

(+/-) Pendulum: Location in the Information Age

Raphael Arar, Ajay Kapur

California Institute of the Arts

raphaelarar@alum.calarts.edu, akapur@calarts.edu

Abstract

The embodiment of physicality amidst digital noise has the potential to artificially harmonize notions of humanity. With society operating both digitally and physically, how do we make sense of an environment that is partially synthetic? (+/-) *Pendulum* operates using the mechanics of the Foucault Pendulum (a mechanism created to demonstrate the Earth's physical properties); however, intangible outlets (a smartphone and web application) inform its location based on participatory user input. Physicality has been not only democratized but thwarted—now malleable to the masses.

Introduction

History is inundated with revolution. Not only politically, socially and economically, but also technologically. Humanity is in constant flux, and as a result, industries develop, advance and adapt to mend to our needs. The Industrial Revolution and the Digital Revolution (or Information Revolution) are two prominent technological movements that have greatly impacted daily life. As a result of advancements and experiments set forth throughout each, the way we operate as humans and the lens in which we view the world has and will continue to change.

The Industrial Revolution served as a pivotal period in the advancement of humanity in its major industrial sectors. Although originating in Britain, it caused a profound domino effect throughout the rest of the world. Its impact paved the way for mass production, lowered cost of goods, urbanization, increased demand for raw materials and trade. These advancements allowed for the Second Industrial Revolution (dated to the latter half of the 19th Century), which brought forth a slew of inventions including the telegraph & Morse code, telephone and light-bulb[1]. The Industrial Revolution propelled technological and scientific experimentation forward in a way that enabled society to think and communicate differently.

Moving forward, the Digital Revolution caused yet another drastic shift. The world now moved from its

traditional manufacturing processes to ones powered by computing and new media. Researchers claim that the current economic climate is one driven by data. Data has even been equated to the “new oil”, since its prevalence can help us refine our information in order to draw valuable conclusions[2].

Although the Industrial Revolution paved the way for the Digital Revolution, when taken out of chronological context, the two can almost be seen as contrary forces—one focused on the development and dissemination of analog technology and its outlets, while the other focused on the scalability of computation. On the other hand, when viewed chronologically, the separation between the two revolutions is far from discrete. This paper seeks to reflect on the malleable intersection of our physical and digital lives by way of the author's installation (+/-) *Pendulum*. By extending upon the basic principles of the Foucault Pendulum (an experiment which concretized the Earth's physical properties), (+/-) *Pendulum* sheds light on the diaphanous divide that currently separates our physical and digital selves.

The Foucault Pendulum

The 19th century presented itself with a series of novel developments in industrialization. Towards the latter half of the century, the Industrial Revolution occurring in Western Europe was beginning to spread globally. The world seemed largely concerned with the design and fabrication of useful industrial machinery and how to improve the physical world. Scientists, theorists and academics focused on uncovering the inner-workings of the world and how its materiality informed technological advancements relevant to the Industrial Revolution.

Around this time, experimental French physicist Jean Bernard Léon Foucault spent much of his career studying worldly materials in relation to celestial bodies. In 1850, he discovered that light travelled faster in air than in water,

which debunked both Newton's and Descartes' corpuscular theory of light. While using a metal lathe to create a conical pendulum for a clock that would keep a telescope focused for long exposures, Foucault accidentally bumped the rod and caused it to vibrate. In the process, the rod maintained its plane of vibration even when rotated. This observation served as the foundation for the Foucault Pendulum, which he created on January 8, 1851 [3]. Foucault successfully vibrated a pendulum two meters in length that maintained position while the floor moved in tandem with the Earth's rotation. The pendulum itself oscillated independently of the Earth's rotation based on the pull of gravity and the tension of its wire.

(+/-) Pendulum: Functional Description

Recent contemporary artwork has exemplified the aesthetic possibilities of manipulating and incorporating preexisting data sets in both digital and post-digital ways. These data-driven works have set a precedent for novel ways to not only manipulate data but also create it in real-time. With mobile computing and robotics, it is now possible to incorporate aspects of content-creation and data in the mechanics of kinetic sculptures and installations driven by participatory smartphone applications. (+/-) *Pendulum* utilizes data to add a collaborative and participatory element to kinetic objects in order to explore dualities ranging from individual/society and analog/digital.

