1.1 Tracing an image by hand: Karl Friedrich Schinkel, *The Invention of Drawing,* 1830. Von-der-Heydt-Museum, Wuppertal.

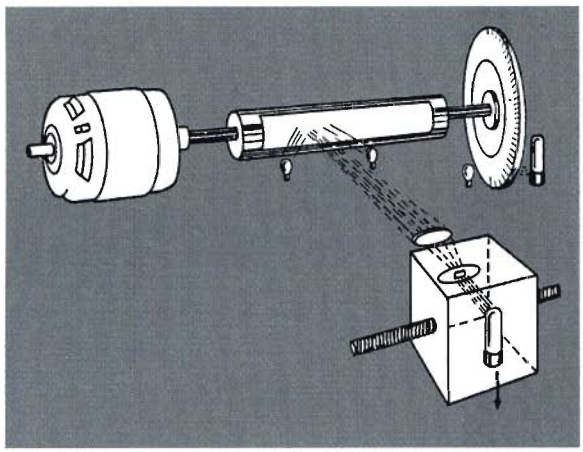
BEGINNINGS

Three Snapshots

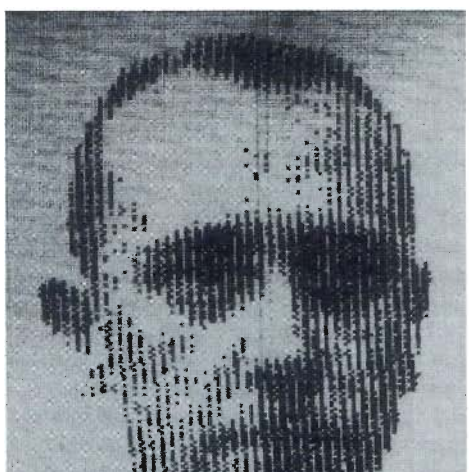
Pliny the Elder tells a mythic tale: a Corinthian maiden traces the shadow of her departing lover.[1] An image is captured by the work of her hand: painting is born (figure 1.1).[2]

William Henry Fox Talbot traces a scene at Lake Como with the help of a camera obscura. He begins to wonder "if it were possible to cause these natural images to imprint themselves durably." By 1839 he has perfected the art of chemically fixing a shadow. He announces to the Royal Society his invention of a way to record images permanently on specially treated paper "by the agency of light alone, without any aid whatever from the artist's pencil."[3] Simultaneously, Daguerreotypes make their public appearance in France. The history painter Paul Delaroche exclaims, "From this day on, painting is dead."[4]

Scientist Russell A. Kirsch and his colleagues, working at the National Bureau of Standards in the mid-1950s, construct a simple mechanical drum scanner and use it to trace variations in intensity over the surfaces of photographs (figure 1.2).[5] They convert the resulting photomultiplier signals into arrays of 176 by 176 binary digits, feed them to a SEAC 1500-word memory computer, and program the SEAC to extract line drawings, count objects, recognize characters, and produce oscilloscope displays (figure 1.3). Patterns of light and shade become electronically processable digital information; an early computer supplants the artist's recording hand.



1.2 Tracing an image electronically: scanner constructed by Russell A. Kirsch and his colleagues at the National Bureau of Standards in the 1950s.



1.3 One of the first digital images: this picture was scanned from a photograph by the NBS mechanical drum scanner, processed by the SEAC computer, and displayed on an oscilloscope.

The Raster Grid

We might, of course, choose to regard the digi tally encoded, computer-processable image as simply a new, nonchemical form of photograp or as single-frame video, just as the automobil was initially seen as a horseless carriage and radio as wireless telegraphy. Indeed the terms "electronic photography," "still video," and "digital camera" have rapidly gained currency But such metaphors obscure the importance o this new information format and its far-reaching consequences for our visual culture. Although a digital image may look just like a photograph when it is published in a newspaper, it actually differs as profoundly from a traditional photograph as does a photograph from a painting. The difference is grounded in fundamental physical characteristics that have logical and cultural consequences.

The basic technical distinction between ana log (continuous) and digital (discrete) represen tations is crucial here. Rolling down a ramp is continuous motion, but walking down stairs is a sequence of discrete steps—so you can coun the number of steps, but not the number of lev els on the ramp. A clock with a spring mechanism that smoothly rotates the hands provides an analog representation of the passage of time but an electronic watch that displays a succession of numerals provides a digital representation. A mercury thermometer represents temperature variation in analog fashion, by the continuous rise and fall of the column of liquid, but a modern electronic thermometer replaces this with a digital readout.

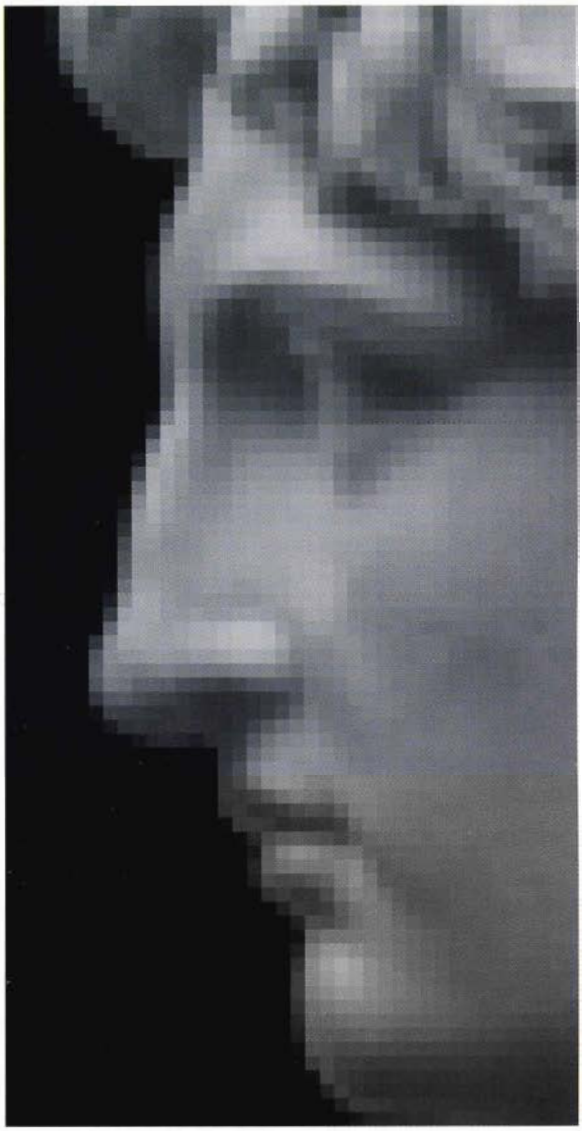
A photograph is an analog representation of the differentiation of space in a scene: it varies continuously, both spatially and tonally. Edgar Allan Poe shrewdly observed this and noted its significance in his 1840 article "The Daguerreotype":

If we examine a work of ordinary art, by means of a powerful microscope, all traces of resemblance to nature will disappear—but the closest scrutiny of the photogenic drawing discloses only a more absolute truth, a more perfect identity of aspect with the thing represented. The variations of shade, and the gradations of both linear and aerial perspective, are those of truth itself in the supremeness of its perfection.[6]

A century later, in an essay concerned with identifying the qualities that characterize photography and distinguish it from other art forms, the modernist photographer Edward Weston echoed Poe precisely:

First there is the amazing precision of definition, especially in the recording of fine detail; and second, there is the unbroken sequence of infinitely subtle gradations from black to white. These two characteristics constitute the trademark of the photograph; they pertain to the mechanics of the process and cannot be duplicated by any work of the human hand.[7]

But images are encoded digitally by uniformly subdividing the picture plane into a finite Cartesian grid of cells (known as *pixels*) and specifying the intensity or color of each cell by means of an integer number drawn from some limited range.[8] The resulting two-dimensional array of integers (the *raster grid*) can be stored in computer memory, transmitted electronically, and interpreted by various devices to produce displays and printed images. In such images, unlike photographs, fine details and smooth curves are approximated to the grid, and continuous tonal gradients are broken up into discrete steps (figure 1.4).



1.4 Enlargement of a digital image: smooth curves and continuous gradients are approximated by discrete pixels.

There is an indefinite amount of information in a continuous-tone photograph, so enlargement usually reveals more detail but yields a fuzzier and grainier picture.[9] (The plot of Antonioni's *Blow-Up* pivots on the observation that a photographic negative may contain more information than immediately meets the eye. We see David Hemmings, the fashionable photographer, obsessively enlarging parts of his negatives to reveal previously unnoticed details—a face half-concealed in the foliage, a hand holding a gun, and a body on the ground.) A digital image, on the other hand, has precisely limited spatial and tonal resolution and contains a fixed amount of information. Once a digital image is enlarged to the point where its gridded microstructure becomes visible, further enlargement will reveal nothing new: the discrete pixels retain their crisp, square shapes and their original colors, and they simply become more prominent.

The continuous spatial and tonal variation of analog pictures is not exactly replicable, so such images cannot be transmitted or copied without degradation. Photographs of photographs, photocopies of photocopies, and copies of videotapes are always of lower quality than the originals, and copies that are several generations away from an original are typically very poor. But discrete states *can* be replicated precisely, so a digital image that is a thousand generations away from the original is indistinguishable in quality from any one of its progenitors.[10] A digital copy is not a debased descendent but is absolutely indistinguishable from the original.

Digital Image Creation

It follows from the fundamental constitution of the raster grid that, just as the elementary operation of painting a picture is the brush stroke and the elementary operation of typing a text is the keystroke, the elementary operation of digital imaging is assignment of an integer value to a pixel in order to specify (according to some coding scheme) its tone or color. Complete images are built up by assigning values to all the pixels in the gridded picture plane.

One way to assign pixel values is to employ some sort of sensor array or scanning device (like that constructed by Kirsch and his colleagues) to record intensities in a visual field—to make an exposure with a digital "camera": this appropriates digital imaging to the tradition of photography. A second way is to employ the cursor of an interactive computer-graphics system to select pixels and assign arbitrarily chosen values to them: this makes digital imaging seem like electronic painting, and indeed computer programs for this purpose are commonly known as "paint" systems. And a third way is to make use of three-dimensional computer-graphics techniques—to calculate values by application of projection and shading procedures to a digital geometric of an object or scene: this extends the tradition of mathematically constructed perspective that began with Brunelleschi and Alberti. The digital image continues but, as we shall see, also redefines these older traditions.

Mutability and Manipulation

Edward Weston also contrasted the workability of a painting with the closure of a photograph. He valued the fragile integrity of a photograph's surface and argued that it inherently resists reworking or manipulation:

> The photographic image partakes more of the nature of a mosaic than of a drawing or painting. It contains no *lines* in the painter's sense, but is entirely

made up of tiny particles. The extreme fineness of these particles gives a special tension to the image, and when that tension is destroyed—by the intrusion of handwork, by too great enlargement, by printing on a rough surface, etc.—the integrity of the photograph is destroyed.[11]

Paul Strand extended this characteristically modernist argument about the inherent qualities of materials by suggesting that photomanipulation of any sort was not only difficult, but also unphotographic and fundamentally undesirable:

Photography, which is the first and only important contribution, thus far, of science to the arts, finds its *raison d'être*, like all media, in a complete uniqueness of means. . . . The full potential power of every medium is dependent on the purity of its use, and all attempts at mixture end in such dead things as the color-etching, the photographic painting and in photography, the gum-print, oil-print, etc., in which the introduction of hand work and manipulation is merely the expression of an impotent desire to paint.[12]

There have always been photographers ready to take issue with this sort of formulation. A few of these mavericks have succeeded in producing convincing composite images: Henry Peach Robinson's and Oscar G. Reijlander's nineteenth-century "combination prints," John Heartfield's photomontages, and Jerry Uelsmann's haunting constructions of the surreal come immediately to mind. But there is no doubt that extensive reworking of photographic images to produce seamless transformations and combinations is technically difficult, time-consuming, and outside the mainstream of photographic practice. When we look at photographs we presume, unless we have some clear indications to the contrary, that they have *not* been reworked.

Here photography and digital imaging diverge strikingly, for the stored array of integers has none of the fragility and recalcitrance of the photograph's emulsion-coated surface. Indeed we can precisely invert Weston's principle: the essential characteristic of digital information is that it *can* be manipulated easily and very rapidly by computer. It is simply a matter of substituting new digits for old. Digital images are, in fact, much more susceptible to alteration than photographs, drawings, paintings, or *any* other kinds of images. So the art of the digital image cannot adequately be understood as primarily a matter of capture and printing, as Weston conceived photography: intermediate *processing* of images plays a central role. Computational tools for transforming, combining, altering, and analyzing images are as essential to the digital artist as brushes and pigments are to a painter, and an understanding of them is the foundation of the craft of digital imaging.

Furthermore, since captured, "painted," and synthesized pixel values can be combined seamlessly, the digital image blurs the customary distinctions between painting and photography and between mechanical and handmade pictures. A digital image may be part scanned photograph, part computer-synthesized shaded perspective, and part electronic "painting"—all smoothly melded into an apparently coherent whole. It may be fabricated from found files, disk litter, the detritus of cyberspace. Digital imagers give meaning and value to computational readymades by appropriation, transformation, reprocessing, and recombination; we have entered the age of electrobricollage.

2.1 Spacecraft imaging: a perspective view, synthesized from Magellan synthetic aperture radar data combined with radar altimetry, of the five-mile-high volcano Maat Mons on the surface of Venus. Courtesy NASA and the Jet Propulsion Laboratory.

Early Development

In the decades following the first experiments with translation of pictures into arrays of integers, digital imaging evolved into a vigorous and increasingly important scientific field. A sophisticated mathematical theory of digital image transformation and combination was worked out and became the foundation for computer image-processing systems. New devices were invented for capturing, storing, transmitting, and displaying digital images. A laboratory curiosity matured into an applied technology; correlated social and cultural practices unfurled. The uses of images—and therefore their meanings and their value as tokens of factual discourse—began to change fundamentally.

