Topics on Aesthetic Data Visualization: Viewpoints, Interpretation, and Alternative Senses

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Abstract

Aesthetic data visualization, which looks at complex data sets from an ingenious perspective, is difficult to empirically organize due to its insufficient records. Fortunately, insightful artists and curators have recently provided some notable interdisciplinary exhibitions and publications. This author was a recent participant at such an event; however, it is not easy to summarize the various projects into a single vision because each artist's value, method, philosophy, and aesthetic preference are unique. This paper categorizes data visualization based on various topics. Aesthetic data visualization is similar to conventional data visualization in that it organizes ambiguous data into a database. Artists then tend to integrate the information into their art. In this regard, it might be possible to identify tendencies and examine data as contemporary iconology, as well as discover hidden possibilities of recent aesthetic data visualizations.

1 Introduction

Data visualization was initiated for the practical purpose of delivering information and to clearly provide information. It was established using various principles such as accurate quantitative representation and concise graphical elements, resolving the complexity of data through its simplicity of design. One of the most basic examples of data visualization is a stock market time-series line graph in a daily newspaper. The graph easily and efficiently links visual perception and data so that readers are able to instantly recognize patterns in overcrowded data. These traditional data visualization methodologies face significant changes due to the invention of computational devices that handle large volumes of data and use procedural operations.
Procedural simplicity, easily defined according to logical principles, has enabled computers to provide major solutions for data mining, classification, visualization and interaction. In fact, many recent data analyses relied on advanced computing power, surpassing the thresholds of data size and complexity. This pushes the limits for aesthetic data visualization, as well as for practical and scientific data visualization.

Aesthetic data visualization aims to converge the two main, independent objectives of practical application and artistic expression. By diminishing practical functionality - or at least not setting it as a primary goal - the burden of obligation was weakened, and artists were able to implement limitless creativity into data visualizations using aesthetic noise. This equivocality lends diversity to aesthetic data visualization, resulting in multiple viewpoints, allowing for various interpretations, and shifting and developing innovative sensoria. In this paper, we explore the various topics of aesthetic data visualization.

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1. 1 What is the Aesthetic Data Visualization?

'Aesthetic' is not a neutral word. The few Information visualization researchers have struggled to define artistic data visualization with aesthetic value, which has ambiguous scope. This term not only focuses on art work but also philosophical practices such as conceptual interpretation, argument of beauty or iconography of symbols. The conventional goal of information visualization -effective information delivery- is shifted to artistic expression in this practice, and eventually leads to old philosophical questions, 'what is art?' and 'what is beauty?' To define aesthetic data visualization we have to review artistic data visualization as a focus of information visualization. Artistic visualization has been defined with subtle differences according to which viewpoint a theorist adopts.

Zachary Pousman *et al.* categorized visualizations into three unique groups: ambient infovis- that which sits in peripheral locations and provides abstract depictions of data that can qualify under the broadest definition of infovis; social infovis - social information that surrounds us and takes forms that lend themselves to being visualized; and artistic infovis - displaying data and transforming it into visual representations, some of which are interactive. Artistic visualization is defined as data-driven art in the paper, which could easily overlap significantly with of other categories.

Robert Kosara defined artistic visualization with three major factors, use of data, production of an image, and having readable and recognizable results. Some artistic visualization examples such as abstract paintings inspired by data do not quite suit this definition due to their free and non-practical production goals. Kosara pointed out visual efficiency does not play a role in artistic visualization, and that the goal is not to enable the user to read the data, but to understand the basic concern. He also suggested that with artistic visualization we can build new things that are much larger and richer than the sums of their parts, which has been one of traditional topics of metaphysical philosophy since Aristotle.

Fernanda B. Viégas and Martin Wattenberg suggested a loose scope for artistic visualization including data-referenced artwork for gallery exhibitions. Under this concept, artistic visualization is obviously different from conventional information visualization, because without understanding an artists' purpose, the artworks are hardly readable. He stated that defining what constitutes 'artistic' visualization is hard, if only because defining art itself is hard.

