MOVEMENT, MUSIC AND MAPPING: SOMNIUM

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ABSTRACT

My research develops a theoretically informed movement paradigm to shape sound while provoking alternative production and performance methodologies within a compositional and sonic arts practice. This work questions how concepts from Rudolph Laban's Movement Analysis, specifically his writings in *Choreutics*, can be coherently integrated into a technologically mediated creative movement/sound practice [1].

1. INTRODUCTION

In the mid twentieth century the dance theorist Rudolf von Laban observed and wrote about human movement as a representation of the harmony of the universe across the micro to macro scale of motion [3]. This paper discusses the foundations for mapping strategies that I have chosen to use in my work thus far to make music with movement through motion capture, various sensors, Digital Audio Workstations (DAWs) Ableton Live and Cycling 73's visual programming language Max. Explanations include interdisciplinary inspiration from mathematical biology used in crystallography for tracking movement in a space, kinesthetic effort theory for dynamic expression and graphic notation and early astrophysics for harmonies and spatialization. Examples of applied integration through pieces, interactive installations and performances are highlighted in each section. This paper concludes with future research directions regarding the investigation of mapping movement to space scales using tones or notes [2].

2. MOVEMENT IN A SPACE

In Chapter 10 of *Choreutics*, *Cubic and Spheric Forms of the Scaffolding*, Laban introduces the cube and icosahedron "showing how it is the crystal form compatible not only with the skeletal frame of the body but also with the angles of movements of the joints" [3, p. 179]. Laban's use of geometric shapes for framing the body's movement was inspired by his classical training in art, architecture and, by mathematical biologist Ernst Haeckels' *Crystal Souls: Studies of Inorganic Life* [4]. Haeckel pointed out that, "crystalline patterns of growth are determined by a basic rule of geometrical space packing…and claimed to recall a natural occurring language of space organization" [5, p. 27]. Though the cube and icosahedron are a part of a two different geometrical classes and crystal systems, cubic and hexagonal, they share an arithmetic class where they reflect dimensions both along and between their lattice directions. This gave Laban a scaffolding upon which to build his movement theories and scales. In technologically mediated areas such as motion capture and 3D imaging, crystal structure generation "as a result of infinitely repeating array of 'boxes' called unit cells" form cubic units that are found in digital imaging [5]. Unit Cell Structure [6, Fig. 1] is the "simplest repeating unit in a crystal: Each unit cell is defined in terms of lattice points the points in space about which the particles are free to [move] in a crystal" [6]. Cubic unit cells support three options for movement mapping with motion capture cameras. Cubic Face Centered structure is comparable to world relative mapping, Simple Cubic structure reflects Screen relative mapping and, Body Centered Cubic structure informs body relative mapping. Mapping body movement in space through motion capture can be done within three relativities:

1. World relative (depth camera)
2. Screen relative (frame of movement)
3. Body relative (relativity to torso)

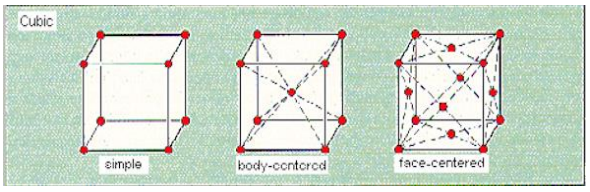


Figure 1: Bravias Cubic Unit Cells, Bodner Research, 2017.

3. DYNAMIC EXPRESSION

Laban's *dynamosphere* in *Choreutics*, as seen in the Laban Cube [7, Fig. 2], is the foundation for research in mapping the body's movement to shape my compositional practice. *The Tesseract* [7] was my preliminary system for capturing and mapping movement to be used in two ways:

1) Shape sound and visual effects during real-time performance.
2) Record movement as automation as a means to extract movement data from the mover.

The early technical flow of *The Tesseract* was: motion capture camera *XBox Kinect 1414* as movement input, *Synapse* by Ryan Challinor as OSC translation, Max4Live [Fig. 3] plugin to map data from OSC to bespoke audio effects racks, and Ableton Live for musical content to be affected and sound output [7].

