CONTROLLING MOZART'S DICE MUSIC USING ACCELERATION SENSORS

Ciril Bohak
University of Ljubljana, Slovenia
Faculty of Computer and Information Science

Masahiro Niitsuma
Queen's University Belfast
Northern Ireland, UK

Matija Marolt
University of Ljubljana, Slovenia
Faculty of Computer and Information Science

ABSTRACT

This paper presents how the modern game controller Wiimote can be used to control Mozart's dice music. The proposed method allows users to explore and expand their experience with endless music within space where note measures are arranged in a 2-layer structure that can be treated as a playlist. Experimental results show that the proposed organization of measures gives higher melodic similarity between consequent parts according to melodic distance measures such as distribution of pitch classes, distribution of intervals and distribution of note durations. The result is a system that allows user to create different music than in Mozart's original Dice game and allows exploration of endless music. We also compare the use of different metrics for organizing individual layers in order to achieve melodically more meaningful music.

1. INTRODUCTION

Listening to the music is natural for all human beings. Everyone has a more or less unique musical taste. Not only do we enjoy listening to music, most of us are also unintentionally creating new music on our own, in our minds, usually expressed by humming or whistling. However, we are not composers, since music composition is mainly done by experienced and musically educated experts. New technologies, as well as input from musicians, in a form of collections of short musical pieces, such as measures or other short musical excerpts, make it possible for everyone to explore and expand their experience with music. One does not need an extensive knowledge of music theory or years of experiences in the field, to make music. It is possible to create new music just by playing a simple game with dedicated input devices such as the Wiimote. With such devices, creation of new music can be both easy and fun. This also shows the possibility of relating music to motion and interaction with visualization systems. In this paper we present an example of such an interactive system for music exploration with modernization of Mozart's dice music. In section 2 we present the research background and related work, in section 3 we describe our approach, in section 4 we present evaluation results and in section 5 we give conclusions and possible future work.

2. BACKGROUND

2.1. Related work

2.1.1. Music information retrieval

In recent years music and motion in relation with music information retrieval (MIR), is becoming a very active research field. Music and motion connects the fields of MIR, that offers solutions of musical problems, with computer vision, as well as the fields of musicology and choreology. Results of such cooperation and interdisciplinary research are many research publications in recent years.

2.1.2. Interaction systems

A system for interactive multimedia performances with virtual musical instruments is presented in [7]. The system was used in several performances with virtual music instruments that can be played with gestures extracted from video. A crucial part of the system is a distributed multimedia server for multi-platform, multi-sensor integration. Authors have also presented demo applications that use face tracking for virtual instrument manipulation.

A good overview of gesture based music synthesis is presented in [10]. The paper explains basic terminology and gives comparison of different techniques used in gesture based music synthesis. Gestures are represented as analog input signals that can be analyzed either as a function of gesture (pressing a button, moving an object, etc.), or according to its physical properties (moving a hand to the left, sitting down, etc.). The possibility of converting analog signals to MIDI is presented, as well as some methods for transforming analog to digital signals. The paper also includes a comparison an analysis of different input controllers.

A musical instrument - SoundSaber - that can be used for prototyping motion capture based musical instruments,

and uses the Wiimote controller, is presented in [8]. The system can be used for high-fidelity motion capture.

A digital conductor system for controlling the virtual orchestra is presented in [4]. The system detects simple conductor baton gestures that are used for controlling tempo and dynamics of a performance. The goal was to build an intuitive and easy to learn system which was later tested and evaluated with trials. The system integrates several state of the art MIR algorithms for tempo adjustment, music stretching as well as video stretching and audio-video synchronization.

In [5], authors present a "FreeDigiter" framework for mobile devices for fast recognition of finger gestures. Custom hardware was designed for finger gesture recognition and tested for fast digit input. The framework uses an infrared (IR) sensor in combination with accelerometers along two axes for tracking finger positions. The system is very tolerant to different lighting conditions and therefore robust in different working environments. Even though the system was primarily developed for digit input, it could be adapted for other uses as well. A touch interface that can replace classical vinyl plates for popular DJ sketching is presented in [2]. The interface uses custom made hardware that can be connected to MIDI input. Presented inputs can be combined with different visualization techniques of music collections. Some techniques for visualizing music collections are presented in [9], where authors use different approaches such as disc separation, square separation and tree maps.

