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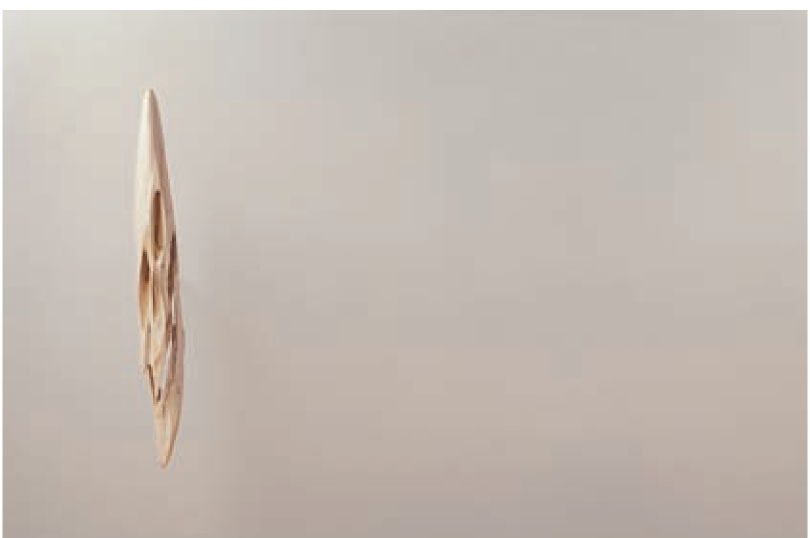
This can be as basic as sculpting with clay, mixing paint, or enlarging a photograph; it is the transformation of raw material into a work. But we typically think of transformation as acting on a preexisting object. Trying to define transformation is a daunting task in itself, and the concept can quickly get away from us. Understanding what transformation is within the context of the arts is almost too broad; instead we will focus on how transformation is used and how code can facilitate visual transformations.



These letters are distorted by applying the same algorithms that CAPTCHAs (Completely Automated Public Turing test to tell Computers and Humans Apart) use. A CAPTCHA is a type of challenge-response test used in computing to ensure that the response is not generated by a computer. A computer should be unable to solve the CAPTCHA, so any user entering a correct solution is presumed to be human.

(i)



(ii)

(iii)

(iv)

skull(i), skull(ii), skull(iii), skull(iv), by Robert Lazzarini, 2000
This series of 3-D human skulls was created using computer modeling techniques. First the skull was scanned and distorted, then it was fabricated using resin, bone, and pigment to create an unsettling series of replicas.

Transformation refers to the act of manipulating a preexisting form to create something new. It suggests a change in shape, behavior, or context, but more importantly, it indicates a change in the viewer's relationship to the object that has been transformed. Take, for example, a common transformation used in photography: converting a color photo to black and white. This technically simple transformation—it is available in every digital camera, image-editing tool, and copy machine—changes the photograph's appearance. Often, the black-and-white version feels more emotional, timeless, and nostalgic. In some cases, a grayscale conversion even enhances our perception of the image. We see it as more important, and it reminds us of a shoe box full of old photographs in grandmother's attic or the work of countless great photographers of the past.

By making reference to existing symbols and schemes within society, transformation can alter our perception in a way that emphasizes our emotional connections. Jasper Johns' 1958 painting Three Flags achieves this to great effect. The potent symbol of the American flag is repeated on top of itself and then scaled.

Johns' use of wax encaustic as the medium combined with a subtle use of transformation imbues the work with a sense of ambiguity. Is it critical? Playful? Both? The repetition and stacking could imply motion, perhaps though time, or simply represent a play on geometric perspective.

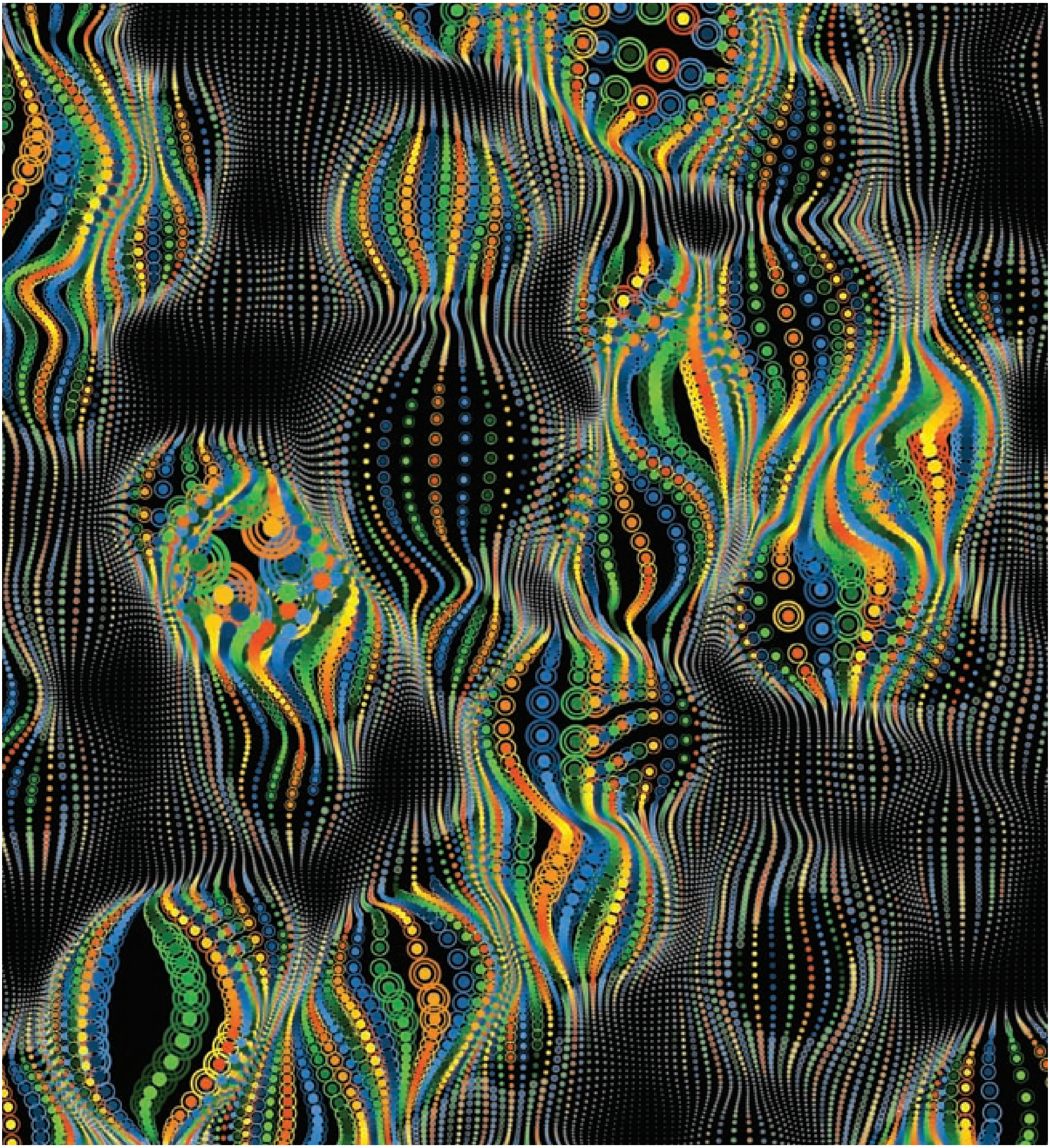
As if to champion the importance of transformation, Johns famously wrote a prescription for art in his notebook:

> Take an object.
> Do something to it.
> Do something else to it.
> “ “ “ “ “
>
> Jasper Johns,
> Notebook [ND], 1965



Encaustic on canvas, Overall: 30.875 x 45.5 x 5 in. (78.4 x 115.6 x 12.7 cm), Whitney Museum of American Art, New York; 50th Anniversary Gift of the Gilman Foundation, Inc., The Lauder Foundation, A. Alfred Taubman, Laura-Lee Whittier Woods, and purchase 80.32. Art © Jasper Johns / Licensed by VAGA, New York, NY.

