Designing for Discovery

Using Interactive Visualization To Encourage Exploration And Foster Discovery In An Information Space

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Abstract

For centuries, people have spent a great deal of time traveling the vast corners of the unknown world in hopes of furthering their understanding and knowledge of it. Not only did their journeys help them discover things about the world they inhabited but it also gave them an important insight into who they were as human beings.

Over the years this natural instinct for discovery has not only increased but has also evolved. In today's digital age, much of our exploration begins as an online search experience of the vast and ever growing virtual world. This virtual world which I refer to as "Information Space" vastly differs from its real–world counterpart — the physical space.

Discovery in an information space is also far from any real world experience. Information space is characterized by its lack of familiar landmarks (such as street signs or stars) for orientation and is instead populated with huge amounts of constantly changing "data". The question that then arises is how can one navigate through this space in ways that will allow for meaningful discoveries to occur.

My thesis, Designing for Discovery, investigates the many ways in which data visualization can be used to interpret data that pervades the information space. Through a variety of case studies that culminate with "Forest Growth Visualizer", I explore ways in which this data can be assigned perceptible visual forms. I also design entire experiences around this space to encourage user exploration and foster unexpected discoveries.

Contents

Introduction

Having traveled a good portion of the last two decades of my life, I am frequently referred to as a "cosmopolitan" by my friends and family. In many ways travel has been the one constant and often pleasurable aspect of my life. I am motivated to travel because of an undying inquisitiveness for the world I live in. I see it as a journey of Discovery — one that not only energizes me but also shapes my perspective of this world. More importantly, it helps me understand who I am and where I came from.

Early in my life the journeys I undertook involved traveling from one geographical place to another. The tools I relied on during my travel often included the use and interpretation of maps and signage native to the location I was in. On occasions when these tools failed, I resorted to simply asking for help from strangers. Over time each of these experiences helped me hone my unfamiliar lands.

I still vividly recall my early days in Tokyo, Japan. Being of Chinese origin I wasn't very fluent in Japanese. I now realize how much I depended on maps and the presence of signage around me to safely guide me from point A to point B. Frequent these were handy and reassuring. They not only let me know where I was but how far I had to go before I reached my destination. I don't remember ever getting lost and so I begain wondering if it was because of my innate spatial skills or if it was on account of Tokyo's well–designed wayfinding system. My guess is that it was the latter. These experiences helped raise my interest in studying the process of designing wayfinding systems. For the next five years of my professional career I heavily focused on understanding and designing signage systems.

After having taught and worked on wayfinding design for close to 5 years, I found that I particularly enjoyed the aspect of information design within wayfinding systems. Information design helped me organize spatial information in a way which was communicable and understandable to the user so they could make informed decisions while navigating from one unfamiliar place to another. During this time, I had the good fortune to meet Don Tarallo, now an assistant professor at Bridgewater State College. In conversations with him, I expressed my interest in information design. He recommended that if I wished to dig deeper into this discipline I should consider studying at MassArt.

Upon his recommendation, I applied to the graduate program at MassArt's Dynamic Media Institute (DMI) and was accepted into it. Upon arriving in Boston, my experience was a lot different from that of being in Tokyo. Once again I was challenged in my travels by the fact that I wasn't fluent in English which made getting from one place to another in Boston quite difficult. Fortunately, this time around I had found a new friend — Apple's "iPhone."

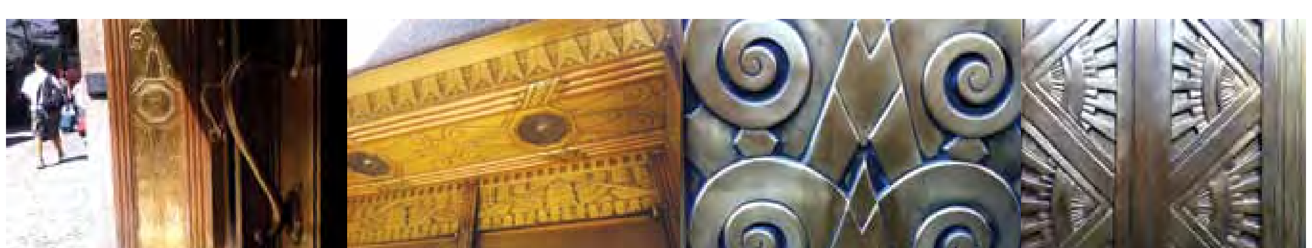
In 2009, a few months before I joined the graduate program at Dynamic Media Institute, Apple announced the release of its mobile phone — the iPhone 3Gs. What was remarkable about this device was that because of its "Global Positioning" capabilities, mobile applications could be created that were sensitive to a user's physical location. The application could then provide the user with content and information specific to their location.

One of my favorite iPhone navigational applications that embody this capability is the "Roadside America App". It is an application that is location sensitive and points out to its user all sorts of nearby tourist attractions. "When on the network, the app knows where you are, so you'll never miss a great sight again." (*Source: http://www.roadsideamerica.com/mobile*) One day while I was waiting for a bus for more than an hour in New York City, I turned on this application. It told me that the building behind was a famous hotel in New York and that it was designed in the Art Deco style which was popular between the 1920s and 1930s. This excited me and I raced into the hotel to have a proper look at it. I enjoyed my surprising discovery; until then Art Deco was merely a term in my Art History textbook from 15 years ago. This experience made me realize the amazing possibilities that can arise from thoughtfully combining technology, wayfinding and design. It also served as an inspiration for my case study, Star Tracker.

In the process of working on Star Tracker, I learned how to analyze and understand the contents of an information space. In this case, the information space consisted of location data which by itself can be of little significance to a user. I learned how to provide a context and visual form to this digital data thereby creating a rich experience that alters our relationship with that space.

I also began to realize that navigational approaches from traditional physical spaces can be adapted to a digital or information space. This is not a new concept as physical spaces and interactions have previously influenced the design and construction of digital or virtual objects, for example, the computer desktop was conceived as an extension to the physical desk top.

My case study, Memento: Film Explorer is an exploration of how to apply traditional navigational and wayfinding design principles to an information space, which in this case were the entire film's sequences. I created a unique interactive interface to allow a viewer of the film to explore the movie's unusual non–linear narrative plot. By designing the interface's visual layout similar to a traditional Japanese garden, I created a circular pathway that lets the viewer explore the movie's plot in chronological and reverse chronological order and thus contribute to their understanding of the movie.



Roadside America, an iPhone application, told me that the building behind was a famous hotel in New York and that it was designed in the Art Deco style which was popular between the 1920s and 1930s.

Visualization plays an important role in understanding the abstract as it gives visual form to what is mostly unseen. While visualization helps with making the unseen seen, it does raise an important question of whether that translates to an understanding of the unseen. This question further guided my thesis research to investigate the importance of data visualization in designing for an information space. My case studies, Gala Redux and Attractivity Meter, explored data visualization and the role of interactivity in designing for information spaces.

Gala Redux is a static visualization (devoid of interactivity) of horizontally connected video frames that obey traditional spatial rules. 34,560 frames are horizontally arranged within four vertical squares in order to put forth an entirely new and engaging visual experience of viewing a video.

On the other hand, Attractivity Meter is conceived as an interactive online application that allows a user to explore how attractive he or she is, and in the process discover how many and which other individuals is similar looking to them.

My final case study, Forest Growth Visualizer, is an exploration into the role of data visualization as a critical tool in enabling discovery particularly in the scientific area. In this case study I finally combine the three components that I identify as essential to designing experiences for discovery, namely —

-1- Analyzing an Information Space
-2- Designing a Wayfinding System
-3- Visualization and Interactivity

Forest Growth Visualizer is an exercise in creating a scientific tool that visualizes a large collection of data pertaining to tropical forest growth. The aim of this tool is to assist scientists in understanding and determining what factors help influence the growth of a tropical forest as well as discover potential relationships between these factors. I achieved this by first analyzing the information space of forest growth data, then conceived intuitive ways to visualizing this data and finally came up with an interface that combines meaningful interaction and familiar navigational techniques to create a rich and engaging experience.

In going through all of the case studies that I have developed while at DMI, I realized that they all share one thing in common — to enable discovery in an information or virtual space. This is of particular importance to me since we are today in a digital age where the information space is being overwhelmed with huge amounts of digital data. Consequently traversing the information space is difficult and confusing. My thesis, Designing for Discovery, has been an ongoing journey in exploring how to create experiences that can best enable exploration of virtual spaces with the goal of fostering unexpected discovery and gaining an insight into something meaningful.

Welcome Aboard!

Contextual History

Since my thesis has to do with "Designing for Discovery" it would be beneficial for the reader to get a sense of how over the years, data visualization as a design approach has helped with facilitating discovery. In this chapter I begin by providing some early examples of data visualization works from the pre–computer era. Because of the time period in which these were developed they are 'static' by nature. I then follow them up by more recent examples from today's digital or informational age where we start to see more interactive works on account of the availability of newer, more advanced technologies.

VISUALIZATION "to form a mental vision, image, or picture of (something not visible or present to sight or an abstraction); to make visible to the mind or imagination"

— The Oxford English Dictionary, 1989

Visualization offers a means to seeing the unseen because, I believe, it can foster profound and unexpected insights and more importantly, enrich the process of discovery.

Early Examples
Of Data Visualization Facilitating Discovery

Map of the Trade Winds (Edmond Halley, 1686)

Edmond Halley's (c. 1686) Map of the Trade Winds is the first known weather map, showing prevailing winds on a geographical map of the Earth. The detailed section shows the cartographic symbolization; which as Halley described, "…the sharp end of each little stroke pointing out that part of the Horizon, from whence the wind continually comes; and where there are Monsoons the rows of strokes run alternately backwards and forwards, by which means they are thicker[denser] than elsewhere." (Edward R. Tufte, *The Visual Display of Quantitative Information*, 2001)

Halley's map helps visualize the 'unseen' invisible wind and the directions it took. What was also amazing about this visualization was that it was accomplished at a time when there were no airplanes or satellites that could afford a higher or bird's eye view of what was happening. Halley's map served as an important tool for early sailors and may have well helped them navigate the unknown waters. This map serves as a great early example of data visualization's potential to facilitate discovery.

Horse in Motion (Eadweard J. Muybridge, 1878)

Moving on to photographer Edward Muybridge's work Horse in Motion. The popular "perception" at that time was that when a horse is in gallop all of its hooves are off the ground with the front legs extended forward and the hind legs extended backwards. Muybridge was hired to prove if that was the case. Muybridge used a clever approach to layout a series of large cameras (that used glass plates) and placed them in a line, each one's shutter being set off by a thread as the horse passed by. Later he assembled all the images in the form of silhouettes onto a disc and viewed it in a machine called a Zoöpractiscope. The series of images helped freeze and thus visualize the horses rapid movements over a gallop.

This is a classic example of how visualization helped bring to vision something so rapid that would have otherwise been unresolved by the human eye. Muybridge's approach and visualization helped lay the ground work for techniques that were ultimately used in developing today's motion pictures.

Map of Trade Winds (Edmond Halley, Philosophical Transactions,1686,153 –168)

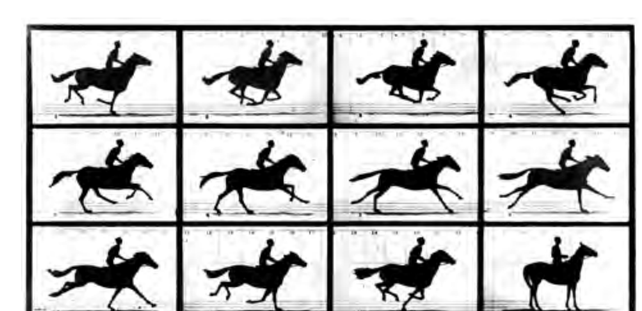
Map of the London Underground Tube (Harry Beck, 1931)

In the 20th century the pace of development and discovery increased and fields such as astronomy, physics, biology and medicine to name a few saw tremendous advances. All of this meant new techniques and approaches were required to communicate the information being generated by such discoveries. One of the most famous early examples of design aimed at communicating every day yet important information was Harry Beck's map of the London Underground Tube.

The version of the subway map prior to Beck's rendition was a collection of underground lines that were laid out geographically and often superimposed over the actual city's map with its roads above the surface. Needless to say the map was information heavy communicating a lot of data points which may not have been relevant to the traveler using the subway.

Beck instead believed that passengers riding the trains were not too bothered about the geographical accuracy, but were more interested in how to get from one station to another, and where to change. So he rendered his now famous diagram, which was more like an electric schematic than a map in its truest sense, on which all the stations were more or less equally spaced. (Source: *http://en.wikipedia.org/wiki/Harry_Beck*)

This map while it provides an insight into the unseen underground network with its downtown centered perspective, it more importantly simplifies what is essential for the traveler to know such as letting him know where they are, how to get from point A to point B, with how many stops in between.



The Horse in Motion (Eadweard J. Muybridge, 1878)

Tube Map (Harry Beck, 1931)

Fast forward to today's digital or information age where, on account of recent technological innovations, data visualizations have transitioned from a strictly static version into works that are animated as well as interactive. Because of these new and improved capabilities, the potential for data visualization as a tool to facilitate greater understanding and fostering of unexpected discoveries have significantly increased.

Data visualization is now viewed as a unique design discipline in its own right. As Ben Fry, a pioneer in interactive data visualization points out, "Visualization as a sub–field of science, statistics, and graphics has only been recognized as its own entity the mid- to late 80s." (*Organic Information Design*, 1997) the dawn of the modern computer technology. Both the discipline and its definition have since been evolving alongside computer technology.

Present Day Examples
Of Data Visualization Facilitating Discovery

Weather Forest Map (McCormick et al,1987)

As stated in the landmark report of 1987, "visualization is a method of computing. It transforms the symbolic into the geometric, enabling researchers to observe the simulations and computations". (McCormick, B., T. DeFanti, and M. Brown (ed.) *Visualization in Scientific Computing*, 1987).

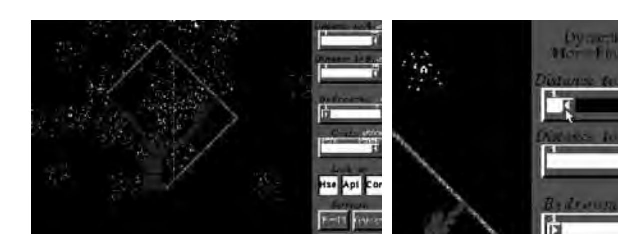
A great example for what McCormick et al above consider as Visualization's capability is the 1982 illustrated Weather Forest Map from the American newspaper *USA Today*. This map was developed by George Rorick. Weather maps are computer generated images based on large quantities of weather data. The data if presented on its own say in a tabular manner would be of no value or serve any practical purpose to the average person concerned with the weather. Instead this data was interpreted and overlaid as a color on a familiar visual form (that being, the map of the United States). This approach to visualizing the data helped communicate the most important and prominent aspects of the data, that being tomorrow's weather both for where the reader lived as well as for the country as a whole.

Weather Map by George Rorick, USA Today, 1982

Dynamic Home-Finder (Shneiderman et al,1993)

With the advent of newer computer technologies enabling a greater deal of interactivity, the field of Visualization has seen a lot of new developments. These recent developments have redefined what constitutes Visualization. Card et al. (*Readings in Information Visualization: Using Vision to Think*, 1999) view visualization as, "the user of computer–supported, interactive, visual representation of data to amplify cognition" clearly identifying the important role "interactivity" had begun to play in data visualizations.

Dynamic Home Finder (Shneidermann et al, 1993) serves as a good example of such an interactive visualization from this period. It was described by Ben Shneiderman as "… which first presented work associated with a well–formed model of direct manipulation." The example allows the user to discover possible homes based on criteria such as price, number of bedrooms, and distance to one's commute but also interactively seeing the relationships between these different attributes through a series of manipulation such as slider manipulation, range setting etc..This example demonstrates the effectiveness of the use of interactivity in visualization and how it can facilitate certain kind of discoveries.



Dynamic HomeFinder, Christopher Williamson and Ben Shneiderman, 1992

On the Origin of Species: The Preservation of Favoured Traces (Ben Fry, 2009)

Visualization can not only help make the unseen visible, it also affords the ability to make abstract things concrete which in turn can lead to a better understanding of them.

In that sense, Ben Fry defines information visualization as, "the use of computer–supported, interactive, visual representations of abstract data to amplify cognition." (Organic Information Design, 2009) His project, Preservation of Selected Traces, is an interactive animation of Darwin's complete text on evolution of the species. In the animation, Fry uses different colors to highlight the changes made by Darwin in each of the six editions of his famous book. Fry further explains that "The idea that we can actually see change over time in a person's thinking is fascinating. Darwin scholars are of course familiar with this story, but here we can view it directly, both on a macro–level as it animates, or word–by–word as we examine pieces of the text more closely.

Ben Fry's project demonstrates the obvious kind of discovery that visualization can help bring about, as the user can now "see how over time the pattern of book's additions and revisions become more and more intricate, as the changes from all the editions accumulate." (Lev Manovich, *What is visualization?*, 2010) There is also the element of unpredictable discovery that I came across. In the process of working on this piece I developed a far greater appreciation for Darwin's ideas than I had in the past." That realization would not have dawned upon me if not for having gone through and experienced this visualization project.

On the original of species: The Preservation of Favoured Traces, Ben Fry, 2009]

Street Museum (Brothers and Sisters, 2010)

StreetMuseum, is a great example of an application that effectively leverages today's technological capabilities and data visualization as a communication tool. It is essentially a mobile phone application that aims to provide its users a window into the history of a city like London. Leslie Wolke in his "*Wayfinding in Your Pocket*" article describes the working of the StreetMuseum application as follows, "… highlights 250 London locations on an interactive Google map. Click on a pin, choose "3D view," and an archival image from that specific viewpoint is composited translucently in real–time over today's street scene via the camera's viewfinder. Pan across a dense intersection, and the history of London is revealed in image after image in an eerie and fascinating way." (*segdDESIGN*, 2010)

This approach to visualizing historical images of the streets of London enable users to know more about the city they are or live in, tell the history associated with the city, and learn about the kinds of changes that has happened over the years.

As we can start to see from the examples highlighted above, data visualization as a design tool and approach is beginning to impact our everyday lives. By providing a visual form to abstract aspects of data and introducing interactivity visualization can reveal the unseen. It can consequently facilitate discovery and bring about a whole new kind of understanding. Its applications are numerous and diverse in areas such as science, art, technology and mobile applications to name just a few. As Manovich aptly summarized, "it is not so easy to come up with a definition which would work for all kinds of information visualization projects being created today and at the same would clearly separate it from other related fields such as scientific visualization and information design." (Lev Manovich, *What is Visualization?*, 2010)

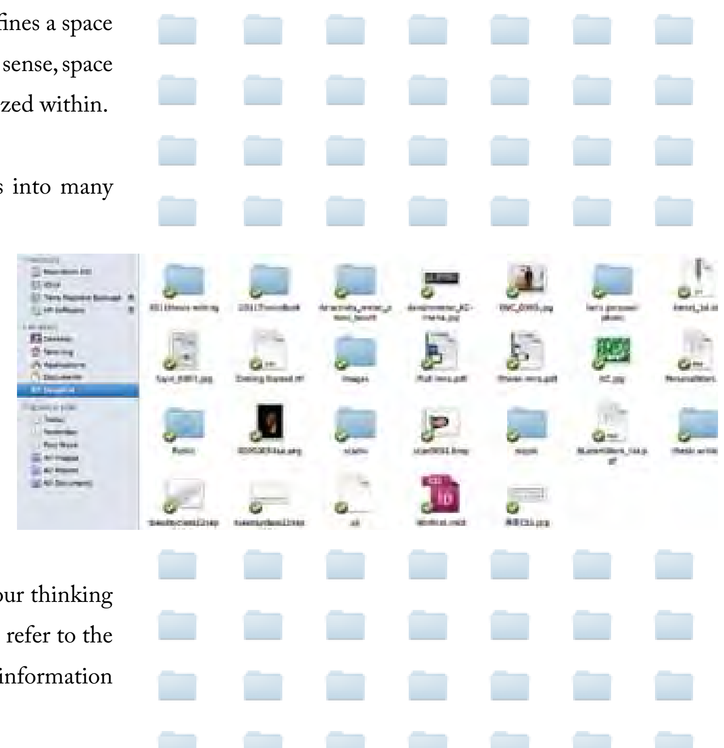
Having attained the necessary contextual background pertaining to data visualization we are now ready to move on to the next chapter where we will take a look at the different components involved with Designing for Discovery.

StreetMuseum, Brothers and Sisters, 2010

Analyzing the Information Space

Robert Colomb, in his book 'Information Spaces', defines a space to be a collection of places where things can be. In this sense, space can also be seen as a place where things can be organized within.

In our everyday life, we tend to organize our things into many different containers. For instance, we use a wardrobe to store our clothes using hooks and hangers to put away or hang our clothes. We use its drawers as a means to separate our clothes by their shape and function. In other words, we are categorizing things, in this case our clothes, and assigning them a place in our wardrobe.



This approach to how we look at and organize everyday physical things around us has greatly influenced our thinking of how to analyze and organize information or data. I refer to the place or space where this information ends up as the "information space."

A great example of what constitutes an information space and how to organize the information within this space is today's ubiquitous personal computer. The "desktop" in a personal computer is very much an extension of the physical desktop — a place where you find a collection of things; in this case files that equate to clothes in our wardrobes. You can also see that in a computer, files are organized in folders which are places within places. You can navigate to these places by simply clicking on them and look at the things within it.

Although the way we organize data within an information space builds on how we organize physical things in our everyday life there are some key principles behind this organization as identified by Richard Saul Wurman. Wurman identified five primary ways of possibly organizing any kind of information, namely by their Location, Alphabetically, by Time, by Category or by Hierarchy. It was up to the designer to determine which of the above would serve as the most appropriate organizational structure to store the information at hand.

While the above speaks to how information can be stored or organized, a more important consideration lies in how one goes about representing the information in order to communicate it. In that regards, Ben Fry points out a laundry list of visual structures that one can use to represent such information, namely table, scatter plot, line graph, bar graph, tree etc… He also points out that "the choice of which structure to represent the data is based on what is the simplest possible form that conveys the most relevant aspects of the data set." (*Computational Information Design*, 2004)

My case study "Star Tracker" that follows this chapter is an attempt at putting to practice this very thinking and understanding outlined above.

Case Study Star Tracker

Overview

Star Tracker is an experimental concept for a mobile phone application that leverages the "location aware" capability found in today's smart phones.

It is conceived as an application that will assist tourists in exploring new and unfamiliar environments in ways that are different from the traditional travel–guide dependent approach. By taking advantage of the phone's ability to be aware of the user's physical location at all times, the application serves up just the right kind of information to make the process of discovering a new place unique, enjoyable and informative.