2.2. Mozart's Dice game

By combining ideas of the described approaches, we decided to make use of new technology and create an application for real-time composition of meaningful endless classical music. The idea is in a way similar to musical games called "Musikalische Würfelspiele", which were popular in 18th century Western Europe. The goal of such games was randomly generated music of the era and games, published in local newspapers, were meant for everyday people. Publishers claimed that even amateur people, without any musical education, could compose an infinite number of compositions on their own, by throwing dice. The most famous example of such a game is Mozart's Dice game from 1787 [6]. A similar game was made by Kirnberger [3].

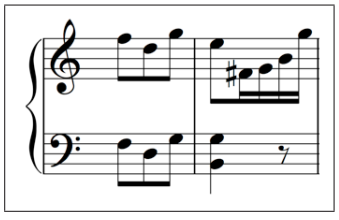

Figure 1. Two measures from Mozart's Dice game collection. The first and the second measure are numbered as 1 and 2 respectively in Figure 2.

In Mozart's Dice game, one Minuet-Trio is composed by choosing sixteen measures for Minuet and another sixteen measures for Trio. Even though there are 176 possible measures for Minuet and 96 for Trio, Mozart's instructions allow us to select from eleven measures for Minuet and six measures for Trio in each turn only. Matrices in Figure 2 specify the possible measures of each turn, which are selected by throwing dice. The correspondent measures to 1 and 2 in Figure 2 are shown in Figure 1. The matrix was composed so that consequent measures fit together according to melodic, rhythmic, and harmonic properties.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
2	96	22	141	41	105	122	11	30	70	121	26	9	112	49	109	14
3	32	6	128	63	146	46	134	81	117	39	126	56	174	18	116	83
4	69	95	158	13	153	55	110	24	66	139	15	132	73	58	145	79
5	40	17	113	85	161	2	159	100	90	176	7	34	67	160	52	170
6	148	74	163	45	80	97	36	107	25	143	64	125	76	136	1	93
7	104	157	27	167	154	68	118	91	138	71	150	29	101	162	23	151
8	152	60	171	53	99	133	21	127	16	155	57	175	43	168	89	172
9	119	84	114	50	140	86	169	94	120	88	48	166	51	115	72	111
10	98	142	42	156	75	129	62	123	65	77	19	82	137	38	149	8
11	3	87	165	61	135	47	147	33	102	4	31	164	144	59	173	78
12	54	130	10	103	28	37	106	5	35	20	108	92	12	124	44	131

(a) Minuet

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	72	6	59	25	81	41	89	13	36	5	46	79	30	95	19	66
2	56	82	42	74	14	7	26	71	76	20	64	84	8	35	47	88
3	75	39	54	1	65	43	15	80	9	34	93	48	69	58	90	21
4	40	73	16	68	29	55	2	61	22	67	49	77	57	87	33	10
5	83	3	28	53	37	17	44	70	63	85	32	96	12	23	50	91
6	18	45	62	38	4	27	52	94	11	92	24	86	51	60	78	31

(b) Trio

Figure 2. Original organization of measures for producing Minuet-Trios in Mozart's Dice game. Rows represent the numbers on dice (in case of Minuets with two dice, in case of Trios one die). Columns represent the position in composition.

Our idea is to modernize the Dice game by using a Wiimote game controller to guide the selection of measures. The second goal is to automatically organize the measure matrix to best fit different melodic features. We also want to eliminate the rule of producing only Minuets-Trios and allow composition of endless music by using Wiimote game controller. There are some known attempts to modernize the game of creating Minuet-Trios by clicking instead of throwing dice and can be found on-line[1].

3. OUR APPROACH

Our idea of modernizing Mozart's Dice game is to use Mozart's collection of measures for production of endless music. While the original game has predefined sets of measures to select from at certain position, our idea was to make a space of measures where each pair of neigh-

[1] Mozart's Dice game for iOS can be found on-line at: http://appshopper.com/music/mozarts-dice-game, older application published by Amaranth Publishing can be obtained at: http://www.amaranthpublishing.com/MozartDiceGame.htm

boring measures have high level of similarity according to selected melodic features. One can move around in this space by using the Wiimote. Wiimote's built-in accelerometers allows user to determine the orientation of the controller. The space can be defined as 2-layer torus structure. The first layer consists of measures from the Minuet collection and the second layer consists of measures from the Trio collection. Both are organized in the same structure (11×16 measures for Minuet and 6×16 measures for Trio). The difference from Mozart's original Dice game is that the edges are connected as shown in Figure 3.

