Data in Art-dimension

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SM2702 Interdisciplinary Practices
Morning Session

List of disciplines used:
Art, Mathematics, Geography, Computer science

Concept: Visualizing the fourth dimension

In this information age where an abundance of statistics and data are obtained, numerous models are utilized to represent the data clearly. Graphs, maps, and charts are among the common tools for visualizing numbers, to allow for quick comprehension and interpretation of data. The tools must lay out the findings accurately and systematically - so that patterns can be easily caught by eye.

However, in this rapidly growing world where 2.5 quintillion bytes of data are created daily[1], will the current models of visualization suffice? In addition to the increasing quantity of data, the very nature of certain data requires a model system of a higher dimension. The current common model is the Cartesian coordinate system, which allows for data presentation of up to three variables. However, data obtained from across sectors consists of statistics requiring a four-variable representation, or even more. For example, in chemistry, the study of red wine and white wine properties may include measurements of residual sugar, sulfur dioxide, sulphates, alcohol, and volatile acidity, in various test samples.[2]

Is there an alternative way to represent data besides the conventional x-y-z coordinate system? How can one visualize the fourth dimension? Some models attempt to represent the fourth dimension with color, inside an x-y-z plotting space. Others explore the possibility of visualizing 4D objects, such as the Klein bottle, with computer graphics. The Klein bottle is a one-sided, edgeless, twisted surface that cannot be built in ordinary space without intersecting itself. Theoretically, it can be constructed in four-dimensional geometry by sewing the two ends of a cylinder together, with a twist. With computer graphics, the Klein bottle can be modeled in animation.[3] The limitation, however, exists in the fact that our perception is confined to that of our 3D experience. With the visualization of the fourth dimension, one might be able to imagine the *concept* of a 4D space, but the actual physicality of a 4D space one cannot grasp. The computer-generated fourth dimension is not effective in presenting data that can be easily interpreted.

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[1] IBM (2017, July 19). Retrieved April 24, 2018, from https://www-01.ibm.com/common/ssi/cgi-bin/ssialias?htmlfid=WRL12345USEN

[2] Sarkar, D. (2018, January 15). The Art of Effective Visualization of Multi-dimensional Data. Retrieved April 24, 2018, from https://towardsdatascience.com/the-art-of-effective-visualization-of-multi-dimensional-data-6c7202990c57

[3] Banchoff, T. (1996). Beyond the third dimension: Geometry, computer graphics, and higher dimensions. New York: Scientific American Library.

Going back to the Cartesian coordinate system with an additional color code, would that be the best option for visualizing multiple-variable data? What about the fifth variable, the sixth, and so forth? What properties can one choose beyond color? In the original three-variable coordinate system, the value of each variable is represented by its distance and direction from the origin. Why choose the property of length as the visualization of numbers? Can one choose other properties, such as color, size, weight, or shape? Or even invisible sensations such as sound, temperature, and smell? Supposedly, anything with a spectrum can be mapped to a set of numbers, which then can model the value of a variable. Our artwork *Data in Art-dimension* will explore this possibility and stretch the definition of a graph.

In the Oxford Dictionary, a graph is defined as "a diagram showing the relation between variable quantities, typically of two variables, each measured along one of a pair of axes at right angles."[4] If we confine to this definition, our artwork is not a graph. It fulfills the conditions of "showing the relation between variable quantities" but fails to satisfy the method of using "a diagram" with "a pair of axes." In *Data in Art-dimension,* the values of each variable are represented not with axes, but with color and size properties. Just as each ordered pair is graphed as a single point with a range of x and y distance, each point in our work is represented by a sculpted piece of clay, with a range of color and size. The total collection of the clay pieces are then composed together in a sculpture form, thus further breaking the condition of "a diagram."

