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Making People Move: Dynamic musical notations

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ABSTRACT

In *Treatise Handbook*, Cornelius Cardew noted that "[musical] notation is a way of making people move" [1]. This paper describes and demonstrates new methods for the dynamic generation and display of augmented musical notation. *The Fluxus Tree* and *Quantum Canticorum* are the most recent in a sequence of musical compositions by the author in which dance and music interact using body-tracking technologies and bespoke sensing devices. Movement is converted into data which trigger and modulate expressive algorithms. Uniquely, these generate in real-time audio material as well as detailed common practice music notation to be performed live. Other techniques allow for the conversion from (and potentially to) graphic images and text. This paper demonstrates the techniques behind these inventions and explains how such techniques may be used to enhance the musical experience of performers and audiences.

Quantum Canticorum is based on a sequence originally commissioned for *Quantum*^{2}, an Arts Council UK funded project led by Jane Turner of the Turning Worlds dance company.

1. INTRODUCTION

Quantum Canticorum (Figure 1) extends research streams previously developed in works such as *Calder's Violin* and The *Fluxus Tree*. *Calder's Violin* uses musically expressive algorithms (see section 5 for a discussion of what these are) to generate both electroacoustic audio as well as common practice music notation. *The Fluxus Tree* extends control of notation to bespoke sculptural sensing devices (implemented by the author and including ultrasound and capacitative touch [2, 3, 4, 5]). Similarly *Quantum Canticorum* utilises collections of musically expressive algorithms for the generation of audio; the same data are also used to spawn the live display of musical notation (Figure 2). In this piece physical data is captured using a Microsoft Kinect 360 sensor.

Live notation is fundamental to this project as the compositions rely on data from a dancer's movements to influence algorithmic processes simultaneously generating audio and notational gestures which may then be performed immediately. It also means that algorithmically generated audio material can be harmonically and rhythmically synchronised with live performance based on this notation in a way that is not feasible with pre-written scores. From a composer's perspective it enables automatic multiple renderings of the same musical idea, allowing free exploration of otherwise unconsidered musical territories [6].

Another composition by the author, *December Variations (on a theme by Earle Brown)*, includes an early version of software which converts the graphic score *December 1952* into common practice notation. In these processes decisions about which graphic parameters map onto which musical ones, how these mappings are arranged, and how the graphic is 'read' are a fundamental part of the creative act. For instance, should the score be read from top to bottom and left to right, in reverse, along some sort of random path or a combination of these approaches (also see section 5)? Although Brown made clear his own interest in trans-domain conversion [7], the software process in its rigour and precision can feel rather at odds with the more intuition-based interpretations of many performers. Brown himself imagined "the possibility of the performer playing very spontaneously, but still very closely connected" to the notation (in this case, he was imagining a version of the piece as a physical machine - another interesting project)[7] . However, John Yaffé, a colleague and personal friend of Brown, feels that he would have appreciated these software based experiments because they were using methods appropriate to their time [8].

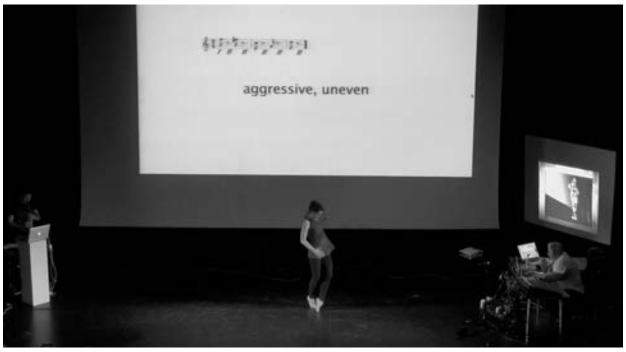

Figure 1. Quantum Canticorum

2. RESEARCH HYPOTHESES

This research is centred around two hypotheses. The first is that live interpreted notation-based performance adds significantly to the expressive potential of the music, taking

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advantage of a musician's years of training, experience and memory (both mental and muscle). Associated with this is a requirement that in order to make the processes fully generative the notation must be generated at the time and so cannot be notated beforehand without compromise. (Altough, of course, the composer is perfectly at liberty to accept this compromise.)