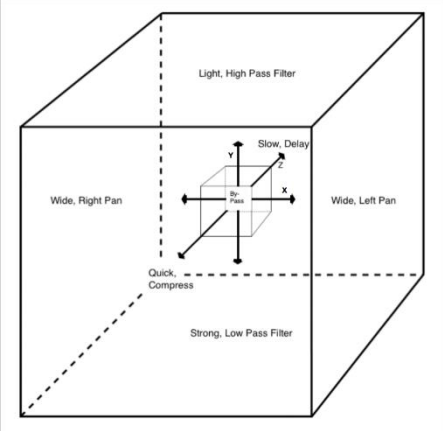


Figure 2: Laban Cube, example of mapping to an effects rack version, *The Tesseract*, 2018, [7].

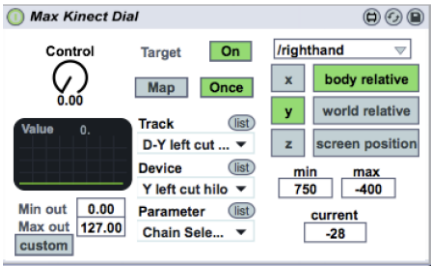


Figure 3: Max4Live, Kinect dial, *The Tesseract*, 2018, [7]

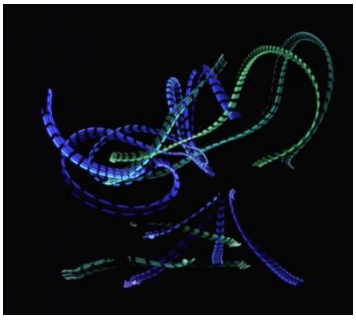
3.1. Real-Time Performance

Inter-Act is an interactive audio/visual installation [Fig. 4] first performed at The University of Huddersfield's Heritage Quay as part of International Women's Day, 2017. The work was projected onto a large immersive concave screen while audio and video were played through Ableton Live and projected by two linked projectors. Movement was captured by the Kinect1414 which was mapped to audio effects in the bespoke effects rack called the *Tesserack.* That affected the sound sources running through the system. Video interaction was caused by audio reactive means—audio frequencies were designated as triggers for video effects through *RokVid*, a M4L plugin by Adam Rokshar. This caused specific distortions, filters and scene changes visually in response to movements affecting and shaping the sound simultaneously. Festival participants and attendees were encouraged to use the system to experiment with *The Tesseract* [7].

Figure 4: Susie Green, *Inter-Act*, at Heritage Quay celebrating International Women's Day, 2017.

3.2. Recording Movement as Automation

I created *I Remember*, [Fig. 4] was by filming a performance of my movement alone, without music using two standard digital video cameras for imagery, while depth movement was captured by a Kinect1414 to automate dials on the *Tesserack.* I wore a black morph suit in a black box theatre in complete darkness, much like Etienne-Jules Marey's chronophotagraphy work in 1883 [5, pg 53]. LED lights were strapped to my wrists and ankles to illuminate the outer most points of my body while they were in motion. I edited the video in Adobe After Effects to create light trails from the LEDs as *traceforms.* The composition and arrangement process used for this piece marked a significant change in the order of my previous workflow. I was able to realize sound from visuals in a way that I had not done before by dropping sound sources into the previously recorded automation and incorporating previous compositional and production processes in the programming of percussion, drums, and bass elements [7].Figure 5: *I Remember*, 2017 [7]



4. GRAPHIC NOTATION

Transcription of dance pieces for multiple dancers is done by intensive observation and notation by hand. The Effort Cross [5, Fig. 6] depicts the three motion factors (Space, Weight and Time) in the Laban Cube [7] and the six polarities along each motion factor axis. Eight effort actions can be created by the various combinations of these factors. Graphic notation and scores for players to sonically enact movement can be created based on these eight efforts in combination with expressive trace-forms [Fig. 7].