Nonetheless, one cannot but notice that *Data in Art-dimension* fulfills the *purpose* of a graph, though not exactly the method of a graph. The purpose of graphics is to "reveal data" as well as "telling the truth," as Edward Tufte[5] stated concerning graphical excellence, in his book *The Visual Display of Quantitative Information.* Like a typical graph, it models the values of two variables with a representative spectrum. To include the artwork in the category of a data graph, the definition of the latter must consequently be expanded. And why not? Rules and definitions are only set by humans to better describe the world. They had been broken many times in the past to include the novelties that are discovered continuously. Historically, the definition of art itself had broadened to include works beyond its original mediums such as paintings, drawings, and sculptures. In contemporary art, it is not the form that qualifies an artwork as much as its context and meaning. Analogously, the scope of the mathematical graph can be expanded to include all data-representing models.

[4] Graph | Definition of graph in English by Oxford Dictionaries. (n.d.). Retrieved April 24, 2018, from https://en.oxforddictionaries.com/definition/graph

[5] Tufte, E. R. (2001). The visual display of quantitative information. Cheshire, Conn: Graphics Press.

According to this presumption then, this artwork is both an artistic sculpture and a data graph. This concurrent state is intriguing to ponder upon, particularly upon the transformation of information. Tracing back to the origin of data, information is first obtained by mere observation of the world's phenomenons. People engage themselves in this process all the time although perhaps subconsciously - commenting that the climate is getting warming in recent years, categorizing that girls like to shop, or experiencing that the public transport is most packed at rush hours. These are non-statistical observations that one obtains by engaging in the tangible world. One learns that trees shed leaves in autumn because one physically perceives the falling of the leaves at certain time of the year. From that, to more accurately describe the world, scientific research methods are used collect quantitative statistics. These data are then visualized in order to ease the process of analysis and pattern-finding. Thus, the sequence of events moves from physical observation to data. *Data in Art-dimension* reverses this order. It starts off with the data as the source, and transforms the data back into a physically observable object. In other words, within the artwork one finds the transformation of physicality to data and data back to physicality.

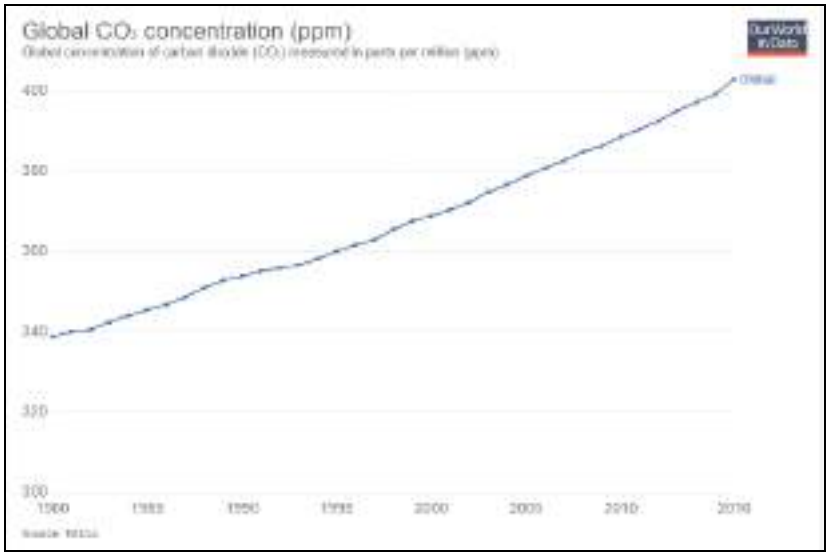
At this point, one might question the effectiveness of presenting data in an artform. After all, one is able to easily interpret data in an x-y graph, but not so conveniently when observing an object's size and colors. In a conventional graph where point A is at y = 5, and point B is at y = 10, one can immediately observe that B is double that of A simply by visual perception of distance. In contrast, it is not intuitive to conclude that B is double that of A, when seeing that B is yellow and A is blue. Why then use models that do not clearly convey the data?

