

Mathew Schwartz
Sculptural Motion

Abstract

This work uses a custom algorithm with motion capture technology to render the performative arts into static sculptural forms in order to create an aesthetic that focuses on the path of motion instead of on the subjects' figure. This research is presented as a multimedia installation comprised of four sculptures with video support. The use of 3D technology has often led to artists extending the concept of long-exposure photography or video. This thesis discusses the history of long-exposure work and how technology has changed the product but not the concept, while this work explores the conceptual shift.

Index

Introduction.....	pg. 3
Background.....	pg. 3
Research.....	pg. 6
Precedence.....	pg. 7
Virtual to Physical.....	pg. 8
Materials.....	pg. 9
Code.....	pg. 11
Current.....	pg. 12
Further Discussion.....	pg. 14

Introduction

Through the creation of the camera and video, people have created an entire world around the capturing of time. With Étienne-Jules Marey and Eadweard Muybridge studying movement cycles and the Gilbreth family researching speed in the workforce, all were able to do so with long-exposure photography. This trend in the art world was growing alongside the technology. With the creation of rapid prototyping machines and 3D modeling software, the transition to the virtual world has been restricted to a lifelike representation of what motion would have looked like in a photograph. This series of works brings an abstraction to the complex high-tech world. This work allows for the audience to ponder the spatial movements that occur during normal life and in performance. The audience views three sculptures on pedestals with reflective black acrylic bases. The back wall has a video going through the process of creating the forms.

Background

After the invention of the camera, many people began realizing the possibilities that it had for capturing data. Some of the early work in the sciences began with studying the human body in different movements. The long-exposure genre of visual art work started with people such as Étienne-Jules Marey and Eadweard Muybridge doing scientific studies with incredible artistic appeal. Étienne-Jules Marey was a scientist and a pioneer in photography. Through early studies of human motion and the motion of birds (Figure: 1), he inspired people to investigate how subjects move through time. These images have created a path and a source of movement that would be used over 100 years later.

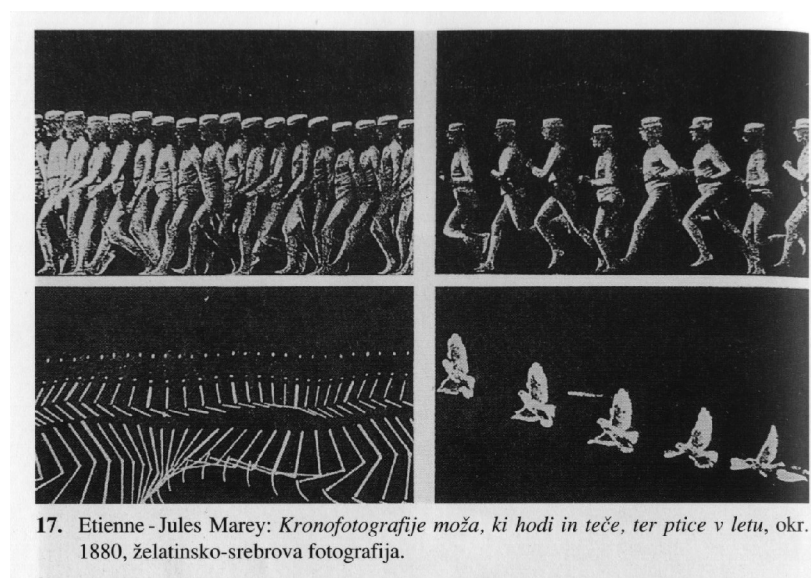


Figure 1: Etienne-Jules Marey, 1880. One of the original studies on different motionpaths created by humans and birds. This inspired the more commonly known bird sculpture.

Preceding Marey was Eadweard Muybridge with studies on humans walking down a staircase (Figure: 2). This image was reference by later artists such as Peter Jansen and Marcel Duchamp. One difference that Marey and Muybridge had was the pursuit of visualization. In the 1860's Marey started researching flights of birds. From this photographic research, he began 20 years later to make bronze and plaster sculptures of his photographic images (Figure: 3).