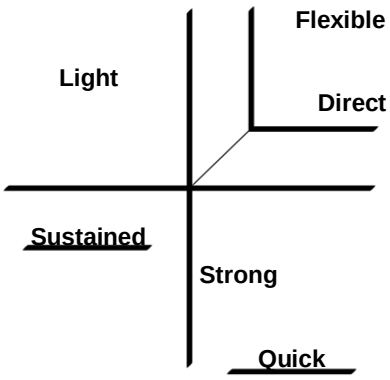


Figure 6: The Effort Cross, *Effort,* 2nd ed., 1973 [8]

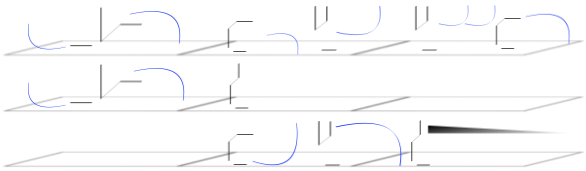


Figure 7: Example of Graphic Notation based on Laban movement notation, S.E.Green-Mateu, 2019

5. HARMONIES AND SPATIALIZATION

In chapter 2 of *Choreutics, The Body & Kinesphere* [10, Fig. 8], Laban "introduces circuits in the kinesphere and their 'mirroring of the ever-circling motions in the universe'" [3, p. 178]. The consideration of larger bodies in motion and a look toward the planets and their ever-elliptical orbits provided the key to map motion to harmonies. Kepler's, Harmonic Law, third law of planetary motion [Fig. 9] "maintains that the cubes of mean distances of the planets from the sun are proportional to the squares of their periods of revolutions" [9, p. 632].

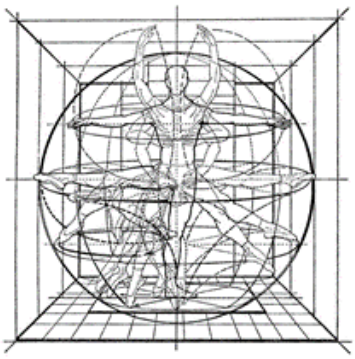


Figure 8: Space Modules of the Arms and Legs (Kirstein et al., 1953) after Rudolph Laban.

My collaborative work *Somnium* was premiered Virginia Polytechnic University's CubeFest 2019 [Fig. 10] as the first movement of a four-movement piece called *Mysterium Copernicum* by Concordia [2], [11]. It used interactivity between planetary data, performers, and controllers. While collaborating on the programming and composition of *Somnium* the harmonic component of Laban's *kineshpere* was realized. The technical set up for this first version of *Somnium* consisted of Ableton Live, two Max patches, mi.mu gloves, iOS application Gliss and Glover to map devices.

Ableton Live was used to play a melody specifically designed and composed for the first five planets in our solar system, respectively. They key, tone, timbre and tempo were based on each of their orbital periods. Performers were able to sonically move from planet to planet by choosing a lead (or "boss") planet on the iOS device. The volume for each planet was controlled by distinct hand postures per planet followed by an up and down gesture through mi.mu gloves. Once a lead planet was chosen and its individual melody began to play, the other 4 planets would harmonize with it. Harmonies were processed through the first Max patch [Fig. 11]. Furthermore, the choice of lead planet altered the overall acoustic experience as the complete ensemble of planets were heard as if through its atmosphere. Sound design was based on the atmospheric character of each planet which was derived by the movement of sound through the primary gas on each planet [11].

The first Max patch used 400 years of orbital data for first 5 planets to generate harmonic content for the performance using Keplers 3rd law. Harmonies were created through calculating the angle that each planet made to one another at any given moment and ranged from octaves, fourths and fifths, through major and minor thirds and sixths , through all twelve tones. Harmonies sounded whenever planets positions within their orbits were conjunct to, or in line with, any other planet in the data set by elliptical longitude observed from the sun's vantage point [11]. The sun, in this case, became the center bypass point as seen in the Laban Cube [Fig. 2]. The complexity of harmonies were played by the performers using mi.mu gloves that were mapped to control chromaticism by a wrist roll gesture to mirror planet orbits with the body's movements, as Laban suggested in his works. The second Max patch, using the same data, determined the spatialization and movement of each planet across the multi-speaker array [11].

