PARTICIPATORY DATA-DRIVEN ART OBJECTS: VESSELS FOR KINETIC INFORMATION

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The ubiquity of data has spawned the emergence of many forms of data-driven artwork ranging from digital to physical pieces and their perceived intersection. This paper presents novel techniques for interaction design, aesthetics and technical implementation in the creation of participatory data-driven art objects. A subset of data-driven artwork is discussed, which covers data visualization art and data objects, both interactive and fixed, in order to place the authors' work in context.

1.INTRODUCTION

The arrival of the information age caused an evident shift in the industrial sector: the world moved from traditional industry and its textbook manufacturing processes to one characterized by computerization and new media. As computers increase in processing power and storage grows exponentially, this revolution brought forth the rise of data in masses (Compaine and Read 1999). Coupled with the growth of multisensory technology and mobile computing, the presence of mass amounts of information is ubiquitous and can now fit comfortably in our pockets.

"Big Data" has been a buzzword rampant among the tech industry sector since the early 21st century. In 2006, market researcher Clive Humbly declared data as "the new oil".[1] By oil, Clive refers to the notion that untapped data is crude and practically useless – it must be refined and broken down in a way that it provides value. The business world has been quick to capitalize on data in its various sources. Marketers in particular have outlined ways in which to make data more valuable: by understanding that data is not insight and that in order for data to mean something it must be placed in context. By placing data in context, one can begin to make sense of the information, and the conclusions drawn become valuable (Mayer-Schönberger and Cukier 2013).

The implications of the information age have been paramount throughout every sector, and these mass amounts of data permeate our lives on a daily basis: from flight arrivals/departures to stock prices to social network news feeds. As of an IBM study conducted in 2012, we create approximately 2.5 quintillion bytes of data daily[2] – this number only continues to rise. As a collective, humanity produces five zettabytes of data a year (Aiden and Michel 2013). While the ways in which data can be utilized from an economic standpoint have been apparent from this digital revolution, other sectors, including art, are beginning to utilize data streams in unique ways in order to ask questions about the world we live in.

In this paper, the authors discuss multiple techniques for data-driven art objects including installations and sculptures. Section two discusses related work including both digital and physical pieces. Section three discusses two participatory data-driven installations that incorporate novel data creation techniques and their applications

1 *http://ana.blogs.com/maes-tros/2006/11/data_is_the_new.html*

2 *http://www.ibmbigdatahub.com/*

in data-driven kinetic work. Lastly, section four discusses the interaction model, affordances and drawbacks as well as future applications of data-driven art.

2. RELATED WORK

The presence of large data sets in art is not a novelty ("Data-Driven Aesthetics" 2014). In fact, data has manifested itself in unique ways across various sects in the media arts realm. The most evident outlet for data-driven art can be seen through digital image work and digital art in the form of data visualizations. However, in recent years, artists are beginning to interpret data in more physical ways, as both interactive and fixed data objects, which seek to provide a more tangible representation of information at large.

2.1. DATA VISUALIZATION ART

In late 2012, the Beall Center for Art and Technology at the University of California Irvine exhibited many works utilizing information visualization techniques that caused viewers to reflect on these mass amounts of information.[3] Various artists were featured including artist duo Fernanda Viégas and Martin Wattenberg and their work *Wind Map (Cook 2013).*

Fig.1 Wind Map
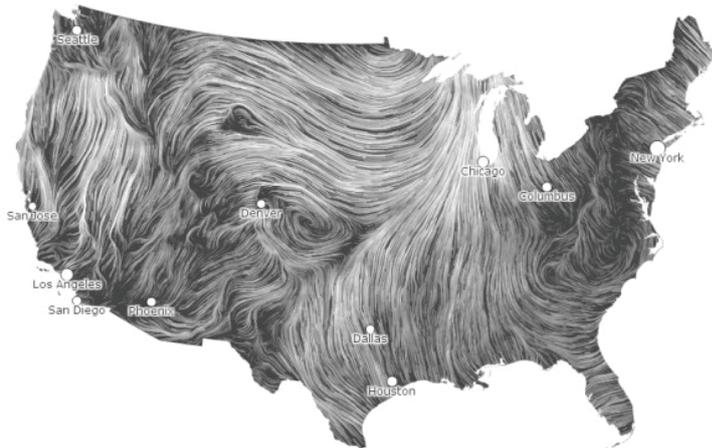
Wind Map, an online application created by Viégas and Wattenberg in 2012 illustrates the course of the winds moving across the United States (Figure 1. Wind Map). The wind surface data utilized in the work is captured hourly

3 *http://beallcenter.uci.edu/exhibitions/dataviz-information-art*

from the National Digital Forecast Database.[4] A programmatic intricate weaving of shaded lines of varying transparencies adds a painterly feel to the work enabling a visual analogy between the physical feeling of wind blowing and its digital representation.