Three Flags,
by Jasper Johns, 1958
Johns uses the repetition and transformation of a powerful symbol to create ambiguity in the mind of the viewer.



ElectroPlastique, by Marius Watz, 2009
Inspired by the work of Victor Vasarely, Watz used a regular grid that deforms progressively over time. Changes in the grid appear as ripples of evolving shapes in bright color. Eventually, the grid is ripped apart, leaving the shapes to float freely.

# GEOMETRIC TRANSFORM

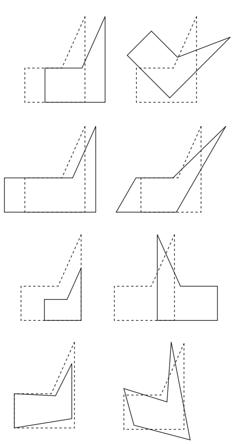


Perhaps the most basic transformation simply involves moving an object. We don't typically think of movement as a type of transformation, but moving elements around is the most fundamental way to make changes to a composition. Another familiar transformation is rotation. An object can be rotated in any number of ways to change its relationship to other objects around it. Flat 2-D items can only be rotated around one axis; for instance, turning a photograph on the wall to change which end faces up. Three-dimensional objects, on the other hand, can be rotated around any number of axes. Another fundamental transformation that has become familiar within everyday life is scaling, but it is difficult to find instances where objects can easily change their size. In the real world, differences of scale are typically seen through a series of multiples or in perspective, as objects appear to shrink as they move further away.

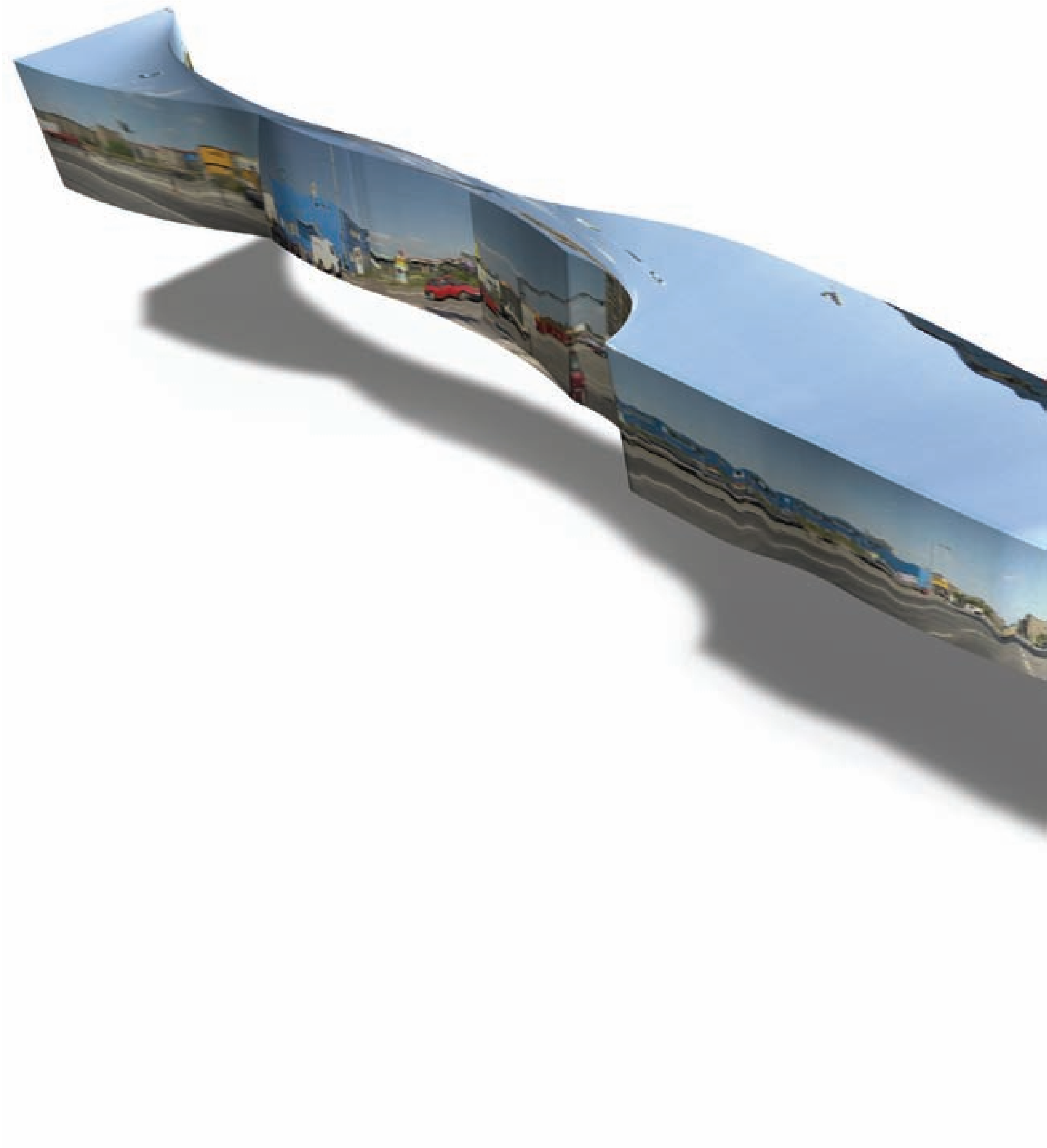
Representing images and objects digitally opens up the possibility for a number of transformations that are not feasible in real life. Objects can be sheared, stretched, reflected, warped, and distorted. In his series of skull sculptures, Robert Lazzarini used techniques of transformation to create a profoundly unsettling installation at the Whitney Museum of American Art. He began with a 3-D scan of a human skull, and applied a series of distortions and projections to the digital model to create an impossible object—one that retained a morbid familiarity (see page 68). Each skull appears to have been transformed using a technique called anamorphosis, a type of visual distortion made popular in the sixteenth century, in which an object is manipulated so that it can only be seen correctly from one vantage point. The most famous example of this technique is Hans Holbein the Younger's 1533 painting The Ambassadors, which features a prominently placed, distorted skull that can only be viewed in full when the painting is viewed from the side. Lazzarini references this disconcerting image; through the use of digital techniques, he creates a series of skulls that have no true vantage point. He constantly puts the viewer on guard, in search of a perspective that allows the onlooker to make sense of the objects.

The advent of computer animation and special-effects software has had a profound impact on the work of film and video artists, as well as architects and choreographers. Many animation software packages use geometric transformations to create smooth transitions between shapes. These tweens, as they are called (an abbreviation of in-between), take a predefined beginning and end state, and they smoothly animate the morphing of one into the other. Architect Greg Lynn has used the intermediate shapes of the tween, along with other computer-animation techniques, as the basis for an animate architecture "defined by the co-presence of motion and force at the moment of conception."[1] Likewise, dance choreographer Merce Cunningham uses software to find new forms and movements that appear when the program is asked to find transitions between two unlikely positions. Both of these creators highlight an important connection between form and code: that code can be a source of inspiration and it can help create previously unimaginable forms.

