Analog-to-Digital (1960s-1990s)

George Legrady © 2022
Experimental Visualization Lab
Media Arts & Technology
University of California, Santa Barbara

“ la Grande Jatte”, Georges Seurat (1884)

https://www.britannica.com/art/pointillism

“The Sower”, Vincent Van Gogh(1888)

https://www.britannica.com/art/pointillism

The Halftone Process (invented in 1852, credited to William Henry Fox Talbot)

Four-Color Halftone Letterpress Images

In theory, all colors should be printable using just a combination of yellow, magenta, and cyan inks. Early experimentation with different types of three-color printing led to the realization that the optical properties of real color pigments used for color photomechanical printing did not produce a good black color. Even the best three-color printed images lack the contrast and color saturation of the color photograph being reproduced. That was the reason for adding a fourth color, black (K, meaning key)—usually but not always overprinting—to the standard printing using cyan (C), magenta (M), and yellow (Y) halftone separation negatives (fig. 20). This was similar to today's high-performance color inkjet printers that also use the CMYK color system and sometimes add pigmented inks to produce perfect prints.

The microscopic details of figure 20 recorded at different magnifications (figs. 21a–21c) show superposition of all four color print layers (CMYK).

Figure 20 A four-color halftone letterpress print made using black as the fourth color.

Figure 21a Microscopic detail of fig. 20, recorded at 10× magnification, showing superposition of all four color print layers.

Figure 21b Microscopic detail of fig. 20, recorded at 25× magnification, showing superposition of all four color print layers.

Figure 21c Microscopic detail of fig. 20, recorded at 40× magnification, showing superposition of all four color print layers.

https://www.getty.edu/conservation/publications_resources/pdf_publications/pdf/atlas_halftone.pdf

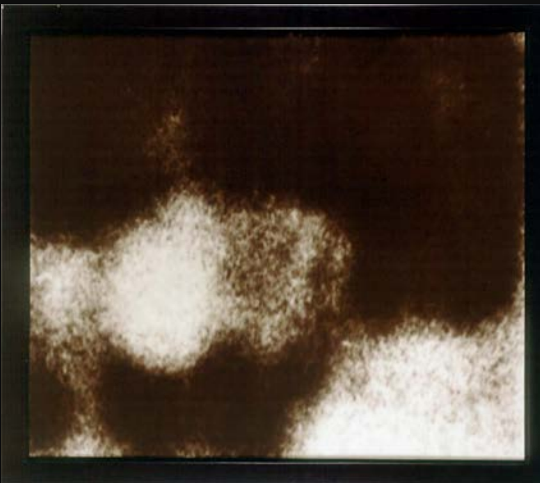
4 Color Halftone Process (Mountain States Lithographing LLC)

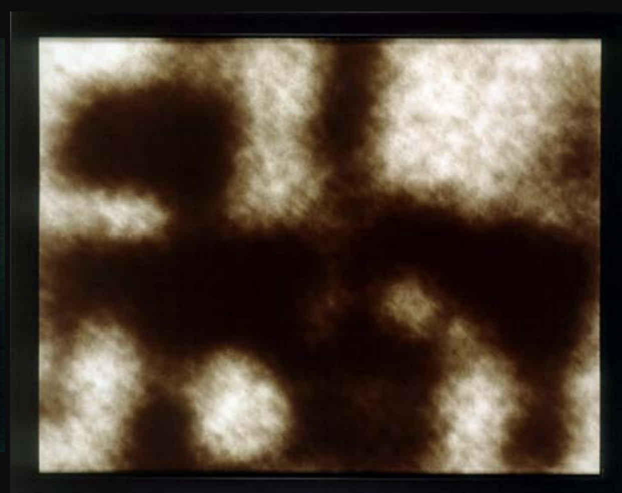
https://www.mslwyo.com/color-printing-process/

Roy Lichtenstein, Pop Artist (1964)

https://www.moma.org/artists/3542#works

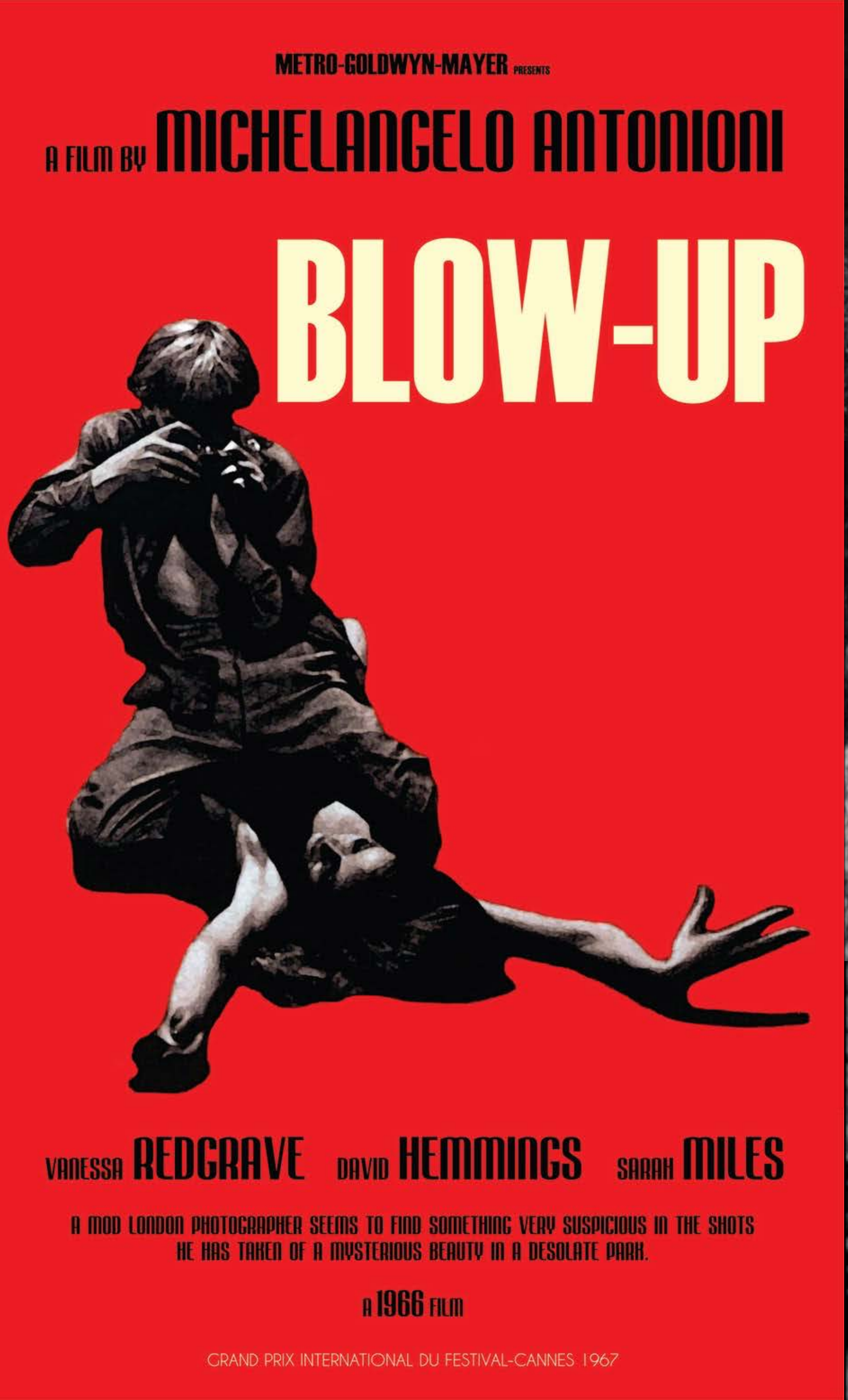
“Perpetual Photos”, Allan McCollum (1989) Chemical-Based Film Grain



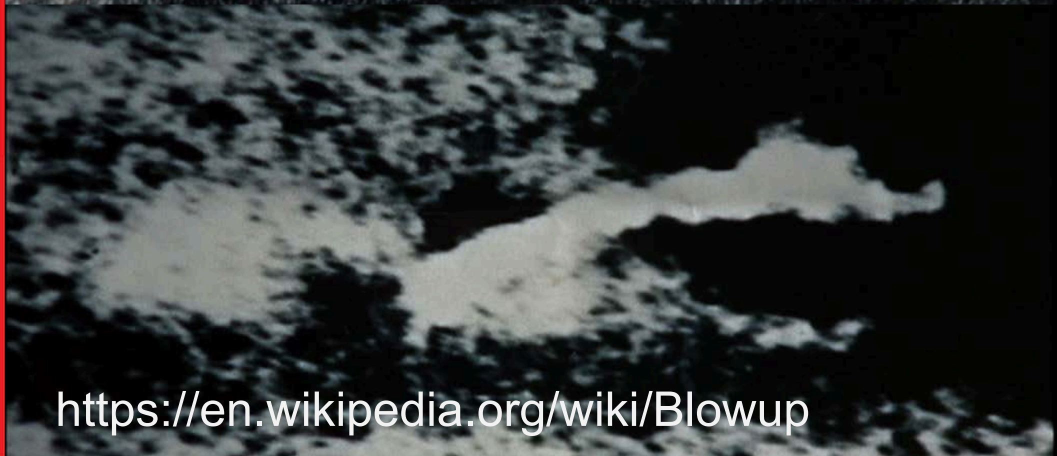


https://www.petzel.com/exhibitions/allan-mccollum2/selected-works?view=thumbnails

Photo scene with digital close-up of painting on wall revealing pixel grid order







https://en.wikipedia.org/wiki/Blowup

IBM 7090 at Lawrence Radiation Laboratory, Livermore, CA, April 1960

https://www.sciencephoto.com/media/409687/view/ibm-7090-computer-1960s

"Dancer Deborah Hay", Leon Harmon, Ken Knowlton, engineers (1966)

The New York Times L+++ 49

Art and Science Proclaim Alliance in Avant-Garde Loft

By HENRY R. LIEBERMAN

In a sound-drenched Lower Manhattan loft building that was enlivened by revolving painted disks, film projections, floating pillows and miniskirted girls in paper smocks, representatives of industry and labor joined a number of artists and scientists yesterday to proclaim a "working alliance" between art and technology.

This modest and uncertain merger seeks to bridge the gap between the two worlds. It is intended to bring modern technological tools to the artist for creating new art forms and fresh insights and viewpoints to the engineer for creating a "people-oriented" technology.

The event was celebrated at a news conference "happening" in the six-story loft building at 381 Lafayette Street used for studio purposes by Robert Rauschenberg, the avant-garde artist.

Kheel's 'Biggest Mediation'

Mr. Rauschenberg, along with Dr. Billy Klüver, an electronics engineer who is specializing in laser research at the Bell Laboratories, and Theodore W. Kheel, the lawyer-labor mediator, are prime movers in the art-technology merger.

with a device operating like a television camera.

