Dance Form

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ABSTRACT

In this project, I worked with a dancer to explore digital media as means to visualize specific movement qualities. It aims to reveal the dynamic aspects of the dancer's movement expression in a series of materialized 3D models. An informal user evaluation is conducted with the dancer, showing that she can identify the implicit movement qualities in the design models and agree that the design helps her re-interpret the dynamics of her movement flow.

Keywords

Dance, Representation of Data, Motion Capture, Computational Design, Movement Qualities

1.INTRODUCTION

In dance, bodies express choreography only in passing moments. Every dance performance presents subtle forms and energy shifts that the audience and the novice dancers may not be conscious of. These include the force and the speed of a wave, or the angle a body bends. As Des Marais & Cardinal states, "Dance is always a temporary drawing; it disappears when the movement ends. So the drawing can be written over, or rewritten at any time. Each performance has to be drawn again the next evening". [1] Peggy Phelan also highlights the character of the instantaneous in dance by saying "It can be performed again, but this repetition itself marks it as different"[2] It is the momentary subtleties that promote the kinesthetic creativity of the body movement and define the personal dancing styles. Every dance performance is made up of many seemingly minute decisions such as these.

There has been a keen interest in developing symbolic notation systems that map animation onto different representations to represent such expressive movement[3]. However, capturing the dancer's dynamics or the emotional dimension of the movement and conveying the subtleties of the personal style is challenging - especially when one is limited to keyframes or single state notations.

This project builds on the efforts of abstracting dance visualization that aims not to reproduce the dance moments but to capture the minute movement qualities. It explores the emergent details of the moving body and aims to translate them into geometric forms to capture and manifest their dynamics. The outcome centers on understanding the intangible dance expressions and materializing an abstract recording of a movement cycle into the visual parameters that represent the movement qualities in a 3D shape.

2.RELATED WORK

Most of the relevant efforts to represent body movement are based on the two well-known ways of recording and analyzing the movement. One is the video camera, and the other is the notation system. Human locomotion was the forerunner for the contemporary methods of movement analysis dominated by the availability and use of the video camera and later computerized motion analysis [15]. It was first developed by Muybridge in the 1890s, who used a sequence of still photos to represent movement phases [16]. This method has been popularly used within HCI and game design. For example, MoSculp uses a series of 2D images that are deciphered from an input video to estimate a human's 3D geometry and to reveal human motion via 3D sculptures [17].
Laban Movement Analysis (LMA) is the most common notation system to describe the movement, which was developed in the 1920s by Rudolf Laban and eventually evolved into modern-day Labanotation. It provides a language for observing, visualizing, interpreting, and documenting all varieties of human movement, in an attempt to record and analyze classic choreographies. Labanotation uses abstract symbols, such as direction symbols, stick figures, musical notes, etc, to define the four movement dimensions -- direction of the movement (Shape), part of the body doing the movement (Body), duration of the movement (Space), and movement qualities (Effort)[4].

Labanotation has been adopted in various projects as a design tool to support movement analysis and movement-based interactions, such as DanceForms, LabanWriter, and LabanDancer[3]. All of these systems share a common goal of transcribing and analyzing the body movement in the directly mapped animation. Many have commented that, as the realism increases, the expressive qualities of the movement in dance may become less obvious [3]. After all, dance, as creative performance art, lives through emotional expressiveness. As Calvert has argued, the problem of representing movement in realistic visualization in digital forms lies in "the difficulty in capturing the emotion or power in a movement from keyframes or notations." [3].

This aesthetic, emotional expressiveness in movement is closely related to the idea of movement quality, which is a fundamental property of body expression and has a seminal role in dance performance [18]. Blom et al. define movement qualities as "the distinctly observable attributes or characteristics produced by dynamics and made manifest in movement" [19]. Laban considered movement qualities as the fourth dimension of the movement—Effort, which is considered as an inter-relatable concept to "dynamics" and is described as a system for understanding the more subtle, personal characteristics about the way a movement is done with respect to inner intention [4]. Wallbott investigated the link between emotions and movement qualities [20]. He specified “movement activity” (overall quantity of motion, i.e., related to the velocity), “expansiveness/spatial extension”, and “movement dynamics/energy/power” as the three categories for characterizing emotions in the movement qualities[18].

This emotional property of movement, widely exists in our everyday practice and performance art, but it has not been widely explored. Some researchers have studied movement qualities as interaction modality. A Light Touch is an art installation that hypothesizes the use of movement qualities to provoke more explorative, expressive and aesthetic interaction modalities [18]. Schiphorst and Moen attempted to explore the embodied cognition and bodily experiences of aesthetics with the use of movement quality in the project Soft(n) [21] and BodyBug [22]. Others have addressed movement-based interaction with real-time interactive visuals. Hsueh explored the links between the interaction patterns and the sensorial body movement by developing a series of parameterized interactive visualizations [23]. Anjos attempted to identify movement qualities in real-time visualization to correlate them to specific meanings and choreographic intentions [24]. Hansen & Morrison explored the nature of the movement data and developed a design tool “Sync” to enable rich embodied communication of the body movement for digital interactions [6].