One may as well consider why the Situationist International redefined cinema by crossing out film strips and why the Lettrist expanded writing by putting symbols in literature. The S.I., a group of artists, scholars and social activists in Europe after WWII, attempted to break down mainstream cinema by scratching out the images of a film, or editing unrelated sounds and footage together. These techniques of destruction were similar to the earlier destruction of writing by the Lettrist. They created hyper-writing by interweaving the use of words, symbols and drawings. Evidently, it is no easier to understand a story in a crossed out film, or to comprehend a reading where words and symbols are scattered across the page. However, it is the process of the constructive and destructive stage that is essential. When one artform develops to its height, the destroying of the form will bring about a new perspective of the form. The creativity that the S.I. explored eventually led to a new form of expanded cinema.

Likewise, the aim of this artwork is to explore and push the limits of the traditional data graph, breaking down the conventional model of the axes, and replacing it with measurable properties. *Data in Art-dimension* poses questions concerning where the boundary of mathematics ends and where the boundary of art begins.

Documentary & Methodology

Data in Art-dimension is a sculpture presentation of statistical data. Crafted in the form of a tree (25.5cm x 26.5cm x 33.5cm), its trunk and branches are twisted with metal wire, accompanied by colorful leaves sculpted with ultralight clay. The data visualized in the work is that of "Global CO_2 concentrations" provided by National Oceanic and Atmospheric Administration,[6] recording the global CO_2 concentration (parts per million) across a span of 37 years (1980-2016).

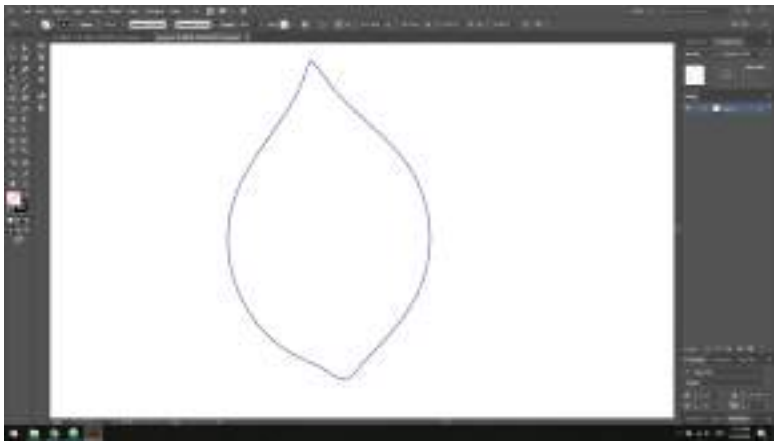


[6] CO_2 and other Greenhouse Gas Emissions. (n.d.). Retrieved April 24, 2018, from https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions

Global CO2 concentrations (ppm)		
Year	CO2 (ppm)	Color Hue
1980	338.8	174
1981	339.99	171
1982	340.76	170
1983	342.44	167
1984	343.98	164
1985	345.46	161
1986	346.88	158
1987	348.61	155
1988	351.14	150
1989	352.79	147
1990	353.96	145
1991	355.29	143
1992	355.99	141
1993	356.71	140
1994	358.2	137
1995	360.03	134
1996	361.79	130
1997	362.9	128
1998	365.55	123
1999	367.63	119
2000	368.81	117
2001	370.4	114
2002	372.42	110
2003	374.96	106
2004	376.78	102
2005	378.81	98
2006	380.93	95
2007	382.67	91
2008	384.78	87
2009	386.28	84
2010	388.56	80
2011	390.44	77
2012	392.45	73
2013	395.19	68
2014	397.11	64
2015	399.41	60
2016	402.87	53

In the data sculpture, each plot of point is “graphed” as a leaf, 37 leaves in total. The size of the surface area of each leaf represents the year, while the color represents the amount of CO_2. Leaves representing recent years are relatively smaller while leaves representing earlier years are larger. Precisely, the leaf representing the year 1980 has an area of 5.0cm^2. Each leaf of the consequential year would be 0.5cm^2 larger.

