The Chrome Age

Dawn of Virtual Reality

Sonya Shannon

THIS ARTICLE CHAMPIONS THE SINGLE MOST DESPISED ARTIFACT of computer graphics—chrome logos—by reconsidering them as conspicuous ambassadors of computer-generated realism. The foundation for today's synthetic worlds was laid when three-dimensional computer animation first moved into television and film, an era the author labels the "Chrome Age." Programmers, in a quest for photographic-quality realism, built the framework for virtual reality—but without artistic training. They overlooked certain aesthetic principles of Renaissance perspective in order to focus on algorithmic techniques, an endeavor that resulted in distinctive plastic-metal textures. Designers, eager to express whatever they could with the new computer-generated look, manipulated the earliest entertainment graphics—show titles and logos—into illusions of precious silver and gold. Due to their symbolic value, chrome logos convinced the public that artificial worlds could eventually become "real" and heralded the high-tech entertainment industry—an edifice of science fused with art.

When everyone dislikes something, it should be examined.
When everyone likes something, it should be examined.
—Confucius [1]

Chrome: The Byproduct of Collaborative Chaos

The inevitable computerization of imagery over the past 20-odd years has confounded many an artist. While chaos is symptomatic of postmodern events in general, the frictions of computer art arise primarily from the diametric temperaments of its collaborators—artists, who seek personal and social truth through human experience, and scientists, who pursue objective verity in the outside world [2]. Evidence of the contrapuntal partnership abounds. The infinite perfect copies of digital art are closer in character to the scientist's reiterative verification process than the artist's singular expressive event, while fractal images and other wildly colored products of scientific visualization compel association with sacred mandalas, intricate decorative patterns, and abstract art. The collision of apparently conflicting goals has strewn new forms of imagery throughout our culture, especially in the entertainment and communications industries. In order to grasp even a fragment of the new aesthetic, we might be advised to examine not an elusive form of high art but rather a dominant shape from the guts of mass media, where the byproducts of art and science inevitably merge. Although certain innovations have been celebrated—notably 3D perspective, the fractal, the morph, and the pseudo-color scheme—one of the most influential byproducts of early computer art has been, quite erroneously, shunned. I refer to the long-misunderstood flying chrome logo—the typography that is likely to package the evening newscast by swerving over some variant of a grid while stars or similar creations zoom in the deep space background (Fig. 1). I use the term "chrome" to encompass all simulations of gold, silver, chromed nickel, copper, and other shiny materials (even glass and metallicized plastic), since together they form a coherent style of gleaming glamour [3]. Indeed, the 3D chrome logo emerges from communications media as no less than the symbolic bounty delivered by science to art, the inaugural icon of virtual reality and an ignored but persistent cornerstone of contemporary design. In light of the chrome logo's ubiquity and significance, I propose we

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Fig. 1. Beveled, extruded chrome lettering attempts to fill the void of virtual space with symbolic references to wealth, space travel, and high technology. The result is a mirage of the ever-futuristic present. (American Multi Cinema (AMC) Feature Presentation; courtesy Metrolight Studios, 1990.)

name the period of its inception the "Chrome Age."

Although ignored by traditional art historians [4] and contemptible to "serious" designers alike, flying logos—nicknamed for their flying-saucer-like behavior—are surprisingly influential, given their origin in an era infamous for rapid obsolescence. Their history is short but profound. The first metallic titles emerged during the late sixties and early seventies, when airbrushing and back-lighting techniques were incorporated into the traditional 2D animation process [5]. Simultaneously, though independent of broadcast production, the earliest computer graphics techniques showed promising development for animation. When software alchemy of the late seventies produced convincing illusions of precious metal, a few visionary entrepreneurs rushed to hawk virtual gold in the profitable entertainment industry. Success came quickly. When computer animation made its debut on television around 1977, it caused a noticeable ripple in graphics production. While 2D animation techniques could be mimicked—albeit awkwardly—on one of the rare electronic painting systems then in existence [6], 3D modeling methods produced superior metal, due to the fact that objects cavorting through space could be automatically animated (Fig. 2). Computed perspective was indeed a stupendous breakthrough for animation—even the simplest cube glinted and gleamed as it tumbled. Such precisely calculated, shaded geometry would be unthinkably labor-intensive to produce by hand.

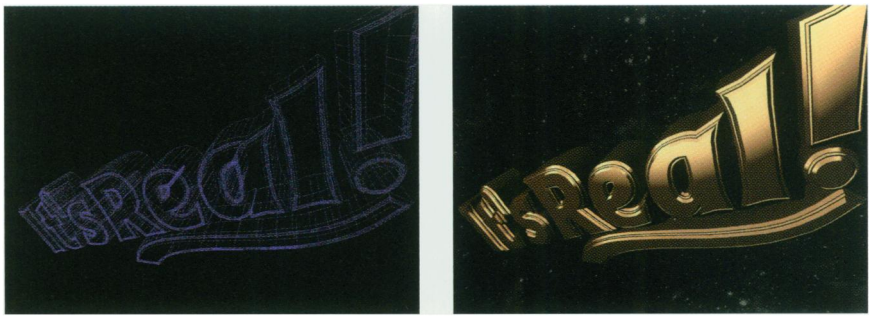
Because it constituted a quantum leap in realism, 3D animation caused an industrywide sensation. The block-lettered chrome word suddenly became a bar of precious metal in the minds of its patrons, ushering in a new phase in the history of image-making. By the early eighties, virtual metal typography dominated television identifications and commercials. When faster, cheaper computers and better software products superseded the monolithic startup industry in 1987, high-tech effects became the cynosure of the entertainment industry. Today, slick 3D titles proliferate everywhere. Though they have gone largely unacknowledged, chrome logos first proved to a mass audience that the virtual world was not just science fiction, but a fact.

Flying Logos: Too Marginal for Art, Too Fanciful for Science

To an outsider, computer art might look like a movement of some kind. Certainly, it draws together a body of people whose endeavors radiate esoteric passion while skirting the fringe of acceptable cultural practice. Contrary to wishful thinking, however, it is hardly an art movement, since graphics systems were initiated by everyone *except* artists and designers. Science, technology, and big business—not art—were at the epicenter of the high-tech revolution. Computer programmers—neither conceptual artists nor aesthetes—erected and furnished virtual reality out of their need to master problems of such complexity that nothing less than computer-assisted simulations would do the trick [7].

