Dynamic music notation in Quantum^2 Canticorum

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Abstract. *Quantum*^{2} *Canticorum* is the latest in a sequence of musical compositions in which dance and music interact using body-tracking technologies and bespoke sensing devices. Expressive movement is converted into data which trigger and modulate expressive algorithms. These generate in real-time both audio material and music notation which is performed live.

1 THREE STREAMS

Quantum^2 *Canticorum* extends research in three streams previously developed in compositions such as *Calder's Violin* [10] and *The Fluxus Tree* [11]. Quantum^2 Canticorum utilises collections of musically expressive algorithms in the generation of audio; the same data are also used to generate the live display of musical notation. Physical data are captured using a Microsoft Kinect 360 sensor as well as bespoke sensing devices. Live notation is necessary as these compositions rely on data from the dancers movements to directly influence algorithmic processes which simultaneously generate audio and notational gestures.

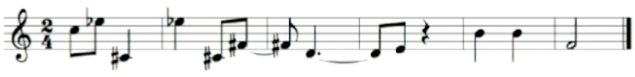

Figure 1. An 'expressive' phrase

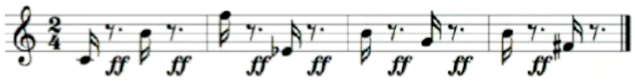

Figure 2. An 'aggressive' phrase

A key hypothesis is that it is possible to translate expressive gestures from the domain of physical movement into the domain of music. Specifically, the resulting music should retain a strong sense of identity: it should be a composition, not a tool for creating compositions. It should also allow sufficient freedom to enable the non-musical performer (assumed on most occasions to be a dancer), to express themselves naturally within the composed structure. The research is currently investigating this middle-ground between composition and tool or instrument and because of this it is important that there is sufficient time during rehearsals to discuss, implement and practice mappings between movement and expressive music. A further hypothesis is that the use of of live notation performed at the moment of creation by a human musician (in addition to algorithmically generated audio triggered and modulated by the same movements) will be able to utilise the musician's training enabling levels of expression, tonal quality, interaction and feedback unobtainable in other ways.

Another area for investigation is the relationships existing between compositions which use these methods and improvisation. Figure 1 and Figure 2 show contrasting phrases which have been generated live during rehearsal or performance. The instrumentalist (in recent performances, a clarinetist) is presented with very specific pitches and durations to play. These are crucial to the identity of the music: in this case two 'types' are deliberately contrasted with each other for aesthetic purposes. In each case, the tessitura is informed by the vertical position of the dancer's right wrist and density of notes by the amount of movement indicated by the dancer's right and left wrists and left hip (these joints are chosen after experiments with the efficacy of various joints in this particular scenario).

These phrases are purely ephemeral. They are generated and then a few moments later are deleted or replaced. While both the instrumentalist and I are aware of the type of material that is likely to occur, we do not know the detail. So, while the instrumentalist is encouraged to follow the score as closely as possible, by definition there can be no wrong or right notes. The process lies somewhere in between performance and improvisation: a position that can take a small amount of time for some performers to get used to fully, but not one that is fundamentally problematic. Unlike some other examples of cross-domain mapping, the techniques used in these compositions rely on the expertise of the instrumentalist to take advantage of the live notation, although the same structures allow a non-expert to express themselves through movement. It is possible, if not musically desirable to use an 'automated' player instead of a human musician - this is also necessary during rehearsals. However, it is my contention that if at all possible, the contribution of human expression should be irreplaceable in qualitative terms.

As well as being a free-standing composition/performance, Quantum^2 Canticorum has also been performed as a part of Quantum^2, an Arts Council UK funded project led by Jane Turner of the Turning Worlds dance company. It has been performed at the Sensations Festival in Chelmsford (September 2013), the opening concert of the Notation in Contemporary Music symposium at Goldsmiths (October 2013) and as a part of the Cambridge Festival of Ideas (Ruskin Gallery, Cambridge, October 2013).

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Figure 3. Image of Quantum^2 Canticorum at Deptford Town Hall, October 2013

2 MEDIA ASSETS

Video recordings of works mentioned in this paper are available as follows:

- *Calder's Violin*, performance by Marcus Barcham-Stevens at the 2012 SuperCollider Symposium in London: https://vimeo.com/42338675.
- *The Fluxus Tree*, performance by Cheryl Frances-Hoad ('cello) and Jane Turner (dance), LIVE INTERFACES: Performance, Art, Music, 7th-8th September, 2012, ICSRiM, School of Music, University of Leeds, UK: https://vimeo.com/77534104.
- *Quantum^2 Canticorum*, performance by Richard Hoadley (electronics) Ann Pidcock (dance), Gareth Stuart (clarinet), Deptford Town Hall, 18th October 2013, Notation in Contemporary Music Symposium, Goldsmiths: https://vimeo.com/49482055.