These studies commonly described that the scope of artistic visualization is on the edge of information visualization. Considering the tendency of art to deviate from a determined

system, artistic visualization gradually tampers and expands on some of the conventional terminology in information visualization. This phenomenon has been frequently witnessed in art history as a form of synthesis between sense and sensibility. This kind of juxtaposition of argument and counter-argument leads to synoptic vision. As analogy, if we consider whole visualization study by this argument, we could arrive at a similar conclusion.

One historical path, one of rational structure, presents Cezanne, Seurat, and various artists of Cubism, who adopted systematic painting. The other path, one of chaotic emotion, presents Gaugin, Kandinsky and various artists in Fauvisme that rely on natural sensibility. We equate conventional information visualization, a systematic process with a clear goal, as the first path; and artistic visualization, which is more intuitive, as the second. (Table 1)

Table 1: *Two paths in art-philosophy history and the analogy of visualization*

Information/Data Visualization	Artistic Data Visualization
Refined Metadata	Noisy
Cezanne, Seurat	Gaugin
Cubism	Abstract Expressionism
Constructivist movement	Surrealism
Intellectual	Intuitional
Structural	Emotional
Architectonic	Organic/ Biomorphic
Geometrical	Curvilinear
Rectilinear	Decorative
Rigorousness	Romantic
Logical reckoning	Mystified, instant, illogicality
Apollo – formal control	Dionysos - basic impulse
Pythagoras - Descartes	Plotinos – Rousseau

The reason some artists and theorists begin to use the term 'aesthetic data visualization' is to cover wide scope of the concept and its philosophical thesis. This new perspective is not fixed on visualized results but to the entire ideology of visualization, including reading or appreciation study, which can be thought of as data iconology.

Historically, some great discoveries have come by accident or as the byproduct of experiments. These artistic visualizations and aesthetic interpretations seem less practical, but considering its experimental nature, it has potential to invent new expressions and analysis methods that address problems that cannot be solved with current visualization techniques. In this paper, we categorize the experiments into three topics based on recent movements of artistic visualization. Additionally, in order to encompass the scope of philosophical theses regarding art as well as the artworks themselves, we use the term 'aesthetic data visualization' in this paper.

2 Topic 1: Viewpoints

2. 1 Different perspectives of a subject

Even with modern technology, it is not easy to accurately predict weather phenomena. Considering the data size – as accuracy is correlated with data sampling - it is no wonder that weather forecasting has become one of the most challenging users of the supercomputer market. Analyzing large amounts of data is a difficult task; however, presenting core information to the public is a far greater challenge. Therefore, researchers in this field have adopted various graphic representations based on human visual perception abilities to organize information for intuitive interpretation, such as contour lines, time-space graphs, color metrics and multi-dimensional mapping to represent atmospheric pressure, annual precipitation, temperature and complex weather conditions.

In 2005, Hurricane Katrina hit New Orleans, causing tremendous damage. After Hurricane Katrina swept across the southern United States, two data visualization projects were shown to the public. One of those was 'Katrina Project: NO-LA'(http://artsci.ucla.edu/katrina/)(Fig. 1, Left), led by Victoria Vesna and interdisciplinary convergence researchers at UCLA. They gathered interviews, voice records, photographs and stories relating to Hurricane Katrina, not to produce an objective data set of the disaster, but to appeal to human emotions. Conversely, 'MSNBC Hurricane Tracker'(http://www.msnbc.msn.com/id/26295161/)(Fig. 1, Right), was a visualization system designed for the practical purpose of forecasting paths and providing detailed information of hurricanes using an interactive web site.

Figure 1: *(left) Katrina Project: NO_LA; (c) 2006 Victoria Vesna et al., (right) MSNBC Hurricane Tracker; (c) 2009 Michal Migurski*

Although both projects were inspired by the same subject - hurricanes – they had different focuses. One concentrated on human emotions, and the other presented an objective observation of a natural phenomenon. Thus, the motives behind the data visualizations resulted in distinctly divergent results. Different motives determine which elements are selected for focus, which in turn directs the information used and the narrative itself.