A telltale sign of a new era is a shift in social strata whereby a despised vocation suddenly assumes high status while a respected profession sinks into oblivion. Consider, in twentieth century America, how acting skyrocketed from gypsylike marginalization to glamorous movie stardom, while teaching plummeted from a revered calling to a scorned excuse-for-an-occupation ("he who can, does; he who can't, teaches"). During the Chrome Age, the major upset in the professional hierarchy was that the technologist soared from nerd to wizard, while the

Fig. 2. (a) The 3D technique for generating chrome logos starts with a geometrical description of the object, shown here in wireframe. (b) The relationship between diffuse surface and specular highlight colors creates a flat and crude-looking chrome. (c) Geometry is partitioned and assigned contrasting diffuse colors to show off its volume better than light algorithms alone can do. (d) Ray tracing provides realistic reflections, though the geometry still reads rather flat. (e) Partitioning combined with adjusted ray tracing provides the highest realism. (Illustrations courtesy of Jens Scott © 1995.)



artist fell from hero to scapegoat [8].

Let there be no doubt about it: during the late seventies and eighties, software engineers were knighted the new "creatives"—an emerging elite of special-effect masters. Quite simply, their algorithms dictated what it was and was not possible to visualize. Before personal computers proliferated, an artist's access to graphics systems was difficult at best. Practically the only way to experiment—unless you chanced to befriend some kindly hackers—was to seek employment at a Chrome Age production company. Here, art (generally, the pictures or algorithms one made during one's spare time) was the legal property of the corporation and could be used for its promotion without even the inclusion of the creator's name, let alone acknowledgment of her rights. Until recently, those who made art with their employer's computers sacrificed individual ownership of expression, whether commercial or not—in theory for the sake of technological progress, and in fact for the corporation's profits. Needless to say, few artists could tolerate such terms.

While an optimistic sprinkling of artists and designers tried to embrace electronic picture-making, many more raged against having their tools and methods revolutionized. But technology advanced ruthlessly, forcing designers *en masse* into computerization. Though traditional artists and critics abhorred algorithmic representations, their objections were flung to the distant sidelines of the imaging revolution. Now, in the mid-nineties, an awakened finger of the art world has finally begun to probe the spaces opened over the past few decades by technologists, namely, the universe of virtual galaxies and its intricate conduit, the World Wide Web. Ultimately, computer art embodies not a movement but the twitch of a limb as we metamorphose into an entirely digital culture [9].

The first negotiations between the long-estranged tribes of Science and Art were conducted on a makeshift raft of television and feature film production. Entrepreneurs summoned financial and management executives, salespeople, computer scientists and programmers, secretaries, and a token designer or illustrator to produce visuals with algorithms fresh from the motherboard. For the financier, the obvious quandary was how to conceive a species of algorithmic skin whose appearance alone could justify the exorbitant cost of producing it. Underneath, the puzzle was how to define a common icon around which adversarial scientists and artists could sophisticate high technology. The chrome logo was an answer to both enigmas. For the programmer, the metal signature was a victory in the quest for photographic-quality realism. For the designer, it was a relatively meaningful expression put forth with tools whose traditions were yet to be defined.

For lack of a more fitting role model, the entertainment branch of computer graphics grew at first like a newly separated Siamese twin of the American military, whose flight- and combat-simulation systems pioneered virtual space and funded the development of algorithms used by the offshoot industries. Though over time the business of high-tech television and film graphics gracefully differentiated itself in many ways from the U.S. Air Force, during the Chrome Age most companies retained a militaristic hierarchy of command, practicing secrecy and surveillance tactics to protect their proprietary code. Under these regimented conditions, the first computer-generated logos were launched into virtual orbit.

As a nerdy militia amassed for the high-tech crusade, the few brave rookie designers who enlisted directly in the Chrome Age were stripped of the power previously granted them for having skillful hands and fertile imaginations. Like immigrants forced to assume a new identity in a land where their native tongue is scorned, the artistically inclined were demoted to the lowliest status possible. They became mere *users,* or—as salespeople and executives referred to them—*operators* (slaves) of the mighty machines. Perhaps it was meant to put them on a par with operators of other equipment, such as fork-lifts, sewing machines, and telephones—or figuratively with the shady operators of underworld schemes, since the designer's main fare, after manual skills, has always been provocation [10]. Yet no one cares how philosophically a steam shovel operator moves earth or with what dancerly flourish a switchboard operator reconnects lines. Similarly, computer graphic operators were expected to confine themselves to being mere technicians who met deadlines with maximum expediency and minimum creativity. And venturesome though they were, because these artists were not trained to program code or configure hardware systems, they were easily trampled by software "artists" who wanted not only to be in charge but to develop and wield the newfound creative power computation afforded them [11]. Artistic design, temporarily bound and gagged by algorithmic logic, became a hostaged profession struggling for its rights after they were seized in a technocultural *coup d'état.*

Plastic Lands: The Crusade for Realism

Computer animation barged into the entertainment business on the strength of a boast, in the short run, to surpass tabletop still life photography and miniature model animation. This claim was founded on computer animation's superior realism

coupled with unprecedented flexibility, such as optional gravity, instant changes in color and surface texture, and the ability to metamorphose object shapes. In the long run, synthetic effects promised—and threatened—to replace human movie stars altogether, just as programmers had replaced artists as the main innovators of picture-making. Years before the words "virtual" and "reality" were joined, realism was the force that drove the technographic typhoon. Technique, witnessed in the algorithmic image, reigned supreme. Money and effort were invested exclusively to improve software tools and hardware performance. While programmers were praised and coddled, graphic artists—formerly the "sensitive" ones—were kept on a strict production agenda whose only aesthetic was glitzy pseudo-realism.