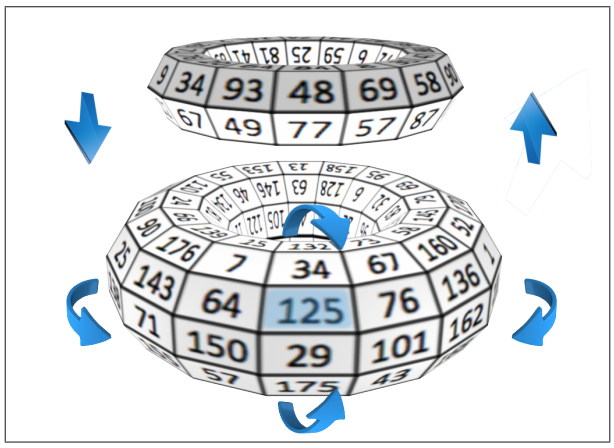

Figure 3. The structure of the Minuet layer in space. The original Mozarts organization (2D matrix) is projected onto a torus.

The main problem we needed to solve is how to arrange measures in space so that the neighboring parts have low distances as well as maintaining a low overall score (Equation 3). Neighboring parts are also consequent parts in a composition. We have to take into account that each position in such a space has 9 neighbors. One to each side in the same layer (that makes eight neighbors) and another one in the other collection of measures. We used a different approach for selection of neighbors between layers, since one layer has 6 and the other has 11 rows. Mapping between layers is described as:

$$Minuet\_layer[x,y] \rightarrow Trio\_layer[x, \lceil \frac{y}{2} \rceil], \quad x \in [1,16], y \in [2,12]; \tag{1}$$

$$Trio\_layer[x,y] \rightarrow Minuet\_layer[x, 2*y], \quad x \in [1,16], y \in [1,6]. \tag{2}$$

Organization of each individual layer was calculated separately, since Minuet and Trio measures melodically significantly differ. Next we presents methods for arranging the measures of each layer.

3.1. Methodology

While the original structure of Mozart's Dice game was put together manually, so that consequent parts melodically fit together. Manually comparing all possible pairs in a collection of 172 measures is not only time-consuming but also difficult. If measures are randomly organized in space, this would lead to problems with pairs that have very low melodic similarity. That is also the reason why such approach was not used in the original Dice game organization.

To calculate similarity between measures we calculated several different melodic features on symbolic representations (MIDI) of measures. The features were calculated with the MIDI Toolbox [1] and are as follows: distribution of pitch classes, distribution of intervals and distribution of note durations. MIDI Toolbox allows simple usage of these measures as distances between music pieces. Our goal was to achieve the lowest overall score s for each layer (Minuet and Trio), defined as:

$$s = \sum_{i \neq j} distance\_measure(i,j); \tag{3}$$

i, j neighboring measures in layer

We used a simple algorithm to arrange measures in space. First, we read-in all the MIDI files and calculated the distance matrix for all pairs of measures according to distribution of pitch classes using the taxicab norm metric for the first 10 samples. The next step is to put together the best organization of measures in individual layers. Because of the number of possible permutations is large, we used an approximate method to find a (suboptimal) solution for organizing measures by shuffling measures in each individual layer, calculating the overall score (Equation 3) and selecting the permutation with the lowest score. As shown by our results, such approach resulted in a lower overall distance score than the original organization.

3.2. Mapping input

In our approach we use accelerometers of the Wiimote controller as an input source for determining the direction of the next move in space. We chose the Wiimote since it is easy to use for tracking hand orientation. Wiimote can be connected to a computer via Bluetooth wireless connection and allows user to make natural gestures that can be tracked by computer. While the orientation of controller around horizontal axes was used to move between measures in the current layer, the vertical orientation was used for switching between layers of measures (from Minuet layer to Trio and back).

The selection of rotation axes is done by a simple thresholding algorithm that checks if acceleration along certain axes is greater than experimentally determined thresholds. In our case threshold values for rotation around horizontal axes are $0.5g$ (g - standard value of gravitational acceleration), and $0.3g$ for vertical axes.

