Zeuxis meets RealityEngine - Digital Realism and Virtual Worlds

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Prologue

How is the realism of a synthetic image different from the realism of the optical media? Is digital technology in the process of redefining our standards of realism as determined by our experience with photography and film? Do computer games, motion simulators and VR represent a new kind of realism which relies not only on visual illusion but also on the bodily, multi-sensory engagement of the user with a simulated world?

Some of my previous writings addressed these questions in relation to digital cinema, computer animation and digital photography. In this essay, I will discuss a number of characteristics which define visual realism in virtual worlds. By virtual worlds I mean 3D computer-generated interactive environments accessible to one or more users simultaneously. This definition fits a whole range of 3D computer environments already in existence: high-end VR works which feature head-mounted displays and photorealistic graphics generated by RealityEngines or similar expensive computers; arcade, CD-ROM and online multi-player computer games; low-end "desktop VR" systems such as QuickTime VR movies or VRML worlds, which increasingly populate the World Wide Web; graphical chat environments available on the Internet and most other major computer networks. More examples will be available in the near future; indeed, 3D environments represent a growing trend across computer culture, promising to become a new standard in human-computer interfaces and in computer networks. What follows then are a few tentative propositions on digital realism in virtual worlds.

1. Realism as Commodity

Digit in Latin means number. Digital media represents everything as numbers.

This basic property of digital media has a profound effect on the nature of visual realism. In a digital representation, all dimensions that affect the reality effect — detail, tone, color, shape, movement — are quantified. As a consequence, the reality effect produced by the representation can itself be related to a set of numbers.

What are the dimensions which determine realism of a virtual world? First of all, it is determined by spatial and color resolution of images seen by the user, i.e., the number of pixels and the number of colors being used. For instance, given the same scene, a 640 x 480 image will contain more detail and therefore will produce a stronger reality effect than a 120 x 160 image. Second, since the world is modeled with 3D computer graphics, the number of geometric points each object is composed of, i.e. its 3D resolution, also affects the reality effect.

Once the user begins to interact with a world, navigating through space or inspecting the objects in it, other dimensions come into play. One is temporal resolution — the number of frames a computer can generate in a second (the larger the number, the smoother the resulting motion). Another is the speed of the system's response: if the user clicks on an image of a door to open it or asks a virtual character a question, a delay in response breaks the illusion.

All these dimensions are quantifiable. The number of colors in an image, the temporal resolution the system is capable of and so on can be specified in exact numbers. For example, a particular VR system may be capable of displaying images limited to 256 colors at a resolution of 320 x 240 pixels.

These numbers also reflect something else: the cost involved. More bandwidth, higher resolution, faster processing result in a stronger reality effect — and cost more.

The bottom line: the reality effect of a digital representation can be measured in dollars. Realism has become a commodity. It can be bought and sold like anything else.

Not surprisingly, all these numbers are prominently displayed in the advertisements for graphics software and hardware. Even more importantly, those in the business of visual realism — the producers of special effects, military trainers, digital photographers, television designers — now have definite measures for what they are buying and selling. For instance, the Federal Aviation Administration which creates the standards for simulators to be used in pilot training specifies the required realism in terms of 3D resolution. In 1991 it required that for daylight, a simulator must be able to produce a minimum of 1000 surfaces or 4000 points.

Michael Baxandall describes how the price of a painting in the fourteenth century Italy reflected the quantities of expensive colors (such as gold and ultramarine) being used in it. By the end of the twentieth century, it became possible to delegate to a computer both the recipes for producing images as well as their pricing. The users can be billed for number of pixels and points, for CPU cycles, for bandwidth and so on.

It is likely that this situation will be explored by the designers of virtual worlds. If today users are charged for the connection time, in the future they can be charged for visual aesthetics and the quality of the overall experience: spatial resolution; number of colors; complexity of characters (both geometric and psychological); and so on. Since all these dimensions are specified in software, it becomes possible to automatically adjust the appearance of a virtual world on the fly, boosting it up if a customer is willing to pay more.