The television-viewing public, apparently either ignorant of or indifferent to graphics production methods, accepted the first computer animation without changing channels. The majority of the entertainment world was less than thrilled about 3D, however, since traditional graphics producers lost vital business to Chrome Age companies. Prejudice quickly arose against flying logos, since, in the quest for realism, synthetic graphics were marketed as being indistinguishable from real scenes and objects. Phrases such as "hyperrealistic," "true-to-life," and "the future is now" clamored wherever high-tech imagery was seen. Unsettled by the computer's easy usurpation of hard-learned craft and desperate to regain lost income, traditionalists began a backlash that assailed the aesthetics of computer-generated goods. Skeptics denounced virtual space as too pristine, plastic, cold, garish, hard-edged, and false. They condemned the robotic movement of logos that jerked to a halt or changed direction mid-air with unmotivated abruptness. The artistic ability of "whoever was responsible" for chrome logos was thoroughly censured—and of course, each party blamed the other. Programmers criticized users for their technological ignorance, while users reproached both programmers, for providing such limited options, and clients (not to mention the public) for being so tasteless as to want shiny metals in the first place.

Two Perspectives: The Renaissance Versus the Chrome Age

To understand why chrome prevails, we must consider the programmers, who were now in charge of design. The schism between traditional artists and software designers widened during the debate over the virtues and vices of computer animation. Undaunted by their ignorance of art history, or possibly feeling that incomprehensible art movements from Abstract Expressionism to Postmodernism gave everyone license to call themselves artists, programmers defiantly ventured deeper into logic to create their own form of art—namely, graphics programs.

Confusion persists over the merits of algorithmic rendering. Because image processing in the nineties—especially photomanipulation—has converged with synthetic 3D graphics, we must reconsider the aesthetics of contemporary realism in light of its digital benefactor, the computer program. It is beyond the scope of this article to discuss photography-related techniques, so we will focus on computed perspective as a source of realism. It is worthwhile here to consider the premises of Renaissance aesthetics as a parallel to digital 3D. In terms of image-making history, the Italian Renaissance represents the apex of constructed pictorial realism. Perspective theory, a central idea in fifteenth century painting, is reincarnated in the very girders upon which virtual realities rest. While 3D software was never intended to uphold painterly ideals, it shares with the Renaissance an aim towards superior realism through a delicate balance of geometry and art. Yet many perspective details of the Renaissance have never been implemented in 3D software, so virtual space has lacked some important depth cues. Ironically, these omissions enhanced the corporeality of chrome logos while falsifying the depiction of more organic subjects.

Both Renaissance picture-making and 3D computer graphics systems were founded on Euclidean geometry and attempted to portray space with unsurpassed accuracy. In the Renaissance, the observer's eye, was conceived of as the apex of a visual cone or pyramid that enclosed a rational, mathematical, homogenous world. The image plane was a surface that cut through visual rays emanating from the eye to objects within view. Such a rendering was constructed by mapping distances between objects and then overpainted in color. Computer graphics employed a similar strategy. Instead of using hand and eye, the data for virtual objects were constructed algorithmically—generally through a points-polygons method, or through volume or surface equations—and stored in the computer. Geometry was placed inside a virtual viewing pyramid and rendered in a "window" by calculations of such attributes as object color, shading, and spatial orientation [12].

Fig. 3. Leonardo DaVinci's *Virgin of the Rocks* (ca. 1486; above right) exemplifies the principles of Renaissance perspective through foreground, middleground, and background planes detailed at right. Note the increasingly compressed range of color values expressive of distance from the eye.

Renaissance perspective expressed a unifying light source through four major principles: linear perspective, atmospheric perspective [13], color perspective, and separation of planes. In contrast, 3D software accommodated (and still does accommodate, in most cases) only linear perspective—the one precept most familiar to lay people. This technique increasingly compresses the size of distant objects until the illusory space drains into a pinpoint on the horizon. The viewing pyramid determines the geometry's distance from the image plane and its relative inflation or shrinkage of scale. Since the linear principle is a brilliant yet simply grasped device for generating spatial illusions, most programmers disregarded the other more complicated perspectives [14].

Fig. 4. Atmospheric and color perspectives are not considered in this digital rendering of sunflowers (below right). Note how the homogenous range of colors contradicts the linear recession of objects from the eye. The slight loss of detail in the distance is a function of pixel size and anti-aliasing relative to the sunflowers' size, rather than the outcome of algorithmically controlled perspective texturing.

Background

Middleground

Foreground

Scala/Art Resource, NY. Leonardo Da Vinci. *The Virgin of the Rocks.* Louvre, Paris, France.

Background

Foreground

Sunflower Field by D. Fowler, N. Fuller, J. Hanan and A. Snider from P. Prusinkiewicz and A. Lindenmayer, *The Algorithmic Beauty of Plants*. Springer-Verlag, New York, 1990.

Illustration by Peter Klüger, 1995

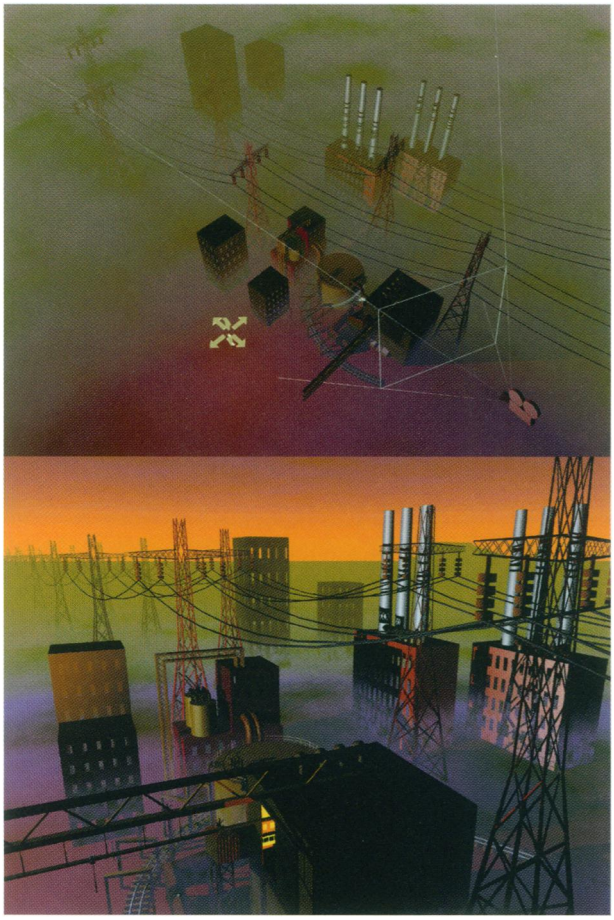


Fig. 5. (a) The contemporary solution to perspective uses a viewing pyramid, visualized here with the camera at the apex and the view window as a 2D slice of space between the camera and the geometry. The arrows indicate the location of a point light source. (b) In the final rendering, two different fog filters create mood and improve the depiction of space. The first is a layer of blue fog nestled near the ground, while the second is a sphere whose green fog intensifies with distance from the origin. (Illustration courtesy of Jens Scott ©1995.)