In this research, I would like to build on these works and tap into a new realm of abstraction that we hardly look into for digital-infused performance art. My work experiments with the possibility of visualizing the dynamic properties of the movements in a physical model with the help of digital technology and personal fabrication. As a methodology for learning and design, model-making in both physical materials as well as computer simulations can be seen as support for systems to understand and represent the world[5]. It opens up new perspectives in the creative process and allows rapid experimentation with a system to understand its limitations[5]. The creation of a computationally augmented model which captures dance motion brings kinetic simulation into the physical world and can increase our capacity to appreciate its implicit aesthetic values. It can help design and re-experience the fleeting forms through the process.

3.DESIGN INVESTIGATION

3.1.Design Criteria

From the background research, I developed a set of design criteria, which required the project to deliver four main qualities:

1. Being expressive: the focus of the design is to translate and reflect the abstract, subtle characteristics of the movement. Being expressive will help people to better understand dance as an expressive form of emotions.
2. Realizing the dance dynamics through parametric design: this means to develop relations among multiple design parameters, so as to automatically generate many design variations with the same dataset.
3. Being extendable: this means the logic behind the design should be able to apply to any other kind of data sets. This would allow the code not only to apply to the dataset collected specifically for this project, but also to any other datasets from other dancers or other tracking sensors.
4. Being fabricable: this means the design shall be 3d rendered, and there should be some constraints in design parameters to ensure the meshes generated remain valid for 3D printing.

3.2.Semantic Mapping: From Data To Shape

My focus is on understanding how movement data may be read, interpreted, shaped and presented in a 3D fabricated form. For each digital abstraction of movement, I need to understand what is registered and how to identify which data I need or how I may use it. Some projects deal with identifying the movement patterns for the choreography[7, 8] . These projects primarily rely on the score-notion system to decipher the logic of choreography. In contrast, I am focusing on abstracting the implicit dynamics of dance movement. In this sense, I found that it is important to identify key movement qualities.

To support this, I build on Hansen & Morrison’s “Movement Schema” for identifying semantic properties of movement dynamics, in which velocity, position, repetition and frequency are identified as the core modalities[6]. Velocity represents the change of speed in an x-y-z number; position refers to the location of velocity; repetition is the continuation of the movement; and frequency is the use of timing[6].

To visualize the movement qualities with the 3 sets of the registered acceleration data, I created a matrix [table 1] that mapped the semantic properties of the dynamics of movement in the data onto the key components of this movement schema - and ultimately onto my visualization (as I will argue later).

Core Modalities [6]	**Interpretation** [6]	**Visual Representation**	**Registered Data**
Velocity	Rate of speed change	Unit shape size change	The analog reading of the acceleration
Position	Location of velocity	Vector direction, Orientation of the visualized body	The inclination angle around the x-y-z axis

Repetition	Continuation of movement; the rhythm of motion	Rigidity, bounciness of the line qualities, the change of distances between shapes	The gravity force
Frequency	Use of timing	The length/ height of the visualized structure	The frequency of data points

Table 1. Semantic Mapping of the Four Movement Qualities

This matrix allows me to align actual motion data with a semantic schema to inform possible visualization approaches.

3.3.Digital Design Process

3.3.1 Towards Discrete Aggregation

Taking inspiration from Mario Carpo's idea that "*any computational process is fundamentally discrete*" [9], and "*every very bit of digital data is the same bit of data in the physical world*"[9], I turn to the logic of discrete aggregation for the digital design process. The idea of the "discreteness" in computational design is realized, for example, in the robotic assembly in Architecture, which is considered as an efficient method to fabricate on the building scale and stands in contrast to the continuous assembly system. This computational design system is an aggregation of discrete unit elements with multiple different scales and a limited number of connection possibilities that can cross-connect repetitively[9]. These unit elements are usually designed in a voxel-like pattern with planar surfaces in most scenarios. The connection between these elements is governed by the rules defined by the designers and constrained by its geometry shape[9]. The resulting buildings are all different in the assembled form yet highly homogeneous.

The discrete aggregation in this project shares the basic property of the idea of discreteness developed by architects: it is connected by a series of unit building blocks in repetition. These unit components are discrete, they have limited connection possibilities and relative local positioning.