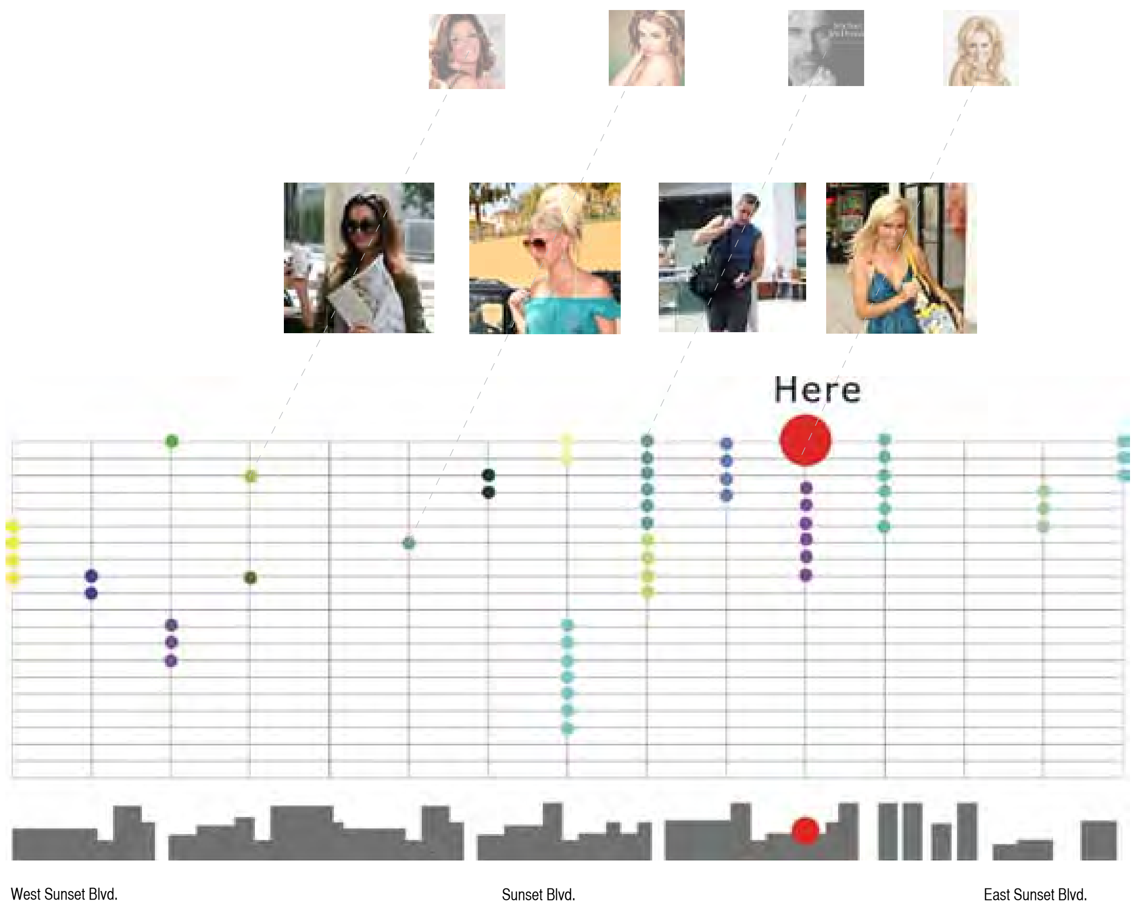
Tourist watching celebrity handprints in Grauman's Chinese Theatre, 2005

Motivation

The motivation for this project stemmed from my own disappointing experiences as a tourist while visiting the famous Sunset Boulevard in Los Angeles. Anyone who has visited this place knows the reason for doing so is to get to know this place through a variety of anecdotes having to do with its famous inhabitants – the Stars of Hollywood. Of course there is also the ulterior motive to possibly catching a rare glimpse of a Hollywood star and if one were lucky enough — be able to shake hands and take a photograph with them. And so there I was.

Unfortunately my experience on the Sunset Boulevard was quite different. The place was extremely crowded with tourists like me with no stars to be found anywhere in the vicinity. This wasn't the Sunset boulevard experience I had envisioned. That's when I realized that visiting a special place does not always translate into one having a special experience.

What I wished for was someone or something that would guide me through this place in a manner that would let me uniquely experience it for what the place was famously known for. In short, I wished to have a uniquely memorable experience of an entirely unfamiliar place.



Information space of Star Tracker

Design Process — Analyzing the Information Space

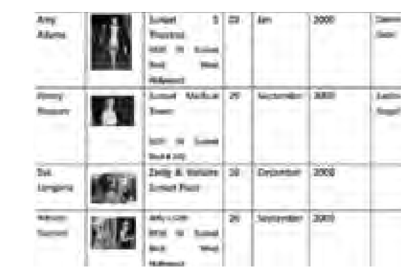
As I reflected on this past experience in the context of my newly found thesis interests I realized that it would lend itself as a great case study.

I began to equate this vast, unfamiliar and yet to be explored geographical location to its online equivalent of a big body of "data" that wasn't yet useful "information." The data in this case was all of the locations and sights along Sunset Boulevard which were famous on account of the celebrities who had once been spotted here. The data being literally scattered all over the boulevard presented a daunting challenge to the novice tourist. How then could a tourist navigate this vast space and end up having a memorable experience of getting to know it.

The challenge before me was to analyze all of this data and be able to design an experience around it that would help the user navigate the unfamiliar physical phase in an informed, intuitive and confident manner.

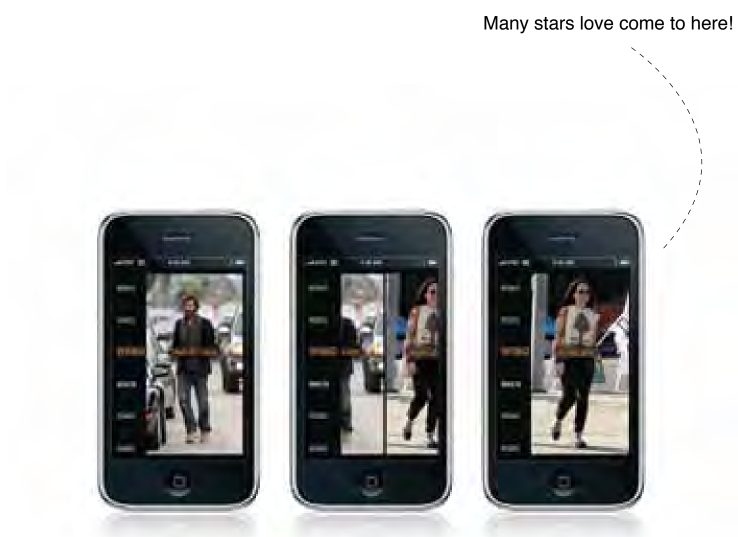
In the beginning I designed a static diagram to display the relationship between the movie stars and the physical locations along the Sunset Boulevard where they were once spotted.

Using the familiar two–dimensional coordinate system I assigned the X axis to be the entire length of the Sunset Boulevard. The individual film stars occupied the Y axis. This two–dimensional arrangement of data allowed me to effectively communicate information about which film stars had been spotted along the specific locations on the boulevard. However, I realized that it would be even more informative to depict the time period of this film star's

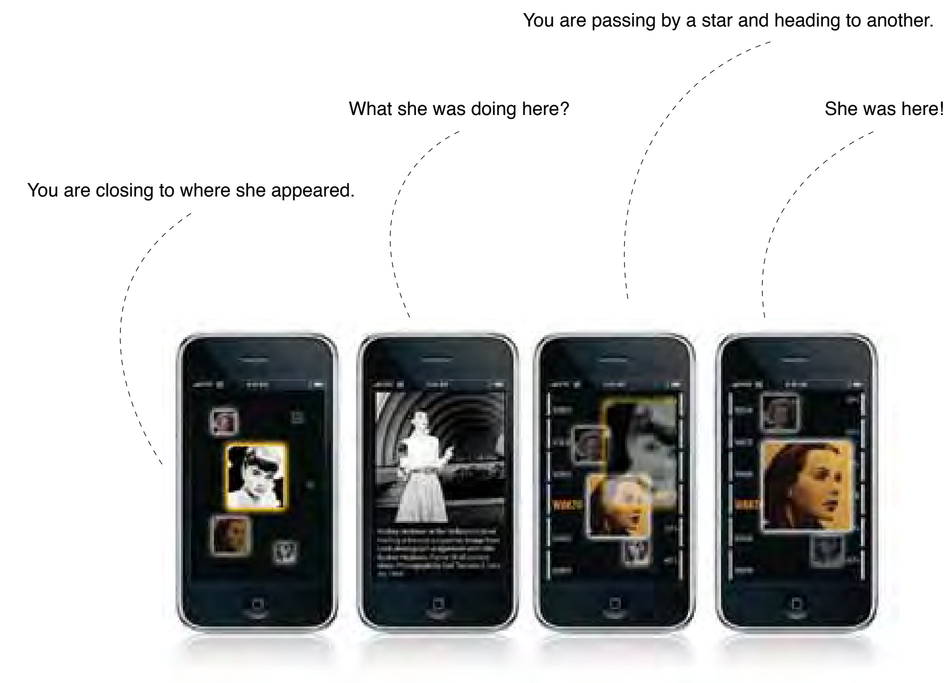

Information oranization in design processing

activity. A third dimension or Z–axis could be used to depict this additional piece of information about the movie star. It would add to the user's experience and make it that much more memorable. It was at this point when I realized that by adding a whole new dimension, I had unconsciously created an "information space".

My approach in analyzing the data to construct an information space around it is quite similar to how one would go about organizing a physical space. I build on familiar spatial sensibilities such as direction, sequence, and location to organize a virtual body of data.



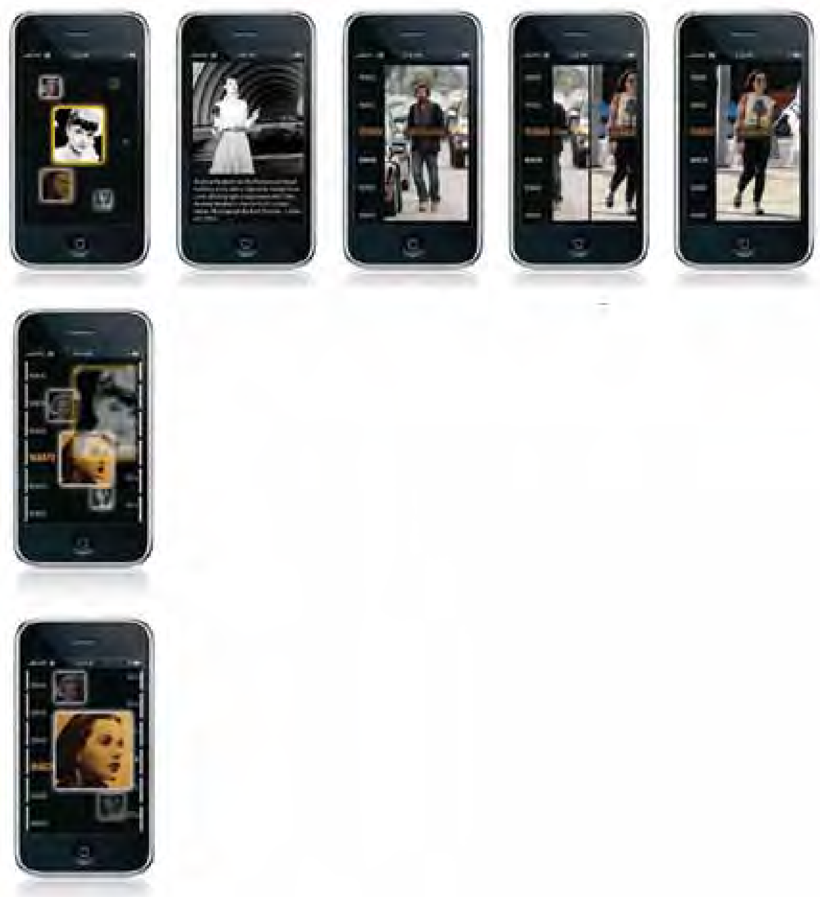
Panning, get to know who has been here.



Clicking, get to know who have been here and who they are.

Double clicking and paning on screen

GPS locating on Sunset Blvd.



Working Of The Application

Star Tracker was conceived as a database of movie stars that kept track of several interesting pieces of information regarding them, such as the time period to which they belonged, background information of where they came from, what they did before becoming a successful actor and more importantly, photographs of them with accompanying information of when and where they were captured.

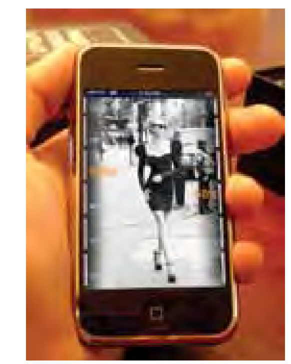
When the user (ala the tourist) would walk on the Sunset Boulevard, the Star Tracker application would then use the user's physical location as an input to fetch out interesting information specific to the user's location. Photographs of movie stars once spotted at this location would slowly fade in on the user's mobile phone. The photograph would also be accompanied by other interesting information about the celebrity which the user could interact with.

The entire experience and interface of 'Star Tracker' was designed with the intention of minimizing the anxiety and sense of being lost that tends to accompany all tourists visiting an entirely new place.

As the user begins to traverse the boulevard their physical locations begin to change. This change in physical location equates to traversing the information space. The constantly changing location also serves as the primary input to the Star Tracker application. The smart phones of today become the natural medium of choice on account of their location–aware and interaction capabilities with its user.

In addition to the user's physical location, I decided to implement a secondary input, namely the ability for the user to pick a particular time period that they were interested in. This ability to track the varying location of the user and accepting the choice of their favorite time period helps refine the resulting photograph of the movie star that the application chooses to display on screen.

Conclusion



I thought of what would constitute a satisfying journey of discovery in a new and unfamiliar setting. I compared it with how one would go about getting to know an entirely new concept or term through the lens of an online search experience. It begins with the user having an inkling of what it is they'd like to know more of. That kernel of thought becomes the term with which they initiate an online search. The search propels the user into a world of potential possibilities which the user then navigates through until they discover what they set out for and perhaps in that process, they might also learn something entirely new and unexpected. That to me is an engaging and satisfying journey of discovery, one that we have come to expect almost instantaneously from today's online search experience.

One of my objectives with the Star Tracker application was for the user to have an unexpected or unpredictable discovery at the end of this experience. In this regards, the Star Tracker experience differs from a typical online search in that the user does not have an idea of what to expect when he or she begins the journey. It is the user's movement that initiates the discovery and extends it as the user moves along the boulevard. The user's movement becomes the input for the system. The reward is the unexpected discoveries that the user makes as they step through a new and unfamiliar setting.

Designing a Wayfinding System

Kevin Lynch in his book "*The Image of the City*" (MIT Press, 1960), coined the term "Wayfinding" to describe how people perceived and organized spatial information in order to navigate through cities. His work identified that users formed mental maps of their surroundings in order to better understand them and pointed out five elements that users typically use to develop such a mental map, namely —

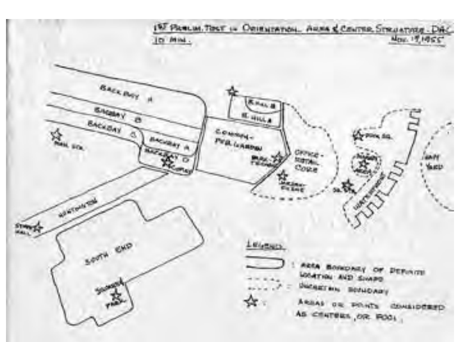
– Paths – the streets and trails in which people travel;

– Edges – perceived boundaries such as walls, shorelines;

– Districts – larger sections of a city grouped by virtue of some character;

– Nodes – intersections or focal points;

– Landmarks – identifiable objects that serve as external reference points.



Kevin Lynch, Sketch Map of Boston, 1955

Myke Gluck (*Making Sense of Human Wayfinding*, 1990) similarly defined Wayfinding as, "the process used to orient and navigate. The overall goal of wayfinding is to accurately relocate from one place to another in a large–scarce space". Peponis,et.al (*Finding the Building in Wayfinding*, 1990), described Wayfinding as " the ability of find a way to particular location in an expedient manner and to recognize the destination when reached".

While the above helps us get a sense of what Wayfinding is all about, Downs and Stea (*Cognitive Maps and Spatial Behavior*, 1973) describe the process behind designing Wayfinding systems. They state that Wayfinding is achieved in four steps.

– Orientation – Determining where one is in respect to nearby objects and the target location.

– Route Decision – Choosing a route that will get one to their destination.

– Route Monitoring – Monitoring the route one has taken to confirm that one is on the correct route and is going in the right direction.

– Destination Recognition – Recognizing that one has reached the correct destination, or at least a point nearby.

Architecture and city planners apply these very theories to tackle Wayfinding problems. The most basic example of such a Wayfinding system is the familiar "You–Are–Here" kiosk maps that we come across in high traffic tourist landmarks. These maps communicate to a tourist where exactly they are in relation to the surrounding area, highlighting easy to spot and recognizable landmarks in order to orient themselves. Frequent signage at critical decision points along the route also help people check, orient and organize themsevles along a route so that they feel confident that they are heading in the right direction.

So far we have looked at the principles or thinking behind Wayfinding systems for physical or geographical spaces. It is interesting to note that these principles have also played a fundamental role in designing similar systems in the virtual world of information spaces.

We can notice the similarities in approach by observing the navigational structure of the World Wide Web rendered through the lens of a web browser. For example, a location in the informational space of the World Wide Web is uniquely identified by its own address called URL (Uniform Resource Locator). This is no different from the physical world where each geographical location has a unique address (a particular latitude and longitude.) This uniqueness is critical to knowing that you have arrived at your desired destination as there is no other place that shares the same address. Additionally, the web has created this notion of back (previous) and forward (next) states and ties them to specific buttons on the browser (identifiable by their visually distinctive back and forward arrows) that allow you to traverse the web and support sequential navigation similar to navigating in the physical world. And perhaps the most important feature of the web browser is its Home button that serves as an important and grounding landmark. Users can always return to Home (as in, to this location) by simply clicking on this button and restart their exploration of the information space once again. This is no different from the 'You–Are–Here' marker on a physical map that always lets one know of your current location and offers you directions from that point on to your eventual destination.

The definitions and perspectives summarized above highlight key aspects of Wayfinding relevant to my thesis investigation. Designing an appropriate Wayfinding system is an important second component to the overall process of Designing for Discovery. It serves a critical function from an information design stand point where the user gets to navigate the unknown information space in familiar ways so they can acquaint themselves with the data. My case study, Memento: Film Explorer, that follows next not only tries to explore but more importantly, apply the principles of good Wayfinding systems discussed above.

Case Study Memento: Film Explorer

Overview

Memento: Film Explorer is an interactive application that offers its users a unique way to experience and explore the film 'Memento.' The film's sequences become a body of information which the users of the application navigate through, in order to form an understanding of what actually transpired in the movie.

The design of the interface and the overall experience of this virtual application build upon traditional wayfinding principles as they pertain to physical spaces. By taking advantage of wayfinding theories, the interface organizes the various sequences in the movie into a navigable information space that the user can then navigate, explore and more importantly, make interesting discoveries regarding the movie's plot.

Motivation

As part of my course 'Design Studio' at DMI, we were assigned the task of creating an interactive interface for a viewer to experience Christopher Nolan's film, Memento (c. 2000) in an alternative manner. This film is famous for its non–linear narrative structure and in particular for how it uniquely presents its story. To those unfamiliar with the movie, Memento is "presented as two different sequences of scenes, a series in black–and–white that are shown chronologically, and a series of color sequences shown in reverse order. The two sequences "meet" at the end of the film, producing one common story." (Andy Klein, *"Everything you wanted to know about "Memento"*. Salon.com. http://archive.salon.com/ent/movies/feature/2001/06/28/memento_analysis/index.html)

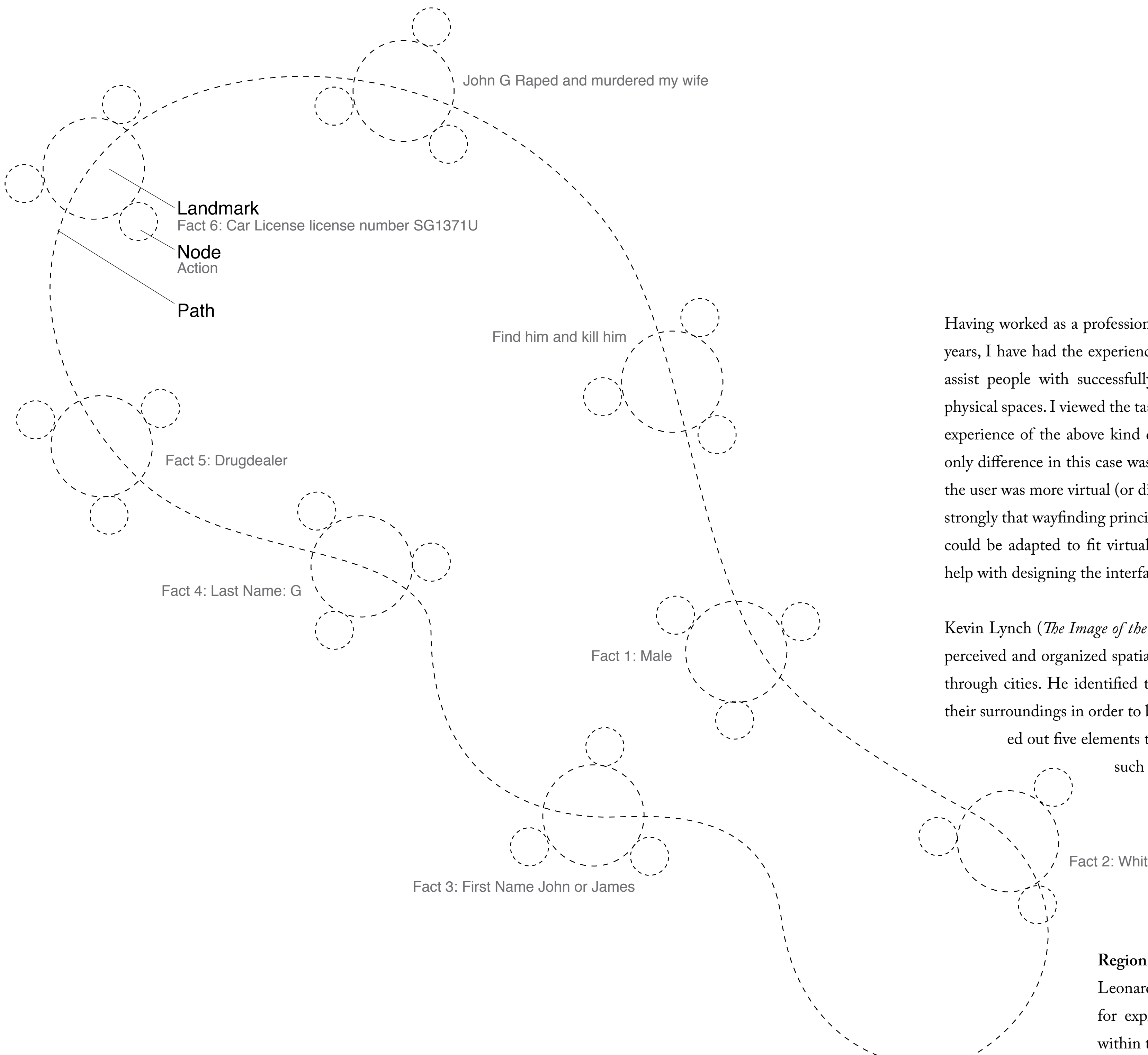
Memento was perhaps the most confusing movie that I had ever seen. It at once became clear to me that there was a need for an interactive interface that would help the viewer in exploring and investigating specific aspects of the movie so as to better understand the movie's plot. Such an interface would help clarify the various relationships between the different cast members and also help validate whether or not the hero's suspicions of the identity of his wife's killer were accurate.

In observing, Leonard Shelby, the main actor or hero of the movie I realized that the numerous tattoo's engraved on his body were not only important to him but also served as important visual clues essential to understanding the movie's plot. Based on this observation, I decided to use Leonard's body as a natural interface for the application.

The decision to use Leonard's body as an interface meant that the various tattoos on his body would now be part of an information space. In order to accurately understand the movie and its plot, users of this application would have to explore and successfully navigate this information space.