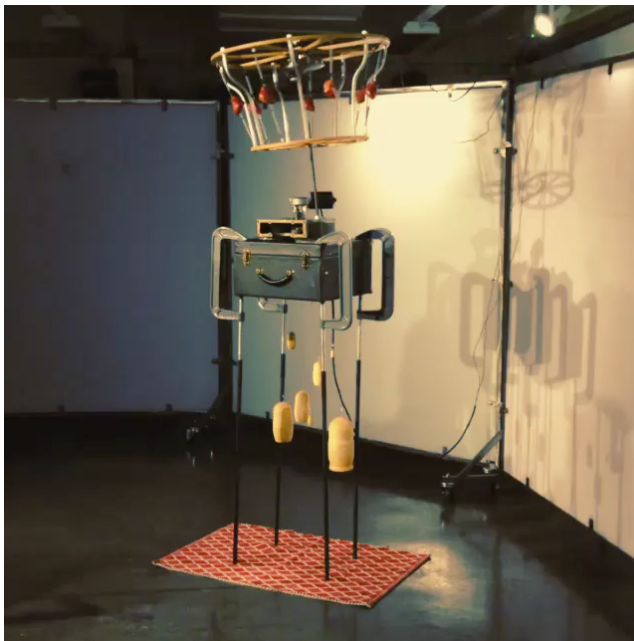


Fig 1. (+/-) *Pendulum*, 2014, Sculpture, Raphael Arar.

(+/-) *Pendulum* is a participatory installation created so that its internal driving mechanism is based on participatory data (Fig. 1). Its intent is to serve as a starting point for the creation and collection of participant data. The work is meant to serve as a microcosm of the intersection of our digital and physical selves. As previously mentioned, the basis of the installation is founded on the mechanics of the Foucault Pendulum. However, unlike a conventional pendulum, the arm of the installation operates horizontally using the same physical properties as if gravity is still impacting it. The conceptual basis of the work is to reflect on the intersection of our digital lives with our physical lives. The Foucault Pendulum was created in the mid-19th Century to exemplify the Earth's physical properties (i.e., the fact that it is round and rotates) [4]. Many may prescribe to the idea that we now live in an era where the Earth's physical properties are of little importance. As a result, the rotation of the (+/-) *Pendulum* is based on participatory user input from a smartphone application, which asks the question "Where do you want to be?" From collective user input, the average of all data points orients the pendulum to a collective desired location, which seeks to show that our world is not flat, round or oblong—it is malleable and democratic in the digital sphere.

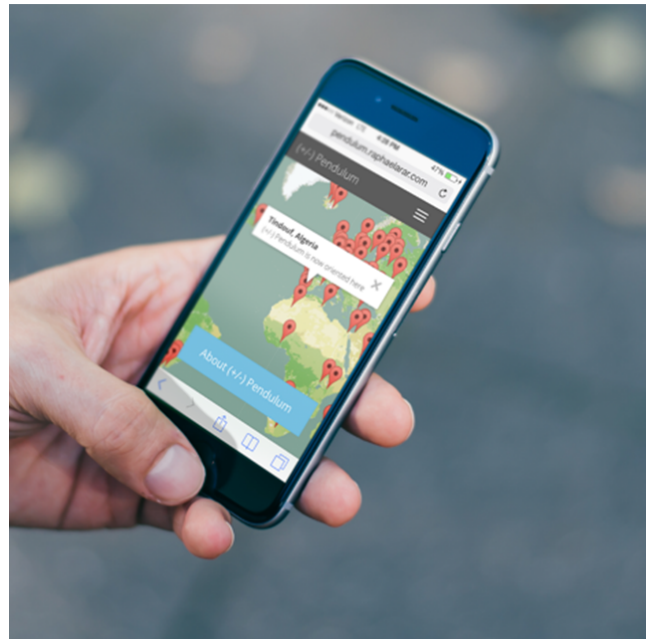


Fig 2. (+/-) *Pendulum*, 2014, Web Interface, Raphael Arar.

The responsive web application (Fig. 2) component provides a minimal user interface prompting the user for a desired location in the world. Upon entry, the user is shown the current physical location and asked for a desired location anywhere in the world. The user experience is

straightforward in that the only option is to submit an entry into the system. After a successful submission, the user is shown not only where the submission lies on a global map, but also the new location of the pendulum, which is collected as a running average of all data points (i.e., latitude and longitude values). The user then has the option to view all collected data points visualized on a map by way of a system that polls a remote web server and runs a query in order to display entries. This screen also provides the user with the ability to understand more of the concept behind the work and its inspiration.

(+/-) *Pendulum* has a two-fold interaction model: the sculptural aspect serves as springboard for content creation from participants, while the digital interface serves as a media container to view and interact with all data points. The sculpture thus serves as a tacit form of interaction, while the web interface is a more explicit dialog with a user. Ultimately, a triangular interaction model arises among the user, physical object and digital interface.