In this way, the logic of pornography will be extended to the culture at large. Peep shows and sex lines charge their customers by the minute, putting a precise cost on each bit of pleasure. In future virtual worlds, all dimensions of reality will be quantified and priced separately.

Neal Stephenson's 1992 novel "Snow Crash" provides us with one possible scenario of such a future. Entering the Metaverse, the spatialized Net of the future, the hero sees "a liberal sprinkling of black-and-white people — persons who are accessing the Metaverse through

cheap public terminals, and who are rendered in jerky, grainy black and white." He also encounters couples who can't afford custom avatars and have to buy off-the-shelf models, poorly rendered and capable of just a few standard facial expressions — virtual world equivalents of Barbie dolls.

This scenario is gradually becoming a reality. A number of online stock photo services already provide their users with low-resolution photographs for a small cost, charging more for higher resolution copies. A company called Viewpoint Datalabs International is selling thousands of ready-to-use 3D geometric models widely used by computer animators and designers. Its catalog describes the models as follows: "VP4370: Man, Extra Low Resolution. VP4369: Man, Low Resolution. VP4752: Man, Muscular in Shorts and Tennis Shoe. VP5200. Man, w/Beard, Boxer Shorts..." For most popular models you can choose between different versions, with more detailed versions costing more than less detailed ones.

2. Romanticism and Photoshop Filters: From Creation to Selection

Viewpoint Datalabs' models exemplify another characteristic of virtual worlds: they are not created from scratch but assembled from ready-made parts. Put differently, in digital culture creation has been replaced by selection.

E. H. Gombrich's concept of a representational schema and Roland Barthes' "death of the author" helped to sway us from the romantic ideal of the artist creating totally from scratch, pulling images directly from her imagination. As Barthes puts it, "The Text is a tissue of quotations drawn from the innumerable centers of culture." Yet, even though a modern artist may be only reproducing or, at best, combining in new ways preexisting texts and idioms, the actual material process of art making supports the romantic ideal. An artist operates like God creating the Universe — he or she starts with an empty canvas or a blank page. Gradually filling in the details, the artist brings a new world into existence.

Such a process of art making, manual and painstakingly slow, was appropriate for the age of pre-industrial artisan culture. In the twentieth century, as the rest of the culture moved to mass production and automation, literally becoming a "culture industry," art continued to

insist on its artisan model. Only in the 1910s when some artists began to assemble collages and montages from already existing cultural "parts," was art introduced to the industrial method of production.

In contrast, electronic art from its very beginning was based on a new principle: modification of an already existing signal. The first electronic instrument designed in 1920 by the legendary Russian scientist and musician Leon Theremin contained a generator producing a sine wave; the performer simply modified its frequency and amplitude. In the 1960s video artists began to build video synthesizers based on the same principle. The artist was no longer a romantic genius generating a new world purely out of her imagination; he became a technician turning a knob here, pressing switch there — an accessory to the machine.

Substitute a simple sine wave by a more complex signal (sounds, rhythms, melodies); add a whole bank of signal generators and you have arrived at a modern music synthesizer, the first instrument which embodies the logic of all new media: selection from a menu of choices.

The first music synthesizers appeared in the 1950s, followed by video synthesizers in the 1960s, followed by DVE (Digital Video Effects) in the late 1970s — the banks of effects used by video editors; followed by computer software such as 1984 MacDraw that came with a repertoire of basic shapes. The process of art making has finally caught up with modern times. It has become synchronized with the rest of modern society where everything is assembled from ready-made parts; from objects to people's identities. The modern subject proceeds through life by selecting from numerous menus and catalogs of items — be it assembling an outfit, decorating the apartment, choosing dishes from a restaurant menu, choosing which interest groups to join. With electronic and digital media, art-making similarly entails choosing from ready-made elements: textures and icons supplied by a paint program; 3D models which come with a 3D modeling program; melodies and rhythms built into a music program.