The early development of the technology coincided with the era of space exploration, so digital imaging systems quickly began to play much the same role in twentieth-century voyages of discovery as topographic and botanical artists had played in eighteenth-century ones: they reported previously unseen marvels and inventoried potentially colonizable territory. First, the moon: by 1964 NASA scientists were able to use digital image-processing techniques to remove imperfections from images of the lunar surface sent back by the Ranger 7 spacecraft.[1] Digital enhancement also gave dramatic clarity to the famous closeup of Surveyor 7's footpad resting on the moon dust in 1968. Then the earth itself: since 1972 ERTS, Landsat, and Spot satellites have been transmitting

back an unceasing stream of multispectral digital images of our planet's changing surface.

Digital imaging systems were crucial to the great Voyager and Magellan missions. In 1979 the information sent back by Voyager 1 was processed to produce astonishingly beautiful, brilliantly colored images of Jupiter and its moons. In 1989 Voyager 2 transmitted digital images of Neptune from a distance of over 2.5 billion miles, and in 1991–92 nearly three trillion bits of data produced by radar scans from the Magellan spacecraft were processed to construct close-up panoramic views of mountainous landscapes on Venus (figure 2.1). As the digital images have streamed back from remote reaches of the solar system, we have gazed in wonder at incomprehensively distant, unexplored worlds of fire and ice and emptiness.

Scientists soon realized that sensors of many different kinds could be combined with computer image-processing technology to yield specialized imaging systems with powers far beyond those of the unaided human eye. Infrared satellite scans could be processed to distinguish lost ruins from surrounding jungle, for example, and radar scans could penetrate desert sand. In the 1980s archaeologists searching the Arabian Peninsula for the lost city of Ubar—as, a century before, Heinrich Schliemann had sought the remains of Troy at the tell of Hisarlik—surveyed the terrain with an imaging radar system carried on the space shuttle, then computer processed the resulting digital images to reveal faint traces of ancient caravan routes.[2] These converged on the well of Ash Shisar near the Qara mountains and then disappeared beneath a sand dune. Ground reconnaissance in 1990 turned up artifacts suggesting that the tracks had been part of the frankincense trade route, and subsequent excavations uncovered an octagonal eight-towered city—probably, indeed, that "imitation of Paradise" whose destruction had been chronicled in the *Arabian Nights*. A NASA geologist forgivably bragged, "Ubar could not have been found without radar and space imagery."[3]

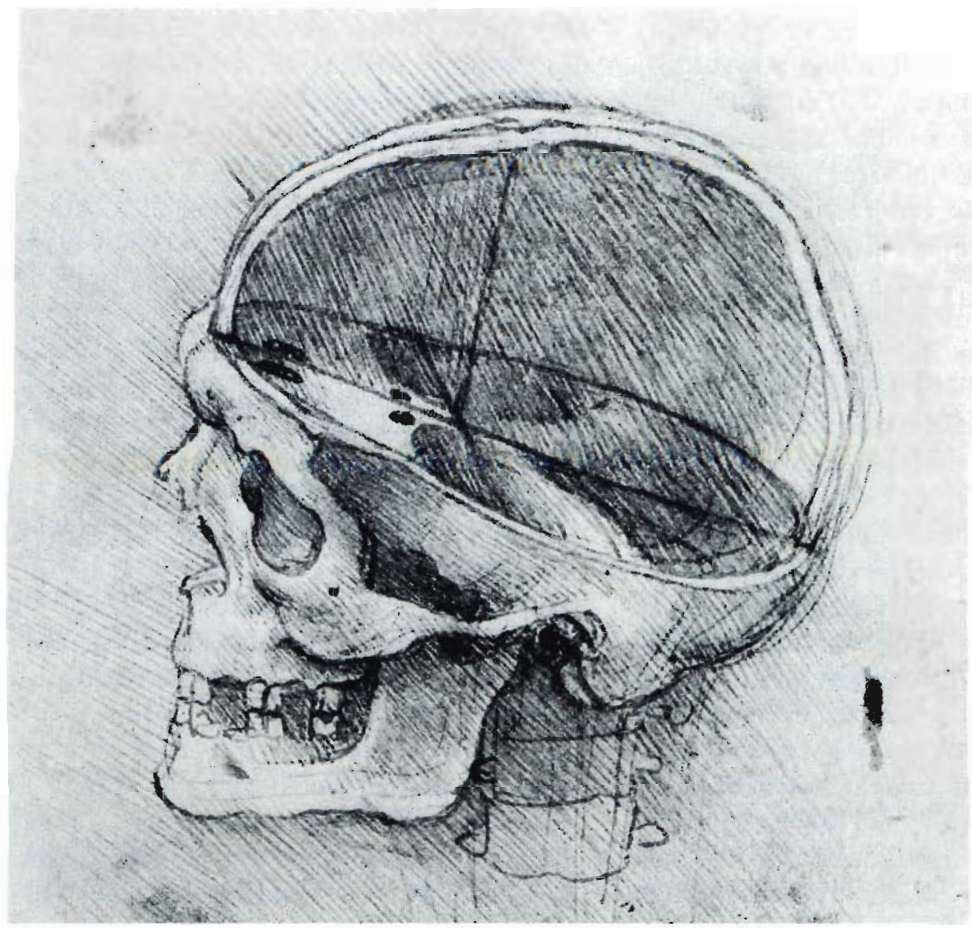
To produce highly magnified images of Lilliputian landscapes that were invisible to the naked eye, both Louis Daguerre and Fox Talbot took photographs through solar microscopes. In the 1970s and 1980s scientists developed new devices for measuring the most minute surface variations and employed computer imaging systems to convert the resulting data into breathtaking perspective views. At IBM's Zurich Research Laboratory, Gerd Binnig and Heinrich Rohrer developed the scanning tunneling microscope and used it to produce the first pictures of atoms forming the surface of silicon.[4] Other scientists joined the hunt and soon captured atomic-resolution images of gallium arsenide, platinum, graphite, benzene, and DNA. And several more varieties of scanning probe microscopes—the atomic force microscope, the friction force microscope, the magnetic force microscope, to name only a few—have emerged in rapid succession.[5] Sharp, detailed pictures of atoms and molecules no longer seem surprising.

Leonardo da Vinci and his Enlightenment successors dissected cadavers to explore the organic complexities concealed within the human body (figure 2.2). Wilhelm Roentgen took the first step toward modern medical imaging when he found a way to photograph the living body as if it were partially transparent. With the development of sophisticated electronic imaging systems—X-ray computed tomography (CT), ultrasound, positron emission tomography (PET), single photon emission computed

tomography (SPECT), and magnetic resonance imaging (MRI) scanners—it is now possible to capture detailed, point-by-point, three-dimensional digital models of human anatomy.[6] These models can be processed by computer to yield highly resolved, vivid, colored images of the body from whatever viewpoints are desired and with tissue sectioned or peeled away in whatever fashion is most revealing for a particular diagnostic or scientific purpose (figure 2.3).

The contemporaneous emergence of artificial-intelligence and neural-network technology has led to electronic realizations of the Cartesian connection between a visual sensor and an interpreting and directing intelligence—computer and robotic systems that analyze and act on the information contained in digital images. Increasingly sophisticated pattern-recognition and scene-analysis systems can now perform such tasks as reading printed and handwritten text, detecting flaws in manufactured products, discovering bombs in luggage, recognizing faces,[7] and enabling robots to see and navigate.[8] Architects employ such systems to convert old drawings into data manipulable at CAD workstations, and banks have even begun to use them for processing checks.[9] More threateningly, as Michel Foucault's texts on panopticism might lead us to expect, these systems have their uses in regimes of surveillance, discipline, and punishment: image-interpretation systems can be employed (with varying degrees of efficacy, according to the stages of development of the relevant artificial intelligence techniques) to monitor satellite imagery for signs of missile silo construction, to identify perpetrators by automatically matching fingerprints from the scenes of crimes to archived samples, and to track people's movements by reading automobile license plates that have been recorded by surveillance cameras and then matching the numbers to license database records. The electronic homunculi inside digital imaging systems have become busier and busier; automatic interpretation of the billions of bits of visual data acquired by these systems has become routine scientific, industrial, and business practice.

And the emergence of digital imaging technology has escalated and redefined the military uses of visual information. Just as World War I military technologists combined the camera and the airplane to produce a powerful new type of reconnaissance system, so Pentagon strategists quickly saw the potential of digital imaging and pressed it into service. By the time of the 1990–91 Gulf War, the American forces depended heavily on digital imaging systems for tactical information, defense contractors had extensively incorporated them into weapons systems, and military spin doctors had realized their propaganda potential. In this war, satellite imaging systems did much of the spying and scouting. Laser-guided bombs had nose-cone video cameras; pilots and tank commanders became cyborgs inseparable from elaborate visual prostheses that enabled them to see ghostly-green, digitally enhanced images of darkened battlefields. There was no Mathew Brady to show us the bodies on the ground, no Robert Capa to confront us with the human reality of a bullet through the head. Instead, the folks back home were fed carefully selected, electronically captured, sometimes digitally processed images of distant and impersonal destruction. Slaughter became a video game: death imitated art.[10]



2.2 Seeing beneath the skin: Leonardo da Vinci, studies of a sectioned human skull. Windsor Castle, Royal Library. © 1992 Her Majesty Queen Elizabeth II.

2.3 Medical imaging: an Instascan MRI image of a brain responding to light simulation. Red and yellow patches show activation of the visual cortex. Courtesy John Belliveau, Massachusetts General Hospital, NMR Center.

News Photography Goes Digital

By the 1980s digital imaging technology had begun inexorably to permeate the communications industry. Television engineers were using it to achieve better picture quality, and printers were employing it for retouching, halftoning, color correcting, and color separating photographs.[11] Use of color electronic prepress systems, in particular, grew explosively in the advertising and publishing industries: in 1989—photography's sesquicentennial year—the *Wall Street Journal* estimated that ten percent of all color photographs published in the United States were being digitally retouched or altered.[12]

As use of the technology gathered momentum, the concept of image "correction" became increasingly elastic. The official photographs of Australia's new Parliament House were undetectably computer enhanced by the addition of a fluttering flag; there was no wind on the day the photographs were taken. The London *Guardian* smirkingly revealed, in an article headlined "Computers make a clean breast . . . or do they?," that the British press had discovered yet another way to exploit photographed female flesh: a cover model's indecorous nipple had been electronically replaced by "lighter flesh tones from elsewhere."[13] The editor of *Mayfair* magazine breathlessly extrapolated, "You could have a color photo of a girl playing at Wimbledon and you could quite literally take her knickers off"—an inexpensive variant on that publication's more usual practice of *paying* young women to take their knickers off. And the editors of *National Geographic* (similarly pursuing a conception of pictorial interest appropriate to *their* readership) published a cover picture in which two of the pyramids at Giza were "retroactively repositioned" (as an editor later put it)—surreptitiously pushed a few picas closer together to make a more picturesquely exotic composition.[14] Was this any more (or less) manipulative than making sure that a passing camel train positioned itself in just the right spot *before* the exposure was made? Photojournalists and press critics debated this question.

Naive enthusiasm for the almost magical possibilities of this new electronic medium soon gave way to alarm. It was a short step, we began to realize, from innocuous enhancement or retouching to potentially misleading or even intentionally deceptive alteration of image content. And that step would put us on a slippery slope: the smug apartheid that we have maintained between the objective, scientific discourses of photography and the subjective, artistic discourses of the synthesized image seemed in danger of breaking down.

Increasingly, digital image manipulation was defined as a transgressive practice, a deviation from the established regime of photographic truth. Press photographers scented a cybernetic dystopia in the making—a world infested with subversive, uncontrollable image hackers who would appropriate photographic fragments at will and recombine them into fictions. They initiated annual conferences to explore the implications of digital imaging technology,[15] and the president of the National Press Photographer's Association gave voice to their growing alarm: "Photographers, editors and publishers need to speak out unequivocally and say 'NO!' to the abuses that can and will creep into newsrooms as the use of digital photo technology becomes widespread. . . . We cannot use this technology to create lies, no matter how tempting or easy."[16] One uneasy photojournalist, quoted by *American Photographer* maga-

zine, anticipated a new division of labor: "If we don't take hold of this technology we'll become clip-art specialists, feeding images to the art department like robots."[17] And the photography critic of *The New York Times* predicted an eventual derealization of the photographed world:

> In the future, readers of newspapers and magazines will probably view news pictures more as illustrations than as reportage, since they will be well aware that they can no longer distinguish between a genuine image and one that has been manipulated. Even if news photographers and editors resist the temptations of electronic manipulation, as they are likely to do, the credibility of all reproduced images will be diminished by a climate of reduced expectations. In short, photographs will not seem as real as they once did.[18]

The species of deception that has aroused such apprehension is not that practiced by Zeuxis, who, as the legend has it, painted grapes so realistically that birds pecked at them.[19] Digital manipulation of photographs does not obliterate the distinction between depictions and their objects, but (characteristically of our age) blurs the boundary between two kinds of depictions—one of which has seemed to have special claims to veracity. We are faced not with conflation of signifier and signified, but with a new uncertainty about the status and interpretation of the visual signifier.

At the end of the 1980s there was an accelerating crisis of the image. André Bazin had once called the development of photography "clearly the most important event in the history of plastic arts" because, he argued in a well-known passage, it allowed us to "admire the painting as a thing in itself whose relation to something in nature has ceased to be the justification for its existence."[20] But, at the very moment when photography's 150th anniversary was being celebrated with elaborate exhibits and retrospective surveys and when critical commentaries were endlessly asseverating the causal rather than intentional character of the photographic process, the relation of the photograph itself to "something in nature" was becoming problematic.[21] We were forced to question whether we could still demand from the photographer, as Doctor Johnson did of playwrights, "a just picture of a real original." Could we still ask, like Lieutenant Joe Friday, for "just the facts?"