Other artists are using data to extend predefined visualization tactics that have developed as the cross-section between programming and art continues to solidify. For example, artists and researchers Andres Wanner and Ruth Beer have coined a Found Data approach in their installation *Breathe/Live/Speak* (Figure 2. Breathe/Live/Speak) that takes two aspects of computational art: generative art and data visualization, and conceptually intermingles them with found objects stemming from the Post-Modern Readymade. Wanner and Beer borrow the "autonomous generative process from generative art, and the emphasis on representation of abstract data from data visualization." By visualizing the data in conventional graphing ways, the artists began to find patterns that could be considered "natural looking", which they then manipulated to effect (Wanner and Beer 2013).

Fig. 2 Breathe/Live/Speak

2.2. DATA OBJECTS

While data visualization artwork may be the most common example of the interplay between data and art, many artists have begun incorporating large data sets in the creation of objects. Sculpture in particular is an area where many artists have begun to incorporate data as the core of the work.

In *She's Coming On, She's Coming On Strong*, artist Nathalie Miebach uses weather data from off-shore buoys all along the Eastern Seaboard to create a musical score in the form of a sculpture, in order to interpret "the Perfect Storm" (Figure 3. She's Coming On, She's Coming

Fig. 3 She's Coming On, She's Coming On Strong

4 *http://ndfd.weather.gov/technical. htm*
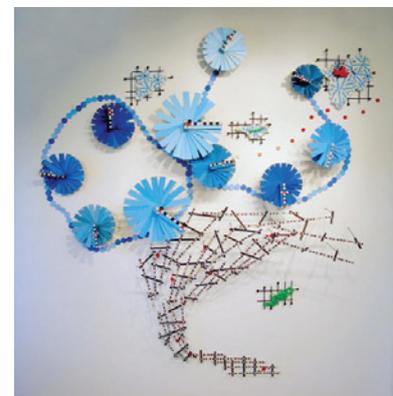
On Strong). Miebach uses data as a starting point in order to construct musical scores, which are then translated to sculptures (Hansell 2013).

Other researchers are directly translating data visualizations from digital outlets to their physical manifestations in the form of sculpture. Yvonne Jansen and Pierre Dragicevic outline an interaction model for beyond-desktop visualizations that combine the visualization reference model with the instrumental interaction paradigm (Jansen and Dragicevic 2013). As a result, the researchers are able to collect large data and visualize them by way of physical objects that can be interacted with. For example, the *Emoto Data Sculpture* utilizes data in the form of Twitter sentiments that have collected during the 2012 Olympic Games (Figure 4, *Emoto Data Sculpture*). Two visualizations serve to represent this data: a 3D surface that displays time-series data through one-shot propagation, and another where a subset of the data corresponding to a particular theme is encoded as a heat map and projected on the 3D surface. Visitors can explore this data using a jog wheel instrument located nearby, which moves a time cursor and displays detailed Tweet information below the sculpture (Sánchez 2013).

Fig. 4 Emoto Data Sculpture
Fig. 5 airFIELD

airFIELD, created by Dan Goods, Nik Hafermaas, Jamie Barlow and NASA' Jet Propulsion Lab, is yet another example of a data-driven installation (Figure 5, airFIELD). Similar to the *Emoto Data Sculpture*, the work aggregates and displays individual datum based on flight data. The data is provided by the FlightAware tracking service[5] through a custom C++ application. However, according to Goods, the work is not as much about visualizing a large data set, but using the data in a poetic fashion.[6]

5 *http://flightaware.com/*

6 *http://www.wired.com/design/2012/11/atlanta-airfield-sculpture/#slideid-352091*

As a result, data is used as a starting place to create a physical manifestation of ambient data in a multisensory and experiential manner.

The data-driven artwork presented in this section is by no means an exhaustive list. However, the works presented in this section have served as inspiration for the authors' current work and exploration in participatory data-driven kinetic sculptures and installations. In the following section, the author discuss an approach for participatory data-driven art that builds off the work discussed but incorporates novel aspects pertaining to user experience and interaction design, aesthetics in both the physical and digital realms as well as computation and technical implementation involving the intersection of smartphone applications, web technology and embedded electronics.