The 21st Century is the era of big data. Undoubtedly, the implications of mass amounts of data affect the daily lives of individuals. Not only does the digital realm provide more choice, but it also increases the amount of information. (+/-) *Pendulum* incorporates data granularly and also allows for its creation by optionally asking users to contribute. In doing so, three themes of heart, harmony and noise weave their way into (+/-) *Pendulum*, as described in the following section.

Thematic Symbolism within (+/-) Pendulum

Various thematic elements pervade the work presented within this paper. Three in particular are recurring: anatomical hearts, harmony and noise. These subthemes act as unifying elements of (+/-) *Pendulum*, each one representing dualities including analog/digital, nostalgia/novelty, physical/metaphysical and self/society.

Heart

The anatomical heart is a symbol imbued with multiple meanings. How does a heart represent humanity and how does this symbol evolve as it relates to aspects of semiotics and people? The author carries the symbolic aspect of the anatomical human heart throughout the piece in order to represent individuals as members of society. The heart, taken out of context of the human body, is mostly seen in medical and entertainment contexts (i.e., horror films and special effects). However, historically the heart has represented a variety of emotions, particularly the duality of both pain and pleasure, especially as it exists in film and literature. In fact, many aphorisms, idioms and phrases

revolve around the heart as an organ that embodies emotion [5]. In (+/-) *Pendulum*, the heart serves as an emblem of an individual, abstracted as part of a larger working system. The metaphor with the heart is more literal, but extends upon the idea that humans are pieces in a greater, moving entity, and that movement is cyclical, largely out of the control of any single person. This is reflected in the collaborative nature of the position of the work. Although many users are contributing independently, their resulting input is being collected and averaged in a democratic fashion.

Harmony

How does inner reflection and spiritualism evolve when technology, particularly computation, demands more of the self? This question is a recurring thematic element of (+/-) *Pendulum* and an integral aspect of the author's thought process. The work at hand explores the duality between ancient and futuristic symbolism and the perceived intersection of the two. With the exponential developments of computation, partially explained by Moore's Law, human beings can now offload more of the mundane, simplistic tasks (e.g., budgeting, planning, etc.) as well as the complex processes (e.g., data analytics, biological tests, forecasting, etc.) to machines. By transferring these processes to machines, humans can theoretically be cleared of tasks that affect stress levels and mood. The question then lies: how does progress affect aspects of inner peace? Are humans more stable or volatile by way of these advancements? The author's interest in these questions relating to intrapersonal interaction serves as a driving mechanism in the creation of (+/-) *Pendulum*.

To be more explicit, the theme harmony manifests itself in the piece sonically as well as figuratively. (+/-) *Pendulum* reflects on harmony in a variety of ways. The significance of the number seven is directly tied to the oscillating Russian nesting dolls, or Matroyshka dolls. In Pagan Russian times, the typical Matroyshka doll set would include seven pieces in order to represent harmony. Since harmony was closely tied to nature, seven was found to be harmonious in natural phenomena and particularly the seven colors of the rainbow. The symbolic ties to seven and harmony appear in other sources as well [6], such as seven days in a week, seven notes in a typical Western music scale (i.e., C-D-E-F-G-A-B) and the Seven Sages of Greece. The historic aspect of the number seven along with its modern day placement within the physical object adds interplay between past and present. The number seven extends further to provide a unifying element to the piece

in its use of seven anatomical hearts that represent time values struck by the pendulum.

Noise

How does communication noise affect humans from both an intrapersonal and interpersonal standpoint? In an article entitled “A Mathematical Theory of Communication” from 1948, Claude Shannon describes the basic elements of communication [7]. First, an information source produces a message. This message is then transmitted to create a signal that is sent through a channel, which in turn, carries the signal over to a receiver. The receiver transforms the signal back into the message intended for delivery to a destination (either a person or a machine). Shannon created a formal concept of a ‘channel’ as one that carries symbols and noise (Figure 3). Both Shannon and Alan Turing point out that the number of symbols must be finite; as they proliferate they become increasingly hard to discriminate, and noise blurs one into another. By dealing with an intermediary device, the opportunity for noise, obfuscation and detachment increases in this model. Whether this form of communication is interpersonal or intrapersonal, the presence of technology presents an interesting shift in our instinctual abilities to communicate—we must now adapt to our devices in order to clearly delineate our messages. The author’s interest in the evolution of Shannon’s original model of communication by way of computational progress exists as a pertinent theme in the conception and execution of the (+/-) *Pendulum*.