Popularization

Early technology for digitally capturing and processing images was expensive, difficult to use, and inaccessible: it provided the means for pictorial deception but not widespread opportunity for it. The end of the 1980s, though, saw a pivotal moment much like that of a century earlier, when George Eastman had popularized photography by introducing his Kodak box camera together with a photofinishing service: the burgeoning technology of digital imaging suddenly spawned a mass medium. (This did not result from some unexpected, breakthrough invention, but from the confluence of several hitherto parallel strands of technical development.) A whole new genus of gadgets evolved.

First came dramatic changes in image-capture devices. The Canon, Nikon, and Sony companies, for example, began to market compact, high-quality, still-video cameras that recorded images directly on miniature floppy

disks and so provided a practical alternative to the use of silver-based photographic film—much as video cameras and videotape had earlier substituted for home movie cameras and 8-mm or 16-mm film.[22] Initially there were costly models intended for professional and industrial use, but by the late 1980s lightweight point-and-shoot versions aimed at the consumer market—such as the Canon Xapshot—were beginning to appear.

Still-video cameras, however, record information in analog format, and it must be converted to digital format for computer processing. This conversion step is eliminated in digital camera systems, which directly record images in digital format on magnetic disk or credit-card-sized magnetic memory cards. Early models—such as the Rollei Digital ScanBack,[23] Fujix Digital Still Camera,[24] and the Kodak Professional DCS[25]—became available in the late 1980s and early 1990s. By 1991 inexpensive point-and-shoot versions such as the Logitech Fotoman, with associated image-processing software for personal computers, were coming onto the market.[26] With the appearance of digital camera systems the distinction between photography and computer graphics completely dissolved. Space-shuttle astronauts began to carry digital cameras on their missions and to use laptop computers for immediate image processing.[27]

At about the same time, a new generation ,of personal computers began to offer the processing power, memory, disk storage, and graphic-display capabilities needed for image-processing work. Recognizing a growth market, software developers and publishers produced a widening repertoire of paint and image-processing systems for personal computers. This software soon became astonishingly sophisticated—making widely available, at low cost, capabilities hitherto accessible only to scientists working with laboratory image-processing systems or graphics professionals working with advanced digital prepress systems.[28] By 1992 personal computers could handle not only storage, manipulation, and display of digital still images, but also storage, editing, and playback of digital video.[29]

Compact disc (CD) technology—introduced in 1983 as a digital sound-recording medium—emerged as an inexpensive way to store large numbers of images. In September 1990 Kodak connected the camera and the CD by announcing a system called Photo CD, which would allow photofinishers to return not only negatives and prints, but also CDs containing images that could be displayed on television sets equipped with special players.[30] (It was shown for the first time at the Consumer Electronics Show in January 1992.) Photo CD also provides storage and playback capability for images from still-video and digital cameras. In 1991 Philips introduced an interactive CD system for home use: among the first interactive CDs released for play on this device was one on photographic technique, with a camera simulator that allowed the viewer to "shoot" pictures and immediately see the effect of decisions about exposure and focus.[31] With the CD as a medium in common, distinctions between still photography, video, computer games, and music-reproduction systems began to erode.

Finally, copier technology began to switch from analog to digital format. First, laser scanners for capturing images from existing slides and photographs, which had been hugely expensive devices confined to use in large printing and publishing establishments, became popular peripherals for personal computers. These could be combined with personal computers and laser printers or imagesetters to cre

ate systems for image capture, transformation, and output. Then in 1991 the Canon company of Japan began marketing the Pixel Epo digital color copier, which integrated all these functions and brought them into everyday work environments. In the United States, Xerox and Kodak also introduced sophisticated digital copiers.

The result was that the means to capture, process, display, and print photograph-like digital images—which had hitherto been available in only a few, specialized scientific laboratories and print shops—now fell within reach of a wide community of artists, photographers, and designers. Concern about the potential social, economic, and cultural effects of the technology reached a crescendo. As photography's 150th anniversary was celebrated, the National Press Photographers Association was calling for a code of ethics to regulate digital image manipulation,[32] the Associated Press was adopting a policy that "the content of a photograph will never be changed or manipulated in any way," and the Norwegian Press Association was proposing that an international standard warning symbol should be inserted into any manipulated photograph.[33] In Hollywood the nonprofit Artists Rights Foundation was established to protect films from electronic and other forms of tampering, and in Washington Congress considered the Film Disclosure Act of 1991, which would require producers and broadcasters to label alterations to filmed work.[34] But it was too late: opportunity to create undetectably altered digital images was no longer centralized, and (for good or ill) there was no longer any practical way of imposing institutional control on their production.

In addition to means and opportunity, there are economic motives for displacing traditional photography. Our world has developed such a voracious appetite for information in visual form,[35] and the digital image has such overwhelming technical and economic advantages as a way of meeting this demand, that it seems certain to succeed the photograph as our primary medium of visual record—much as the photograph itself succeeded the hand-drawn and painted image.[36] Unlike silver-based photographic film the digital image does not consume scarce, nonrenewable resources. It does not require a time-consuming and expensive chemical development process. It can be stored compactly, accessed by computer, manipulated freely, and transmitted to remote locations within seconds of creation. And, by virtue of its inherent manipulability, it always presents a temptation to duplicity. So the inventory of comfortably trustworthy photographs that has formed our understanding of the world for so long seems destined to be overwhelmed by a flood of digital images of much less certain status.

In his prophetic novel *1984* George Orwell imagined a sinister Records Department containing "elaborately equipped studios for the faking of photographs." What really happened in the 1980s was that elaborately equipped studios became unnecessary. It became possible for anybody with a personal computer to fake photographs.

The Displacement of Photography

Sometimes it is argued (usually by radical historians or theorists) that technical innovation results from irresistible social pressure—that, for example, "the year of Daguerre's invention, as in every important invention, meant nothing but the moment when the acquired knowledge had become so convincing and the need of realizing this invention so pressing that it could

no longer be delayed by any difficulties or obstacles."[37] On this view, it is hardly surprising that chemical photography made its appearance in the century of realism and self-confident positivism—of Dickens and Flaubert, of Courbet and Millet, of Comte and John Stuart Mill.

Symmetrically, it can be proposed (typically by commentators of more positivistic and conservative outlook) that technical innovations emerge autonomously and create new social and cultural potentials. Erwin Panofsky, for example, began his well-known essay on film with the remark, "It was not an artistic urge that gave rise to the discovery and gradual perfection of a new technique; it was a technical invention that gave rise to the discovery and gradual perfection of a new art."[38]

Either way, we can identify certain historical moments at which the sudden crystallization of a new technology (such as printing, photography, or computing) provides the nucleus for new forms of social and cultural practice and marks the beginning of a new era of artistic exploration. The end of the 1830s—the moment of Daguerre and Fox Talbot—was one of these. And the opening of the 1990s will be remembered as another—the time at which the computer-processed digital image began to supersede the image fixed on silver-based photographic emulsion.

Thus late in the century of Joyce and Borges, of cubism and surrealism, of Wittgenstein's loss of faith in logical positivism and of post-structuralism's gonzo metaphysics, the production of reproduction was again redefined. From the moment of its sesquicentennial in 1989 photography was dead—or, more precisely, radically and permanently displaced—as was painting 150 years before.


LIBYAN MIG-23 FLOGGER
AA-7 APEX
AA-8 APHID
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INTENTION AND ARTIFICE

Claims to Credibility

Photography's sesquicentennial year opened, fittingly enough, with an international drama turning on the credibility of photographs as evidence—on a claim that the camera does not lie. On January 4, 1989, US Navy fighters shot down two Libyan MiG-23s over the Mediterranean near the Libyan coast.[1] Libya denounced the action and called for an emergency session of the United Nations Security Council to condemn it. Ali Sunni Muntasser, Libya's UN ambassador, said that the planes were unarmed reconnaissance craft on a routine mission. A US spokesman challenged that assertion and noted, "We have the pictures to prove they were not unarmed," which means, he added, that "the Libyan ambassador to the UN is a liar." The Libyan diplomat responded in kind: "The man who said that I am a liar, he is a liar, because we are sure that our planes were not armed." Later, US Ambassador Vernon Walters exhibited blurred photographs of what he claimed was one of the MiGs visibly armed with air-to-air missiles (figure 3.1). "Do you think this is a bouquet of roses hanging under the wing?" he demanded. Libyan Ambassador Muntasser immediately suggested that the photographs were doctored. "It is completely fake," he protested, "It is untrue!" The pictures were "fabricated," they were "directed in the Hollywood manner."[2]

This cynical and loutish dialogue reveals very little about what actually took place off the Libyan coast that January day, but it does

3.1 Photographs used as evidence: US Ambassador Vernon Walters, at the United Nations Security Council on January 6, 1989, exhibits a blurred picture to support his claim that a Libyan MiG-23 shot down by US fighters had been armed. Fred R. Conrad/NYT Pictures.

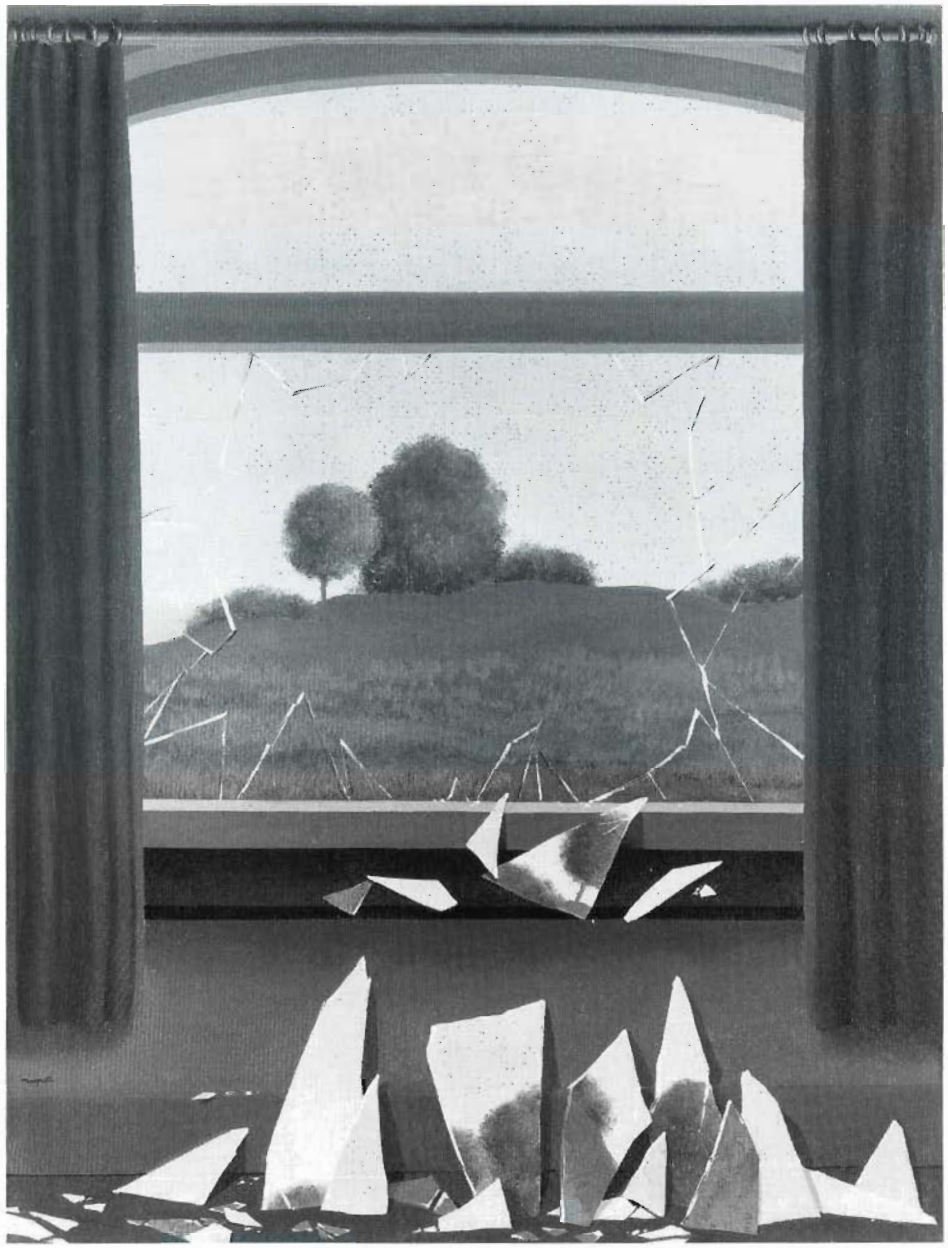
demonstrate the extraordinary tenacity of the camera's claims to credibility: as Susan Sontag has put it, "A photograph passes for incontrovertible proof that a given thing happened." Ambassador Walters could urge with a straight face that "you can see for yourself whether there were or were not missiles," even though his photographs were barely decipherable as images of aircraft and showed no detail at all. Aware, like all of us, of the powerful presumption that a photograph shows something that *did* exist, Ambassador Muntasser chose not to dismiss the photographs as simply meaningless. Instead, he made the more damning suggestion that they were false evidence—fabrications produced to deceive the gullible by trading on the photograph's privileged connection to reality. This suggestion is by no means technically implausible: anybody with access to some pictures of aircraft, an image-capture device, and a personal computer with inexpensive image-processing software could produce this sort of image in a few minutes.

The play of claim and accusation over the Libyan fighter incident recalls the cogent symmetries of Aristotle's definition of truth—to say of what is that it is, or to say of what is not that it is not, is the truth; but to say of what is not that it is, or to say of what is that it is not, is falsehood—and raises some urgent questions. How is it that photographs seem to say of what is that it is? What is the foundation for their undeniably powerful implicit truth claims? When should we be wary of these? Exactly how are these claims subverted by the emergence of digital imaging? Must we now, like jesting Pilate, throw up our hands? Not surprisingly, as we shall see, the most useful answers turn out to be intimately bound up with different philosophical doctrines about the nature of meaning and truth.