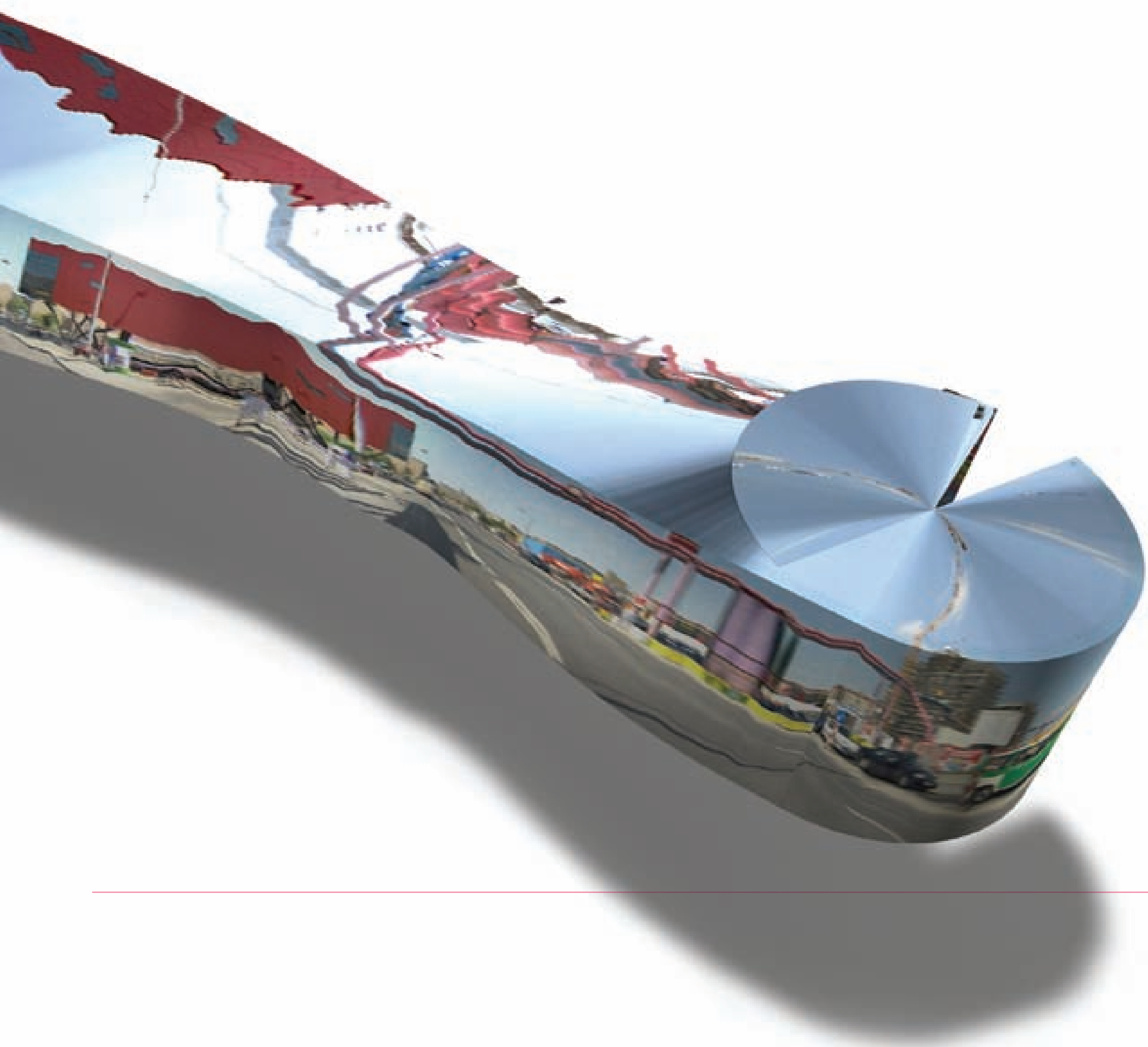
[1] Greg Lynn, Animate Form (New York: Princeton Architectural Press, 1999), 11.



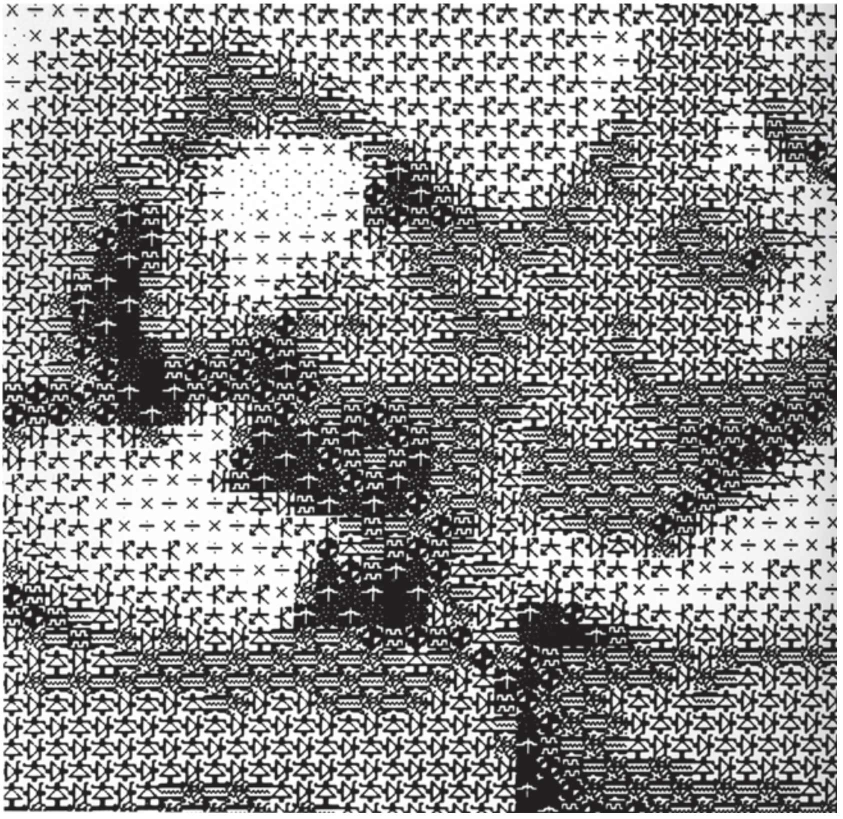
Geometric Transformation
Each 2-D transformation preserves some features of the original while destroying or distorting others.

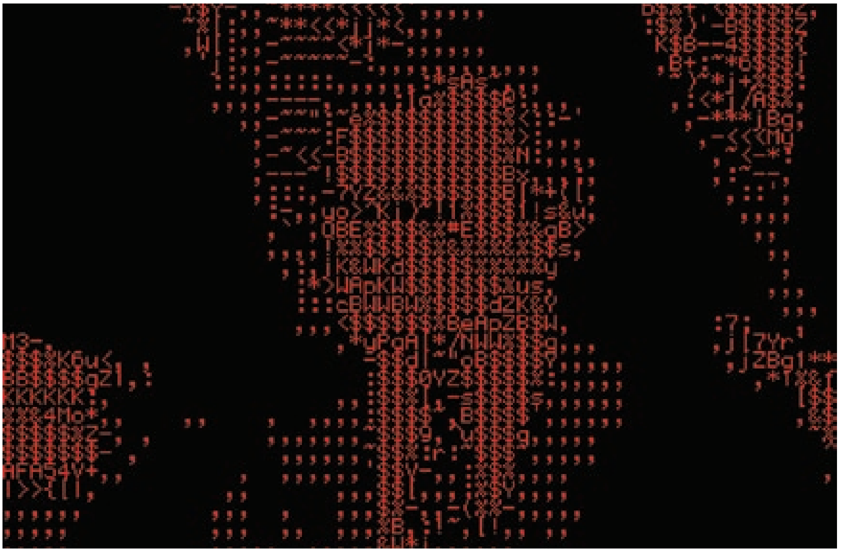


The Invisible Shape of Things Past, by ART+COM, 1995
The idea that a video can be imagined as a physical object is the foundation for this project. Because each frame is flat and 2-D, it can be stacked in space to produce a 3-D object that can then be viewed from any angle. As the camera moves with a pan, tilt, or turn, the frames twist and turn, producing unexpected and fascinating shapes.



TRANSFORM





Mural (detail), by Ken C. Knowlton and Leon Harmon, 1966
A series of photographs were transformed into images composed of engineering symbols. Each point was represented as a grayscale value, then replaced by a graphic symbol.