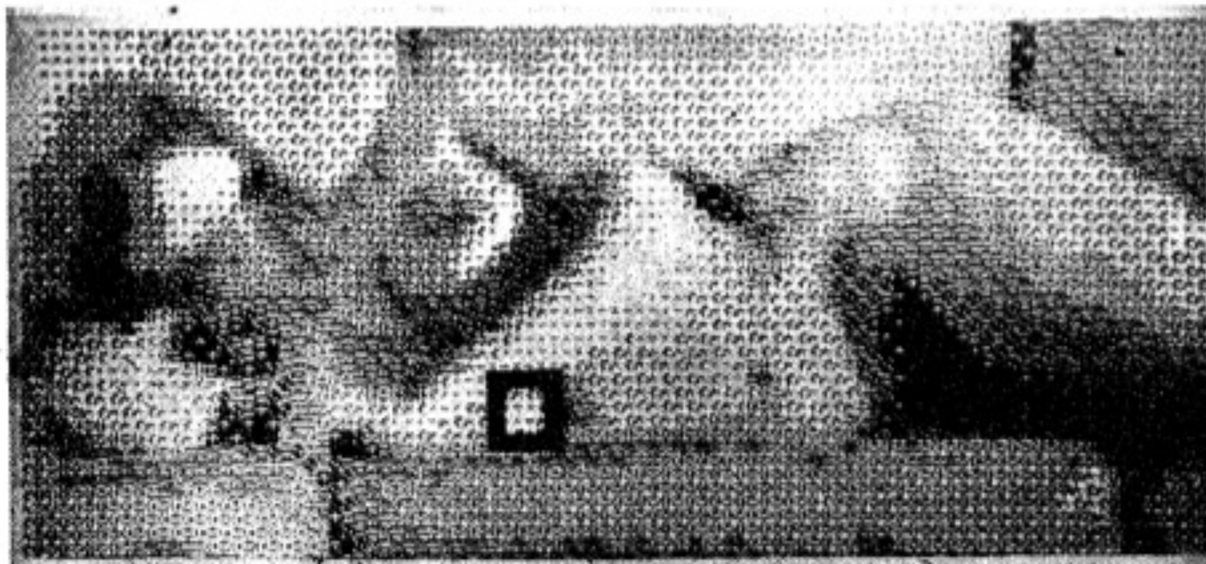
The information on the transparency was then stored on magnetic tape in the form of pulses standing for digits, with the brightness level of the picture elements represented by numbers ranging from 0 to 7. After processing all the numbers, the computer printed a drawing of micropatterns formed by clusters of symbols used in electronic design.

Visitors at the studios were intrigued by a sculptural representation of a woman taking a shower. As droplets of water dripped from the shower-head in a white stall, moving-picture images of the woman were registered by a projector behind the stall on a sand-blasted Plexiglass panel.

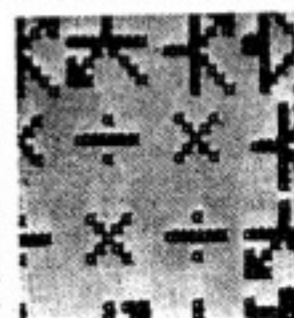
Rauschenberg's 'Oracle'

Another sculptural construction was a sound-emitting assembly consisting of a tire, truck door, window frame, bathtub and air vent. This is Mr. Rauschenberg's "Oracle."

Five radios are used, with the tuning dial of each being rotated by motor. Thus, each radio picks up snatches of the broadcasts of all the local



Drawing of nude above was generated by a computer under direction of L. D. Harmon and K. C. Knowlton, engineers. Black square encloses the detail shown.



contribution dollar that goes to the arts."

"Along with its obligation to be a profit-maker for its owners, the modern business corporation has an obligation to be a good citizen in the community," he said. "As a basic part of this obligation, the corporation must examine carefully its responsibility to

dividuals in seeking to make "valuable contributions."

He noted that union members were also consumers, members of audiences and citizens concerned with the quality of society.

The event served to dramatize a drive to win organizational support for the art-technology merger and to mark the transfer of Experi-

with human problems caused by automation — notably the problem of individual "isolation."

Dr. Brodey, who heads M.I.T.'s science camp for underprivileged youngsters, noted that new technologies had opened large new areas of creativity. While the in-

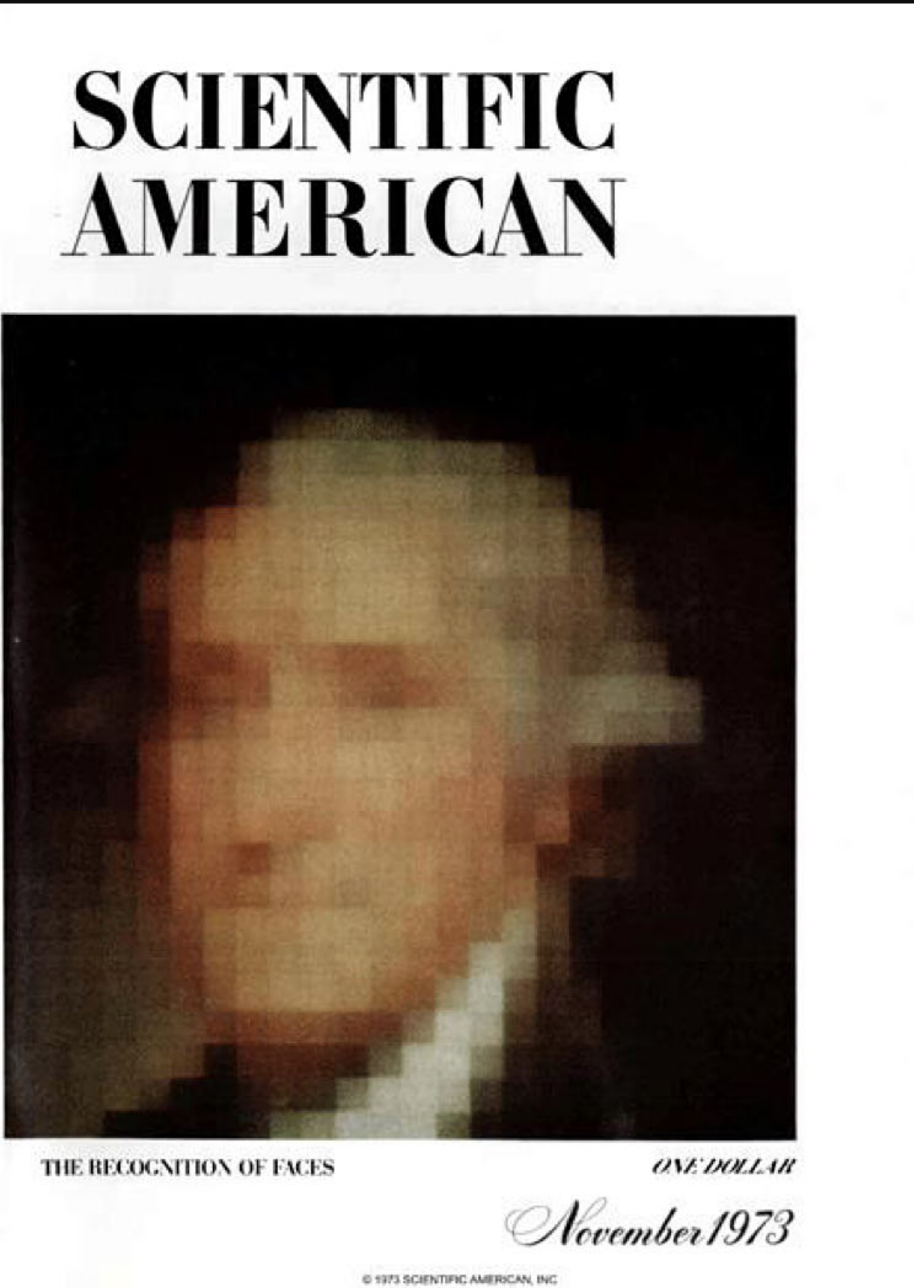
http://dss-edit.com/plu/NYT_Art-Science_10-11-1967.pdf

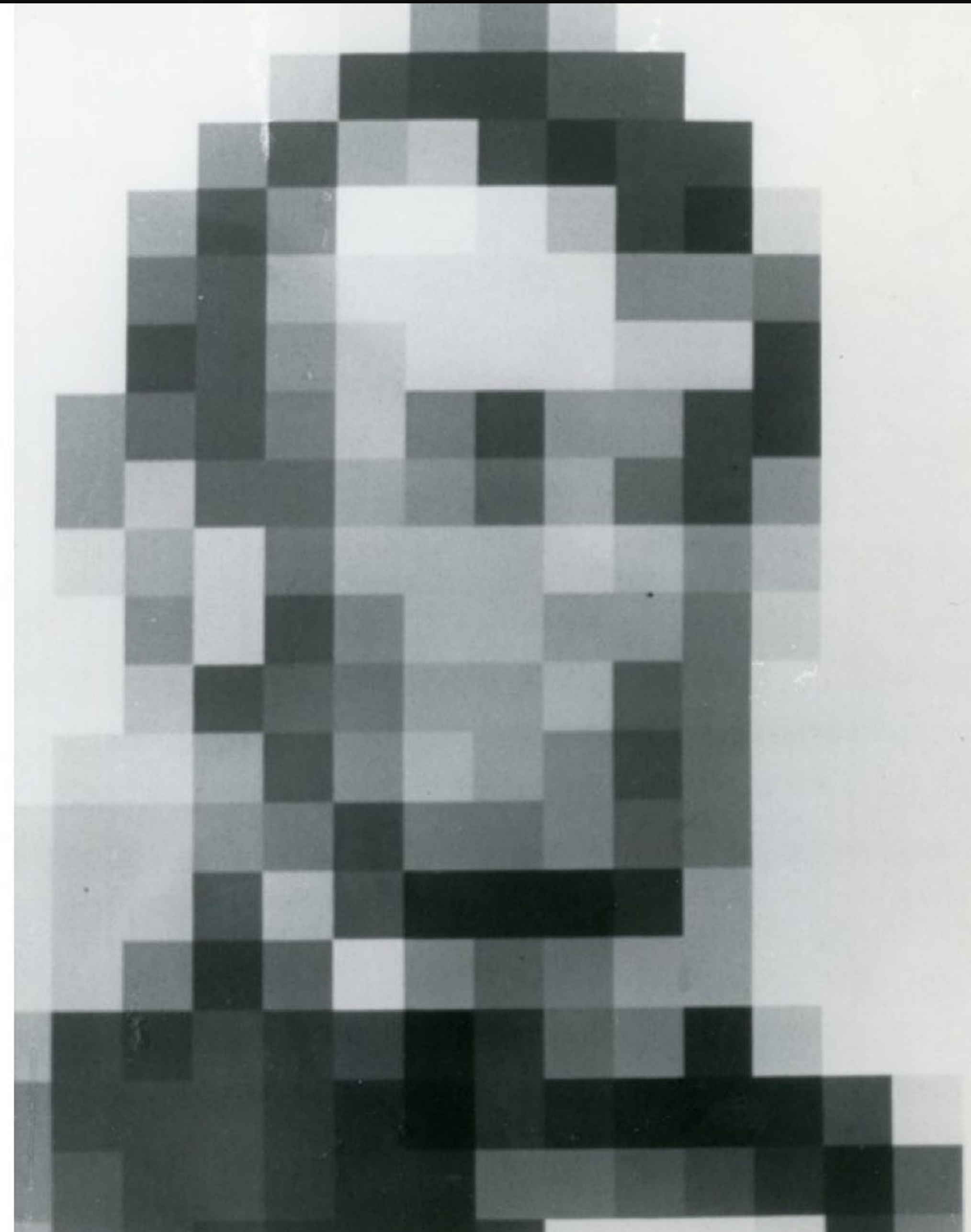
“A mulher que nao é B.B.”, Waldemar Cordeiro (1971

moma.org/collection/works/166022?sov_referrer=artist&art

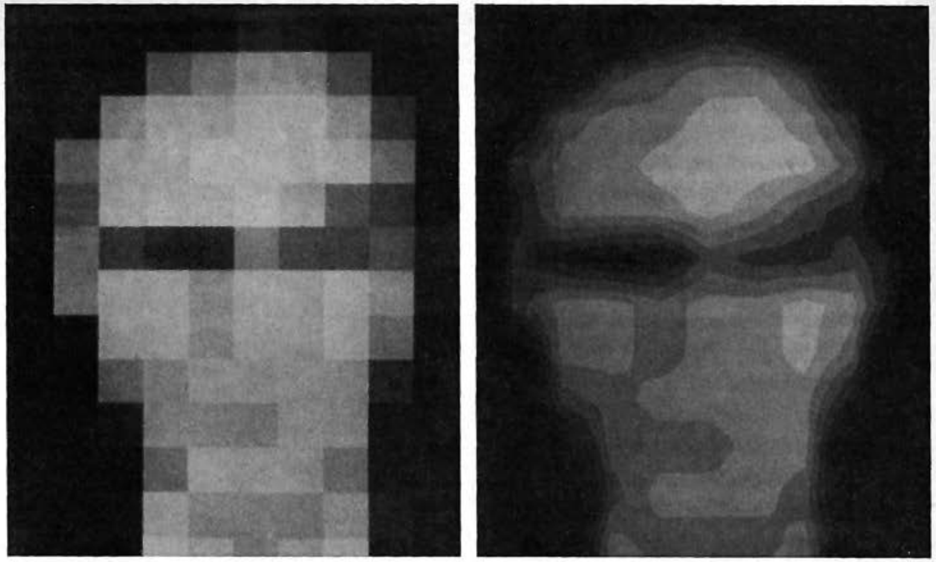
“Writing New Codes”, Exhibition installation at Mayor Gallery, London (2018)