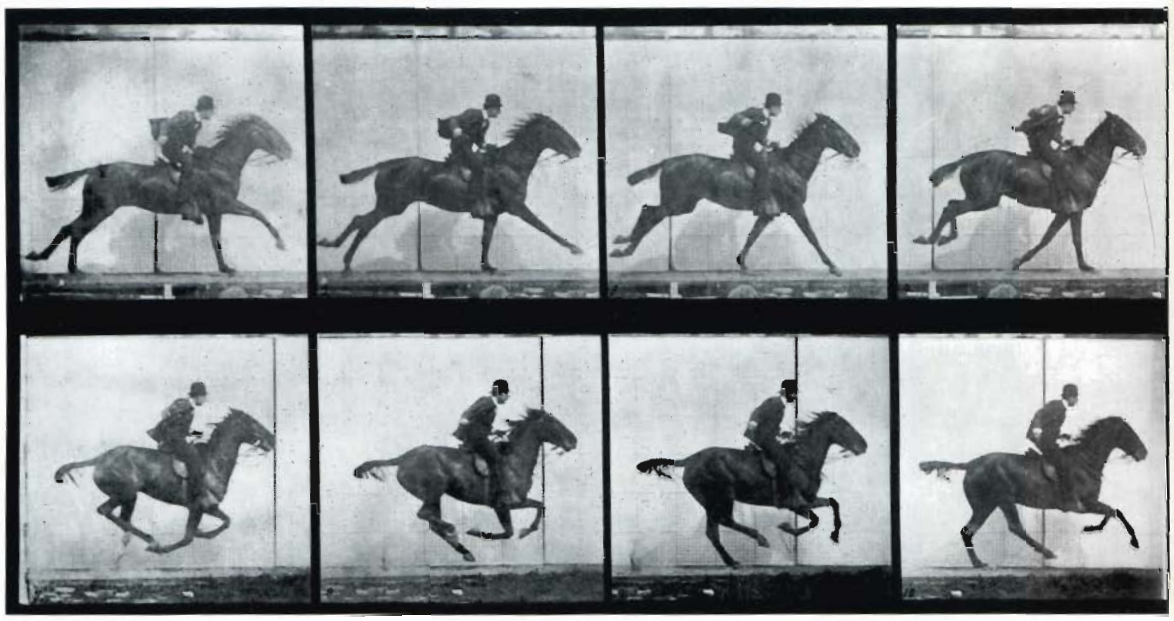
Adherence of the Referent

For these questions to become meaningful we must assume, first of all, that a photograph depicts something, that it is not just an abstract pattern resulting from a chemical reaction. Whether photographs depict through resemblance (as suggested, for example, by James J. Gibson) or through the action of a denotative symbol system (as vigorously argued by Nelson Goodman) is an interesting and vexed question, but one that need not detain us here.[3] One way or another, a photograph provides evidence about a scene, about the way things were, and most of us have a strong intuitive feeling that it provides better evidence than any other kind of picture. We feel that the evidence it presents *corresponds* in some strong sense to reality, and (in accordance with the correspondence theory of truth) that it is true because it does so.[4]

A photograph is fossilized light, and its aura of superior evidential efficacy has frequently been ascribed to the special bond between fugitive reality and permanent image that is formed at the instant of exposure. It is a direct physical imprint, like a fingerprint left at the scene of a crime or lipstick traces on your collar. The correspondence with reality is thus causally established. According to Sontag, "A photograph is not only an image (as a painting is an image), an interpretation of the real; it is also a trace, something directly stencilled off the real, like a footprint or a death mask."[5] The death-mask metaphor goes back (at least) to André Bazin's 1945 essay "The Ontology of the Photographic Image," in which he compares photographs to mummies and relics—objects that exhibit a "transference of reality from the thing to its reproduction"—and mischievously



3.2 The referent adheres: René Magritte, *La Clef des champs,* 1933. Thyssen-Bornemisza Collection, Lugano, Switzerland.

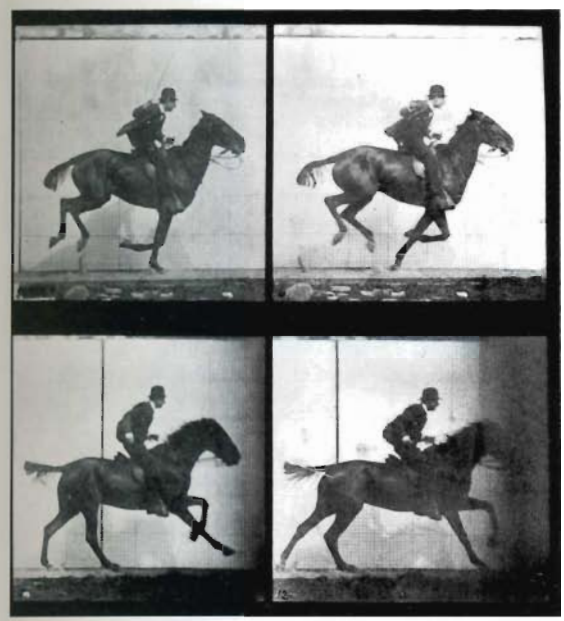


describes the Holy Shroud of Turin as a combination of relic and photograph.[6] In *Camera Lucida* Roland Barthes (perhaps recalling René Magritte; see figure 3.2) introduces another telling metaphor—that of the windowpane and the landscape—and claims that "the referent adheres."

In his brilliantly epigrammatic essay "Understanding a Photograph," the influential Marxist critic John Berger insists that the interest of a photograph depends *totally* on this tenacious adherence of the referent.[7] Photographs, as he defines them, are quite simply "records of things seen . . . no closer to works of art than cardiograms." They engage us because they result from some photographer's decision "that it is worth recording that this particular event or this particular object has been seen." Every photograph becomes "a means of testing, confirming and constructing a total view of reality."

This attitude has, no doubt, been reinforced by photography's successes in showing aspects of the physical world that would otherwise escape us, and sometimes in doing so exposing the errors of painting. Eadweard Muybridge's famous photographs of horses in motion, for example, showed that the "flying gallop" position depicted in many earlier paintings simply does not occur (figure 3.3). His sequences of instantaneous photographs, made at closely spaced intervals, provided the irrefutable evidence. As Aaron Scharf commented: "The meaning of the term 'truth to nature' lost its force: what was true could not always be seen, and what could be seen was not always true. Once again the photograph demonstrated that for many artists *truth* had really been another word for *convention*."[8]

After more than a century and a half of photographic production, we also have to contend



3.3 Photography exposes the errors of painting: Eadweard Muybridge, horse in motion. International Museum of Photography at George Eastman House, Rochester, New York.

with the powerful "reality effect" that the photographic image has by now constructed for itself. In his influential 1921 essay "On Realism in Art,"[9] Roman Jakobson sketched the mechanism by which certain types of images come to seem "natural" and more "faithful to reality" than others:

> The methods of projecting three-dimensional space onto a flat surface are established by convention; the use of color, the abstracting, the simplification, of the object depicted, and the choice of reproducible features are all based on convention. It is necessary to learn the conventional language of painting in order to "see" a picture, just as it is impossible to understand what is said without knowing the language. This conventional, traditional aspect of painting to a great extent conditions the very act of our visual perception. As tradition accumulates, the painted image becomes an ideogram, a formula, to which the object portrayed is linked by contiguity. Recognition becomes instantaneous. We no longer see a picture.

Extending this line of argument from painting to photography yields the seemingly paradoxical proposition that, since photographs are very strongly linked by contiguity to the objects they portray, we have come to regard them not as pictures but as formulae that metonymically evoke fragments of reality. Barthes has elucidated another, complementary aspect of the reality effect by pointing out that works of realistic art often incorporate seemingly functionless detail just "because it is there," to signal that "this is indeed an unfiltered sample of the real."[10] Since photographs are rich in such details, they always connote the real.

For all these (not necessarily consistent) reasons, then, the camera has commonly been

seen as an ideal Cartesian instrument—a device for use by observing subjects to record supremely accurate traces of the objects before them. It is supereye—a perceptual prosthesis that can stop action better than the human eye, resolve finer detail, remorselessly attend to the subtlest distinctions of intensity, and not leave unregistered anything in the field of its gaze. And photographs seem to bond image to referent with superglue.

Intention and Objectivity

Even more tellingly, we can also point to the fact that there is no human intervention in the process of creating the bond between photograph and reality, this apparent Kryptonite connection to the referent: it is automatic, physically determined, and therefore presumably objective. Photographs are thus connected to the ancient Judeo-Christian tradition of *acheiropoietoi*—"true" images of Christ made "not by human hand" (figure 3.4).[11] Furthermore, this automaticity accords splendidly with poststructuralist hostility to the idea of authorial control of meaning: photography can be seen as a kind of automatic writing.[12]

André Bazin—among many to tackle this theme of physical determination—crisply formulates the crucial difference from painting as follows:

> For the first time, between the originating object and its reproduction there intervenes only the instrumentality of a nonliving agent. For the first time an image of the world is formed automatically, without the creative intervention of man. The personality of the photographer enters into the proceedings only in his selection of the object to be photographed and by way of the purpose he has in mind.[13]

3.4 A "true" image of Christ: Francisco de Zurbarán, *The Veil of Veronica*. National Museum, Stockholm.

Such exclusion of human bias is the point of many standard scientific procedures, such as random sampling, double-blind clinical trials, and setting statistical significance levels before conducting experiments. It also motivates the "plain," ostensibly unrhetorical style of formal scientific discourse. The photographic procedure, like these scientific procedures, seems to provide a guaranteed way of overcoming subjectivity and getting at the real truth. Indeed, it has often been taken as the quintessential way, and writers who want to suggest neutral recording without the subjectivity introduced by human selection or organization often invoke

the image of the camera. Thus Christopher Isherwood memorably opens *Goodbye to Berlin*, "I am a camera with its shutter open, quite passive, recording, not thinking."[14]

This impersonal, objective neutrality has ontological implications. Isherwood's camera eye supposedly records real people in a real place, "the man shaving at the window opposite and the woman in the kimono washing her hair." The conservative philosopher Roger Scruton—wanting like the Marxist Berger to distinguish photography from fine art, but for different reasons—has usefully formulated this point by teasing out the differing intentional relations of the painter and the photographer to the objects that they depict:

> If a painting represents a subject, it does not follow that the subject exists nor, if it does exist, that the painting represents the subject as it is. Moreover, if x is a painting of a man, it does not follow that there is some *particular* man of which x is the painting. Furthermore, the painting stands in this intentional relation to its subject because of a representational act, the artist's act, and in characterizing the relation between a painting and its subject we are also describing the artist's intention. The successful realization of that intention lies in the creation of an appearance, an appearance which in some way leads the spectator to recognize the subject.[15]

But he makes this analysis of photography:

> A photograph is a photograph *of* something. But the relation here is causal and not intentional. In other words, if a photograph is a photograph of a subject, it follows that the subject exists, and if x is a photograph of a man, there is a particular man of whom x is the photograph. It also follows, though for different reasons, that the subject is, roughly, as it appears in the photograph. In characterizing the relation between the ideal photograph and its subject, one is characterizing not an intention but a causal process, and while there is, as a rule, an intentional act involved, this is not an essential part of the photographic relation. The ideal photograph also yields an appearance, but the appearance is not interesting as the realization of an intention but rather as a record of how an actual object looked.

In other words, the nonexistence of angels need not prevent you from painting a picture of one, but it certainly prevents you from taking a photograph of one. (We must make an exception to this general rule for convinced realists: recall Courbet's famous remark "Show me an angel and I will paint one."[16]) The existence of horses means that you can take a photograph of some particular horse, but it does not prevent a horse painting from showing no horse in particular. You cannot, however, take a photograph of no horse in particular. Thus the representational range of paintings is wider than that of photographs because a painter does not have to accept a causal relation between a depiction and the object to which it refers.

Scruton exaggerates the second part of his case by reducing the photographer's intentional acts to inessentials. Selecting a station point, framing the scene, and choosing the moment to expose are all intentional acts—the essence, for example, of Henri Cartier-Bresson's photographic art. This is demonstrated by the fact that photographers are sometimes accused of deliberate deception through tendentious framing or selection of moment to expose. (The

documentary photographer Lewis Hine remarked that, "while photographs may not lie, liars may photograph."[17]) Many serious photographers (though not amateurs who use autoexposure, autofocus, point-and-shoot cameras) also regard manipulation of exposure and focus variables as important means of realizing their intentions. And in some views of photographic practice—as represented, for example, by Ansel Adams—the darkroom acts of development, enlarging, cropping, and printing are also taken as essential.

However, Scruton's distinction between intentional and causal components in image-production processes is helpful, particularly if we do not insist on a clearcut dividing line between paintings and photographs but think rather of a spectrum running from nonalgorithmic to algorithmic conditions—with ideal paintings at one end and ideal photographs at the other. A nonalgorithmic image, which is the product of many intentional acts, neither establishes that the object depicted exists nor (if that object does exist) provides much reliable evidence about it, but reveals a lot about what was in the artist's mind. An algorithmic image, which to a large extent is automatically constructed from some sort of data about the object and which therefore involves fewer or even no intentional acts, gives away much less about the artist but provides more trustworthy evidence of what was out there in front of the imaging system. In between, there are images that are algorithmic to a degree.

Freehand sketching, for example, is a mostly nonalgorithmic process: every freely made mark that the artist chooses to execute is the realization of an intention, and the result is usually something that has a strongly personal character. Prestige attaches to skillful and accurate work of this kind: not everybody can do it. But when an artist traces a form with the assistance of a stencil or physiognotrace, or a scene with the aid of a camera obscura (as Fox Talbot did on the shores of Lake Como), the process has a much more algorithmic character: there is little prestige to be had through accuracy.[18] And, when hand tracing is replaced by a highly standardized, automatic chemical process, there is almost no room left for the realization of intention.[19] So modern photography, as conceived of in the famous slogan "You press the button, we do the rest," stands near the algorithmic, depersonalized extreme of image-production processes.[20] As Sontag has said, "Photographs don't seem deeply beholden to the intentions of an artist . . . the magic box insures veracity and banishes error."