The second hypothesis is that it is creatively interesting to map physical movement, images and other expressive domains onto the musical one. It may be considered that this is happening already - in the expressive movements of performing musicians perhaps subconsciously seek to amplify musical expression, in the 'conversion' of visual data into the freely-composed musically expressive material of opera or film composers, or perhaps in the creations of synaesthetes [9]. Ultimately, judgment over the validity or otherwise of these hypotheses rests on the experience of the compositions for audience and performers.

The representations created by these projects is not confined to common practice notation. Of particular interest is the ability to generate graphic, image and text elements alongside music notation, making it feasible to generate graphics similar to those of Cornelius Cardew (for instance, *Treatise* [10]) automatically, interactively and algorithmically.

Emerging from the live generation of common practice notation are new perspectives on the relationship between improvisation and notation and on the nature of sight-reading. This method of composition means that, to an extent, performers are required to sight-read the music. However, it is also the case that during rehearsal performers become increasingly aware of the type of music that awaits them. It is part of the creative process to ensure that the music can be semi-improved satisfactorily. The author has discussed this issue extensively with collaborating musicians and all have expressed enthusiasm and interest in the system after experimentation [11]. By definition the process produces neither 'right' or 'wrong' notes, so a 'platonic' version of the piece does not exist [12].

Figure 2. Generated notation in Quantum Canticorum (clarinet)

3. MEDIA ASSETS

Videos of performances of the compositions mentioned in this paper are available for viewing or download at the following addresses:

- Calder's Violin: `http://www.goo.gl/ktp6KA`
- The Fluxus Tree: `http://www.goo.gl/bY80Y`
- Quantum Canticorum: `https://vimeo.com/91736284`
- December Variations: `http://www.goo.gl/gHvy5X`

4. TECHNICAL METHODS

In these compositions algorithmic material is generated through scheduling, physical interaction via a range of bespoke and manufactured devices, image analysis or a combination of these elements. Functions and processes are constructed within the language part of the SuperCollider (SC) environment [13] or directly on any microprocessors used (usually Arduino or mbed). The algorithms generate time, frequency, amplitude and control values which are then sent to either the SC synth or via Open Sound Control (OSC), (using an SC class by the author) to the programme INSCORE [14] which is able to generate a variety of notations, including standard music notation. While, for both technical and musical reasons I am currently concentrating on the latter aspect, I am involved in other collaborative projects using generative graphics and text.

5. MAPPING EXPRESSIVE ALGORITHMS

Although regarded by some as at best a mixed blessing, for there to be interaction between the physical world and digital processes, some form of mapping must be designed and implemented - a huge amount of research has gone into the investigation of this complex area (see section 6 for a small selection). While there are as many mapping strategies as there are new instruments and compositions, in general a balance is sought between responsiveness, control, consistency and reward. To illustrate, an example one such strategy is described here. It should be emphasised that a composition may well include any number or type of such strategies and that their adoption by performers must be considered an integral part of the rehearsal process. In *Quantum Canticorum* the aim was to find a way of reflecting the dancer's movements in the expression contained within the musical notation as well as within the generated audio. The music originates in a number of algorithms which use sequences of pitch/frequency values. An example of one such sequence is [0, 3, 1, 0, 1, 0, 9, 10, 11, 1, 7, 0, 8, 2, 4, 6, 5]. One such mapping strategy within the piece takes position data from the dancer's wrists and right hip. These data are then used to determine two musical parameters. The general tessitura of the music will be determined by the average height of the dancer's wrists (the depth of the averaging is also a creative decision). Then, the average amount of movement indicated by the data influences the density of notes generated - typically, as might be predicted (but not predicated), more movement generates a higher density of notes. Other similar parameters can be used to determine note length, for instance. Usually, such parameters are used in order to generate material with particular expressive features. Examples of contrasting phrases generated in this way are illustrated in figures 3 and 4.