3. PARTICIPATORY DATA-DRIVEN ART OBJECTS

The aforementioned works exemplify the aesthetic possibilities of manipulating and incorporating pre-existing 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. Two works in particular, *Metal Hearts* and the *(+/-) Pendulum*, utilize data in order to add a collaborative and participatory element to kinetic objects.

3.1. METAL HEARTS

Metal Hearts consists of three nearly identical objects; in each, a bare solenoid strikes an aluminum-coated 3D-printed model of a human heart (Figure 6. Metal Hearts Installation & Smartphone Interface). A fundamental biological human process has now been automated by an electrical circuit serving as a reflection on human autonomy in light of technological progress. Collectively, the hearts beat in harmonic motion to delineate a mechanization of individuality.

The installation's driving mechanism is based on participatory data. Its intent is to serve as a starting point for the creation and collection of participant data.

Participants are able to download and install a smartphone application that captures heart rate and stores it in a database. The master clock of the installation defaults to an average pulse of 72bpm. With each new addition, the average of all heart rates collected over time is distributed to the installation, which adjusts the phasing and computational diastoles of all hearts. Every five minutes, the database is queried and a new average is collected.

**Fig. 6** Metal Hearts Installation & Smartphone Interface
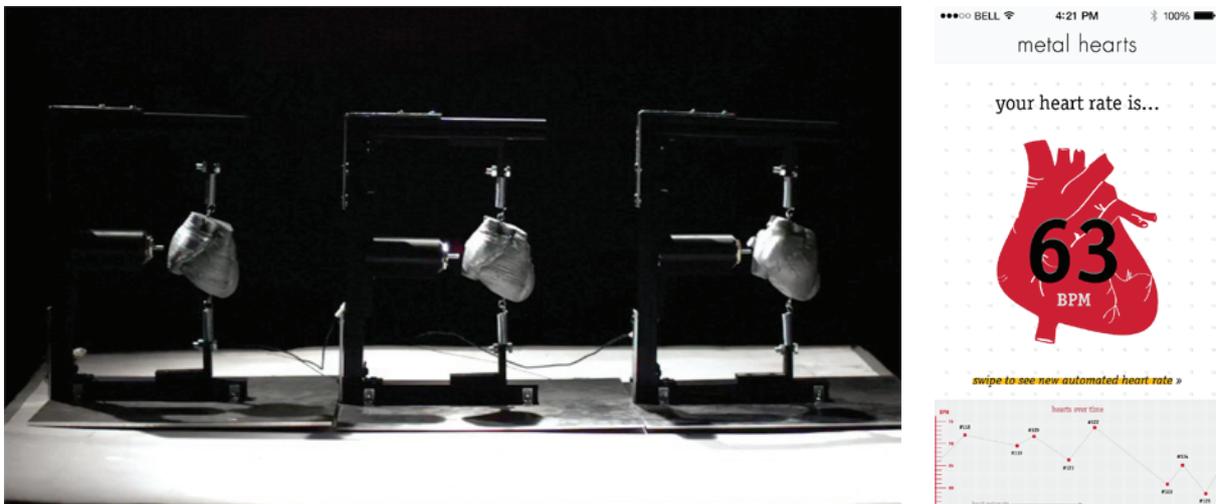
Although the physical manifestation of this aggregate data is not seen at large since only the average is computed and experienced, the smartphone application contains a data visualization of all heart rates collected over time. On the one hand, data is used for purely aesthetic reasons in the sculptural aspect of the work; it is a starting point intended to pique curiosity in the participant. On the other hand, participants have the opportunity to interact with all of the data collected over time in the smartphone application.