There are some other key differentiations as well. In the Discrete Assembly, the resulting geometry is mainly driven by the part-part relationships. This refers to the connectivity rules of the unit elements, which are arbitrarily defined by designers and the shape of the element. Each unit element is equal and not customized throughout the aggregation process. In this project, the limitation in the connection possibilities does not result from the pre-defined rules and the geometry of the unit component itself, but is driven by the transformation of each unit element. Each unit element is considered as a distinct visualization of the digital data acquired from the dancer's movement in the physical world. Therefore, the final form is always different and customized through the translation of the corresponding digital data. Designers can define how the properties of each unit element transform based on their interpretation of the relationship of any two adjacent digital data points. The individual unit components are interconnected based on their local positioning along the spatial time curve. The heterogeneity of the resulting whole depends on how widely the designer decides to differentiate between the unit elements - as well as on the underlying dance data set. The more heterogeneous, the more diversity we should see in the properties of the dancer's movement, such as the change of the location, speed adjustments, strength and force of movement, etc.

3.3.2 Unit Component: From 2D To 3D

As the building block for the aggregated shape, the unit geometry defines the properties that can be built and transformed based on the meaning of the corresponding digital data. With the three types of digital data acquired from the dancer's movement (the acceleration, the gravitational acceleration, and the inclination angles), the transformation of each unit shape forms the relationship to the previous one in terms of the changes of location along the spatial curve, the size, and the orientation.

I started with a 2D shape: the ellipse served as the basic shape for each data point, and a circle served as the movement path. The rate of speed change in an x, y or z dimension was indicated by the change in the size of the ellipse in the data points representing each logged dance data. That is, movement is registered as a change in any of the x, y, or z planes, measured by the rate of speed change in its position. This, in turn, is visualized, so that an increase of how fast the dancer moves in the x and y dimension will extend or shrink the ellipse in the horizontal and vertical dimensions (Figure 1-2). The ellipses are continuously drawn on the circular trail, which allows the visualization to build up the repetitions of movement qualities visually and relationally. The frequency of the ellipses depends on the length of the chosen dance movement and the data set and becomes apparent through the alignment of the individual ellipse/ points along the visual trail. (Figure 3-4). The direction of the velocity is indicated by the angles by which any ellipse is rotated along this central circular trail. An increase in the direction change, such as a full-body spin, would exaggerate the rotations of the ellipses. This translation from data to shape not just applies to ellipses, but possible to other shapes.

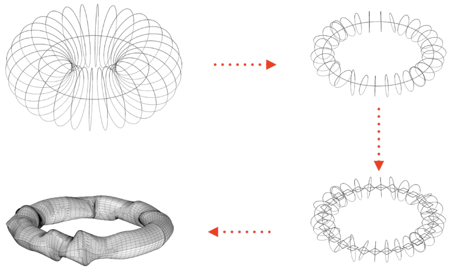


Figure 1. Generative process of the first design iteration, in which 2D ellipse is transformed as they aggregate based on the corresponding data sampled from the author's own movement

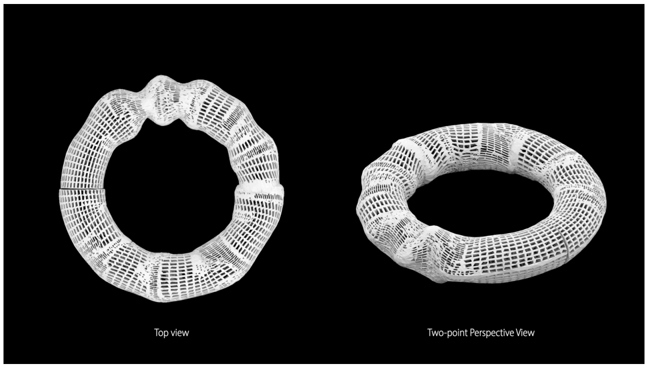


Figure 2. Rendered views of the first design iteration

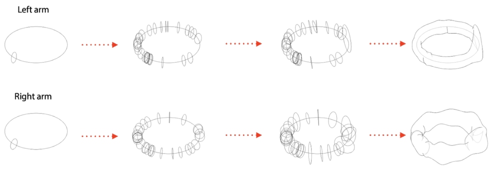


Figure 3. Generative process of the second design iteration, in which 2D ellipses are transformed as they aggregate based on the digital data sampled from the dancer's movement.