Only a small portion of data is logically perceivable. This implies that visualization of data is not deterministic but is entirely dependent on the influence of the user, including data selection, implementation, and interpretation. In quantitative data visualization, the disciplines of statistics and design are engaged, utilizing numbers and graphics, respectively, to determine the proper perspective through which to reveal the attributes of choice. In aesthetic data visualization, an artist performs multiple roles as, a statistician, a designer, and an interpreter.

2. 2 Different perspectives of the same data source

Even though many artists focus on the same subject, each result is unique. Evidence of this variety is easily identified in conventional art and also has an influence on aesthetic data visualization. Furthermore, because an artist defines his/her own meta-data - data describing data - the artist's viewpoint is even more important, producing various visual results not only for the

same subject, but for the same data. Each artist may have a different perception of data visualization. By altering the original goal of data visualization, efficient information delivery, artists move toward the extraction of a nested message and inspiration for their artwork.

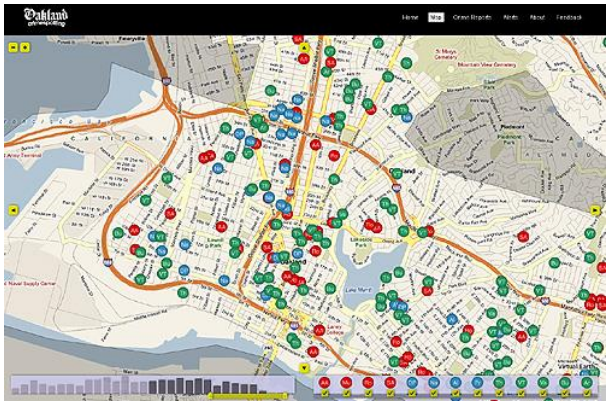

Figure 2: *Oakland Crimespotting; (c) Michal Migurski, Tom Carden, and Eric Rodenbeck*

'Oakland Crimespotting'(http://oakland.crimespotting.org/)(Fig. 2) is a practical example of data visualization. This tool was designed to report the cumulative incidences of crimes associated with a particular location. Viewers can visualize crime concentration in terms of types of crime common to specific regions using a single image provided interactively on a web site; for example, a reader can identify crime patterns, such as luxury car thefts in the richer residences or prostitution in the red-light district. The identification of crime patterns provides a viewer with virtual compartmentalization in space and time.

Another visualization using crime data, but with a completely different aesthetic perspective, is 'Out of Statistics: Beyond Legal'(Fig. 3). Unlike the preceding example, this tool generates a unique image pattern which corresponds to each state in the United States, showing the rates and tendencies of specific crimes. This crime data is used as a source of abstraction, and the image created is aimed at producing an aesthetical visualization of data, rather than practical efficiency for delivering information.

Figure 3: *Out of Statistics: Beyond Legal, 'Connecticut' and 'New York' versions of visualization of 52 digital prints on rice paper; (c) 2009 Rebecca Ruige Xu and Sean Hongsheng Zhai. Reproduced with permission of the copyright holder.*

Rebecca Ruige Xu and Sean Hongsheng Zhai stated that 'Even based on the same data, different designs of drawing strokes and/or different mapping relations to the crime types may produce dramatically different outcome, thus alter the viewer's perception of the information'. In terms of usability, 'Out of Statistics: Beyond Legal' does not provide clear information; however its ambiguity sometimes successfully and subtly implies the cause of an anomaly – the essence of the data. There is no single correct answer for multiformity, which is the nature of analytical reasoning, and it is better to be approximately right than exactly wrong.

3 Topic 2: Interpretation

3. 1 Conventional art as a data source

E. H. Gombrich said that there is no innocent eye. Data visualization is also vulnerable to individual perceptions and preferences, and the impact is more dramatic because every step of the visualization is transparent - the process is defined clearly with procedural steps. This transparency allows data visualization to reflect the philosophical process of 'world making'. From the perspective of data visualization, a traditional landscape painting can be described as the graphical interpretation of visual input data by a single artist or as the data materialization process mined by the sensorium of the artist. Thus, data visualization and traditional paintings are not so different in terms of their construction processes, although the materialization methods are dissimilar. The aesthetic data visualization process is, however, affected by the artist's intentions and experiences, which are naturally inscribed on the results. The first step in the design of a painting schema is determination of the subject. The importance of the step is still truth when the subject is not a landscape but a painting of landscape; subject as an artwork.