ASCII Bush, by Yoshi Sodeoka, 2004
An ASCII-based filtering technique was used to create a new version of the State of the Union addresses given by former presidents George W. and George H. W. Bush. Sodeoka said that he wanted to make something “from the debris of our culture by recycling these dreadful and painfully long presidential orations.”

## NUMERICAL TRANSFORM



When an image or object is represented in digital form, it must first be described in numerical terms. This description allows for countless new types of transformations. While geometric transformations (discussed above) require that objects be described using coordinates, image-based transformations are described using the numerical terms of pixel values. We can apply mathematical formulas to the values of each pixel, such as color, brightness, and transparency. This process weakens the connection between the object being acted upon and the transformed version of it. For instance, scaling will only make an image smaller or larger, but applying a mathematical function to the pixel values may create something that looks little to nothing like the original. For example, in 1966, computer engineers Kenneth C. Knowlton and Leon Harmon exploited this feature of digital images to create Mural, an image of a woman composed entirely of engineering symbols. Each section of the image was analyzed for its relative darkness and then replaced with a symbol having an equivalent tone. A similar technique is often seen in so-called ASCII transformations in which pixels are replaced with alphanumeric characters to form an image.

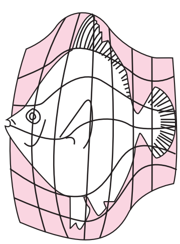
Among the most useful mathematical transformations are image filters. By looking just at the numerical values of pixels, filters can perform a surprising number of useful operations, such as blurring, sharpening, edge finding, and color conversion, to name just a few. Two common families of filters are called high-pass and low-pass filters. Low-pass filters dampen abrupt changes in value so as to produce a smoother, blurred image, and they are often used to reduce noise in digital images. High-pass filters do just the opposite; they preserve values with sharp transitions and are useful for sharpening features in images and enhancing the edges of elements.

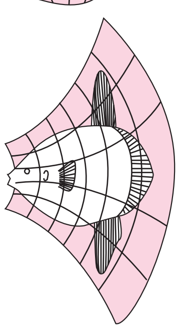
In On Growth and Form, first published in 1917, mathematical biologist D'Arcy Wentworth Thompson described a way to apply mathematical formulas to study the development of form in living creatures. This science, which he termed morphology, used a numerical description of form (similar to the one discussed in this chapter) as a foundation. In Thompson's words:

> The mathematical definition of a 'form' has a quality of precision which was quite lacking in our earlier stage of mere description....We discover homologies or identities which were not obvious before, and which our descriptions obscured rather than revealed.[2]

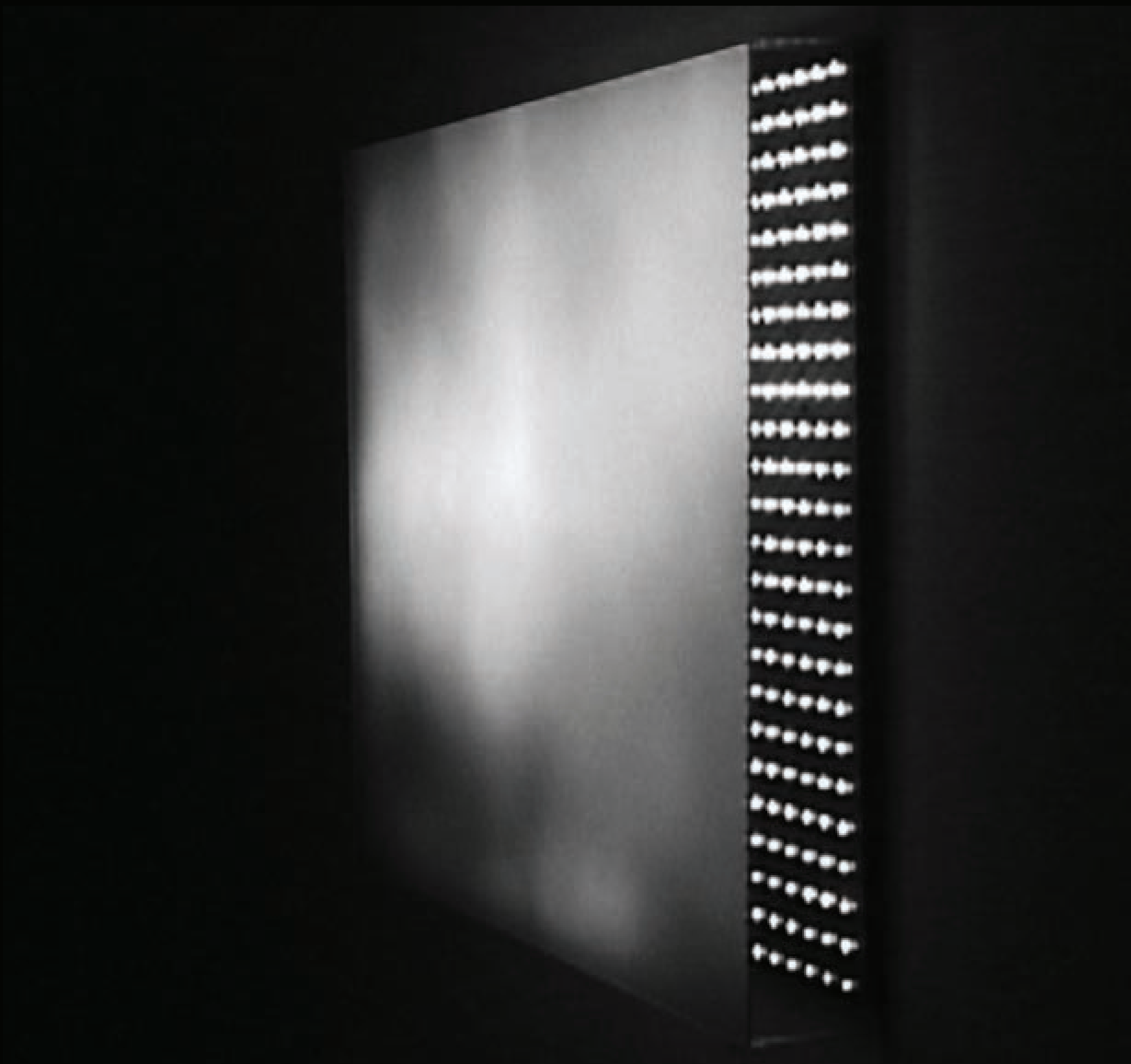
By describing form in mathematical terms, Thompson was able, through the use of transformations, to find continuity in the evolution of species. His work, however, took a slightly different approach. Rather than consider the transformation as acting upon the form, he characterized it in terms of the coordinate system in which the form was described. For example, consider an image printed on a piece of rubber; by poking and stretching the rubber sheet, endless variations of the original image can be produced, but the connections between each of them remain obvious. Thompson would manipulate and transform images by plotting them on new coordinate systems. These included scaled and sheared grids, systems based on logarithms, and polar planes. Thompson was able to describe (in mathematical detail) changes in the shapes of bones from one species to the next, and even make predictions about intermediate species in evolutionary history.

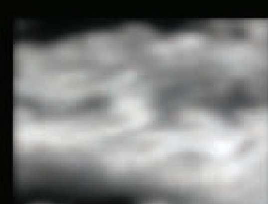
[2] D'Arcy Wentworth Thompson, On Growth and Form: The Complete Revised Edition (Mineola, NY: Dover Publications, 1992), 1027.



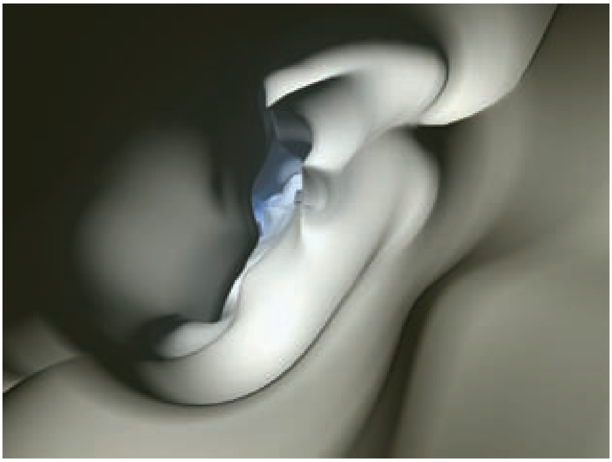


On Growth and Form, by D'Arcy Wentworth Thompson, 1917
In this book, Thompson demonstrated how a series of geometric and topological transformations could explain, even predict, morphological changes in animal species.