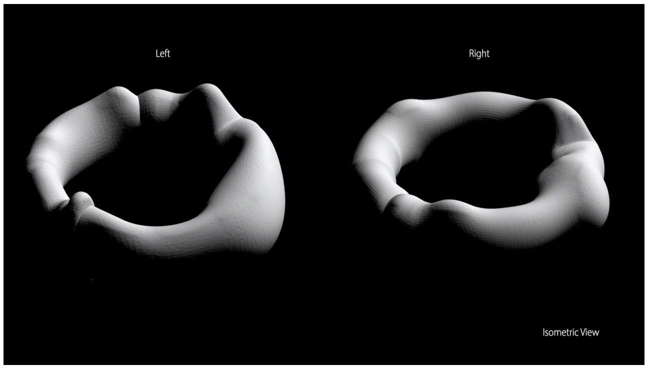
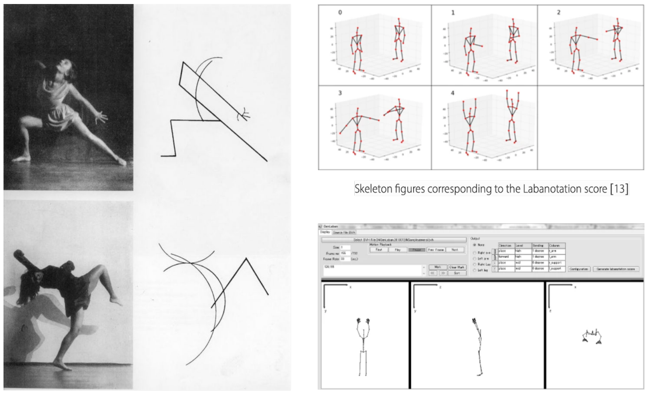


Figure 4. Rendered views of the second design iteration

Working with 2D shapes has its limitations. First, the shape transformation with the 2D ellipse is constrained to the two-dimensional planes, which restrains the full use of the dataset. Second, the unit ellipses are aggregated along the movement path in the air without touching each other. Otherwise, the complete model would be likely to result in an invalid mesh and become useless for fabrication. On the one hand, this requires to set more strict domain requirements when mapping the data to the shape, such as the rotation angles for the ellipses, to avoid collision between any two ellipses. On the other hand, the more strict domain requirement constrains the degree of the transformation of the shapes to optimally translate the dancer's movement dynamics. This led me to experiment with 3D shapes that embrace more transformation possibilities and can be aggregated directly without causing fabrication dilemmas.

I referred back to Laban's skeleton-like notation system and Kandinsky's line drawings abstracted from the body movement[12, 13, 14][figure 5], and redesigned the unit component to resemble the transformation of the body shapes. The central sphere represents the center of the body mass, which changes when the dancer moves. The branched sphere and branches represent the movement of the body parts which are being tracked with the sensors[figure 6]. This enables the flexibility to generate many design variants based on how many body parts are being tracked, where the body center is, and how the tracked body parts are oriented[figure 7]. Starting with one unit component, the following elements will transform in shape properties (local positioning, size, orientation) and be added to the previous data point along the central axis [figure 8].


Wassily Kandinsky: "Dance Curves" [12]

Skeleton figures corresponding to the Labanotation score [13]

Interactive graphical user interface of GenLaban [14]

Figure 5. Style reference to generate the unit geometry

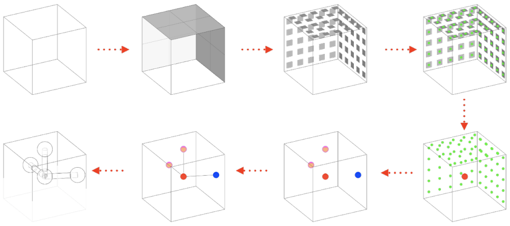


Figure 6. Generative process of the unit geometry

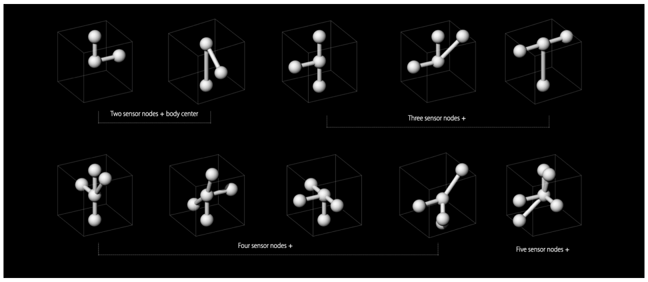


Figure 7. Design variants of the unit geometry

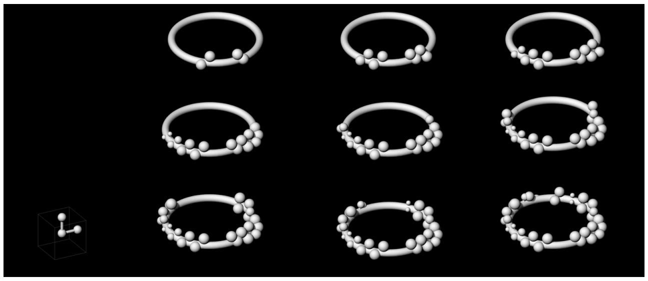


Figure 8. Evolving process of the unit geometry aggregation

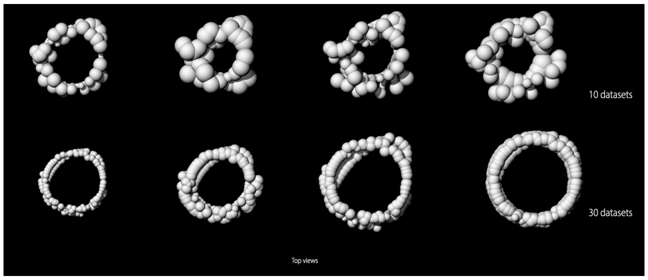


Figure 9. Design variations of applying unit geometry along the time line

The design iterations ultimately led to a non-hierarchical and component-driven approach. Instead of focusing on a single closed visualization, this approach allows for a more individual and extendable 3D design that still presents the motion data in an interrelated way [figure 9]. Thus, it answers to the main design criteria outlined for the project.