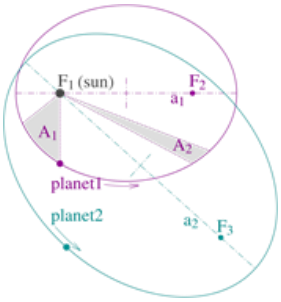


Figure 9: Diagram illustrating Kepler's laws: 1. Two elliptical orbits with major half axes a_1 and a_2 and focal points F_1, F_2 for planet 1 and F_1, F_3 for planet 2; the sun in F_1. 2. The two sectors A_1, A_2 of equal area are swept in equal time. 3. The ratio of orbital periods t_2/t_1 is $(a_2/a_1)^{3/2}$, Han-Kwang Nienhuys

Figure 10: *Somnium*, Virginia Tech, Cubefest 2019

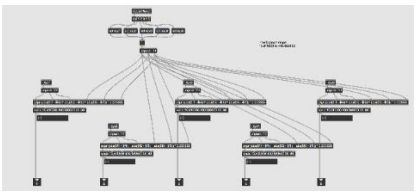


Figure 11: Max patch for distance calculation, *Somnium*, 2019, [2]

6. CURRENT DEVELOPMENTS

Several adaptions of *Somnium* have been created for various venues and as an installation. To tailor these experiences controllers such as Sensel Morph, leap motion and stream deck were used in place of mi.mi gloves and the iOS device.

Plans are underway to use the Kinect Azure, which can track multiple users, in yet another iteration of *Somnium*. Ideally, mapping will include: 1) Laban's Choreutics for dynamics and expression mapped to each individual performer as their own *Tesseract* to shape sound. 2) Kepler's 3rd law for harmonies using comparative distance and interactivity between dancers.

7. FUTURE INVESTIGATION

In chapter 7 of Choreutics, *The Standard Scale*, Laban "deals with the more technical aspects of space harmony practice using terminology, such as 'scales' to connect with music and 'chains' to connect with [movement]" [3, p. 178]. Laban's standard scale or primary scale consists of 12 parts around the edge of the kinesphere [12], [Fig.12]. "The scale systematically passes through the girdle and cluster on every second location, through the three basic planes on every third location and basic triangular forms on every fourth location" [3, p. 178]. Other sub-movement scales integrated within the standard scale are the axis scale for movements that cross through the center of the space or across the body and the equator scale for movements that flow around the center of the space or do not cross the center of the performers body. [3, p. 179]. Future experiments with mapping tones/notes to a virtual toroidal flow or mobius [Fig. 13] using markov chains [Fig. 14] can help to create "space scales" where-by a performers' movements play a room like an instrument [13], [15]. Connections between movement scales and music scales, temperament, and tuning can provide foundations for a solid mapping approach for a program, plug-in or DAW for interactive composition and performance.

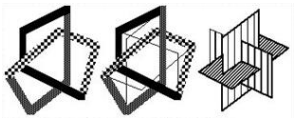


Figure 12: *9-part knot*, (kinesphere, möbius, Icosaheadral Planar sequence) from Laban Collection Archive, University Leeds.

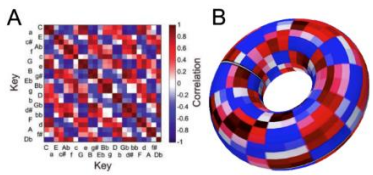


Figure 13: *Toroid model of tonal space*, 2013, [14], [15]

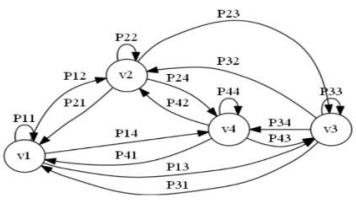


Figure 14: *Markov chain for note value*, 2017, [13]

8. CONCLUSION

The realization of an interactive movement mapping system as inspired by Laban's Choreutics has led to the exploration of human movement, astrophysics, and crystallography which have respectively informed the mapping of movement in space (both spherical and cubic using body movement, gestures and movement data) to dynamics, effects and harmonies in music. A demonstration of the prototype of the system will be performed at the Alliance of Women in Media Arts and Sciences Conference, February 2020, in Santa Barbara, CA.

9. ACKNOWLEDGMENT

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