Figure 3. An 'expressive' phrase

Figure 4. An 'aggressive' phrase

These algorithms are described as 'musically expressive' because the principal motivation in their design is to emulate my own ideas and gestures: imaginings that are traditionally expressive in musical terms. This iterative process of imagining, implementing, re-imagining, re-implementing and so on, itself plays a very important role in the development of both algorithm (function), musical gesture and indeed the musical context in which these gestures are to occur, as it does in more traditional notation-based composition. All of these components work together as musical composition. In order to make the gestures produced by the algorithms fully a part of the composition, elements (arguments) were included in order to increase what I would term their 'expressivity': controls on note duration (tempo/rubato), amplitude, note length (articulation), etc. In other projects, these functions might be extended in a way that reflects both the extension of an algorithm's functionality in software and the musical development of a melody, a phrases shape or the nuance of a harmony [11].

6. RELATED WORK

While there is a significant amount of related work in each of these areas, there has been less effort spent in connecting them. It is the increasing ubiquity of communication protocols such as OSC that has enabled similar work to develop as well as an acceptance of the importance of composable design in software. Examples of one of the more prominent research areas regularly presented at relevant conferences have involved the investigation of mapping between interface and audio; movement and gesture of course play a major role in this [15, 16, 17, 18, 19], etc.

There has been a tendency to focus less on the use of music notation itself, perhaps reflecting the view that technology has previously only had a role in the replacement of older music engraving technology rather than playing an active part in the creative development of the score itself.

Interest in this area has been developing, however: see Wulfson [6] and more recently Resch [20]. Hope [12] provides an excellent overview of the area. Related projects described elsewhere include *MaxScore* [21], *eScore* [22] and the *Bach Project* [23]. While notation generated digitally inevitably originates from algorithmic sources, there are fewer examples that include manipulation and display of common practice notation detail rather than the manipulations of pre-generated graphics files. As some of the main elements of common practice notation, such as notes and durations, are easily algorithmically controllable (under certain constraints), this is significant.

Examples of compositions where the use live notation is crucial include *Zero Waste* by Nick Didkovsky (2002), *No Clergy* by Kevin Baird (2005) [24], *Leave No Trace*, by Michael Alcorn (2006) [22], *Flood Tide* by John Eacott (2008) [25], *Live Cell* by Kingsley Ash and Nikos Stavropoulos (2011) [26], *Native Alien* by Sandeep Bhagwati (2011), *Roomtone Variations* by Nicolas Collins (2013), and a performance led by Lyle Mays utilising the Bach Project [27]. Ryan Ross Smith provides an excellent web-based collections of animated and open scores on his website [28].

7. CONCLUSIONS

This demonstration paper seeks to draw general techniques from practice-led research into music interfaces and the real-time algorithmic generation of material. In particular it attempts to integrate this with musicians' live performance through the use of performance data in the generation of common practice music notation.

8. REFERENCES

[1] C. Cardew, *Treatise Handbook*. London: Peters Edition, 1971.

[2] R. Hoadley, "Implementation and development of sculptural interfaces for digital performance of music through embodied expression," in *Proceedings of the Electronic Visualisation and the Arts Conference*, ser. Electronic Workshops in Computing, A. Seal, J. Bowen, and K. Ng, Eds. London: British Computer Society, July 2010, pp. 246–253.

[3] ——, "Form and function: Examples of music interface design," in *Proceedings of the British Computer Society Human Computer Interaction Conference*, T. McEwan and L. MacKinnon, Eds. University of Abertay, Dundee, UK: British Computer Society, 2010, pp. 479–483.

[4] ——, "Sculpture as music interface," in *Proceedings of International Computer Music Conference*, M. Adkins and B. Isaacs, Eds. Huddersfield: International Computer Music Association, 2011, pp. 441–444.

[5] ——, "The fluxus tree (performance)," in *Proceedings of the LIVE INTERFACES: Performance, Art, Music Symposium*, Leeds, September 2012.

[6] H. Wulfson, G. Barrett, and M. Winter, "Automatic notation generators," in *Proceedings of New Interfaces for Musical Expression*, New York, 2007.

[7] E. Brown, "On December 1952," *American Music*, vol. 26, no. 1, pp. 1–12, 2008.