In addition to Leonard's tattoos, the film sequences were also of obvious importance. After viewing the movie several times I came up with a way of classifying the movie clips (or sequences) in to 3 main categories — scene, evidence and action. Thus, the information space for this application now consisted of two main elements, namely

– The collection of tattoos on Leonard's body
– The various movie clips or sequences



Having worked as a professional Wayfinding designer for over 8 years, I have had the experience designing navigational aids that assist people with successfully navigating new and unfamiliar physical spaces. I viewed the task of designing a virtual interactive experience of the above kind quite similar and challenging. The only difference in this case was that the space to be navigated by the user was more virtual (or digital) as opposed to physical. I felt strongly that wayfinding principles that applied to physical spaces could be adapted to fit virtual or informational spaces and also help with designing the interface to explore and navigate them.

Kevin Lynch (*The Image of the City*, 1960) described how people perceived and organized spatial information in order to navigate through cities. He identified that users formed mental maps of their surroundings in order to better understand them and pointed out five elements that users typically used to develop such a mental map, namely Paths, Edges, Districts, Nodes and Landmarks. I began by finding the equivalent entities for each of these elements in the information space.

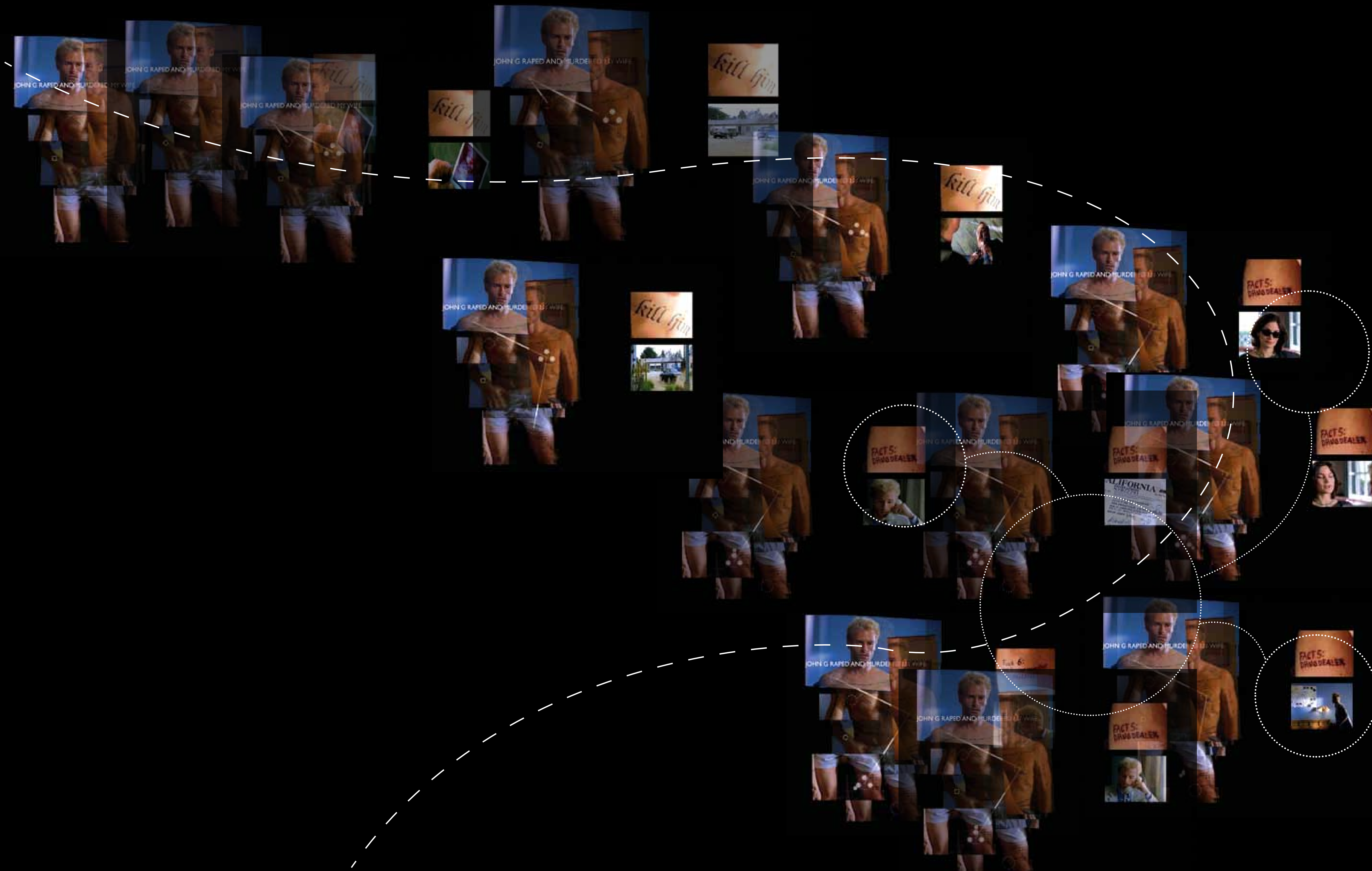
Region: I consider the entire body of Leonard Shelby as the "region" available for exploration and for people to travel within this application.

Paths: Lynch defines paths as "channels by which people move along in their travels" in physical space. In this case, a circular path emerges as I start to link different regions with a line. Once the beginning and ending points of these regions are enclosed, a two way route emerges that allows the user of the application to navigate the sequences within the movie in chronological or reverse order.

Landmarks: Since Lynch defines landmarks as "a store, mountain, school, or any other object that aids in orientation when wayfinding", I decided to treat every tattoo on Leonard's body as a landmark in its own right. Each tattoo has an underlying connection tied to an important fact that contributes to the user's understanding of the overall film's plot line.

Nodes: Lynch defined nodes to be "intersections or focal points". In my case, I can see the individual film sequences or clips as nodes or places within a space.

Finally, design principles pertinent to wayfinding signage where employed to design the interface for the application. The interface consists of a body map embedded with landmarks, routes and nodes, and all of the film clips from the movie arranged alongside nodes in a two way path. My application's interface allows exploration of the film's information space in a layout very similar to that of a Japanese garden. The reason for this particular layout was to mimic the navigational experience of a person visiting a Japanese garden where they can traverse the entire garden and view it from all possible angles without ever repeating the same sight twice.


JOHN G RAPED AND MURDERED
kill him
FACTS:
DRUG DEALER

Working

As mentioned previously, I intentionally chose to use Leonard's body as an interface for this application since the tattoos on his body were critical to understanding the movie. The sequence of movie clips become the virtual 'information space' that the user has to explore and navigate in order to comprehend the movie's plot. The user's exploration of this space begins by their moving of the mouse over the layered and collaged body of Leonard. I see the interface as metaphorically similar to the "You–Are–Here" map that often helps people orient themselves in new and unfamiliar places.

As the user moves their mouse over a tattoo or landmark on Leonard's body, an interactive graphic appears over this landmark. When the user clicks on the landmark, a related landmark (or tattoo) is highlighted. This newly highlighted landmark tries to hint to the user the next one in sequence that they should perhaps look into. In this way the interface tries to guide the user on to landmarks in a sequence that best explains the movie's plot.

By double clicking on a landmark, related landmarks and lines connecting them appear. These connecting lines indicate to the user likely routes that they can take and the landmarks that they can next explore. The capability of the application's interface to selectively reveal and highlight suggested routes and landmarks to next explore, attest to the applications wayfinding attributes which assist the user in easily identifying what lies ahead, and how to go about exploring it.

When the user moves his mouse over a particular kind of landmark that happens to be associated with several important facts critical to understanding the movie's plot, the interface not only highlights the landmark but additionally presents three additional circles surrounding it. The three circles represent the three categories of movie clips namely, scene, evidence and action. Interacting with the three circles by clicking them will automatically play the associated movie clip. This feature of the interface helps the user explore an important landmark in greater detail by viewing what actually transpired in the movie thus contributing to the user's understanding of the movie.

While the interface selectively reveals landmarks over time in a manner best designed to understand the movie's plot it also does not prevent the user from exploring landmarks of their choosing. The user can always choose to take their own path or route to explore the various landmarks (tattoos) on Leonard's body in chronological or reverse chronological order to verify their understanding of what transpired in the movie. The interface is thus designed to be flexible enough to allow for a users instinctive exploration.

The above features in the application's interface help create an interesting interactive environment that effectively contributes to the user's understanding of the movie.

Conclusion

Memento: Film Explorer was a great exercise for me in exploring how traditional wayfinding strategies as they apply to physical spaces can be adapted to fit the design challenges of information spaces. Wayfinding design principles heavily influenced almost every aspect of my case study namely, navigation, the interface for the application, choice of how to represent landmarks, selectively highlighting landmarks and routes or path to traverse from one to another, providing instant access to related content such as movie clips from 3 different vantage points of scene, evidence and action and allowing the user to traverse these routes either of their choosing or by that of the application. Overall, wayfinding design principles helped me create an interesting and interactive interface that allowed a user to uniquely explore the non–linear narrative structure of the feature film, Memento.

Visualization And The Role Of Interactivity

The Oxford English dictionary defines Visualization as, "to form a mental vision, image, or picture of (something not visible or present to sight or an abstraction); to make visible to the mind or imagination." In other words visualization offers a means to showing the unseen. However, this raises an important question of whether seeing necessarily translates to an understanding of the unseen?

I believe that data visualization has the potential to facilitate an understanding of data. By conceiving visualizations that provide visual form to abstract data and by additionally introducing the element of meaningful interactivity one can create engaging and rich experiences that contribute to an understanding of the data. I see this step as an important and final component to "Designing for Discovery."

Ben Fry best described the role and potential of interactivity as an exploratory tool within a data visualization. He states "Interaction is an essential component of visualization, particularly for enabling the representation of much larger structures by relying on user interaction. The ability to show and hide elements of interest, or to zoom in to a particular area of interest for a more detailed view are capabilities unique to interactive interfaces." (*Organic Information Design*, 2000)

With the advent of newer and more powerful computer technologies the field of data visualization has advanced tremendously. We now have the ability to work with a variety of media that can provide not just visual but aural form to abstract data and more importantly, the capability to introduce 'interactivity'. Today's data visualizations range from static animations to those with incredibly rich interactive capabilities. Besides the above mentioned features, the user interfaces to access these experiences have also undergone a sea change. The early graphical–user–interfaces offered a single person point and click interaction. These interfaces have also evolved in to more advanced multi–touch gesture based or voice responsive interfaces affording greater room for interaction and exploration.

Gone are the days of linear and predictable experiences, instead the interactive experiences of today are more dynamic, non–linear and can take the user in many different directions resulting in unanticipated outcomes. This flexibility has allowed the user to adapt the overall experience to better fit their cognitive style of thinking and understanding. The simplest example of such an experience is that of our interaction with an email application where you begin to notice how the application uses iconography that relates metaphorically to how we communicate in our everyday life. Users have the capability to sort, rearrange, and filter emails based on their likes and needs.

At the same time, it is important for the choice of interactions to be limited and thoughtful. Merely introducing interaction into an experience for the sake of it can result in confusion and take away from the meaningful exploration that is possible. As part of my thesis investigation, I am interested in exploring the amount and range of interactivity that can be introduced into data visualizations so as to encourage user exploration and foster unexpected discoveries.

My case studies Gala Redux and Star Tracker respectively explore the process of Designing for Discovery without and with the presence of interactivity in them. Gala Redux is a static visualization (devoid of interactivity) of horizontally connected video frames that obey traditional spatial rules. 34,560 frames are horizontally arranged within four vertical squares in order to put forth an entirely new and engaging visual experience of viewing a video. Attractivity Meter is conceived as an interactive online application that allows a user to explore how attractive he or she is, and in the process discover how many and which other individuals are similar looking to them.

These two case studies, which are discussed in greater detail in the next section, demonstrate how visualization can serve as a unique approach in exploring and understanding abstract data sets and also explore the role of interactivity.

Case Study

Gala Redux

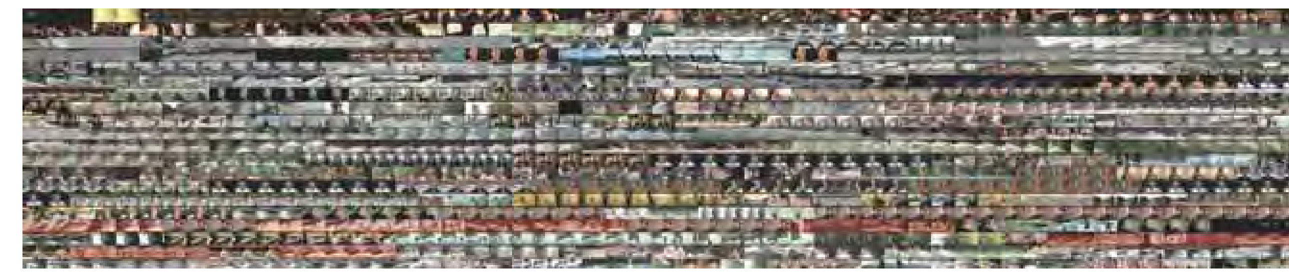
Project Overview

I first encountered Cinema Redux, the work of artist Brendan Dawes, at The Museum of Modern Art (MoMA) where I was confronted by an enormous wall of tiny pictures stringed together row after row that happened to be a sample representation of the entire length of a movie. I was struck by both its visual impact and rather unusual form of depiction. Dawes explains his project as an effort to create a single visual distillation of an entire movie. The result of his work is a unique fingerprint of an entire movie, born out of taking many moments in a film and placing them all together in one single moment to create something entirely new.

I recall the conversation that followed with my friends regarding the contemporary visual culture of China. We were personally frustrated with the vivid redness that was so prominent and pervasive in our mainstream media. At a personal level, I was also worried at being Sovietized on account of the omnipresent red. If we were back home in China we probably would never have had that conversation or publicly voiced our opinion — we would have only quietly thought about it.

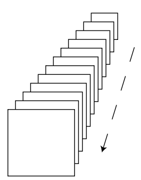

The program of CCTV Gala, 2007

Motivation

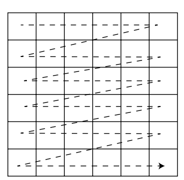

Keep Surfing, Brendan Dawes, 2004

The inspiration for Gala Redux came from 'Cinema Redux'. Dawes's work however provided me a whole new perspective on how to observe streaming video. It also inspired me to take a serious look at how one would go about quantifying the amount of 'redness' that pervaded the media. Would the resulting outcome help prove that I had a legitimate concern or would it dispel my exaggerated worry?

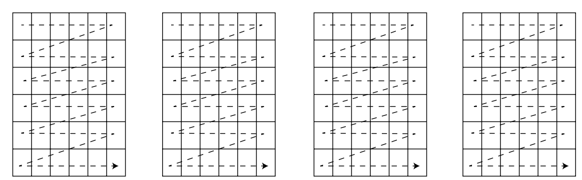
I began to think of video recordings from various 'events' that could serve as an ideal representative sample for my experiment. The video recording of the Lunar New Year celebrations seemed like a perfect match for my case study. This celebration or gala is an annual Chinese tradition inviting scores of viewers. It is an all–night stage show with acts ranging from traditional song and dance, to pop music and comedy alongside a heavy dose of state propaganda. The event being a yearly production would help my experiment have access to a rich set of data spanning several years. I was curious of the outcome of this experiment and to find out if it would help me satisfactorily answer the questions I had raised above.



Sequence of Movie



Sequence of Cinema Redux

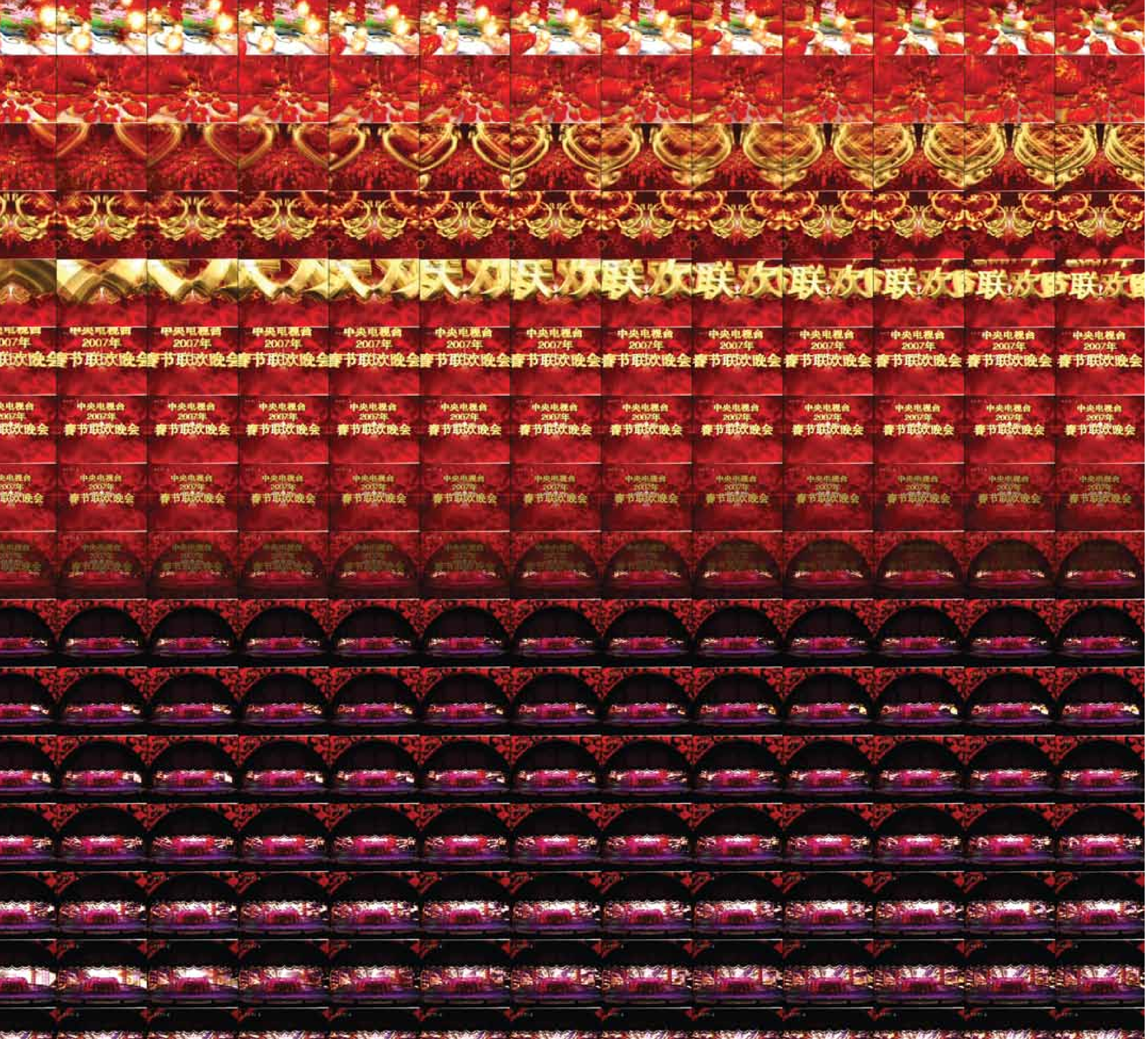


Sequence of Gala Redux

Structure

I further analyzed the approach taken by Dawes in his execution of '*Cinema Redux*'. I observed how his decision of breaking out the once linearly arranged frames of a movie into more of a Zig–Zag pattern that filled only that many spots in a row before repeating the process on an entirely different line actually added to the visual impact of the overall project. This innovative approach allows one to observe a movie in a completely different perspective thus leading to a whole new experience of the same content.

The visual representation of Gala Redux is borrowed from Dawes's rendition but with a slight modification. I digitally visualized just the first three minutes of the video from successive years, namely 2007 to 2010. The width of the column containing the movie frames for a given year is significantly lesser than that of Dawes's. I do this so that I can combine and juxtapose the visual results from each year in order to help highlight the 'red'ness present in the video recordings spanning four years. The changes in density, color, and brightness also add to this effect. I felt that this approach was the most appropriate to highlight and answer the concerns I had at the onset of this project.