Leon Harmon

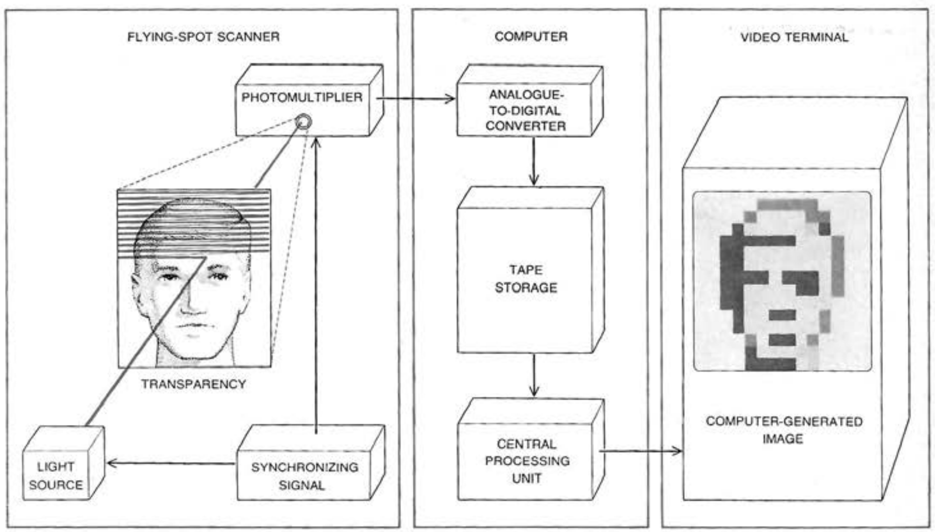




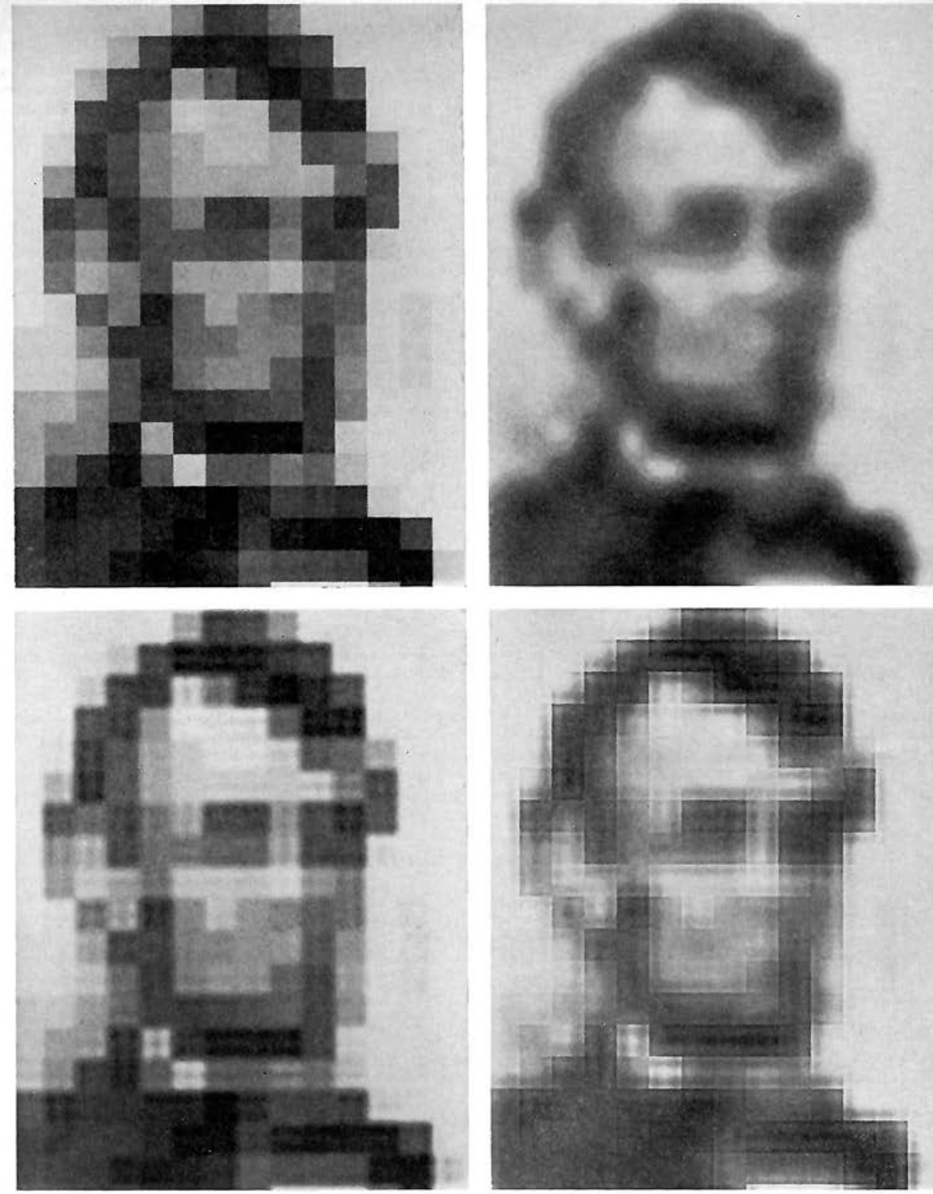
The Recognition of Faces. Scientific American (1973 Nov) 229(5):71-82



REDUCED-INFORMATION-CONTENT PORTRAITS were generated by a computer. The picture at left is a block portrait; it is an array of 16 × 16 squares, each one of which can assume any one of 16 levels of gray. Not all the 256 squares are required to represent the face. The contoured representation at right was produced by filtering the block portrait to remove high frequencies.



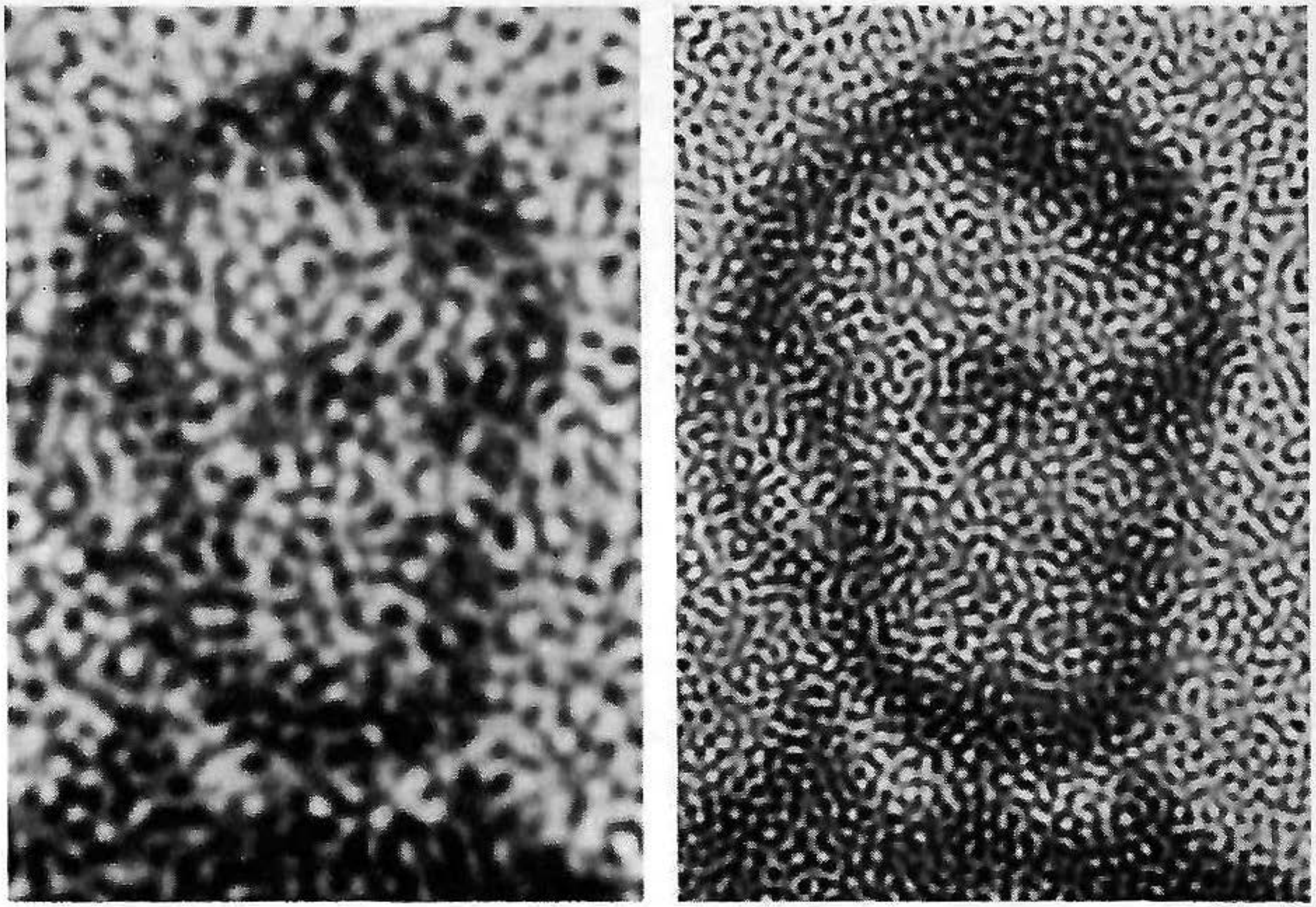
SYSTEM FOR MAKING BLOCK PORTRAITS uses a flying-spot scanner, a device similar to a television camera. The image, usually in the form of a 35-millimeter photographic transparency, is scanned in a raster pattern of 1,024 lines. In the analogue-to-digital converter each line is sampled at 1,024 points and the brightness of each point is assigned one of 1,024 values. Using this information stored on magnetic tape, the central processing unit divides the image into $n \times n$ squares and averages the brightness values of all the points within each square. The number of permissible brightness values is then reduced to eight or 16. The resulting image is displayed on a video terminal (a television screen) and photographed. The computer can also be made to operate a facsimile printer, which produces a finished picture directly. Most of the portraits used in these experiments were made by the latter process.