3.3.3 Spatial Curves: The Language Of The Space

Although the circular trail is good to indicate the animation cycle, it is limited in showing the movement flow in space. Taking inspiration from Laban's idea of kinesphere [10] [figure 10], which uses the body as the main reference point in space, and William Forsythe's space-tracing notation [11] [figure 11], a variety of spatial curves can be generated by tracking the primary locations in space where the dancer passes by. These "primary locations" can be interpreted as the anchor points where the body repetitively passes by or stays for a longer time. The simulation of the movement flow starts with a bounding box as the unit space wherein the dancer can move. The dance itself forms the spatial curves by connecting the "anchor points" on the surfaces of one unit box or the aggregated multiple boxes [figure 12-14].

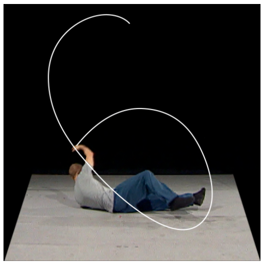


Figure 11. William Forsythe's Space Tracing Notation

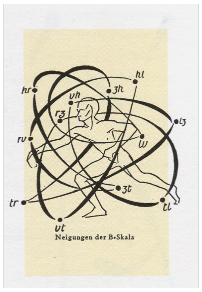


Figure 10. Laban's Kinesphere concept

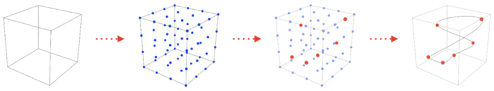


Figure 12. Generative process of the spatial curve

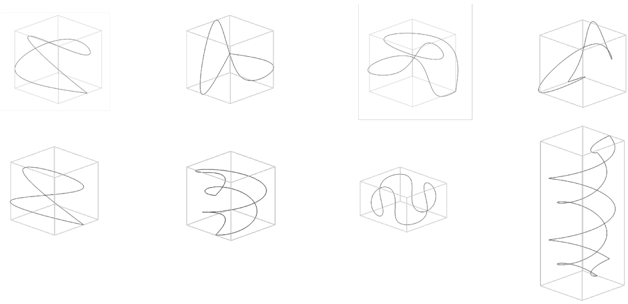


Figure 13. Design variations of the spatial curves based on the “anchor points” where the dancer passes by

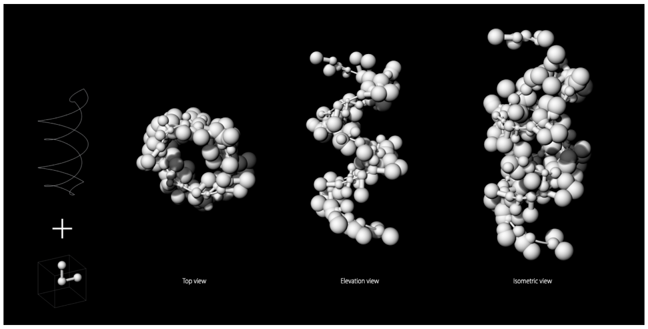


Figure 14. The design model of the unit geometry transforms and aggregates along the spatial curve

This third design iteration takes spatial positioning into account and leads to a less time- and more space-based visualization. Yet. both are still integrated in the resulting model.

4.IMPLEMENTATION

4.1.Pre-Digital Design: Movement Data Capture

There are two types of data that are crucial to the design of body movement: one is the shape of the movement flow, the other are the factors that impact the movement qualities, which includes the speed, the force, the amplitude of motion, etc. In the implementation phase, the project had to select feasible ways to record these dimensions.

Microsoft’s Kinect sensor has been widely used in motion sensing: it uses video and depth data from infrared sensors to identify 15 joint points of a full body movement.
The initial experiment with Kinect shows that a large collection of point cloud can be captured via processing. The large number of data points presents a challenge to the abstraction of the dataset into meaningful geometry symbols in one solid model. The software chosen for this task was grasshopper. Although it is possible to process the dataset into a smaller number of values that are most purposeful to the digital simulation, it requires machine learning skills. The Kinect approach did not work in practice as it ultimately offered too many data points that were by themselves not directly showing the necessary semantic features outlined above.