To ensure the precision in sculpting each leaf’s size, we used printed outlines as guides. First, a leaf is drawn with vector strokes using Adobe Illustrator CC 2018.



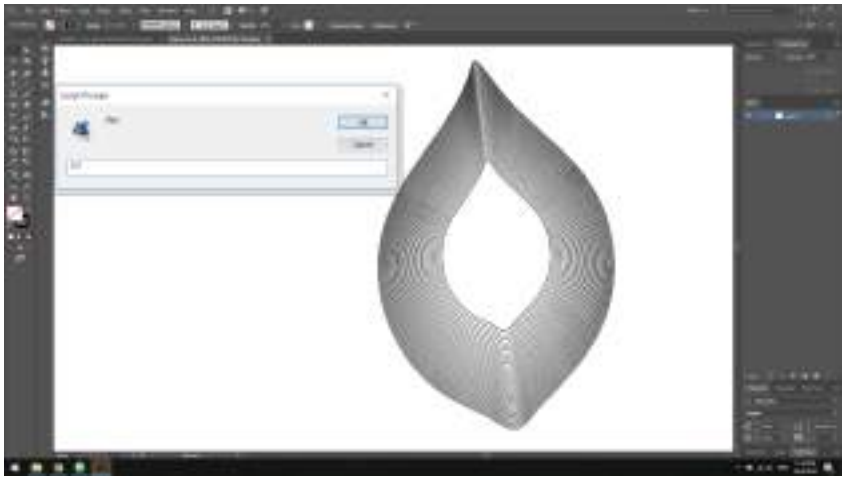
Next, a piece of javascript code is written to generate the 37 leaves with the exact measurements of area as described previously.

area-copy.js

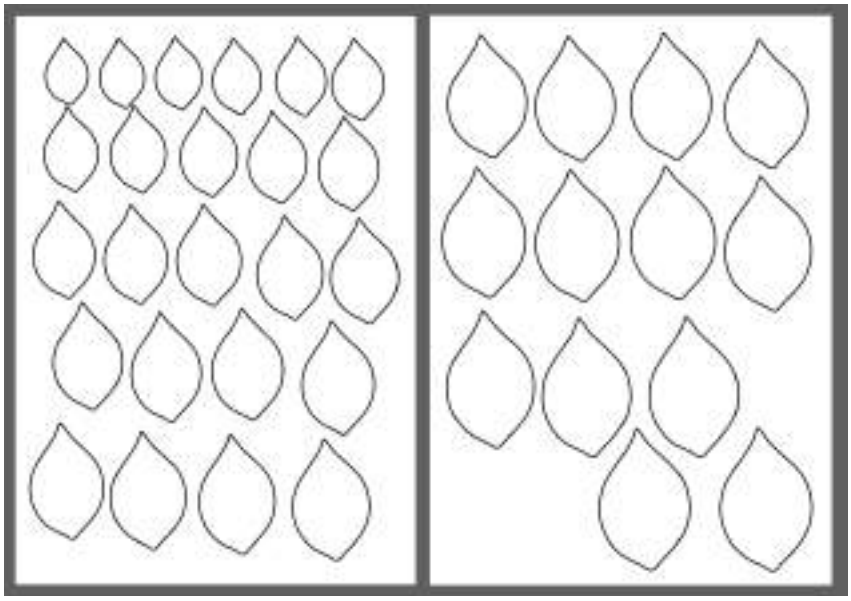
```
var step = prompt("step:");
var original = app.activeDocument.selection[0];
var sz = Math.abs(original.area/803.521617);

for(var i = 0; i< 37; i++){
var scale = (Math.sqrt((5 + step*i)/sz))*100;
original.duplicate().resize(
    scale,
    scale);
}
```

(The above script, when runned in Illustrator, will prompt an input of “step.” We entered a value of 0.5 for step, allowing an increase of 0.5cm^2 per leave generated. It then generates 37 copies of leaves, beginning with the first with 5.0cm^2.)



