MAPPING TIME

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GALLERY @ CALIT2

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EXHIBITION CATALOG N°10

MAPPING TIME

EXHIBITION DATES

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INTRODUCTION

BY LEV MANOVICH

Since 2008 our lab (Software Studies Initiative, softwarestudies.com) has been working on experimenting with new visualization techniques particularly suitable for visual and interactive media – visual art, photography, graphic design, web design, computer games, cinema, animation, motion graphics, comics, manga, and so on.

Following the already established pattern among the practitioners of "artistic visualization," we think of our works as simultaneously having research and artistic value. That is, we hope that the best of our visualizations simultaneously reveal meaningful and unexpected patterns contained in large sets of cultural data, allow us to ask new kinds of questions about culture, and also function as new cultural artifacts in their own right.

The exhibition Mapping Time presents a selection of our visualizations created in 2009-2010. The works selected for the exhibition are organized around a single question – how to analyze and visualize temporal changes in culture. In other words: **what are the "shapes" of cultural time?** For instance, how do the layout, typography and use of images in a magazine change over decades of publication? How do the periods of intense kinetic activity (moving around the space, fighting enemies) and inactivity (watching full motion video, configuring menus) alternate during video game play? How does the graphical style of a manga series change during 10 years of its publication?

Each visualization in the exhibition aims to reveal the unexpected and intricate patterns of temporal change in a particular artifact – or our experience of these artifacts. Taken together, they demonstrate how we can visualize different kinds of gradual changes over time at a number of scales, ranging from a few seconds of an animated film to 130 years of Science magazine (1880-2010).

Because the patterns revealed by visualizations are based on the actual "data" of culture, they have richness of detail and visual complexity that is both intellectually fascinating and aesthetically engaging. Moreover, in our experience these patterns are usually different from what we may have expected. Instead of a smooth curve, we find a strait line; instead of a gradual increase in some quality over time we see a line that nervously wiggles, oscillating between randomness and structure.

The exhibition also suggests that while we commonly think of a cultural artifact as having a **meaning** that we can arrive at through interpretation, when we are confronted with large sets of such artifacts a **pattern** may emerge as the new basic "unit" of our cultural understanding. The exhibition presents a number of such patterns "extracted" from different artifacts at different time scales.

The visualizations in this exhibition were created in our lab as part of a larger paradigm to explore cultural data sets using software. We call this **cultural analytics**. In addition to using existing programs, we also develop our own software tools. These tools map visual data differently than standard graphing applications. If Excel or Google Charts can only display data as bars, points, lines or other graphic primitives, our software displays the original images. We call information visualizations that are composed of original images **media visualizations**.

The exhibition includes two types of media visualizations: **montages** and **image plots**. In a montage, images are sorted in one dimension by some metadata, but then wrapped into a 2D image, much like a line of text is wrapped into a paragraph on the page. An example is Mapping Time. In an image plot, images are positioned on the X and Y axis according to their visual features as measured by software. An example of this is 1000000 manga pages.

MAPPING TIME

DIGITAL VIDEO.

LEV MANOVICH AND JEREMY DOUGLASS. 2009.

Data:

Covers of every issue of Time magazine published from the first issue in 1923 to summer 2009.

Total number of covers: 4535.

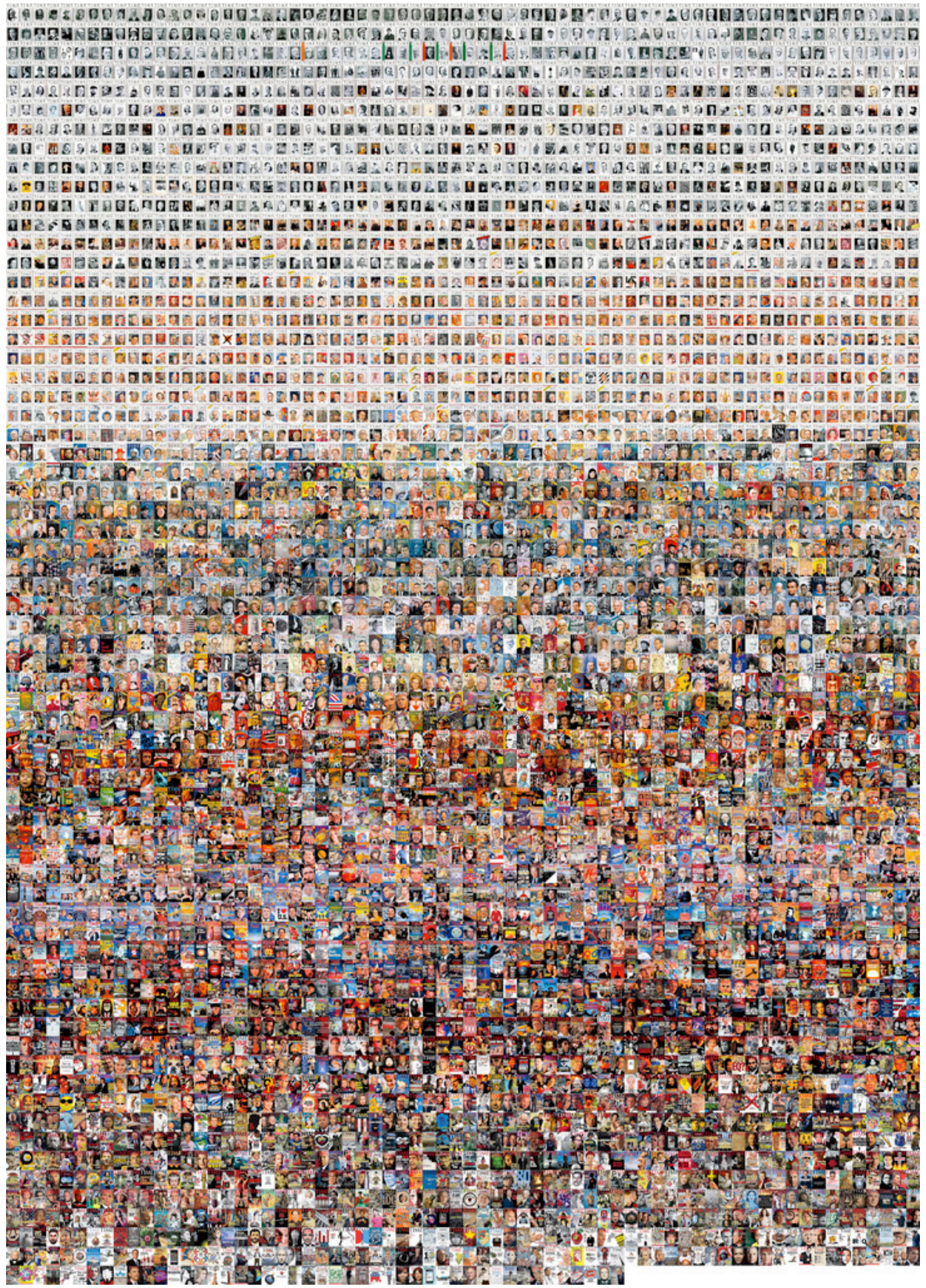
Distinctive red borders have framed Time magazine cover designs since 1927. In order to highlight changes within these borders, we cropped all images to eliminate their margins (red or otherwise).

Timescales:

Artifacts: 1923-2009.
Animation: 1 minute 15 seconds.

Mapping:

86 years of Time magazine covers are mapped into a 1 minute 15 second sequence. Covers appear in order of publication (1923 to 2009), arranged in a grid layout (left to right and top to bottom).



Arranging 4535 Time covers into a grid organized by publication date reveals a number of historical patterns. Here are some of them:

Medium: In the 1920s and 1930s Time covers use mostly photography. After 1941, the magazine switches to paintings. In the later decades the photography gradually comes to dominate again. In the 1990s we see emergence of the contemporary software-based visual language which combines manipulated photography, graphic and typographic elements.

Color printing: The shift from early black and white to full color covers happens gradually, with both types coexisting for many years.

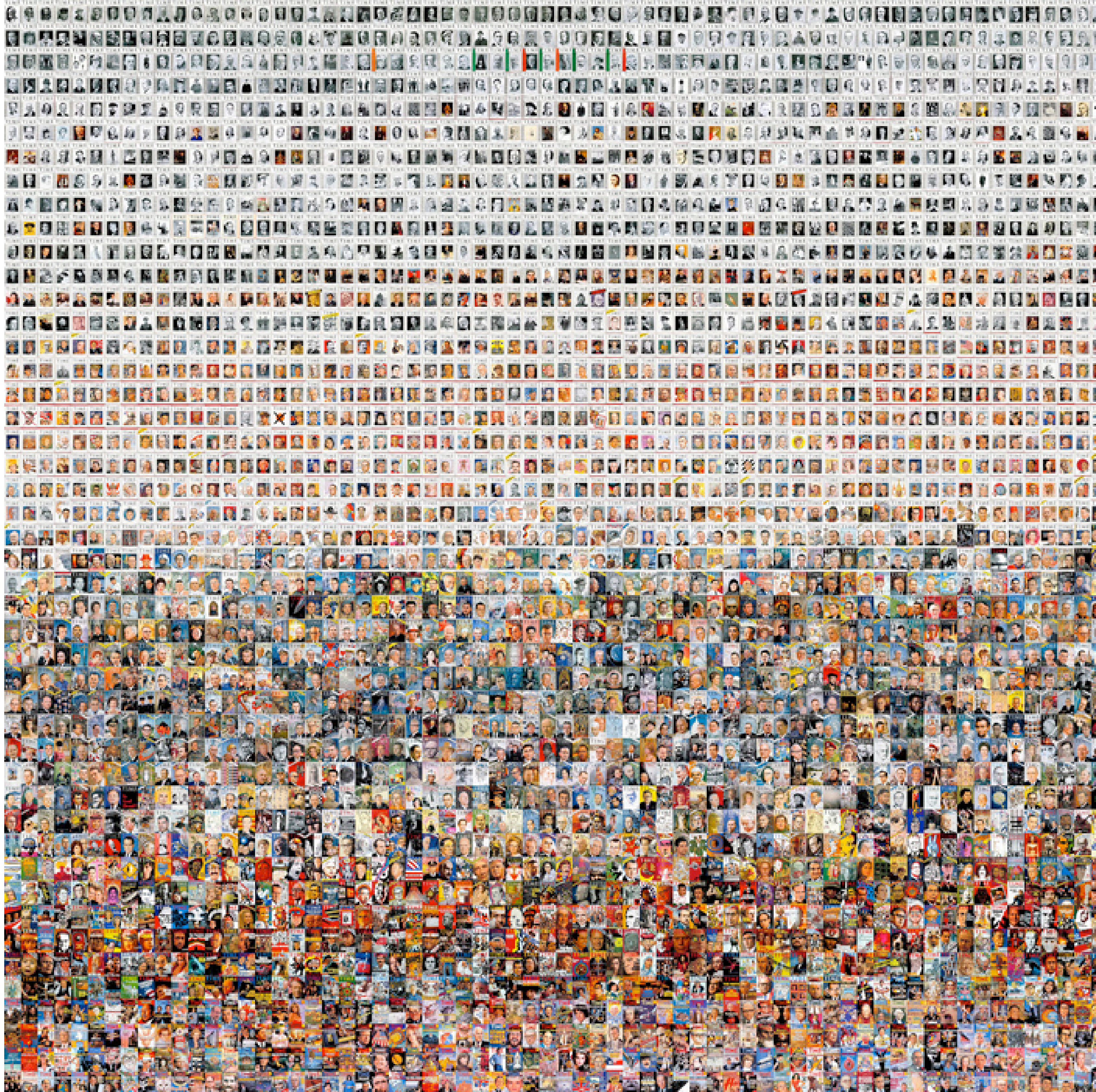
Hue: Distinct “color periods” appear in bands: green, yellow/brown, red/blue, yellow/brown again, yellow, and a lighter yellow/blue in the 2000s.

Brightness: The changes in brightness (the mean of all pixels’ grayscale values for each cover) follow a similar cyclical pattern.

Contrast and Saturation: Both gradually increase throughout the 20th century. However, since the end of the 1990s, this trend is reversed: recent covers have less contrast and less saturation.

Content: Initially most covers are portraits of individuals set against neutral backgrounds. Over time, portrait backgrounds change to feature compositions representing concepts. Later, these two different strategies come to co-exist: portraits return to neutral backgrounds, while concepts are now represented by compositions which may include both objects and people – but not particular individuals.

The visualization also reveals an important “metapattern”: almost all changes are gradual. Each of the new communication strategies emerges slowly over a number of months, years or even decades.



TIMELINE

DIGITAL PRINT TRIPTYCH.

LEV MANOVICH AND JEREMY DOUGLASS. 2009.

Data:

Covers of every issue of Time magazine published from the first issue in 1923 to summer 2009.

Total number of covers: 4535.

Distinctive red borders have framed Time magazine cover designs since 1927. In order to highlight changes within these borders, we cropped all images to eliminate their margins (red or otherwise).

Timescale:

1923-2009.

Mapping:

4535 Time magazine covers spanning 86 years are plotted across the three triptych panels, left to right.

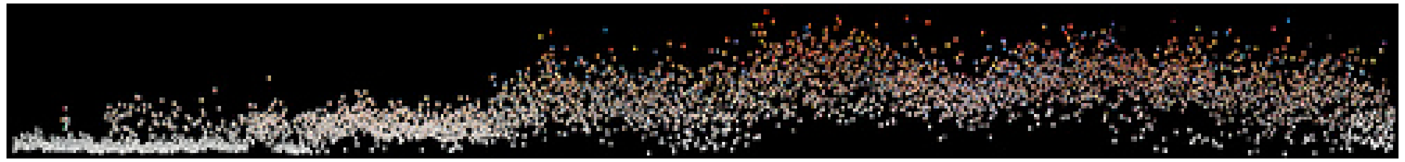
X axis: Publication date, 1923-2009.
Y axis: Composite of automatically measured saturation and brightness (mean value of all pixels) for each page (low to high).

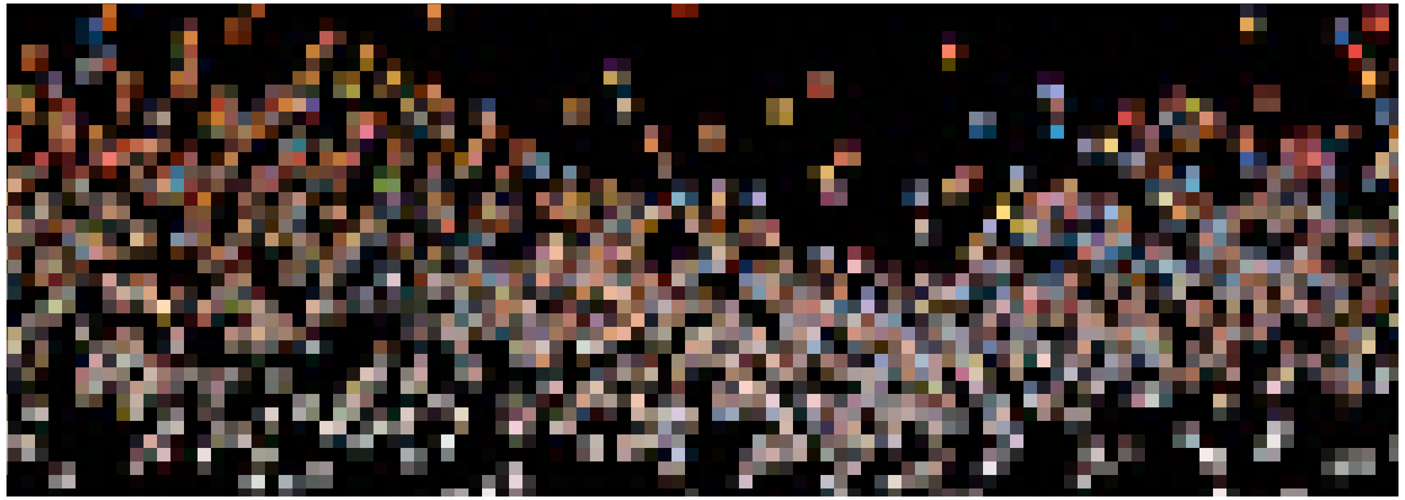
Visualizing 4535 Time covers reveals a number of historical periods and patterns.