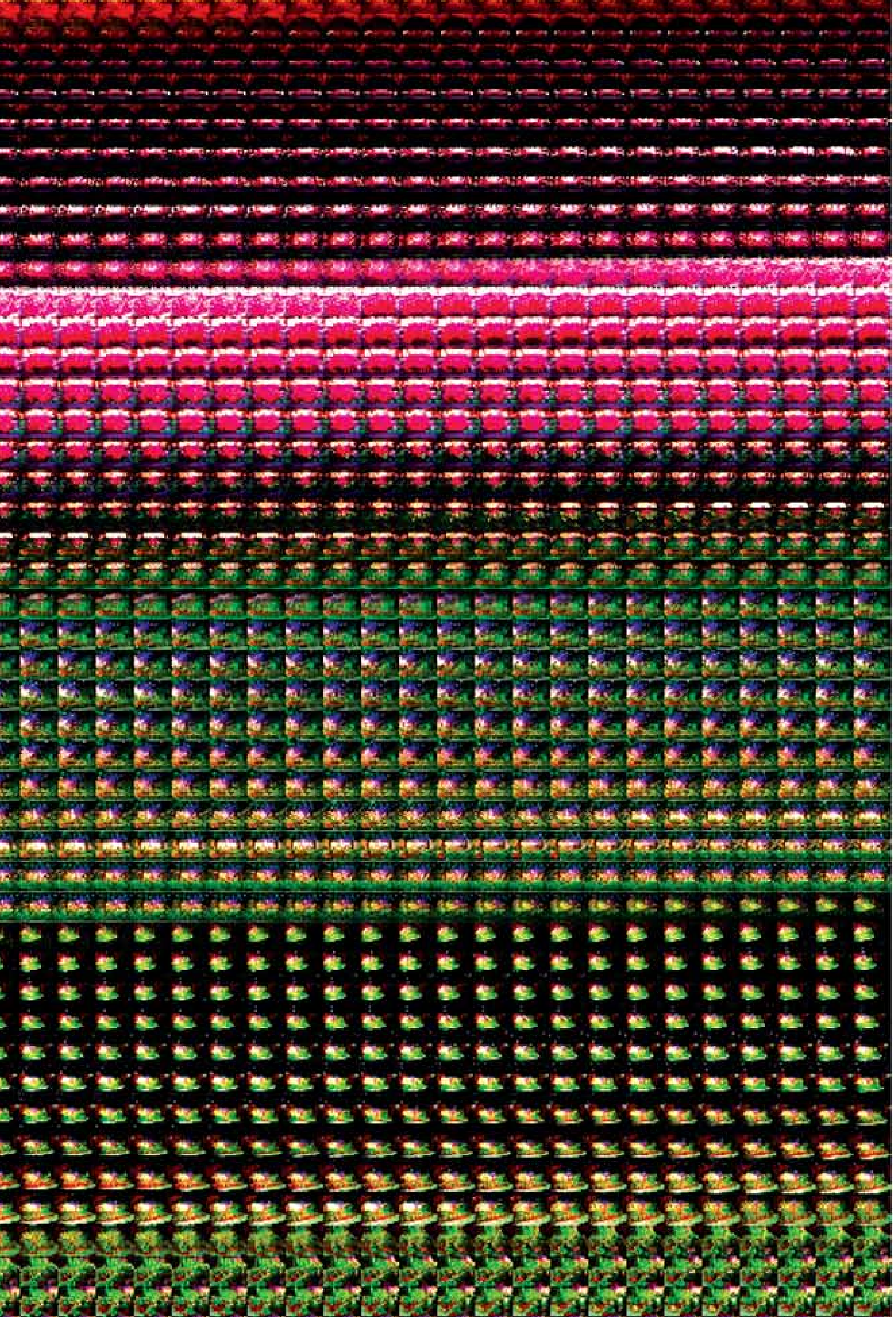
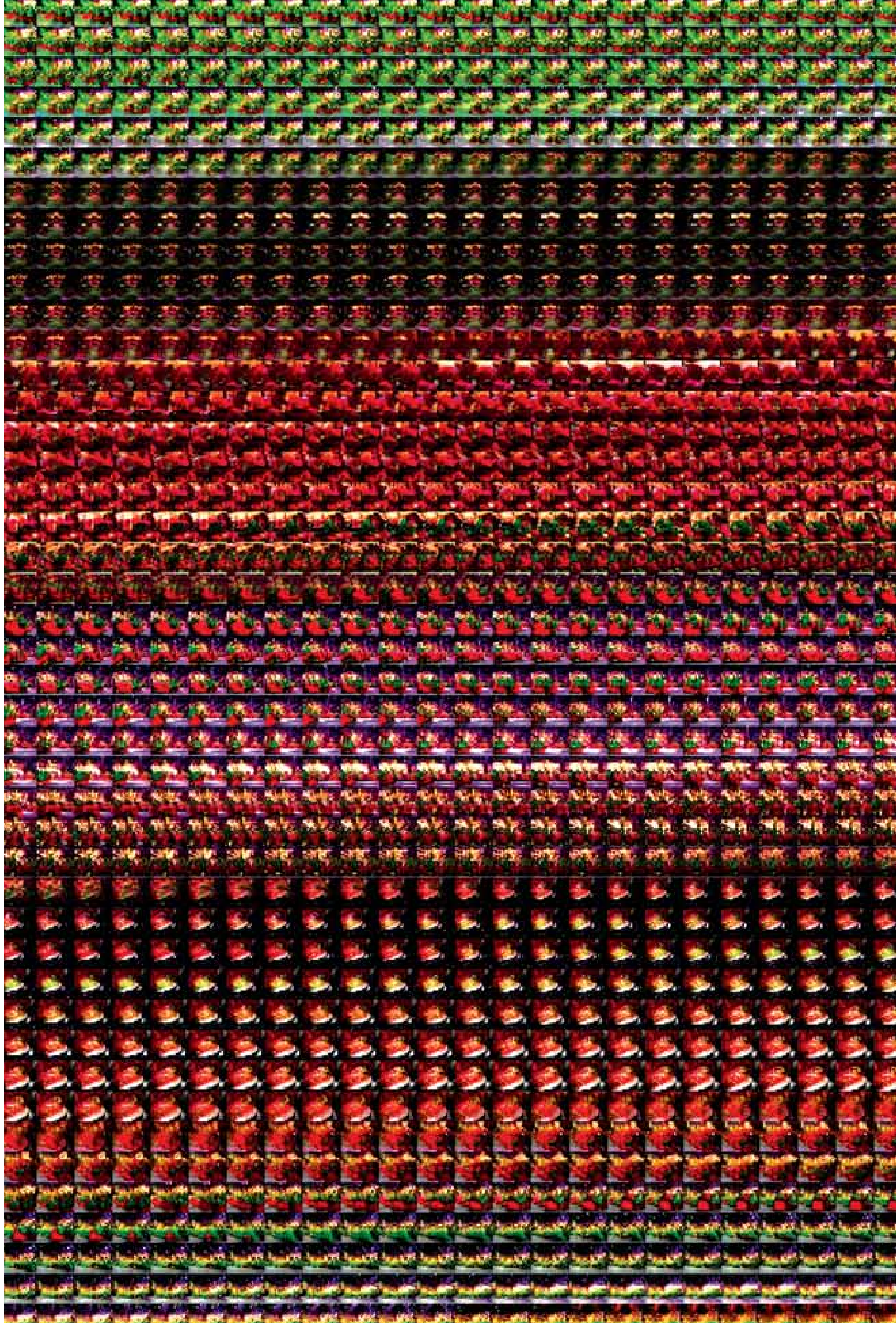


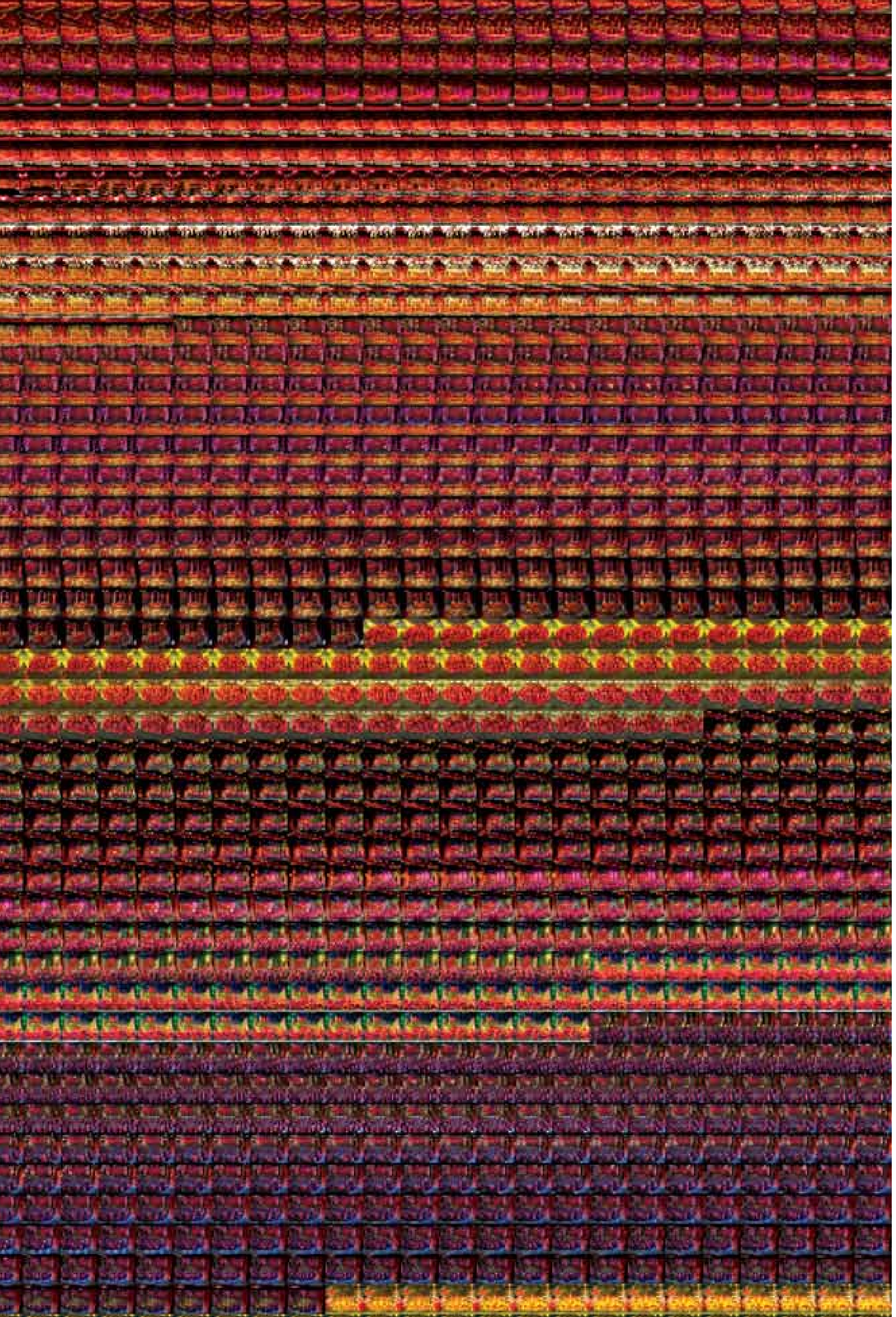
Process

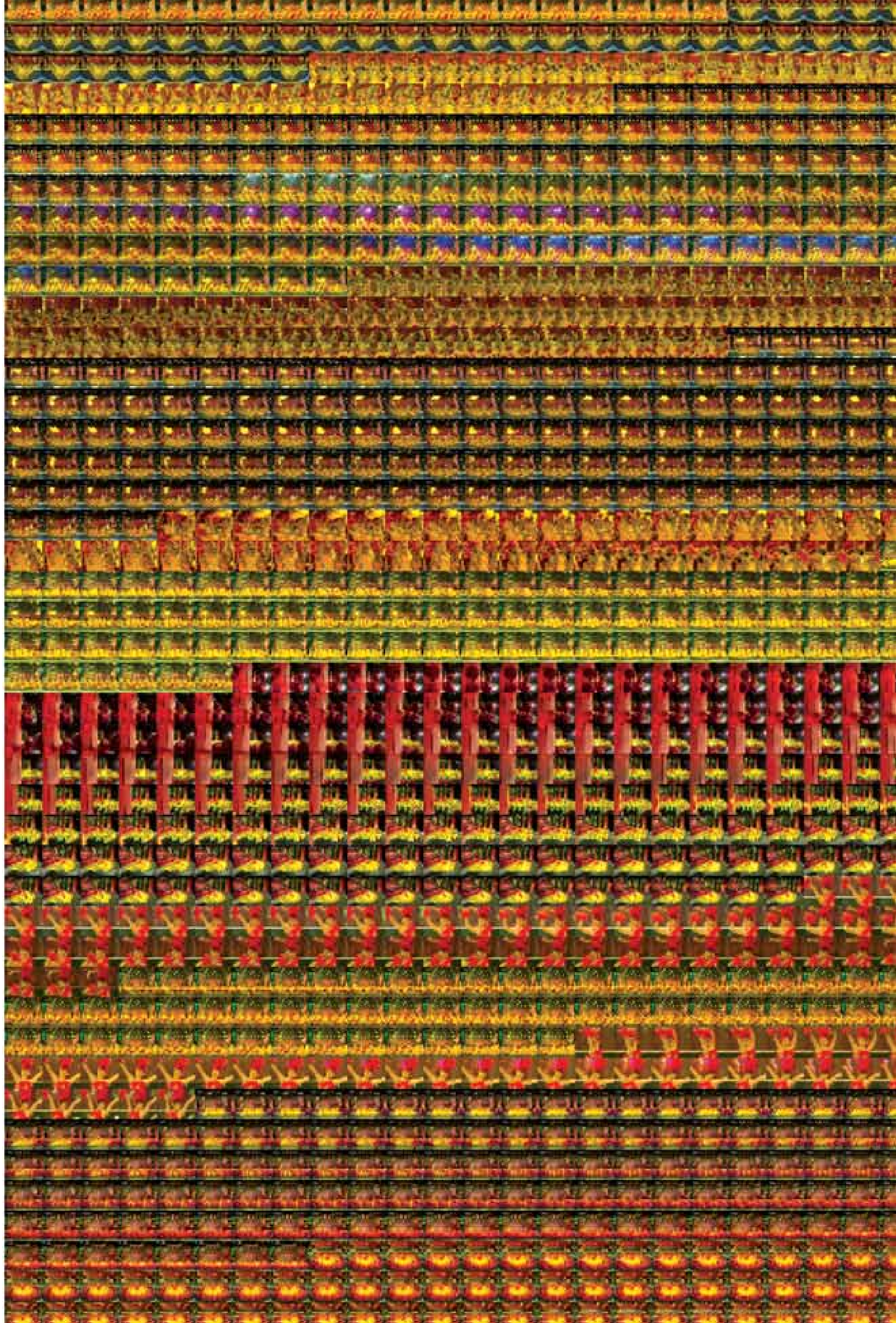
As mentioned previously, I digitally visualized the first three minutes of 4 years worth of video recording starting from 2007 to 2010, of the celebrations from the Lunar New Year.

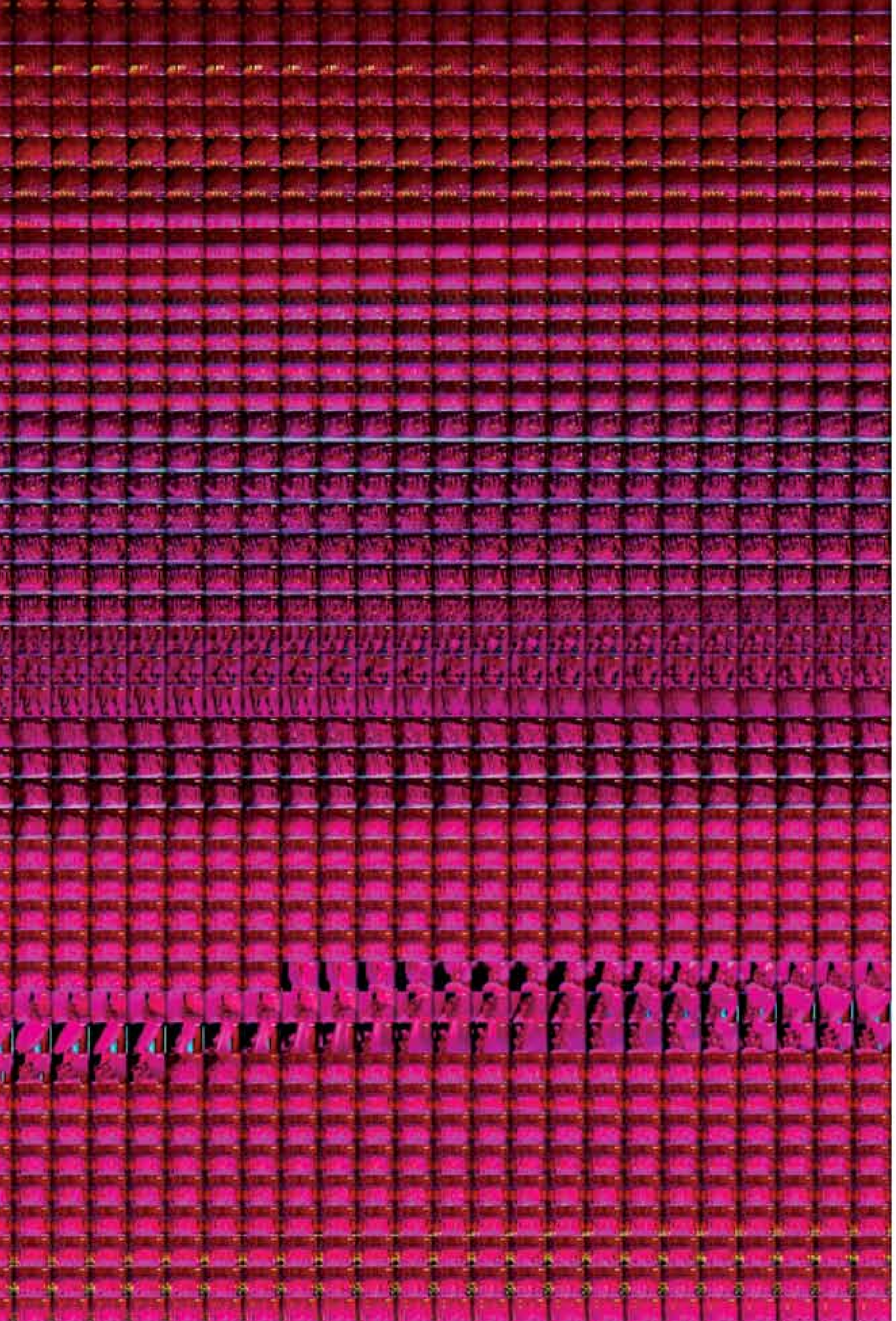
I built an application that could read the videos of the event using the open source computer programming software, Processing and another open source computer vision library called openCV, which assists with real time image processing. I then sampled the first three minutes of video from each year's event at a rate of one frame per 1/24 second. The result was then scaled to fit the entire frame of the animation. I then programmatically arranged these frames in a rectangular grid with each row representing a single second of the video. The resulting grid or column consisting of 8640 frames (24 times 360) now represented the first 3 minutes of each year's video. Finally, I decided to the place the grids from each year next to one another so as to possibly highlight any 'red'ness that might be evident from the video recordings.

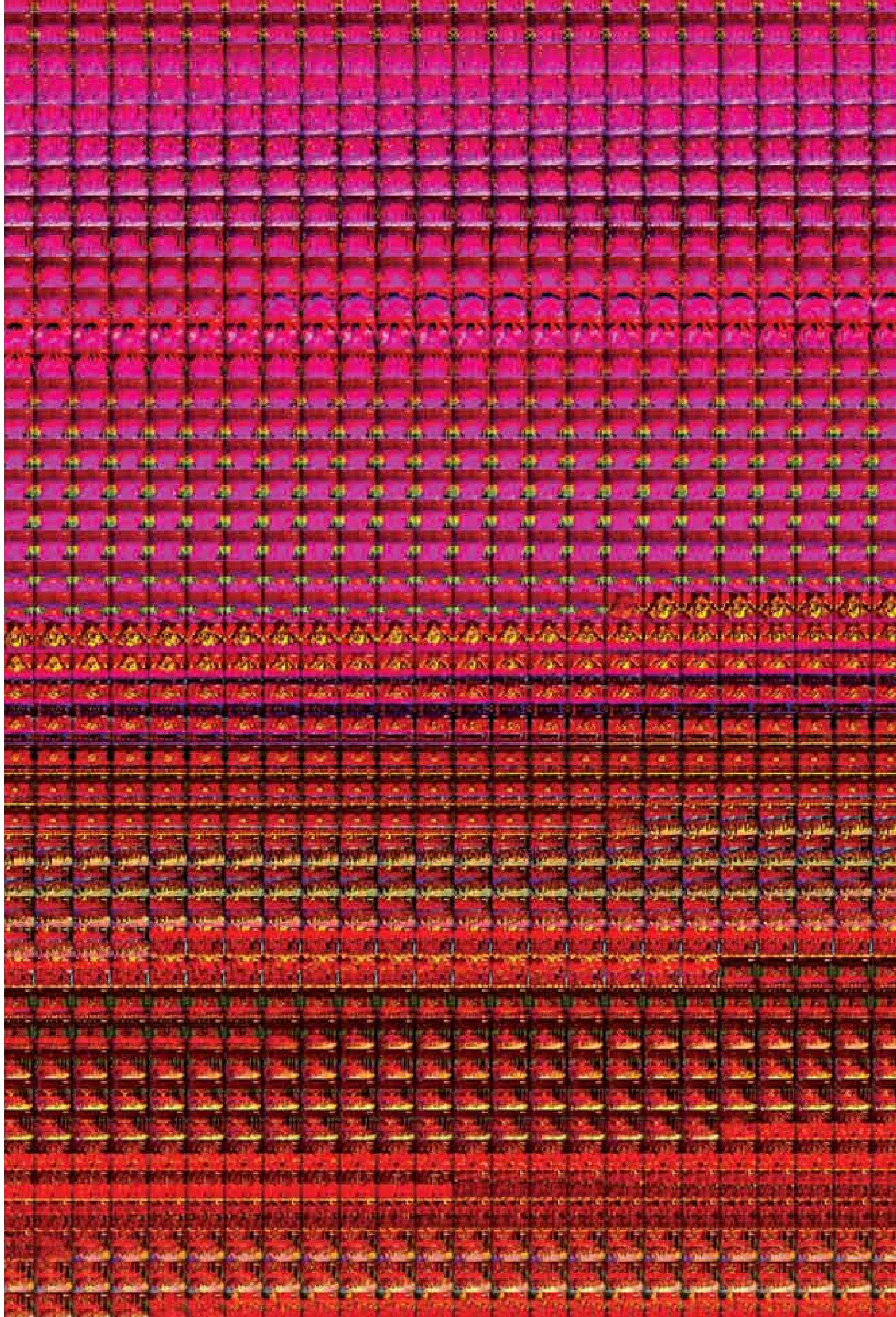
Building off of Lev Manovich's suggestion where in when having been confronted with a "trade–off between the two possible extremes: preserving all the details of the original artifact and abstracting its structure completely." (*What is Visualization?*, manovich.net, 2010) I intentionally gave up on the additional details in the original frames instead opting for a higher degree of abstraction that would allow the pattern of 'red'ness to emerge clearly. I felt that this not only allowed it to be more visually engaging but also successful at revealing a pattern over a duration.