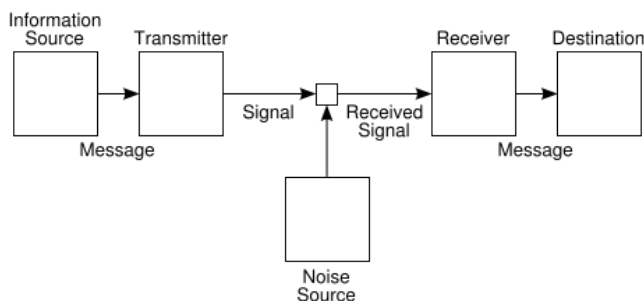


Fig 3. *Shannon's Schematic Diagram of a General Communication System*, Wikipedia.

(+/-) *Pendulum* can be characterized by having a participatory interaction model. Inherent to the work is a systemic feedback loop that occurs between participants and the kinetic object. Input into a responsive web application transmits a signal to a web server, which transmits a signal to a microcontroller that ultimately

drives a physical object. As a result, there are multiple communication streams operating simultaneously with a variety of users. Broken down in Shannon’s Communication Model [7], this signal stream can be directly translated to have multiple opportunities for noise to arise. Since each stream can be seen as a microcosm of technologically oriented societies, noise has the potential to be a more persistent element of daily life.

Art & Design: Counterbalances

On February 3, 1851, Foucault presented his pendulum in the Meridian of the Paris Observatory. Although the rotation of the Earth was no longer in dispute [4], his demonstration served as physical proof of its measurement. As a result, even unscientifically minded individuals were able to comprehend the physical properties of the Earth. Shortly after a public viewing, Foucault designed and implemented a larger demonstration in the Panthéon in Paris with painstaking attention to detail and visible consideration in aesthetic execution. The Panthéon showing sparked deep interest in the pendulum’s operation, and this interest spread globally.

The wonder and awe caused by the experiment served as a catalyst for the popularization of a scientific community interested in the physical sciences as well as an interest in the intersection of the arts and sciences. Astronomer Benjamin A. Gould stressed that the Foucault pendulum was unique among physics experiments and “probably none more beautiful was ever devised; certainly few have ever attracted equal attention from all classes of scientific men and from the public.[8]” One may glean that although Foucault engrossed himself deeply in the sciences, he maintained a clear vision in balancing scientific accuracy with aesthetically-driven execution. Foucault’s pendulum serves as not only the seed from which the concept behind (+/-) *Pendulum* grows, but also Foucault’s Panthéon demonstration serves as inspiration for the author’s artistic process by encompassing a focus on a duality between aesthetic concept and design-thinking execution.

Design Principles within Art

The author’s process in creating (+/-) *Pendulum* employed the incorporation of iterative design principles within an aesthetic process. The participatory nature of the work caused the author to embark on a user-centered design approach. In doing so, various design principles have been considered. Don Norman, a cognitive scientist and engineer, has pioneered many ideas surrounding this

approach. Based on his research that forms the basis of *The Design of Everyday Things*, Norman outlines a handful of relevant design principles [9]:

- Visibility—can a user see the state of a device and its possible actions?
- Feedback—what is the object (tangible or intangible) doing? How does the user know the effect of an action?
- Affordance—what are the perceived and actual properties of the object that give clues to its operation?
- Mapping—what is the relationship to the controls and their effect?
- Consistency—how can objects be designed that are intuitive to the user?

These principles form the basis of Norman's user-centered design methodology. While the most apparent associations with these principles lie in interactive objects, such as interfaces both physical and digital, they can be extended for implicitly interactive objects. Even if a work itself is not interactive, these principles can be employed in the process of creating a fixed and/or non-interactive object.

(+/-) *Pendulum* makes explicit use of Norman's principles in its responsive web application component due to its inherent interactive affordances. The sculptural aspect of the work, however, incorporates these principles but in a more implicit manner. For example, mapping of latitude to the stepper motor may not be explicitly delineated to the user; however, the user may notice a relative change as the average position of the pendulum changes. Additionally, consistency can be seen in the work's motif of the number seven (i.e., seven Russian nesting dolls and seven hearts).