The image makes visible the pre-color printing era on the far left, a cluster of brief early experiments in color printing (with left-margin coloration), and then the gradual shift from black and white to full color covers, with both types coexisting for a number of years.

Taking a step back, we can see that brightness and saturation follow a cyclical pattern of rising and falling, with dramatic peaks and valleys only becoming apparent over periods of a decade or more. Standing apart from the overall curve are extreme exceptions: glowing bright images and pale designs that float above or below the cloud of covers typical of an era.

Taking another step back, we can compare our present decade to the entire 86 year magazine history. The drop in saturation since the end of the 1990s (end of right panel) echoes a somewhat similar period of unsaturated covers during the mid-1960s (bottom of center panel).





KINGDOM HEARTS I & II

DIGITAL PRINTS.

WILLIAM HUBER. 2009.

Data:

The data are the game play sessions of the video games Kingdom Hearts (2002, Square Co., Ltd.) and Kingdom Hearts II (2005, Square-Enix, Inc.) Each game was played from the beginning to the end over a number of sessions.

The video captured from all game sessions of each game were assembled into a singe sequence. The sequences were sampled at 6 frames per second. This resulted in 225,000 frames for Kingdom Hearts and 133,000 frames for Kingdom Hearts II.

The visualizations use only every 10th frame from the complete frame sets:

Kingdom Hearts: 22,500 frames.
Kingdom Hearts II: 13,300 frames.

Timescales:

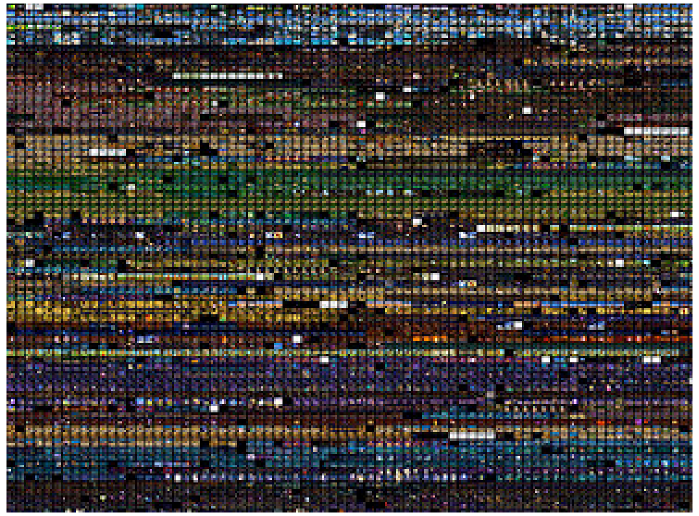
Japanese role-playing games such as Kingdom Hearts can take from about 40 to over 100 hours to complete.

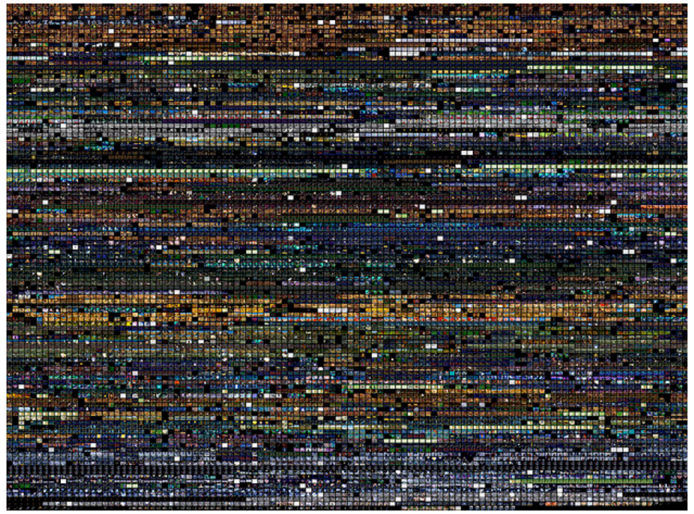
Kingdom Hearts game play: 62.5 hours of game play, in 29 sessions over 20 days.

Kingdom Hearts II game play: 37 hours of game play, in 16 sessions over 18 days.

Mapping:

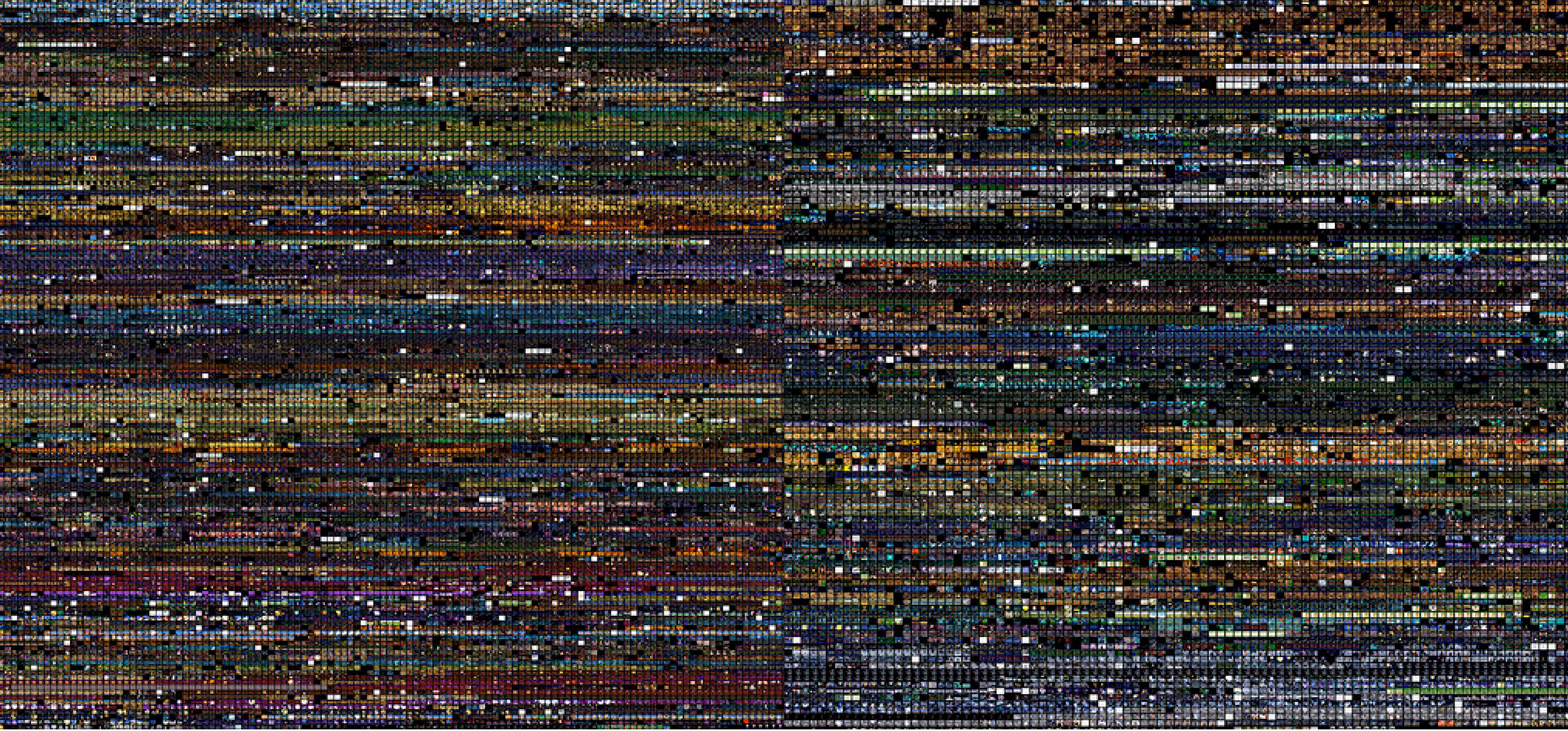
Frames are organized in a grid in order of game play (left to right, top to bottom).





Kingdom Hearts is a franchise of video games and other media properties created in 2002 via a collaboration between Tokyo-based videogame publisher Square (now Square-Enix) and The Walt Disney Company, in which original characters created by Square travel through worlds representing Disney-owned media properties (e.g., Tarzan, Alice in Wonderland, The Little Mermaid, The Nightmare Before Christmas, etc.). Each world has its distinct characters derived from the respective Disney-produced films. It also features a distinct color palettes and rendering styles, which are related to visual styles of the corresponding Disney film.

Like other software-based artifacts, video games can have infinite varied realizations (since each game traversal is unique). Compressing many hours of game play into a single image and placing a number of such visualizations next to each other allows us to see the patterns of similarity and differences between these realizations. Such visualizations are also useful in comparing different releases of the popular games – such as the two releases of Kingdom Hearts shown here.



CATALOG N°10
KINGDOM HEARTS I & II BY WILLIAM HUBER

KINGDOM HEARTS WORLDS CRAWL

DIGITAL VIDEO.

WILLIAM HUBER. 2009-2010.

Data:

Sampled frames from the video capture of the complete traversal (playing the game from the beginning to the end) of the videogame Kingdom Hearts (2002, Square Co., Ltd.).

Timescales:

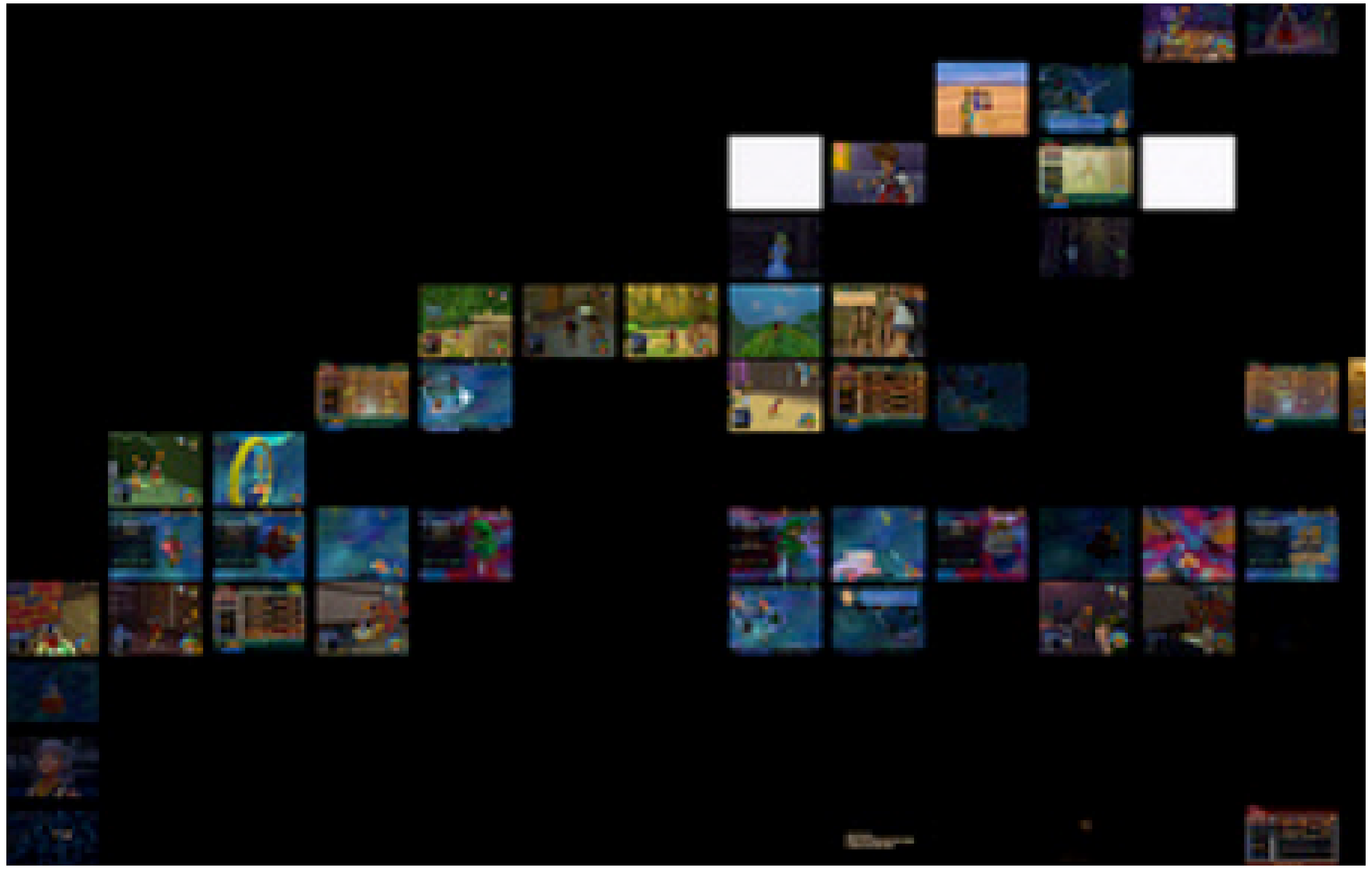
Game play length: 62.5 hours, in 29 sessions over 20 days.
Animation: 7.8 minutes.

From the original video capture done at 1 frame per second, every 16th frame was sampled. In the animation, these sampled frames are played back at 30 frames per second.

Mapping:

Completing Kingdom Hearts took 29 separate sessions. The sampled frame sequences are positioned from left to right in the order of sessions.

In the course of the game, a player moves through a number of different worlds. The ordering of frame sequences from bottom to top corresponds to the order of the worlds as they are visited during the game play.



GOOGLE LOGO SPACE

DIGITAL PRINT.

JEREMY DOUGLASS. 2009.

Data:

587 design variations of the original Google logo, which appeared on google.com pages from 1998.

Some versions, which celebrate important events and people, appeared worldwide; others were only used on google.com home page in particular countries.