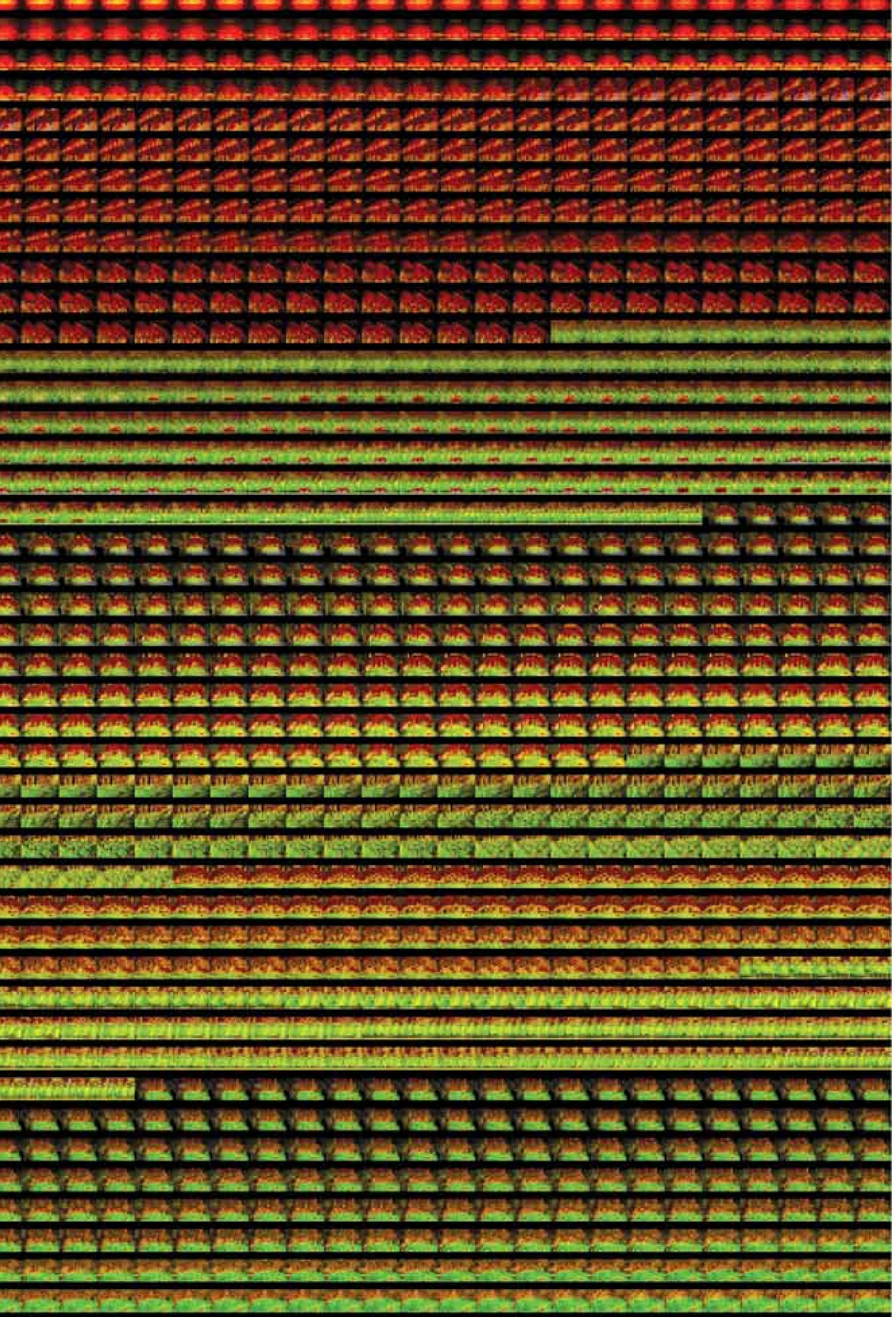
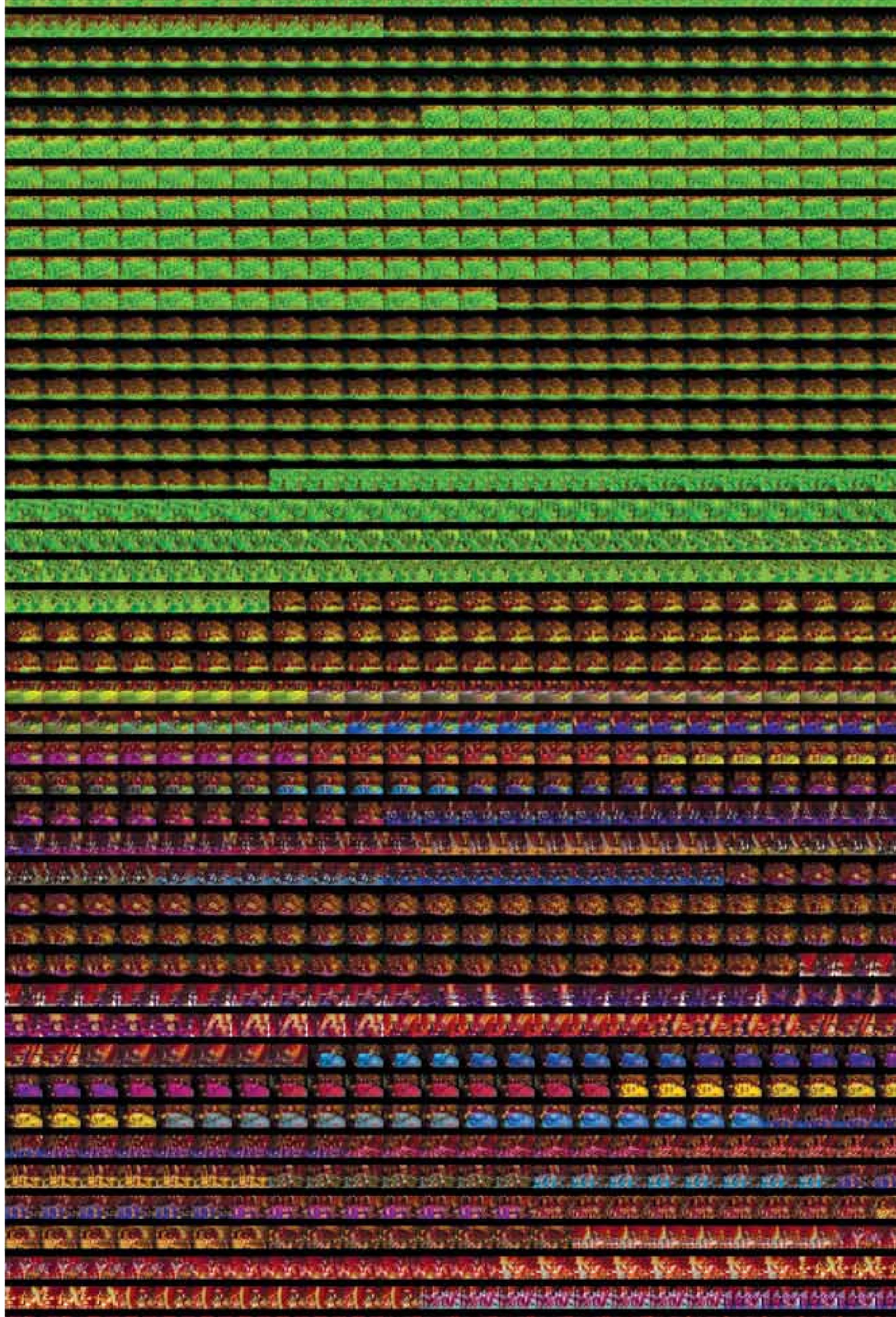



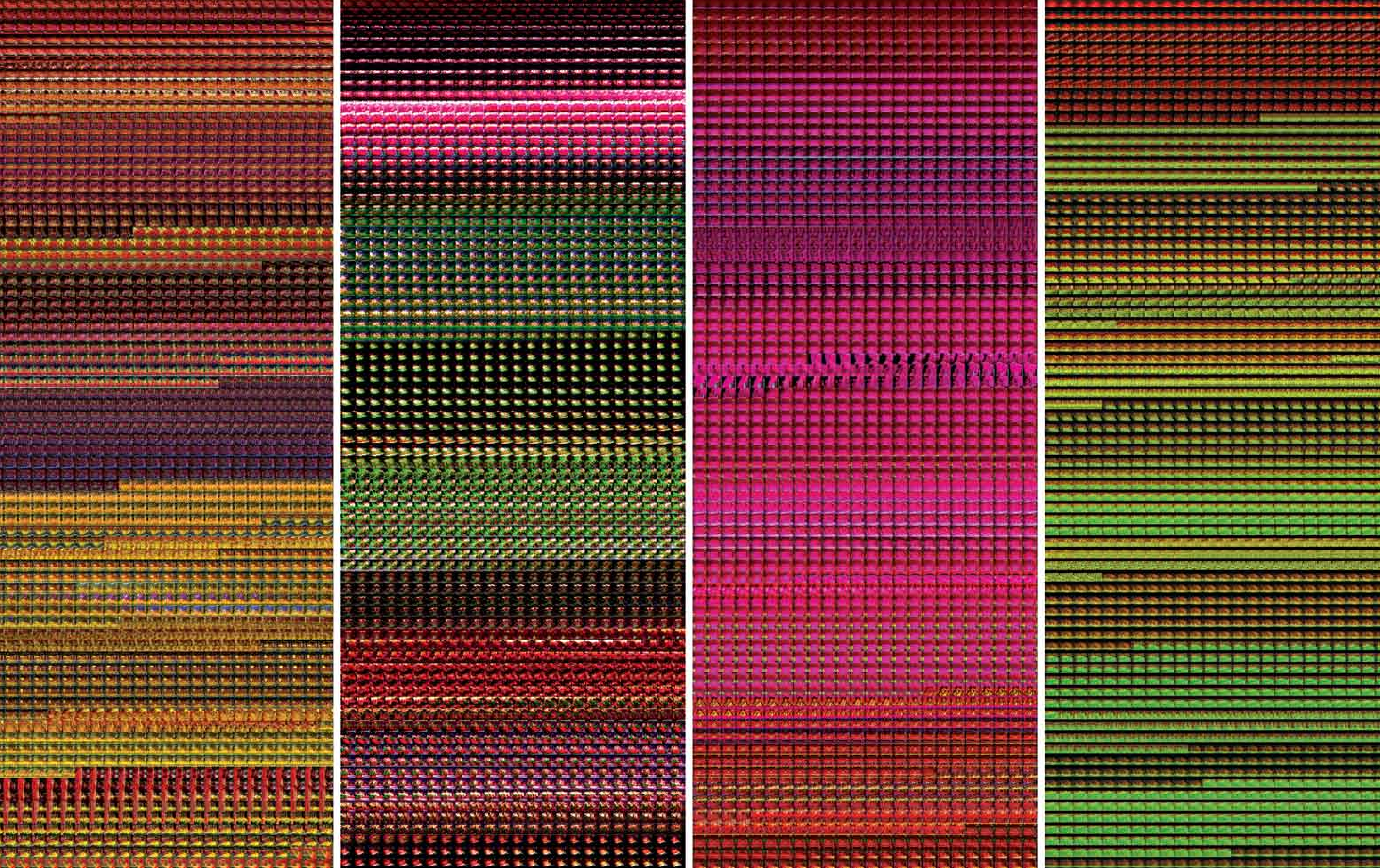










Gala Redux, 2010
Inkjet Print on Paper, 72cm x 100cm

Conclusion

Gala Redux was exhibited in the Carol Grillo Art Gallery at Endicott College and the Museum of Art at Guangzhou Academy of Fine Art. The response from viewers was both enthusiastic and enlightening in that it helped me refine my work further.

Some of the feedback I received from viewers was that they didn't quite understand where the vivid colored dots came from. Their response triggered a debate in me on how best to visually represent data — would a detailed approach or a more abstract approach work better? I realized it was a question I would often find myself asking with each new project fully realizing that there was no right answer rather it was the final intent of the project that would best determine what works.

The execution of Gala Redux also helped me learn a lot about technology and computation, particularly how to programmatically work with video. The skills I learned in this project greatly assisted me in the projects that followed since.

Case Study Attractivity Meter

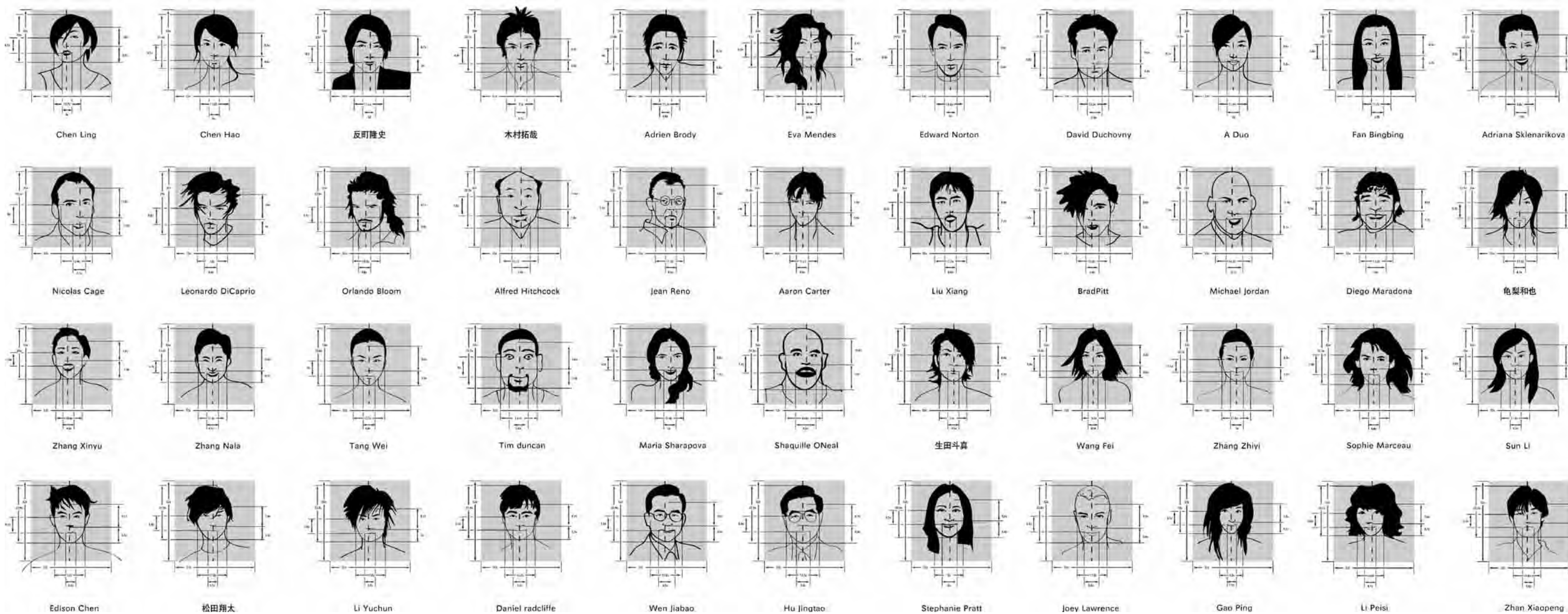
Project Overview

Attractivity Meter was conceived as an online interactive application, that allows its user to explore how close their facial characteristics are to those of an "average" attractive face (as determined from the data accumulated by University of Regensburg's Psychology Department). Additionally, the application allows them to compare their facial proportions to those of other users in its database in order to facilitate the discovery of similarly proportioned (or that I refer to here as, attractive) individuals as themselves.

Motivation

About a decade ago, my professor, Ota Yukio, told me that I looked like a very famous Japanese person by the name of "Ms. Sazae". Not knowing who Ms. Sazae was and especially how she looked. I was clearly worried as to what exactly my professor meant. Did he mean that I looked as beautiful and attractive as her or did he mean the opposite?

Needless to say, I quickly researched any and all photos of this mysterious Ms. Sazae. Much to my surprise, Ms. Sazae actually turned out to be quite attractive. This experience of mine began to make me wonder how the anxiety that often follows simple comments, such as "… you look so much like this person …" could be lessened. Was there a way to offer people a means to find out how they appeared when compared to other individuals? Although, beauty lies in the eyes of the beholder, I was curious to find out if there was such a thing as an "average" attractive face, how one would go about comparing themselves to such a face, and how many other individuals in the world were similarly attractive as themselves. These curiosities and questions inspired my case study, Attractivity Meter.



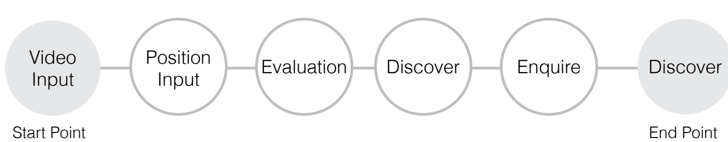
Sketch of face proportion measurement

Structure

In thinking of the structure, navigation and overall experience of this application I considered two aspects namely, the sequence of events or interactions that transpire between the user and application and the amount of control that the application has versus that of what the user has. I believe these decisions greatly influenced the user's overall experience as well as the expected and unexpected outcomes of the application.

Sequence

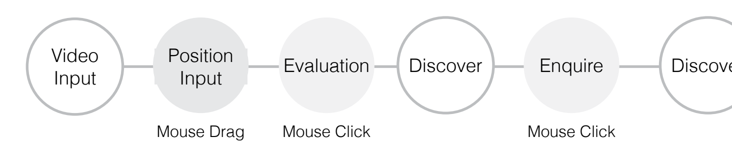
Several interactions within the game such as, video and positional input, evaluation of the user's attractiveness and finding similarly attractive individuals are all linearly sequenced. This is done intentionally so as to lead the user through a series of actions that ultimately lead to the user discovering how attractive they are and also being delightfully surprised towards the end at finding someone similarly attractive to them.



The sequence of game

Amount of Control

Although we have a variety of advanced facial recognition technologies that can take as input a digital image of a human face, analyze it and immediately produce a data set of facial proportions with little or no effort I intentionally chose not to use any such technology in Attractivity Meter. I decided instead to provide the control to the user. The user is expected to drag the feature points (explained in detail further down) with a mouse over their image and place them carefully over their own face. By offering this control to the user, I not only engage them in having a dialog with the application but also enhance their trust in the outcome and reliability of how the application goes about calculating the Attractivity rating and identifying other similarly attractive individuals.



The section of user control in gaming

The two ways of data input, web camera capturing and manual dragging.

Process

Input

In order to enable the comparison of a user's attractiveness (essentially, their facial proportions), I needed two types of data. The first being the image of an average attractive face as determined by the research of University of Regensburg's Psychology Department. This image would serve as the reference or base line image against which all other images would be compared to. The second set of data would be the image of the user of this application. These two pieces of data would be central to the working of my application.

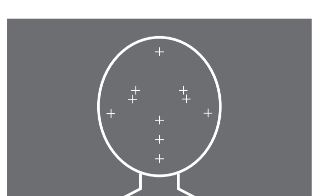
Interaction

In addition to the above data, two different kinds of user input or interactions were envisioned for the working of this application. The first being the capture of the user's image which I decided could be carried out using a basic web camera. The second interaction had to with how the user would carefully position and align the facial markers (which I refer to as feature points, explained in detail below) over their own image so that the application could then determine how to calculate the user's facial proportions.

Feature Points

Attractivity Meter requires the user to assign feature points on their face as data inputs. Generally facial image recognition and processing software tend to use crosshairs as markers for identification. However, I was very puzzled at which crosshairs should go to what position on the face since all of them looked identical. How could I or the user for that matter, be able to determine which marker belonged to which facial part. In order to make this part of the process more intuitive and easily recognizable I decided to create my own markers whose visual form would conform to those of the facial parts on which they were to be positioned. The resulting feature points, one each for the face, mouth, chin and brow could be easily recognized and instantly used without any explanation. I consider these icons as the pictograms of the interface instead of a legend as they instantly and instinctually communicate to the user.

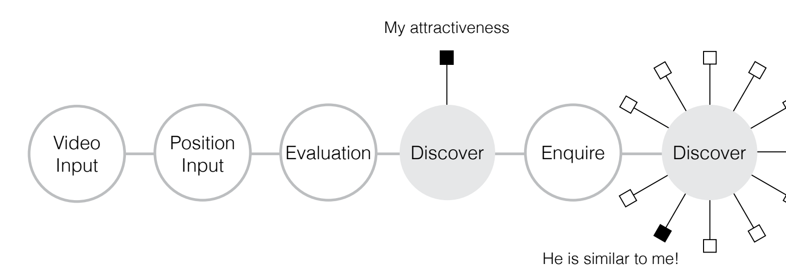
Feature pictograms



Feature points

Evaluation and Outcome

Once the application receives the necessary data that comes from aligning the feature points, it calculates what I call an Attractivity rating. This rating is basically a ratio of the user's facial proportions to those of the baseline image of an average attractive person. The rating not only helps with determining how attractive the user of the application is as compared to an average attractive person but also identifies who else in the system are attractive on a similar scale.



There are two discoveries user could get throught gaming

User Testing and Feedback

The gaming experience on Attractivity Meter

Some interesting observations and useful suggestions came out of the user testing of Attractivity Meter. They provided me some good direction and rich areas of investigation for subsequent iterations of this project.

– The feature points could be bigger to facilitate ease of interaction with a mouse.

– The feature points by appearance do not make them as intuitive for use as in they can be dragged or interacted with.

– The application should take into account the gender of the user and accordingly only compare female users to female entries or male users to male entries in the database.

– The comparisons should also be extended to more people, perhaps all of the users's Facebook friends. This approach would widen the pool of users it compares the user against resulting in a more unpredictable outcome.

Conclusion

In today's culture where people spend large portions of their life staring in a mirror at themselves Attractivity Meter attempts to change that rather lonely and isolating experience. Through a mix of technology, and thoughtful and engaging interactivity I have tried to engage the user's participation. Beginning with the user taking an image of them I effectively immerse them in the interactive experience. Vanity, being what it is, then captivates the user and invites them into investing further in to the application. The inherent desire to try to always present our absolute best to the rest of the world motivates the user to take the time and accurately position the feature points so that they can discover the outcome of this experience.

While the final outcome of the experience happens to be the identification of a similarly attractive individual from its database I intentionally displayed a much smaller image of this individual than that of the user's. I do so just so the emphasis is more on the user, their own beauty and Attractivity. The goal of this case study was to explore the use of visualization coupled with engaging interactivity to place more emphasis on self–discovery and to avoid an unhealthy competition that can arise from comparing one's Attractivity with that of another.

Thesis Project

Forest Growth Visualizer

Overview

Data visualizations can play an active role in the process of scientific analysis. By giving concrete form to abstract data, visualization can help reveal hidden relationships amongst the data that might otherwise appear unrelated. Thus thoughtfully designed visualizations have the potential for enabling unexpected discoveries.

However the scientific visualization process has its own set of challenges. Firstly, the data set being visualized often tends to be quite large making it difficult to visualize or organize. Secondly, representing multiple relationships amongst the data sets is challenging, and finally in order to thoroughly understand and make sense of the visualized data a specialized knowledge of the subject matter is required.

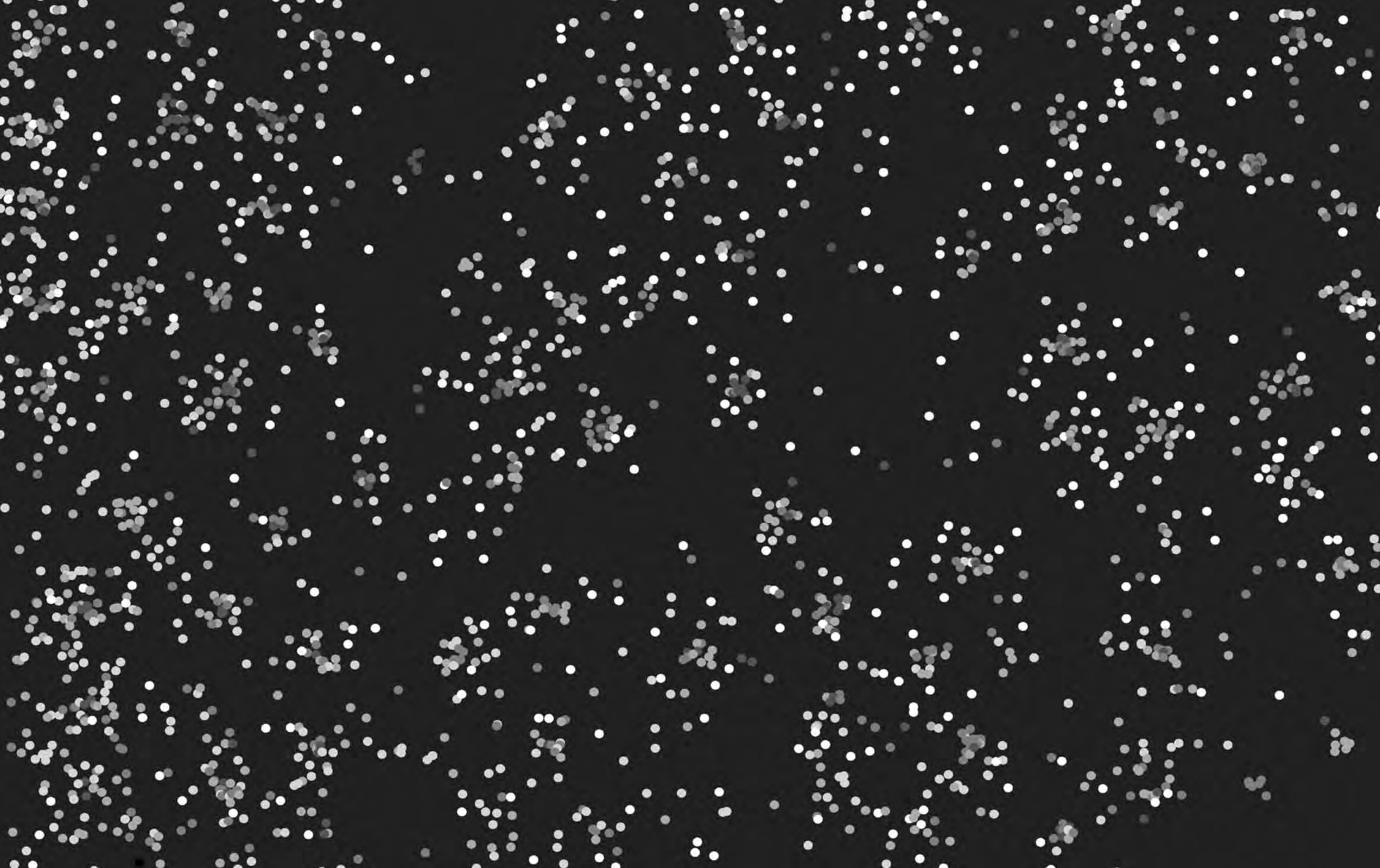
These challenges highlight the importance for scientific visualizations to be simple and intuitive to use, with "low cognitive loads and higher participation" (Fen ChienSheng, *Supporting Information Navigation in Generative Design Systems,* 1998)so that they allow its users to easily navigate the visualized information.