The Artist as Designer

Art and design can be broken down, dissected and analyzed in a variety of ways; however, as these entities pertain to the author's creative process, art and design are unique counterbalances that exist symbiotically in the creation of artistic objects. Art and design are akin to Yin and Yang in Taoism. In Taoist ideology, Yin and Yang are two opposing forces that are thought of to be

complementary [10]. Their symbolism references a sense of balance in the world. From the author's point of view, the duality of art and design serves as a balancing mechanism; the former provides mental fuel for aesthetic questioning, inner reflection and creative thinking, while the latter provides mental fuel to answer the question set forth in the most unobtrusive, concise and intuitive way possible. This process is by no means linear; there is a natural push-pull dynamic between the artistic process and design process. Iteration and fluidity between the two poles are paramount, and the question-and-answer phases are ongoing.

Conclusion: The Evolution of Noise

Machined systems and computation are now vital parts of our daily lives. Many of us cannot live without some form of technology—from transportation to social interaction, complex systems are the clocks that keep the world moving forward. Many of us are also unaware of the remarkable growth rate of our global footprint. (+/-) *Pendulum* represents the author's reflection on the ways progress has affected daily life by interweaving our physical and digital lives.

The work also reflects on notions of interaction. Inherent in design, interaction fundamentally connects individuals to individuals and/or individuals to themselves. Undoubtedly, technological developments have altered the way in which we communicate with others and ourselves. This work serves to reflect upon these rapid changes by synthesizing various dualities, the most apparent one being analog and digital. In order to do so, the author has expressed these changes by incorporating symbols and themes such as hearts, harmony and noise within the work. Furthermore, the piece serves as a reflection on technology's ability to incorporate greater complexity from user input and the opportunity for more participatory interaction models within technological art. Although the work relies heavily on technological mechanisms including computation and embedded electronics, the medium is not the primary message. On the contrary, the medium serves as a lens to magnify and exaggerate the drastic, ongoing evolution by shedding an ambiguous light on technology's ramifications.

By taking a Yin/Yang approach to the idea of analog/digital, individual/society and life/death, (+/-) *Pendulum* seeks to reflect on the implied balance that must exist in order for harmony to exist in a system often littered with noise. Society at large can be thought of as a well-

oiled machine propelled forward by a collection of individuals. In this piece, anatomical hearts serve as a symbolic reference to an individual as part of a larger entity, while the system in its participatory manifestation, reflects on the interplay between harmony and noise that result from a number of moving parts.

Adaptation and assimilation are remarkable characteristics in human beings. Technology has provided incredible opportunities—new developments are constantly emerging that allow us to not only expand our human reach but also simplify our lives. Industrial progress has enabled society to improve machinery enabling more complex technological developments. However, despite these perceived improvements, the nature of humanity is complex, and the social characteristics of an individual are difficult to overlook. How will the exponential momentum of technological progress ultimately affect the world? As the world churns forward with its new developments, more devices impede our mental and social signal flow resulting in more opportunities for noise to arise in our microcosmic and macrocosmic systems. While prophesizing about the evolution of communication is a complicated feat, the future of interaction is changing drastically and the potential to lose sight of physicality may be on the horizon.

References

- [1] M. R. Levin, *Urban modernity cultural innovation in the Second Industrial Revolution*. Cambridge, Mass.: MIT Press, 2010.
- [2] V. Mayer-Schönberger and K. Cukier, *Big Data: A Revolution That Will Transform How We Live, Work, and Think*, Reprint edition. Boston: Eamon Dolan/Mariner Books, 2014.
- [3] W. Tobin, *The Life and Science of Léon Foucault: The Man who Proved the Earth Rotates*. Cambridge, U.K. ; New York: Cambridge University Press, 2003.
- [4] A. D. Aczel, *Pendulum: Léon Foucault and the triumph of science*. New York: Atria Books, 2003.
- [5] H. A. Williams, “Heartfelt sympathies,” *New Statesman*, p. 43, 1999.
- [6] “The Secret Doctrine: The Synthesis of Science, Religion, and Philosophy. 2 vols. By H. P. BLAVATSKY. New York, William Q. Judge. 8Dagger,” *Sci. Sci.*, vol. ns-13, no. 313, pp. 89–90, 1889.
- [7] C. E. Shannon and W. Weaver, *The mathematical theory of communication*. Urbana: University of Illinois Press, 1949.
- [8] M. F. Conlin, “ARTICLES - The Popular and Scientific Reception of the Foucault Pendulum in the United States,” *Isis.*, vol. 90, no. 2, p. 181, 1999.
- [9] D. Norman, *The Design of Everyday Things: Revised and Expanded Edition*, Revised Edition edition. New York, New York: Basic Books, 2013.
- [10] A. Watts and A. C. Huang, *Tao: the watercourse way*. New York: Pantheon Books, 1975.