This paper proposes a method to automatize Cadential Retention by applying it to a time-span tree, which is exported from ATTA without any consideration of harmonic information. In the proposed method, Cadential Retention is divided into following three processes. Firstly, the harmonic progression is analyzed. Assuming a chord sequence is already given as chord symbols such as C7 and Bdim in an input score, a key and a harmonic function are assigned to each chord. Secondly, cadential harmonies are searched by checking with conditions to be a cadence defined in GTTM. Finally, the input time-span tree is modified by Cadential Retention rule so that it reflects cadential structure.

With regard to the first step, harmony analysis for chord symbols is proposed by Sakamoto et al. In their method, all possible pairs of a key and a degree is enumerated for each chord symbol. For example, a chord C can be interpreted as I/**C**, IV/**G**, V/**F**, iii/**a**, or vi/**e**, therefore five possibilities are generated. Then, the most plausible harmonic progression is estimated by the shortest path search. Each cost of a path is calculated as the chord distance between two adjacent chords. The chord distance is defined in another music theory, Tonal Pitch Space (TPS), proposed by Lerdahl. The smaller a chord distance is, the smoother the chord progression is perceived. This paper employs the harmony analysis by the shortest path, however, with two revisions on TPS; an additional level in the basic space and restriction to the harmonic minor scale for minor keys. In the former, proposed by Yamaguchi et al., the basic space is a hierarchical expression of a chord. The extension to it is to express tetrad chords more appropriately. The latter, proposed by Matsubara et al., is to find more cadences in a minor key. This paper clarifies that these revisions involve disuniform changes in the chord distance and discusses their influence.

Matsubara et al. also proposes a special handling for a half cadence with preceding double dominant V/**V** → V/**I**. Although a half cadence consists of only one chord V/**I**, it is frequently preceded by V/**V** and forms a dominant motion like an authentic cadence V → I. Therefore, a cadential V/**I** and the preceding V/**V** should be bound to one unit. This paper assents this argument and assumes such type of half cadence to be two-element as well as an authentic or a deceptive cadence. In addition, this paper proposes a local cadence, which is a harmonic progression with possibility of satisfying the conditions to be a cadence by selecting interpretation of each chord arbitrarily, regardless of the result of the harmony analysis for the whole input.

This paper implements the proposed method of Cadential Retention and experiments it with 127 phrases and their structures analyzed by exGTTM. As a result, it is shown that the method is able to modify a time-span tree so that it reflects the cadential structure. However, it is hard to evaluate the method quantitatively in the present situation on account of variety of interpretations on a musical piece. Also, further consideration is necessary for improvement on the harmony analysis, properness of the local cadence, and the structural level in a time-span tree. Nevertheless, a time-span tree with consideration of harmony has not been able to obtained automatically. The contribution of this paper is automatic acquisition of time-span trees with harmonic information. The proposed method is able to show new interpretations of a musical piece.