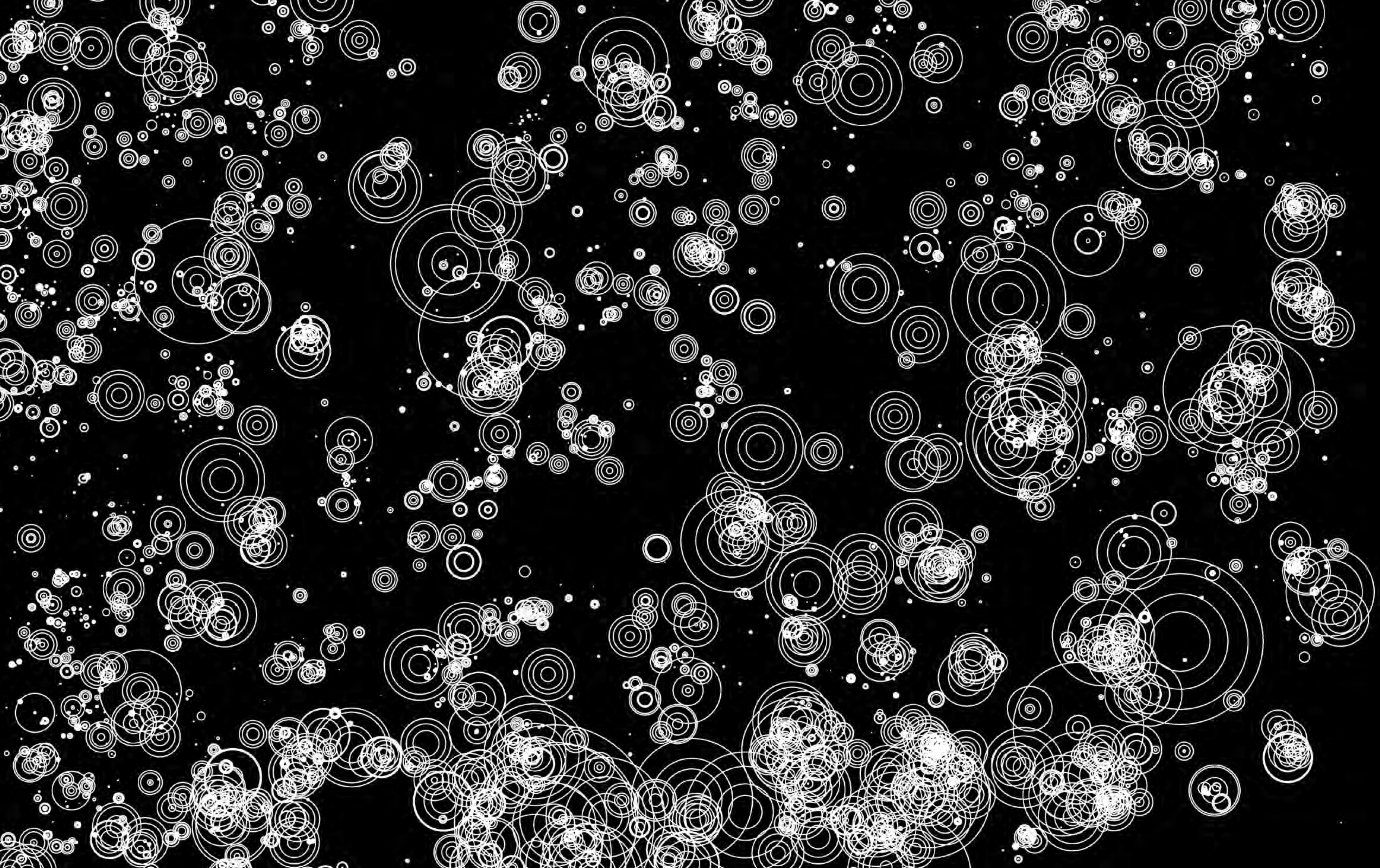
My final case study, "Forest Growth Visualizer" visualizes scientific data pertaining to forest growth that was collected over a span of two and half years. Scientists can view and interact with the visualization using an interface that I developed in order to understand and ideally, discover key factors that might have contributed towards the growth of tropical forests.

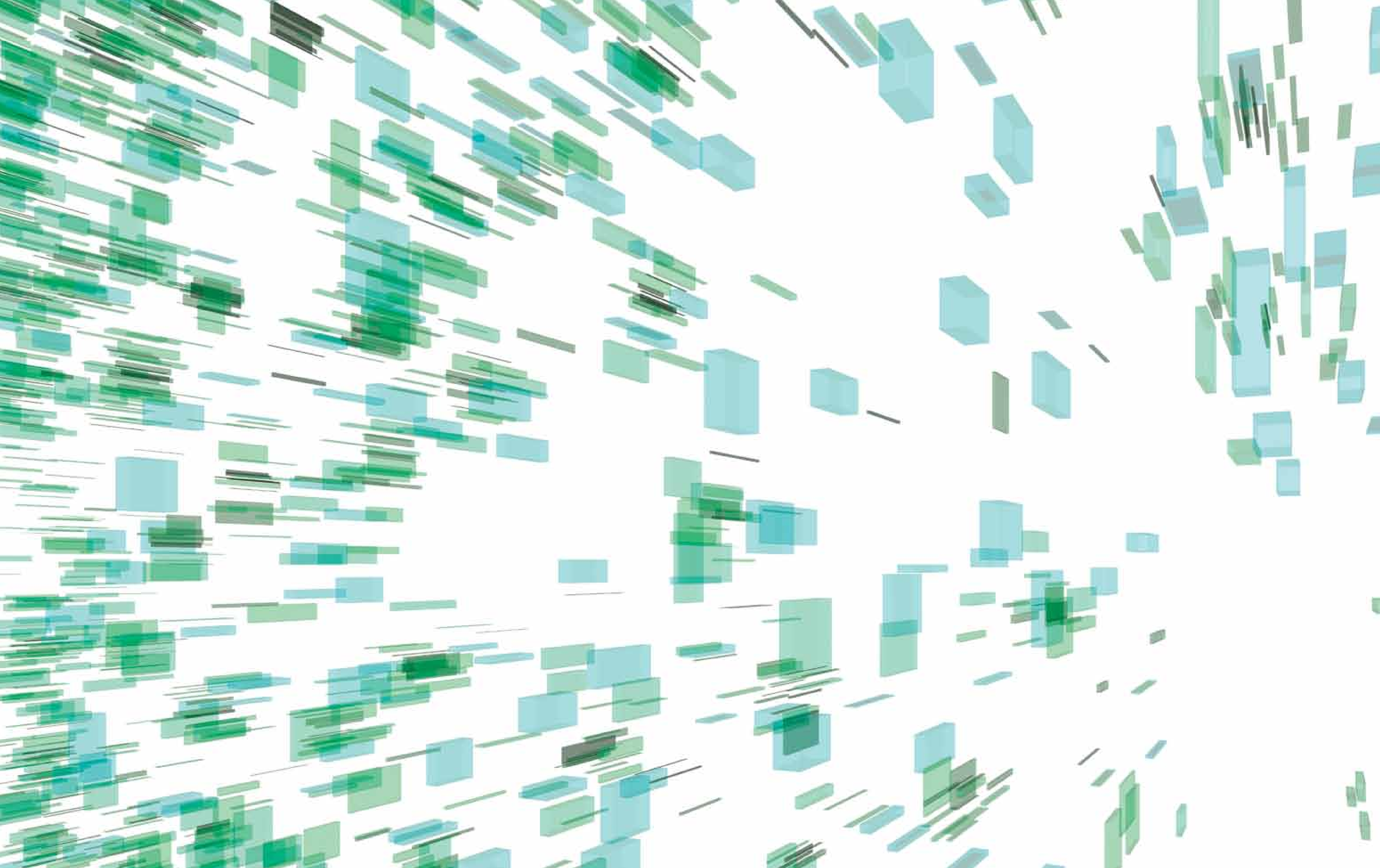
My personal goals in this case study were to understand how to go about designing an environment where one could visualize large quantities of data, and also explore the role of interactivity in revealing hidden relationships amongst the data elements that could potentially lead to unanticipated discoveries.

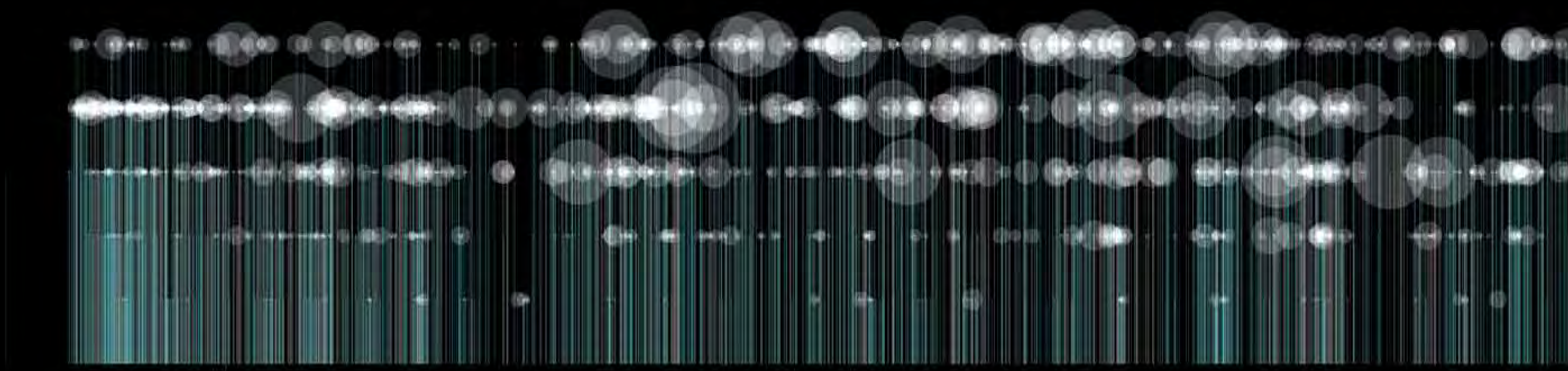
The approach I took in designing the visualization as well as the interface for it puts to practice the three essential components for Designing for Discovery that I previously identified in Chapter 3. I highlight them below for the benefit of the reader. They are:
– Analyzing the information space.
– Coming up with a wayfinding system.
– Designing visualizations and introducing meaningful interactions.

Tag	X	Y	Cli	DBH-0	DBH-1	DBH-2	DBH-3	DBH-4	Wood Density
10518	0.52	148.73	3	362.00	362.78	363.54	364.32	364.78	0.56
10644	0.78	195.25	3	446.00	446.27	446.72	447.44	446.33	0.73
10621	1.63	182.33	3	230.00	229.81	229.72	230.03	229.74	0.62
10455	1.66	132.37	4	474.00	474.40	477.48	478.98	480.39	0.60
10476	2.34	135.76	4	523.00	522.87	524.52	524.53	524.30	0.59
10619	2.52	176.01	4	504.00	504.02	504.01	504.69	505.04	0.37
10526	2.54	93.21	4	360.00	359.82	361.19	361.25	361.05	0.59
10659	3.24	201.03	4	564.00	560.83	560.64	565.86	566.88	0.62
10220	3.27	59.65	5	751.00	755.12	755.78	760.63	762.80	0.62
10453	3.40	99.2	4	412.00	412.72	412.41	413.87	413.41	0.59
10623	3.36	183.15	4	449.00	450.80	454.08	455.28	456.96	0.37
10640	3.54	187.42	4	470.00	472.08	476.09	482.29	485.11	0.62
10331	3.64	91.93	4	355.00	354.57	354.81	354.60	354.71	0.59
10520	4.02	151.25	5	1148.00	1148.68	1150.58	1154.74	1158.22	0.62
10510	4.82	149.05	4	410.00	410.21	411.56	412.89	413.55	0.57
10154	5.35	42.7	4	396.00	396.01	398.67	400.49	401.28	0.84
10197	5.24	50.07	4	394.00	393.99	394.25	394.13	394.35	0.60
10742	5.39	234.17	4	368.00	368.13	368.32	369.50	367.70	0.62
10278	5.70	75.56	4	356.00	359.70	361.24	362.09	361.75	0.62
[illegible]									









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Design Process

Data

As mentioned previously, the data being visualized as part of this case study was collected by researchers over a period of two and half years. Data concerning 5 factors were recorded for each tree as part of this study. The factors being —

– Light – Amount of sunshine available to the tree.

– Density – The concentration of wood in the tree.

– Location – The physical location of the tree.

– Period – The specific period in which the tree was observed and recorded. As mentioned, the researchers tracked the trees once every 6 months over a period of 2.5 years (which makes it a total of 5 periods.)

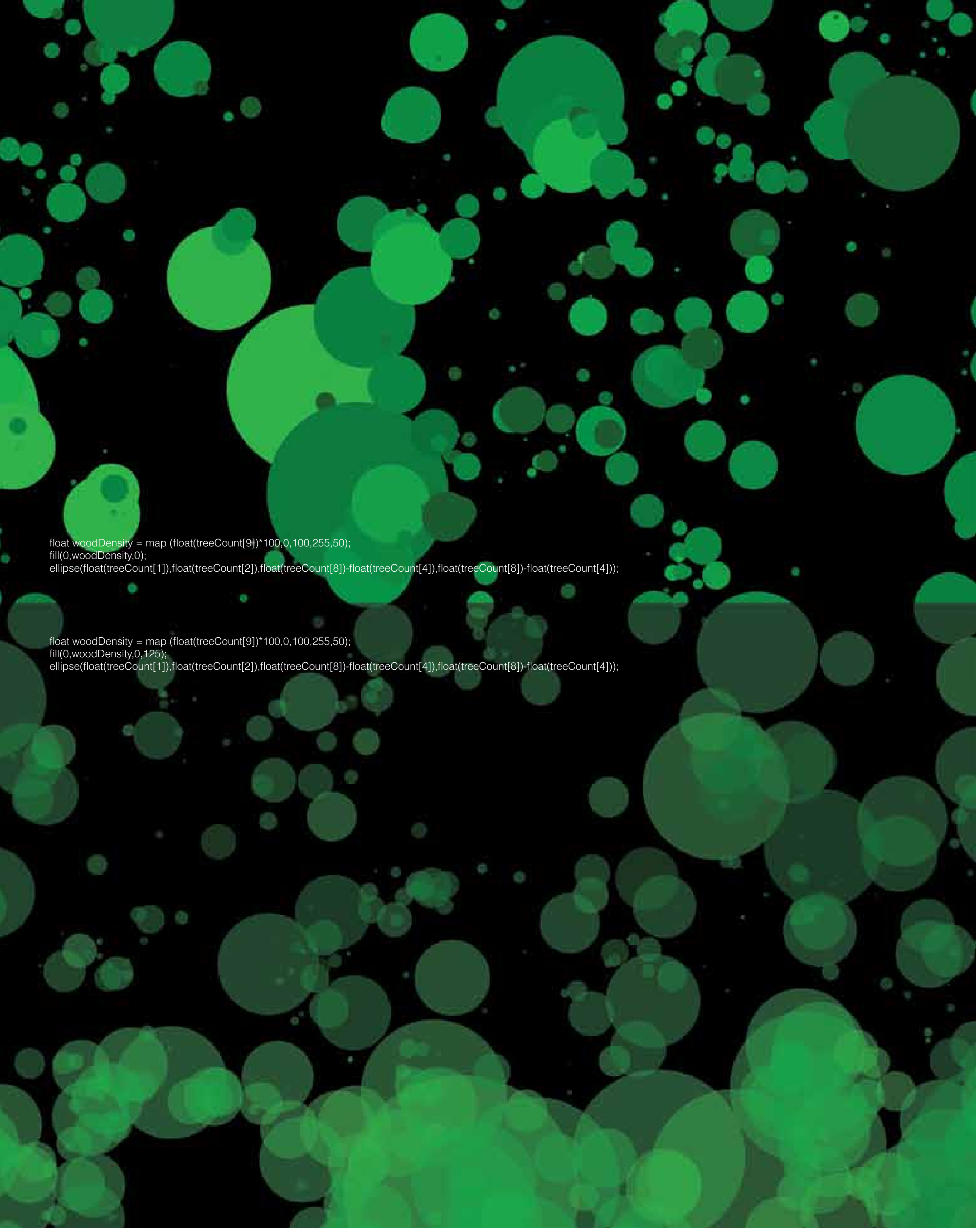
– Growth – The overall growth of the tree, as measured by the diameter of the tree trunk.

The goal in analyzing this data was to determine which of the following factors: Light, Density or Location, whether individually or in combination with one another, had a positive or negative influence on the growth of trees in the forest.

Approach

As I began to analyze all of the data, I realized that it was going to be a challenge to visualize such a vast quantity of data and depict more than one relationship, if any, amongst the different factors. These observations lead me to the following questions:
– How would I go about organizing all of the possible relationships amongst these 5 factors?
– How would I design an interface that would be flexible enough to allow the scientist the ability to explore the data set in ways that made more sense to them?
– Finally, how would I design the interface to enable the scientist navigate the vast set of data (information space) without getting overwhelmed by the data or getting lost in it?

I decided to approach each of these questions from the point of view of the three components essential to designing for discovery that I previously identified. I first reviewed all the literature and research pertaining to information space to come up with approaches that would be helpful to efficiently and clearly organize the information within this space. Second, I researched traditional wayfinding design principles pertaining to physical spaces and how to go about adapting them to the information space in question. I felt that these principles would help guide my approach in designing the interface and navigational aspects of the application. Finally, I would try to introduce meaningful and appropriate interactivity to help the user (scientist) further explore the information space in ways that would lead to potential and unexpected discoveries in the data.



Working Of The Application

Information Space

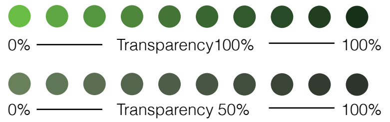
The first step or component to designing for discovery is to carry out an analysis of the information space. In this case, the information space consisted of data regarding the growth of trees in a tropical forest. As described in the previous section (titled 'Data'), this data consisted of 5 factors — Light, Density, Location, Period and Growth, which were recorded for each tree as part of this study.

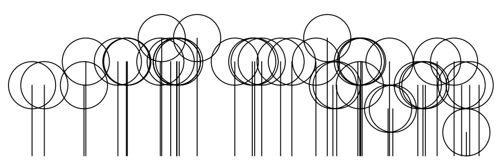
Given that the above data was quite abstract in nature and would be difficult for a user to make much sense of it on its own I decided to give it a visual form. To begin with, I decided to denote each tree as a circle. There would be as many circles as there were trees to ensure that all of the visualizations as part of this application would consist of the entire data set so the user can get an accurate sense of what the data was telling them. I then decided to come up with ways in which I could map the 5 factors pertaining to a tree, recorded as part of the study, on to the circle.

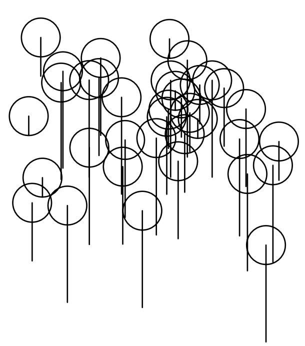
-1- Density

I decided that density would be mapped to the color that filled each circle. Because there were a range of density values for each tree, assigning a unique color to each density value would be impractical and also confusing to the user. Instead I decided to use just one color for all the trees but vary its saturation. The more saturated the fill color of a circle, the denser the tree was.

However when I applied this approach to the visual form of the tree on screen, I quickly realized that for those trees closer to one another, the biggest of them tended to cover up the smallest of them. This meant the exclusion of data from visual sight. In thinking more about this representation, I decided that I should perhaps look into using a semi transparent color instead. The color would be transparent and allow the trees under it to be still visible. Using a 50% transparency but still sticking with the idea of a single color scheme I was able to reasonably represent density — one of the factors in this data set.





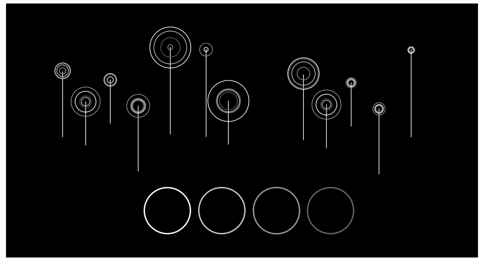


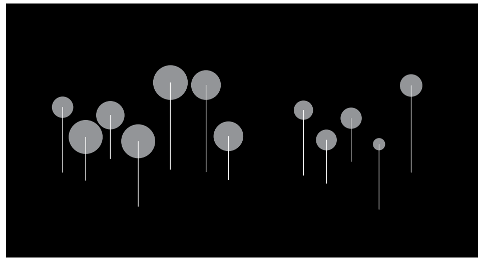
-2- Light

In order to represent the factor of Light (the amount of sunshine that each tree received), I chose to add a stem to each circle. The length of the stem represents the level of light that the tree receives. In comparison to density, Light is not a unique value instead it is one of five predefined levels. This level determines the specific length the stem needs to be for each tree.

-3- Location

Since the study was conducted over a designated area of the forest, I decided to map this entire "physical" area of the study on to the virtual area of the screen. In other words, the area where the visualization is projected is scaled to a version of the actual physical space. Thus the center of each circle (tree) is placed on the visualization area where it maps to the physical coordinates of the tree it represents.





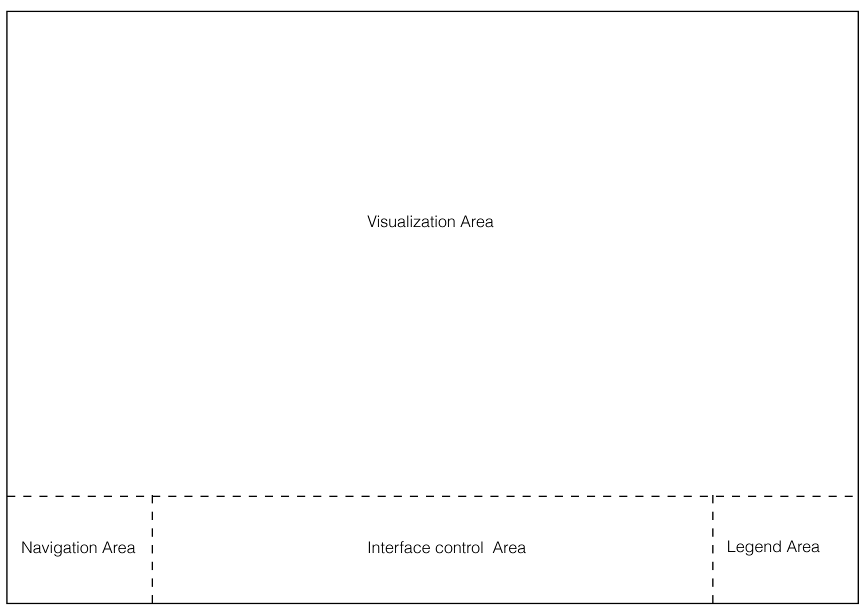
-4- Period

The diameter of the circle represents its growth at any given point in time. Since there are a total of 5 periods over which the growth was recorded I depict each period's growth as a concentric circle growing outwards from the center. Thus the diameter of the inner most circle would be the growth recorded for the very first period.

-5- Growth

Consequently, the diameter of the outermost circle represents the overall growth of the tree at the end of all 5 periods.

Having worked out the above visual system to represent the abstract data of the study I was ready to proceed to the next step or component in the process, that being designing a wayfinding or navigation system which would help the user explore and navigate this newly created informational space of visual forms.