Wave Modulation, by Jim Campbell, 2003 As a part of the Ambiguous Icons series, this work reduces a video image so that it can be displayed on a coarse matrix of LEDs. A treated Plexiglas panel placed in front of the LEDs diffuses the individual points of light into a ghostly image of ocean waves. Over a period of ten minutes, the waves change from undulating in real time, to slowing down, to a still image, and back to their original speed.





Tuboid,
by Erwin Driessens and Maria Verstappen, 1999–2000
For this sculpture, the artists combined a series of 2-D cross-sections to create a 3-D form. Starting from a single point at the top, it grows downward in steps. The shape of each cross-section is controlled using a genetic algorithm to change the lengths and rotations of spokes within each otherwise circular section. In essence, it uses a transformation of polar coordinates to create a unique form. An interactive software version of Tuboid makes is possible to navigate and travel through the form.

Amodal Suspension, by Rafael Lozano-Hemmer, 2003
Lozano-Hemmer used incoming text messages to control the light display above the Yamaguchi Center for Arts and Media (YCAM) in Japan. The frequencies of letters were translated into flashes of light in the night sky above the museum.

## TRANSCODING

One direct consequence of describing information numerically is transcoding or the conversion of one type of digital information into another, for instance, converting a file from a JPEG to a PNG format. Transcoding can also be used to create completely new forms by interfering with how the computer handles a set of data. For example, it can allow the bits of an audio file to be read by a program that normally operates on the bits representing an image. Transcoding uses the file data as raw material for computation.
A good example is a simple substitution cipher, where each letter is replaced with a number corresponding to its position in the alphabet. This cipher turns the name Ben into the numbers 2, 5, and 14. Once the conversion is made, the numbers can be used in a variety of ways to create new values. These values can, in turn, be used to create new images or artworks. For example, the number can be added together to get 21, which, in turn, can be used to set the red value of a pixel in an image. (But since the word “at” also has a value of 21, this will only create a very loose connection between the original word and the color of the pixel.) Because the letters have been converted to numbers, they can be transformed in atypical ways.

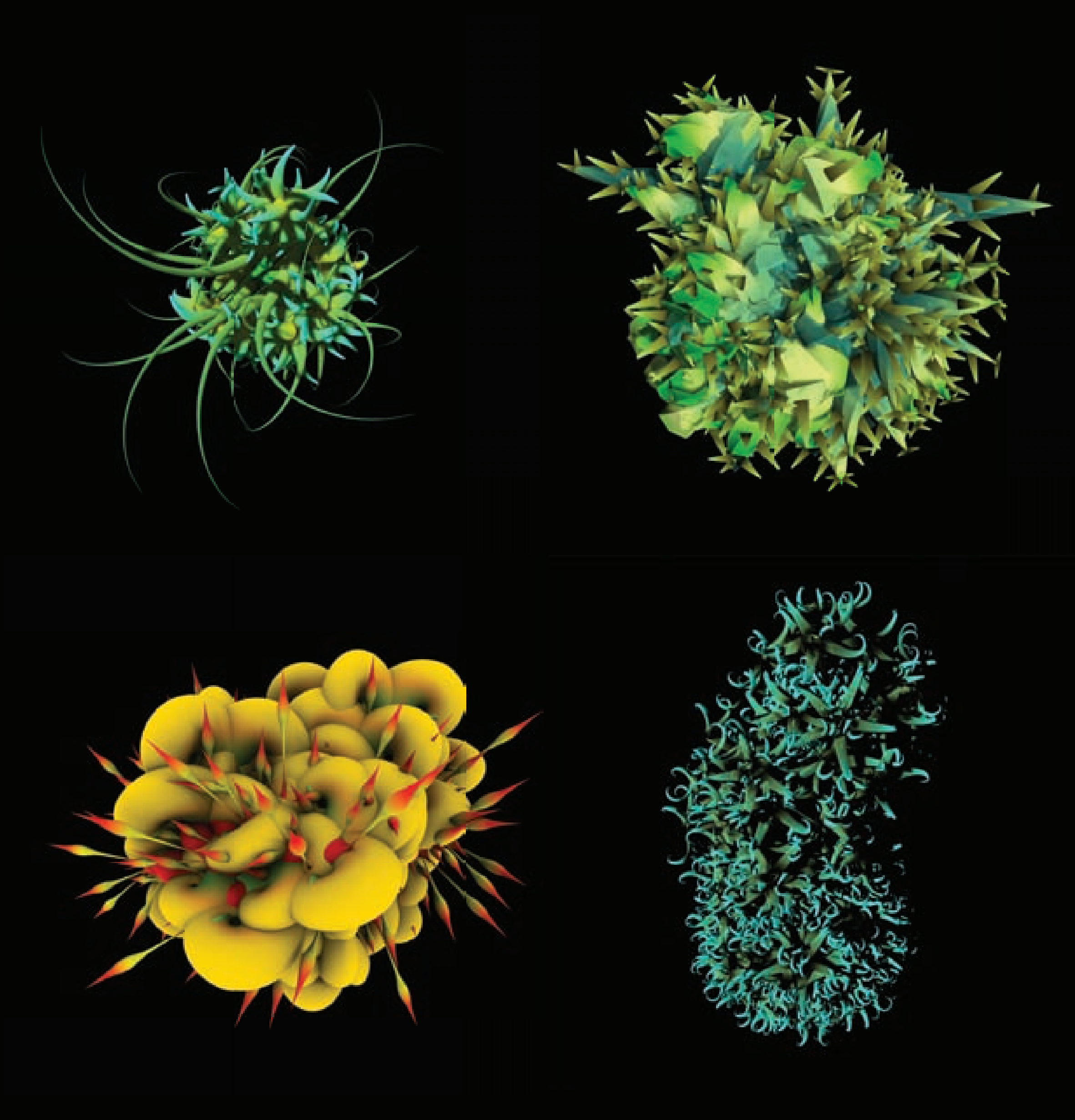
Rafael Lozano-Hemmer’s 2003 installation *Amodal Suspension* transforms text messages into light beams, from spotlights projected into the sky above the Yamaguchi Center for Arts and Media (YCAM) in Japan. The transformation scheme used by Lozano-Hemmer produced a particularly striking display. The letters contained in each text message were analyzed based on the frequency with which they appeared. The frequency values were used to control the intensity of the spotlight: the letter A would push the light to full brightness, while Z would appear as a dim glow. In this way, our everyday language is transformed into something akin to the flashes of fireflies.

The continuity provided by the numerical representation of information is exploited to its fullest in the programming environment Max. Inspired by the patch cables of analog synthesizers, a Max program is composed of input and output patches that control the flow of data. When used with Jitter (a program extension that adds video features), Max can connect the frames of a video to a sound generator, run them through a filter, and reconnect the results back to a video generator. In the same way that the flow of electricity can be used to power any electronic device, the flow of binary data can be applied to any number of Max’s software patches.