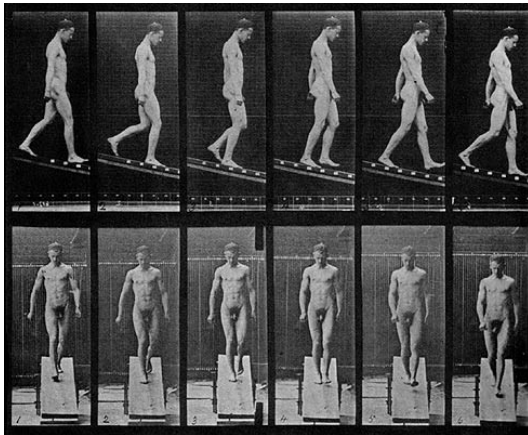


Figure 2: Eadweard Muybridge multiple exposure man walking down stairs

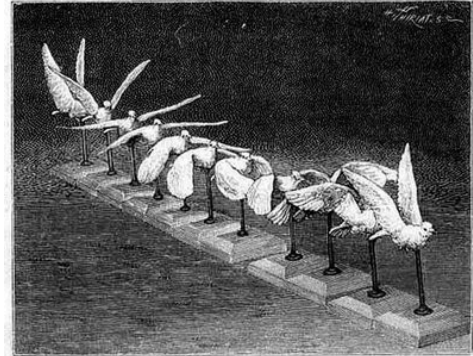


Fig. 8. — Figurines de bronze représentant 11 attitudes successives de l'aile d'un pigeon à des instants successifs d'un coup d'aile.
 Figure 3: Etienne-Jules Marey sculpture of a bird in flight



Figure 4: Reviews of Nude descending a staircase no2 1912 by Marcel Duchamp



Figure 5: Duchamp descending a staircase. Eliot Elisofon. 1952.

Marcel Duchamp later revisited Muybridge in a painting, then later in a photograph (Figure: 4, 6) . The painting was referenced as lying between Cubism and Italian Futurism. It was one of the first direct artistic representations of the knowledge gained from the scientific works of

Marey and Muybridge. In the present, Peter Jansen and Geoffrey Mann are at the forefront of artistic representation of movement. Both these artists have moved into the digital-3D realm, and while both have brought digital works into the physical world, Geoffrey Mann has emphasized it in his work. While Peter Jansen referenced Muybridge walking down a staircase (Figure: 7), Geoffrey Mann references Marey bird in flight (Figure: 6).



Figure 7: Peter Jansen



Figure 6: Geoffrey Mann

Separate from the history of “long exposure” artists there are other abstract artists that have used a similar theme. Bird in space (Figure: 8) shows an abstraction of a bird flying through space in which the form of the bird was elongated. This gestural movement is what most closely ties to the bronze sculpture created for this thesis.



*Figure 8: Bird in space.
Very similar concept of
abstracting movement.
Took the shape of bird
and moved through space
creating an elongated
form.*

Research

Sculptural Motion entailed the exploration of computer and human knowledge of motion. As systems such as motion capturing and computer animation begin to develop, there is a desire for a computer to not only visualize motion but to create it. Computers and humans seem to trace the outline of a person in order to understand what movement is being created (Figure: 9). When this motion is abstracted to a point in space as in Figure 10, much can be learned about how humans perceive motion. In a paper titled “Using Movement and Intentions to Understand Simple Events,” by Jeffrey M. Zacks, researchers did a study with participants watching the same animation, and one being told it was intentional movement by actors and one being told it was not intentional by a computer. The findings in their interviews were as follows: Out of the participants, 100% of the intentional interpretation group used intentional terms to describe the animation whereas only 37% of the participants of the random interpretation group used intentional terms.

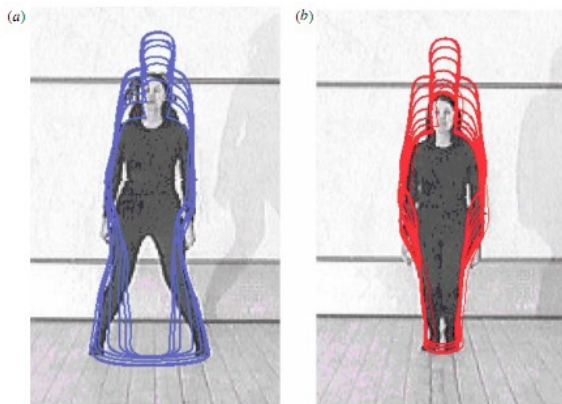


Figure 9: Motion classes used in the experiment. In order to illustrate the motion, contours of previous time-steps are superimposed on one frame. (a) Half star: a ‘star jump’ without arm moment. Notice that both motions begin with an upwards acceleration. Hence it is difficult to discriminate between both motions. (b) Pure jump, i.e. jumping up and down without lateral arm or leg movement.