Timescales:

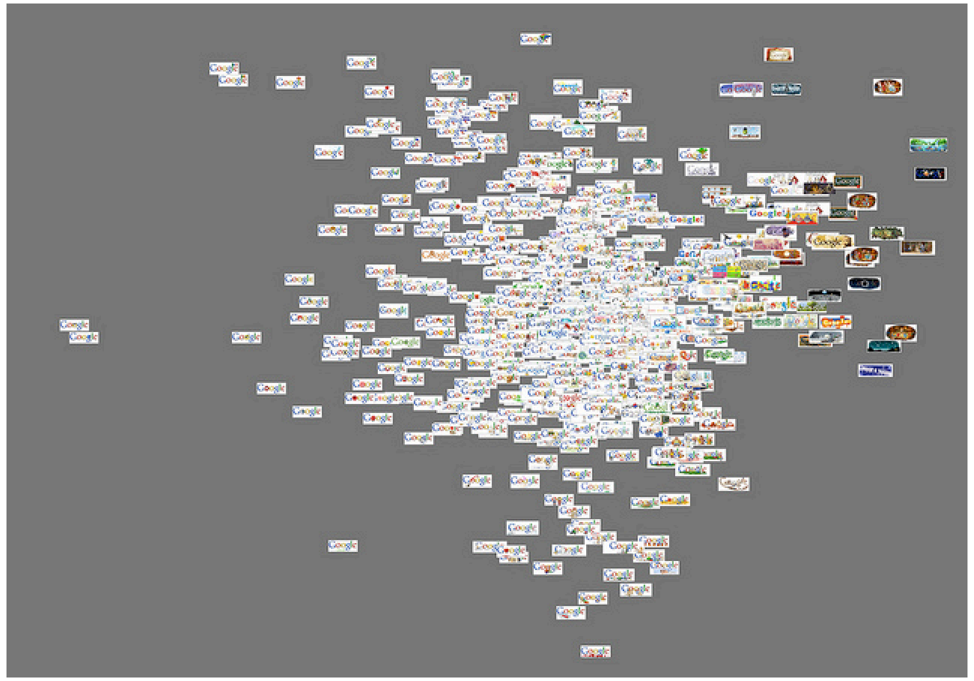
1998-2009.

Mapping:

Each logo version was automatically analyzed to extract a number of visual features. The visualization uses these features to situate logos in 2D space so that their positions indicate how different each logo is from the original. This "difference" could be defined in many ways, and each definition would result in a different visualization. Our visualization shows only one of these possibilities.

Horizontal placement indicates the amount of each logo's modification from the original. The least modified logos are on the extreme left; the most modified are on the extreme right.

Vertical placement indicates which part of a logo was modified. Logos where most of the modifications are in the upper part appear in upper part of the visualization; logos where most modifications are in the lower part appear in lower part of the visualization.



Every day billions of people see a new logo appear on Google's homepage. Since 1998 these logo variations have explored an ever-growing range of design possibilities while still retaining the "essence" of the original logo.

Our visualization of 587 logos shows the space of these variations. Only a few logos have very small or very large modifications. These logos appear around the edges of the "cloud" in the center that consists from logos with moderate changes.

The overall "shape" of this space of Google logo design variations is similar to the well-known normal (Gaussian) distribution, which describes variability of all kinds of data encountered in natural and social sciences. However, if we are to plot the logos over time (not shown in this visualization), we will find a different pattern – the amount of logos' modifications from the original design has been increasing significantly over last few years.

Certain types of subject matter result in similar design solutions, which further organizes the space of design variations. For example, specific national observances often feature top-heavy additions of flags, fireworks, or crowns that cluster towards the top of the cloud, along with a set of logos featuring athletes in the air, while natural seasonal themes of grass, wheat, and fallen leaves, etc. cluster to the bottom.

Visualizing a set of artifacts according to their differences gives us a way to study the patterns of variability in any area of culture – graphic design, manga, painting, cinema, print, or video games.

CATALOG N°10
GOOGLE LOGO SPACE BY JEREMY DOUGLASS

FREAKANGELS TIME CURVE

DIGITAL PRINT.

JEREMY DOUGLASS WITH LEV MANOVICH. 2009-2010.

Data:

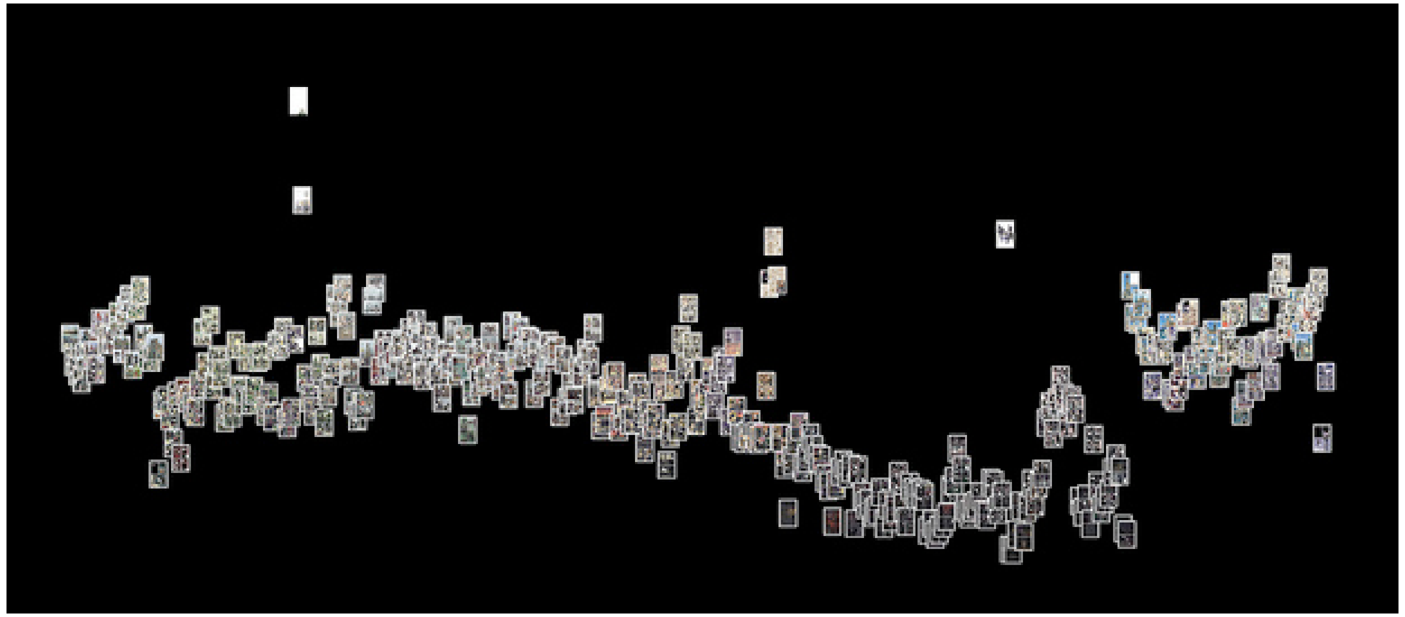
The serial web comic Freakangels (www.freakangels.com).
57 episodes of 6 pages.
Total number of pages: 342.

Timescale:

The episodes used in the visualization were published between Feb 15, 2008 and June 6, 2009.

Mapping:

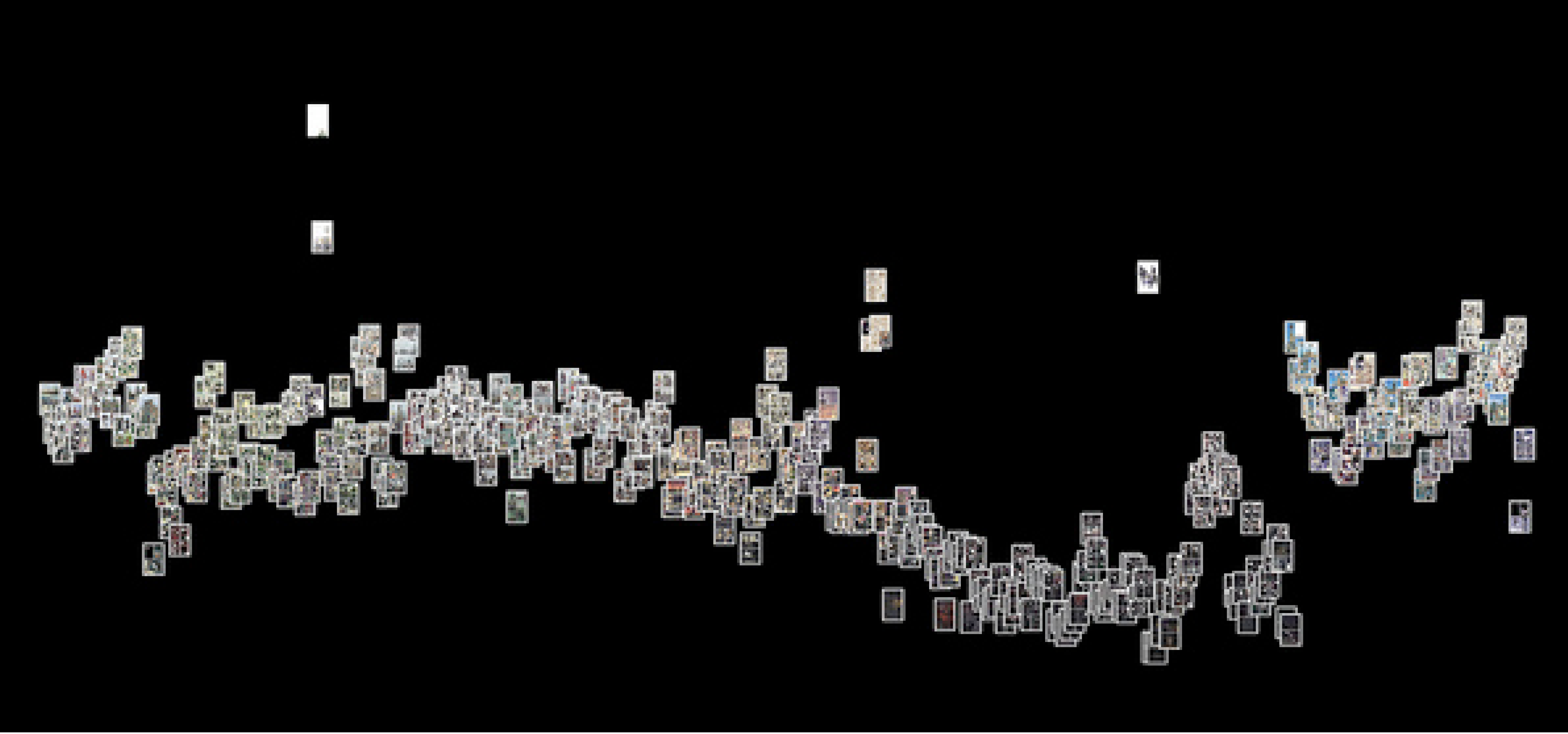
X axis: page publication order.
Y axis: brightness (mean value of all pixels' grayscale values in each page).



Like print comics and manga, web comics may run for years with new episodes added daily, weekly, or monthly. How does their visual style change over the duration of publication? Are the temporal patterns gradual or abrupt? How do these patterns relate to development of a narrative?

To create this visualization of 342 consecutive pages of the web comic Freakangels that were published over 15 months, we used one of the simplest visual features that can be automatically measured with software – the average of all pixels' grayscale values in an image. These average values were used to position the pages vertically. The horizontal placement of the pages corresponds to the order of publication (left to right).

Despite the weekly intervals that separate the episodes of Freakangels, our visualization shows that its visual form is remarkably consist. For the larger part of the publication period, the changes in brightness (the same applies to hue and saturation) follow a smooth curve. Visualization reveals this unexpected pattern and allows us to see the exact shape of the curve.



SCIENCE MAGAZINE

DIGITAL VIDEO.

WILLIAM HUBER AND LEV MANOVICH. 2010.

Data:

All issues of Science magazine from the beginning of publication in 1880 to 1906. Our data set samples every 3rd page from every issue.
Number of sampled pages: 9801.

Timescale:

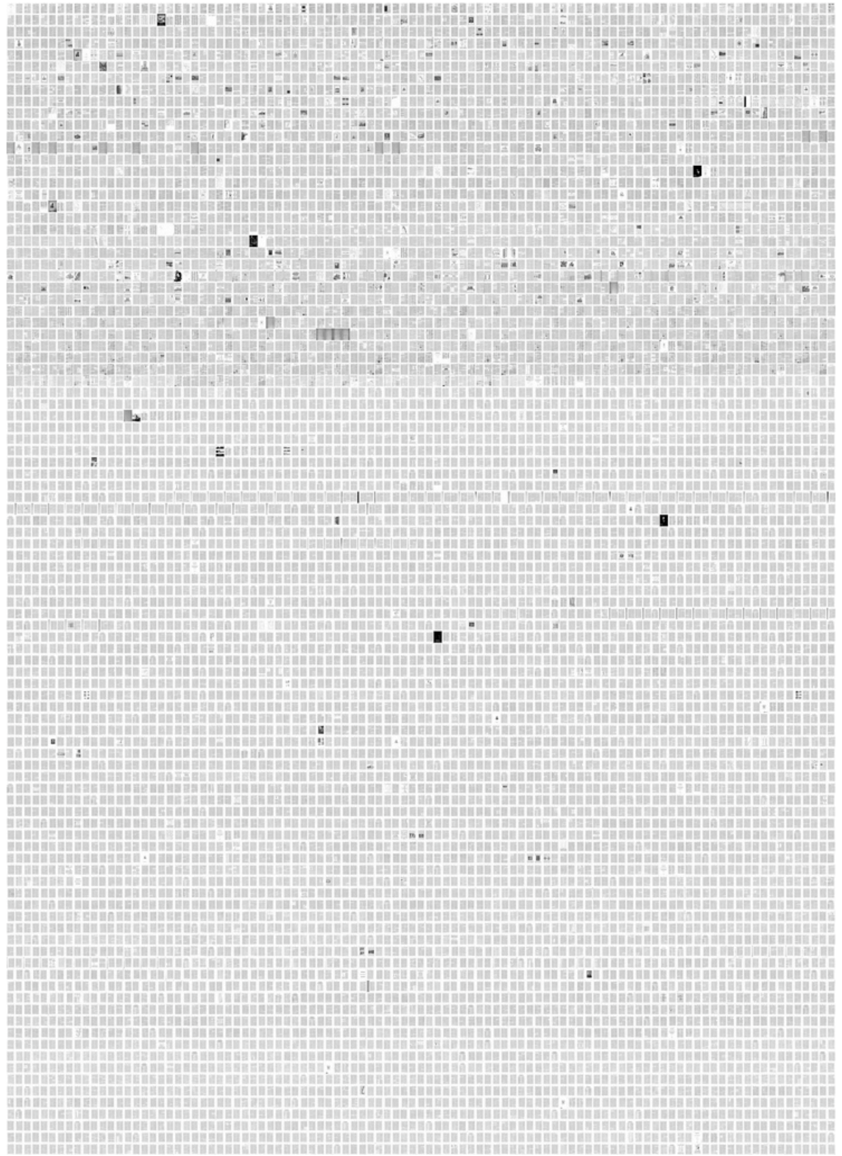
Artifacts: 1880-1906.
Animation: 13 minutes 21 seconds.