Atmospheric perspective—the soft, naturalistic lighting effects that rendered a hazy and, in Leonardo da Vinci's words, "not highly finished" [15] quality to painted objects in the distance—expressed the essential Renaissance idea that the atmosphere was invisible yet volumetric. Atmospheric perspective also accounted for a loss of light-dark value contrast in the distance. Fifteenth century painters rendered this illusion by deteriorating a sharply textured, richly contrasted surface into a generalized blur of medium-value color at a distance (Fig. 3). On the other hand, even the best Chrome Age software rendered all objects at maximum allowable detail, regardless of their position in space—as though in a vacuum. Value contrast as a function of atmosphere was completely absent from commercial 3D systems. Highly textured objects had an unconvincing clarity about them (Fig. 4) and "boiled" or squirmed distractingly across surfaces when animated (this is still a problem with even the best 3D packages). An algorithm called a *fog filter,* however, bleached distant objects from the bottom up. Though it was not altogether objectionable, this foggy weather condition was applied irrespective of setting, scale, or relative distance. Although fog failed to solve the more subtle problems of diminished detail and decreased value contrast seen on a clear day or in a large interior, the algorithm created better realism than no filter at all (Fig. 5).

Perhaps the most subtle detail missing from Chrome Age space was color perspective. Renaissance theory assigned warm, saturated, and opaque colors (reds and yellows) to the foreground and cool, grayed-down, transparent colors (blues, greens, and purples) to the background. Light colors were mixed with red and dark colors shifted towards blue as they receded in the painting. Though inhibiting to later artists, fifteenth century color perspective achieved a natural realism and still seems advanced compared to the absence of color perspective in 3D software today. The most brilliant Chrome Age (and mid-nineties) hues, no matter how far away from the virtual camera, remained at maximum purity. Yet the illusion of virtual depth could have been heightened if surface hues were adjusted algorithmically to their individual distances in space. (Of course, users could make these adjustments painstakingly by hand, but only if they had enough artistic training to begin with.)

Finally, a separation of planes resulted from the convergence of the three other Renaissance principles. Linear, atmospheric, and color perspectives were combined in a series of distinct yet connected planes that overlapped one another in increments from far to near, somewhat the way theatrical flats imply zones of depth. Since Chrome Age software did not address atmospheric and color perspectives, it did not separate planes unless a flat background was set behind 3D objects. The only indication of increased space between camera and figure came through miniaturization, the overlapping of distant objects, and the intervention of fog if a filter was employed. Unless they came from the hands of a trained artist who spent days refining appearances, either of which was highly unlikely, Chrome Age 3D images were shallow, sterile, and cold—qualities unsuitable for organic objects but ideal for showing off beveled metal logos (Fig. 6).

3D Purists: Computational Solutions

The virtual world had to prove itself. Mainly, this meant paying for the cost of its development by furthering its most singular properties. Programmers generally scorned "brute force" image-making methods that emphasized user skill—such as cinematic-style compositing or individualized adjustment of object properties—over algorithmic means. The consensus was to create an entirely computed, "pure 3D" universe. It is important to remember here that 3D software was never intended to make static images to hang on a wall but instead was developed to computerize the animation of objects in space. Computed perspective was applied automatically to any piece of geometry, regardless of its complexity. The operator needed only to

Fig. 6. The dominant attributes of perspective in the Renaissance, contrasted with those of the Chrome Age, followed by more recent developments (right).

	THE RENAISSANCE (c. {1300} 1495 - 1520)		THE CHROME AGE (c. 1975 - 1987)		VIRTUAL REALITY (c. 1988 - present)	
LINEAR PERSPECTIVE	Drafted. Geometry foreshortened by construction of a viewing pyramid. Distant objects rendered with less detail than near objects.		Computed. Geometry scaled algebraically in a virtual viewing pyramid. Complexity of geometry rendered regardless of distance from the virtual camera.		Computed. Geometry scaled algebraically in a virtual viewing pyramid. Variable geometric resolution as a function of distance from the virtual camera.	
ATMOSPHERIC PERSPECTIVE	Painted.		Algorithmically computed with a fog filter, or nonalgorithmically composited using two-dimensional backgrounds behind three-dimensional geometric renderings.		Algorithmically computed with one or more of the following: fog filter, density map, hierarchical radiosity, physically based atmospheric scattering, ray tracing & radiosity, etc. Also non-algorithmically composited.	
	Foreground Techniques	**Background Techniques**	**Foreground Techniques**	**Background Techniques**	**Foreground Techniques**	**Background Techniques**
	Sharp textures. High detail.	No texture. Blurred edges.	Sharp textures due to ray tracing. No algorithmic distinction within viewing pyramid between foreground and background space.		Sharp textures. High detail.	Decreased texture. Blurred edges. Simulated depth of field.
	Expanded value range.	Compressed value range.	Little algorithmic distinction between foreground and background space, although background value range may be moderately compressed with fog filter.		Expanded value range.	Compressed value range.
	Strong volumetric rendering through light and shade.	Flatness rendered through diffused light and shade.	Little algorithmic distinction between foreground and background space. Strong volumetric rendering throughout, although background objects may appear incidentally less volumetric, due to compressed value range of fog filter.		Strong volumetric rendering through light and shading.	Flatness rendered through multiple algorithms.
COLOR PERSPECTIVE	Determined by palette, then painted.		Not addressed in software.		Addressed through arbitrary use of density maps, but unformulated by aesthetic theory.	
	Foreground Techniques	**Background Techniques**				
	Warm colors.	Cool colors.				
	Bright, saturated colors.	Muted, neutralized colors. Light colors shifted towards red. Dark colors shifted towards blue.				
	Opaque, solid colors.	Transparent colors.				
	Wide range of temperature contrasts.	Unified temperature.				
SEPARATION OF PLANES	Result of linear, atmosphere, and color perspectives together.		Nonalgorithmically addressed through compositing, where the background is visually separate from 3D geometry.		Hierarchy of algorithms applied according to distance from the virtual camera. Multiple levels of detail. Also nonalgorithmically addressed through compositing.	