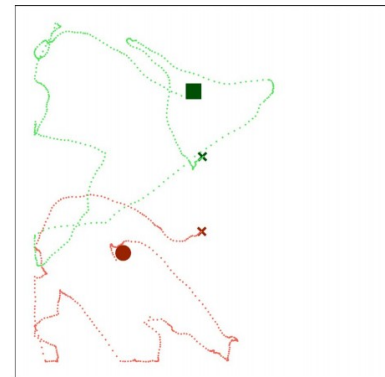


Figure 10: Illustration of the animations. The image shows the two objects depicted in the animation, a green square and an orange circle. The small dots depict the path of each of the objects during the first 40 s of the animation used in Experiment 1, sampled at 10 frames/s, and x’s mark the objects’ initial positions. (The black frame bordering the canvas was not visible to the participants.)

Research: Informal

Prior to finding Zack’s paper these images were shown to ~10 people (Figure: 11, 12). Although some knew a little about this work, most knew nothing. The interviewee was first asked to describe what they saw and anything they thought was happening. All participants explained that one image looks random (Figure: 11) and one looks intentional (Figure: 12). Afterward they

were told the image they thought looked random was tracking movement of the hands while the image thought to look more intentional was tracking of the feet. This was important to the images since the human motion occurring was an activity that concentrated on the movement of the legs, whereas the arms did not have a specified movement. After being told what the image was the participant was then asked if the information changed their mind of what the image represented. The response was unanimously yes except for one who later explained his reasoning which excluded him from the study. The interviewees had explained they understood how the image was created, but by simply knowing how it was created, the aesthetic did not change. This is an interesting point when looking at the relationship between concept and form. The relationship between the concept influencing the aesthetic may only go so far.

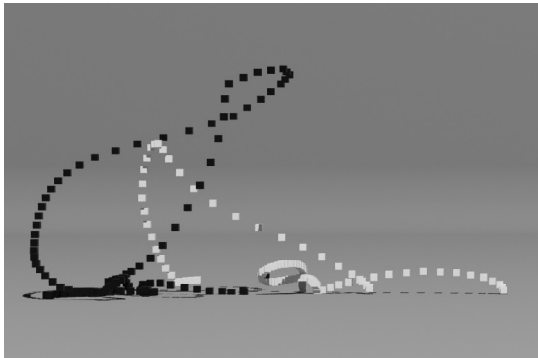


Figure 12: Tracking of feet. White and Black represent two different people. The farther the squares, the faster the movement.

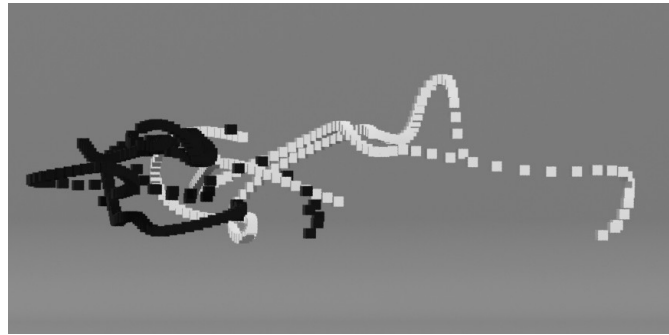


Figure 11: Tracking of hands. White and black represent two different people. The further the squares from each other, the faster the movement at that time.