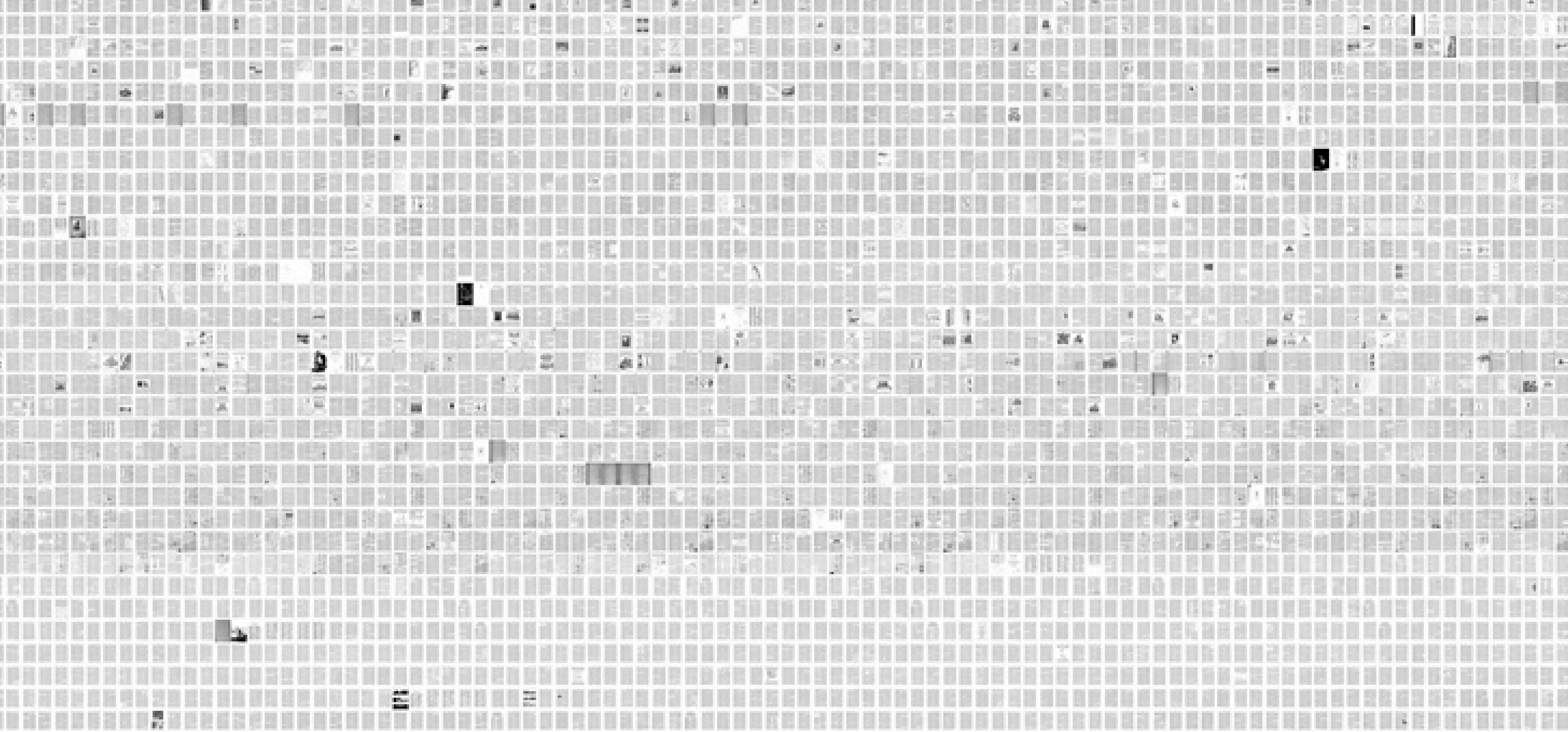
Mapping:

The pages are arranged in the order of publication (left to right, top to bottom).

In the animation we gradually circle around a part of our complete visualization focusing on the first decade of Science publication (1880s). At first, Science includes photographs and hand crafted illustrations. These images are the legitimate parts of the process of creating scientific knowledge. However within about 10 years they disappear almost completely. The only images that are now generally permitted are graphs: illustration and photo documentation are increasingly treated as a way of communicating the work of science, rather than belonging to the work of science itself.

In the last decades of the 19th century scientists make new discoveries that are translated into key technologies of modern society (electricity, wireless communication, etc.) These technologies and the models that inform them are less about understanding the visible and increasingly about the knowledge of, and the explanatory power of, the invisible. Visualization of 9801 pages of Science reflects this increasing importance of the invisible, and the relegation of the visual to explanation.





POPULAR SCIENCE MAGAZINE

DIGITAL VIDEO.

WILLIAM HUBER AND LEV MANOVICH. 2010.

Data:

All issues of Popular Science magazine from the beginning of publication in 1872 to 1922. Our data set samples every 3rd page from every issue.
Number of sampled pages: 9900.

Timescale:

Artifacts: 1872-1922.
Animation: 13 minutes 21 seconds.

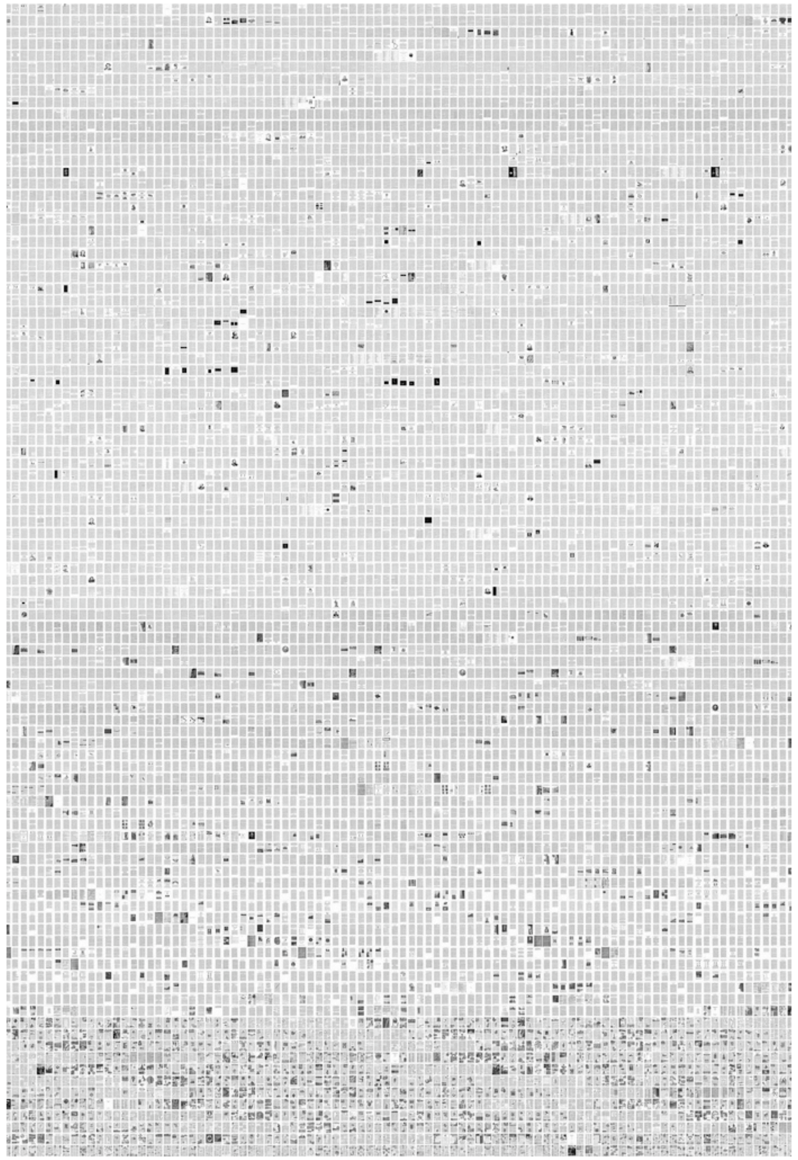
Mapping:

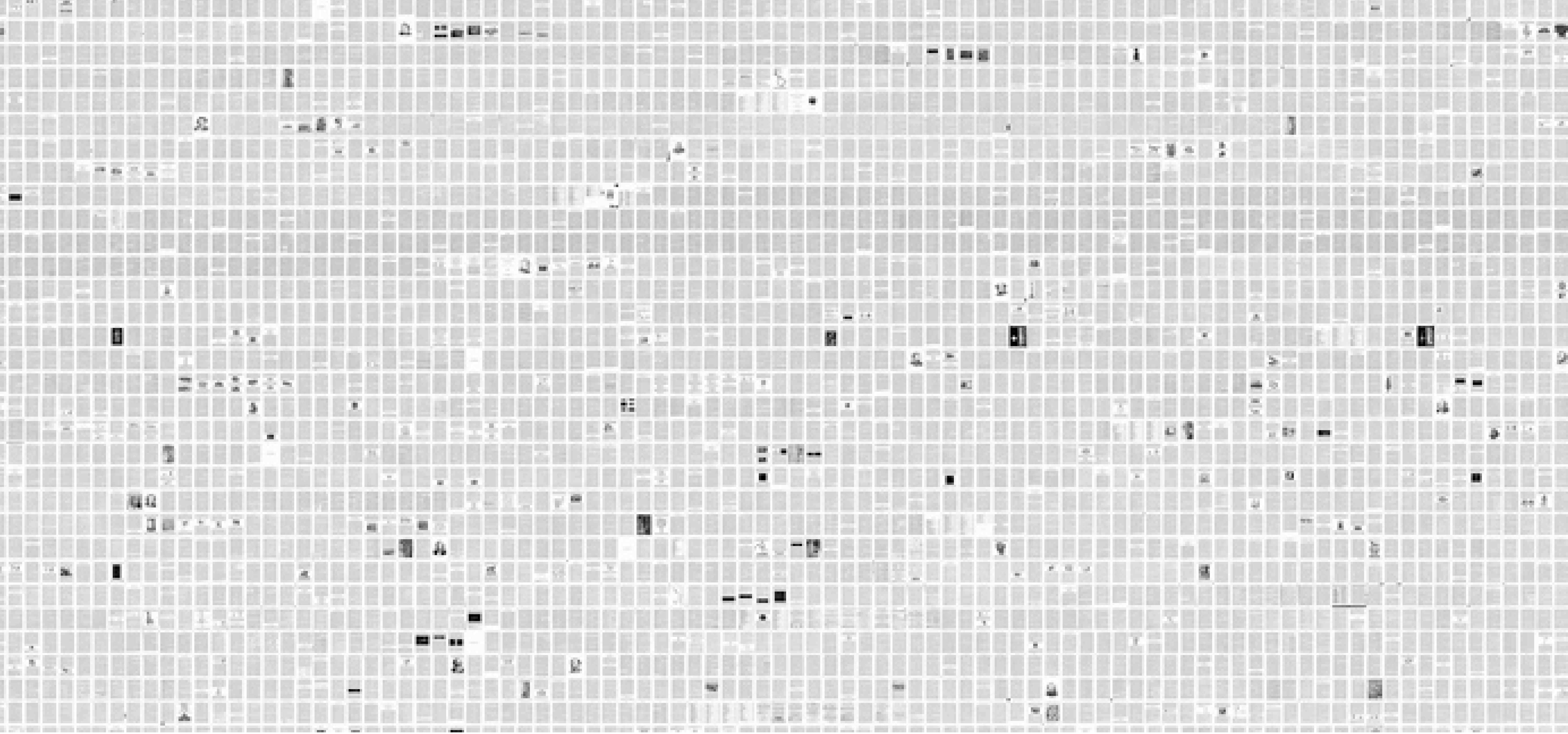
The pages are arranged in the order of publication (left to right, top to bottom).

In the first three decades of its publication, Popular Science used very few images. In fact, if we compare Science and Popular Science in the 1880s, we discover that the latter was at first more "scientific." While photographs and illustrations accompanied Science articles, Popular Science used only occasional graphs.

Over time the two magazines reverse their visual strategies. Science banishes photographs and illustrations as they come to be considered inappropriate for proper scientific discourse. Popular Science moves in reverse direction becoming highly visual.

Mapping 9900 magazine pages into a single high-resolution image reveals this transition. The animation circle around a part of this image that contains issues published in the first two decades of the 20th century. The change in magazine ownership in 1912 dramatically manifests itself in the sudden jump in the number of images and ads and new layout strategies. However, when we zoom out to see the whole visualization, we notice that this change was already anticipated by the gradual increase in the number of images during the preceding decade.





ANNA KARENINA

DIGITAL VIDEO.

LEV MANOVICH. 2009-2010.

MISSING IMAGE

Data:

The compete text of Lev Tolstoy's Anna Karenina (English translation: Constance Garnett).
Number of words: 351,000.
Number of lines: 43,200.

Timescale:

Artifacts: the novel was published in serial installments from 1873 to 1877 in the periodical The Russian Messenger.

Animation: 12 minutes 47 seconds.

Mapping:

The text of the novel is arranged on a single page in vertical columns.
Reading order: top to bottom, left to right.

While recent advances in computing open new possibilities for visualizing patterns in cultural artifacts, we can find many important precursors created much earlier without use of computers. For example, beginning in the early 1960s, many media and later new media artists have been restructuring TV programs and films in a variety of ways (slowing down, speeding up, sampling and repeating, etc.) to reveal ideological and formal patterns in this media content. Another relevant practice is the use of diagrams by artists, choreographers, architects, composers and others to plan and analyze their own works.

We can also find interesting precursors in print culture. For instance, a familiar book index can be understood as a visualization technique. Looking at the book index you can quickly see if particular concepts or names are important in this book – they will have more entries than the concepts that take up only a single line in the index.

Our visualization of Anna Karenina is inspired by a common reading practice of underlining important lines and passages in a text using magic markers. The visualization maps the complete text of the novel into a single image. To create this visualization we designed a program that reads the text from a file and renders it from top to bottom and from left to right; it also checks whether text lines contain particular words (this version checks for the word Anna) and highlights the found matches.

MANGA STYLE SPACE ANIMATION

DIGITAL VIDEO.

LEV MANOVICH AND JEREMY DOUGLASS. 2010.

Data:

883 manga series from the scanlation site OneManga.com.
Total number of pages: 1,074,790.

In Fall 2009, we downloaded 883 manga series containing 1,074,790 unique pages from this site. We then used our custom software system installed on supercomputers at the National Department of Energy Research Center (NERSC) to analyze visual features of these pages.