construct the object and position it in the virtual theater [16]; the computer then slavishly rendered the precise perspective transformations undergone as the object moved. Eighteen hundred video images were needed for each minute of animation, at a rate of 30 per second. Accordingly, computation time became the chief consideration of software design. If Chrome Age businesses were to survive, every effort had to be made to improve the system's performance. Perspective enhancements beyond the linear principle were considered visual frills, too slow and complicated to compute relative to whatever small improvements might be observed. After all, most 3D animation was destined for television or video, formats already notorious for spatial flatness and the inability to supply artist-quality resolution.

Of chief concern to programmers, besides geometric modeling tools, were software procedures for lighting and surface shading. Strings of numbers defined the location, direction, intensity, range, and hue of hypothetical light sources (lamps or a sun). The original secret behind the chrome look was that the highlight or shiny spot on an object could be colored independently from the rest of the object, though both received illumination from the same algorithm. Programmers, not in the habit of mixing colors, naively used primary colors: red, green, blue, cyan, magenta, yellow, black, and white. Light is rarely if ever pure white, however—a fact most artists and color scientists know well. Programmers nevertheless conceived of color intellectually rather than perceptually, and lights were invariably set at 100% white. Since plastics characteristically have white highlights, virtual objects generally looked plastic. Metals, on the other hand, have highlights of the same hue as the diffuse or body color. In fact, polished metals are so specular they are largely colored by highlights and have little diffuse color. In computer graphics, a highlight the same hue as the object's diffuse color gave a reasonable illusion of brushed metal. Thus, a gold object with a white highlight looked plastic, while the same object with a golden highlight looked metallic. Quickly mastering this sophistication, programmers expanded their palettes to include silver and gold objects with silvery or golden highlights. Executives and clients thrilled at the semblance of precious metals, and further research was funded.

Software writers strove to expand the definition of virtual lighting and began to seek more physically based solutions. Inadvertently, their efforts promoted chrome, silver, gold, and glass beyond anyone's expectations. As early as the late seventies, a procedure called *ray tracing* was designed to increase realism. Without ray tracing, early 3D objects could be given color, a little texture, and even transparency through coloring vertices in the object's polygon skin. Though they received light and shading, virtual objects cast shadows neither on their "ground" nor upon one another—nor could they reflect each others' colors. Ray tracing produced geometrically accurate reflections and shadows on surfaces, giving birth to a superior order of virtual metal and glass. Even though ray-traced images produced inordinate detail in a sterilized, vacuous space, it was a depiction many people wanted. Ray tracing deserves credit as the single most important algorithm to propagate chrome logos, which in turn secured 3D animation's stronghold in entertainment.

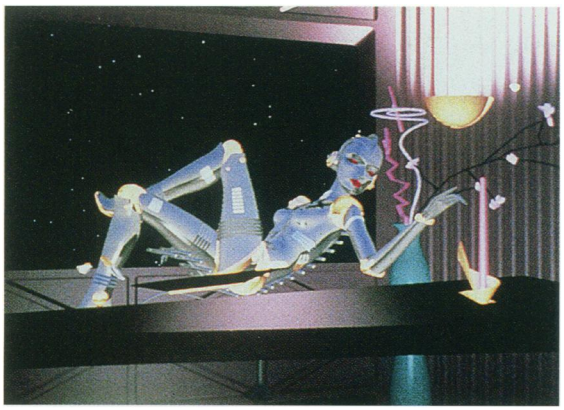
Of course, one limitation posed by any new algorithm of the Chrome Age was how to implement it in the face of the endemic secrecy and information withholding. Corporations pressured programmers to emulate their rivals' spectacular algorithms, but with varying degrees of success. Even if the essential formula for an algorithm—such as ray tracing—was published at SIGGRAPH, the quirks of proprietary software had to be taken into account, and rendering speed was always the chief consideration. Not until the Chrome Age was over did most production companies offer functional code to outsiders, let alone have it for themselves.

The Chrome Age ended around 1987 with the major transformation of the 3D animation business in the mid-eighties, which coincided with a sharp economic recession and changes in the tax laws. Two or three companies came out with expeditious systems for basic 3D that undersold the market for flying logos, hitherto the bread and butter that funded software research. Silicon Graphics introduced the Iris line of workstations. Soon thereafter followed the release of software already written, tested, and ready to drive from Wavefront, Alias, Symbolics, and others—complete with relatively friendly graphical user interfaces. The industry could no longer sustain a cumbersome, back-to-the-drawing-board approach to algorithms for daily production. Abruptly, every Chrome Age computer graphics company save one went bankrupt [17].

Refugee programmers fled to Europe and Japan, helping to launch entertainment graphics there, while others regrouped to create the facilities in business today. The industry widened to include video postproduction houses, which began animating their own flying logos. Realism continued to improve as computer graphics programmers gravitated increasingly to physically based illumination algorithms. The most significant innovation, *radiosity,* finally simulated the soft propagation of light around surfaces, though it has yet to be implemented cost effectively in most commercial applications. In 1988, the parody animation *Flying Logos, Inc.* by Conn, Homer and Associates presented itself as a sardonic eulogy for the Chrome Age, ridiculing the reign of extruded type in the hope (however futile) of burying it once and for all. At the same time as prepackaged software and cheaper, faster computers brought the Chrome Age to an end, the desktop publishing frenzy began. Suddenly everyone wanted to "Be a Graphic Designer (or Look Like One)." Artist's tools became widely available and easy to use on personal computers, putting a new emphasis on creativity. In the squabble over visual imagery, the artist—at long last—could have a chance of competing with the programmer.