So, if you want to attack the veracity of a photograph (as did the Libyan ambassador), you can suggest that the standard procedure was *not* actually followed—for example, that some airbrushing was done or that the negative was flipped before printing.[21] (In a similar way, scientists may attack reported experimental results—such as those purporting to show cold fusion—by arguing that norms of scientific procedure were violated.) Conversely, if you want to defend its truthfulness, you can produce confirmation that the standard procedure *was* followed. You might produce the original negative to show that it had not been retouched or witnesses to attest that no deviation was introduced. Courts, passport authorities, and the users of clinical photographs often specify particularly detailed algorithms (leaving very little discretion to the photographer in choice of lens, lighting, framing, and so on) for production of photographs that will be acceptable as reliable evidence.[22] The United States Immigra-

tion and Naturalization Service, for example, requires identification photographs to be three-quarter color portraits with the right ear exposed (no earrings or hats), framed so that the head fits within an oval of strictly specified dimensions, made with a white background equal in reflectance to bond typing paper, sharply focused and correctly exposed, unretouched, printed on glossy paper at a standard size, and not stained, cracked, or mutilated. Snapshots that deviate in the slightest way from this specification are rejected, so the seedy photo studios that cluster around immigration offices set themselves up to produce the standard product and have a steady stream of clients.

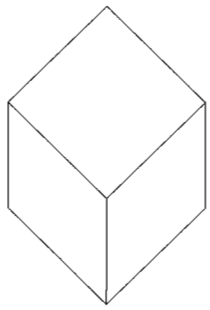
Digital imaging dramatically changes the rules of this game. It creates a condition in which the image maker may choose among many different devices and procedures for mapping from intensities in a scene to intensities in a display or print, in which image fragments from different sources may quickly and seamlessly be combined, and in which arbitrary interventions in the image-construction process are easy to introduce and difficult to detect. The distinction between the causal process of the camera and the intentional process of the artist can no longer be drawn so confidently and categorically. Potentially, a digital "photograph" stands at any point along the spectrum from algorithmic to intentional. The traditional origin narrative by which automatically captured shaded perspective images are made to seem causal things of nature rather than products of human artifice—recited in support of their various projects by Bazin, Barthes and Berger, Sontag and Scruton—no longer has the power to convince us. The referent has come unstuck.

Coherence

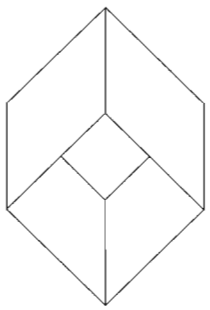
If we cannot find grounds to conclude that a given image *is* a true record of a real scene or event, we can take the opposite tack and attempt to demonstrate that it could *not* be a true record.[23] We can try, like a suspicious jury, to see whether the visual evidence that is presented really hangs together. We can look for inconsistencies—play a sophisticated game of "What's wrong with this picture?" This, then, grounds the analysis on some kind of coherence theory rather than a correspondence theory of truth—a move that will commend itself to those who want to remain uncommitted to the existence of a unitary extrapictorial reality.

We can start by trying to show that the visual evidence cannot yield any consistent, plausible interpretation as a perspective projection of illuminated three-dimensional objects. Let us consider, for example the simple image shown in figure 3.5a. We unhesitatingly interpret it as a view from above of a cube, with the Y shape in the center seen as a convex exterior corner. (We can debate whether interpretation of the Y shape as a convex corner helps us decide that the whole thing must be a cube or whether recognition of the whole thing as a cube tells us that the Y shape must be a convex corner. Either way, interpretation of the part must be consistent with interpretation of the whole.)

With equal certainty, we interpret the next image (figure 3.5b) as a view from below of a hollow cubic box. Notice, however, that the same Y shape appears in the center, but it is now seen as a concave interior corner. The same piece of visual evidence, seen in a different context, is interpreted very differently.



(a)



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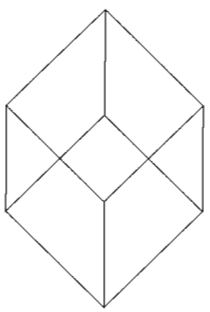


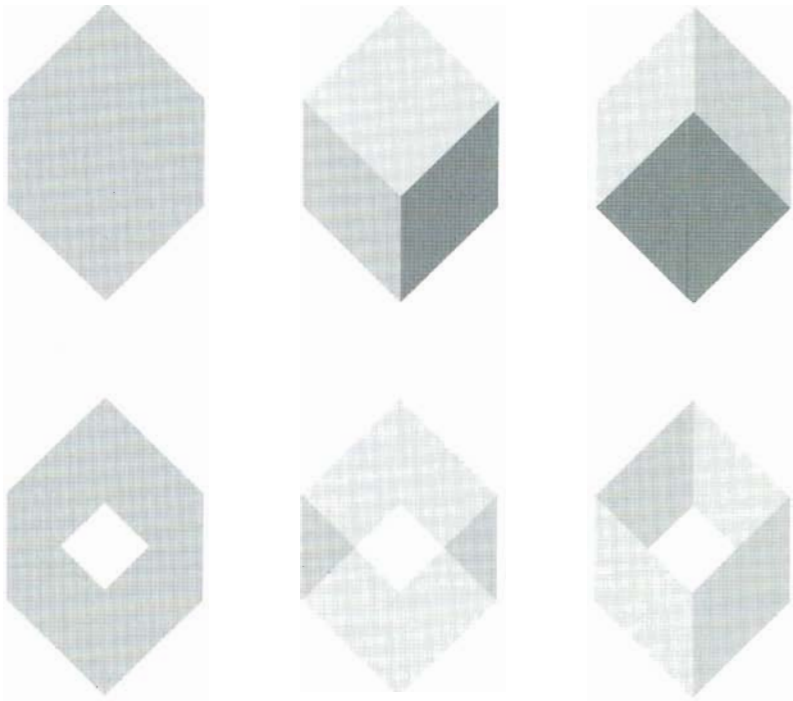
(c)

3.5 Line drawings of a cube.

a. Solid cube.

b. Hollow box.

c. Wireframe.



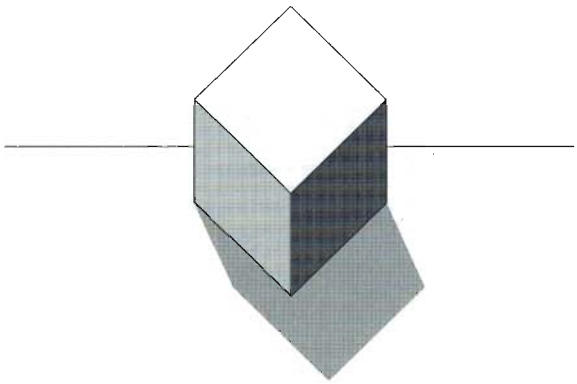
3.6 Shaded images of a cube.

The image in figure 3.5c has two consistent interpretations. We can see it as a wireframe cube from above or as a less plausible skewed object from below. The central Y shape is a convex corner in one interpretation and a concave corner in the other, but we cannot see it as simultaneously convex and concave. The context of the whole here allows two consistent interpretations of the part, and we use an assessment of relative likelihood to choose between them. (Most Westerners immediately plump for the interpretation of this figure as a cube and probably do not even consider the other. But someone from a culture less populated with right-angled objects might see it the other way.) Or, if we like, different interpretations of the part prompt different interpretations of the whole.

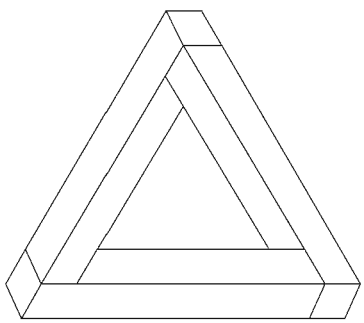
Figure 3.6 shows the image translated, in various ways, from line to tone. A painter might accomplish these translations by first constructing the outlines of the faces and then filling them in. Some of the translations read as two-dimensional patterns, some are teasingly difficult to interpret, and some vividly suggest a three-dimensional cube. Those that read three-dimensionally have a common formal characteristic: the shading is consistent with the foreshortening. More precisely, if we assume a consistent direction of incident light and diffuse reflection from the faces, we can expect that the intensity of a face will vary according to its orientation to the light; so intensity provides orientation information that we can use to assist in interpretation of foreshortened shapes. Conversely, if we interpret the skewed quadrilateral shapes in the image as perspective projections of square faces at different orientations to the picture plane, we can then read the shading as the result of consistent lighting. Either way, an interpretation suggested by one kind of visual evidence is confirmed by another. Such consistency still does not necessarily constrain us to a single interpretation, however; some shaded objects can be read as either concave or convex, depending upon our assumptions about lighting direction.

Figure 3.7 contains still more visual information: in addition to surface shading there is a cast shadow. The shape of the shadow is consistent with reading the faces as foreshortened squares, and the light source suggested by the direction of the shadow is consistent with that suggested by the variation of shading. The weight of all this consistent evidence makes it very difficult (though it remains a logical possibility) for us to read the presented pattern of shaded polygons as anything but a cube on a plane surface illuminated by a single source of light. (I do not exclude the possibility that somebody with very different cultural background and expectations might find some other reading equally compelling.)

The final image in this series (figure 3.8) is more insidiously constructed. It appears, at first glance, to show some kind of three-dimensional object, and we can find reasonable interpretations of vertices, lines, and polygonal faces that begin to confirm this conjecture. But if we look closely we can always find other visual evidence that does not fit the same interpretation. We must conclude that this is an impossible object—something that, contrary to first impressions, does *not* have a consistent three-dimensional interpretation.[24] The works of Maurits Escher often depend for their paradoxical effect on this sort of ambiguity in the visual evidence (figure 3.9).



3.7 Consistent foreshortening, shading, and cast shadow.

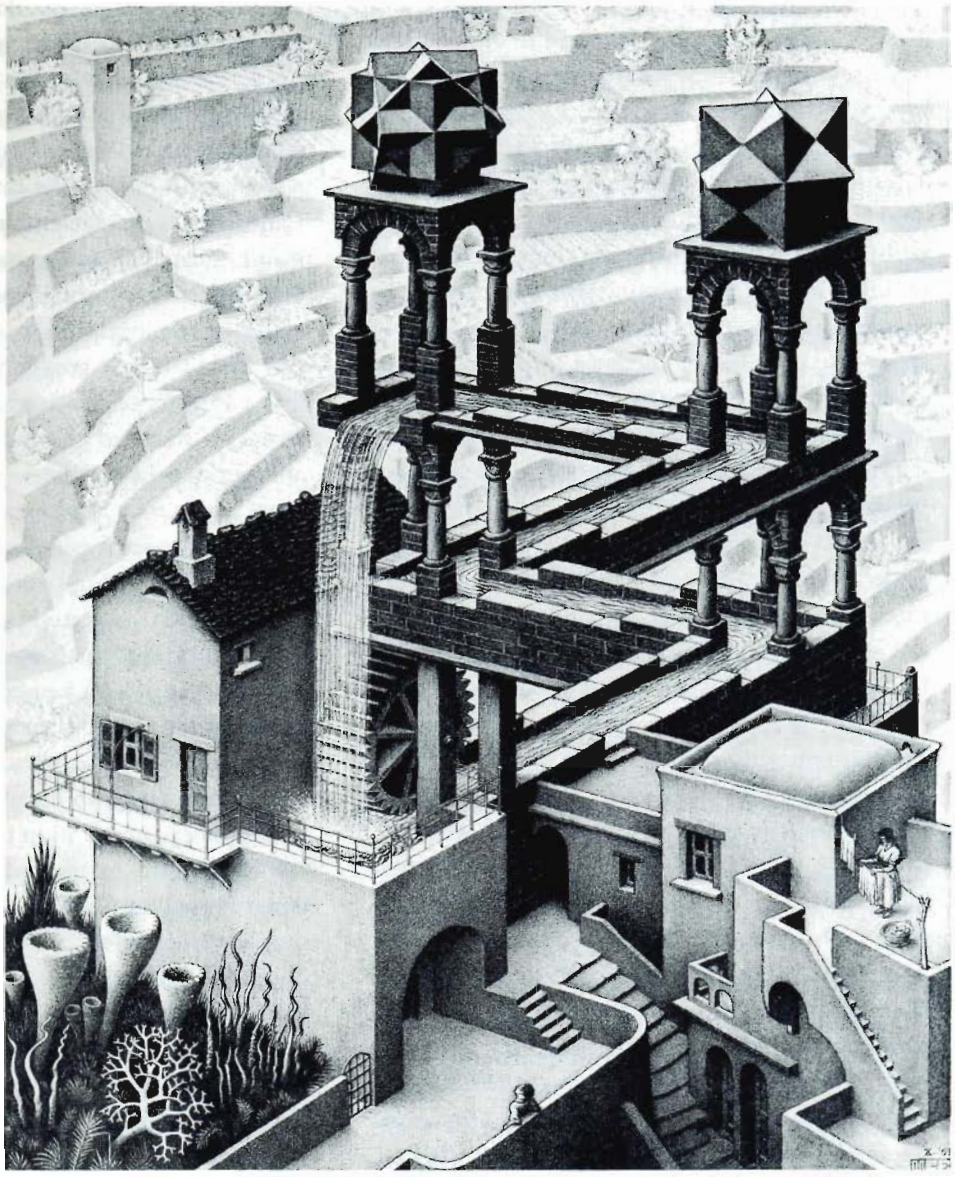


3.8 An impossible object: the Penrose triangle.

In forming interpretations of images, then, we use evidence of the parts to suggest possible interpretations of the whole, and we use the context of the whole to suggest possible interpretations of the parts. (Depending on your presuppositions, you can regard this process as high-flown Gadamerian hermeneutics or as mundane and fairly mechanical consistency checking programmable by an MIT undergraduate. It is, in fact, the basic process of many computer programs for scene interpretation.[25]) Some images turn out to have unique consistent interpretations, some like the Necker cube are ambiguous in the sense that they have multiple consistent interpretations, and some—while by no means meaningless—contain irreconcilable contradictions.