'Synchronous Objects for One Flat Thing, Reproduced' (Fig. 4) used unconventional data - conventional art - for visualization. This project extracted the pure elements of an already completed and proven art form - dance - and converted it into another unique and abstract visual-based mixed art that stimulates multiple sensoria. In this process, the aesthetic quality of the results is irrelevant to the original art work because the visualization used only selective cores of the source art form. Interestingly, this extraction process possibly enhanced the essence of the source artwork by emphasizing the motion and rhythm in dance.

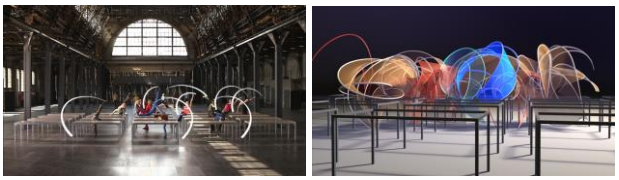

Figure 4: *Synchronous Objects for One Flat Thing, Reproduced; form flow (left) and 3D alignment forms (right); (c) 2007 Maria Palazzi (Ohio State University). Reproduced with permission of the copyright holder.*

In computer science, there are numerous examples of complex human movements that have been converted to numerical data using computation technologies; e.g., motion capture in dance, HCI (human computer interface) research regarding gestures, and a combination of visual data for the performing arts. Choreography is a very complex, time-based art, and it is impossible to exactly reproduce a performance, even with detailed video recording. In this regard, while engineers try to preserve and represent artistic movements, choreographers experiment with innovative time-based art. As a result, many remarkable pieces have resulted through recent collaborations between scientists and choreographers. By refining motion data

and removing noise from the dancers, the only properties left are the fundamental elements of rhythm and dynamics. The source data - dance - and target visualization share a homogeneous core structure; however, each possesses they own form of expression.

Figure 5: *'Poetry on the Road' theme images 2006 (left), 2010 (right); The images are generated by a computer program that converts text into an image; (c) 2006, 2010 Boris Müller. Reproduced with permission of the copyright holder.*

Similar attempts have been used for other genres of art. Boris Müller's 'Poetry on the Road' (Fig. 5) is an example of visual poetry, which has been presented as a visual theme of a showcase in international literature event held annually in Bremen, Germany since 2002. This type of work can be classified as a textual visualization. Using poetry as the data, the selected pure elements of the original text are rhythm, alliteration and rhyme. The results of the visualization are not another poem but a creative abstract visual art work.

3. 2 Narratives on data

In the practice of data visualization, many artists depend on the development of powerful personal computational devices and intuitive programming tools. In addition, the infinite data available to the public via the Internet must also be credited. Without enhanced Internet speeds and data proliferation, it would be much more difficult to collect or classify data on a specific subject. For example, rather than a simple collection of pictures about a certain topic, it is now possible to attain detailed information with embedded data, including location, recording date, and reference links (e.g. Flikr; www.flickr.com). Rather than short conversational texts, it is possible to retrieve complex social information which can be used to illicit social capital on websites such as Facebook (www.facebook.com). These new environments motivate the development of adventurous interdisciplinary artists who began to experiment, not only to reveal underlying information in unorganized data, but also to suggest a visual expression inspired by the incomprehensible data. Its divergent goals testify to the strength of aesthetic data visualization, and its metaphorical ability to convert a hypothesis into multiple opinions; e.g. individual aesthetic ranking and abstract patterns.