SELECTIVE FREQUENCY FILTERING influences the ease with which block portraits are recognized. The original block portrait of Abraham Lincoln is at top left. It consists of the photographic "signal," whose highest spatial frequency is 10 cycles per picture height, and noise frequencies extending above 10 cycles. As was anticipated, filtering out all spatial frequencies above 10 cycles (*top right*) greatly enhances recognition. Selective removal of only part of the noise spectrum, however, reveals which frequencie most effectively mask the image. At bottom left all frequencie above 40 cycles have been removed; even though the sharp edg of the squares are eliminated, perception is improved only sligh ly. When the two-octave band from 10 to 40 cycles is removed (*bo tom right*), the face is more readily recognized. The phenom non apparently responsible for this effect is critical-band maskin

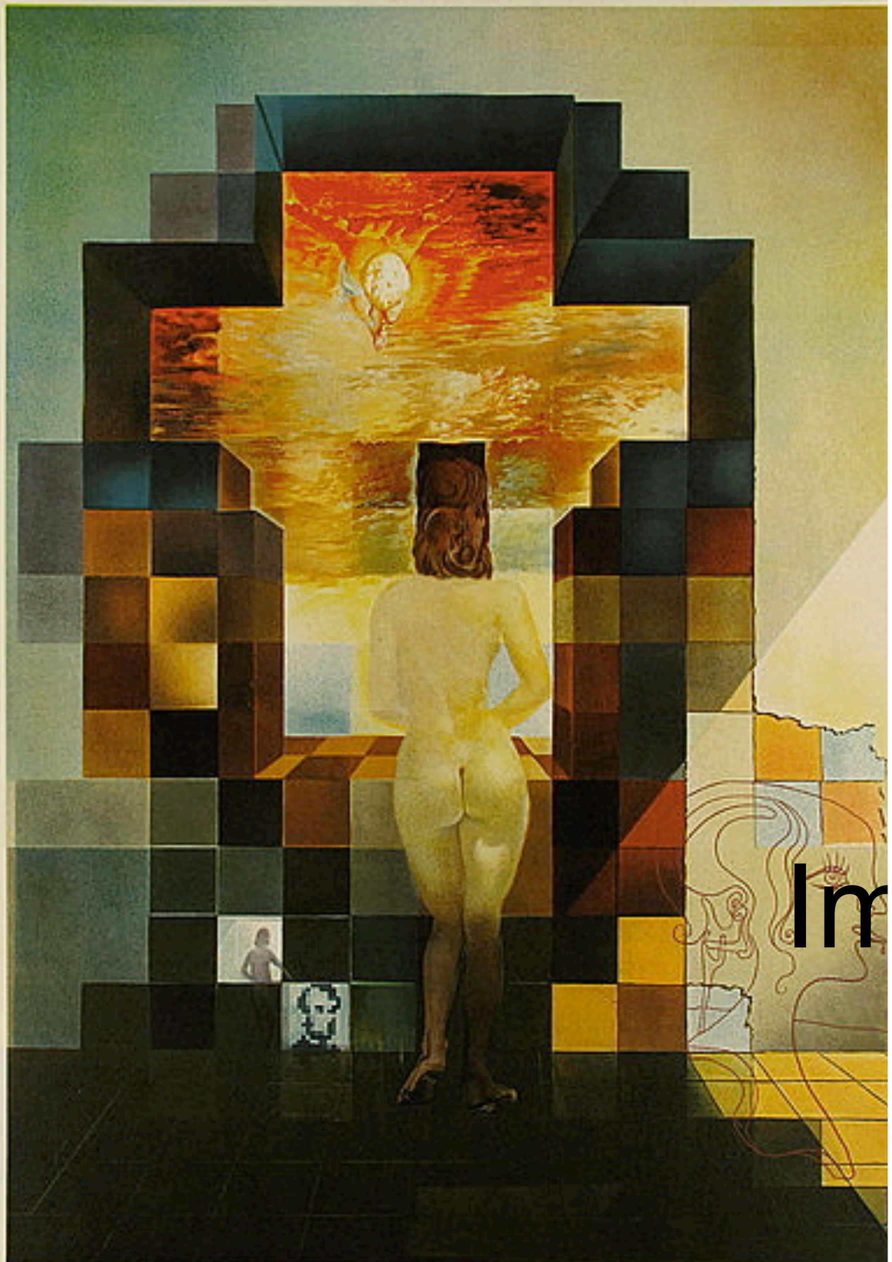
https://psychology.wikia.org/wiki/Leon_Harmon

Leon Harmon, Bell Labs (American Scientific, 1973)



RANDOMLY DISTRIBUTED NOISE of uniform amplitude is added to smoothly blurred portraits of Lincoln. When the noise is in the band adjacent to the signal frequencies (*left*), it obscures the picture more effectively than when it is at least two octaves removed from the picture frequencies (*right*), confirming that critical-band masking is the most important mechanism limiting the recognition of degraded or blurred images such as block portraits.

How much information is required for recognition and what information is the most important



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https://archive.thedali.org/mwebcgi/mweb.exe?request=record;id=152;type=101

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Nowhere to Hide: Algorithms Are Learning to ID Pixelated Faces

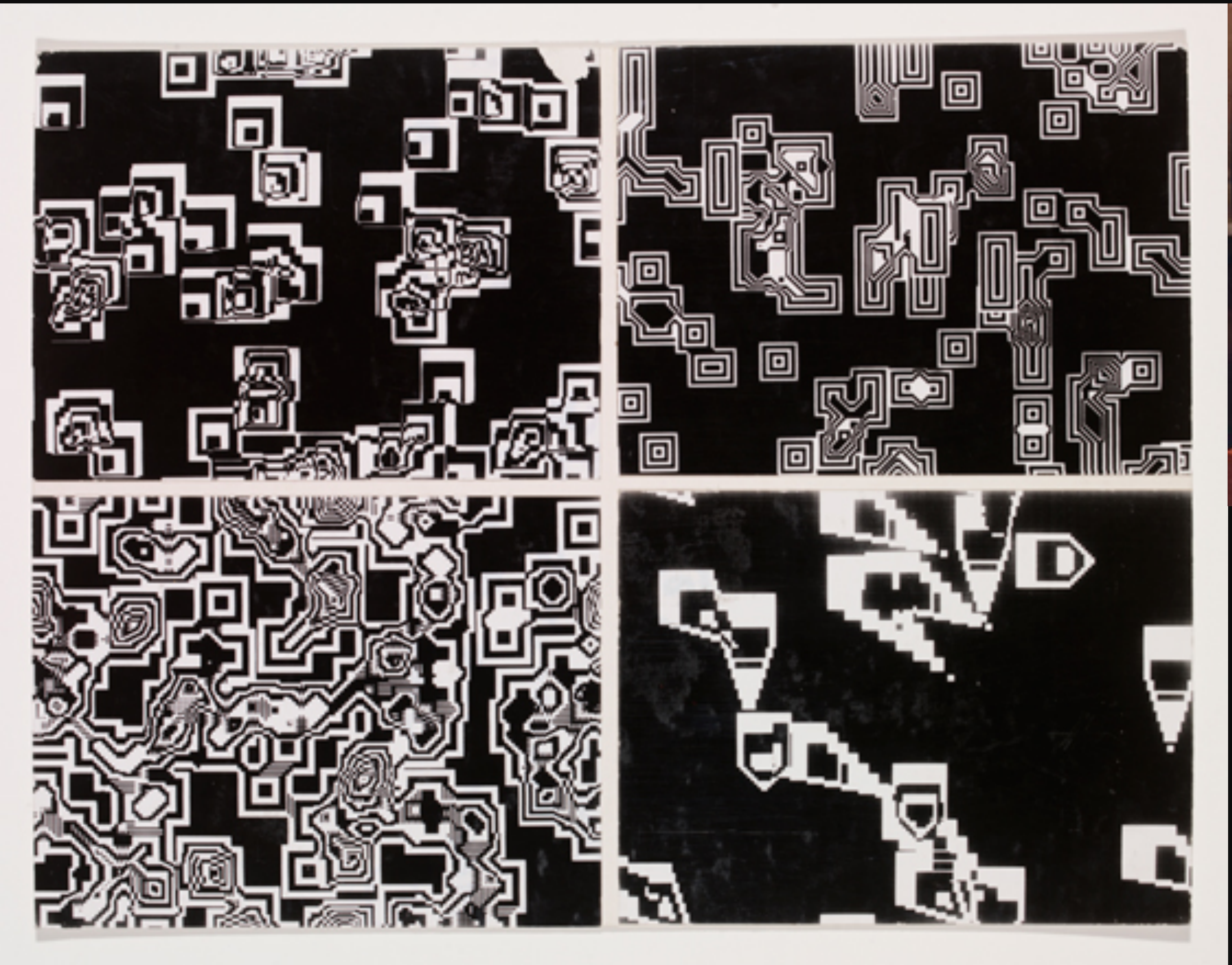
The new tech can identify faces or numbers even if they've been blurred out.

// BY AVERY THOMPSON SEP 13, 2016

Images

https://www.popularmechanics.com/technology/security/a22829/machine-learning-blurred-faces/

“Pixillation”, Lillian Schwartz & Ken Knowlton (1970)



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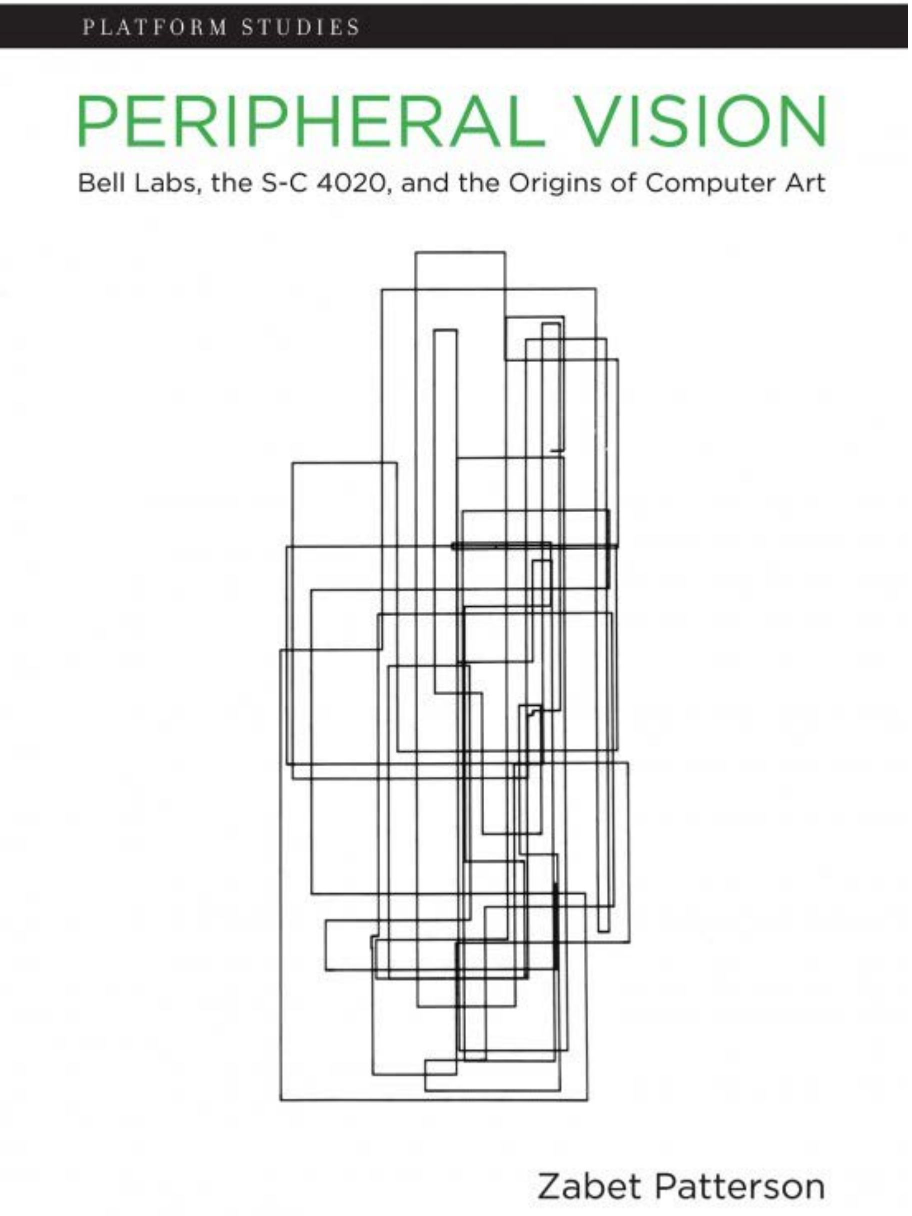


Peripheral Vision

Bell Labs, the S-C 4020, and the Origins of Computer Art

Zabet Patterson

2015

How the S-C 4020 – a mainframe peripheral intended to produce scientific visualizations – shaped a series of early computer art projects that emerged from Bell Labs.