Precedence

This precedence work has been an inspiration to the current work explained in this thesis. A look into my recent artistic background shows two sculptures that bring a contrast to the realm of movement within sculpture. One is a classical figure sculpture, the other a contemporary sculpture (Figure: 13, 14). The steel sculpture was created through the knowledge of dance. The movement between two people was analyzed to abstract the spin and relationship of the limbs to each dancer. As a flat plate, all the pieces aligned, the angles were based on the compression of the body just as the spine is able to compress to bend into form. The amount of curvature of each piece is correlated to the amount of spin and speed of that segment of the limb would be going at that moment in time. This is in contrast to the development of classical figure sculpture. Figure 14 shows a classical sculpture of a woman waiting for a man. Time and movement are still themes within this work yet are represented realistically as a twist in the torso and the cold and lasting nature of concrete. The current work discusses movement and time of

humans by not just abstracting their form but by eliminating it. This is not to say that no connection between the current sculpture and human forms can be seen. The nature of the human body's movement allows the audience to make a connection and visualize the human form by knowledge of the movement.



*Figure 14: Metal Sculpture.
Exploring the compression and rotation a dancer encounters during a Viennese Waltz.*



*Figure 13: Figure Sculpture.
Representing the waiting of a Korean woman for a man.*

Virtual to Physical

The concept of Sculptural Motion is not specifically about time nor movement but how we view them. This thesis allows for a unique view of the relationship between time, movement, and how the audience experiences it. The original hypothesis of this thesis was as follows: sculpture can be defined through the physical movements of sculptural motion, i.e Martial arts, musical practice, and dance. The work would then use dance, Taekwondo, and everyday movement as source material. One of the reasons this project was taken into the physical world was the difference in audience reaction to physical objects.

Although people were able to comment on the virtual object, it was much more about the exact object they were looking at. After the first version of the form was created (Figure: 15, 16), the conversation turned from the exact form that it exists in to ideas of scale, color, and new ideas of form. The remaining battle of balancing physical and virtual is the cost and time aspect in relation to feedback and personal value.

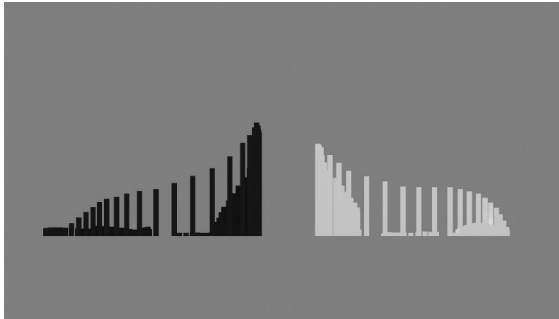


Figure 15: 3D Still of the side plan for acrylic model.

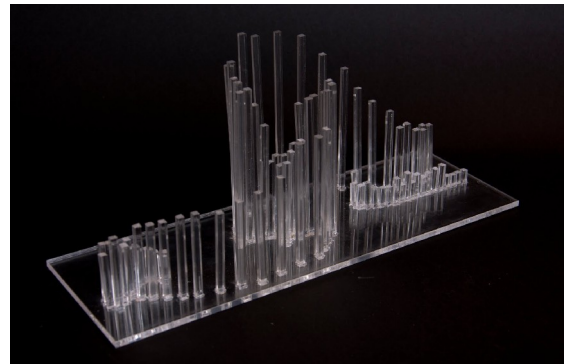


Figure 16: Acrylic Model. Speed represented by distance between bars. Bars follow path of motion.

Before completing the script to automatically generate forms there was one model made by hand (Figure: 17, 18). By individually sizing the cross sections, a sculpture holding the final aesthetic was created. This form was given good feedback so it was decided to continue that path.



Figure 18: Plaster model. Silver Paint. Two fighters interacting.



Figure 17: Plaster model. Silver Paint. Two fighters interacting.

Materials

The link from virtual to physical requires then a conversation on what material means to a physical object. The following three materials are discussed individually in order to explain why or why not they did not work as a final material.



Figure 20: Sodium Acetate in a rubber mold



Figure 19: Sodium Acetate being taken out of mold. The brittle nature of the material prevented a clean release.

Materials: *Sodium Acetate*

The idea that crystals are always a solid structure yet unique in overall composition brought into question sodium acetate. This chemical goes from liquid to solid instantly with a process known as super cooling. When this happens, the liquid instantly crystallizes, each time with a unique structure. This comparison brought attention to the uniqueness of every movement the human body creates. No matter how much someone can try, they can never exactly imitate a movement. After using sodium acetate to form a sculpture in the rubber mold used for wax, a small critique was held (Figure: 19, 20). The critique group felt that although there was a strong connection between the concept and material, the material itself was not showing the connection as well as first thought.