Photographs, unlike for example simple line diagrams, present rich arrays of visual evidence for us to interpret: shape and shading are registered with high precision. Furthermore (if the exposure was instantaneous) we know that they must be in essentially correct perspective projection and consistent light. So we can think of them as highly redundantly coded messages, like digital transmissions that incorporate redundancy for error-correction purposes. This redundancy gives them a ring of truth, since interpretations suggested in one way are usually confirmed in numerous other ways: no matter how we cut it, we find that the visual evidence always adds up to the same result.[26] The "layers" of visual information in a photograph are like independent witnesses that perfectly corroborate each other.

This unrelenting internal consistency also distinguishes photographs from handmade drawings and paintings, which, even when they adopt much the same conventions of perspective and shading, characteristically contain



3.9 The paradoxical effect of inconsistent visual evidence: M. C. Escher, *Waterfall,* 1961—a composition derived from the Penrose triangle. © M. C. Escher/Cordon Art, Baarn, Holland.

Rashomon-like ambiguities and inconsistencies. The resulting play among the visual codes of a drawing or painting yields more complex interpretations, and may even support ludic Derridean readings of the image against itself.[27] A painting may, for example, show different objects in a scene from different vantage points—but a photograph must depict them all within a single, fully consistent perspective space. And the spatial cues given by foreshortening and shading of surfaces in a photograph must be precisely consistent with each other, while this need not be so in a painting.

It follows that we can refute claims that an image is a photographic transcription of physical reality by cross-checking the visual evidence and identifying inconsistencies.[28] This requires a suspicious frame of mind: if we do not somehow expect inconsistencies, we are likely to overlook even quite blatant ones in our effort to make sense of what we see before us. Photographic manipulators do not necessarily have to do a very good job in order to fool us, at least initially. But if we are alerted we can ask, for example, whether the foreshortening, shading, and cast shadows are consistent with each other and with reasonable assumptions about viewpoint and lighting conditions? Do indicators of time, such as clocks and shadows, seem consistent with each other? When a viewpoint suggested by the weight of visual evidence is assumed, do objects seem to be in plausible scale relationships? Do some objects seem surprisingly light or dark in relation to their surroundings? Are inserted objects betrayed by lack of expected cast shadows or by shadows cast at angles different from those cast by other objects?[29] Do unexpected discontinuities in the background suggest that objects must have been deleted from the foreground? Are there shadows that do not seem to be cast by any object? Are shadows and specular highlights consistent with the same assumptions about locations of light sources? Do highly specular surfaces show mirror reflections consistent with our spatial interpretation of the scene?[30] Are modifications of surface and shadow intensities due to interreflection effects between surfaces consistent with our understanding of surface shapes and relationships? Are the scale and gradient of texture on a surface consistent with assumptions about the surface's size and orientation? Are geometric and aerial perspective consistent with each other? Is there a consistent gradient of sharpness from some focus plane? If there are *n* different types of visual evidence to consider, there will be *n*-squared interrelationships to cross-check for consistency, so this sort of forensic analysis can be elaborated almost endlessly. Often it will unmask as spurious an image that, at first glance, had readily passed as an authentic photograph.

The more information there is in an image, the harder it is to alter without introducing detectable inconsistencies: usually it is much quicker and easier to introduce undetectable changes into fuzzy, low-resolution, black-and-white images like that of the Libyan MiG than to do the same with sharp, high-resolution, full-color images. Furthermore, the difficulty of convincing alteration grows exponentially with the variety of types of visual evidence present. If an image shows only a silhouette, you have to give convincing shape to only the altered profile. But if there is differentiated surface shading, you also have to alter the distribution of shades to make this consistent with the new profile. If there are cast shadows, you must adjust them to maintain consistency with the ge-

ometry suggested by the new profile and shading, and so on. If you manipulate a stereo pair, you must very carefully coordinate the marks made on the left and right images; otherwise, when the images are viewed in a stereoscopic display, your marks will appear to "float" implausibly in space. A photographic manipulator, like a dissembler who weaves a tangled web of lies and eventually trips himself up, is likely to be caught by some subtle, overlooked inconsistency.

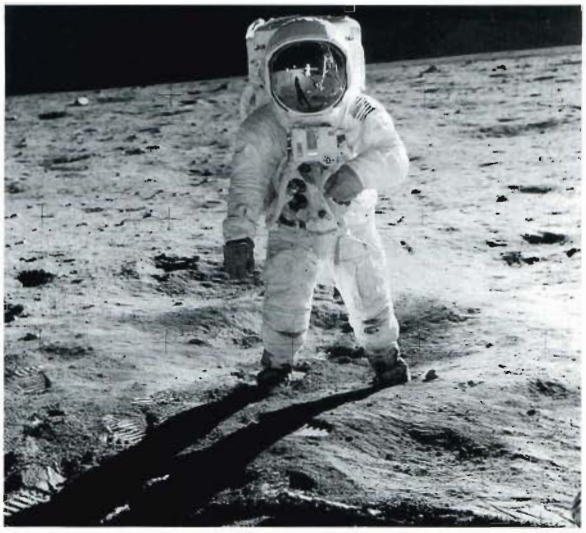
To illustrate the application of this principle of absolute coherence, let us examine the famous photograph that, the original caption claimed, was taken by the astronaut Neil Armstrong on July 20, 1969, and that shows fellow astronaut Edwin Aldrin walking on the surface of the moon (figure 3.10). The claim that man's first moon walk took place on this date, in the manner depicted, is extremely plausible, since the picture is sharp and clear—including a reflection of the photographer in Aldrin's visor—and since there are no detectable inconsistencies with the well-known facts of the first moon voyage. This picture convinced the world. Two decades later, in Fall 1989, *Time* magazine concluded a special issue on "150 Years of Photojournalism" with "a picture of something that never took place . . . produced on a computer screen." This picture, made from Armstrong's famous shot, shows seven space-suited astronauts apparently walking on the surface of the moon (figure 3.11). If we are at first persuaded to believe this evidence of our eyes, we can quickly be dissuaded by considerations of internal coherence: it is easy to miss at a casual glance, but close examination reveals an inconsistency in the reflections. Each visor shows the image of just one other astronaut, not the several that we would expect.

Relationship to Visual Discourses

If an image seems internally coherent, we can then ask whether the facts it purports to present are plausible—whether they seem consistent with other facts that, independently of the image in question, we believe to be true. (This is a procedure that has been given considerable attention, in a different context, by philosophers of history.[31]) The approach is nicely suggested by William Hogarth's famous satire on the incompetent perspectivist (figure 3.12). We can read this well enough as a depiction of a three-dimensional scene, but we laugh because doing so forces us to accept some implausible and amusing assumptions about the size and orientation of figures, architectural elements, fishing rods, and so on.

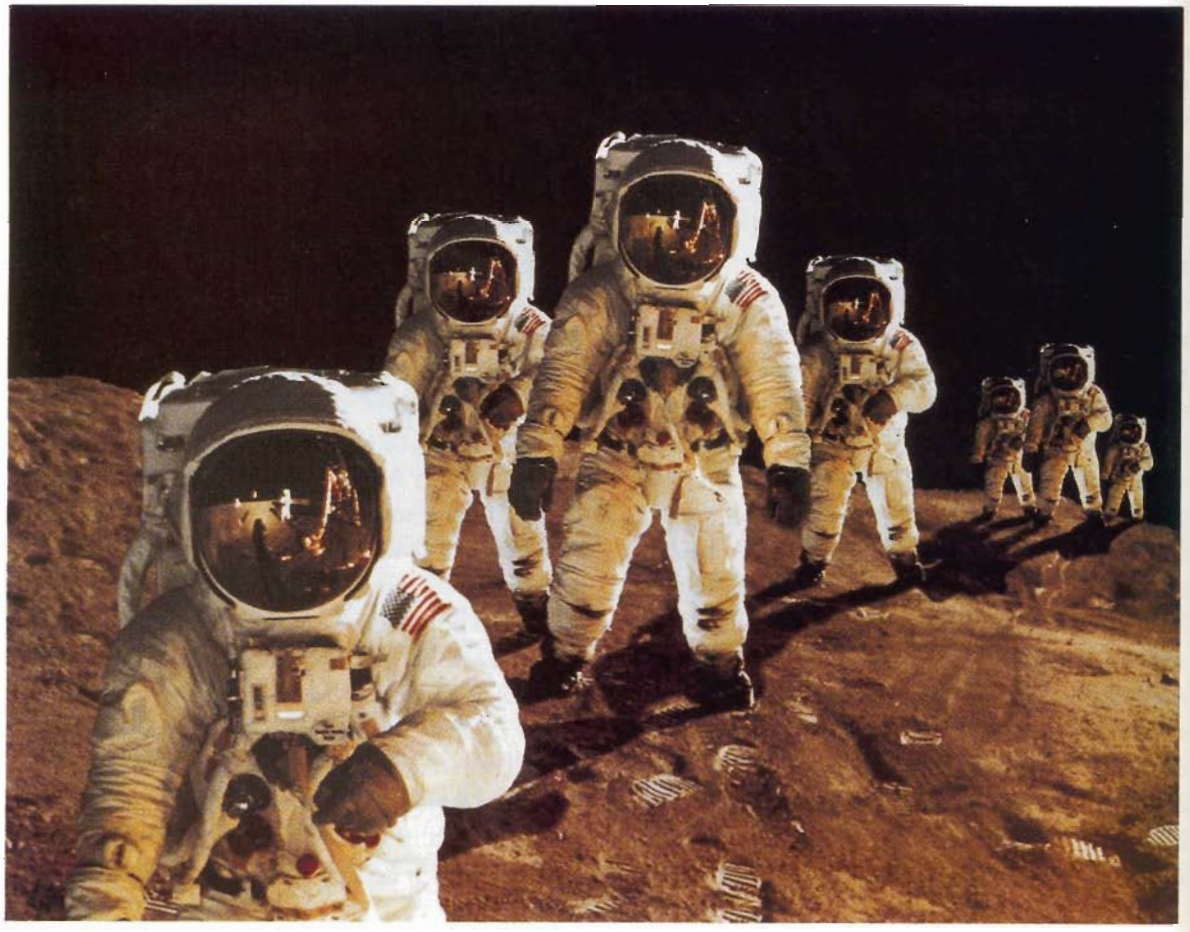
Our capacity to evaluate plausibility is not, however, conferred simply by built-in common sense. It is—as discourse theorists of various stamps will be quick to argue—constructed by our positioning within discourses (which direct our attention and set boundaries on what counts as evidence and knowledge) and constrained by limits on our stores of relevant facts. One person's vivid, compelling, important piece of visual evidence may be another's factoid, irrelevant fragment of trivia, misleadingly constructed propaganda, or aberrant result of observational error. Plausibility is relative to an ideological framework and an existing knowledge structure.

Consider, for example, the reception of spacecraft images. When we first saw pictures of the far side of the moon—something on which humankind had never set eyes before—we could cross-check them only against what we knew of the front of the moon: there was nothing else to compare them with. And when



3.10 Astronaut Edwin F. Aldrin, Jr., on the moon, July 20, 1969. Courtesy NASA.

3.11 Seven astronauts on the moon. Manipulated image created by MarLo Bailey on the Quantel Graphic Paintbox at HBO Studio Productions, New York, New York, for *Time* magazine special issue "150 Years of Photojournalism." Original photography supplied by NASA.



3.12 Implausible assumptions required to make sense of a picture: William Hogarth's *Perspectival Absurdities,* from Joshua Kirby's *Dr. Brook Taylor's Method of Perspective Made Easy in Both Theory and Practice,* 1754. Courtesy Yale Center for British Art, New Haven.

close-up photographs of the rocky surface of Mars were first published in 1976, we simply *had* to believe them: since none of us had ever been close to the surface of Mars, we had virtually no relevant knowledge against which to cross-check them. At best, we could make comparisons with barren, rocky deserts on Earth.

A clever deceiver can take advantage of such ignorance. For example, after the Chernobyl nuclear power plant explosion, a video clip of an Italian cement factory was passed off to American television networks (NBC and ABC) as being footage of the damaged reactor.[32] The images initially seemed plausible enough, since few people had any idea of what a Soviet nuclear reactor might look like. Similarly, when a 4,000-year-old mummy was discovered in an Alpine glacier in 1991, an Austrian newspaper published what it claimed to be a CAT scan of the mummy's brain—demonstrating, according to the accompanying article, that this prehistoric man had been epileptic.[33] This was a fairly safe ploy: expertise in the interpretation of CAT scans of mummies is not widespread. But the image was later shown to be that of the thorax of an unmummified twentieth-century man, published upside down.

An image which is proffered to support a surprising or extravagant claim, but which presents few confirmable specifics, invites suspicion. This difficulty arises with the photographs that Robert E. Peary produced to support the controversial claim that his expedition reached the North Pole on April 6, 1909. They merely show team members in a featureless landscape of ice hillocks and might have been taken anywhere in the snowy wilderness (figure 3.13). But we do know with certainty one fact about the Pole at the moment at which Peary claimed to have exposed the film—the altitude of the sun—and we can check the cast shadows in the photographs for consistency with this. The National Geographic Society has analyzed the shadow angles and has concluded that they are indeed consistent with Peary's claim.[34] Skeptics, however, suggest that the margin of error in measurements of shadow angles is sufficiently great to make them worthless as confirming evidence.

Sometimes the visual evidence presented by an image supports alternative assertions, and we must decide which is the more plausible. Where the propaganda value of an image is at stake, the issue may become hotly contested. Consider, for instance, the famous photograph by Robert Capa shown in figure 3.14. It was published in *Vu* in 1936, then in *Life* in 1937 with the caption "Robert Capa's camera catches a Spanish soldier the instant he is dropped by a bullet through the head in front of Cordoba." The visual evidence seems consistent with belief that this the caption is truthful. But Phillip Knightley has pointed out, in *The First Casualty,* that the evidence would be equally consistent with a different and much less affecting caption, such as "A militiaman slips and falls while training for action."[35] In evaluating the truth of this photograph we need to ask not only whether the visual evidence that it presents supports the caption, but also whether the caption can more plausibly be reconciled with the facts, as we know them, of Robert Capa's career and of the Spanish Civil War than with the less dramatic alternative.