In 1959, the electronics manufacturer Stromberg-Carlson produced the S-C 4020, a device that allowed mainframe computers to present and preserve images. In the mainframe era, the output of text and image was quite literally peripheral; the S-C 4020 – a strange and elaborate apparatus, with a cathode ray screen, a tape deck, a buffer unit, a film camera, and a photo-paper camera – produced most of the computer graphics of the late 1950s and early 1960s. At Bell Laboratories in Murray Hill, New Jersey, the S-C 4020 became a crucial part of ongoing encounters among art, science, and technology. In this book, Zabet Patterson examines the extraordinary uses to which the Bell Labs SC-2040 was put between 1961 and 1972, exploring a series of early computer art projects shaped by the special computational affordances of the S-C 4020.

The S-C 4020 produced tabular data, graph plotting and design drawings, grid projections, and drawings of axes and vectors; it made previously impossible visualizations possible. Among the works Patterson describes are E. E. Zajac's short film of an orbiting satellite, which drew on the machine's graphic capacities as well as the mainframe's calculations; a groundbreaking exhibit of "computer generated pictures" by Béla Julesz and Michael Noll, two scientists interested in visualization; animations by Kenneth Knowlton and the Bell Labs artist-in-residence Stan VanDerBeek; and Lillian Schwartz's "cybernetic" film Pixillation.

1982

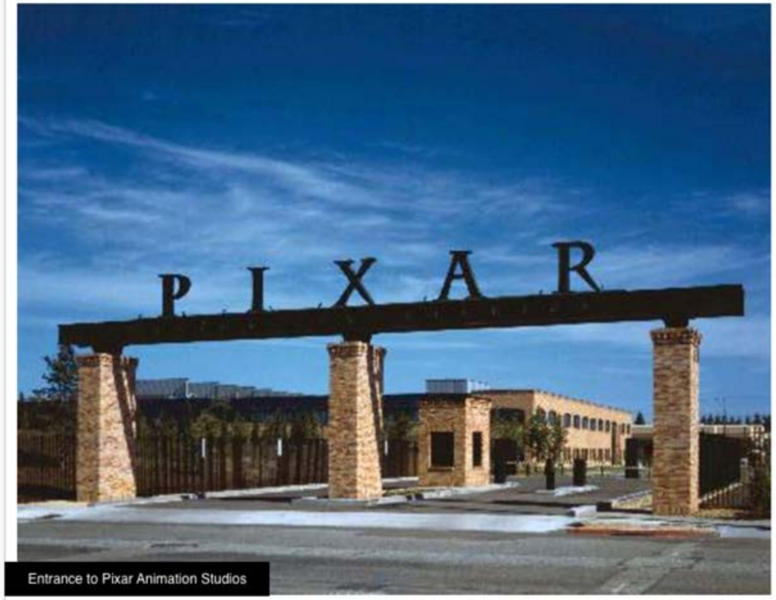
ILM produces The Genesis Effect for *Star Trek II – The Wrath of Khan*

Still from the *Genesis Effect*

Star Trek II – The Wrath of Khan, features one of the most groundbreaking segments in the history of early computer graphics, *The Genesis Effect*. Portraying the rebirth of a barren planet, the computer graphics group of Lucasfilm created the sequence, basing it partly on the simulation of satellite fly-bys done by Jim Blinn for NASA's Jet Propulsion Laboratory. The team, directed by Alvy Ray Smith, produced the effect using Lucasfilm's DEC VAX computer and an Evans and Sutherland Picture System. The sequence, considered to be one of the major milestones in computer animation, lasts just over a minute, and took two person-years of work to complete.

1986

Pixar is founded



Entrance to Pixar Animation Studios

Pixar was originally called the Special Effects Computer Group at Lucasfilm (launched in 1979). The group created the computer-animated segments of films such as *Star Trek II: The Wrath of Khan* and *Young Sherlock Holmes*. In 1986, Apple Computer co-founder Steve Jobs paid 10 million dollars to Lucasfilm to purchase the Group and renamed it Pixar. Over the next decade, Pixar made highly successful (and Oscar-winning) animated films. It was bought by Disney in 2006.

1988

A STILL VIDEO SYSTEM (DRAFT COPY - 3/20/87)

E. Brooks, L. Goolsby, E. Kendrick, T. Nutting, F. Oleson, D. Pophal
Eastman Kodak Co.
Electronic Photography Division
Rochester, New York 14650

INTRODUCTION
A complete Still Video System has been developed that includes all the components necessary for capturing, displaying, printing and sending and receiving Still Video Images.

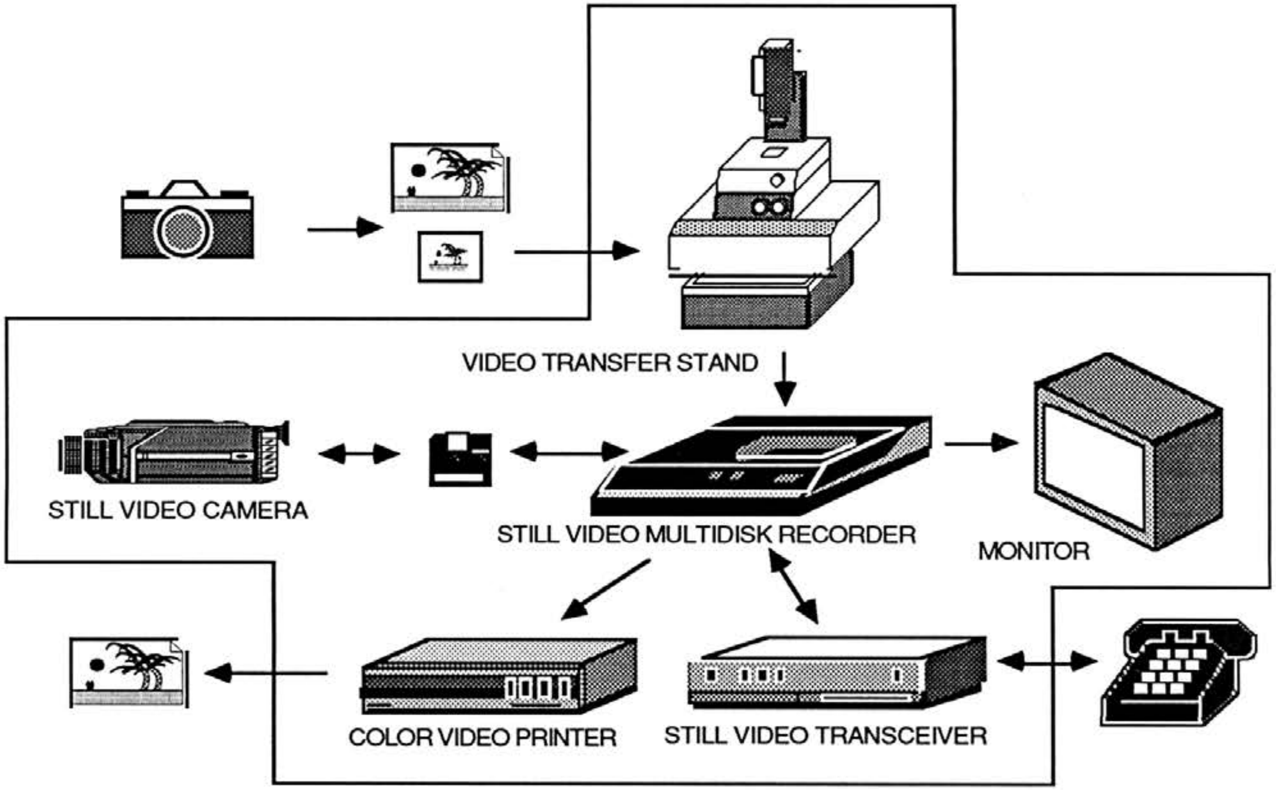


Figure 1 - The Still Video System

SYSTEM CONCEPT
The system consists of a Still Video Camera, a Multidisk Recorder (and player), a Printer, a Video Transfer Stand, a telephone line Transceiver and a TV monitor. The Camera and Recorder utilize

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TRUEVISION ADVANCED RASTER GRAPHICS ADAPTER

High Spatial-Resolution Frame Capture And Display

Inroducing a technological triumph from AT&T – the Truevision Advanced Raster Graphics Adapter (TARGA™) series of single-slot graphics boards. The five separate TARGA models digitize and display pictures of striking clarity and realism at even higher spatial resolution than the Image Capture Board.

TARGA captures continuous-tone images in real time: one-thirtieth of a second per frame. And TARGA is elegantly engineered for speed, performance, and reliability. Its robust gen-lock capability lets you digitize video signals from a variety of sources, including video cameras, VCRs, and video disc players. TARGA incorporates a number of sophisticated hardware features, including 2X, 4X and 8X zoom. Smooth, independent horizontal and vertical panning. Bit plane masking and other programmable options offer incredible flexibility in working with continuous-tone images.

The TARGA series provides up to 512 by 482 pixel resolution at different color depths. Display device options include analog RGB monitors for TARGA models M8, 16, 24 and 32. Composite video monitors for TARGA 16. And monochromatic video monitors for TARGA 8 and M8.