A recent study by Lev Manovich, 'Cultural Analytics,' reflects diverse perspectives on a vast amount of cultural data. In collaboration with his implementation team, Manovich attempted to identify patterned flows in the accumulated data of cultural events. One of his experiments, 'Content and communication strategies in 4535 covers of Time magazine'(Fig. 6) generated an image composed of the chronological listing of the covers of 'Time magazine.' Its goal was not aesthetic completeness or direct intuitive information transfer but to expose a hidden narrative in the historical records. From the covers of the Time magazines, he successfully extracted intriguing stories on social and cultural transformation, such as world wars, racism and discrimination. From the de-saturated successive cover pages used in certain periods, he noted a lack of material due to world wars and perceived increases in racial equality from the increasing color variation.

The methodologies of Manovich's visualization - data mining, meta-data design and visualization styles - may be not the most ingenious. Nonetheless, focusing on his interpretations and commentaries from a cultural historian's viewpoint, the project becomes an interesting excavation. He excellently recites heroic, tragic, fairy, moral, and romantic tales from arid data, giving not a single answer but various suggestions. Combined with his publication, viewers can fully understand the visualization and appreciate the true value of the data.

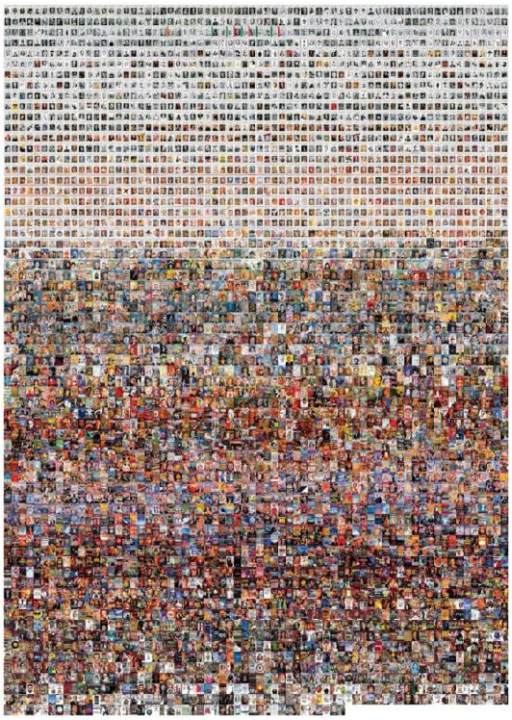

Figure 6: *'Mapping time' with the covers of every issue of Time magazine published from 1923 to summer 2009, total number of covers: 4535; (c) 2010 Lev Manovich. Reproduced with permission of the copyright holder*

The 'Visual Genealogy' project(Fig. 7) is a graphical representation of 'Jokbo' - a Korean family book - composed using the information visualization algorithm. Each Korean sharing a same last name also shares the same 'Jokbo' that sometimes contains more than one million names in a single book spanning more than 500 years. Although the large historical record of a family is a valuable and unique database, the names do not provide history nor narrate a story by themselves. The author reveals hidden narratives imbedded in the image with his published artist's statement. Each childless node suggests people who died young and a ring with abnormally blank spots due to a cluster of childless nodes indicates tragedy such as wars, drought and plague. When observing the artwork, the author perceives

not only family relationships, but also lives, deaths and a partial history of mankind. In other words, interpretation of the data is not fixed. Artists can pick any perspective from which to construct a distinguished story, and each opinion creates an individual visualization. Although the ambiguity is a critical defect in conventional - practical - data visualization, aesthetic data visualization benefits from these challenges.