While previously the great text of culture from which the artist created her or his own unique "tissue of quotations" was bubbling and shimmering somewhere below the consciousness, now it has become externalized (and greatly reduced in the process) — 2D objects, 3D models, textures, transitions, effects which are available as soon as the artist turns on the computer. The World Wide Web takes this process to the next level: it encourages the creation of texts that completely consist of pointers to other texts that are already on the Web. One does not have to add any original writing; it is enough to select from what already exists. Put differently, now anybody can become a creator by simply providing a new menu, i.e. by making a new selection from the total corpus available.

The same logic applies to much of interactive art and media. It is often claimed that a user of an interactive work becomes its co-author: by choosing a unique path through the elements of a work, she or he supposedly creates a new work. Yet, what the user is actually doing is only activating a part of the total work that already exists. If a complete work is a sum of all possible paths through its elements, then the user following a particular path only accesses a part of this whole. Just as with the Web example, rather than adding to a corpus, the user only selects from it. This is a new type of creativity which corresponds neither to pre-modern idea of providing minor modifications to the tradition nor to the modern idea of a creator-genius revolting against it; it does, however, fit perfectly with the age of mass culture, where almost every practical act involves choosing from some menu, catalog, or database.

The shift from creation to selection also applies to 3D computer graphics — the main technique for building virtual worlds. The amount of labor involved in constructing three-dimensional reality from scratch in a computer makes it hard to resist the temptation to utilize pre-assembled, standardized objects, characters, and behaviors readily provided by software manufacturers — fractal landscapes, checkerboard floors, complete characters and so on. Every program comes with libraries of ready-to-use models, effects or even complete animations. For instance, a user of the Dynamation program (a part of the popular Wavefront 3D software) can access complete pre-assembled animations of moving hair, rain, a comet's tail or smoke, with a single mouse click.

If even professional designers rely on ready-made objects and animations, the end users of virtual worlds on the Internet, who usually don't have graphic or programming skills, have no other choice. Not surprisingly, Web chat lines operators and virtual world providers encourage users to choose from the libraries of pictures, 3D objects, and avatars (graphic icons representing users in virtual worlds) they supply. Ubique's site features "Ubique Furniture Gallery" where one can choose images from such categories as "office furniture," "computers and electronics," and "people icons". VR-SIG from the U.K. provides VRML Object Supermarket while Aereal delivers the Virtual World Factory. The latter aims to make the creation of a custom virtual world particularly simple: "Create your personal world, without having to program! All you need to do is fill-in-the-blanks and out pops your world." Quite soon we will see a whole market for detailed virtual sets, characters with programmable behaviors, and even complete worlds (a bar with customers, a city square, a famous historical episode, etc.) from which a user can put together her or his own "unique" virtual world.

While a hundred years ago the user of a Kodak camera was asked just to push a button, she still had the freedom to point the camera at anything. Now, "you push the button, we do the rest" has become "you push the button, we create your world."

3. Brecht as Hardware

Another characteristic of virtual worlds lies in the peculiar temporal dynamic: constant, repetitive shifts between an illusion and its suspense. Virtual worlds keep reminding us about their artificiality, incompleteness, and constructedness. They present us with a perfect illusion only to reveal the underlying machinery next.

Web surfing circa 1996 provides a perfect example. A typical user may be spending equal time looking at a page and waiting for the next page to download. During waiting periods, the act of communication itself — bits traveling through the network — becomes the message. The user keeps checking whether the connection is being made, glancing back and forth between the animated icon and the status bar. Using Roman Jakobson's model of communication functions, we can say that communication comes to be dominated by

contact, or phatic function — it is centered around the physical channel and the very act of connection between the addresser and the addressee.