Specifications:

Spatial Resolution Modes

A. 512 x 482 pixels (interlaced only); board memory accommodates one 512 x 512 image
B. 512 x 240 pixels (interlaced/non-interlaced); board memory accommodates two full-screen 512 x 256 images
C. 256 x 240 pixels (interlaced/non-interlaced); board memory accommodates four full-screen 256 x 256 images

Gen-Lock Capability

A. Master or slave
B. Automatic switching to master mode in the absence of video input

Capture Time: 1/60th of a second per field, 1/30th of a second per frame

Hardware Zoom: 2X, 4X, and 8X

Hardware Panning: Independent horizontal and vertical smooth panning

Programmable Options

A. Independent vertical and horizontal screen centering
B. Display modes: selectable border color or live border

Bit Plane Read/Write Mask

Vertical Scrolling With Wrap-Around ■

	TARGA 8	TARGA M8	TARGA 16	TARGA 24	TARGA 32
Color Resolution	256 levels of grey	256 grey levels; or 256 colors from a palette of 16,777,216	32,768 colors	16,777,216 colors	16,777,216 colors
Input Signals	RS 170 compatible (black and white) video	4 RS-170 compatible (black & white) video channels, or analog RGB (for sequential color capture); Digital RGBI input (for pass-through of CGA output)	RS 170A compatible (color) video Analog RGB	Analog RGB	Analog RGB
Output Signals	RS 170 compatible (black and white) video	Analog RGB Monochrome, RS-170 composite video	RS 170A compatible (color) video Analog RGB	Analog RGB	Analog RGB
Overlay Capability		Overlay live input with memory (one entry in color look-up table)	Overlay live input with memory (1 bit)		Overlay live input with memory (1 bit) and 128 levels of mix for blending live input with memory (7 bits)
Memory	8 bits/pixel 256K bytes	8 bits/pixel 256K bytes	16 bits/pixel 512K bytes	24 bits/pixel 768K bytes	32 bits/pixel 1,024K bytes

Overscan For TARGA

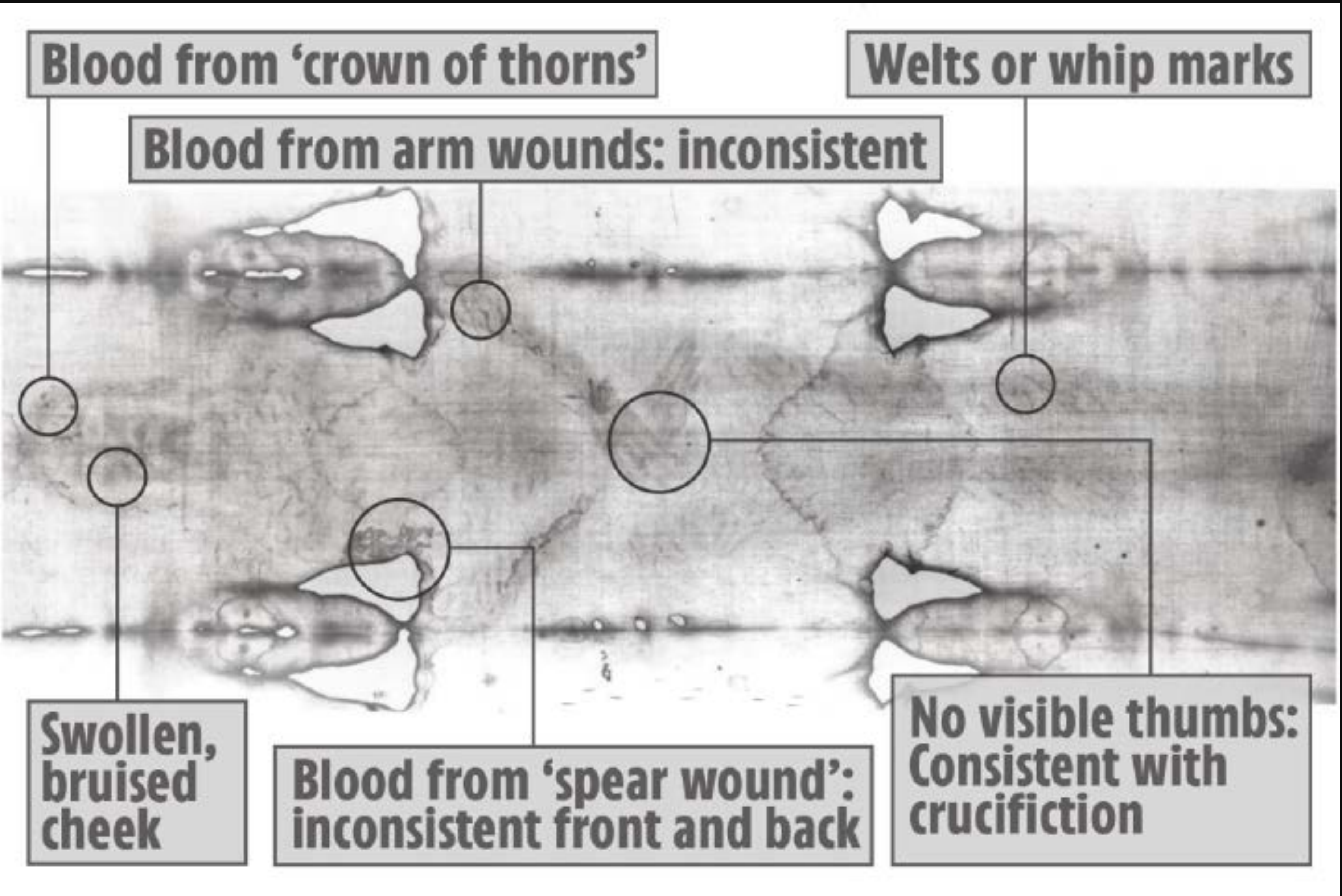
TARGA has been developed so that your images will always appear within a safe title area (44 microsecond active video interval). However, it is possible that for certain video and video production-oriented applications, you may need to go to a full 52.6 microsecond video width (10.9 microsecond blanking interval).

Now you can increase your visual image area with our TARGA Overscan Option, available with any of the TARGA models we offer. And you'll find our Truevision Image Processing Software (TIPS) to be compatible. An Overscan-equipped TARGA will occupy two slots in your PC. ■

Targa Imaging Capture Board, 512 x 512 pixels, 32768 colors with alpha channel (1985)

Legrady Studio with IBM/Targa Imaging System and Jetgraphix prints, Los Angeles (1988)

Shroud of Turin (*the first chemically recorded image?*)

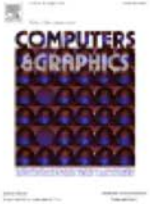


https://www.thesun.ie/tech/4879407/believers-in-shroud-of-turin-that-covered-jesus-christ-call-for-re-test-after-cloth-dated-to-just-800-years-ago/

ELSEVIER

Computers & Graphics

Volume 12, Issue 1, 1988, Pages 81-90



Technical section

Rendering of the Shroud of Turin using sinusoidal pseudocolor and other image processing techniques

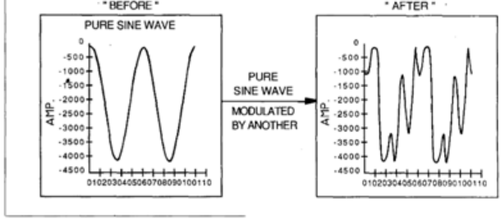
Clifford A. Pickover

Show more

https://doi.org/10.1016/0097-8493(88)90012-X

Abstract

To help characterize noisy and subtle features in images, computers with graphics can be used to produce visual representations with a spectrum of perspectives. In this article, processed images of the Shroud of Turin—a 2000-year-old linen burial cloth—are computed, and they are presented with accompanying descriptions of patterns produced by the image processing. The images of the Shroud are created by using sinusoidal pseudocolor functions, and the resultant pictures reveal a beautiful, complex picture and help to differentiate various regions of potential interest. This paper differs from others in that it focuses on mathematical techniques for rendering this image which include unusual equations, shading, and convergence schemes.



then the standard deviation at any point in the average image is given by

$$\sigma_f(x, y) = \frac{1}{\sqrt{M}}\,\sigma_s(x, y) \qquad (4)$$

which indicates that as M increase the variability of the pixel value decreases[7]. With the Shroud, like other archeological artifacts, the "noise" is in the object itself

Using this technique, a graphically "rich" lookup table function can be produced with only a small number of input parameters. By exploring a variety of α and ρ certain features can be made to visually contrast well with others. In order to use $f(\alpha, \rho, x)$ to transform the Shroud, the value of each (x, y) element of the resultant picture is obtained by taking the kth element in $f(k)$, where k is the value (intensity) of the element at (x, y) in the original image. This approach produces

Fig. 2. The image on the Shroud has many of the facial features of the standard bearded face of Jesus in art. This engraving by Albrecht Durer entitled "Man of Sorrows by the Column" was created in 1509 and displays Christ with the traditional long nose and hair, and full beard. The Shroud either reflects or has influenced the way most artists have portrayed Jesus for centuries.

Fig. 6. Image produced by a non-monotonic lookup table defined by $f(\alpha, \rho, x) = \sin[\alpha x + \sin(\rho x)]$ where $\alpha = 1$ and $\rho = 1$. This figure visually brings out those parts of the face which touched the cloth or were in contact with it the longest. Note that certain well defined closed regions (bloodstains) on the forehead and hair at the side of the face are also made evident—and these are precisely where hemoglobin has been found (see arrows).

Fig. 7. A negative of Fig. 6.

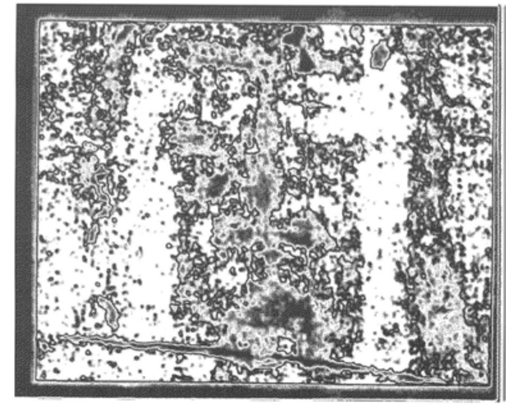


Fig. 8. Image produced using a LUT defined by $\sin^2(x)$.

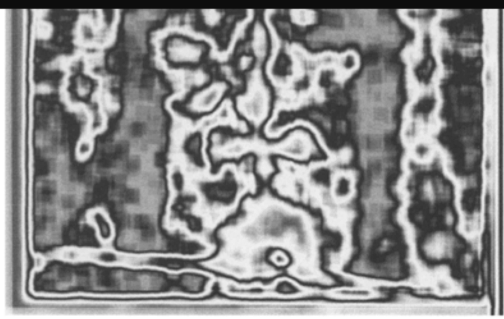


Fig. 9. Image produced by a non-monotonic lookup table defined by $f(\alpha, \rho, x) = \sin[\alpha x + \sin(\rho x)]$ where $\alpha = 3$ and $\rho = 3$. In addition, a strong local averaging is performed ($n = 23$). This figure appears to visually bring out the region where coins are suggested to have been placed over the eyes, a first-century Jewish custom.

created using a pseudocolor look-up-table for mapping gray scale images to color. I generated the look-up-table from three sine waves (one each for red, green, and blue) each with random phase (ϕ) and frequences (α). For example,

$$f_{red} = \beta \sin(\alpha x + \phi) + \beta, \qquad (7)$$

where $\beta = 125$. Like the previous method, this protocol produces continuous color change, and the non-monotonic LUT is useful in revealing various low-contrast features. Local averaging is also performed for these pictures. Note that this approach produces well saturated colors (i.e., pure colors not diluted with much white light). β allows the user to control the color changes in a picture; for example, reducing the β parameter gives a more correlated image with less color extremes and less rapid changes in color.

CONCLUSIONS

Among the methods available for the characterization of complicated physical phenomena and objects, computers with graphics are emerging as an important tool (for several papers by the author, see [10]). In the current article, images of the Shroud of Turin are created by using sinusoidal pseudo-color functions, and the resultant pictures reveal a beautiful, complex image, and in some cases improve the pictorial information for human interpretation. With the choice of proper contour, a number of objectively different patterns can be made to appear in the Shroud which are not as evident when seen by the eye or with conventional photography. The color renditions appear to be best for such purposes, but even the monochrome pictures have a certain degree of utility. For example, Figs. 6, 7 and 8 visually bring out those parts of the face which touched the cloth or were in contact with it the longest. Figure 9 appears to highlight the region where other authors have suggested that coins have been placed over the eyes, a first-century Jewish custom. In some figures the blood stains are apparent and can be highlighted. For example, Fig. 6 shows certain well defined regions on the forehead and hair at the side of the face—and these are precisely where hemoglobin has been found.

