MELODY SLOT MACHINE HD

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ABSTRACT

Melody Slot Machine HD is an application that allows one to generate melodies using music structures while playing a slot machine. The user can create new melody combinations by rearranging melody variations using the slot machine. When the user composes a melody with variations, the structure of the melody is analyzed using a theory of music known as the generative theory of tonal music. Even if the melody switches variations in the middle, the overall structure will not be disrupted. Our original Melody Slot Machine has been exhibited in academic conference as a demo system. Due to Covid-19, however, it has become difficult to exhibit in places where many people gather, so we developed an app version for the iPad, Melody Slot Machine HD, to give many people access to it through the Appstore. We conducted an experiment to evaluate Melody Slot Machine HD, and the results indicate that when five participants listened to new variations of melodies generated by random combinations using Melody Slot Machine HD, 85.6% of the melodies were judged as natural or almost natural.

1. INTRODUCTION

This paper describes Melody Slot Machine HD, an iPad application that can generate a huge number of combinations of melodies by connecting multiple variations of melody fragments and performance-video fragments. The main advantage of the application is that even musical novices can edit melodies.

It is generally difficult for a musical novice to create a melody from scratch or edit an existing melody to create a new one. For example, certain sequence software have many preset melody fragments prepared in advance, and it is possible to create a melody by concatenating these fragments. However, many trial and errors are required until a novice can combine them in an appropriate order to generate a natural melody.

There are 12 melody fragments in Mozart's dice game, but a natural melody is generated no matter what order they are concatenated [1]. The purpose of the musical dice game is to combine the melody selected by the dice in order.

Melody Slot Machine HD was inspired by the dice game idea in terms of changing the melody. However, the melody-composition methods for Melody Slot Machine HD and the musical dice game are very different.

Melodies in the dice game are elaborately designed so that they sound natural in any order. The melody-morphing method used in Melody Slot Machine HD uses the results of the music structural analysis from the generative theory of tonal music (GTTM) [2]. Even if the melody is changed, the essential structure is the same and only ornamentation notes change.

2. MELODY MORPHING METHOD

The GTTM consists of four modules, each of which assigns a separate structural description to a listener's understanding of a piece of music. The time-span tree is a binary tree, a hierarchical structure that represents the relative structural im-portance of notes to differentiate the essential parts of a melody from ornamentation.

Figure 2 is an example of abstracting a melody by using a time-span tree. There is a time-span tree from melody D, which embodies the results of the GTTM analyses. The structurally important notes are connected to a branch nearer the root of the tree. In contrast, ornamentation notes are connected to the leaves of the tree. We can obtain an abstracted melody E by slicing the tree in the middle and omitting notes that are connected to branches under line E.

It had been difficult to obtain results of the time-span reduction automatically [3]. Through using deep learning, how-ever, it has become possible to effectively reduce the time-span [4].
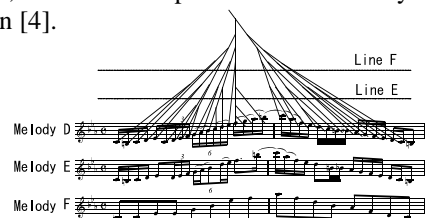

Figure 1. Time-span reduction of GTTM

In melody morphing, we use the primitive operations of the *subsumption relation* ($\sqsubseteq$), *meet* ($\sqcap$), and *join* ($\sqcup$), as proposed by Hirata and Aoyagi [5]. *Subsumption represents* the relation by which "an instantiated object" $\sqsubseteq$ "an abstract object." The $\sqcap$ extracts the largest common part or the most common information of the time-span trees of two melodies in a top-down manner. The $\sqcup$ joins two time-span trees in the top-down manner as long as the structures of two time-span trees are consistent.

By using time-span trees σ_A and σ_B from melodies A and B, we can calculate the most common information, $\sigma_A \sqcap \sigma_B$, which are the essential parts of melody A, as well as those of melody B. The $\sigma_A \sqcap \sigma_B$ are abstracted from σ_A and σ_B, and the discarded notes are regarded as the difference information of σ_A and σ_B (Figure 2a). We argue that there are

features without the other melody in the difference information of σ_A and σ_B. Therefore, we need a method for smoothly increasing or decreasing these features. The melody-divisional-reduction method can abstract the notes of the melody in the differential branch of the time-span tree (Figure 2b). We use $\sqcup$ to combine melodies α and β, which are the results of the divisional reduction or augmentation using the time-span tree of melodies A and B (Figure 2c) [6].
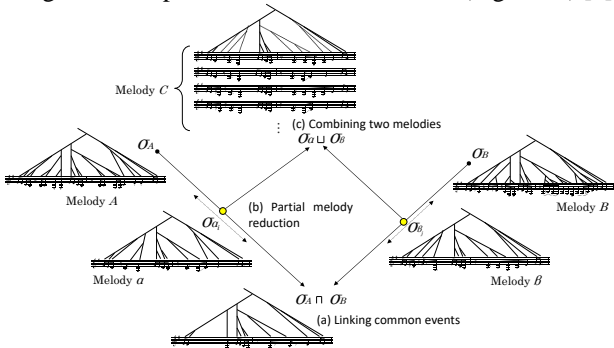

Figure 2. Melody morphing method

3. RELATED WORK

Our original *Melody Slot Machine* has a dial-type interface that allows parts of the melody to be replaced so that anyone can easily create the melody (Fig. 3) [7-9]. There is a rectangular hole in a part of the acrylic board sandwiching the score, and the dial interface on a tablet can be operated with fingers through that hole. When the red lever on the right side of the score is pulled down, all the dials rotate, and one of the melody segments on the dial is randomly selected.