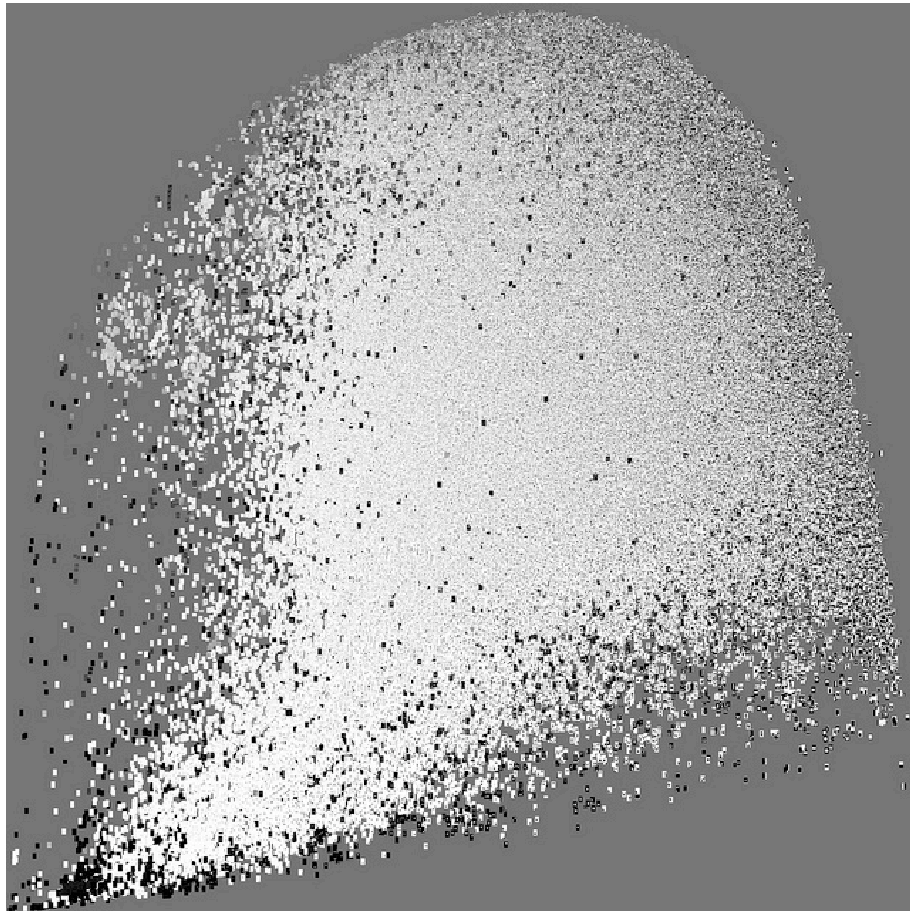
Timescale:

Artifacts: The longest running manga series has been published continuously since 1976. The most popular series on OneManga.com are Naruto (1999-; 8835 pages) and One Piece (1997-; 10562 pages). Along with such long manga series, our data set also contains shorter series that appeared in 2000s and only run for 1-3 years.

Animation: 13 minutes 21 seconds.

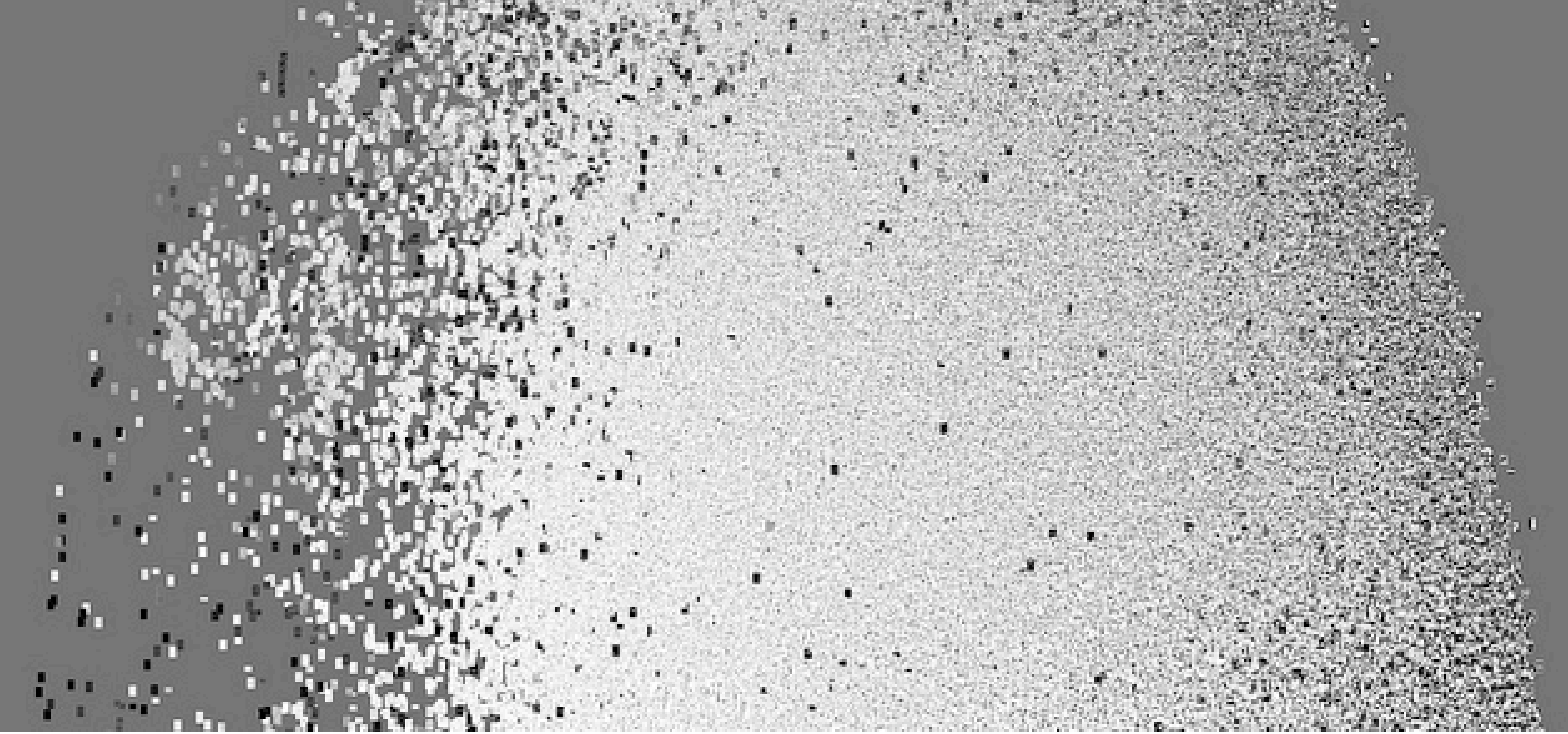
Mapping:

X axis: A mean of standard deviation of pixels' grayscale values in a page.
Y axis: A mean of entropy measured over all pixels' grayscale values in a page.



The animation pans slowly across a visualization of 1 million manga pages organized by differences in visual style. Pages at the top of the visualization have high detail and texture, while pages at the bottom are the most graphic (with low detail and texture). Pages with high contrast are on the right, while pages with low contrast are on the left.

As we gradually move across these four extremes following a clockwise circle, we see every possible stylistic variation in between. At the end of each 12 minute cycle, the camera pulls back to reveal the entire visualization.



CATALOG N°10
MANGA STYLE SPACE ANIMATION BY LEV MANOVICH AND JEREMY DOUGLASS

ESSAY:
THE OUTBURST OF VISUALIZATION
BY MANUEL LIMA*

*Manuel Lima** bio here

The concept of visualization is certainly not new. Humans have been involved in the visual representation of information for more than 30,000 years. During this time, there has been a variety of portrayed subjects, many of them pertaining to natural phenomena, but the common underlying purpose of communicating a message has always been present—whether through cave paintings, cuneiforms, maps, or charts.

Even though visual artifacts have been a central element in the history of humankind, over the last twenty-five years, the term *visualization* has become immensely popular across a profusion of analogous fields such as information visualization, data visualization, scientific visualization, software visualization, geographic visualization, knowledge visualization, flow visualization, and even music visualization. While their distinction is occasionally thin, the emergence of this plethora of labels is indicative of the outburst of a new practice, or what some might call a new medium.

Over the past decade, visualization has been able to shed light into an incredible array of subject areas, covering various physical, political, cultural, economic, and sociological themes. By doing so, visualization became the target of attention, turning the spotlight on itself. Due in part to increasingly accessible data sets and easy to use development tools, visualization has recently brought together people from many distinct areas as it swiftly permeates the public realm. A clear sign of widespread adoption has been the growing number of initiatives outside the academic community, what Fernanda Viégas and Martin Wattenberg labeled as "Vernacular visualization". So, what are the key drivers for the recent tipping point? Although there are numerous variables to take into account, we can clearly point out five main causes behind the recent outburst of visualization.

Computing Storage

In face of contemporary technological accomplishments, our ability to generate and acquire data has by far outpaced our ability to make sense of that data. Some might argue that information overload can only be understood as a failure of design. But how will design cope with the prospect of an ordinary laptop storing every book ever written or every song ever produced? This is not so distant as one might think. Kryder's Law, first introduced in an article at Scientific American in August 2005, points to a periodic trend defined by the doubling of hard disk capacity every two years. Considering Kryder's Law, and even taking into account occasional delays, we can estimate that within twenty to twenty-five years, a personal computer will have the ability to store one petabyte of data—the equivalent of one million gigabytes. Abstract numbers like these do not tend to resonate with most people, but if translated to ten times the entire volume of books in the United States Library of Congress—currently the largest library in the world—then we can have a better grasp of this astounding storage capacity.

Accumulating one million gigabytes in a regular portable laptop might sound like an incredible achievement in itself, but

ON TABLE: SANDIN ANALOG IMAGE PROCESSOR. THIS VIDEO SYNTHESIZER WAS USED STAND-ALONE OR IN CONJUNCTION WITH GRASS SYSTEM FOR MOST VIDEOS IN THE SHOW. PHOTO BY JOHN HANACEK the biggest struggle we will encounter, and possibly one of the major challenges of this century, relates to the management of this quantity of data. Meaningful information is not a given fact, and particularly now, when our cultural artifacts are being measured in terabytes and petabytes, organizing, sorting, and displaying information in an efficient way is a crucial drive for intelligence, knowledge, and ultimately wisdom. This is where visualization undertakes an important mission.

Open Data Sets

Data has never been so widely accessible at such a minimal cost. More frequently, companies, governments, and institutions are opening up their private data sets to the general public and allowing a growing number of people to depict them in whatever way they feel appropriate. This trend is further propelled by a profusion of file formats that seek an effortless transfer and broad compatibility of data, e.g., XML, RDF, APML, XMPP. This growing openness has also been a key driving force for many online visualization services, such as Swivel and IBM's Many Eyes, which allow users to upload their own data sets, or use existing ones on the site, and visualize them in different ways. But perhaps one of the most prominent examples of this growing movement has been the launch in May 2009 of Data.gov—a cohesive public portal collecting freely accessible data from a multitude of American governmental bodies, agencies, and institutes, which users can then download in a variety of formats. More recently, in January 2010, the British government followed suit with the release of Data.gov.uk, a similar service congregating more than a thousand data sets and led by Sir Tim Berners-Lee. It is expected that many more analogous initiatives will arise across the globe, stimulating the rising appetite for visualization, as a way of finding relevant patterns in the vast abundance of data.

Online Social Network Services

It is not a fortunate coincidence that the recent outburst of visualization followed the same dramatic rise of the newest boom of Web services, commonly labeled with the now weary term of Web 2.0. There are different reasons that explain this parallel progress:

Complex Social Groups

Most social-networking services, as the name implies, rely on a community of people sharing information, interests, and activities. Many of these online communities reach striking numbers over many millions of users. It is widely said that if Facebook were a country, with more than 360 million users, it would make up the world's third most populous nation, just behind China and India. This naturally creates a challenge, particularly if a service aims at mapping relationships amongst its numerous members—a common feature in many professional networking sites. Anyone interested in social network analysis understands how a regular friend-of-a-friend network, starting with one individual, can quickly escalate into millions of nodes. The level of complexity of many of these online social services has pushed visualization forward as it tries to come up with different solutions to visualize and analyze these vastly convoluted structures.

Shared Content

Members of these online communities are also engaged in collaborative actions in the creation and exchange of content, which in turn becomes a remarkable resource for exploration. As we look into the information exchange through a visualization lens, various patterns start to emerge: how humans categorize information, through the analysis of social bookmarking services like Del.icio.us; or the hidden connections between music genres, by exploring services like Last.fm.

Tools

Besides its social nature, many online services provide a profusion of tools that allow you to track and map every daily activity imaginable. From tracing how many miles you run, charting the geo-coordinates of your photos, or even plotting your sexual activities, many new tools keep pushing the boundaries of self-tracking methods and enabling the user to visualize the most mundane personal behavior.

Democratization of Visualization Tools

Only ten years ago, the retrieval, analysis, and visualization of large complex data sets were only available to a select few. It was very serious stuff done by experts for experts. But over the past few years, many accessible packages, like Flash, Processing, VVVV, and a variety of toolkits and open-source initiatives, such as Prefuse and Modest Maps, have greatly contributed to a wider reach of the discipline, bringing in people from all sorts of backgrounds. These tools have made it easier for someone without in-depth knowledge of programming to conduct adequate research and development in visualization, which has lead to a sprout of fresh innovation. The positive outcome of this rising accessibility is obvious. With more brains involved in the process we will be much better equipped to face ever more complex challenges and create new visualization methods to better unravel them.

Mainstream Media

Mainstream media has been a central driving force for the latest outburst of interest in visualization. Newspapers like the *New York Times*, magazines like *WIRED*, and TV channels like CNN have embraced an assortment of new methods for displaying information, which has contributed to a heightened awareness of the discipline. During the media coverage of the 2008 U.S. presidential elections, users were bombarded, and enthralled by CNN's large-display telepresence and the *New York Times's* copious numbers of interactive graphics. It is through these original initiatives that the general public's grasp has extended far beyond the familiar pie charts or bar charts.

News outlets are at the front lines of our struggle with information overload, dealing on a daily basis with data in all shapes and sizes, across a variety of channels. As they continuously seeks enhanced ways of exploring and filtering the plentiful quantity of data at their disposal, so will people become more aware and increasingly interested in these unconventional approaches. This in turn will drive the demand for richer methods of representation and the development of visualization.

The previous set of motivations is behind a new massively contagious visualization commotion, far-reaching in its chosen topics, and slowly consolidating as a new medium in its own right. Empowered with its aspiration for simplification, clarification, and sense making, this emergent practice provides an extraordinary lens of insight into the meanders of our culture. Also, by stripping down culture to its most inner fragments, visualization is able to scrutinize various past and present manifestations with an acute quantitative filter, delivering recurrent new perspectives into its modus operandi. When we start looking collectively at our cultural artifacts through its associated raw data, and providing the right tools to visually explore these large datasets, the possibility for new patterns to emerge is highly likely. The outcome of this effort is not only insightful, but also highly captivating and engaging; it's human culture at its best.

Mapping Time delivers a riveting view on the role of visualization as a tool for cultural analysis, a tool for discovery and understanding in the whopping sea of data. It shows how visualization can continuously retell familiar stories, always adopting a new unseen perspective. It explores a wide view of our culture across different time scales, where the whole predominates over the individual part. It exposes culture's internal data points, tying them together in various patchworks with unconventional threads of insight. And while many of these patchworks provide alternative points of view into familiar territories, they also constitute a new cultural object, able to decode the inherent complexity of our contemporary society.