Knightley carried out an investigation of this issue. He asked first about the circumstances in which the picture was taken. When and where did Capa take it? Who is the man? Since the terrain is unspecific and the face is blurred, the

3.13 Shadow angles may indicate the time and place of a photograph: Admiral Peary at the North Pole. Photograph by Robert E. Peary. © National Geographic Society.

3.14 Contested captions: "Robert Capa's camera catches a Spanish soldier the instant he is dropped by a bullet through the head in front of Cordoba" or "A militiaman slips and falls while training for action." Robert Capa, Spanish Civil War photograph, September 5, 1936. © Robert Capa/Magnum Photos, Inc.

image itself does not provide many clues. Knightley talked to Cornell Capa (the photographer's brother) and to professional associates such as Cartier-Bresson; none of them was able to provide specific details. Finally, he concluded that the photograph "turns out to be not the clear and simple statement of fact that it at first sight appears."

Other famous war photographs have been subjected to the same sort of scrutiny. Alexander Gardner's image of a dead "rebel sharpshooter" at the Battle of Gettysburg (figure 3.15) was shown to have been staged: a dead body, which had earlier been photographed elsewhere as that of a "Union sharpshooter," was dragged into the scene and arranged as in a still life.[36] Joe Rosenthal's shot of four marines planting the flag at Iwo Jima (figure 3.16) has seemed implausible to many observers because it is so rhetorically charged that it looks as if it *must* have been posed—and indeed this turns out to have been the case.[37] It is histrionics, not history. Seeking to reduce the impact of Huynh Cong Ut's picture of a terrified, naked little girl fleeing from a napalm attack in Vietnam (figure 3.17), General William Westmoreland cynically proposed that her burns were caused by "a hibachi accident."[38]

In general, if an image follows the conventions of photography and seems internally coherent, if the visual evidence that it presents supports the caption, and if we can confirm that this visual evidence is consistent with other things that we accept as knowledge within the framework of the relevant discourse, then we feel justified in the attitude that seeing is believing. But failure to satisfy any one of these requirements motivates suspicion. We dismiss supermarket tabloid photographs purporting to show the immortal King of Rock and Roll wolfing fries at McDonald's in Kansas City, no matter how compelling the likeness, because we cannot reconcile them with abundant, sober evidence that Elvis expired long ago. (Of course, the publications we sneak glances at in the eight-items-or-less checkout lane do not expect to be taken too seriously: the outrageous implausibility of their claims—both verbal and visual—is part of the fun.) An image of a cement factory can pass for an image of a nuclear reactor just so long as we do not have any knowledge of nuclear reactors against which to cross-check it, but the more we know about reactors the less plausible it will seem. We become skeptical of Peary's purported North Pole pictures and Capa's "moment of death" image because much less dramatic captions than those proposed by the authors can be suggested and seem to fit the visual evidence equally well. But General Westmoreland's contemptible quip failed to discredit the fleeing child image in the eyes of the public because this heartbreaking picture is detailed, internally coherent, and far more plausibly described by the original caption than by the alternative he attempted to supply.

Provenance

Finally, in addition to examining an image for internal coherence and considering whether it can stand up to cross-checking against what we know of a situation, we might ask for evidence that it is an authentic record—just as we might question whether a contract or will is genuine. Was it produced at the time and place claimed, by means of a process guaranteeing fidelity, by the person identified as its originator?[39] Is the originator trustworthy and

3.15 Staging a photograph: the same body appears in two different photographs.

Below: Alexander Gardner, *Slain Rebel Sharpshooter,* July 1863. Prints and Photographs Division, Library of Congress.

Right: Alexander Gardner, *Fallen Sharpshooter,* 1863. International Museum of Photography at George Eastman House, Rochester, New York.

3.16 Rhetorical re-enaction: Joe Rosenthal's famous photograph of marines hoisting the stars and stripes atop Suribachi Yama, Iwo Jima, February 23, 1945. AP/Wide World Photos.

3.17 Napalm attack or "hibachi accident"? June 8, 1972. Photo by Huynh Cong "Nick" Ut. AP/Wide World Photos.

authoritative? How did the image come to be presented to us? Are there suspicious gaps in its history?

In July 1991, for example, a photograph supposedly showing three lost Vietnam War fliers stirred an emotional debate in Washington (figure 3.18).[40] The families of the men that it apparently portrayed adamantly maintained that it was authentic. Some government officials, on the other hand, suggested that it might have been a hoax perpetrated by bounty hunters. There was some argument about coherence and plausibility, and *The New York Times* reported:

> Pentagon officials note that the three fliers look unusually well nourished for having been held in captivity for more than two decades. Some photography experts say the head of the man standing in the middle is out of proportion, suggesting that his picture was taken separately from those of the other men. Other analysts have noted that the cryptic sign held up by the men appears to have been photocopied and pasted on the picture.

But most discussion focused on the question of whether the image had a verifiable provenance that could establish its authenticity. Its history, according to *The New York Times*, was as follows:

> The Pentagon originally received the photo by fax machine last November from a naturalized American of Cambodian descent living in Los Angeles. A Defense Intelligence Agency official provided Colonel Robinson's daughter, Shelby Robinson Quast, with the name of the man who transmitted the photograph. A friend of her family said that Mrs. Quast met with the man and that he gave her two contacts to locate in Cambodia and a handwritten note demanding $2 million for two of the three men. Mrs. Quast flew to Phnom Penh to track down the two contacts. She found one, who maintained he took the photograph when he was a prison guard.[41]

So the claim of authenticity was based on identification of a photographer (the mysterious man in Phnom Penh), a time and place of exposure ("when he was a prison guard"), and a chain of transmission.

To find evidence for or against this claim, the US government sent a ten-member Pentagon team to Thailand to "find out the circumstances under which the photograph was supposedly carried across the Thai border into Cambodia." Soon after, a Pentagon report suggested that the provenance was suspicious and that the authenticity of the photograph was therefore doubtful: "One principal source of the photograph lies in a ring of Cambodian opportunists led by a well-known and admitted fabricator of P.O.W.-M.I.A. information," it claimed.[42] Pentagon investigators suggested that the photograph may have had the same source as some known fakes that were produced by manipulating pictures found in Soviet magazines.[43] Sufficient doubt was created for *The New York Times* to report, "Last summer, copies of a photograph purporting to show three captive American pilots were circulated, but U.S. authorities, after studying them, decided they were not valid." Eventually, Defense Department officials produced a convincing original—a 1923 photograph of three Soviet farmers that had been published in the December 1989 Khmer-language issue of a magazine called *Soviet Union*.[44] Apparently the original had been cropped, the features of the farmers had been disguised by addition of Stalinesque

3.18 Suspicious provenance: a photograph that surfaced in July 1991 as "evidence" of the continued imprisonment of three lost fliers in Vietnam (Reuters/ Bettmann) and the source image from which it was apparently produced—a 1923 photograph of three Soviet farmers.

moustaches, and the banner lauding collective farming had been replaced by a cryptic placard indicating captivity. False anchorage of the purported chain of transmission had been demonstrated, so this photograph completely lost whatever initial credibility it may have had.

A really bold liar (particularly one who can exploit some mantle of authority) can simply appropriate legitimate pictures to false narratives by providing them with fake provenances—much as confidence tricksters equip themselves with fake biographies. One of Ronald Reagan's more egregious falsehoods was his claim to have been one of the Signal Corps photographers who filmed the Nazi death camps. The horrifying pictures certainly exist, and Reagan told Israeli Prime Minister Shamir that he had kept a copy of them for himself in order to be able to prove that six million Jews had been exterminated. But the provenance that Reagan supplied was a completely spurious, self-serving fabrication: in fact, he never left the States in World War II.[45]

Originals and Copies

As framed above, the question of authenticity suggests that images are unique, that they are produced by individuals, and that there is a fundamental difference between originals and copies. We might ask, for example, whether a particular sketch was an original Rembrandt or merely a copy, whether a particular Polaroid print was an authentic David Hockney, or whether a particular Signal Corps death camp photograph was really by Ronald Reagan. Where we can distinguish clearly between originals and copies we usually value the originals far more highly—both for their aura as relics of a particular human hand and for their superior status as direct rather than secondary evidence.

But the conditions for distinguishing between originals and copies do not hold in all the cases of interest to us here, and this raises some perplexities. Photographs, for example, have negatives and multiple prints. Is the negative the original? Is each print an original? Who is the author of a print made from the negative of some long-dead photographer?[46] Are Polaroid prints more truly "originals" than prints from negatives? What are we to make of photographs of photographs?[47] Sherrie Levine pointedly raised these questions when she photographed a well-known photograph by Walker Evans, then signed and exhibited the resulting print. And Brett Weston dramatized the issues by burning his negatives on his eightieth birthday—declaring that only he could print them in the way that he intended and that he did not want somebody else to make prints after his death.[48]

Digital images seem even more problematic, since they do not even have unique negatives. An image file may be copied endlessly, and the copy is distinguishable from the original only by its date since there is no loss of quality. Unlimited numbers of displays and prints may be made from each copy, and displays may be fleeting like musical performances rather than permanent like paintings. The original image file may be destroyed within a short time of its creation, but many of its descendents may live on. In some cases, digital images are not captured but synthesized by application of rendering procedures to geometric data. Is the geometric database, then, the original? What if different rendering procedures are applied to the same geometric database? Does each appli-

cation of a new rendering procedure produce a new original work of art? Is the rendering procedure really the original (as one might argue that the recipe rather than the individual dish is the original work of culinary art)?

A famous incident in the history of computer graphics has dramatized these questions. In the very early days of three-dimensional computer graphics, a beautiful digital model of a teapot was produced at the University of Utah. Copies of this model have since found their way to computer-graphics laboratories throughout the world, and dozens of very different rendering procedures have been applied to it to produce thousands of variant teapot images—smooth teapots and rough teapots, transparent ones and reflective ones, metal, stone, wooden, fleshy, and furry ones. At one SIGGRAPH computer-graphics conference there was even a teapot-rendering competition.

In his magisterial *Languages of Art* Nelson Goodman has introduced some technical distinctions that clarify the problem of differentiating appropriately between originals and copies.[49] First, he distinguishes between one-stage and two-stage arts. Production of a pencil sketch or a Polaroid print is a one-stage process. But production of music is often a two-stage process: composition followed by performance. Many images are also produced in two stages: plates are etched then printed, photographic negatives are exposed and developed then printed, and digital images are encoded then displayed. In a two-stage process, the work is often divided among different individuals: a pianist may perform a work composed by somebody long dead, a photographer may print an archived negative produced by some forgotten predecessor, and a computer hacker may generate a display from an image file of anonymous origin that was read from some distant bulletin board.

Secondly, Goodman distinguishes between autographic and allographic arts. Painting, for example, is autographic, but scored music is allographic. The essential difference is that a musical work is specified in some definite notation system, whereas a painting is not. The musical score can be copied exactly, character by character, and any correct copy is as much a genuine instance of the work as any other. In effect, Goodman suggests, the fact that a work "is in a definite notation, consisting of certain signs or characters that are to be combined by concatenation, provides the means for distinguishing the properties constitutive of the work from all contingent properties—that is, for fixing the required features and the limits of permissible variation in each." But in painting, where the work is not specified in such a notation system, "none of the pictorial properties—none of the properties the picture has as such—is distinguished as constitutive; no such feature can be dismissed as contingent, and no deviation as insignificant."[50] A copy of a score need not, then, be the product of the composer's own hand in order to qualify as a genuine instance of a work, but a painting can be a genuine work only if it *is* actually an object made by the purported artist. If it is the work of some other hand, it is a forgery.

Autographic works such as paintings or videotapes consist of analog information: they cannot be copied exactly, and repeated copying always introduces noise and degradation. But the specification of an allographic work consists of digital information: one copy (of a musical score, of the script of a play, of an image file) is as good as another. Notice, incidentally, that two-stage works are frequently, but not

necessarily, allographic: an etching plate or photographic negative consists of analog information, cannot be copied exactly or used to make precisely identical prints, and does not specify the constitutive properties of the work in the rigorous way that a script or score does.[51]

Allographic works can be instantiated limitlessly (but the concept of instantiation does not apply to autographic works—they are unique): a musical work is instantiated in a performance that faithfully follows the score, a play is instantiated in a performance that faithfully follows the script, and a digital image is instantiated in a display or print that faithfully follows the tones or colors specified in the image file. Instances of the same work can vary (sometimes widely) in their contingent properties but must display the required features in order to count as instances. Thus musical and theatrical performers are free, to some extent, to interpret a work—and, indeed, we may place a high value on unusual and innovative interpretations that reveal hitherto unsuspected dimensions of the work. Similarly, a computer may mechanically interpret a work in different ways, using different algorithms and devices, to produce significantly differing instances.

Digital images, then, are two-stage, allographic, mechanically instantiated works. We can take a display or print to be a true record if the image-capture process was an automatic one, if the image file that was used is an exact copy of the one that was originally captured, and if a correct interpretation algorithm has been applied. When these conditions can be shown to hold, we can place at least as much confidence in the image as in an unretouched photograph—perhaps more, since copying does not produce noise and degradation and since interpretation algorithms are less beholden to human intentions than the darkroom processes used by photographers.

But it is usually extremely difficult, in practice, to demonstrate that the conditions do hold, since electronic recording media are made to be reused, and there is simply no equivalent of the permanently archived, physically unique photographic negative. Image files are ephemeral, can be copied and transmitted virtually instantly, and cannot be examined (as photographic negatives can) for physical evidence of tampering. The only difference between an original file and a copy is in the tag recording time and date of creation—and that can easily be changed. Image files therefore leave no trail, and it is often impossible to establish with certainty the provenance of a digital image.