A Cornerstone of Late Twentieth Century Design

Given the stupendous progress of computer animation to date, one is compelled to ask why the flashy chrome logo still preponderates in our media. Almost everyone considers it a tasteless display of greed, mediocrity, and homogenized gaudiness—in short, everything despicable in American advertising—yet the chrome logo has been popular for years now in television, movie titles, advertis-

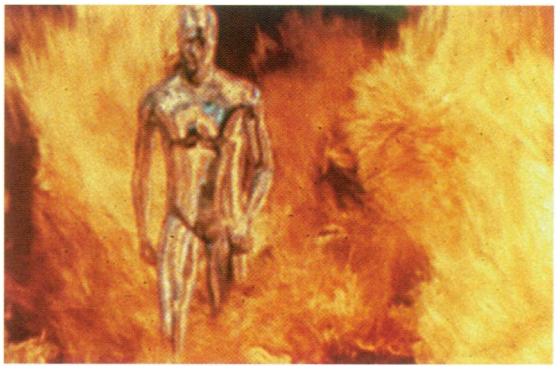


ing, packaging, and even fine art [18]. Although the fanciful hues of pseudo-coloring have lately found their way into broadcast graphics, chrome logos—far from being eliminated—abound as promotions for networks, news, and serious-minded concerns. Computers make it a relatively trivial task to change colors and textures once the geometry is built. With an inexhaustible range of virtual materials with which to dazzle the viewer, it is of historical significance that chrome is so widely used, and not something else say, wood, stone, or high-tech patterns.

Emanating from the center of digital wizardry as it does, exactly what aspect of late twentieth century culture does the flying metal logo express? The answer lies in our unconscious desires—particularly those thwarted by the twists of high technology over the last three decades. How many of us were convinced in the sixties and seventies that we, personally, would visit the moon or sojourn at a distant space station? Of course, we now know *we* will never go, but at least science will go there for us. We have been lucky enough to see distant worlds up close, through satellite and space-expedition imagery—arguably among the most exciting pictures in the history of art. Besides, our disappointment has been subverted by virtual reality, with its promise of escape into a hallucinogenic yet immaculate environment over which we have godlike control. Herein lies the chrome logo's true significance: it serves as a surrogate missile for those of us whose dreams of extraterrestrial travel evaporated with the end of the space race.

Aesthetically, the chrome logo's holographic black background evokes the limitlessness of the cosmos. Our planet is more crowded now than ever before with human presences, but despite our dearest wishes we are earthbound. As we exhaust earthly resources it is little wonder that we turn toward virtual terrain and synthetic gold to exercise our innate territoriality and possessiveness. Only our imaginings can ascend, as always, into heaven—no longer the clouds-and-sunbeams heaven of nineteenth century painting but the late twentieth century heaven of black holes, whirlpool galaxies, and undulating nebulae brought to us by science. Our longing to step back from the planet and reach an inspired consciousness is genuine, even noble, in light of the problems we have yet to solve among ourselves. In these days of scientific visualization, recovered memories, and photomanipulated journalism, the realism of 3D operates as a portal to another dimension—the virtual one where we can manifest in lavish detail whatever our hearts desire. For idealists like me, it is conceivable that visions of unparalleled beauty and peace may one day coexist there alongside the war games and science fiction horrors.

The computer-fabricated silver logo, then, took us on our maiden voyage into virtual reality. Its subsequent incarnations have led to novel amusements—from special-effects movies to motion-based theme parks, from home entertainment centers to video-game arcades. When you strip away the stereoscopic goggles and data suit, or the joystick and motion mechanism, virtual reality is little other than animated 3D computer graphics—a descendant of the chrome lineage.



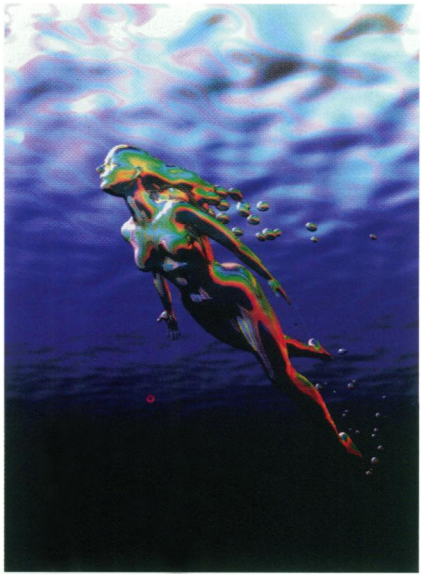


Fig. 7. Icons of the Chrome Age include (a) the sexy female robot, (b) the indestructible T-1000, (c) the melded virtual lovers, and (d) the mermaid-like spirit. Their malleable yet impervious surfaces glamorize utopian aspects of the simulated world. [(a) Still from *Brilliance* appears courtesy of Robert Abel and Associates ©1985. (b) Still from *Terminator 2: Judgement Day* appears courtesy of Carolco Pictures Inc. Motion Picture ©1991 Carolco Pictures Inc. All Rights Reserved. (c) Still from *Lawnmower Man* ©1992, New Line Productions, Inc. and Allied Vision/Lane Pringle. All rights reserved. Photo by Douglas Kirkland. Photo appears courtesy of New Line Productions, Inc. (d) Eiji Takaoki & META Corporation, Japan, from *Venus,* ©1990.]