Materials: *Aluminium*



Figure 21: Wax in rubber mold prepared for lost wax process.



Figure 22: Aluminium castings with gas releases still attached.

Originally aluminium was inspired by the renderings done with the original forms. The shiny forms looked beautiful and elegant as they were clean lines with smooth reflections. There was a quality to them that was appealing just in the surface quality. Although this is an attractive feature, the aluminium did not have a strong connection to the concept, distracting the audience from the concept and turning the object into another shiny sculpture (Figure: 21, 22).

Materials: *Bronze*

Bronze is the most traditional metal for sculpture. This is the strongest reason for realizing the sculptures in bronze. With the sculptures drawing a connection between movement and physical form, it was most suited to use a traditional metal to show this new way of thinking into a traditional form. With technology such as rapid prototyping, the sculptures were able to be cast exactly as the form existed on the computer. By using ABS plastic from an FMD machine

the sculpture was able to be cast from printing to bronze without the loss of integrity that happens through mold making and the lost wax process.

The final step for this material was surface finish. The final pieces were a sandblast finish. Although the original visualization was of reflective surfaces, the matt finish and shimmered surface from the light source kept a modern look to a contemporary sculpture.

Code

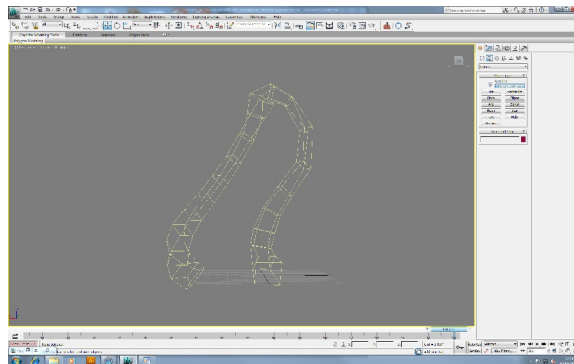


Figure 23: Screenshot of the cross sections for a movement.

A major aspect to this project is the algorithm used to create the forms. The original forms were done by hand, measuring the distance between the markers and changing the cross-section accordingly (Figure: 24). Although this is still within the concept, it only allows for individual sculptures, not a comparison within movements. With support from the UM3D Lab a script was developed in 3D Studio Max in order to analyze the motion (figure 17). Any motion can be sampled in a time frame by entering a start and end time. The user then builds a spline along the path of motion that is used as the center point for the cross-section. The algorithm is somewhat simple but effective. The script has an option for a “size-variable” which corresponds to a photographer changing the F-stop on a long-exposure shot. A minimum and maximum size variable has been offered for cases of extreme speed variations (although it was not used in this body of work).

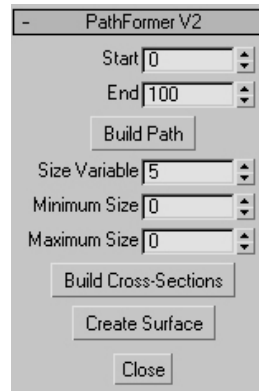


Figure 24: 3D Modeling script, title Pathformer

 Authors: Eric Maslowski, Mathew Schwartz

$$\frac{((\text{length of the spline}) / (\text{the frames in the motion})) * (\text{The users size variable})}{((\text{length of the spline}) / (\text{the frames in the motion})) + (\text{the distance between the current and last rectangle})}$$

The possibilities for further work and development from this thesis have the greatest chance of developing out of this script. More work can be explored in different motions by using this script. Further thought has already risen on an interactive installation that allows a user to move and see their movement in realtime or in a virtual system.