3 TECHNIQUES INVOLVED

Algorithmic material is generated live through scheduling, physical interaction or a combination of both. These processes are constructed within the language part of the SuperCollider audio environment or directly on the microprocessors used (in these cases Arduino or mbed). The algorithms generate time, pitch, amplitude and control values which are then sent to either the SC synth or, via OSC (implemented as an SC class by the author), to the programme INScore [7] 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 collaborative projects using generative graphics and original, algorithmically generated text.

One of the key issues in this work is the attempt to achieve the appropriate balance between performance and expression determined by the performer/dancer and by myself, the composer. The result lies somewhere in the middle, but the real issue is the way in which music such as this redefines the roles and relationships between performers and composer. As the non-musical performer is usually a dancer, differences between the two domains of dance and music are made very clear. During the composing process, I might imagine a dancer's movements and 'compose' the environment in which these movements would take place. However, during actual rehearsals, it often becomes apparent that expression through dance, unsurprisingly, contains much that does not refer to music and musical gestures. As an example, stillness and silence might be mapped, but how does one articulate this either in general terms, or in detail? A dancer might want to change their routines on the spur of the moment, adding a pause here, or an arabesque there. How should one, as as composer, accommodate these or, as in some collaborations between Cage and Cunningham, should one ignore such interactions?

Two of the features of through-composed music which I am anxious to retain are the ability to precisely synchronise complex rhythmic structure as well as the use of higher level compositional construction such as contrast (see Figure 1 and Figure 2) and dynamic development of material. Although a compromise, I have in these compositions used a series of what I have called scenes. These are sets of configurations used to determine how a given movement, interaction or algorithm will behave at a particular time or in a particular context. This has the advantage that the devices can be used expressively in different contexts, and that a general shape can emerge as a part of an extended piece of music. However, it also makes interaction less predictable, at least without extensive rehearsal and/or feedback mechanisms from the devices and this can be felt as limiting and confusing to the performer. This is a central issue in this research representing as it does the boundary between the creation of an instrument for performance and a composition to be performed.

In terms of algorithmic techniques used I had to consider what would happen if the dancer chose to deviate from patterns we had rehearsed. Should the dancer pause unexpectedly or leave the range of the Kinect it would not necessarily be desirable for all musical events to stop. The majority of the melodic material is therefore generated separately from any physical action; in one case the latter might influence the former by responding to greater movement by increasing the density of notes. In another case the tessitura of a melody might be modulated through transposition of notes or phrases according to the physical positioning of a chosen body part. Pitches and durations decided previous to modulation are from a variety of pre-composed melodies, scales and other arrays of values.

A number of reviewers have commented on the matter of potential delays in the system from the time of a dancer's movement to the musical response from the SuperCollider synthesis engine or from the musician playing the notation modulated by that movement. Inevitably there are delays - not least involving the Kinect itself - although I have not attempted to measure what these might be; and I suppose for some composers and in some circumstances these may prove intolerable. For myself, and possibly as this piece has been composed very much through my own use and development of the devices and systems, this has not been a problem: perhaps unconsciously I have composed music that does not requires precise and detailed rhythmic coordination.

4 RELATED WORK

While there is significant other work in all of these areas, there is not so much which combines them. A fundamental concern for some has been the investigation of mappings between movement and touch from whatever source and audio (see [8], [13], [14], [16], [17], etc.), but there has been less interest in mapping into music notation itself. Dominique Fober, the developer of INScore, provides a presentation of this [7] alongside an account of the ability of that software to generate convincing and flexible common practice notation alongside text, graphics and other image manipulation; Fober also places INScore among other current and historical paradigms of score generation such as Guido and Music XML. Quantum^2 Canticorum uses

physical movement to influence music notation as well as audio and so the ability to format this notation live is of central importance.

In terms of the tools for live notation, related work includes eScore [12] and [3]: a recently updated system exploring composer/performer interactions through real-time notation developed for others to use, but presented with particular compositions as examples.