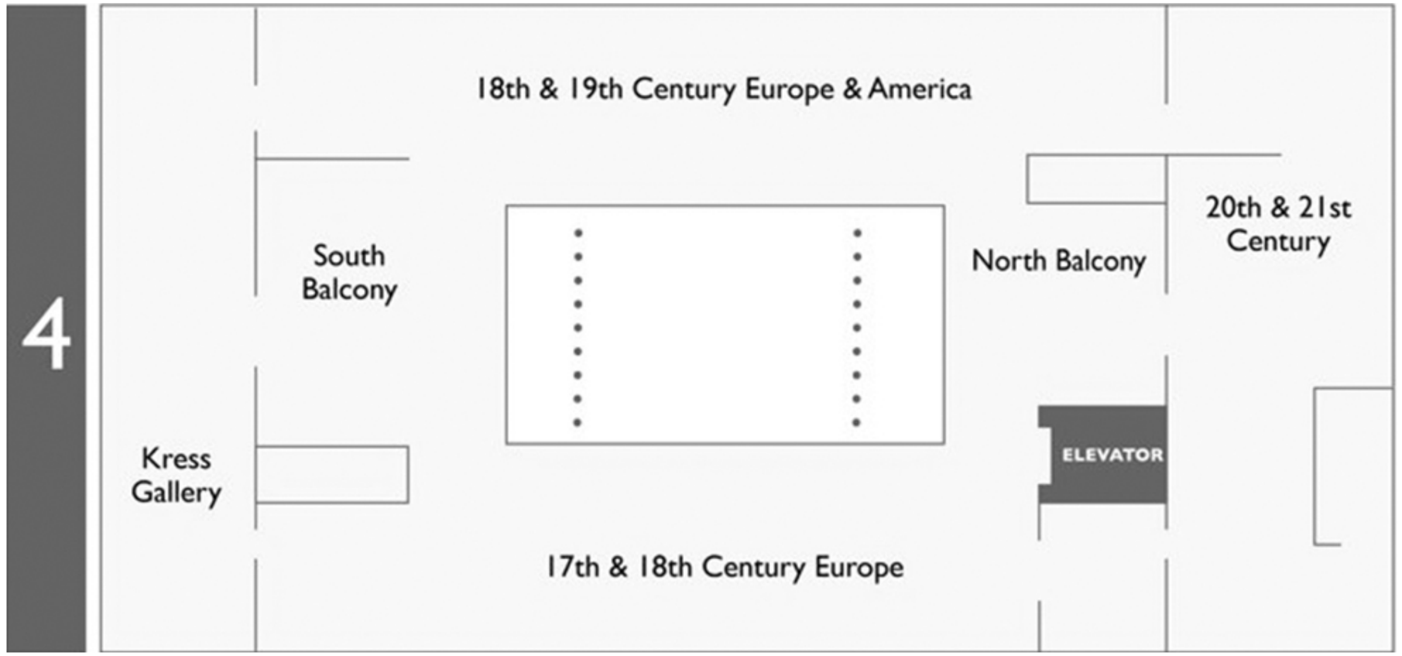
ESSAY:
VISUALIZING CHANGE

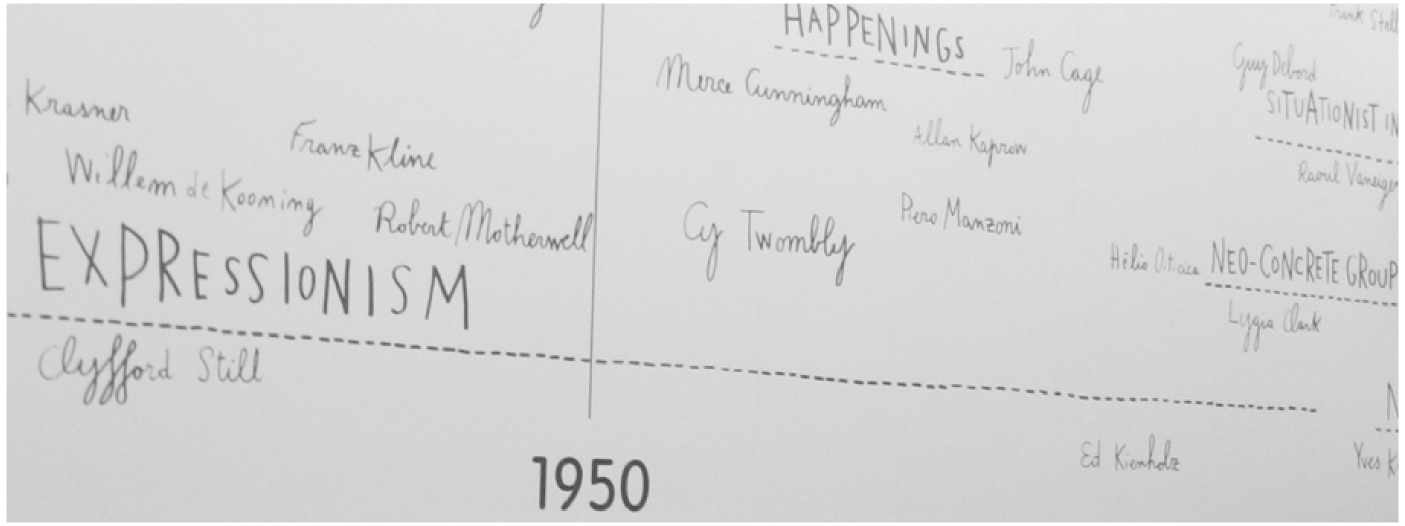
BY LEV MANOVICH AND JEREMY DOUGLASS

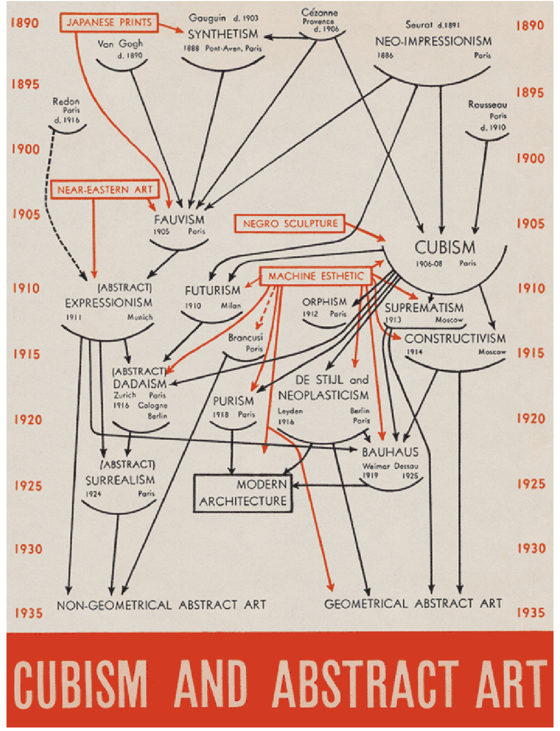
From the 18th century onward, geographic maps started to show not only discrete boundaries and paths, but also continuous changes in elevation and relief. However, our representations of cultural time have remained discrete—typically, they are timelines that partition historical processes into periods. How can we "map time" with the same fluidity as we now do with space?

While the explosion of new ideas and methods in cultural disciplines from the 1960s onward affected the subjects being written about and exhibited and their interpretations, one important aspect of our presentations of cultural histories did not change.[1] Books and museums devoted to art, design, media, and other cultural areas continue to arrange their subjects into small numbers of discrete categories—periods, artistic schools, -isms, cultural movements. The chapters in a book or the rooms of a museum act as material dividers between these categories. In this way, a continuously evolving cultural "organism" is sliced and segmented into a set of artificial boxes.

In fact, although on a technological level the shift from analog to digital media is a rather recent event, we have already "been digital" on a theoretical level for a long time. That is, since the emergence of modern institutions of cultural storage and cultural knowledge production in the nineteenth century (i.e., public museums and humanities disciplines housed in universities) we have been forcing the continuity of culture into strictly discrete categories in order to theorize, preserve, and exhibit it (figures 1–2).



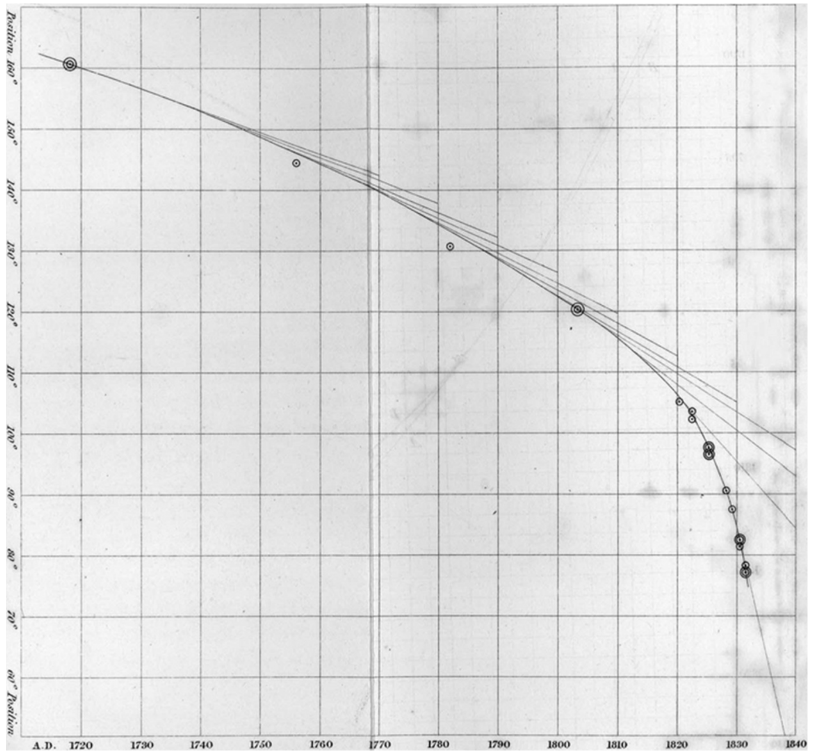


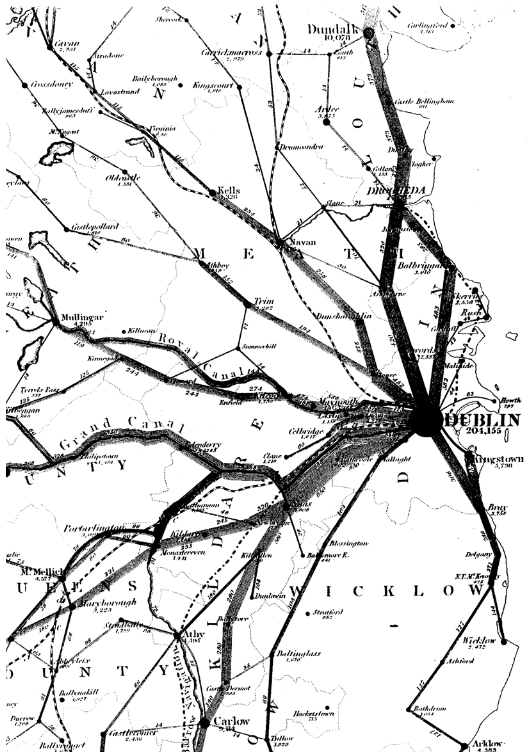


We can ask: If we are currently fascinated with the ideas of flow, evolution, complexity, heterogeneity, and cultural hybridity, why do our presentations of cultural data not reflect these ideas?

The use of a small number of discrete categories to describe content went hand in hand with the refusal of modern humanities and cultural institutions to use graphical representations to present this content. Many people know the famous diagram of the evolution of modern art made by Barr (the founder and first director of MoMA in New York) in 1935 (figure 3). This diagram still uses discrete categories, but it is an improvement over standard art timelines and art museums' floor plans since it represents cultural process as a 2D graph. Unfortunately, this is the only well-known art history diagram produced in the twentieth century.

In contrast, since the first decades of the nineteenth century, scientific publications began to widely use graphical techniques that allowed the representation of phenomena as continuously varying. According to the online history of data visualization by Michael Friendly and Daniel Denis, during that period, "all of the modern forms of data display were invented: bar and pie charts, histograms, line graphs and time-series plots, contour plots, and so forth"1 (figures 4–5).

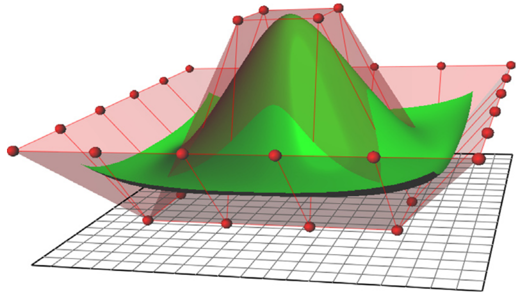




Although a systematic history of visual data display remains to be researched and written, popular books by Edward Tufte illustrate how graphs representing quantitative data had already become common in various professional areas by the end of the nineteenth century.[2]

The use of visual representations of continuous qualities became especially popular after the 1960s when computers were adopted to create 2D and 3D graphics automatically. In 1960, William Fetter (a graphic designer for Boeing Aircraft Co.) coined the phrase "computer graphics." Around the same time, Pierre Bézier and Paul de Casteljau (who worked for Renault and Citroën, respectively) independently invented splines—mathematically described smooth curves that can be easily edited by a user. In 1967, Steven Coons of MIT presented mathematical foundations for what eventually became the standard way to represent smooth surfaces in computer graphics software: "His technique for describing a surface was to construct it out of collections of adjacent patches, which had continuity constraints that would allow surfaces to have curvature which was expected by the designer."[3] Coon's technique became the foundation for surface descriptions in computer graphics (the most popular such description today is NURBS—Non-Uniform Rational Basis Spline) (figure 6).

When design, media, and architecture fields adopted computer graphics software in the 1990s, this led to an aesthetic and

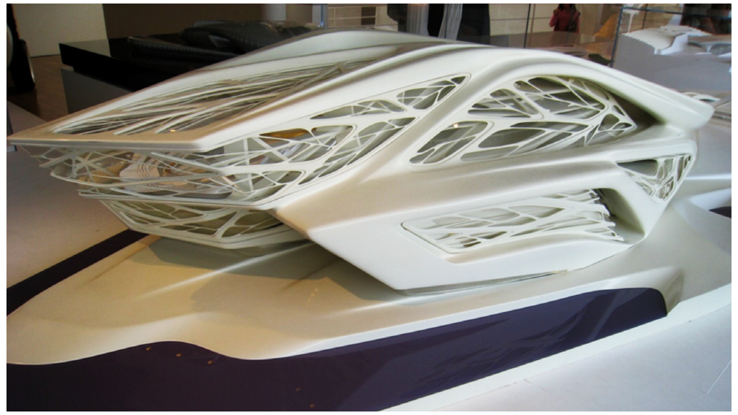


intellectual revolution. Until that time, the only practical technique for representing 3D objects in a computer was to model them through collections of flat polygons. By the early 1990s, the faster processing speeds of computers and the increased size of computer memory made it practical to pursue NURBS modeling developed by Coons and others in the 1960s. This new technique for representing spatial form pushed architectural thinking away from rectangular modernist geometry and toward the privileging of smooth and complex forms made from continuous curves. As a result, at the end of the twentieth century the aesthetics of such complex smooth surfaces (called "blobs" by journalists) come to dominate the thinking of many architecture students, young architects, and even well-established "star" architects (figures 7–8). Visually and spatially, smooth curves and freeform surfaces have emerged as the new expressive language for the globalized networked word where the only constant is rapid change. The modernist aesthetics of discreteness and simplicity was replaced by the new aesthetics of continuity and complexity.