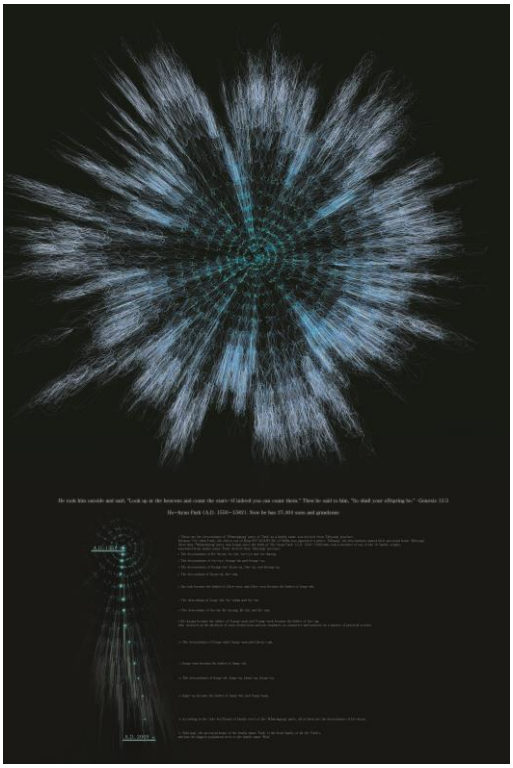

Figure 7: *A digitally generated paternal family tree of Mr. Park (Myrang branch, Hwarok sub-branch); Among more than 30000 nodes, which represent each person in the family, the center node is the founder of a 'Hwarok' branch of 'Park' families who lived about 500 years ago; (c) 2007-2009 Jin Wan Park. Reproduced with permission of the copyright holder.*

Studying trends in art history or artists' transitions in style helps one to understand and appreciate art. As only a person highly trained in iconography can understand the hidden meaning in medieval religious art works, data visualization also requires viewer interest and effort to discover the true nature - Wesenserschauung - of the data.

4 Topic 3: Enhancement and transition of senses and development of sensory organs

4. 1 Augmented Sense

The typical ingredients of artistic visualization are non-visual, implicative data; however, 'I'm Not There: Extending the Range of Human Senses to Benefit Wildlife Corridors'(Fig. 8) is one of the rare examples that used only visual data as its visualization source. There are two major approaches for re-visualizing visual data. One approach extracts the meta-data from the stimuli and creates abstract images; the other amplifies and purifies the stimuli, converting them into a transcendent vision. The latter would be a case of augmented visualization.

Figure 8: *I'm not there: extending the range of human senses to benefit wildlife corridors; Baby birds under daylight (left). Reflectance study, simulated, IR light (middle) and UV light (right); (c) 2009 Carol LaFayette. Reproduced with permission of the copyright holder.*

The above project of LaFayette enables humans to experience wildlife from the viewpoint of a wild animal, illustrating senses that are not possessed by humans. At first glance, the piece seems very intuitive; however, visual augmentation provides the viewer with an opportunity to consider the limitations of human senses. To enhance the inferior human visual capacity relative to that of a wild animal capable of night vision enlightens us to the fact that our sensory receptors are able to capture only a small amount of the data present in the world. Conversely, this imperfection arouses an interesting question. If our sensors are so ineffective, in data visualization, why do we keep downgrading a multi-dimensional massive input data into a lower dimension for perception? Is it not better to shift or create a new conceptual sensorium which is capable of handling high-dimensional data? LaFayette's artwork of heterogeneous sensorium mapping addresses these questions that lead to redefinition of senses.

4. 2 Shifting/ Inventing Senses

Although visual data is capable of surpassing other senses, the eyes are not the only sensory organs to induce perception. The 'News Knitter' piece (Fig. 9) is a good example of the shifting and distribution of input data over multiple sensory organs. Abstract patterns of news during in a certain time period were visually programmed into a textile machine, which generated unique designs reflecting the flow of current news into a textural reification. Like a living creature, the streaming of news morphed the shape and patterns of the data. In the end, the visualization was adapted to an environment which reflected common interests of the public.

Figure 9: *The News Knitter; this project converts information gathered from the daily political news into clothing which is tangible object; (c) 2007 Ebru Kurbak. Reproduced with permission of the copyright holder.*

'Multiscale Meta-Shape Grammar Objects for: ..... a grain of sand turns the balance and ATLAS in silico'(Fig. 10) is a good instance of complicated interdisciplinary cooperation. Using an enormous amount environmental and life data from oceans, the team abstractly developed a hieroglyph, another highly abstract form of presentation. For years of accumulated data, they refined

the molecular protein structures of microbes in the oceans throughout the world. They adopted various techniques to visualize the data collected, including large-scale data mining, virtual reality, allosphere presentation, sound simulation, and real-time visualization, and they amassed a broad range of knowledge on biotechnology, engineering, and the humanities. As a result, the visualization they created embodies an n-dimensional representation, in which the characters are symbol of the life mechanism represented by a lettering algorithm, or allegedly a computational cyber logographic system.