Figure 3. Original Melody Slot Machine

We then prepared a display showing a performer so that the result of the melody creation can be visually understood as well as aurally. A holographic display was used to show the performer to increase the feeling of presence. To interpolate videos between two melody segments, we developed the audio-based video interpolation technique for generating an adaptive interpolated video depending on the combination of melody segments [9]. This bridges the discontinuity of the videos, and the users can feel like they are controlling a performer by playing a melody.

We then built the app *Melody Slot Machine on iPhone* [10] so that many people can create a melody by making it possible to download the application from the Appstore (Fig. 4). Due to the limited screen size of the iPhone, the entire slot dial could not be displayed, and scrolling horizontally caused a problem of poor visibility during operation.

Figure 4. Melody Slot Machine on iPhone.

4. MELODY SLOT MACHINE HD

We thus built *Melody Slot Machine HD* for the iPad and has three screens: grid tile, slot machine, and performer. In the grid-tile screen, the horizontal axis is time, and by touching the grid instead of the dial, the user can switch the variations of the melody (Fig. 5 top-left). In the slot-machine screen, by replacing grid level changes with symbols, even people who cannot read music can understand the changes in variation visually. For example, a heart is displayed in a pattern that goes from a high level to a low level then to a high level again (Fig. 5 bottom-left). The performer screen displays the image of the performer at the top of the screen (Fig. 5 left). The user can see the performer playing new combinations of melodies determined by the slots or grids.
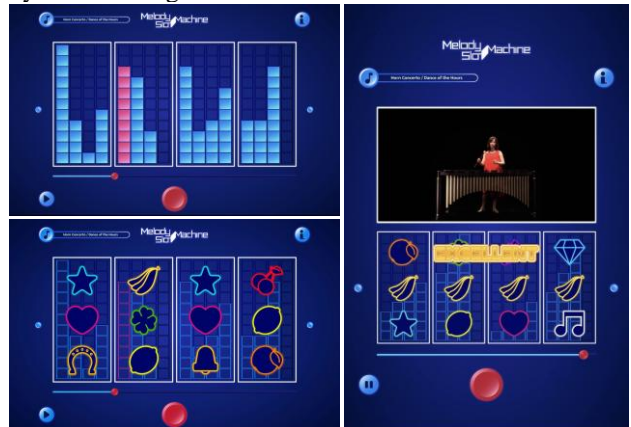

Figure 5. Melody Slot Machine HD

5. EXPERIMENTAL RESULTS

Three participants listened to 100 melodies randomly generated by Melody Slot Machine HD and judged them as unnatural, a little unnatural, almost natural, natural, and 85.6% of the melodies were judged as natural or almost natural.

6. CONCLUSION

We described Melody Slot Machine HD with which even a music novice can change the combination of melody fragments. Melody Slot Machine HD and the introductory video can be accessed through the following URL.
https://gttm.jp/hamanaka/en/melodyslotmachinehd/

If the app is used 30 times, the guide to a page asking to fill out a questionnaire will be displayed. We would appreciate if users would take the time to fill out the questionnaire. We plan to build and release a new iPhone version and add new content for both iPad and iPhone versions.

7. REFERENCES

[1] P. Langston, "Six Techniques for Algorithmic Composition," in *Proc. of the International Computer Music Conference* (ICMC1989), Ohio, 1989, pp. 153–156.

[2] F. Lerdahl and R. Jackendoff, R, *A Generative Theory of Tonal Music*. Cambridge, The MIT Press, 1983.

[3] M. Hamanaka, K. Hirata, and S. Tojo. "Implementing A Generative Theory of Tonal Music," *Journal of New Music Research*, 35(4): 2007, pp. 249–277.

[4] M. Hamanaka, K. Hirata, and S. Tojo, "Time-span Tree Leveled by Duration of Time-span," *in Proc. of the 15th International Symposium on Computer Music Multidisciplinary Research* (CMMR2021), 2021, pp. 155–164.

[5] K. Hirata and T. Aoyagi, "Computational Music Representation Based on the Generative Theory of Tonal Music and the Deductive Object-Oriented Database," *Computer Music Journal*, 27(3), 2003, pp. 73–89.

[6] M. Hamanaka, K. Hirata, and S. Tojo, "Melody Morphing Method Based on GTTM," in Proc. of the 2008 International Computer Music Conference (ICMC2008), Belfast, 2008, pp. 155–158, Michigan Publishing.

[7] M. Hamanaka, "Melody Slot Machine: A Controllable Holographic Virtual Performer," *in Proc. of the 27th ACM International Conference on Multimedia* (MM'19), Nice, October 2019, pp. 2468–2477.

[8] M. Hamanaka, T. Nakatsuka, and S. Morishima, "Melody Slot Machine", *ACM Siggraph2019 Emerging Technologies*, Los Angeles, July-August 2019, ET-245.

[9] T. Nakatsuka, M. Hamanaka, and S. Morishima, "Audio-guided Video Interpolation via Human Pose Features," *in Proc. of the 15th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications* (VISIGRAPP2020), Malta, 2022, pp. 27–35.

[10] M. Hamanaka, "Melody Slot Machine on iPhone," https://gttm.jp/hamanaka/en/melodyslotmachine/, Accessed on November 5, 2022.