Mutation and Closure

Traditionally, musical scores, literary texts, and other specifications of allographic works have had final, definitive, printed versions. The act of publication is an act of closure. You can modify a printed score or text by hand, but this produces a new (if unoriginal) work, not a redefinition of the existing finished work. Where scores or texts are corrupted in some way, scholars often expend considerable effort in attempting to recover definitive versions. But there is no corresponding act of closure for an image file. In general, computer files are open to modification at any time, and mutant versions proliferate rapidly and endlessly. Scholars can often trace back through a family tree of editions or manuscripts to recover an original, definitive version, but the lineage of an image file is usually untraceable, and there may be no way to determine whether it is a

freshly captured, unmanipulated record or a mutation of a mutation that has passed through many unknown hands. So we must abandon the traditional conception of an art world populated by stable, enduring, finished works and replace it with one that recognizes continual mutation and proliferation of variants—much as with oral epic poetry.[52] Notions of individual authorial responsibility for image content, authorial determination of meaning, and authorial prestige are correspondingly diminished.

Furthermore, the traditional distinction between producers and consumers of images evaporates. A scientist interpreting a digital image may, for example, apply transformations to the digital data in order to bring out features and relationships of interest, then store the result in a new image file. The reading becomes a new work, with perhaps as much or more claim to our interest and attention as the original. We might best regard digital images, then, neither as ritual objects (as religious paintings have served) nor as objects of mass consumption (as photographs and printed images are in Walter Benjamin's celebrated analysis[53]), but as fragments of information that circulate in the high-speed networks now ringing the globe and that can be received, transformed, and recombined like DNA to produce new intellectual structures having their own dynamics and value.[54] (Text fragments manipulated by word processors and digital sound samples manipulated by computer music systems have a similar character.) If mechanical image reproduction substituted exhibition value for cult value as Benjamin claimed, digital imaging further substitutes a new kind of use value—*input* value, the capacity to be manipulated by computer—for exhibition value. The age of digital replication is superseding the age of mechanical reproduction.

The cultural production system now emphasizes processability. The digital structures that are produced and consumed do not just refer to each other, they are actually *made* from each other, so that they form mirror mazes of interpictoriality hooked to the external physical world (at relatively few points) by moments of image capture. Images do not just mirror the world directly, as they once seemed to do, but reflect traces (perhaps tinted or distorted) of other images. That loss of the external referent, and the growing self-referentiality of symbol systems, which has so preoccupied poststructuralist theory, are here escalated to a new level. Logical associations of images in databases and computer networks become more crucial to the construal of reality than physical relationships of objects in space. Digital imaging now constructs subjects in cyberspace.[55]

Image Ethics Redefined

As digital images have become increasingly important items of exchange in the worldwide electronic-information economy and as traditional conceptions of image truth, authenticity, and originality have consequently been challenged, ethical and legal dilemmas have emerged. Many of the traditions, standards, and laws developed in the predigital era seem inadequate when they are extended to the new situations created by the new technology.

Since the development of printing, for example, the concepts of "fixing" and "publication" of definite "works" have played key roles in copyright law. There was a basic assumption that production of copies—either as pieces of handiwork or as industrial commodities—was a difficult and expensive process and that copies were valuable material artifacts existing in

limited numbers. The US Copyright Act of 1909 was typical: it gave protection to intellectual and artistic works—such as books and photographs—that were "published with notice." The more up-to-date provisions of the Berne Convention dispense with the idea of formal publication as the starting point for copyright protection and extend it to works that are merely "fixed in some tangible medium of expression." But the speed and informality of digital image production, the practical difficulties of distinguishing between "draft" and "published" versions and between originals and copies, the existence of digital images in forms that are not eye-readable, their ease of duplication, their mutability and lack of closure, their tendency to proliferate limitless variants, and their unconventional channels of distribution conspire to make them very difficult to pin down in this way.[56] There is an erosion of traditional boundaries between artist or photographer, editor, archivist, publisher, republisher, and viewer. And digital images do not necessarily come embedded in manufactured material substrates, like texts in books and musical performances on records: often, you can just download them from a database. In multiple and sometimes subtle ways they resist treatment as privately owned material commodities.

The traditional concept of a derivative work—as exemplified by translations of books, films based on novels, paintings made from photographs, and the like—is also under challenge. As we have seen, a digital image file is *made* to be processed—to be transformed into something else—and any file is the potential progenitor of an endless sequence of descendents. It seems far from straightforward to specify the distinctions between outputs from image-processing operations that are trivially different from the inputs, outputs that contain sufficient original content to be classified as distinct but derivative works, and outputs that are most reasonably regarded as genuinely original productions. How does this practical reality affect whatever moral and legal rights a photographer, graphic artist, or film director may have to control the production of derivative works and to prevent undesirable transformations? And when should image-processed derivatives themselves be entitled to copyright protection?

In 1986 the purchase of the MGM film library by the television entrepreneur Ted Turner raised the issues of film protection in dramatic fashion. Turner announced his intention to apply digital colorization to one hundred old feature films and commented: "The last time I checked, I owned those films. I can do anything I want with them." Many prominent directors and cinephiles protested against the colorization of black-and-white film "classics," and the Directors Guild of America called it "cultural butchery."[57] In 1991 *Star Wars* director George Lucas suggested that colorization was only, in fact, the tip of the iceberg:

> The agonies filmmakers have suffered as their work is chopped, tinted and compressed are nothing compared to what technology has in store. . . . Unless the United States achieves uniformity with the rest of the world in the protection of our motion picture creations, we may live to see them recast with stars we never directed, uttering dialogue we never wrote, all in support of goals and masters we never imagined we would serve.[58]

However rights to reproduce digital images and produce derivative works from them are established and protected, the question of what these rights are worth and how they should be transferred remains. Marxist analysts are disconcerted to note that the labor theory of value is not much help here; photographers, stock agencies, and museum directors wonder what to charge for rights and how to collect their money. Photographers, for example, have traditionally retained economic control of images by keeping the negatives and selling prints, but this strategy becomes impossible when images are archived and distributed as files of digital information. Should image CDs, then, be treated like stock-photo catalogues, with users required to purchase separately the reproduction rights to any of their contents, or should such CDs become direct sources of immediately reproducible images? Should electronic reproduction rights be sold like print rights? If they are, there are some difficult pricing and contractual issues to resolve. Since electronic images are disseminated in different ways and in different quantities from print images, for example, it can be argued that rights should be priced on some different basis. And controls that museums have traditionally exerted over the quality and distribution of print reproductions become much more difficult to enforce with electronic reproductions.

If a digital image does have value to a collector, how can this be preserved? Paintings are unique and often appreciate in value, print runs are limited, and photographers can destroy their negatives to prevent the production of further prints that might devalue the ones already in existence. But, since digital image files can be replicated endlessly and prints can be made mechanically whenever desired, there is no act equivalent to burning the negative or breaking the mold: any copy of the image file will serve as well as any other as the source for further copies.

When does processing or manipulation add value to an image? It might well be argued, for example, that colorization of film adds value. What about enhancement of a poor-quality image by sharpening, or smoothing of a portrait to make it more flattering? If value is added, who is entitled to claim recompense for this?

Where does an image actually reside? The network distribution of digital images can make it difficult to determine image locations—unlike the case of, say, paintings that reside in museums. Images can exist as multiple, geographically distributed identical copies, and these copies can be moved around as in a gigantic, extremely high-speed shell game. Networks frequently cross boundaries of legal jurisdiction, potentially putting image copies beyond the statutory reach of law-enforcement and regulatory agencies.[59] This creates policing problems. Political censors will find it increasingly difficult to prevent the infiltration of their territories by seditious or otherwise unwelcome images, pornography will be harder to control, and the subjects of visual libel may not have any effective way to prevent the dissemination of offending images.

And what is fair use of a digital image? It is generally accepted that a scholar may copy short portions of a published text into his or her notes and subsequently use those excerpts in new works of criticism, comment, news reporting, teaching, and so on. Can that same scholar select part of an electronically distributed digital image and use desktop-publishing software to paste it into a page layout? If so, how much of the image can fairly be reused in

this way? Surely it is unethical, and in many cases a violation of copyright, to reuse a complete image without appropriate permission. Just as clearly, though, it would be absurd to complain about copying the value of a single pixel from an image (or a single sound from a musical performance)—it's just a number. At what intermediate point can we reasonably draw the line? What if a pattern or texture is extracted and reused in production of a computer-synthesized perspective rendering of a building? What about a dramatic sky extracted from an Edward Weston landscape photograph and reused in a new landscape composite? Where does visual plagiarism begin? Graphic artists will have to evolve norms governing fair use of digital imagery analogous to the traditions and conventions that govern the quotation, recombination, and paraphrase of fragments of text.

Finally, how should the rights of photographic subjects be defined and enforced, and are established ways of compensating subjects still adequate?[60] Does a model's signed release of an image extend to the use of that image in an electronic "clip art" collection and to its endless transformation and recombination to produce new images? How should releases be written, and how should a model be paid for this sort of use? And what limits are there to electronic transformation of photographic images to produce unflattering caricatures or scenes that show recognizable individuals in a discreditable light? The photograph's air of reality makes a difference here: a digitally manipulated photograph showing a prominent politician in a compromising or damaging situation has a very different effect from that of a drawn cartoon showing exactly the same thing. In the 1990 Massachusetts gubernatorial election campaign, for example, the candidate John Silber was videotaped in a particularly offensive outburst against working mothers, whereupon his opponent quickly produced an effective television spot from this footage—manipulated to make Silber seem particularly menacing by showing him enlarged and slightly distorted.[61]

For photojournalists, as we have seen, the ethical issues dramatically present themselves as ones of creative control, individual and institutional responsibility for image content, and formulation of codes of conduct. Are press photographers to be reduced to little more than fleshy bipods—mobile supports for image-capture devices that send streams of pictures back to an editor's desk, where the crucial selection and framing decisions are made? Who controls the tonal and color qualities of an image—photographer, photo editor, or computer-graphics technician in the production department? When does a succession of small and apparently innocent manipulations add up to significant deception? How can this gradual degradation of evidential value be controlled? Who guarantees the integrity of a news photograph, and who checks whether an image of doubtful provenance might be a tendentious fabrication? When a digital image is the product of many hands, how should the image credit be written? And, if that image deceives or defames, who bears ultimate moral and legal responsibility?

As these signs of ethical and legal strain show, the digital image is emerging as a new kind of token—differing fundamentally from both photographs and paintings—in communicative and economic exchanges. It demands new rules for structuring those exchanges.

Devaluation

The painter, the photographer, and the digital imager have different social and cultural roles to play. A painter, firstly, is traditionally seen as an artificer, a patient maker, an urbanized craftsperson who transmutes formless raw materials into images. We naturally use the language of personal intention—reference, comment, expression, irony, conviction, truthfulness, and deception—to describe this process. There seems a comfortable fit with the Aristotelian conception of a fabricator, impelled by an anticipatory idea, who imposes form on matter.

But photography evokes predatory metaphors: a picture is "taken," the photographer operates in a ruthlessly competitive economy of image hunting and gathering. Photographs are trophies—won by skill and cunning and luck, by being in the right place at the right time, and by knowing how to aim and when to shoot.[62] Form is out there to be discovered, then impressed on matter by means of a swift, automatic process.

Long ago, Oliver Wendell Holmes fancifully described what he took to be the capitalist political economy of the photographic image (in the specialized form that particularly interested him—the stereograph).[63] He first imagined expeditions of visual conquest and plunder:

> There is only one Colosseum or Pantheon; but how many millions of potential negatives have they shed—representatives of billions of pictures—since they were erected! Matter in large masses must always be fixed and dear; form is cheap and transportable. We have got the fruit of creation now, and need not trouble ourselves with the core. Every conceivable object of Nature and Art will soon scale off its surface for us. Men will hunt all curious, beautiful, grand objects, as they hunt the cattle in South America, for their *skins*, and leave the carcasses as of little worth.

Then he spoke of photographs as cognitive cold cash, the value of which was defined by reference to a kind of gold standard of nature:

> Again, we must have special stereographic collections, just as we have professional and other special libraries. And, as a means of facilitating the formation of public and private stereographic collections, there must be arranged a comprehensive system of exchanges, so that there may grow up something like a universal currency of these bank-notes, or promises to pay in solid substance, which the sun has engraved for the great Bank of Nature.

Since Marx, of course (and more directly to the point, since Althusser on ideological apparatuses), many have greeted the idea of such buccaneering enterprises with far less enthusiasm. Susan Sontag, for one, has seen panoptic photographic production as a potentially sinister ally of the late-capitalist state:

> A capitalist society requires a culture based on images. It needs to furnish vast amounts of entertainment in order to stimulate buying and anesthetize the injuries of class, race, and sex. And it needs to gather unlimited amounts of information, the better to exploit natural resources, increase productivity, keep order, make war, give jobs to bureaucrats. The camera's twin capacities, to subjectivize reality and to objectify it, ideally serve these needs and

strengthen them. Cameras define reality in the two ways essential to the workings of an advanced industrial society: as a spectacle (for masses) and as an object of surveillance (for rulers). The production of images also furnishes a ruling ideology. Social change is replaced by a change in images. The freedom to consume a plurality of images and goods is equated with freedom itself. The narrowing of free political choice to free economic consumption requires the unlimited production and consumption of images.[64]

Digital imaging has upped the ante in the debate defined by the formulations of Holmes and Sontag. Now there is a new, postindustrial economy of images, with superimposed processes of gathering and stockpiling raw materials, extraction, manufacture, assembly, distribution, and consumption. Perhaps the most striking illustration of this new economy is provided by the EROS Data Center near Bismarck, North Dakota. More than six million satellite and other aerial images have been stockpiled there for distribution to the public. Satellites continue to scan the earth and send images of its changing surface back, causing the stock to grow at a rate of twenty thousand per month. These ceaselessly shed skins are computer processed, for various purposes, by mineral prospectors, weather forecasters, urban planners, archaeologists, military-intelligence gatherers, and many others.[65] The entire surface of the earth has become a continuously unfolding spectacle and an object of unending, fine-grained surveillance.

In the digital image economy, form has become even cheaper and more swiftly transportable than Holmes could ever have imagined. Furthermore, the connection of images to solid substance has become tenuous. The currency of the great bank of nature has left the gold standard: images are no longer guaranteed as visual truth—or even as signifiers with stable meaning and value—and we endlessly print more of them.