4. RESULTS

Our main goal was to allow users to create music with seamless transitions between subsequent measures, which

we measure by the melodic distance between measures. A comparison of different melodic distance measures can be seen in Table 1. The table shows overall similarity scores (Equation 3) for different organizations of Minuet and Trio measures in each layer (a lower number means lower overall score and thus better, more seamless result). The overall similarity is calculated by using different distance measures for all pairs of neighboring measures in same layer. For all distance measures we found an organization that has a significantly lower overall score than for average random organization - for *distribution of note duration* we obtained a more than 70% lower overall score. This holds for both Minuet and Trio collections of measures. Results also show that according to selected distance measures even average random organization of measures has a better score than Mozart's organization. However the selection of next measures is done differently in Mozart's game than in the presented approach, where we only took into account very simple melodic distance measures.

The developed system was tested by a small number of people who confirmed that music created with the developed algorithm is easier on the ear than music from original or random organization, but no detailed evaluation of user experience was done by the time of paper submission.

Score	DPC		DI		DND	
	M	T	M	T	M	T
Best	**6.83**	**5.97**	**6.0**	**6.0**	**3.0**	**4.17**
AVG	14.02	13.25	13.87	13.82	13.94	13.73
Mozart's	11.53	13.41	14.01	14.28	13.73	15.0

Table 1. Table shows scores for different distance measures: Distribution of pitch classes (DPC), Distribution of intervals (DI) and Distribution of note durations (DND) for Minuet (M) and Trio (T) organizations for best found distribution (Best), average random distribution (AVG) and Mozart's original organization.

5. CONCLUSION

In this paper we presented a new approach that uses the collection of measures from the Mozarts Dice game for real-time creation of music with the Wiimote controller. We are no longer limited to production of Minuet-Trios only, but can compose endless music from a well organized collection, where selection of the next possible measure is guided by a similarity measure. This makes the transition between measures more seamless, while also giving the creator a chance of creating more diverse music than with the original game.

There are many possible extensions of our current solution. Instead of using only melodic features of symbolic data we could use audio samples as well, to create a more diverse organizations of measures. Instead of using a fixed layer organization of measures, we could introduce a dynamic space for selection of the next measure, as well as global scoring measures (such as Dominant and Tonic) for achieving a better harmonic structure of the final result. We could also omit separated collections for Minuet and Trio measures and use one combined collection instead. The platform could also be transferred to mobile phones and tablets, which already have accelerometers integrated.

6. ACKNOWKEDGMENT

Authors would like to thank anonymous reviewers for their constructive comments, suggestions and for pointing out errors; they helped make this article better.

The work was partly supported by the Slovenian Govern-ment-Founded R&D project EthnoCatalogue: creating semantic descriptions of Slovene folk song and music.

7. REFERENCES

[1] T. Eerola and P. Toiviainen, "Midi toolbox: Matlab tools for music research," *University of Jyväskylä Kopijyvä Jyväskylä Finland*, 2004.

[2] K. F. Hansen and R. Bresin, "Dj scratching performance techniques: Analysis and synthesis," in *Proc. Stockholm Music Acoustics Conference*, R. Bresin, Ed., vol. 2, Stockholm, aug 2003, pp. 693–696.

[3] J. P. Kirnberger, "Der allezeit fertige polonaisen und menuetten komponist (trans.: The ever ready composer of polonaises and minuets)," 1757.

[4] E. Lee, T. Karrer, and J. Borchers, "Toward a framework for interactive systems to conduct digital audio and video streams," *Computer Music Journal*, vol. 30, no. 1, pp. 21–36, Spring 2006.

[5] C. Metzger, M. Anderson, and T. Starner, "Freedigiter: A contact-free device for gesture control," *Wearable Computers, IEEE International Symposium*, vol. 0, pp. 18–21, 2004.

[6] W. A. Mozart, "Musikalisches würfelspiel," *Journal des Luxus und der Moden*, 1787.

[7] K. C. Ng, "Music via motion: Transdomain mapping of motion and sound for interactive performances," *Proceedings of the IEEE*, vol. 92, no. 4, pp. 645–655, 2004.

[8] K. Nymoen, S. A. Skogstad, and A. R. Jensenius, "SoundSaber - A Motion Capture Instrument," in *Proceedings of the International Conference on New Interfaces for Musical Expression*, 2011, pp. 312–315.

[9] M. Torrens, P. Hertzog, and J. L. Arcos, *Visualizing and Exploring Personal Music Libraries*. Universitat Pompeu Fabra, 2004, pp. 421–424.

[10] M. M. Wanderley and P. Depalle, "Gestural control of sound synthesis," *Proceedings of the IEEE*, vol. 92, no. 4, pp. 632–644, 2004.