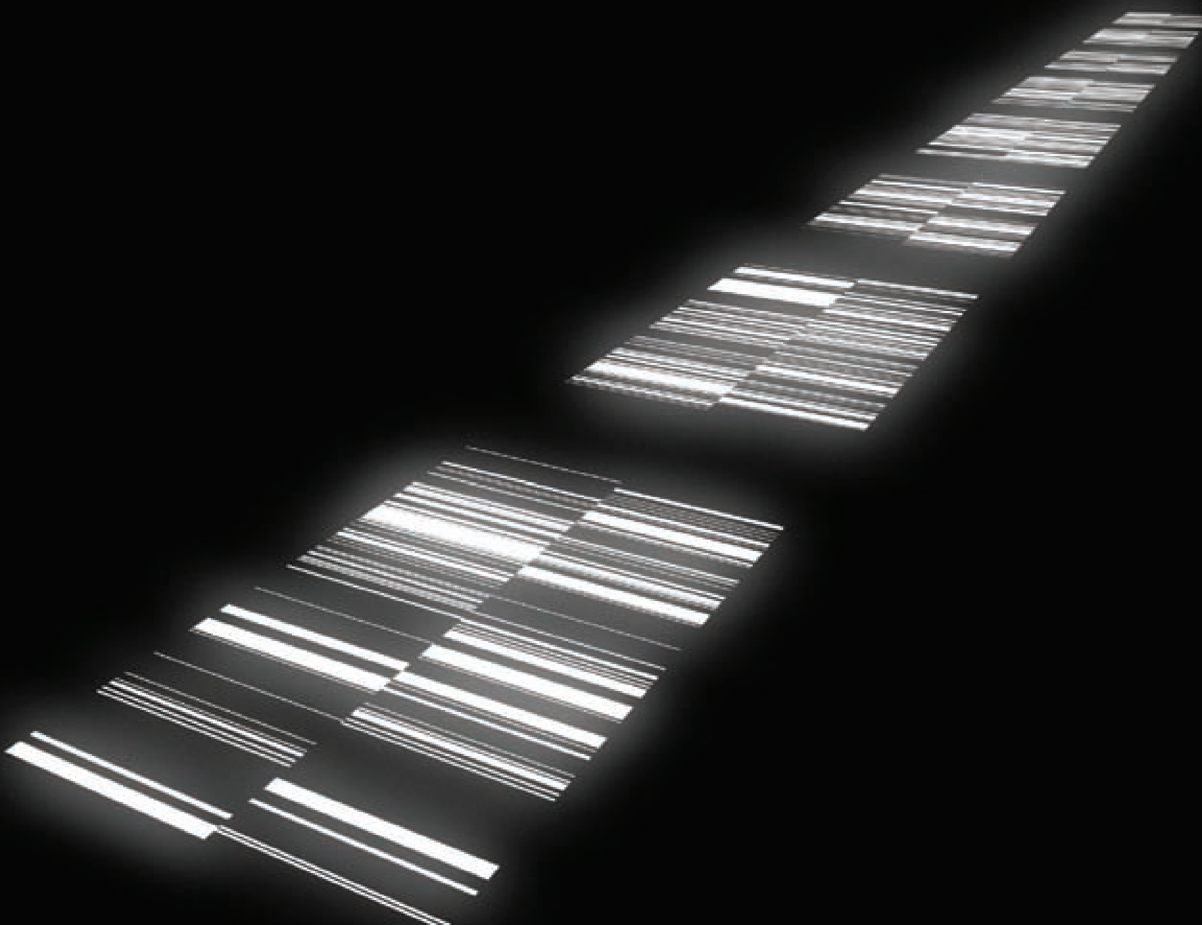
Transformation provides a way to express continuity between forms, data, and ideas. When a work utilizes techniques of transformation, it retains a connection between its original and transformed versions, and such radical transformations can reveal entirely new relationships.



*Data Diaries*, by Cory Arcangel, 2003 Arcangel tricked his computer into reading its memory as if it were a QuickTime movie. No complicated substitutions or interpretations were necessary, and no predetermined conversions were set up, such that a certain value from the memory file would cause a specific result. This was a direct translation, similar to reciting driving directions aloud like poetry.



Malwarez,
by Alex Dragulescu,
2007
This project converts the source code of computer worms, viruses, trojans and spyware into visual images. Dragulescu's software analyzes subroutines and memory addresses stored in the spyware to create 3-D forms exhibiting patterns found in the code.



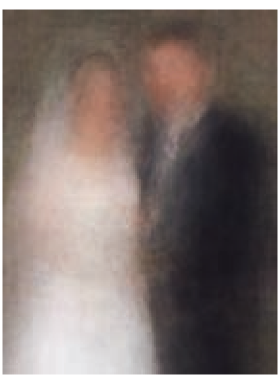


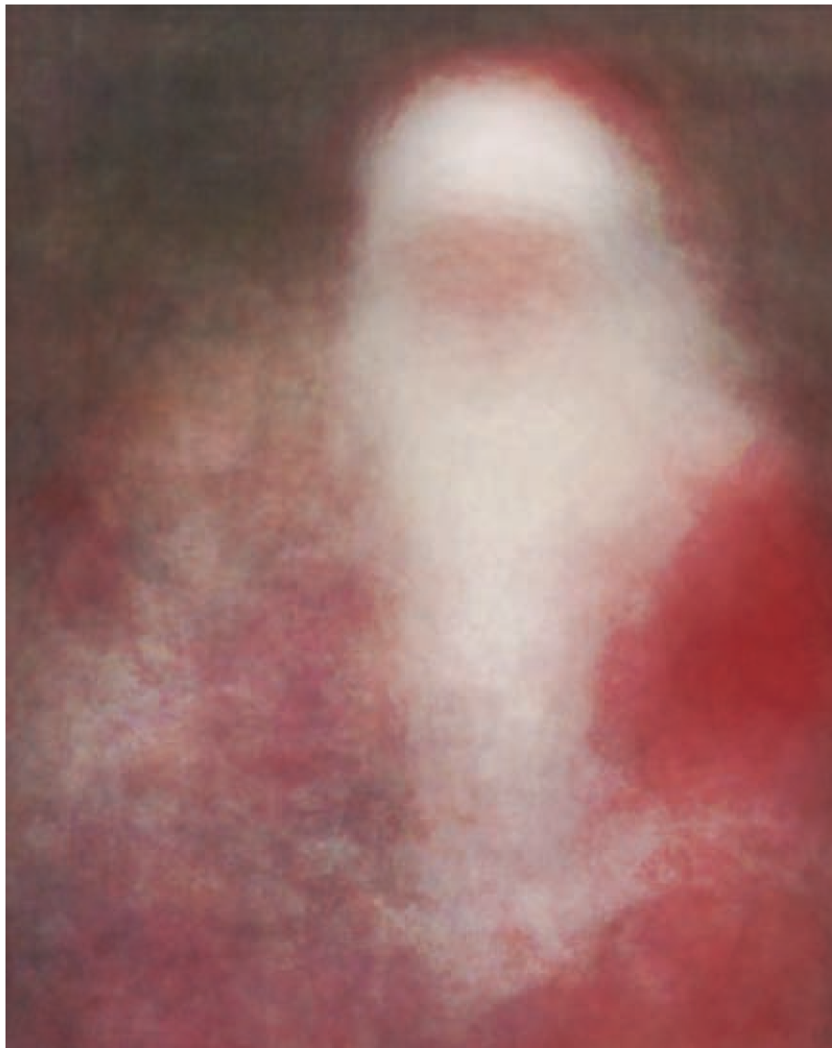
test pattern [nº1], by Ryoji Ikeda, 2008
In this audiovisual installation, the sound from the loud speakers is converted in real-time to a sequence of barcode patterns displayed on the monitors. Ikeda explains: “The velocity of the moving images is ultrafast, some hundreds of frames per second at certain points, providing a performance test for the devices and a response test for visitors’ perceptions.”

netropolis,
by Michael Najjar, 2004
The netropolis series combines multiple perspectives of the same city into images of an imagined networked future; shown clockwise from the top: New York, Berlin, and Shanghai.

