Reconstituting a theory related Cadential Retention in the GTTM

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It has been considered that there exists some grammar in music for a long time. If it is possible to find the grammar, it is possible to apply the various methods in linguistics to music analysis. It may be worth finding grammar and implementing it on a computer. A Generative Theory of Tonal Music (GTTM) is a music theory which gives a rule-based procedure and outputs a tree structure as result of the analysis and has a Chomskian viewpoint. As the rules of the theory are proposed as handwork analysis, they are very ambiguous to implement on a computer. On the other hand, there is another music theory called exGTTM that is a reconstruction of GTTM. However, it is not complete to implement "Cadential Retention (CR)" that adds harmonic information to the tree structure in GTTM. The reason for the difficulty is that music and harmonic theories are totally ambiguous, and the definition of the CR is also ambiguous.

We believe that to analyze harmonic information it is necessary to implement CR. Tonal Pitch Space (TPS) has been proposed by the same author of GTTM to compensate the deficit of it, and a part of it is implemented by Sakamoto et al. TPS is independent of GTTM, and it decides the quantitative distance in the between pitches, chords, and keys. In brief, it can calculate quantitative distances between chords in different keys. These chords are stable and give us good feelings when the distance is nearer, and are unnatural and give us bad feelings when the distance is further. It is considered that harmonic information is quantitatively analyzed by a computer using the theory, however, the theory is not applicable directly to CR, and there is also some ambiguity in the theory itself. We find it is slightly difficult to implement TPS on a computer, and to apply it to CR. Cadences in harmony are a part of a piece of music where we feel the music is reaching the end or a break.

In this paper, the goal is to find a cadence that is applied to CR to analyze why it is difficult to implement it, to find a method to implement it, and to examine it as the preliminary step. Moreover, reorganizing it in Sakamoto's framework is necessary to implement it, and that is also the goal of this paper.

For this goal, first we have studied constructive music theory. Second we have found the ambiguity and the method of solving that using the database of GTTM. We found the ambiguity in CR as follows:

Ambiguity1 The role of Time-Span Tree in GTTM is ambiguous.

Ambiguity2 The rule of TSRPR7 in GTTM says "apply this rule to cadence", but it does not specifically say where the cadence is.

Ambiguity3 There is no specific criteria for deciding which part is correct to add an *egg*, which is a sign for each cadence.

Ambiguity4 The procedure and the method to reconstruct the tree structure in case of the female cadence is not explained specifically.

For Ambiguity1, We reconsider the component of GTTM, and propose a Rhythmic Structure Tree, and change the name of Time-Span Tree to Time-Span Tree with Cadence to easily understand the disposition of the tree. It seems that the Time-Span Tree with Cadence is a intermediate product for constructing a Prolongational Tree, and is more proper. Moreover, it seems that each role of tree structures becomes specific.

We also experimented with the finding process for cadence to elucidate the problem of Ambiguity2. We clarified by this experimentation as follows:

1. Finding cadence by a length of grouping is not proper, so it should not be used.
2. To analyze harmony it is necessary to find it.
3. The rule of TSRPR7(iii) in GTTM is very useful to judge whether it is cadence or not.
4. It is necessary for finding the female cadence to use the results of harmony analysis and grouping structure analysis.
5. The range of cadence (that is not added the *egg* by CR) is decidable, using and considering bass reduction and pedal point.
6. It is effective for choosing a *head*, which is the most important note(s) of a part of music pieces, of a cadence to use the results of grouping structure analysis.

7. It is necessary to consider the anticipation using the method outlines above.

8. It is necessary to structure a Time-Span Tree with Cadence from the beginning. That is, reconstructing a Time-Span Tree with Cadence from the Rhythmic Tree is not correct.

And we also propose the data structure TimeSpanXML with *egg* that is able to express Time-Span Tree with Cadence.

Moreover, we also propose harmony analysis theory for CR using the TPS. It is important for applying TPS to CR to find a dominant in cadence, because CR is applied to full, half, or deceptive cadence. In addition, harmony analysis that finds the dominant of a cadence is more important when we analyze the relationship between a harmony and a remote harmony. By these reasons, we propose the harmony analysis theory and system.

This theory is a method to find the dominant, so it is a little different from standard harmony theory, but it is mathematically well-defined and also based on TPS in accordance with standard harmonic theory.

In this theory, we consider that a harmony occurs based on a scale in a key, so the chord is restricted by a major scale or a harmonic minor scale. The theory looks complicated but it is useful when we implement it via a programming language. However, there is room for improvement for this because its functions are very complicated.

We also experiment, and check whether the theory is correct or not. In addition, we also analyze some music scores using it, so we found out some useful properties that can find cadence for CR. Their properties are as follows:

1. The system can find a modulation (a change of key) that is not written on the score but is felt by musical intuition.

2. The system can judge whether a harmony that looks like cadence by the Berklee method is really cadence or not.

3. We can judge whether a harmony that looks like cadence by the system is really cadence or not using the result of grouping structure analysis.

The future works are as follows:

- Reconstituting GTTM by these theories and methods that are proposed.
- To consider and to set a parameter that decides a priority to choose a *head*.
- To consider adding an *egg* in the higher level.
- To implement the system with a lot of scores.