The second attempt with motion sensing used movement tracking sensors attached to the dancer’s body. They are connected to an Arduino, which captures the data and uses Bluetooth to transmit it to the computer, while the dancer moves. Whether a person is dancing, walking or exercising, the position, the velocity (change of speed and direction), and the movement rhythm are constantly changing. While we are unable to get the position data with only the accelerometer sensor, the change of velocity can be acquired. This proved to be more feasible for my project.

I used two 3-axis accelerometer ADXL335 and a bluetooth module HC-06 for the experiment [figure. 16]. The output of the measurement displays the calibrated acceleration values (m/s^2) on each axis. With the map() function in Arduino IDE, the gravitational acceleration values can be acquired between -1g to 1g. With the trigonometry function, the inclination angles with each axis can be obtained too.

Figure 15. Record a short performance with a dancer

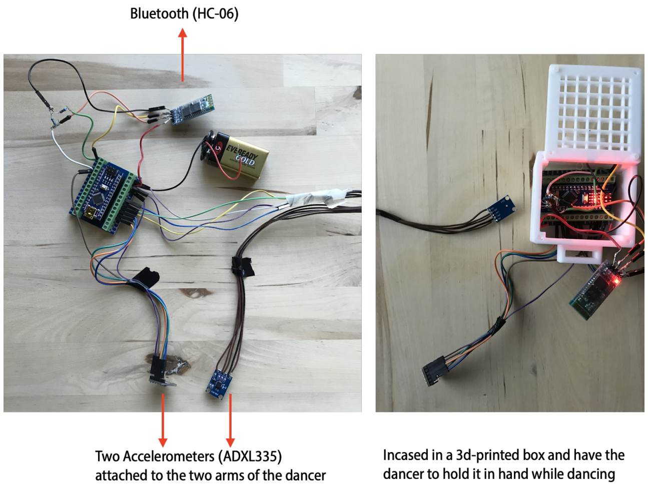


Figure 16. The set up of the motion capture

The experiments in sensing were a balancing act between the need of the project as set out by the main qualities and the design on the one side and different sensing technologies on the other. In the end, the accelerometer solution managed to provide the necessary data quality and density.

This setup was first pilot tested by the researcher to assure the workflow from movement data capture to 3D model generation in grasshopper. Once this was confirmed, it was used to record a short dance performance [figure. 15]. The restrictions of the Covid regulations made it impossible to test the same set up with different dancers (such as Georgia Tech dance troupes) but the main data set was collected from this original dance recording and would be used forward to generate the visualization.

4.2.Post-Digital Design: 3D Printing

The original dance was sighted and a short segment of about 20 seconds was used. Data was collected every 500ms. This same data set was used to generate different 3D models in grasshopper based on the design iterations outlined above. The final stage was to produce the physical models that the original design asked for (figure 17). This responds to the fourth design criteria. Models were printed at Georgia Tech's Invention Studio.

Limited access to campus resources made this step more time intensive than it would have been in non-Covid conditions. Still, the final results demonstrate the transition from the abstract visualization in 3D using the virtual procedural model generation in grasshopper to the material representation of these data.

Figure 17. Final printed design models of all the design iterations

5.RESULTS

5.1.Making Sense Of The Movement Qualities

Reflecting on the goal of the project, which is about the capture and abstract visualization of dynamics in dance motion, I went back to the semantic mapping. The 4 movement qualities of the movement schema outlined in the semantic mapping remained central to the visualizations. The core variables were tested across different iterations - each of them showing the 3D generation as well as 3D printing results. In the final version, the four key criteria are represented in inter-connected sphere representations. Velocity is interpreted as the speed change, the size of its sphere's radius and the connecting branch length are transformed to indicate it; position is translated into how the branches rotate with each data point; repetition is defined by how far or close the unit components aggregate to each other; the length of the trail path indicates the duration of the movement, or the frequency(figure 18a-b).

The resulting models illustrated the technical feasibility of the project and the success of the implementation.