Afterwards, each leaf in the Illustrator artboard is positioned apart to fill up two sheets of A4 paper. These pages are then printed, and used as outlines for sizing each clay leaf.



The color of each leaf represents the amount of CO_2 in ppm. This y-variable ranges from 338.80ppm to 402.87ppm. We chose to represent the smaller amounts with blue hues and the larger amounts with yellow hues, the in-betweens being green. Each hue is calculated based on the CO_2 ppm value, using the following equation:

$$H = (410 - y)*1.875 + 40$$

The color is generated in an HSB mode. The H in the equation is the value for the hue. The saturation and brightness of all the colors remain constant at 70% and 75%

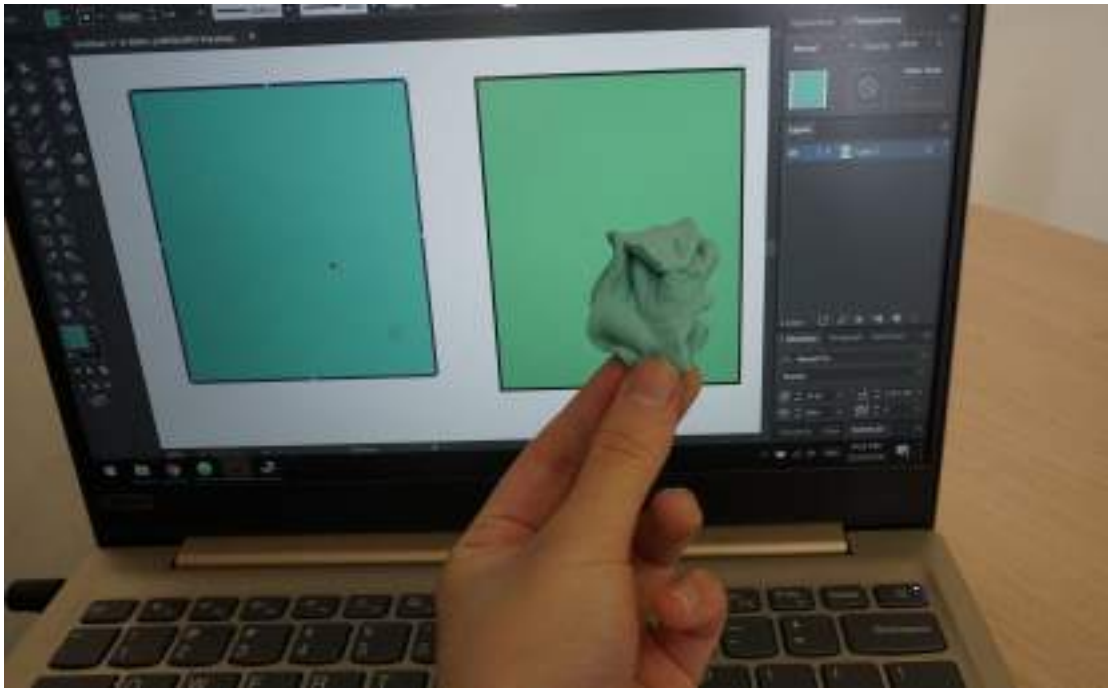
respectively. The hue value ranges from 40 (brownish yellow) to 190 (turquoise blue). Thus, the above equation is produced based on the following information:

H: 190 - 40 (range: 150)
S: 70%
B: 75%

CO_2 ppm: 330 - 410 (range: 80)

H = (410 - y)*150/80 + 40

The colors are then implemented into the leaves by applying watercolor pigment to the ultralight clay until the leaf's hue corresponds to the wanted hue. First, the wanted hue is requested and displayed on the computer, again, using Illustrator. Then, by using the human eye, the color of the clay is matched as much as possible to the color on the screen.



Each leaf, then, has its specific size and color. Once the basic shape is formed, details are added to the leaf for aesthetic purpose. Gentle vein marks are etched into the leaves to model real leaf patterns. Each leaf is then bent in elegant curves to produce a natural shape. A hole is poked at the end of the leaf to allow for attachment to the stems later.