Another related area is animated notation, for which Ryan Ross Smith [15] has provided an interesting body of work as well as links to many examples of other work in the same area. Although animated notation includes a variety of methods which do not include the live generation of material, it is clear that as software becomes available the latter is playing an increasingly important role.

While Collins [4] provides an overview of algorithmic and generative composition without music notation, Michael Edwards' *Slippery Chicken* [6] is a computer aided composition (CAC) system featuring the ability to generate sophisticated common practice notation based scores.

Didkovsky and Hajdu [5], Hajdu et al [9], Agostini and Ghisi [2] describe systems which include methods for defining and projecting notation live. MaxScore/JSML and the Bach Project use live notation as a part of more general CAC systems rather than as dedicated live notators.

Work involving skeletal tracking and rudimentary mapping has been undertaken with the Kinect and related units [8], [13], [14], [16], [17].

5 CONCLUSIONS AND FUTURE WORK

The creative work presented here is a novel method of composition and it is inevitable that issues arise through the iterative processes of composition, implementation, rehearsal, performance, analysis and revision. As with other forms of composition, these issues are often considered for revision in future performances, or as features of new works. Some of these issues have been discussed above, but in terms of the future development of what should be considered to be an immature method, reservations include the current lack of annotated detail in the generated score (a particular and perhaps unsurprising concern of some contemporary composers). Relatively few phrasing, articulation and dynamic markings are used in the pieces mentioned here, due not least to the complexity of the OSC strings required for INScore - common practice notation is a complex graphical and semantic phenomenon. As the project develops it is clear that a significant restructuring of the current system to allow for more robust methods of coding INScore will be necessary.

A recurrent concern focuses on when a 'page turn' should occur and what indeed it represents in this system. Almost certainly entailing the implementation of some sort of machine listening (another feature mentioned by many people), this naturally suggests the incorporation of audio feedback from the performing musician into the generative process.

Other planned enhancements include the implementation of algorithms for multiple dancers, allowing cooperative forms of interaction and entrainment. There is also significant potential here for therapeutic uses; these are currently being developed as a part of the related Touching Sound project which is investigating the use of music technology in music therapy [1].

REFERENCES

[1] S. Aaron, P. Barnard, S. Gill, I. Cross, T. Himberg, R. Hoadley, H. Odell-Miller, and R. Toulson, 'Touching sound: Vulnerability and synchronicity', in *CHI workshop on Designing For and With Vulnerable People*, Paris, (2013).

[2] A. Agostini and D. Ghisi, 'An environment for computer-aided composition in max', in *Proceedings of International Computer Music Conference*, ed., ICMA, pp. 373–378, (2012).

[3] M. Alcorn, M. Ortiz-Perez, and J. Yang, 'Composer-conductor-performer - realtime manipulation of through-composed musical notation', in *Proceedings of the Notation in Contemporary Music Symposium*, Goldsmiths, University of London, (2013).

[4] N. Collins, 'Musical form and algorithmic composition', *Contemporary Music Review*, **28**(1), 103–114; 103, (2009).

[5] N. Didkovsky and G. Hajdu, 'Maxscore: music notation in max/msp', in *Proceedings of International Computer Music Conference*, ed., ICMA, SARC, Belfast, (2008).

[6] M. Edwards, 'An introduction to slippery chicken', in *Proceedings of International Computer Music Conference*, pp. 349–356, Ljubljana, (2012).

[7] 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).

[8] 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*, pp. 39–42, Michigan, (2012).

[9] G. Hajdu, K. Niggemann, A. Siska, and Andrea Szigetvari, 'Notation in the context of quintet.net projects', *Contemporary Music Review*, **29**(1), 39–53, (2010).

[10] R. Hoadley, 'Calder's violin: Real-time notation and performance through musically expressive algorithms', in *Proceedings of International Computer Music Conference*, ed., ICMA, pp. 188–193, (2012).

[11] R. Hoadley, 'The fluxus tree (performance)', in *Proceedings of the Live Interfaces: Performance, Art, Music Symposium*, Leeds University, (2012).

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

[13] 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*, pp. 453–456, Oslo, Norway, (2011).

[14] 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*, pp. 499–502, Ann Arbor, Michigan, (2012).

[15] R. Ross Smith. Animated notation website: http://ryanrosssmith.com, February 2014.

[16] 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*, pp. 103–108, Ann Arbor, Michigan, (2012).

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