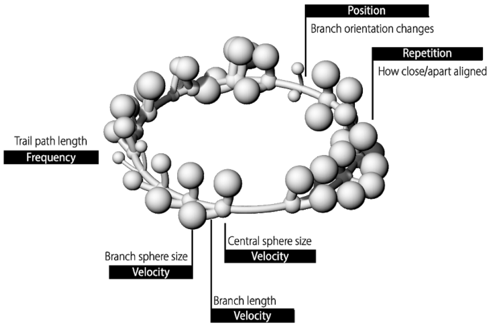


Figure 18a. Diagram illustrates how to interpret the shape of the design model

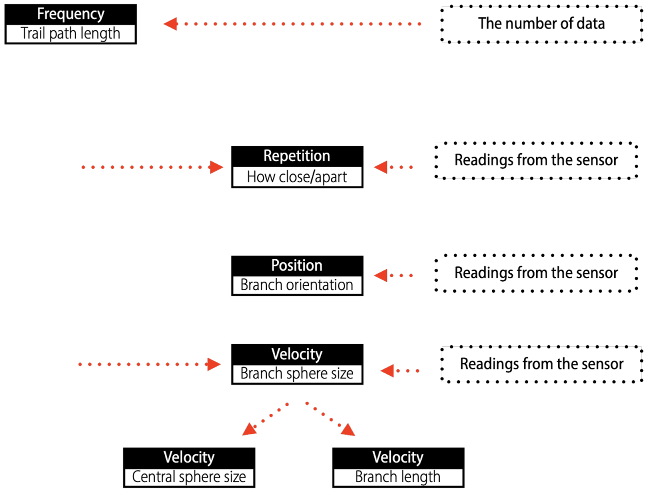


Figure 18b. Diagram illustrates the relationships of the four movement qualities, the data and the shape properties

5.2.Collecting Feedbacks From The Dancer

In an informal evaluation, the results of the 3D models were presented back to the original dancer. The following is the summary of the primary concerns and comments from the dancer.

1. Overall shape changes are effective to help understand the movement dynamics, while too many details could be distracting. My dancer appreciates the subtle flow change in the 1st and 2nd iterations --*"There's both subtleness in change when you zoom in to see in, but when you zoom out, I can also tell the significant change between the starting part and the middle till the end, It seems to tell me when you danced, you generated a lot more energy at the beginning, but fade away gradually"*. On the other hand, she commented on the lattice-like texture of the first iteration as *"distracting"*. Although she likes the softness in bubble-like form from the last iteration, she also thinks too many bubbles connected seem to distract her from understanding the overall movement flow--*" I want to see it as a whole picture of the movement, rather than recording every detail of it"*

2. The sharp creases between the aggregation of the discrete elements break the continuity of the movement flow. She imagines dance as a movement like water flows and expects the design to be organic and fluidic. The sharp creases in some connection areas break the continuity of the flow.

In combination, the original task of the project - to re-interpret dance movement into 3D structures in order to find novel forms of visualization of such data - managed to speak to the dancer. The dancer could identify different points of the movement in the structure and detected key qualities such as "energy." At the same time, more fluidity was requested.

6.LIMITATIONS AND FUTURE WORK

In this project, I explored the visualization process of the movement qualities in order to manifest the subtle, dynamic characteristics of a particular dance movement. The results indicate a successful semantic mapping of the four movement qualities the visualization is built on. They provided a convincing foundation to translate the data into shapes in a meaningful manner. The logic of the discrete aggregation of the digital simulation relies on matches with the semantic mapping to generate multiple design variations that illustrate the different characteristics in each movement.

There are some inherent limitations that leave the potential for the existing design to be more convincing, applicable and expendable.

1. Lack of sufficient data. This relates to three issues. One is about the length of movement to capture. Due to the Covid regulations, I was only able to record one 20-second performance from a dancer. The design models illustrated above capture this 20-second dance movement. This makes me wonder whether a longer recording and simulation might be better suited to tell the story of the dynamics of the movement. The other is about the diversity of the dance genre. Different dancers have different dancing styles, which have a direct impact on the movement qualities. With the data obtained from the one dancer, it is hard to tell how the design models generated from the algorithm might differentiate among different dancing styles or genres. I believe it would be useful to test the algorithm on different dance genres to prove whether the logic of the semantic mapping and the design algorithm still work with these data sets. Lastly, since the design of spatial curves described above lacked the real data to generate the "anchor points" in space due to the very limited recording opportunity, including a Kinect to track the position of the dancer within the space and obtain the real spatial information might provide another opportunity for the future work. All of these issues can be resolved by inviting more dancers for multiple recordings when the Covid regulation is suspended.

2. Is the accelerometer data sufficient? In this project, I used accelerometers to capture the movement data. Besides the velocity information, other data, especially biometric data, could also have a close relationship with the movement qualities. This indicates a future work to try out heart rate, temperature, respiration sensors to explore what data are more pertinent to the dynamics of the movement.

3. Is the discrete aggregation the best form to simulate? The discrete aggregation algorithm aligns well with the logic of the semantic mapping and works well with the limited number of data and the shape properties. With future improvements, the discrete aggregation may not be sufficient anymore. Thus, to provide a solid logic of the design simulation, the future work should also include experiments with other algorithms when working with different sensor data or dancing genres and a user study to gather users' opinions for comparison.

In the future, I envision optimizing the algorithmic implementation to smooth out the sharp creases that currently break the continuity of the shape flow, and to test the project on a larger data set (for example, more data from a longer movement duration, data from a different dance genre, data that support the spatial curve information, data that go beyond the current velocity information). I also envisage packing the algorithm as an application to test it in diverse use scenarios and having the application communicate with Arduino or Kinect directly to generate the design model.