## TRANSFORMATION TECHNIQUE
## IMAGE AVERAGING

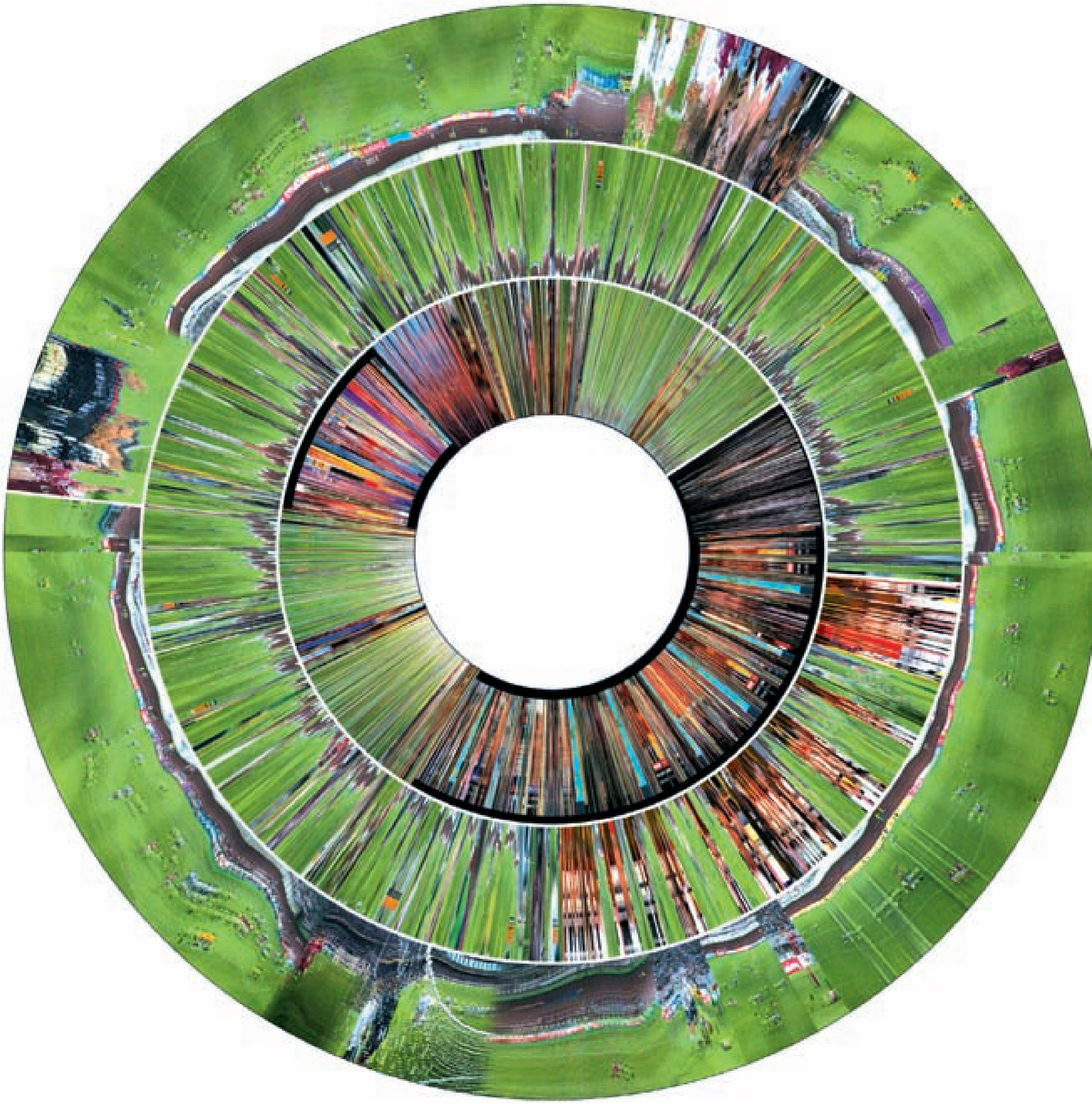
The most compelling transformations of images often involve repetition. Image averaging, for example, is one technique for calculating the median color or brightness value for pixels contained in an image. It then reassembles those values into a composite. By repeatedly combining related images, one can expose behavioral norms, reveal expectations, and find new connections that were less obvious when the images were viewed as a series separated in space.







100 Special Moments, by Jason Salavon, 2004
Salavon applies an image-averaging algorithm to sets of commemorative photographs, such as wedding pictures or children with Santa Claus, to show the similarities between these otherwise unique moments.

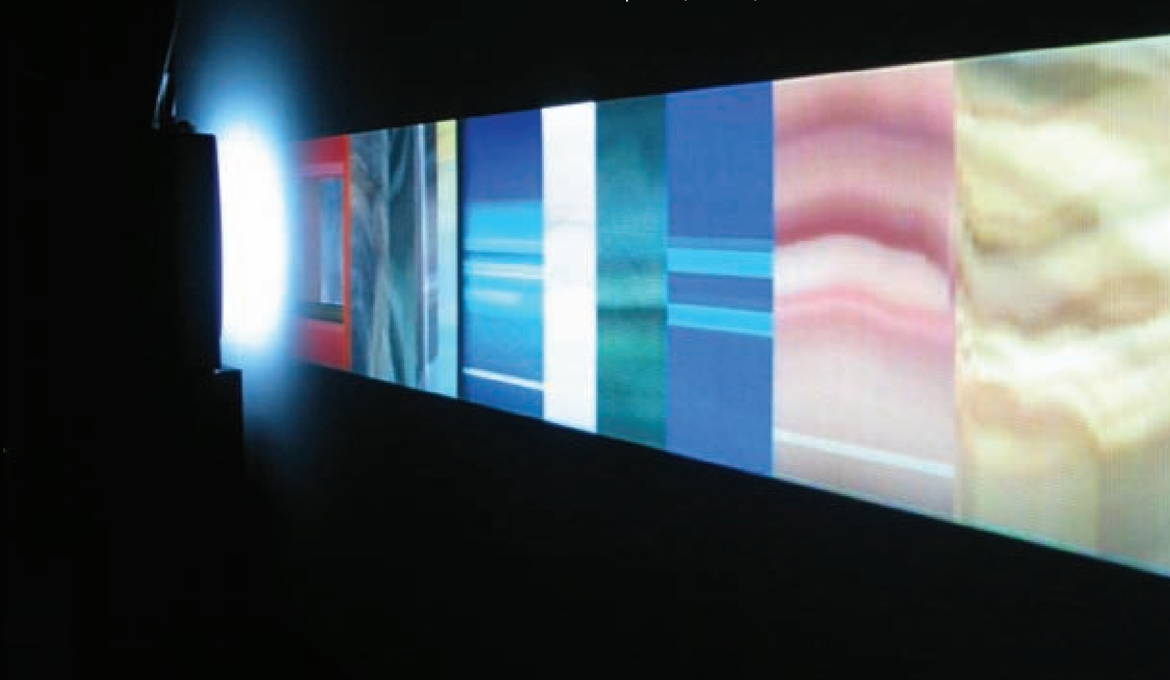


Last Clock,
by Ross Cooper and Jussi Ängeslevä, 2004
This project reinvents the clock to display the passage of time as an image capturing the history of video feeds in durations of seconds, minutes, and hours.

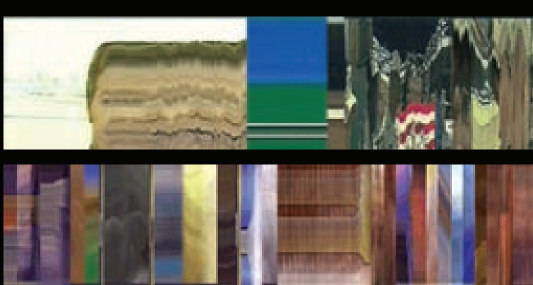
## TRANSFORMATION TECHNIQUE

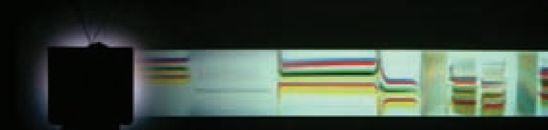
### SLIT-SCANNING

Slit-scanning is a technique that transforms the frames of a video into an image to convey the passage of time or movement through space. Although there are a number of different ways to create a slit-scan image, they all involve one basic concept. For each frame of a video, capture a single column of pixels (or a slit) to make a very narrow camera. Then recombine the columns to create a single image. Slit scanning can also be used to create animations that emphasize movement. Perhaps the most well-known example of slit-scanning was executed by Douglas Trumbull for Stanley Kubrick's film 2001: A Space Odyssey.