The wire tree is twisted from metal wires of two thicknesses - 0.8cm and 1.2cm. Together, they add an artistic variety to the branches. First, we cut the wires into long strips of about 40cm long. Taking the bunch, we twisted it into the main tree trunk. From there, the smaller stems branch outward to constitute the tree form. Likewise the roots are branched out and twisted together to form a spreading base.

Once the leaves are finished and dry, they are attached to the wire tree. The wire branches are ringed through the holes in the leaves, and the ends are twisted back onto the branches. We decided to scatter the yellow leaves generally at the top shoots, and the larger blue ones at the lower branches.

Finally, the main structure of the art-graph is completed. Finishing touches and tweaks are added to ensure the angle of branches and leaves are aesthetically positioned, maintaining a balance in all perspectives. The tree is generally upright, with turning curves and slants in the branches to bring out the natural look.

Professional Display

Our installation *Data in Art-dimension* will be displayed in an indoor exhibition room with high ceiling and of size no smaller than 200m^2. The walls of the room should be white. The installation (25.5cm x 26.5cm x 33.5cm) will be displayed in the rectangular glass cabinet with the size (150cm x 100cm x 100cm), 2 meters from the nearest wall, so as to allow viewing from all perspective. The glass cabinet should be placed on a rectangular wooden stand with a height of one meter, so as to allow better viewing from the eye level.

Eight small light bulbs of gentle yellow-tinted white light will hang from the ceiling one meter above the glass cabinet to light up details. They will surround the installation to add a glowing effect to it, which can make the colour of the tree leaves more noticeable.

Additionally, a printed graph of the data “Global CO2 concentrations (parts per million) from 1980-2016(NOAA)” will be displayed behind and to the right of the sculpture on the wall.

Background: Visualizing global warming

According to the news[7] of Hilary Brueck- a science reporter at Business Insider, there is a breaking record of natural disaster in 2017, which has a coherent relationship with the global warming. Global warming always is the concerning issue around the world as it can create numerous effects,both beneficial and detrimental. Beneficial effects such as the agriculture productivity may rise in high-latitude as the ice melt ,bringing more fresh water for the farmer there and boosting the local economy. It is a pleasant news which global warming can bring,however, it also bring adverse effect such as causing the shrinking of ice sheets which destroying the homes of polar bears and penguins ,ocean acidification building up negative effects to the marine habitat and more extreme weather events. For instance, a recently extreme weather events--- flooding in South Asia has caused around 1,200 death and shut 1800 school (Siddique,2017)[8].

[7] Brueck, H. (2017, December 24). Natural disasters set records around the world in 2017 — these were the worst. *Business Insider*. Retrieved April 13, 2018, from http://www.businessinsider.com/worst-natural-disasters-hurricane-flood-wildfire-2017-12

[8] Siddique, H. (2017, August 31). South Asia floods kill 1,200 and shut 1.8 million children out of school. *The Guardian*. Retrieved April 23, 2018, from https://www.theguardian.com/world/2017/aug/30/mumbai-paralysed-by-floods-as-india-and-region-hit-by-worst-monsoon-rains-in-years

Moreover, it is be estimated that more than 10,000 death and around 306 billion loss due the harmful effect of natural hazard in 2017(National Oceanic and Atmospheric Administration,2017)[9]. Not only do these news showing the powerfulness of natural hazard, but it also remind us the accelerating impacts of Greenhouse effect, the occurrence of more extreme weather events.

And the main cause of the intensified greenhouse effect is - the rapid increase greenhouse gases that human activities have producing, such as the Carbon dioxide from the air-conditioner, the Nitrous Oxide from a the combustion of fossil fuels emitted from the power plants and the method from the landfills and biomass burning. These human activities indeed emitted enormous amount of greenhouse gases and worsening the environment.Therefore, it is inevitable that we need to confront the problem of the leap of the greenhouse gas emission and relieve the problem now.