7.REFERENCES

[1] Belgian Moroccan choreographer Sidi Larbi Cherkaoui's comments, http://danceconsortium.com/milonga/bios/sidi-larbi-cherkaoui.php?iframe=true&width=745&height=90%#:~:text=Dance%20is%20always%20a%20temporary,or%20rewritten%20at%20any%20time.&text=Sidi%20Larbi%20Cherkaoui%20regards%20them,for%20a%20contemporary%20dance%20language

[2] Peggy Phelan, Unmarked The Politics of Performance, http://hemi.nyu.edu/course-nyu/advanced/materials/text/phelan.html

[3] Tom Calvert, Animating Dance, Graphics Interface 2007, Simon Fraser University

[4] Labanotation, https://en.wikipedia.org/wiki/Labanotation#:~:text=Labanotation%20or%20Kinetography%20Laban%20is,Written%20Dance%E2%80%9D)%20in%201928. (Access May 06 2021)

[5] Parkes, Amanda J , Topobo : A Gestural Design Tool with Kinetic Memory, 2004

[6] Lise Amy Hansen, Andrew Morrison, Materializing Movement — Designing for Movement- based Digital Interaction, International Journal of Design 2014, Vol 8, No. 1

[7] Carlota Torrents, Marta Castañer, Toni Jofre, Gaspar Morey, Ferran Reverter, Kinematic Parameters That Influence The Aesthetic Perception Of Beauty In Contemporary Dance, Perception, 2013, volume 42, pages 447 – 458

[8] Harry Brenton, Andrea Kleinsmith, Marco Gillies, Embodied Design of Dance Visualizations, MOCO 2014

[9] Gilles Retsin, Discrete Assembly and Digital Materials in Architecture, FABRICATION | Robotics: Design & Assembling - Volume 1 - eCAADe 34

[10] http://www.laban-analyses.org/laban_analysis_reviews/laban_analysis_notation/space_harmony_choreutics/kinesphere_scaffolding/polyhedra.htm; https://thespaceintherelationship.wordpress.com/kinesphere/ (Access May 06 2021)

[11] William Forsythe & Paul Kaiser, Dance Geometry, A Journal of the Performing Arts, Volume 4, 1999, Issue 2: On Line https://www.tandfonline.com/doi/pdf/10.1080/13528165.1999.10871671?needAccess=true

[12] Susan Laikin Funkenstein, Engendering Abstraction: Wassily Kandinsky, Gret Palucca, and "Dance Curves", Modernism/Modernity, Baltimore Vol 14, Issue 3

[13] Katsushi Ikeuchi, Zhaoyuan Ma, Zengqiang Yan, Shunsuke Kudoh, Minako Nakamura, Describing Upper Body Motions Based On The Labanotation For Learning-From-Observation Robots, International Journal of Computer Vision 2018

[14] Worawat Choensawat, Minako Nakamura & Kozaburo Hachimura, GenLaban: A Tool For Generating Labanotation From Motion Capture Data, Multimed Tools Appl 2015

[15] Lian Loke, Toni Robertson, Labanotation For Design Of Movement-Based Interaction, Interactive Entertainment 2005, University Of Technology Sydney, Australia

[16] Muybridge, E. The Male And Female Figure In Motion. Dover Publications, New York, 1984.

[17] Xiuming Zhang, Tianfan Xue, Tali Dekel, Andrew Owens, Jiajun Wu, Stefanie Mueller, William Freeman, Mosculp: Interactive Visualization Of Shape And Time, UIST 2018

[18] Sarah Fdili Alaoui, Baptiste Caramiaux, Marcos Serrano, Frédéric Bevilacqua, Movement Qualities As Interaction Modality, DIS 2012

[19] Blom, L.A. And Chaplin, L.T. The Intimate Act Of Choreography. Pittsburgh, Pa. : University Of Pittsburgh Press, 1982.

[20] Wallbott, H.G. Bodily Expression Of Emotion. European Journal Of Social Psychology 28, 6 (1998), 879-896.Wallbott, H.G. Bodily Expression Of Emotion. European Journal Of Social Psychology 28, 6 (1998), 879-896.

[21] Schiphorst, T. (2009). Soft(N): Toward A Somaesthetics Of Touch. CHI 2009. Boston, MA, USa

[22] Moen, J. (2007). From Hand-Held To Body-Worn: Embodied Experiences Of The Design And Use Of A Wearable Movement-Based Interaction Concept. Tangible And Embedded Interaction. Baton Rouge, Louisiana, USA.

[23] Stacy Hsueh, Sarah Fdili Alaoui, Wendy E. Mackay, Understanding Kinaesthetic Creativity In Dance, CHI 2019

[24] Rafael Kuffner Dos Anjos, Claudia Ribeiro, Carla Fernandes, Three-Dimensional Visualization Of Movement Qualities In Contemporary Dance, MOCO 2018