Fig. 10. Image produced by using a clipped sinusoid ($\alpha = 2$, $\rho = 3$). Many figures produced by this approach have an artistic appeal reminiscent of the works of Picasso and other abstract painters.

From an artistic standpoint, these approaches provide a vast and deep reservoir from which artists can draw. Some of the figures contain an artistic appeal reminiscent of the works of Picasso and other abstract painters (Fig. 10). The computer is a machine which, when guided by an artist, can render images of captivating power and beauty. New "recipes," such as those outlined here, interact with such traditional elements as form, shading and color to produce futuristic images and effects. The recipes function as the artist's helper, quickly taking care of much of the repetitive and sometimes tedious detail. By creating an environment of advanced computer graphics, artists with access to computers will gradually change our perception of art.

The beauty and complexity of these drawings correspond to mappings which no one could fully have

from their "artistic" appeal, these images are useful in visually differentiating features of interest in the Shroud (see Fig. 11). One large question remains: How did the image on the cloth form? To date, scientists have not been able to account for the manner in which the image was imprinted on the cloth. The Shroud's authenticity has been called into question repeatedly, but the 1978 tests did not prove conclusively either that the Shroud was genuine or a hoax[11, 12]. The age of the Shroud has not been established with certainty although enhanced images suggest that Pontius Pilate coins were placed over the eyes[1], and this may add further credibility to the Shroud.

A report such as this can only be viewed as introductory; however, it is hoped that the techniques, equations, and system will provide a useful artistic and

computers will gradually change our perception of art.

The beauty and complexity of these drawings correspond to mappings which no one could fully have appreciated or suspected before the age of the computer. This complexity makes it difficult to objectively characterize structures such as these, and therefore, it is useful to develop graphics systems which allow the maps to be followed in a quantitative and qualitative way. To reiterate, the richness of resultant images contrasts with the simplicity of the LUT formula. Apart

ductory; however, it is hoped that the techniques, equations, and system will provide a useful artistic and archeological exploratory tool, and stimulate future studies in the graphic characterization of the morphologically rich structures produced by unusual image processing techniques.

Note: For more information on color Shroud renditions, contact the author.

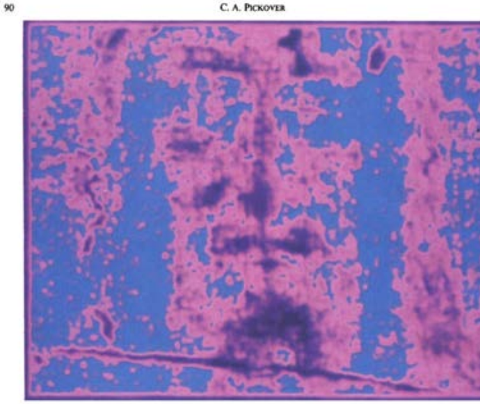
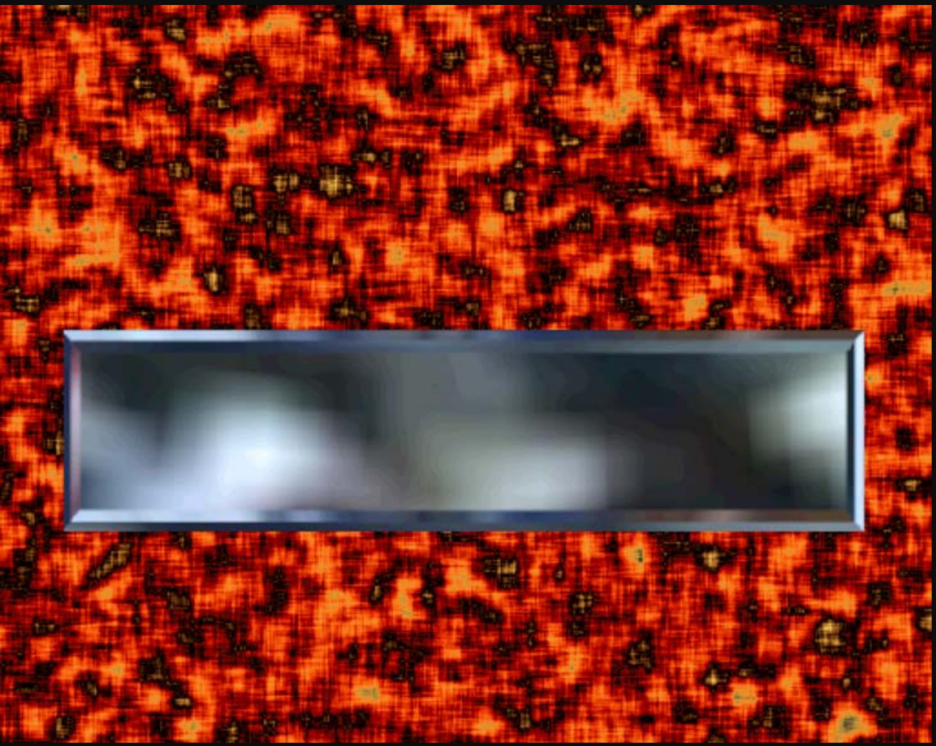
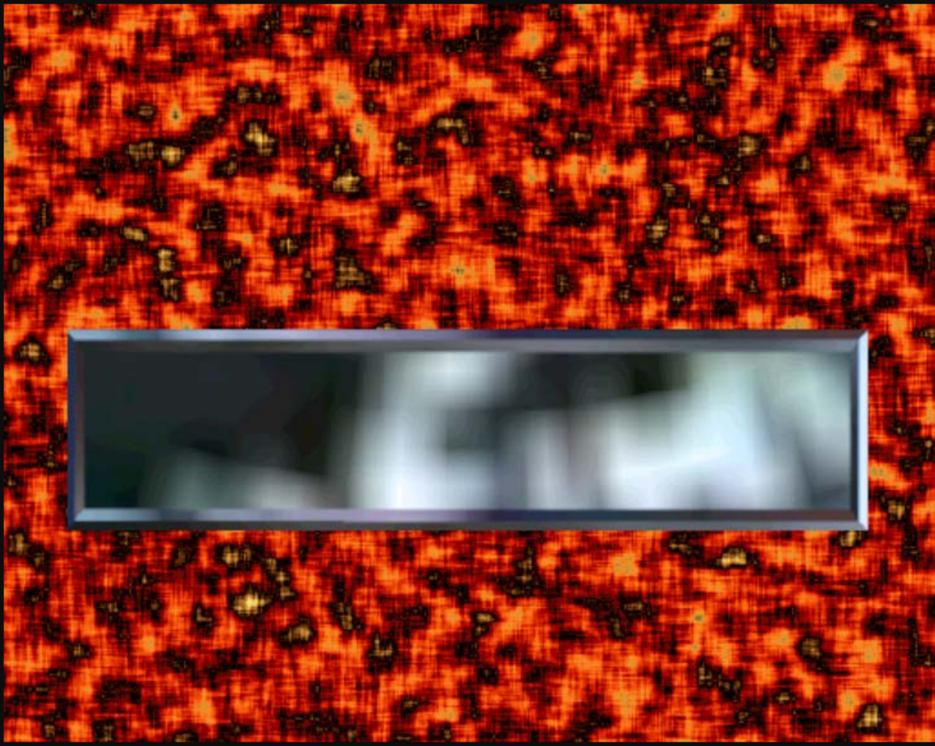
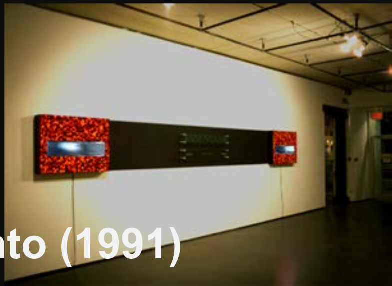


Fig. 11. Pseudocolor rendition of the Shroud. Dark red areas are those parts of the face which touched the cloth or were in contact with it the longest. Dark red blotches above the eyes ("bloodstains") are also made evident—and these are precisely where hemoglobin has been found.

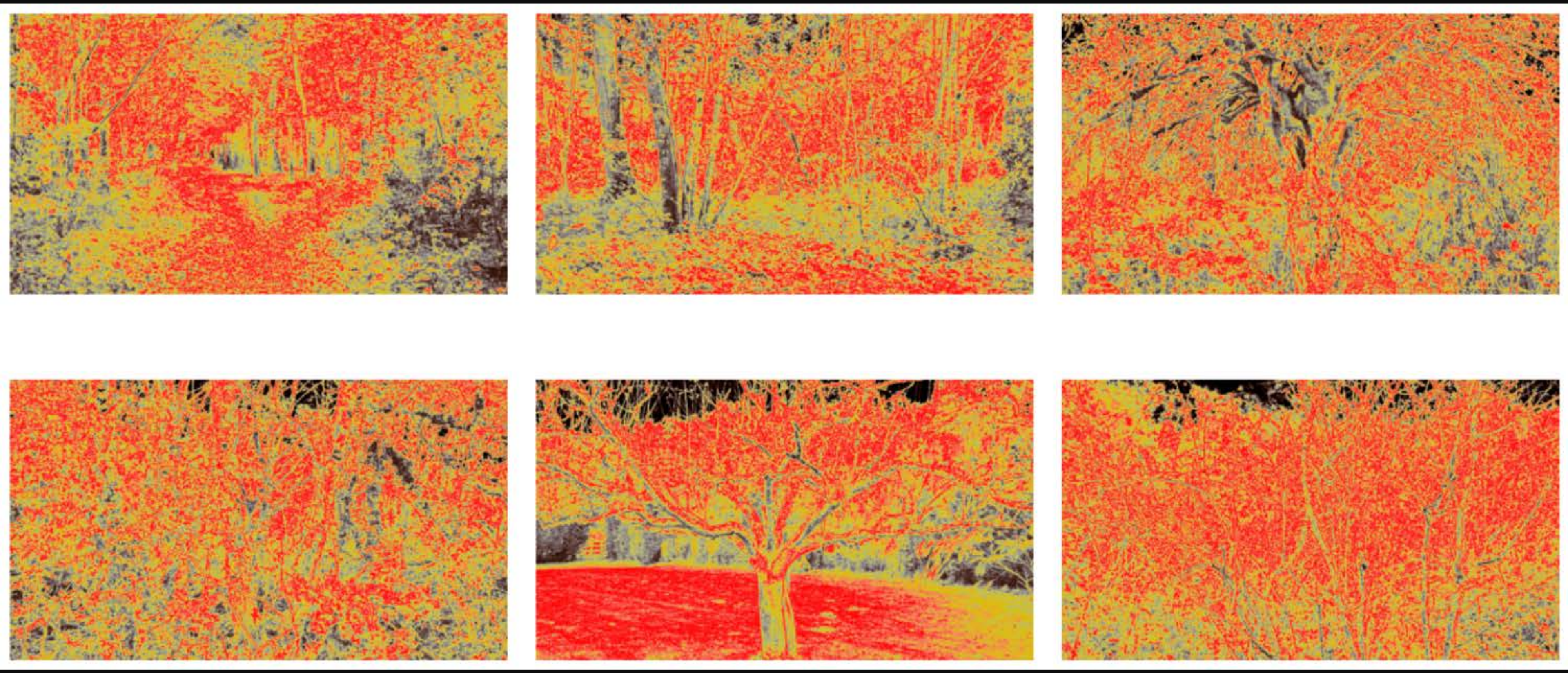






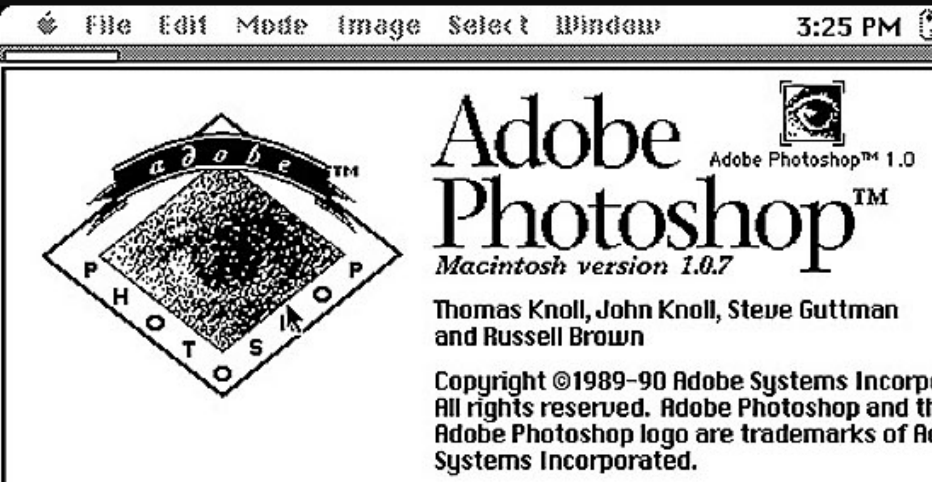
Software generated images, 3D graphics, installation at YYZ Gallery, Toronto (1991)