Wayfinding System

Kevin Lynch, in his book "The Image of the City" (MIT Press, 1960), described how people perceived and organized spatial information to navigate through cities. He also pointed out how they formed mental maps of their surroundings in order to better understand them. He identified 5 elements that users typically used to develop such a mental map. These elements are described in greater detail in a previous chapter (3. Designing for Discovery, section — Designing a Wayfinding System), I will simply list them out here for the benefit of the reader. They are — Paths, Edges, Districts, Nodes and Landmarks. I relied on Lynch's research and observations to help design the layout of my interface.

Visualization Area

I designated a rectangular area in my application to be the place where all of the visualizations would get generated and appear. It occupies a majority (3/4th of the area, to be precise) of the application's viewing area. It is located at the top left hand corner of the application window. By assigning such a large and prominent area of the interface for the purpose of visualization, I place greater emphasis on it.

Navigation Area

Located towards the bottom left of the visualization area is the navigational area, where the controls to navigate through the visual information space (visible on top) reside. I will talk in greater detail about the nature and working of the navigation controls in the following section.

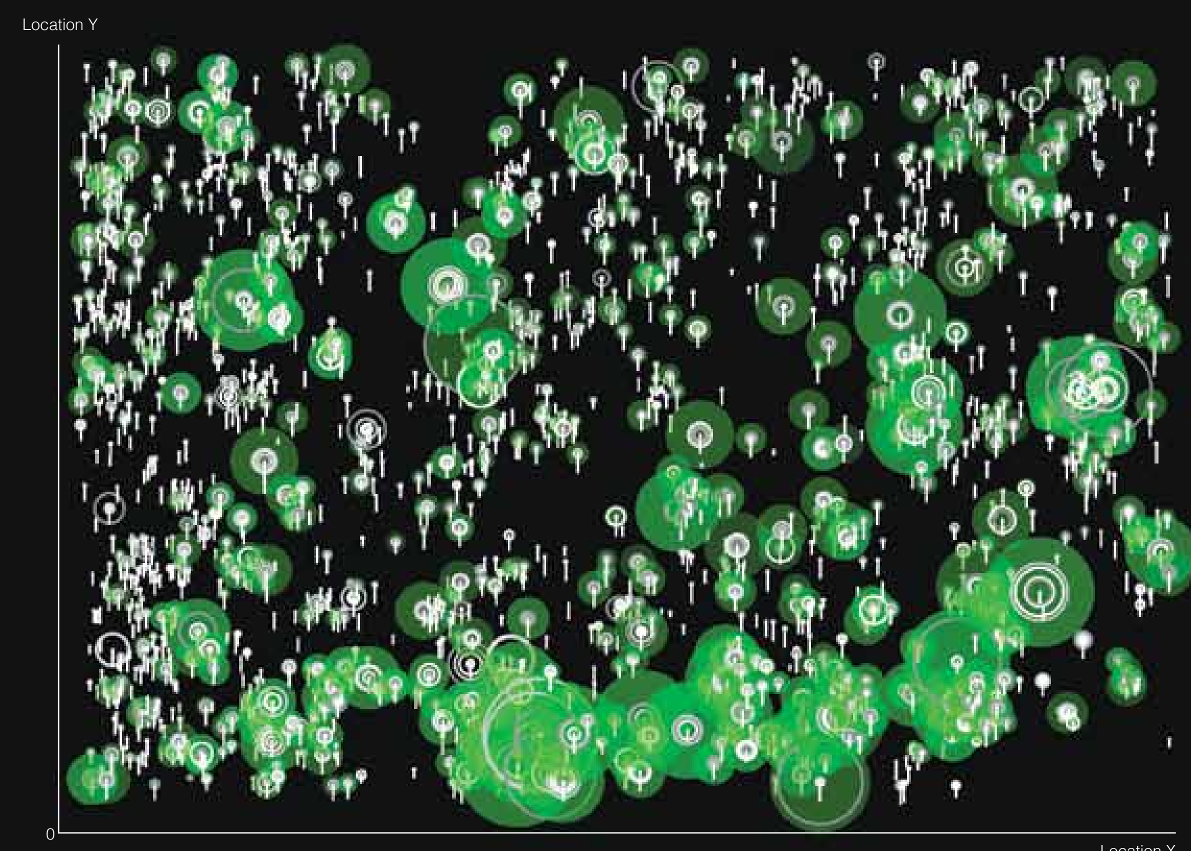
Interface Control Area

The interface controls to the interface reside here, right under the visualization area and located at the center of the viewing area. Placing the interface controls in this location was intentional as it grounds the user to the visualization and makes its controls available in a comfortable way. The working of these controls will also be discussed in the following section.

Legend Area

The legend area holds information on some of the visual attributes of the visualization that is being looked at such as how density is being visually represented, the different levels of light, and the various periods of growth.

With the wayfinding aspects of the application laid out as described above I began to think of ways in which the abstract data and its visual form could be turned into a dynamic visualization, and also think of ways to introduce interactivity aimed at helping the user explore the data in ways that foster discovery.



Visualizing The Data And Adding Interactivity

The last and final step to designing for discovery is to create engaging visualizations that provide visual forms to abstract data and to additionally introduce the element of meaningful interactivity.

Data Visualization

After having decided on the visual form for a tree to be a circle (see earlier section. Information Space) and mapping specific attributes of the circle to depict each of the 5 factors (Light, Density, Location, Period and Growth) I began to think of the various ways to visualize the data set using the open source programming language, Processing.

While creating the different visualizations of the data set I also simultaneously worked on the layout and behavior of an interface that would allow the user to control and manipulate these visualizations.

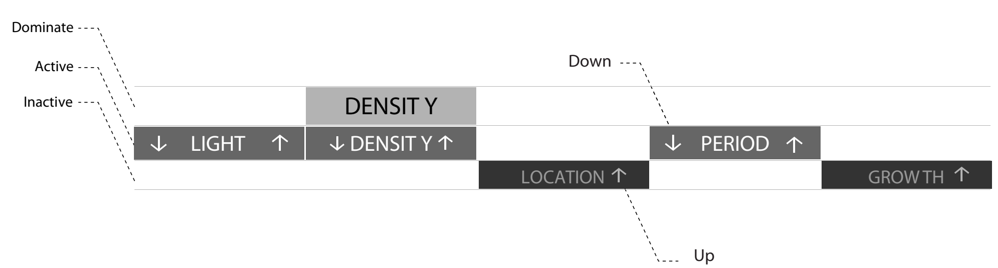
Interface Design

Ben Fry best described the role and potential of interactivity as an exploratory tool within a data visualization. To truly maximize the potential of interactivity I knew I had to conceive an interface where the user had the ability to control the visualization which got me thinking about the type and kind of controls that would make sense for the interface. After careful thinking I realized that the very 5 factors of the tree that were recorded as part of the study could serve as the ideal controls to the visualization.

I initially conceived these elements as toggle controls that would add to or filter out growth related information from the visualization. That way the user could actually see the result of adding or removing a factor and consequently discover the kind of effect (positive or negative) it had on the growth of trees. A few iterations of this approach made me realize one shortcoming — what if the growth of trees were affected not by just one single factor but rather a combination of factors? In its present form, the toggle capability of a control did not lend itself for evaluating the effect of more than one factor at the same time.

I needed a mechanism to allow the user to select more than one control at a time so that they can view their combined affect on the growth visualization. I also realized that should the user choose more than one factor then it was necessary for only one particular factor out of those choices be designated as the "dominating" factor. This dominating factor can be of the user's choosing and is always assigned to the Y–axis. I give the user the freedom to choose the dominating factor so that they have flexibility over how to explore the data set and which of the factors become the driving factor. I consider this flexibility as an important consideration while designing for discovery. Also, by always assigning the dominating factor to the Y–axis, I ensure that the user can easily interpret the dominating factor's significance on the growth of trees.

By allowing the user to choose more than factor at a time but restricting them to assign only one of them as a dominating factor I realized that I actually had 3 possible states for my 5 interface controls. The three states being —



– DOMINATE – When a factor is specifically designated by the user as the primary factor based on which the combined effect of all other 'active' factors are visualized. Only one of the active factors can be selected to be a dominating factor. The dominating factor is always assigned to the Y axis.

– ACTIVE – when a factor is chosen by the user to affect the output of the visualization. More than one factor can be selected by the user to be an ACTIVE factor. Active factors are assigned to the X axis.

– INACTIVE – when a factor is not chosen by the user to affect the visualization's outcome.

Nature and Role of Interactivity

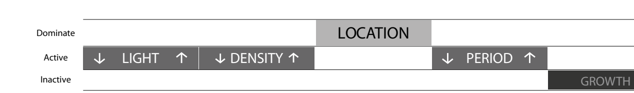
In order to show the above 3 states for each factor I designed the dashboard for my interface control to have three floors. Each floor would map to one of the states.

The bottom most floor is where all 5 factors would first start out. This is also referred to as the INACTIVE floor where all factors not yet selected to affect the visualization would reside.

The next level up (or the middle level) is where all the chosen or ACTIVE factors would reside. These factors would be assigned to or visualized on the X–axis.

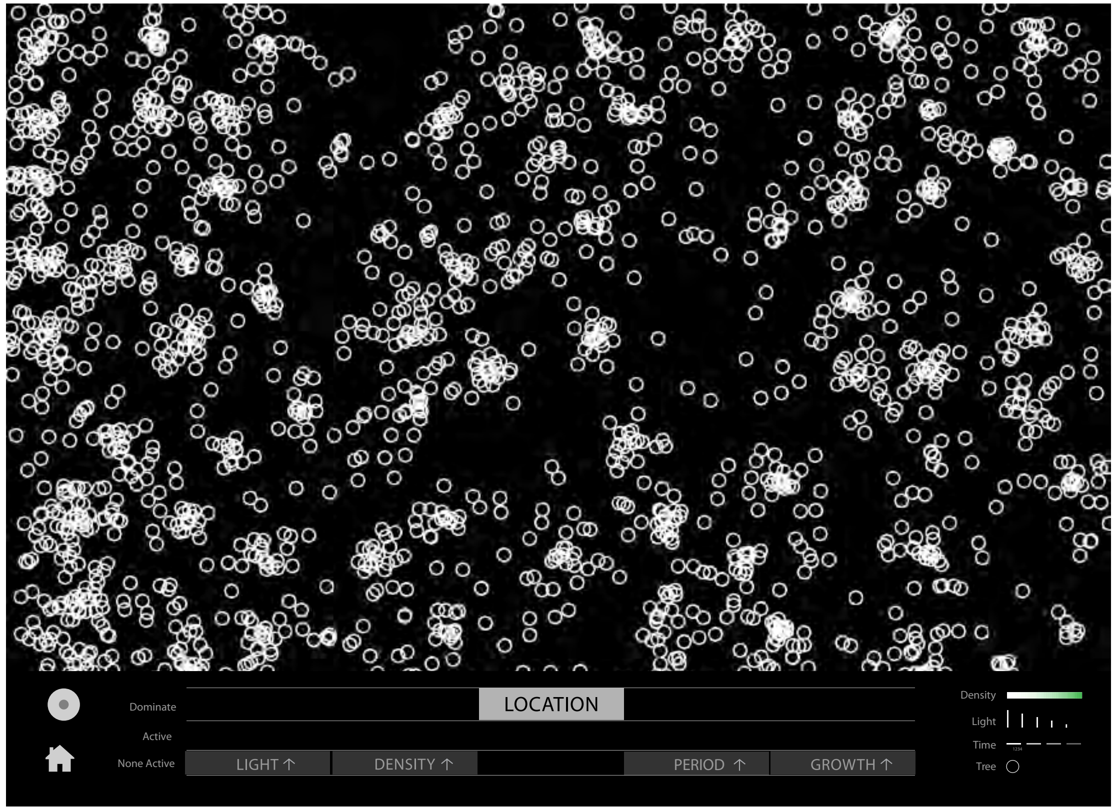
The last or top–most floor is where the dominating factor would always reside. Only one active factor can be selected by the user to be the dominating factor. Dominating factors are always assigned to or visualized on the Y–axis.

To help the user select and deselect factors, I created buttons for each of the 5 factors. The buttons were labeled similar to how the factors were referred to.
Additionally, I added up and down arrows on either side of the button label to indicate to the user that by clicking these arrows

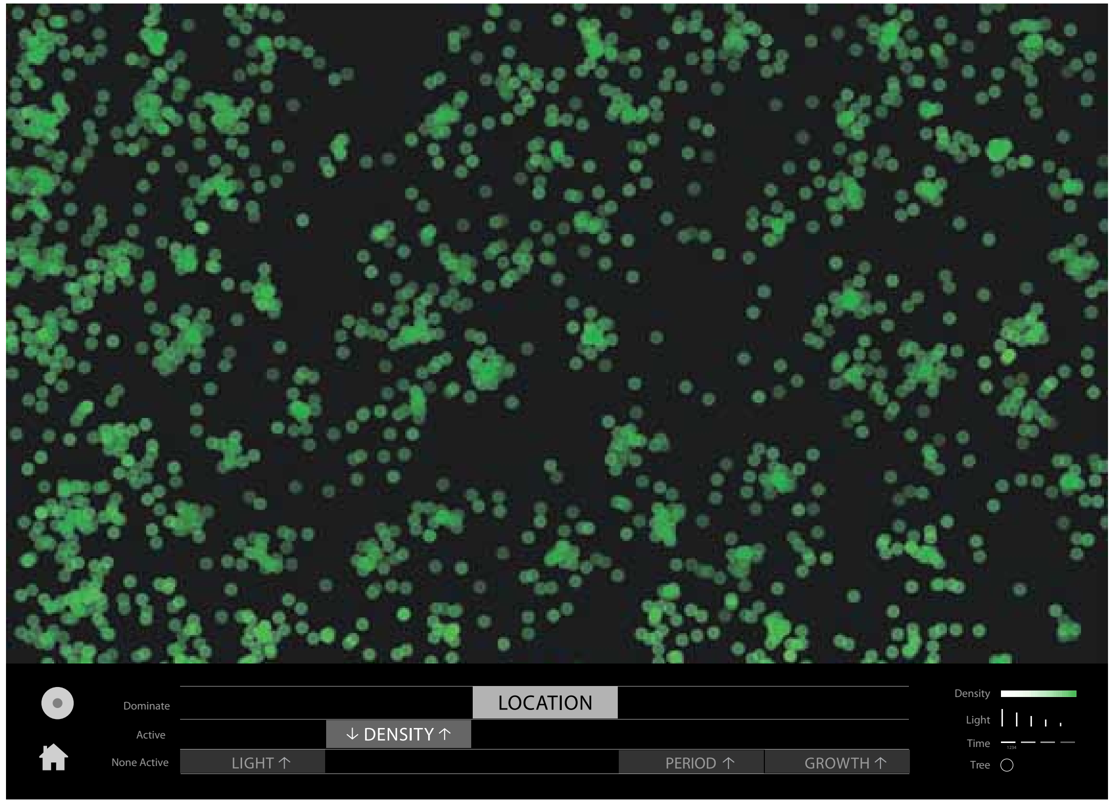


you could move the factor up and down the different floors of the dashboard interface. In other words, you could select a factor and have it move between the different states, namely — INACTIVE, ACTIVE and DOMINATING.

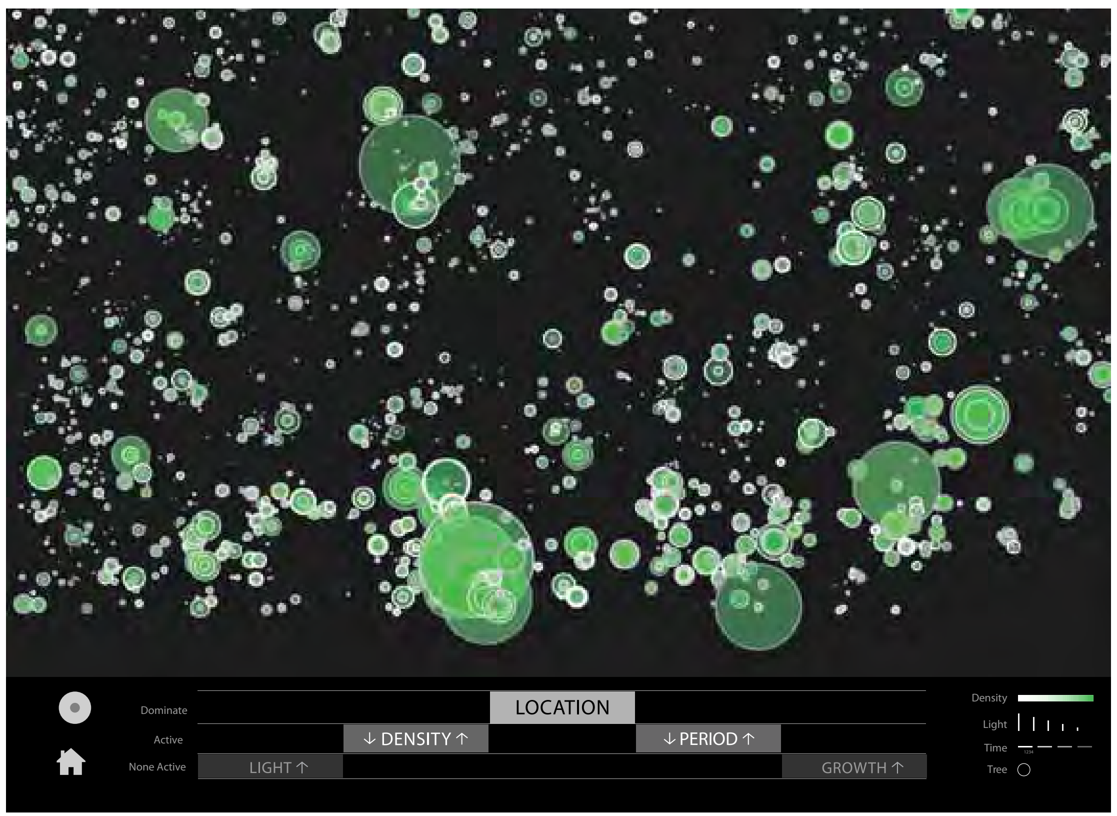
Selecting or moving the buttons up and down would additionally trigger the visualization to refresh based on the newly chosen set of controls (or factors). This ability to instantly view the changes associated with selecting a certain set of factors with one of them being the dominating or primary factor can help the viewer to actually see or visualize the effect of a factor on the growth of trees. It can also help the viewer discover potential relationships, if any, amongst the multiple factors on the growth of trees.



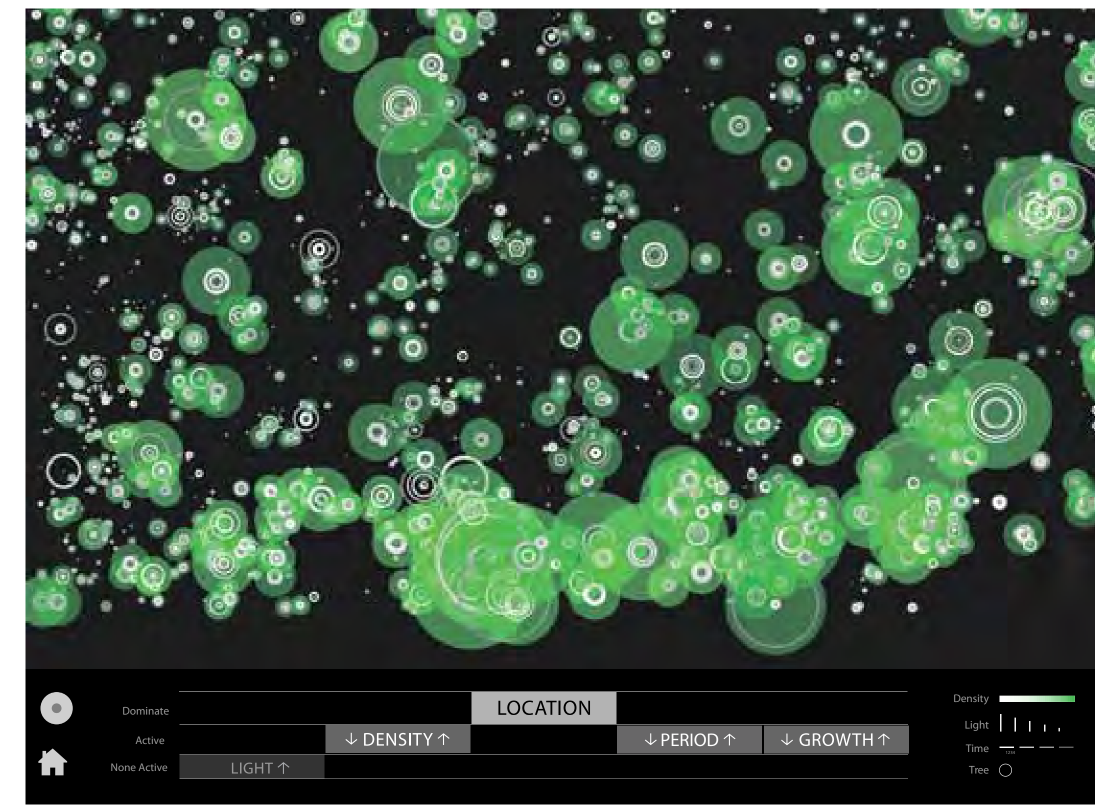
Visualizing of location.



Visualizing of location and density.

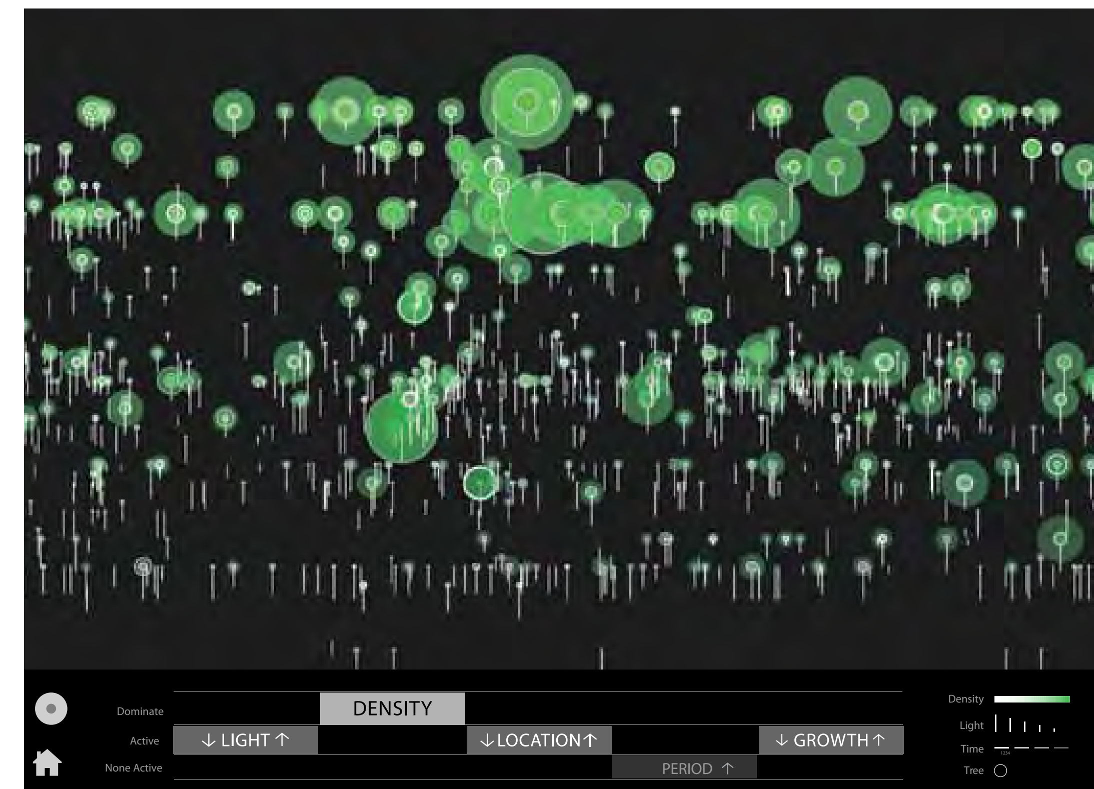


Visualizing of location, density, and period.