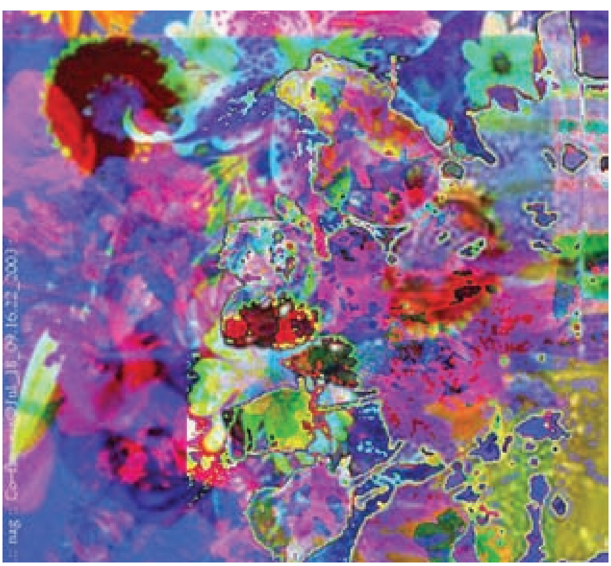


We interrupt your regularly scheduled program..., by Osman Khan and Daniel Sauter, 2003

This project uses slit-scanning to explore the vivid and manic imagery of broadcast television. The artists used custom software to collapse each frame into a single column of pixels, which they projected onto a wall as a steady stream of color.

## TRANSFORMATION TECHNIQUE
## COLLAGE ENGINEERING

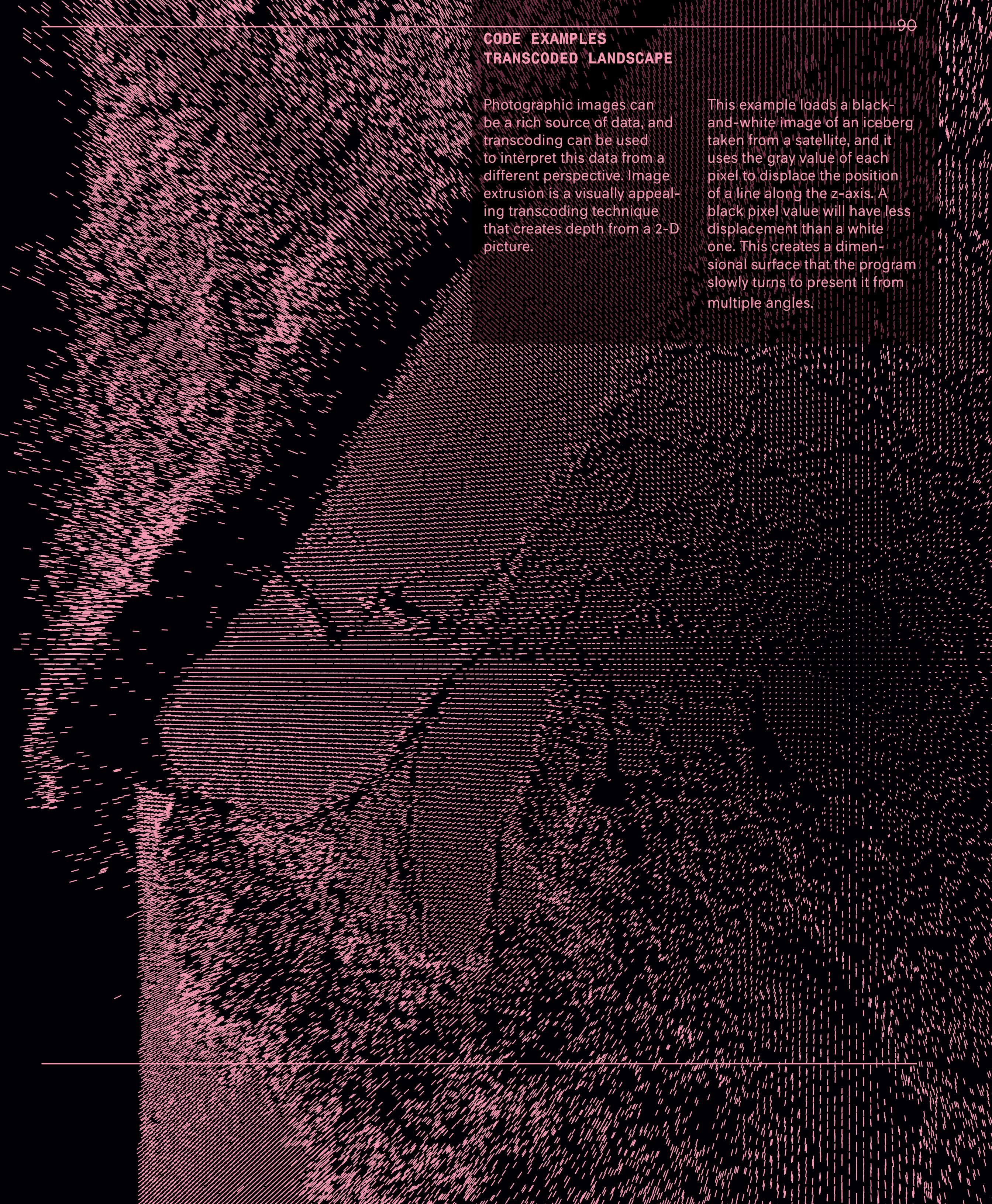
Collage engineering combines a number of different techniques for collecting, modifying, and compositing images and text. Some rely on the digital representation of texts and images and their widespread availability on the Internet. Others focus on classic collage techniques, such as cut-ups, décollage (in which an image or object is cut or torn away to create a new composition), and assemblages.

Untitled,
by Tom Friedman, 2004
Applying physical construction techniques, Friedman used an algorithm to disassemble and recombine thirty-six identical S.O.S. laundry detergent boxes into a single, larger box. It transforms them into something familiar, yet quite different.

net.art generator Series 'Flowers,'
by Cornelia Sollfrank, 2003
The net.art generator (net.art-generator.com) asks viewers to enter a search term for their soon-to-be-realized creation. It uses a series of algorithms to collect and combine images to create a completely unique web page from many online sources.

Untitled V,
by James Paterson, 2005
Paterson's Objectivity Engine software uses random values to define the color, position, and rotation of his small drawings to make a larger collage. Each time the software is run, a different composition emerges within the space of the parameterized limits.



## CODE EXAMPLES
## TRANSCODED LANDSCAPE

Photographic images can be a rich source of data, and transcoding can be used to interpret this data from a different perspective. Image extrusion is a visually appealing transcoding technique that creates depth from a 2-D picture.

This example loads a black-and-white image of an iceberg taken from a satellite, and it uses the gray value of each pixel to displace the position of a line along the z-axis. A black pixel value will have less displacement than a white one. This creates a dimensional surface that the program slowly turns to present it from multiple angles.

## CODE EXAMPLES
## SLIT-SCAN

As mentioned earlier, slit-scanning is a process for transforming the frames of a video into a single image. Slit-scans can produce a variety of interesting visual effects and, depending on the source, can often reveal interesting patterns in the source video.

This example works with a movie file or webcam to supply a continuous feed of images. For each image read from the movie file or camera, only one row of pixels is used (the rest are ignored). New slices are added to the right, while older slices shift to the left and are automatically deleted when they reach the edge of the screen.

Download the code at http://formandcode.com