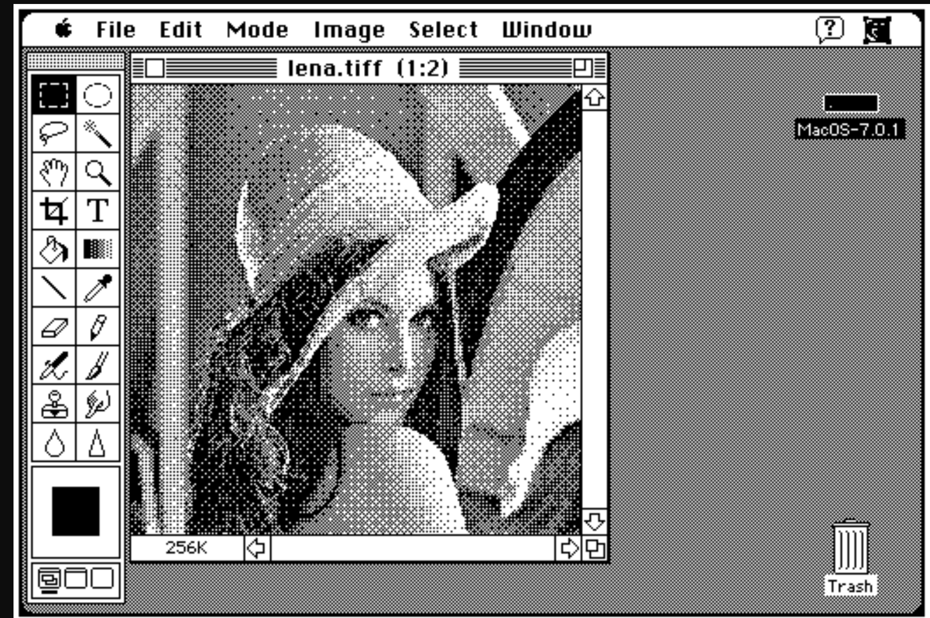
Shroud Sinusoidal Algorithm & Fontainebleau (2018)

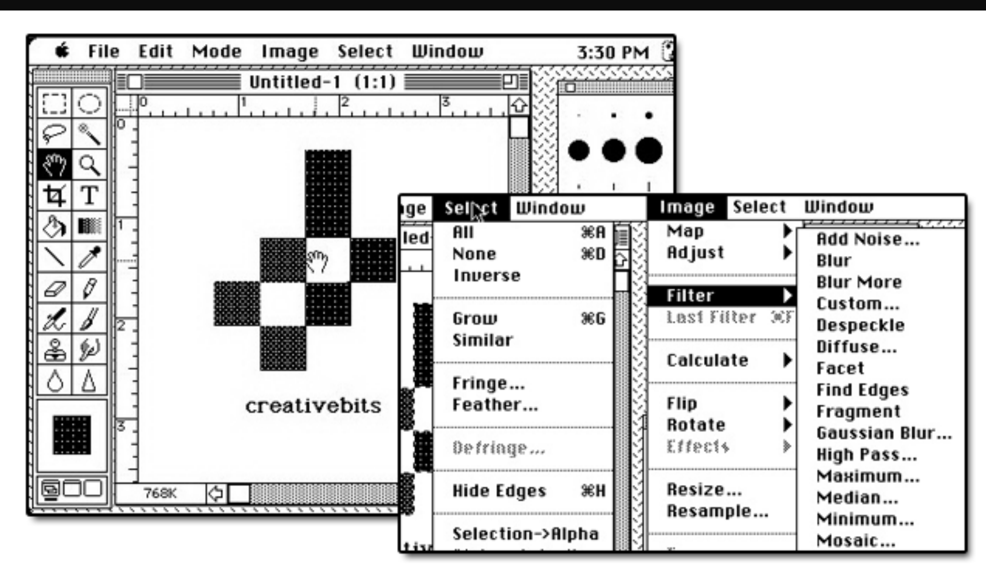


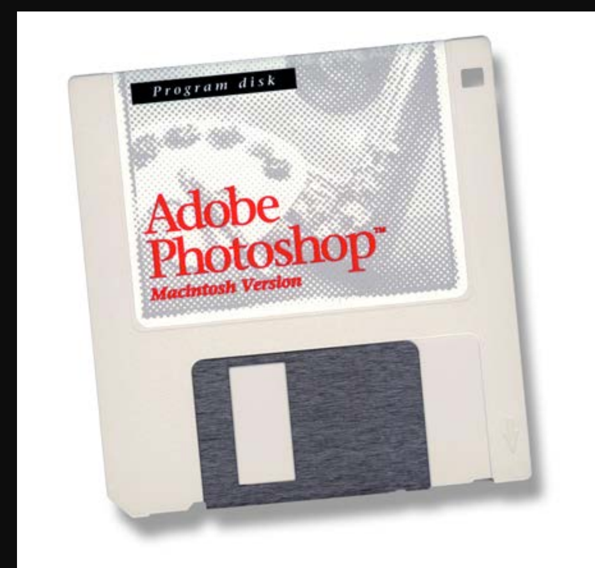
https://www.mat.ucsb.edu/~g.legrady/glWeb/Projects/fb/shroud.pdf

Photoshop Vers 1.07, Raster graphics editor (1990)



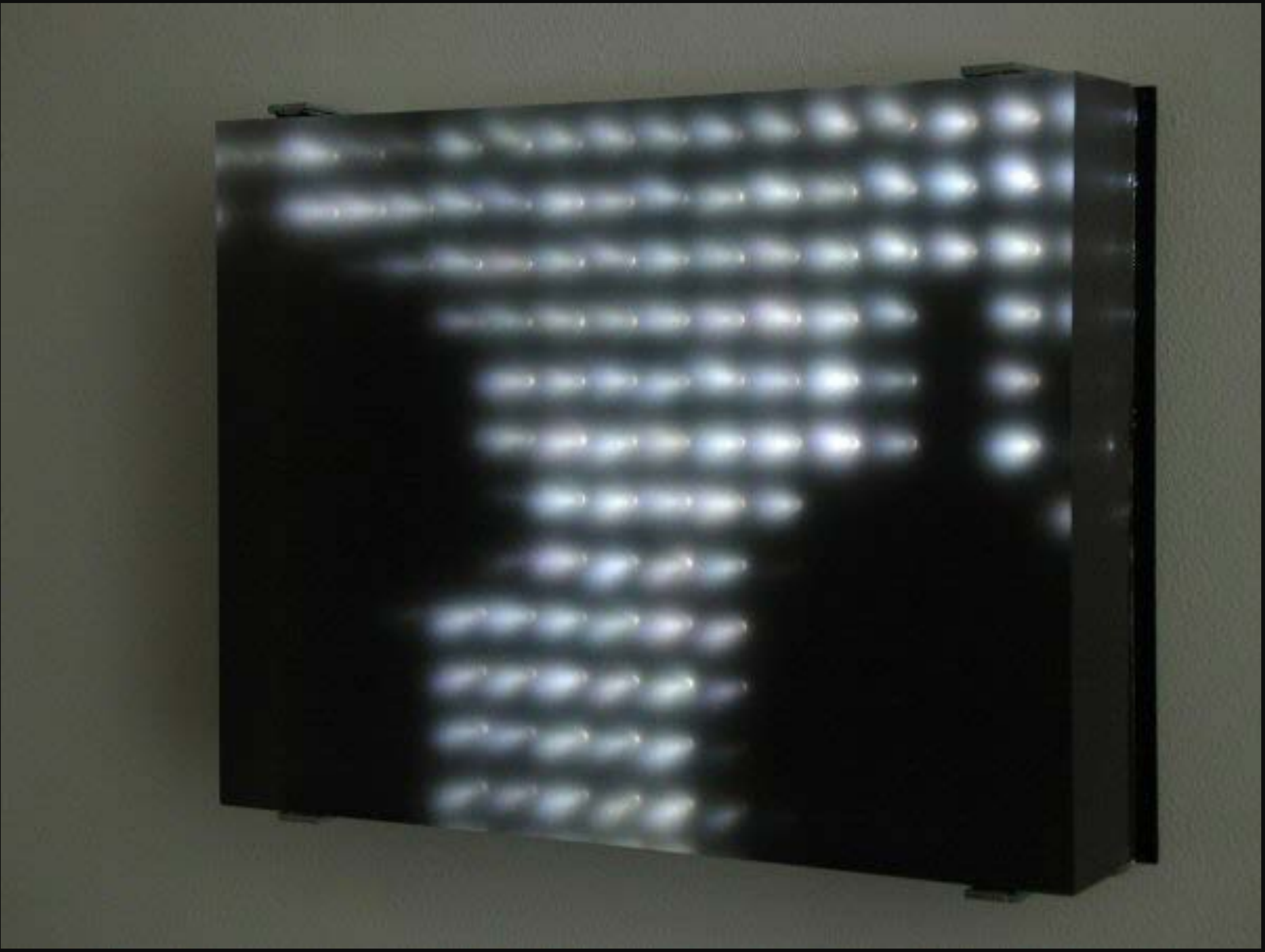






https://en.wikipedia.org/wiki/Adobe_Photoshop

“Reconstruction #1”, Jim Campbell (2002)



http://www.jimcampbell.tv/

ESSAYS & REVIEWS

Invisible Images (Your Pictures Are Looking at You)

By TREVOR PAGLEN · DECEMBER 8, 2016

An audio version of this essay is available to subscribers, provided by curio.io.

"Winona"
Eigenface (Colorized),
Labelled Faces in the Wild Dataset
2016

I.

JR eyes are fleshy things, and for most of human history our visual culture
s also been made of fleshy things. The history of images is a history of
gments and dyes, oils, acrylics, silver nitrate and gelatin–materials that one could use to paint a
ve, a church, or a canvas. One could use them to make a photograph, or to print pictures on the
ges of a magazine. The advent of screen-based media in the latter half of the 20th century wasn't
different: cathode ray tubes and liquid crystal displays emitted light at frequencies our eyes
rceive as color, and densities we perceive as shape.

The overwhelming majority of images are now made by machines for other machines, with humans rarely in the loop…

To be continued…