(Another useful term, coined for this new architecture focused on research into the new possibilities of spatial form enabled by computation and the new construction techniques necessary to build them, is "non-standard architecture." In winter 2004 Centre Pompidou organized a show, Non-Standard Architectures,[4] which was followed by a conference at MIT, Non Standard Practice.)

This change in the imagination of spatial form was paralleled by the adoption of a new intellectual vocabulary. Architectural discourse came to be dominated by concepts and terms that parallel (or directly come from) the design elements and operations offered by the software—splines and NURBS, morphing, physically based modeling and simulation, parametric design, particle systems, simulation of natural phenomena, artificial life (AL), and so on. Here are a few examples:

The Campus is organized and navigated on the basis of directional drifts and the distribution of densities rather than the key points. This is indicative of the character of the Centre as a whole: porous, immersive, a field space. (Zaha Hadid [London], description of a design for Contemporary Art Center in Rome [currently under construction])



Scenarios of hybridization, grafting, cloning, morphing give rise to perpetual transformation of architecture which strives to break down the antinomies of object/subject or object/territory. (Frédéric Migayrou on R&Sie [Francois Roche and Stéphanie Lavaux, Paris])

Fuzzy logic thinking is another step of helping human thought to recognize our environment less as a world of crisp boundaries and disconnections and more as a field of swarming agents with blurred borders. (MRGD [Melike Altinisik, Samer Chaumoun, Daniel Widrig], description of Urban Lobby [research for a speculative redevelopment of the Centre Point office tower in central London])

Although computer graphics was not the only source of inspiration for this new conceptual vocabulary—important influences came from French philosophy (particularly Derrida and Deleuze) and the sciences of chaos and complexity—it obviously played its role. Thus, along with becoming the language of contemporary design and architecture, the language of computer graphics also functions as inspiration for architectural discourse about buildings, cities, space, and social life.

Representing Cultural Processes: From Discrete Categories to Curves and Surfaces

If architects adopted the techniques of computer graphics as theoretical terms to talk about their own field, should we not do the same for all cultural fields? But, rather than using these terms as metaphors, why not actually visualize cultural processes, dynamics, and flows using the same techniques of computer graphics?

The time has come to align our models of culture with the new design language and theoretical ideas made possible (or inspired) by software. Design, animation, and visualization software allow us to start conceptualizing and visualizing cultural phenomena and processes in terms of continuously changing parameters—as opposed to categorical "boxes" still standard today.

Just as software replaced the older Platonic design primitives (cubes, cylinders, spheres) with new primitives (curves, flexible surfaces, particle fields) better suited for representing complexity, let's replace the traditional "cultural theory primitives" with new ones. In such scenario, a 1D timeline becomes a 2D or 3D graph; a small set of discrete categories is discarded in favor of curves, freeform 3D surfaces, particle fields, and other representations available in design and visualization software.

This was one of the motivations behind the establishment of the Software Studies Initiative (www.softwarestudies.com) in 2007—a research lab located at University of California, San Diego (UCSD) and California Institute for Telecommunication and Information Technology (Calit2). Drawing on the recognized strengths of UCSD and Calit2 in digital art and IT research, we have been developing techniques for the graphical representation and interactive visualization of cultural artifacts, dynamics, and processes. Our inspirations come from many fields, which all rely on computer graphics to visualize data—scientific visualization, information visualization, "artistic visualization" (see <http://infosthetics.com>), information design, and interface design. (For example, the standard graphical interfaces used in media editing, composition, and animation software such as Final Cut, After Effects, Maya, Blender, and others use curves to visualize the changes in various parameters of an animation over time.)

Turning Culture into Data

Before we venture into folds, fields, particle clouds, complex surfaces, and other more advanced computer-driven representations, let's start with a basic element of modern spatial representation: a 2D curve. How do you represent a cultural process that unfolds over time as a continuous curve?

If, like many 19th century historians, we were to believe that cultural history follows simple laws—for instance, that every culture goes though a cycle consisting in an early stage, a "golden age," and a decline stage—things would be quite simple. We would use mathematical formulas that represent the processes of growth and change (e.g., trigonometric, exponential, or polynomial functions) and feed their variables with the data representing some conditions of the historical process in question. The result would be a perfectly smooth curve that represents a cultural process as a cycle of rise and fall. However, today this paradigm of history is clearly out of favor. What we want to do instead is to create a curve that is based on the actual detailed data about the cultural process in question taken as a whole.

A 2D curve defines a set of points that belong to this curve. Each point, in its turn, is defined by two numbers—x and y coordinates. If the points are dense enough, they would visually form a curve by themselves. If they are not dense enough, we can use software to fit a curve through these points. Of course, we do not always have to draw a curve through the points—for instance, if these points form clusters or any other obvious geometric patterns, this is valuable in itself.[5]

In either case, we need to have a set of x and y coordinates from which draw the points. This means that we have to map a cultural process into a set made from pairs of numbers. In each pair, one number would represent a moment in time (x- axis) and the other number would represent some quality of the process at that time (y-axis.)

In short, in order to "map time," we need first to turn "culture" into "data."

Definitions of culture include beliefs, ideologies, fashions, and other nonphysical properties. However, on a practical level, our cultural institutions and culture industries deal in a particular manifestation of culture—material (and recently, digital) objects. This is what is stored in the Library of Congress and the Metropolitan Museum, created by fashion and industrial designers, uploaded by users to Flickr, and sold by Amazon. Spread over time or distance, cultural objects manifest changes in cultural sensibility, imagination, or style. So even though later on we will need to challenge the assumption that a cultural process can be equated with objects, if we can begin by using the sets of these objects to represent the gradual changes in cultural sensibility or imagination, that would be a good start.

Getting numbers for the x-axis (i.e., time) is not difficult. Usually cultural objects have some discrete metadata attached to them—the name of the author, the size (of an artwork), the length (of a film), and so on—including the date and the place of creation. So if we have the dates when the cultural objects were created, we can plot these numbers as metadata on the x-axis. For example, if we want to represent the development of painting in the twentieth century, we can plot the year each painting was completed. But what do we use for y-axis? That is, how do we compare the paintings quantitatively?

To continue with the same example, we can manually annotate the contents of the paintings. However, we will not be able to use natural language precisely to describe the finer details of their visual structure. Alternatively, we can ask experts (or some other group of people) to position the paintings on some discrete scale (e.g., historical value, aesthetic preference)—but such judgments can only work with a small number of categories.[6] More importantly, these methods do not scale well—they would be very costly if we want to describe hundreds of thousands or millions of objects. Moreover, even if we can afford it, there are inherent difficulties in ordering a large number of objects that are all very similar. Therefore, we need to resort to some automatic computer-based method to describe large numbers of cultural objects quantitatively.

In the case of texts, this is relatively easy. Since texts already consist of discrete units (i.e., words) they naturally lend themselves to computer processing. We can use software to count occurrences of particular words and combinations of words; we can compare the numbers of nouns versus verbs; we can calculate the lengths of sentences and paragraphs; and so on.

Because computers are very good at counting as well as running more complex mathematical operations on numbers, digitization of text content such as books and the growth of websites and blogs quickly led to new industries and epistemological paradigms that explore computational processing of texts. Google and other search engines analyze billions of Web pages and the links between them to allow users to search for those pages that contain particular phrases or single words. Nielsen Blogpulse mines over 100 million blogs daily to detect trends in what people are saying about particular brands, products, and other topics its clients are interested in.[7] Amazon.com analyzes the contents of the books it sells to calculate "statistically improbable phrases" or SIPs, used to identify unique content.[8]

In the field of digital humanities, scholars have also been doing statistical studies of literary texts for a long time (although on a much smaller scale). Some of them—most notably, Franco Moretti—have produced visualizations of the data in the form of curves showing historical trends across sets of literary texts.[9] During the last few decades Russian scholars have also published a large number of books and articles that use quantitative methods and visualization to study patterns in literature and other arts[10]—although this work is practically unknown in the West. Recently, international grant competitions such as the Digging into Data Challenge[11] have drawn increased attention to questions of how "big data" changes the research landscape for the humanities and social sciences, while ambitious text-mining projects such as the n-gram analysis of Google Books and its public N-Gram Viewer interface[12] have enabled new quantitative explorations of large-scale cultural trends.

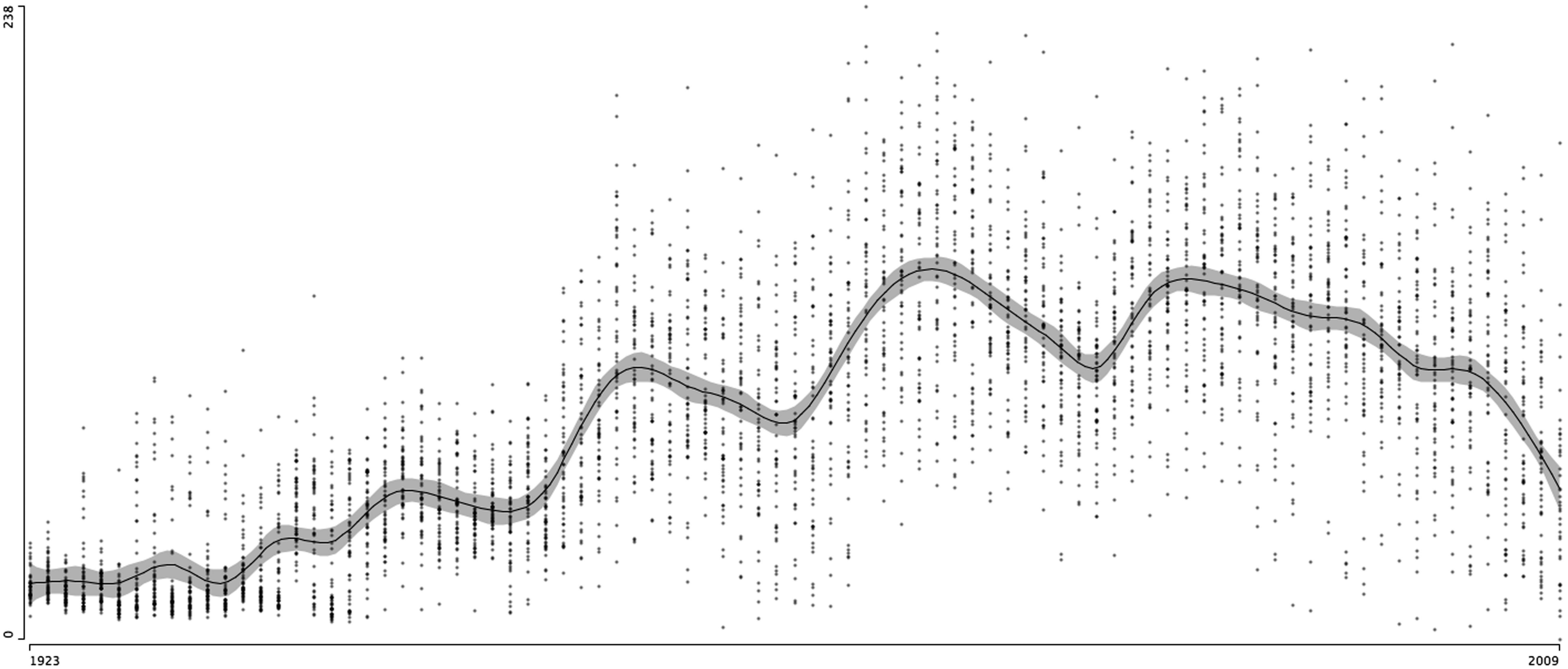
But how do we automate the description of images or video? Many kinds of visual media such as photographs do not have clearly defined discrete units equivalent to words in a text. Additionally, visual media do not have a standard vocabulary or grammar—the meaning of any element of an image is defined only in the particular context of all other elements in this image. This makes the problem of automatic visual analysis much more challenging—but not impossible. The trick is to focus on visual form (which is easy for computers to analyze) and not semantics (which is hard to automate).

Since the middle of the 1950s, computer scientists have been developing techniques to describe visual properties of images automatically. Today we have techniques for the analysis of distributions of gray tones and colors, orientation and curvature of lines, texture, composition, and literally hundreds of other visual dimensions. A few of these techniques—for instance, the histogram—are built into digital media editing software (e.g., Photoshop, iPhoto) and also into the interfaces of digital cameras. (When you take a photograph with most cameras today, you have the option to see a histogram of the image captured by the camera.) Many more techniques are available in specialized application software or described in professional publications in the fields of image processing, computer vision, multimedia, and media computing.

The field of digital image processing began to develop in the second half of the 1950s, when scientists and the military realized that digital computers could be used to reduce artifacts automatically and analyze aerial (and soon satellite and manned-spacecraft) images collected for military reconnaissance or scientific research. Some Photoshop's filters that automatically enhance image appearance (e.g., by boosting contrast, or by reducing noise) come directly from that era. Since that time, image processing has found many applications in robotics, medical imaging, astronomy, neuroscience, and dozens of other scientific fields. The examples of visual features that can be analyzed include brightness, saturation, hue, the most important colors, texture, line orientations, and their character, such as curvature.

Our approach (which we call cultural analytics) is to use image-processing techniques to automatically analyze images to generate numerical descriptions of their visual structure. These numerical descriptions can then be graphed and also analyzed statistically. For example, if we plot the creation dates for a number of images on the x-axis, we can then use the measurements of their visual structure (brightness, saturation, or many other characteristics, which can be used by themselves or in combination) to position them on y-axis, and then ask the computer to draw a curve (a trend line) through these points.

