A Versatile Model for Music Creation Utilizing Tension States

Heikki Ruuska, Yoichi Takebayashi

Abstract:

We investigates novel methods for creating systems for assisting musical composing. In this presentation we describe some previously neglected problem areas in musical structure analysis: knowledge-based computational expectation mapping and narrative-based structure. We also investigate how results from musical pattern analysis might be used for predicting human cognitive processing of general commonsense domains in everyday life. We conclude with a statement of how investigating music can lead to insights in other fields of cognitive science.

Keywords: *musical composition, music analysis, cognitive science, computer-generated music.*

1. Introduction

This paper aims to examine musical listening and composition processes from a cognitive science standpoint: what kinds of cognitive processes music engages, what kinds of effects it causes, and how those processes and effects could be simulated on a computer. We propose a tension-release model for analyzing expectations aroused by progressions in common musical pieces, and a computational model for analyzing scalable musical structures from an affective viewpoint. We test our theories on classical Western music and traditional Japanese music, and propose a framework for software to assist in music creation.

Most current research on music analysis and composition assistance is based on mathematical analysis of repeating patterns, applied to datasets (existing pieces of music represented according to some schema), often coupled with classic Western music theory [1],[3],[4],[5],[6]. We view music as an interdependent projection and compliment of non-musical mental activities. This view necessitates comparing and relating musical activities to non-musical behavior, which is the topic of chapter 2.

2. Music as a Cognitive Process

2.1 Music as Stories

Music and stories share similar structural aspects, and making the analogy allows for some insights. We limit our inspection to common practice music which shares these elements.

A. Musical pieces have a beginning and an end.

B. Musical pieces commonly have some protagonists and antagonists (instruments or parts), which act with or against each other. These are identified by a combination of some or all of timbre, typical melody, typical rhythm, or relative pitch.

C. Musical pieces are placed in a setting – this can be a subset of the tonal world of Western classical music or Gamelan rhythmic repertoire, or a pitch range – with both tacit and explicitly suggested rules and discrete pitch and rhythmic blocks as basic units.

An illustration is given in Figure 1.

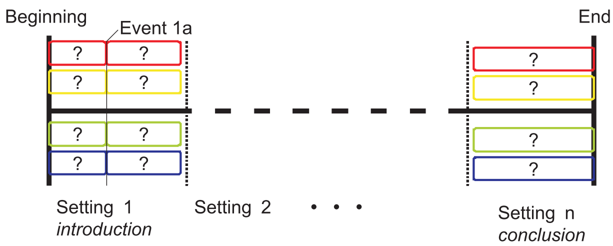

Fig. 1. Rough story model for a musical piece.

2.2 Narrative Centers

Taking spoken stories as a base analogy, there are some basic observable facts regarding story frame structure of most music.

- Musical cultures have taken a long time to build. This suggests an evolution has taken place where the musical culture has adjusted itself to its surroundings – in cognitively and culturally comfortable position.
- Most pieces in common practice music are 5-15 minutes long. Longer pieces typically consist of shorter parts. This observation leads to suggest that 1) short pieces are not cognitively satisfactory: they either have too little material or too few repeats, and 2) long pieces either overload the cognitive machinery or bore the listener with too many repeats.
- Most pieces have a few melodic or rhythmic patterns which are repeated, possibly with variations, throughout the piece. This could be due to an inability to remember patterns with a single effort, similarly to natural language.
- Most music is pulsating with discretely observable beats: commonly less than 30 or more than 200 per minute, which suggests a cognitive linkage with human heartbeats and their associated mental states.

3. Tension State Model

3.1 Overview

We have constructed a tension-release model for examining basic musical processing. The model treats each musical event as a signal which calls for resolution, causing expectations in the listener. These expectations are organized in layers for convenience, roughly reflecting familiarity with the musical matter but not necessarily implying strict structural hierarchy.

3.2 Patterns and Progressions

Two ways people process music are by dividing it into discrete blocks (phrases and parts) and/or linear patterns (accelerating, slowing beats).

For explaining listeners' attentive interest in a piece of music, we propose the following tension-release model: each invocation of an identified pattern creates a mental tension which can have one or multiple expected release patterns. Tension and release patterns can be grouped into multiple layers. Table 1 illustrates three rough classes for patterns.

Table 1. Tension-controlling Patterns (classes).

Immediately observable Physical Properties	
Rising – lowering pitch	(Pm)
Hammering - continuous melody	(Mm)
Consonance - dissonance	(Cm)
Style-specific Knowledge	
Harmonic Progressions	(Hm)
Overall Piece Structure: forms	(Fm)
Explicit-relation Knowledge	
Comparison with other pieces, explicit quotations	(Qm)
Abstract structural references	(Am)

In the following sections, we use the tension-release model to analyze existing music. The abbreviations in brackets will be used.

3.3 Case Study 1: Western Tonal Music

Western classical tonal music has been widely analyzed, not only by music theorists and composers but also by mathematicians and AI researchers (eg. Lerdahl [3], [4], Levitt [1], Mazzola [5]). However, current theoretical analysis fails to answer questions such as why certain phrases and/or their combinations cause pleasure, frustration, excitement and other emotive reactions.

Western music is often composed of equal-length patterns divided into clear blocks: these blocks can further be subdivided into phrases, which also are often of equal length. The equal-length and scalable system creates default assumptions for when each phrase begins and ends. Once a phrase has been introduced, a repetition of its beginnings will create an expectation of something similar following.

Figure 2a and 2b provide an illustration of this: an excerpt from Nocturne in g Op. 15 No. 3 by Frederick Chopin.