Current

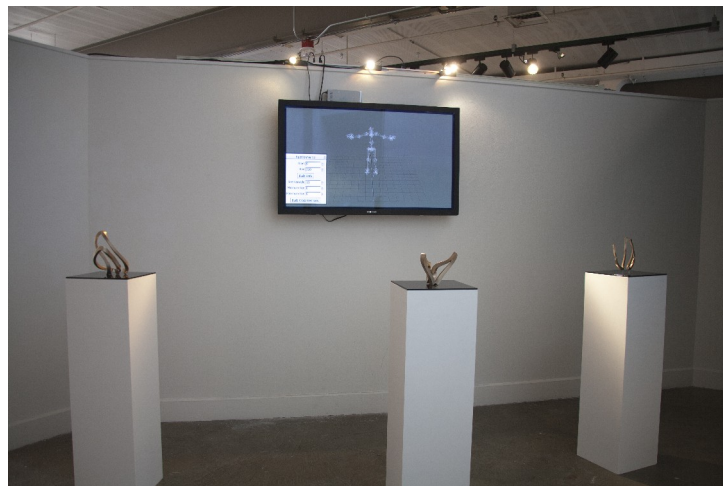


Figure 25: The installation put together.

The resulting work is an installation comprised of three sculptures with video support (Figure: 25). The forms are created from a square cross-section that follows the trajectory of the tracking marker. The cross-section increases or decreases in size based on the speed of the

marker. This draws a direct correlation to a long exposure photograph with a light source across the screen. Since these sculptures are analyzing human motion in terms of sculptural forms, The three movements are all performative. There is a high kick, ballet movement of hands, and a split kick. Applying the same algorithm to all movements allows for a non-biased comparison for the audience. This connection allows for the audience to take back a new way of understanding performance and why they believe something is a “beautiful” movement.

The video in the installation is a breakdown of the entire process. The video starts with showing a dancer in a motion capture suit, then progresses to a view of the tracking markers within a 3D modeling application. The final section of the video goes through the motions with the cross-sections being created. The explanatory video allowed the audience to not be stuck pondering how the sculptures were made but instead think of the possibilities of other movement. By having the sculptures physically in front of the audience, the audience is able to see a path of motion 'frozen' in front of them tying together the virtual world of recording to the physical world of photography (Figure: 26, 27).

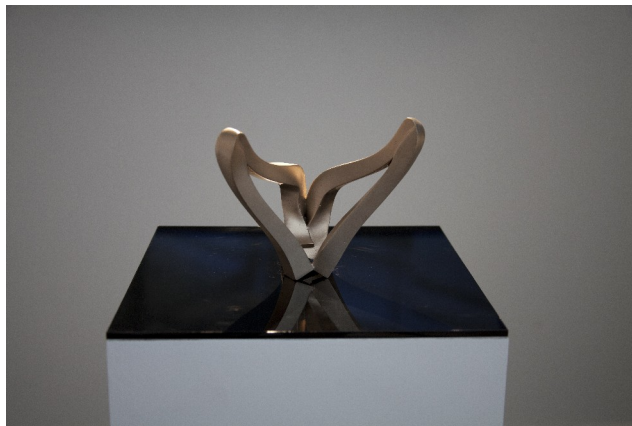


Figure 26: Sculpture of a split kick made by using the algorithm designed for this project.

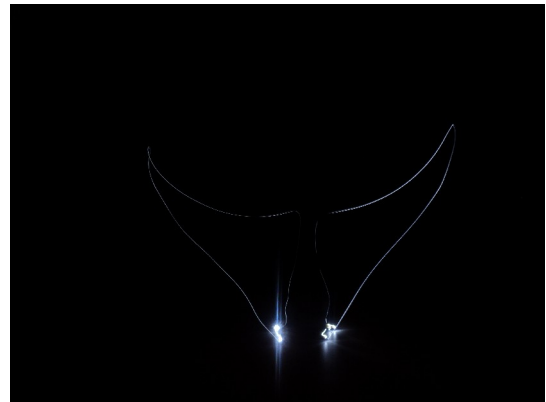


Figure 27: Long exposure photograph of LEDs attached to the feet. This image is the same split kick used in the motion capture session.