We use a similar approach to analyze and visualize temporal changes in a video. Since a video is a collection of still images (i.e., frames) we apply the same image-processing techniques to each video frame and then plot values over x and y. In such a graph, x represents the time of a video, and y shows the values on one or more visual parameters in a video over time.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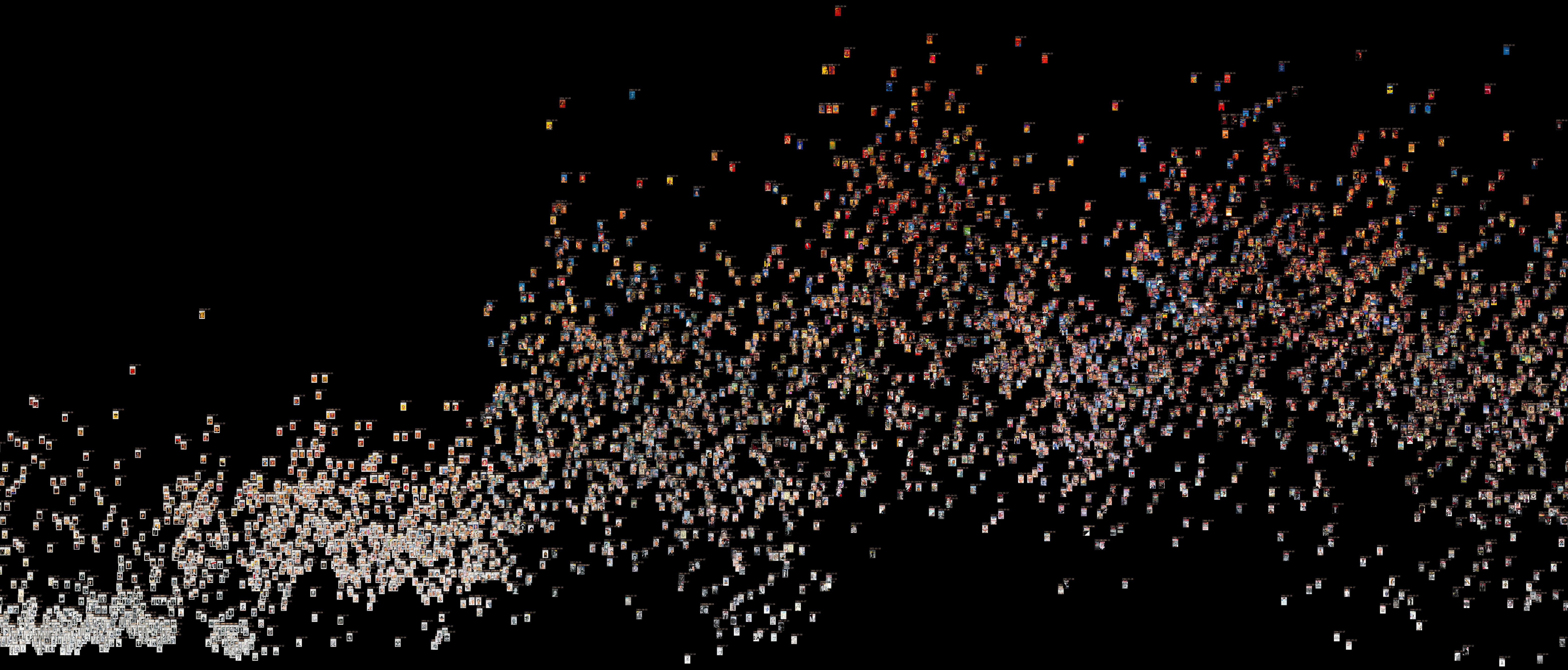

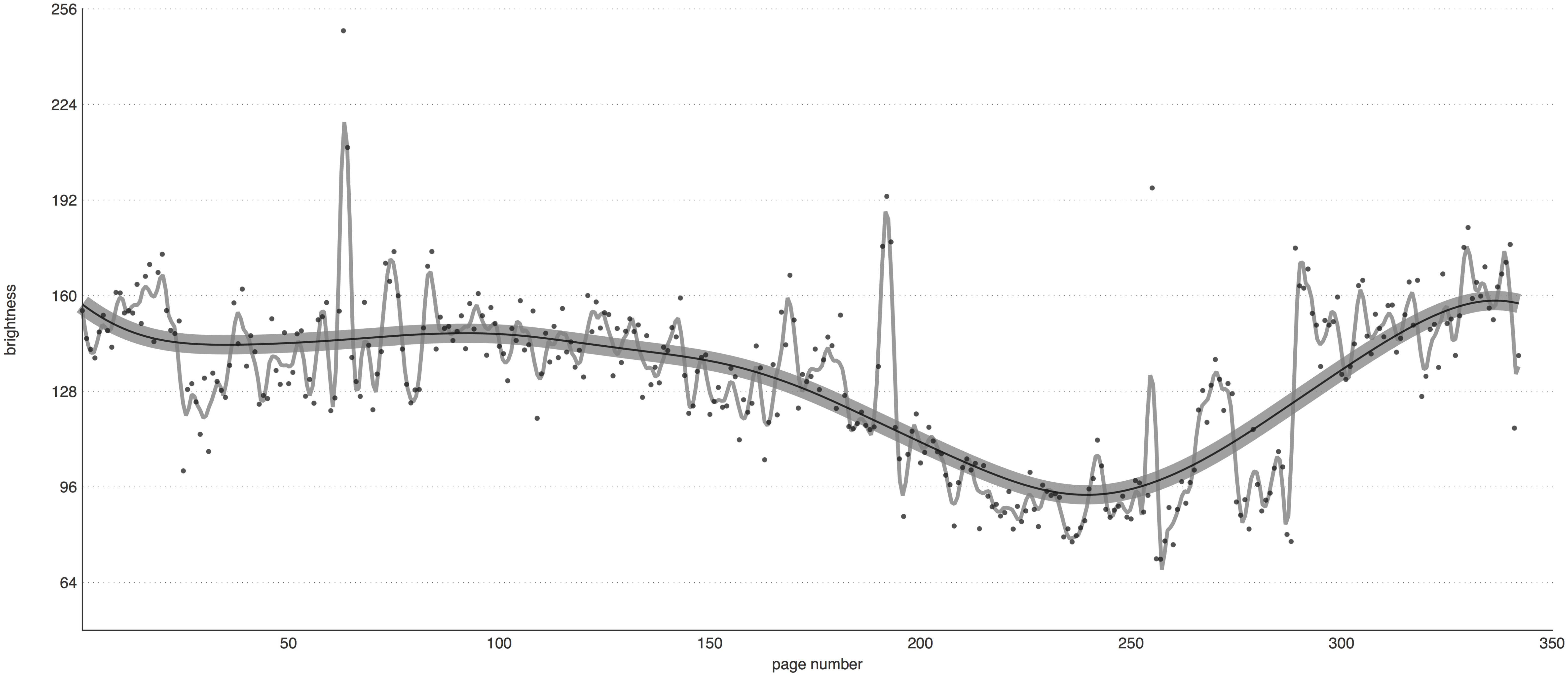
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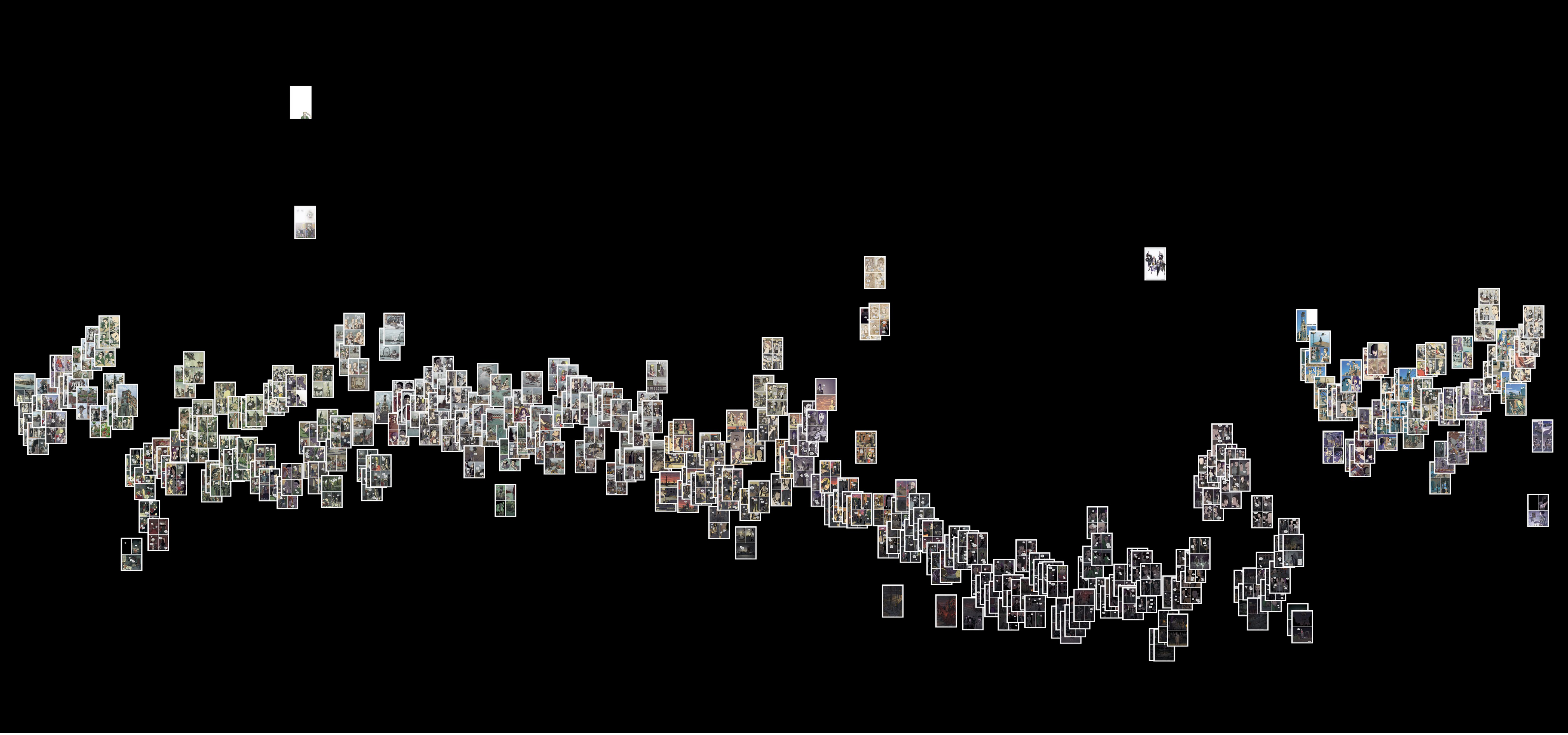

Conclusion

Our work on visualizing cultural changes is inspired by commercial trend mapping software such as Google's Web Analytics, Trends, and Flu Trends and Nelson's BlogPulse, as well as projects by artists and designers such as the seminal *History Flow* by Fernanda Viegas and Martin Wattenberg, Lee Byron's *Listening History*,[13] and *The Ebb* and *Flow of Movies*.[14] Until now, most visualizations of cultural processes used either discrete media (i.e., texts) or the metadata about the media. Thus, *History Flow* uses histories of Wikipedia pages' edits; Lee Byron's *Listening History* uses data about his use of last.fm; and *The Ebb and Flow of Movies* uses data on box office receipts. In contrast, our method allows for the analysis and visualization of patterns as manifested in changing structures of images, films, video, and other types of visual media.

The projects presented in the exhibition Mapping Time demonstrate how we can visualize gradual changes over time on a number of scales—from hours of gameplay to over a century in magazine history. Google Earth allows you to navigate space across scales—from the view of the Earth as a whole to a street view that puts you in the position of a driver in a car or a passerby on the street. In the same way, we should be able to navigate through cultural time, moving from the scale of a short cultural encounter or a single cultural artifact to the scale of decades and centuries.

Visualization of gradual changes in visual and media culture over longer historical periods is an idea that appears to us particularly timely. Humanities disciplines, critics, museums, and other cultural institutions usually present culture in terms of self-contained cultural periods. Similarly, the most influential contemporary theories of history by Thomas Kuhn ("scientific paradigms") and Michel Foucault ("epistemes") also focus on stable periods rather than transitions between them. In fact, relatively little intellectual energy has been spent on thinking about how cultural change happens. Perhaps this was appropriate given that, until recently, cultural changes of all kinds were usually very slow. However, since the emergence of globalization, these changes have not only accelerated worldwide, but the emphasis on continual change rather than on stability has became the key to global business and institutional thinking, as expressed in the popularity of terms such as "innovation" and "disruptive change." It is time, therefore, to start treating "change" as a basic unit of cultural analysis—rather than limiting ourselves to discrete categories such as "period," "school," and "work." In short, it is time to start *mapping* time.

Notes

1. Michael Friendly and Daniel J. Denis, "Milestones in the History of Thematic Cartography, Statistical Graphics, and Data Visualization" (2001), <http://www.math.yorku.ca/SCS/Gallery/milestone/sec5.html>.

2. Edward Tufte, The Visual Display of Quantitative Information, 2nd ed. (Cheshire, CT: Graphics Press, 2001).

3. Steven A. Coons, Surfaces for Computer-Aided Design of Space Forms, MIT/LCS/TR-41, June 1967, <http://publications.csail.mit.edu/lcs/pubs/pdf/MIT-LCS-TR-041.pdf>.

4. See <http://www.designboom.com/contemporary/nonstandard.html>.

5. We are not talking about the statistical technique of cluster analysis but simply plotting points in two dimensions and visually examining the resulting graph.
6. Such a method is an example of a much more general technique called scaling: "In the social sciences, scaling is the process of measuring or ordering entities with respect to quantitative attributes or traits." From <http://en.wikipedia.org/wiki/Scale_(social_sciences)>.

7. "BlogPulse Reaches 100 Million Mark," <http://blog.blogpulse.com/archives/000796.html>.

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9. Franco Moretti, Graphs, Maps, Trees: Abstract Models for a Literary History (London: Verso, 2007).

10. Vladimir Petrov, "Problems and Methods of Empirical Aesthetics" (in Russian), in Works in Theory of the Arts: A Dialog between Humanities and Sciences, ed. Vladimir Koptsik, Vladimir Ruzov, Vladimir Petrov (Moscow: OGI, 2004).

11. "Digging into Data Challenge," <http://www.diggingintodata.org/>.

12. Jean-Baptiste Michel et. al, "Quantitative Analysis of Culture Using Millions of Digitized Books," in Science v1199644. Published online 16 December 2010.

13. See <http://www.leebyron.com/what/lastfm>.

14. See <http://www.nytimes.com/interactive/2008/02/23/movies/20080223_REVENUE_GRAPHIC.html>.

ARTIST BIOGRAPHY

LEV MANOVICH

Lev Manovich is the author of Software Takes Command (Milan: Olivares, 2010), Soft Cinema: Navigating the Database (The MIT Press, 2005), and The Language of New Media (The MIT Press, 2001) which is described as “the most suggestive and broad ranging media history since Marshall McLuhan.” Manovich is a Professor in Visual Arts Department, University of California, San Diego, and a Director of the Software Studies Initiative at California Institute for Telecommunications and Information Technology (CALIT2). He is much in demand to lecture around the world, having delivered 450 lectures, seminars and workshops during the last 10 years. His art projects have been presented by, among others, Chelsea Art Museum (New York), ZKM, The Walker Art Center, KIASMA, Centre Pompidou, and the ICA (London) Since 2008, Manovich has been directing the development of Cultural Analytics - a new methodology for researching and teaching visual and interactive media.

ARTIST BIOGRAPHY

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ARTIST BIOGRAPHY

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Show content was created with: Adelheid Heftberger, Agatha Man, Alex Avrorin, Bertrand Grandgeorge, Bob Li, Chanda L. Carey, Christa Lee, Christine Pham, Colin Wheelock, Daniel Rehn, Devon Merill, Jia Gu, Kedar Reddy, Laura Hoeger, Michael Briganti, Nichol Bernardo, Ong Kian Peng, Rachel Cody, Sergie Magdalin, So Yamaoka, Steven Mandiberg, Sunsern Cheamanunku, Tara Zepel, Victoria Azurin, Xiangfei Zeng, and Xiaoda Wang.

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gallery@calit2 reflects the nexus of innovation implicit in Calit2's vision, and aims to advance our understanding and appreciation of the dynamic interplay among art, science and technology.

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