Fig. 2a). Nocturne Op. 15 Nr. 3 (excerpt).

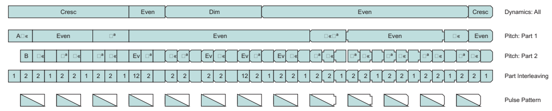

Fig. 2b). Western Music Tension Model.

Figure 2b depicts a partial analysis (*Pm, Mm, Fm*) of the said Nocturne. The following is a tension-release analysis of rhythmic changes at phrase end.

Western music is typically constructed to an even pulsating rhythm, with fluctuations occurring in between or at the end of beginning of phrase blocks. *(Tension: (M(Pulse=C)))*. Actual interpretation of the piece, which may or may not be written down in the score, often includes a slight "breath" at the end of the phrase (marked * in Fig. 2b). As a general pattern, phrase endpoints are often accompanied by a ritenuto. This creates a new level expectation: the phrase is going to end soon. (*Tension: (M(Rit)) => Tension: (F(PhraseEndSoon=t))*). And, if the phrase does actually end, creates an emphasis on it. (*Tension:(F(PhraseEndSoon)) and Release:(F(PhraseEnd)) => (Tension:(F(Emphasis=Phrase?)))*). In some pieces, the next phrase may be precluded by a slight acceleration to balance the rhythm.

3.4 Case Study 2: Traditional Japanese Music

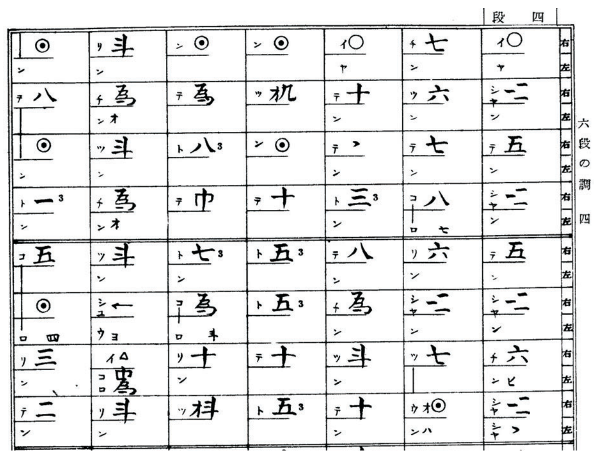

Fig. 3a). Rokudan no Shirabe (excerpt).

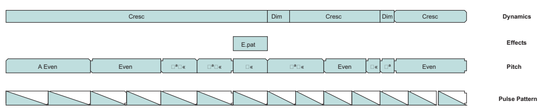

Figure 3b). Japanese Music Tension Model.

Japanese traditional music, not very well known in the West, has methods for creating variations and expectations quite different from those used in Western classical music. For an introduction to the style, the reader is encouraged to refer to Malm 2000 [7]. The use of pentatonic scales, alongside a tendency to not to compromise individual sound qualities over ease of modulation in instrument evolution, have resulted in a musical culture where complex harmonies and scale modulation are not as readily usable as in Western music. Instead, expressive power of individual instruments, complex rhythmic nuances and constant fluctuation of tempo are used to create tensions and variation.

Figure 3a and 3b show a part of a classical Japanese piece Rokudan no Shirabe (Six Variations) by Kengyo Yatsuhashi (16??). The excerpt is taken from the fourth variation.

An accelerative pattern is noticeable from the pulse line. (*Tension:(M(Acc=C))*). This would generally continue until the end of the section, with slight pauses (rest-stops) in between. Further local tensions are caused by jumps in pitch, which often signify phrase change. (*Tension:(F(PhraseEnd))* associate *Tension:(P(HighJump))*).

4. Experimental Music Creation

4.1 Related Research

Much previous research exists on electronic composing assistance technologies. Beside now-common tone synthesis and automated digital alteration of timbre and pitch, there is software for chord completion, melody generation and improvisation. Most of these are based on mathematical formalization, statistical pattern analysis, or rule-based evaluation of commonly occurring chord, rhythmic and melodic patterns (for example [?], [/], [?], respectively). However, the methods are limited to analysis of tonal structure in Western music.

4.2 Current Data

Currently, we have 24 tension pattern types for classical Western music and 14 types for traditional Japanese music, gathered from three compositions (total of 437 measures according to notation, or 115 annotated phrases). Whereas the number of music samples is limited, the in-depth analysis has enabled us to create a suggestive grammar for improving annotated ad hoc improvisations. As noted in Section 2.3, a full musical piece should be at least a few minutes long, which makes meaningful evaluation impossible with the current data set.

5. Discussion and Future Work

5.1 Performance and Education Assistance

Ability of computers to engage in collaborative musicianship is poor: a machine works in a pre-programmed fashion, without ad hoc stopping or taking of breaths. An anticipating, backtracking model for mid-level analysis should help in a more interactive communication between a synthesizer and musicians in a live performance.

5.2 New Music and Cultural Aspects

What kind of cognitive machinery is associated with processes in learning music? We take by assumption that one of the reasons people like music is because it gives them a challenge-release framework, like stories. Some basic characteristics remain the same, but by inclusion of new patterns, people can find new insights and ways to think about what they are and have been doing.

6. Contributions

We have presented a case for cognitive affect analysis of musical processing. To partially explain human attraction to music, we have constructed a model where musical patterns create musical goals in human minds, which require resolutions. Interest in following the piece to the end depends on how satisfactorily these resolutions are carried out. Called tension-release model, we have analyzed existing musical pieces for tension-creating patterns on a more concise scale than done before, and found it useful for explaining cognitive effects of variations within a piece of music.

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