SCIENCE	VIRTUAL REALITY	ART
Discipline is abstract, theoretical, and immaterial in nature.	Discipline is both abstract and sensorially perceptual in nature.	Discipline is generally physical, concrete, and organic in nature.
Process goes from general denotation to precise abstraction.	Process goes from abstractions to vivid experience.	Process goes from specific, precise abstraction to vital connotation.
Major intent is construction of genuine propositions.	Major intent is simulation of perceptible events.	Major intent is communication of feelings.
Concerned with information.	Concerned with presentation of information as evocative experience.	Concerned with evocation.
Expression of factual truth based on general observation converted into theorems and abstractions.	Expression of appearances and behaviors based on pure data or common observations converted first into data and then into perceptible environments.	Expression of personal, social & political judgments based on individual perception and converted into physical or conceptual works.
Meaningful statements delivered according to strict protocol.	Vivid perceptual experiences delivered by imitating or simulating protocol of actual experiences.	Self-expression delivered by furthering or overturning previous protocol.
Standards for evaluation are accepted and understood universally.	Standards for evaluation are not yet established.	Standards for evaluation are not necessarily accepted or understood without critical interpretation.
Value of contribution to field determined by ability to be reiterated and expanded upon by others.	Value of contribution to field currently determined by intensity, conviction, and singularity of experience.	Value of contribution to field determined by authenticity, originality, singularity of work, and its ability to influence or inspire others.
Cultural status of scientific approach comparable to a major religion.	Cultural status of virtuality currently comparable to a fad or obsession, but still unresolved.	Cultural status of various art "isms" comparable to cults.

Fig. 8. Some attributes that situate virtual reality between science and art.

Dynamic simulations of mirror-finished space are the common denominator of the computerized entertainment industry, and chrome logos are merely their humblest denizens—the made-for-TV version, so to speak.

Undeniably, the decade I've called the Chrome Age (1975-1987) hardly constitutes an age in the ancient sense. To avoid exaggeration, I might have called it the Chrome *Hour,* associating the birth of VR with the time module endemic to television. Lately though, it seems that time accelerates as quickly as our money devalues, and an age simply isn't what it used to be (somehow, the fleeting Space Age seems the most fitting example). When information, machines, software, and markets are outmoded within a few of history's minutes, the "hour" of chrome takes on more significance than one might suspect. If mythology is a measure of cultural sophistication, I am persuaded by the fact that the Chrome Age already has several deities to its credit (Fig. 7). The silver Goddess Supreme is none other than Robert Abel and Associates' sexy robot, while the liquid chrome Lord of the Underworld is the remarkable T-1000 from James Cameron's *Terminator 2: Judgement Day.*

An age is erected by its authors. Yet, like the anonymous artisans of ancient Greece, China, and Egypt, the identities of most Chrome Age programmer-animators have been lost or obscured (if they were ever noted). Still, I suspect their work will occupy many a track on tomorrow's art history CD-ROMs (or whatever format archives take). I interpret the copious and continuing emulation of chrome logos as certification of their noteworthiness in our culture; they have attained a status on a par with Marilyn Monroe, the Beatles, MacDonald's, Disneyland, and Pong. Though still excluded from scholarly critique, the chrome logo is as distinguished an element of twentieth century design as Art Deco's graceful geometry, Art Nouveau's elegant twines, and the psychedelic era's exuberant paisleys. With their nostalgia for postwar automobile fenders and trademarks like Chevrolet, Frigidaire, and Westinghouse, they are a symbol of the American Dream. They

also represent the pre-third-millennium high-tech promises of robots and rocketships—and, of course, computers. Not only do they continue to serve as ideal, sterilized packaging for the evening news, but chrome logos give us a traditional image of riches to replace what we have lost as our financial exchanges are effected increasingly with plastic and paper.

Today's print media owe their reliance on 3D perspective, morphing, and warping directly to Chrome Age tools. Despite its flaws, the flying logo remains an invincible iteration of the word in the heyday of distressed, illegible typographic design. In fact, grunge graphics, dirty-face fonts, and the whole "stupid culture" are, among other things, art's deliberately messy rebellion against science's precision and cleanliness—a rebellion aimed at computer-generated wireframes, grids, and PostScript typography. Science offered images and digital imaging tools that are genuinely new; art responded with the exhausted ruins of letterforms—a personification of distress over the confiscation of its previously exclusive visual territory.

A few years have passed, yet we are still ambivalent about the legitimacy of three-dimensional animation, our legacy from the Chrome Age. Can it ever be art? Or perhaps the question should be, can art ever be Art again, in post-virtual, scientifically visualized reality? And, as artists, what do we do about our continued sibling rivalry with techno-science types who prefer machines to human beings and artificial worlds to the real one—and worse, whose prowess in digital imaging incites our jealousy, rage, and fear? While these may be questions without answers, perhaps we can understand virtual reality better if we see it as a cultural barometer of interests, fears, and hopes common to artists and scientists alike. Whether we like to admit it or not, our reflection in time's mirror shows us to be a culture whose chief fantasy, next to godlike control over the natural world, is the acquisition of fortune in all its nostalgic, buried-treasure-chest glamour. In this light, the chrome logo is an emblem both of the American Dream and of our lurking fear that this dream of free enterprise leading to the good life is as hollow as a computer-animated object. It is the same suspicion we bring to digital technology—fearing that it will empty our lives of the solid, traditional treasures we believe our grandparents had and, like a Midas touch of chrome, leave us with mere simulations of everything in the world, even love. While the sun was rising on the virtual dominion we were momentarily blinded by the glare of flying chrome and mistakenly concluded that commercialized art—already the trash of the art world—had become a kind of indisposable toxic waste. But in retrospect, we were actually witnessing the alchemical moment of science fusing with art and popular entertainment.

Ultimately, the realism potential in software can be understood by artists in one of two ways. Taken at face value, it is the programmer's gift to the artist. Calculated realism is like an instant set of foundation skills. Technique always comes at the beginning of creativity, before expression can develop further. Of course, while the computer can draw images almost as well as a camera takes photographs, we have yet to teach it to invent artistic ideas. Artists can rest assured that human dreams, fantasies, hopes, and imaginings are as indispensable to the future of art and entertainment as they have ever been. We can learn to share imaging with scientists if we see virtual reality as the ultimate studio, not its usurper.