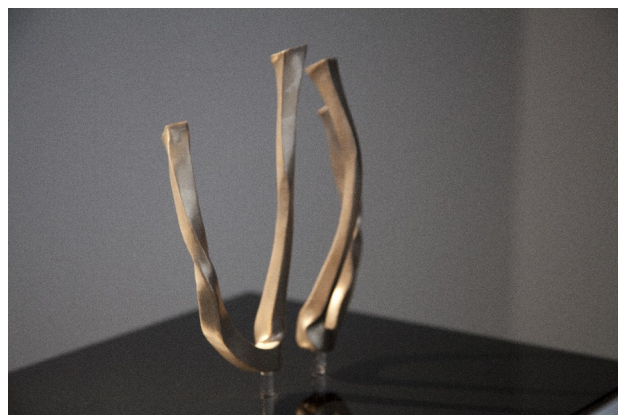


Figure 29: Sculpture of hand tracking during ballet.



Figure 28: Sculpture of feet tracking during Taekwondo kick.

Further Discussion:

In physics and related fields in order to have complete knowledge of a system in motion you must know both the position and velocity of all its components. Even if you know everything about the forces on a body, if you were to take a snapshot of its motion that gave you complete information about its position, without knowledge of its velocity you cannot predict where it will be in the next moment. In an exploration of the difference between a hand movement while it drinks a cup of coffee at a constant speed vs if the hand varies speed, the information of what the motion actually is will be lost when speed is not factored in. The previous work in the long exposure genre does not take into account both path and speed as key factors to display the movement. In classical physics, knowing the path and speed gives you complete information. Looking at a planet orbiting a sun, if just looking at the path, there is no information gained from that knowledge since it is impossible to find out why that path is created. When speed is factored into the equation, it is then possible to see what the cause of the movement is, such as the gravitational pull of the sun causing a change in speed.

By using a phase diagram which is an image representing the position and momentum of a particle, it is possible to understand non-linear differential equations and chaos. By using this type of diagram, these two key factors form a unique shape. This shape then defines the motion of the particle. Since we understand the law of motion for the human body (for example, range of motion and forces muscles exert) if we combine this knowledge with the position and momentum of all of the parts of the body, we can completely characterize the motion.

Bibliography

"Constantin Brancusi Bird in Space." Web log post. *Information World*. Web. 19 Apr. 2011. <<http://worldinformation.blogspot.com/2011/02/constantin-brancusi-bird-in-space.html>>.

"Etienne Jules Marey." Web log post. *Nicholas And Nick*. Web. 19 Apr. 2011. <<http://nickgarrettfeed-noise.blogspot.com/2010/09/etienne-jules-marey.html>>

Étienne-Jules Marey : Movement in Light : Aviation. Rep. Web. 19 Apr. 2011. <<http://www.ctie.monash.edu.au/hargrave/marey.html>>.

Flight Exposure. Photograph. *MoCo Loco - Modern Contemporary Design & Architecture*. Web. 19 Apr. 2011. <<http://mocoloco.com/archives/004455.php>>.

Mathematical Modelling of Animate and Intentional Motion
 Jens Rittscher, Andrew Blake, Anthony Hoogs and Gees Stein
Philosophical Transactions: Biological Sciences
 Vol. 358, No. 1431, Decoding, Imitating and Influencing the Actions of Others: The Mechanisms of Social Interaction (Mar. 29, 2003), pp. 475-490
 (article consists of 16 pages)
 Published by: The Royal Society
 Stable URL: <http://www.jstor.org/stable/3558127>

Marcel Duchamp - Painting - Nude Descending a Staircase No. 2. Photograph. *AMERICAN MUSEUM OF BEAT ART*. Web. 19 Apr. 2011. <<http://www.beatmuseum.org/duchamp/nude2.html>>.

"Peter Jansen." Web log post. *Sheelagh M Dornan*. Web. 19 Apr. 2011. <<http://sheelagh-m-dornan.blogspot.com/2010/05/peter-jansen.html>>.

Shaw, Sandra J. "Lectures by Sandra J. Shaw." Art History 1. *Sculpture by Sandra J. Shaw*. Web. 19 Apr. 2011. <<http://www.sandrashaw.com/AH1L17.htm>>.

Web log post. *2010gc's Blog*. Web. 19 Apr. 2011. <<http://2002gc.wordpress.com/>>.

Zacks, J. M. (2004), Using movement and intentions to understand simple events. *Cognitive Science*, 28: 979–1008. doi: 10.1207/s15516709cog2806_5