In studying the art-graph, the viewer is able to appreciate the artistic beauty of the sculpture as well as to recognize the data. One is able to notice without much effort, that the larger leaves are blue-tinted, and that the smaller ones are yellowish. By catching on to this pattern, the viewer will understand that the amount of CO_2 is increasing over the past years.

Data in Art-dimension aims to strike people with realization the emission of the amount of greenhouse gases is increasing these years due to our consuming behaviors and ignorance of the natural habitats, enbrighten their mind to take up the social responsibility such as nurture a habits of being environmental friendly, creating less carbon print and greenhouse gases to protect of our environment. And what is more? It will depending on how the viewer see our installation by relating their daily activities independently.

Artistic aspect: Combining the art and information

Maxence(2016)[10], “By blurring boundaries between art and information, data art dispels the myth of the romantic artist while offering a fundamental artistic act in a critical

[9] Mooney, C., & Dennis, B. (2018, January 8). Extreme hurricanes and wildfires made 2017 the most costly U.S. disaster year on record. *The Washington Post*. Retrieved April 23, 2018, from https://www.washingtonpost.com/news/energy-environment/wp/2018/01/08/hurricanes-wildfires-made-2017-the-most-costly-u-s-disaster-year-on-record/?noredirect=on&utm_term=.4566ae45bf84

[10] Grugier, M. (2016, May 09). The digital age of data art. Retrieved April 24, 2018, from https://techcrunch.com/2016/05/08/the-digital-age-of-data-art/

commentary of the digital age in which we live.” If various of data functions and formula display in the art museum, what do you think about it? Do you understand the data? It is understandable that it is hard to analysis the complex formulas and the data if you are not familiar with those mathematical things. But if we are displaying the data, the formula in the art form-installation.

Considering the figure of the tree, leaves colour and size are two of the variables can represent the data. Thus, there is a colour range between different size of trees. when we are modifying our ultralight clay leaves instead of just painting the colour on the leaves surface, as the data is not the surface of the art, but it does emerged as an art, combine certain of facts and the meaning of the art. Because our data represent the colour, the colour represent the art.

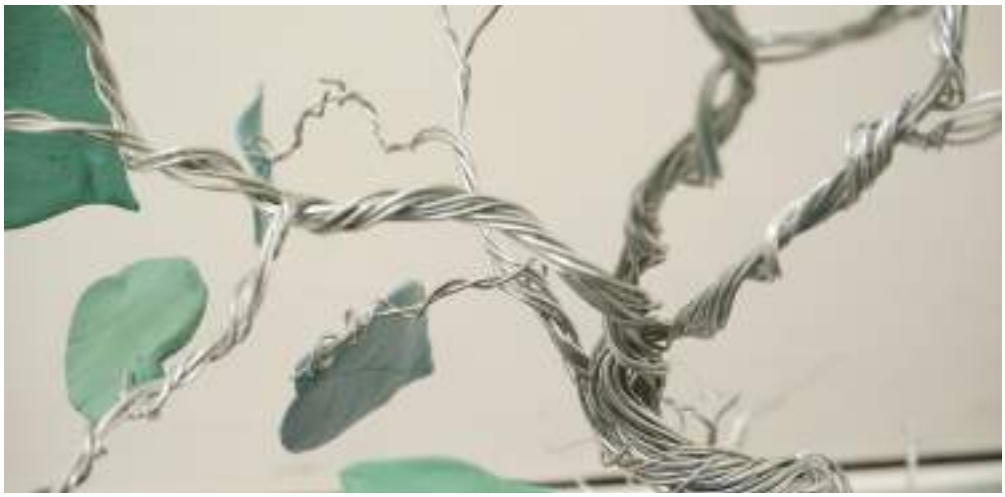
To create a harmonious colour combination of our tree, colour gradient from lime green to turquoise is used. This idea is related to the Analogous color schemes which means using the colours of the colour wheel that are sides-by-sides. We chose to use the primary hue colour Green, and the lime green and turquoise as the supportive colour as it is the natural range of the colour so it is more comfortable and pleasing to our eyes, there is balance inside these colour.