[8] J. Yaffe, *personal communication*, October 2013.

[9] J. Harrison, *Synaesthesia: The Strangest Thing*. Oxford: OUP, 2001.

[10] C. Cardew, *Treatise*. New York: The Gallery Upstairs, 1967.

[11] R. Hoadley, “Calder’s violin: Real-time notation and performance through musically expressive algorithms,” in *Proceedings of International Computer Music Conference*, ICMA, Ed., 2012, pp. 188–193.

[12] C. Hope and L. Vickery, “Screen scores: New media music manuscripts,” in *Proceedings of International Computer Music Conference*, ICMA, Ed., Huddersfield, 2011, pp. 224–230.

[13] S. Wilson, D. Cottle, and N. Collins, Eds., *The SuperCollider Book*. Cambridge, MA: MIT Press, 2011.

[14] D. Fober, Y. Orlarey, and S. Letz, “Inscore: An environment for the design of live music scores,” in *Proceedings of New Interfaces for Musical Expression*, Oslo, Norway, 2011.

[15] M. Schedel, P. Phoenix, and R. Fiebrink, “Wekinating 000000swan: Using machine learning to create and control complex artistic systems,” in *Proceedings of the International Conference on New Interfaces for Musical Expression*, Oslo, Norway, 2011, pp. 453–456.

[16] M. Yoo, J. Beak, and I. Lee, “Creating musical expression using kinect,” in *Proceedings of the International Conference on New Interfaces for Musical Expression*, Oslo, Norway, 2011, pp. 324–325.

[17] N. Gillian and J. Paradiso, “Digito: A fine-grain gesturally controlled virtual musical instrument,” in *Proceedings of the International Conference on New Interfaces for Musical Expression*, Michigan, 2012, pp. 39–42.

[18] A. Senturk, W. Sang, S. Avinash, A. Daruwalla, and G. Weinberg, “Crossole: A gestural interface for compostiion, improvisation adn performance using kinect,” in *Proceedings of the International Conference on New Interfaces for Musical Expression*, Ann Arbor, Michigan, 2012, pp. 499–502.

[19] G. Vigliensoni and M. Wanderley, “A quantitative comparison of position trackers for the development of a touch-less musical interface,” in *Proceedings of the International Conference on New Interfaces for Musical Expression*, Ann Arbor, Michigan, 2012, pp. 103–108.

[20] T. Resch, “note for Max - an extension for Max/MSP for media arts and music,” in *Proceedings of New Interfaces for Musical Expression*, vol. 15, KAIST, Daejeon, Korea, November 2013, pp. 210–212.

[21] N. Didkovsky and G. Hajdu, “MaxScore: music notation in Max/MSP,” in *Proceedings of International Computer Music Conference*. SARC, Belfast: ICMA, 2008.

[22] C. McClelland and M. Alcorn, “Exploring new composer/performer interactions using real-time notation,” in *Proceedings of International Computer Music Conference*. SARC, Belfast: ICMA, March 2008.

[23] A. Agostini and D. Ghisi, “An environment for computer-aided composition in Max,” in *Proceedings of International Computer Music Conference*, ICMA, Ed., 2012, pp. 373–378.

[24] K. C. Baird, “Real-time generation of music notation via audience interaction using python and gnu lilypond,” in *Proceedings of New Interfaces for Musical Expression*, Vancouver, BC, Canada, 2005, pp. 240–241.

[25] J. Eacott, “Flood tide see further: Sonification as musical performance,” in *Proceedings of International Computer Music Conference*, ICMA, Ed., Huddersfield, 2011, pp. 69–74.

[26] K. Ash and N. Stavropoulos, “Livecell: Real-time score generation through interactive generative composition,” in *Proceedings of International Computer Music Conference*, ICMA, Ed., Huddersfield, 2011, pp. 360–364.

[27] L. Mays, “Tedx caltech 2011,” 2011. [Online]. Available: http://tedxcaltech.com/content/lyle-mays

[28] R. Ross Smith, “Animated notation website,” February 2014. [Online]. Available: http://ryanrosssmith.com