After a more profound analysis, however, virtual reality can be deciphered as an art in its own right, namely, the art of science made manifest (Fig. 8). For artists to dismiss 3D realism in the mistaken belief that it reduces art to craft is no less a crime than for scientists to dismiss Abstract Expressionism for its unforgivable (and possibly intentional) resemblance to a toddler's smears. If art is the creation of forms expressive of human feeling, then virtual reality expresses a profound human passion to understand nature in terms of logical abstractions and reiterative, verifiable formulas—nothing other than the quest of many a scientist. The algorithms of realism convey the deep, almost religious conviction that creation is intelligible by cosmology alone. Just as abstract painting demonstrates to the intellect that profound ideas can be invoked by minimized visuals, virtual reality demonstrates to the eye that the genesis of complex surfaces can be compact, human-determined abstractions. Our culture has become obsessed with the look of success parading as wealth, progress posing as reconciliation between art and science, and science promising a safe landing at the end of our mission into the great mystery of existence. No better icon could represent the art of synthesized universes than chrome—a fabricated veneer masquerading as real metal, the cynosure of art's subjective reality and science's objective verity fused into one.

References and Notes

1. Analects 15:28, from *The Essential Confucius: The Heart of Confucius' Teachings in Authentic I-Ching Order*, translated and presented by Thomas Cleary (New York: Harper Collins, 1992) p. 145.

2. I use the term "computer art" as an umbrella for expressive works, including entertainments, that should be distinguished on the basis of intent from computer science pursuits such as medical visualizations, military simulations, and the like.

3. Chrome, in this context, is a strictly American term that is both noun and adjective. Initially, I was surprised not to find the word "chrome" in British or Canadian English dictionaries. Etymologically, the American "chrome" comes from chromium, as in chromium steel, a lustrous silvery metal alloy used as a corrosion-resistant electroplated coating. During the fifties the word "chrome" became a popular short form for decorative chromium steel automobile fenders, and during the eighties, an adjective for computer-generated shiny logos.

4. Philip B. Meggs's authoritative *History of Graphic Design* (New York: Van Nostrand Reinhold, 1992) is typical in its utter omission of chrome logos, despite coverage of corporate identity, television titles, and computer-generated typography for print.

5. Sequential inked drawings create the illusion of movement when recorded and played back. In film the frame rate is 24 images per second, or 1440 frames per minute, while in television it is 30 frames per second, 1800 per minute. Persistence of vision connects the frames into smooth motion.

6. According to Alvy Ray Smith in conversation, the first electronic painting application was developed at Xerox Parc in 1974. Smith's program Paint, which evolved into one named Images, was conceived at the New York

Institute of Technology and ran initially on Digital Equipment Corporation PDP-11 series VAX computers. The Quantel Paintbox came out in the mid-eighties.

7. Jaron Lanier, an artist, musician, and cybervisionary, is credited with coining the term "virtual reality." Author William Gibson created the word "cyberspace." Yet both of these wonderfully imaginative terms arose in great measure from the decades of software engineering that created 3D space.

8. During the cold war, the American artist was held up as a symbol of freedom of speech and thought. Nowadays, artists are blamed for disturbing society, as evidenced by the recent controversy over whether the National Endowment of the Arts should fund Robert Mapplethorpe, Andres Serrano, and other artists whose work is deemed pornographic or otherwise unacceptable by some people.

9. Timothy Binkley defines digital culture in his landmark essays "Digital Dilemmas" (*Leonardo,* Supplemental Issue: SIGGRAPH '90 Art Show Catalog, 1990, pp. 13–19) and "The Quickening of Galatea" (*Art Journal,* Fall 1990, pp. 233–240).

10. A person who specializes in ideas yet works in the lowest rank of a militarylike structure is generally considered subversive, to be kept under close watch or expelled. I recall the dishonorable discharge of one talented and soon-to-be-pregnant "operator" after she evinced serious concern over electromagnetic emissions—considered potentially dangerous to the fetus—from the display devices. Another artist (yours truly) was temporarily demoted from hands-on animator to hands-off office assistant/secretary after insisting too enthusiastically that z-buffer imagery (wildly colored intermediate renderings used for depth calculation) would make stunning material for a logo treatment.

11. In the short history of computer art, early shows such as "Cybernetic Serendipity" (1966), "The Machine as Seen at the End of the Mechanical Age" (1967), and the first several SIGGRAPH art shows lavishly credited the hardware, the software, and its author (the programmer)—with scarcely an artist in sight.

12. See Timothy Binkley, "The Wizard of Ethereal Pictures and Virtual Places" (*Leonardo,* Supplemental Issue: SIGGRAPH '89 Art Show Catalog, 1989).

13. I am following the recommendation put forth by William Dunning in *Changing Images of Pictorial Space: A History of Spatial Illusion in Painting* (Syracuse, NY: Syracuse University Press, 1991), pp. 43-44. Dunning argues against the term "aerial perspective" and comes down in favor of separate terms for its two features, atmospheric and color perspective. This distinction accords with entries in Leonardo da Vinci's notebooks.

14. In an interview, Eugene Troubetzkoy (of Blue Sky Productions and author of highly respected rendering algorithms) acknowledged the need for better atmospheric and color perspectives, but pointed to the already slow rendering times as the chief limiting factor. To simulate the physical forces underlying these perspectives would require code at least as cumbersome as that required for radiosity. Non–physically based solutions, such as density maps and particle systems, finally appeared in high-end commercial software in the early nineties.

15. *The Notebooks of Leonardo da Vinci,* edited by Pamela Taylor (New York: The New American Library, 1960) p. 61.

16. The virtual theater is like a flotilla in a vast space. Its interchangeable camera positions, delivered through a small screen, resemble elements of the stage combined with cinema and TV.

17. Pacific Data Images (San Francisco) not only survived the demise of the Chrome Age but became one of the industry leaders through such innovations as the morph. Chrome Age companies that went bankrupt included Omnibus (Toronto, New York, and Los Angeles), Robert Abel and Associates (Los Angeles), Digital Effects (New York), Digital Productions (Los Angeles), Magi Synthavision, Cranston Csuri (Chicago), and Fantastic Animation Machine (New York).

18. Photorealist painters Robert Cottingham, Don Eddy, and Richard Estes explored signs and other chromed consumer artifacts; Ken Feingold expressed Buddhist slogans through animated chrome logos in *The Surprising Spiral* (1991); Nancy Dwyer sculpted superlatives in chrome and other metals.

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