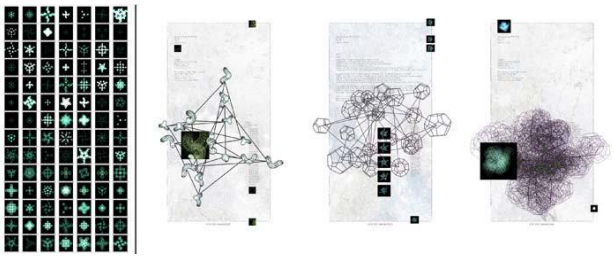

Figure 10: *Multiscale Meta-Shape Grammar Objects for: ..... a grain of sand turns the balance and ATLAS in silico; (c) 2009 Ruth West.*

The hieroglyphic system is interesting and unique, but it cannot be practical considering that the characters are impossible to read, pronounce or recognize. Creating characters based on a blueprint of life is a grand plan, but the results are as ambiguous as is the source data. Is the only way to allow for perception to degrade complex data and connect it to our sensory system? There are projects which enhance our senses or distribute stimuli to multiple sensoria, but they still rely on the assumption that our senses are capable of understanding the data.

Although visual perception is a powerful and effective tool to discover immediate patterns, it has its limitations. Images on the retina are 2D data. Even with binocular disparity depth cues, still information is not able to accurately convey multi-dimensional complex data. When adapting data to the range of human cognition by lowering its dimensions, information is sometimes incomplete or distorted. Although our senses may be good enough to receive all of the information, it may be received in an incomplete and distorted way because we are able to see and hear only small segments of the light and sound frequency ranges. Moreover, for any data received through a sensory system, the processing of high level conception is performed within the brain and cannot be described with one or two simple algorithms. We agree with and are moved by a subject, not in part, but as a whole, through the comprehension of the context and a resonance of emotions.

Data visualization is thus an effective but incomplete way to deliver information. Accepting our sensory receptor limits forces us to consider the possibility of specialized sensoria that have nothing to do with the human body.

5 Discussion and Conclusions

The Aesthetic Data Visualization has many analogous names such as Information Visualization, Information Art and Information Aesthetics. We used the term 'Aesthetic Data Visualization' as a 'Cognitive Art with Philosophical Arguments' that uses features of traditional 'Data Visualization' of design, statistics and computer science.

We suggested three distinct topics: viewpoint, interpretation and alternative senses. These topics are closely related to historical arguments in art history. 'Viewpoint' relates to the Renaissance movement when individual artist become self-reliant with unique styles. 'Interpretation' relates to the modern art revolution where the public came to appreciate artworks, and iconology theory flourished. 'Alternative senses' relates to contemporary art, especially media art, which uses media as an art source and for inspiration. It is interesting that the topics make a brief chronicle of art history.

Expressing contemporary data is a common challenge for artists and scholars in interdisciplinary fields. Smart phones and ubiquitous network devices have infiltrated every aspect of life, existing as unceasing data emitting objects. Social network archives create not only perceptible data such as text messages, photographs, notes, comments, and multimedia files, but also collective human behaviors that define individual social egos. When we forecast weather or anticipate an earthquake using social network data, we are making predictions of the future. Although the amount of data is almost impossible to analyze, it provides strong clues for understanding human beings, which is the historical task of cultural anthropologists, sociologists, psychologists and artists.

We examined various aesthetic data visualization projects, including experimental results which do not wholly rely on visual perception. Unlike practical information visualization, aesthetic data visualization is not yet a mature practice; however, considering its potential, more attention should be given to this art form. Multiple viewpoints, various interpretations, and more highly developed or mutated senses are not the typical characteristics of data visualization. However, as data becomes more complex and more intense, low-dimensional quantitative representation is becoming increasingly difficult. Paying attention to aesthetic data visualization is important for understanding the multitude of data available in the world.

Acknowledgement

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