3.2. (+/−) PENDULUM

(+/−) Pendulum is another participatory installation (Figure 7. (+/−) Pendulum Materials) created in the same data-driven vain as *Metal Hearts*. The work is meant to serve as a microcosm of the intersection of our digital and physical selves. The basis of the installation is founded on the mechanics of the Foucault Pendulum. 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) (Aczel 2003). 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 operation of the *(+/-) Pendulum's* rotation 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. 7 (+/-) Pendulum Materials
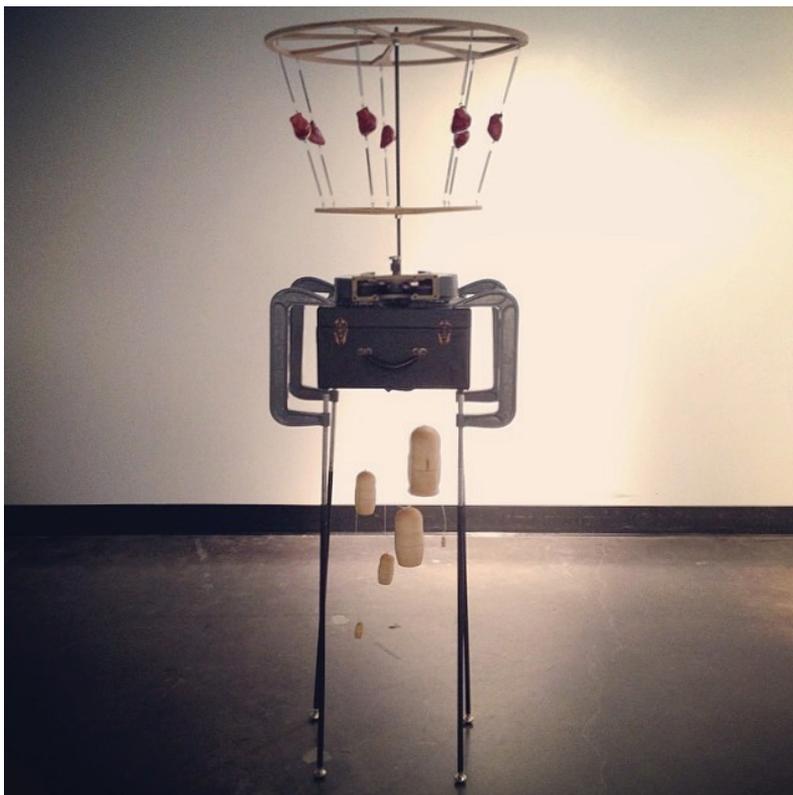
The smartphone application component provides a minimal user interface prompting the user for a desired location in the world. After a successful submission, the user is shown the new location of the pendulum, which is collected as running average of all data points in the

system. The user then has the option to view all collected data points visualized on a map. Similar to *Metal Hearts*, the *(+/-) Pendulum* has the same two-fold approach: 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 (Figure 8, (+/-) Pendulum Paper Model and Smartphone Interface).

4. CONCLUSION

Data sets that emerge from questions (whether direct or indirect) generated from artwork have the opportunity to generate unique information by a subset of the population (i.e., art communities) that may not necessarily be grouped together. One potential benefit of this approach is that it allows for participatory artwork as opposed to interactive artwork, which requires participation. As a result, this approach may appeal to a wide variety of users: those who are interested in gleaning more from the participant data and those who may only be interested in experiencing a seemingly fixed kinetic work. Despite these potential benefits, there may be drawbacks inherent with this approach, which were particularly evident in the initial prototypes of *Metal Hearts* and the *(+/-) Pendulum*. While collecting numerical data and calculating the mean may prove interesting for a smaller, more varied data set, as the data set grows and becomes more diverse, the mean remains relatively static. From a mechanical and robotic standpoint, this approach simplifies development; however, the lack of variance in relation to a growing data set highlights issues pertaining to scale. As a result, the aforementioned works will incorporate variants of weighted moving averages, particularly the exponential weighted moving average (Figure 9, Exponential Weighted Moving Average, where the coefficient α represents the degree of weighting decrease (between 0 and 1), Y_t is the value at time period t and S_t is the value of the average at any time period t.), in order to filter out the data, which may be one approach to reestablish variance in the system.

Fig. 9 Exponential Weighted Moving Average, where the coefficient α represents the degree of weighting decrease (between 0 and 1), Y_t is the value at time period t and S_t is the value of the average at any time period t.

$$t > 1, S_t = \alpha \bullet Y_{t-1} + (1 - \alpha) \bullet S_{t-1}$$

As the amount of data in the world continues to explode, governments, businesses and society at large will continue to try to harness, cultivate and utilize it to devise solutions to increasingly complex problems. Many artists, on the other hand, have been using data in ways to ask questions about the mass amount of information in the world (Hirshberg 2013) in order to try and make sense of the value versus noise. Data-driven art is here to stay. The 21st century has witnessed an emergence of art that exploits the massive data sets we create on a daily basis, and artists can now be making work that not only questions data but also creates it, especially as it relates to the institutions that house works of art (i.e., museums, galleries, etc.), in order to shed light on art communities in addition to the world at large.

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