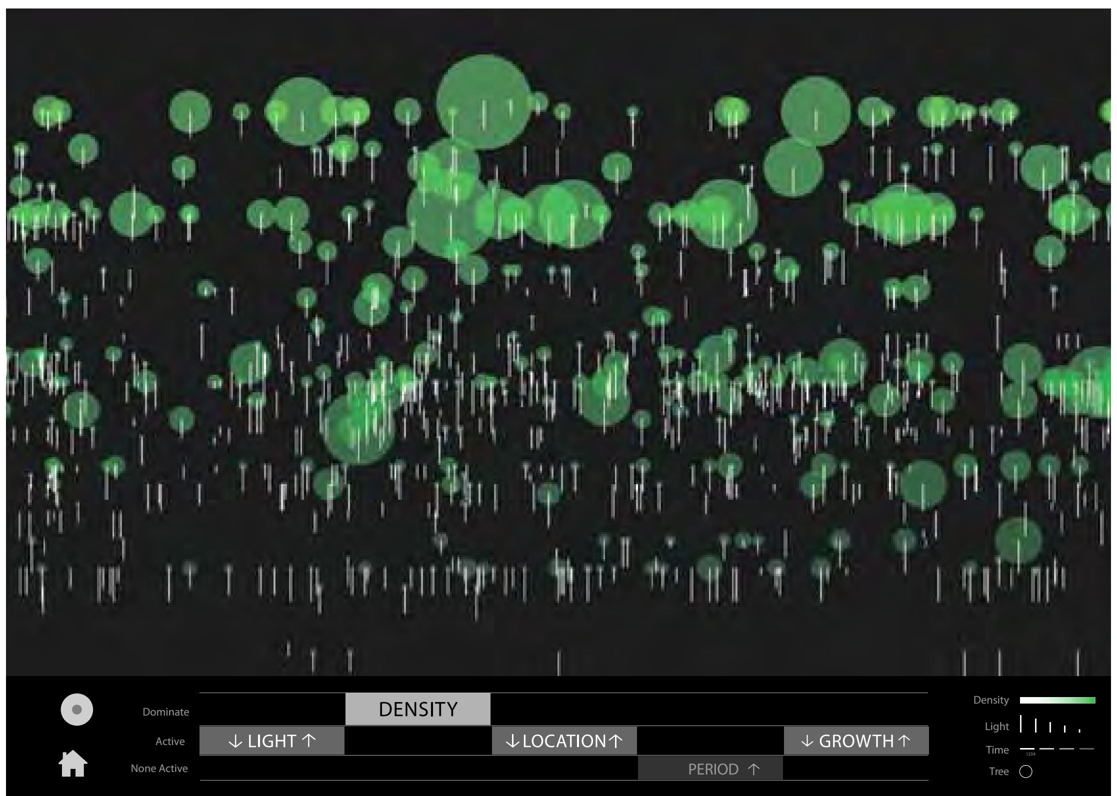


Visualizing of location, density, period and growth

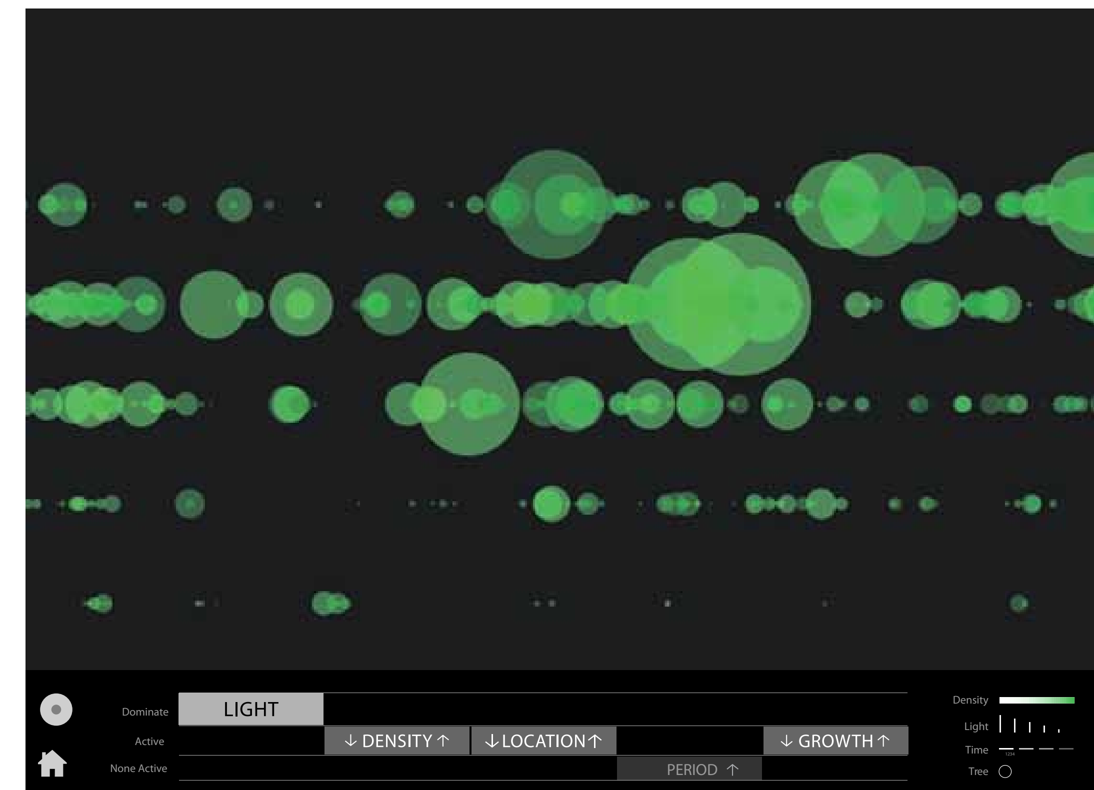
Visualizing of density, light, location and period.



Visualizing of density, light, location and growth.



Visualizing of density,light,location and growth.



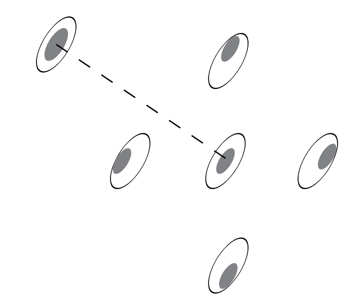
Visualizing of light, density,location and growth.

Visualizing of density,light,location, period and growth.
Magnified view plus panning.

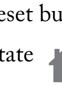
Navigational Controls

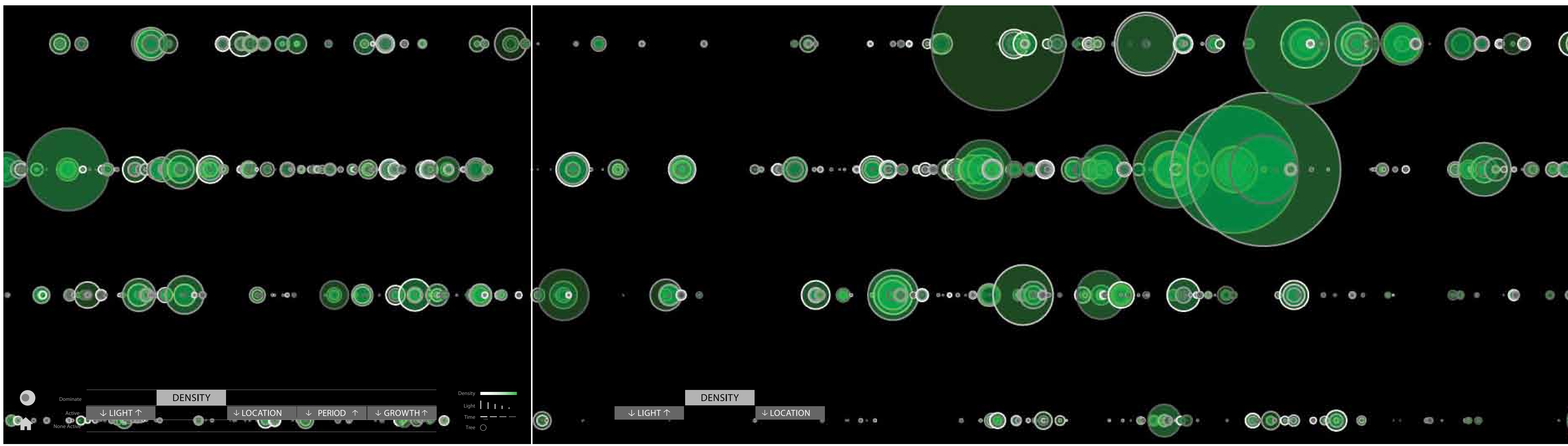
Finally, I designed two additional controls for navigational purposes.

The Zoom/Pan button was specifically designed to allow the user to further navigate and explore in detail the visualization they had just created by selecting factors on the dashboard. Here I tried to design the appearance of the button to resemble an eye. I saw the eye as a metaphor to the act of observation. When the user clicked at the center of the eye (or, its pupil), the pupil would either grow or shrink and correspondingly alter the scale at which the visualization would be viewed — as in, it would either zoom in to show greater detail of parts of the visualization or zoom out to show the entire visualization. Additionally, clicking on and dragging the pupil would allow the user to pan across sections of the visualization. This way the user could get to sections of the visualization that were not currently in view.



The Home button was designed to help the user reset their visualization at any given point in time. It is like any other reset button that brings the user and the system back to its initial state so that the user can once again initiate another exploration of the data set.





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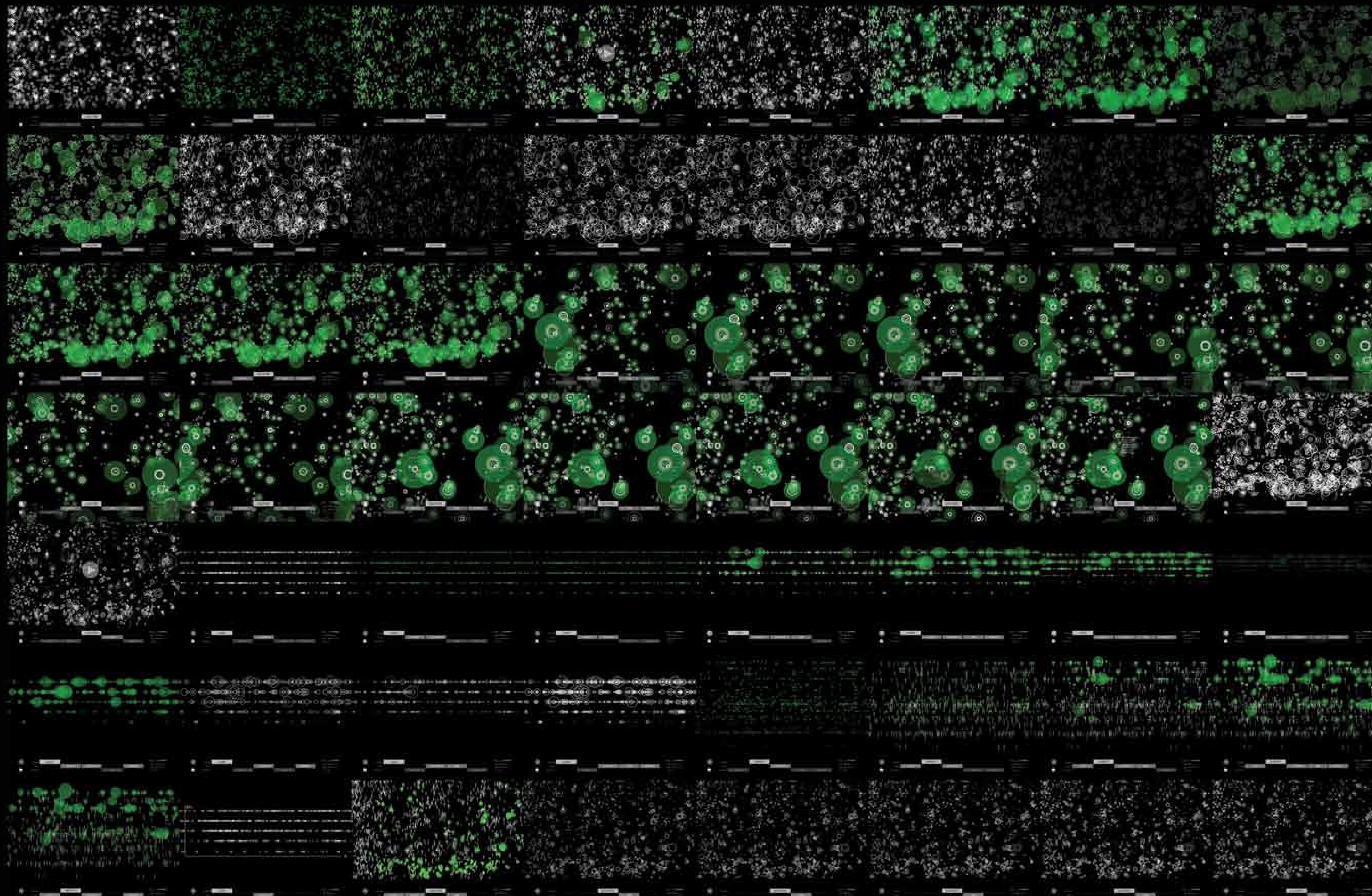
Video recording of Shirley Dong interacting with Forest Growth Visualizer.

User Interacting And Feedback

I was able to test the initial prototype with my friend, Shirley Dong, who also happened to be one of the researchers on this study. This was important since her feedback and observation as a participating researcher of this study would be extremely relevant and valuable to its subsequent improvement.

After interacting with my application, she concluded that the visualizations generated as part of this application using the controls I had devised had indeed verified her own conclusions determined through statistical analysis. She confirmed that while the factors of Light, Density and Location positively influenced the growth of trees in the tropical forest, there was no one factor that absolutely stood out.

She also pointed to another observation, similarly verified in my visualization, that the factor of Location when selected as the dominating factor seemed to exhibit the most positive effect on the growth of trees more than the influence of Light and wood Density.



Findings

Forest Growth Visualizer was a rewarding case study as it allowed me to apply the 3 essential components to "Designing for Discovery," identified as part of my thesis investigation, and to also evaluate if my approach to designing an information space could help bring about discovery.

I learned how to design an interactive interface that visualized data sets with multiple characteristics. By giving the user the capability to manipulate these characteristics (one or more than one, at times), I was able to design a multi–parameter data visualization system that allowed users to navigate the information space in more than one way. The visualization instantly responded to user selection/interaction by updating itself. In doing so, any change that occurred was given a concrete visual form, thus revealing hidden and potential relationships amongst the various parameters.

As is evident from the user–interacting and feedback that I received, my approach to designing for discovery, at the least, corroborated what the scientists had determined through their own statistical analysis. In addition, the visualizations generated by manipulating the different factors helped the scientists discover that no one factor contributed significantly to the growth of forests. More importantly, it encouraged them to look beyond the 5 currently observed factors and dig deeper into aspects such as amount of water a tree received, the composition of the tree's soil, etc…

In this sense, I was very happy to see that my case study succeeded in enabling the scientist to discover something of consequence.

Conclusion

Today we live in a world flooded with data. According to Eric Schmidt, CEO of Google Inc., "every two days now we create as much information as we did from the dawn of civilization up until 2003." It's clear from this statement and from all that we know and see around us that this trend will only continue to grow.

Some nights when I look up at the sky and watch the millions or billions or who knows how many stars that inhabit it, I get both excited and nervous for the same reasons of what lies out there and how do we make sense of this enormous universe? In many ways, this question from our physical world is just as applicable to the digital world we now live in — What lies in this vast digital world and how do we begin to make sense of the enormous amounts of data that we collect each and every day?

Having previously designed wayfinding systems that conveyed spatial information to people navigating unfamiliar physical places, I arrived at DMI to acquaint myself with the unfamiliar language of New Media. The question of "how to make sense of the enormous amounts of data that we collect" was constantly on my mind as I worked on various projects. Eventually I saw the connection and realized that my body of work was all about enabling discovery in an information or virtual space which motivated the rest of my thesis investigation.

I took advantage of my prior knowledge in traditional wayfinding design principles and navigational techniques surrounding physical spaces and figured out ways in which I could adapt these to virtual (information) spaces consisting of digital data. Case studies Star Tracker and Memento: Film Explorer were examples of this thinking in play. I realized that the content of information spaces was abstract by nature which meant that to form any kind of understanding of this data it was necessary for me to visualize them. Additionally the quantity of data being dealt with was enormous and possibly had multiple characteristics to it that were not always evident by simply looking at them in a static form. All of these observations made it clear to me that to further exploration and foster discovery in an information space I needed to not only "visualize" the data but also build in "interactivity." Case studies Gala Redux and Attractivity Meter were exercises in experimenting with data visualization as well as introducing the element of interactivity.

In working on these case studies and learning from their outcomes, I was able to come up with a formal approach to designing information spaces that can foster discovery. My approach consisted of three components, namely —
– Analyzing the Information Space
– Designing a Wayfinding System
– Visualization and the Role of Interactivity

My final case study, Forest Growth Visualizer, was an exercise in putting to practice these three components. I designed an interactive environment where data pertaining to tree growth is visualized with the aim of assisting scientists to discover factor(s) or relationships amongst factors that affect the growth of trees.

In working on Forest Growth Visualizer, I was confronted with numerous challenges pertaining to visualizing a large body of information. This challenge can often overwhelm new designers and

force them to quickly jump to the final step of the process, that of 'visualizing' it. In doing so, they don't fully understand the goals of the visualization and how to go about effectively using the information space, the visual form and interactivity to their advantage. I myself was a victim to such a rush to judgement.

While I am happy with the preliminary outcome of this case study in that it helped verify some of the scientist's findings as determined from their own statistical analysis, I also realized from the results of the user testing and feedback that there were many areas to improve upon. The choice and role of "color" in the interface required a rethinking; the use of metaphors from everyday life to design navigational icons may not always be clear or intuitive for the user; the meaning associated with certain aspects of the visual form of a tree in my visualization were in certain occasions unclear; and lastly, designing a variety of user interfaces and visualizations followed by frequent testing with users would have added to improving the user experience of the application.

A few important lessons that I learned in working through all of my case studies were that —
– Quicker and more traditional means to prototyping visualizations are not only valuable but more effective.
– Frequent prototyping will additionally help with clarifying the effectiveness of a user interface or visualization.
– Not all 'traditional' wayfinding design principles or strategies can be easily adapted or applied to the digital world.

Perhaps the most important lesson or revelation I have had as part of my thesis investigation has been that, the fields of data visualization and interaction design are relatively new. We don't fully understand how to apply it to information design problems of today since the data we are dealing with is constantly evolving in nature and growing in quantity. While we can learn from and apply the knowledge of traditional design and communication disciplines (such as Graphic Design and Psychology) to this new and emerging field, there are no clear and obvious paths. Only by undertaking a range of projects and through experimentation will we able to come up with effective ways to Designing for Discovery.

As I end my journey here at DMI I also fully realize that it is only the beginning for the kind of problems and projects that I'd like to next take on as an interactive and new media designer. Just as travelling to new and unfamiliar spaces helps me understand who I am and is a passion of mine, I see my desire to create visual and interactive experiences that allow for exploration and discovery of the vast digital landscape of data as a natural extension to this passion.

I would like to continue exploring the similarities amongst physical and informational spaces, how our relationship with physical space can influence our understanding and interpretation of the digital space; and how to use space as a medium to convey information. In essence, I would like to better understand the relationship that we, as human beings, hold with the space we live in.

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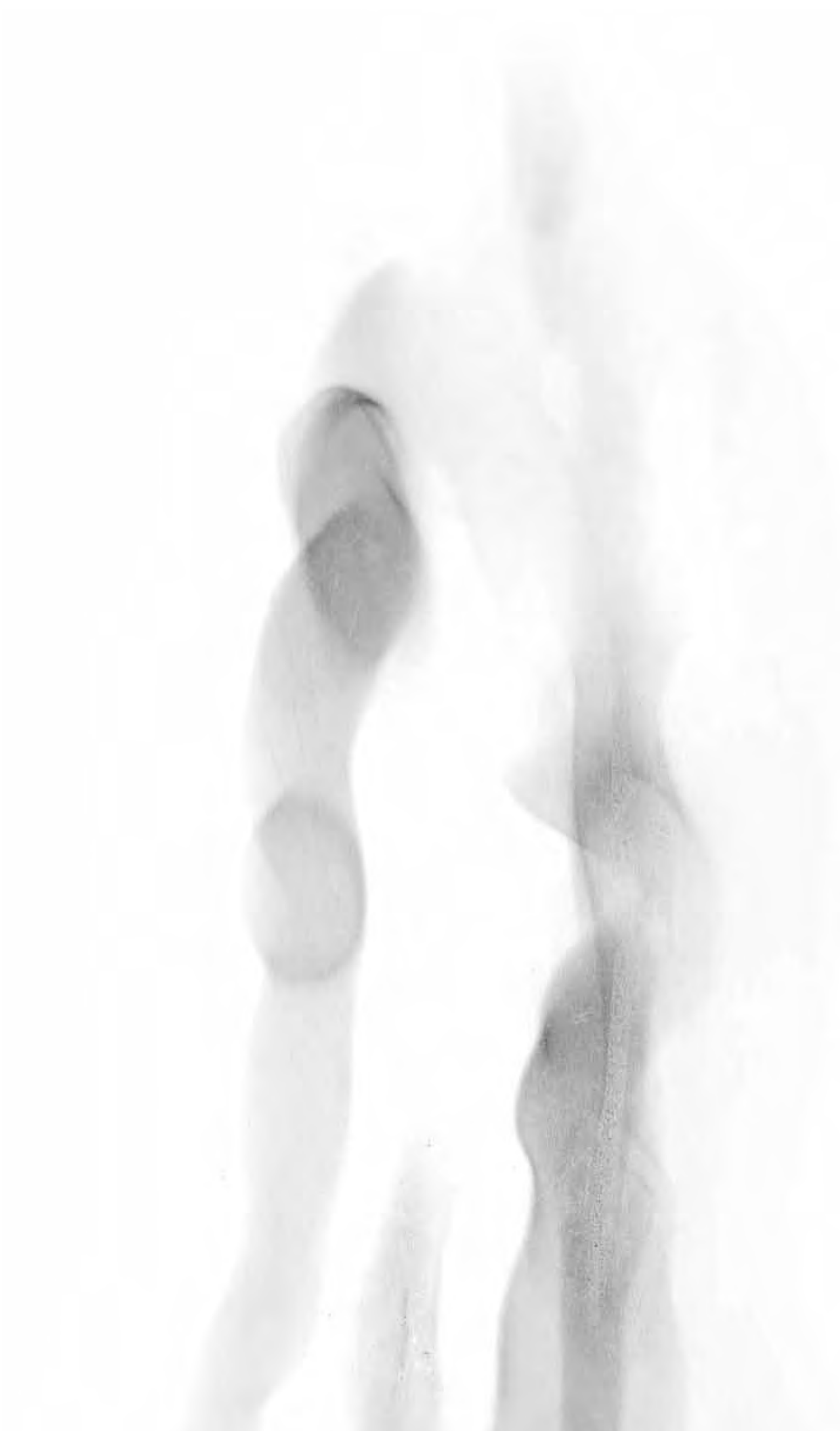

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