Furthermore, Colour surround us can influence our mood and affect the point of views when we are seeing an object,”there are social or culture levels as well as personal relationships with particular colors,” explains Leslie Harrington, executive director of The Color Association of The United States”(Rachel,2013)[11]. For example, seeing red and

[11] O. (2013, May 28). Seeing Red And Mellow Yellow: The Science Of Why Color Affects Our Mood. Retrieved April 25, 2018, from https://www.huffingtonpost.com/2011/11/27/how-color-affects-our-moo_n_1114790.html

orange colour may let you think about the passion and enthusiastic as the colour of fire are like these, seeing purple colour may let you related the elegance and wisdom as many noble wear purple custom in 20th Century. And the colour range we use are lime green to turquoise, green usually represents nature and environment, the turquoise usually related to calm, however, as mentioned above, colours are also associate with the experiences of the people, so our installation will deliver diverse feeling to the different people who with different backgrounds.

Not only do we concern the balance of the colour, but we also do concern balancing control of the elements. When we were rubbing our ultralight clay leaves, we were not just rub them flat, but we were creating various of curves of the leaves, thus building a more natural shape of the leaves. As same as the leaves, the tree trunks made by the silver wire also twisted in a curvely shape instead of tall and straight trunks because a straight tree trunks is more like the tree in jungle, presenting seriousness. We have used harmonious and pleasing colour, so we also bent our tree trunks into a natural, harmonious, curvely shape.



Artistic References

Installation:'seven magic mountains' photos by gianfranco gorgoni [12]

The composition of this installation is simple yet complex. The simple part is that the structure, the artist arranged the painted lime boulders into vertical way and create multiple stacks of boulders with different color. The complex part is the use of the colours distribution, first of all, the colour placed on the same stacks do not repeated, next, the colours used all are the primary secondary hue colour which is mixed with the 3 hue primary ,and black and white, colour(Green,Red,Blue), also, it applied fluorescent colour effect. These 3 methods makes the installation look sharp and stunning with the clear hue.

Therefore, this installation inspires us to control the use of colour. Our installation considered to generate the formulas, data into the colour range from lime green to turquoise creating a harmonious effect which can attract the eyes of people.

Ai WeiWei had collected around 14,000 orange life vest from the greek island and drew a lot of attentions from public about the refugees issue.

The life vests are representing the data (certain number of refugees) and attached on the pillars, although people cannot see the exact value of the data and know the number of refugees, the art do displayed the seriousness of the refugees issue as the life vest are tightly packed like a large number of refugees running from Greece to Europe nervously.

[12] Ugo rondinone erects seven magic mountains in the nevada desert. (2016, May 12). Retrieved April 25, 2018, from https://www.designboom.com/art/ugo-rondinone-seven-magic-mountains-desert-nevada-05-12-2016/

Ai WeiWei Art in the landmark konzerthaus in berlin photo by oliver lang[13]

In our installation, the data of the mean of the greenhouse gases, are stored as the colour of our leaves, and filled as the part of the crown of tree. People can get to know the data (emission of greenhouse gases) from the year 1980 to 2016, witness the change and the phenomenon of greenhouse effect, may arouse complex feeling or even an inspiration from our installation.

[13] Ai weiwei wraps berlin's konzerthaus with 14,000 life jackets. (2016, October 03). Retrieved April 25, 2018, from https://www.designboom.com/art/ai-weiwei-life-jackets-refugee-konzerthaus-berlin-02-15-2016/

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O. (2013, May 28). Seeing Red And Mellow Yellow: The Science Of Why Color Affects Our Mood. Retrieved April 25, 2018, from https://www.huffingtonpost.com/2011/11/27/how-color-affects-our-moo_n_1114790.html

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