Jakobson writes about verbal communication between two people who, in order to check whether the channel works, address each other: "Do you hear me?," "Do you understand me?" But in Web communication there is no human addresser, only a machine. So as the user keeps checking whether the information is coming, she actually addresses the machine itself. Or rather, the machine addresses the user. The machine reveals itself, it reminds the user of its existence — not only because the user is forced to wait but also because she is forced to witness how the message is being constructed over time. A page fills in part by part, top to bottom; text comes before images; images arrive in low resolution and are gradually refined. Finally, everything comes together in a smooth sleek image — the image which will be destroyed with the next click.

Interaction with most 3D virtual worlds is characterized by the same temporal dynamic. Consider the technique called "distancing" or "level of detail," which for years has been used in VR simulations and is now being adapted to 3D games and VRML scenes. The idea is to render the models more crudely when the user is moving through virtual space; when the user stops, details gradually fill in. Another variation of the same technique involves creating a number of models of the same object, each with progressively less detail. When the virtual camera is close to an object, a highly detailed model is used; if the object is far away, a lesser detailed version is substituted to save unnecessary computation.

A virtual world which incorporates these techniques has a fluid ontology that is affected by the actions of the user. As the user navigates through space the objects switch back and forth between pale blueprints and fully fleshed-out illusions. The immobility of a subject guarantees a complete illusion; the slightest movement destroys it.

Navigating a QuickTime VR movie is characterized by a similar dynamic. In contrast to the nineteenth-century panorama that it closely emulates, QuickTime VR continuously deconstructs its own illusion. The moment you begin to pan through the scene, the image

becomes jagged. And, if you try to zoom into the image, all you get are oversized pixels. The representational machine keeps hiding and revealing itself.

Compare this dynamic to traditional cinema or realist theater which aims at all costs to maintain the continuity of the illusion for the duration of the performance. In contrast to such totalizing realism, digital aesthetics have a surprising affinity to twentieth-century leftist avant-garde aesthetics. Bertold Brecht's strategy to reveal the conditions of an illusion's production, echoed by countless other leftist artists, has become embedded in hardware and software themselves. Similarly, Walter Benjamin's concept of "perception in the state of distraction" has found a perfect realization. The periodic reappearance of the machinery, the continuous presence of the communication channel in the message prevent the subject from falling into the dream world of illusion for very long, making her alternate between concentration and detachment.

While virtual machinery itself already acts as an avant-garde director, the designers of interactive media (games, CD-ROM titles, interactive cinema, and interactive television programs) often consciously attempt to structure the subject's temporal experience as a series of periodic shifts. The subject is forced to oscillate between the roles of viewer and user, shifting between perceiving and acting, between following the story and actively participating in it. During one segment the computer screen presents the viewer with an engaging cinematic narrative. Suddenly the image freezes, menus and icons appear and the viewer is forced to act: make choices; click; push buttons. (Moscow media theorist Anatoly Prokhorov describes this process as the shift of the screen from being transparent to being opaque — from a window into a fictional 3D universe to a solid surface, full of menus, controls, text and icons. Three-dimensional space becomes surface; a photograph becomes a diagram; a character becomes an icon.)

The effect of these shifts on the subject is hardly one of liberation and enlightenment. It is tempting to compare them to shot / counter-shot structure in cinema and to understand them as a new kind of suturing mechanism. By having periodically to complete the interactive text through active participation the subject is interpolated in it.

Yet clearly we are dealing with something which goes beyond old realism. We can call this new realism meta-realism since it incorporates its own critique inside itself. Its emergence can be related to a larger cultural change. Old realism corresponded to the functioning of ideology during modernity: totalization of a semiotic field, "false consciousness," complete illusion. But today ideology functions differently: it continuously and skillfully deconstructs itself, presenting the subject with countless "scandals" and "investigations". Correspondingly, new meta-realism is based on oscillation between illusion and its destruction, between immersing a viewer in illusion and directly addressing her.

Can Brecht and Hollywood be married? Is it possible to create a new temporal aesthetic based on cyclical shifts between perception and action? So far, I can think of only one successful example — a military simulator, the only mature form of interactive media. It perfectly blends perception and action, cinematic realism and computer menus. The screen presents the subject with an illusionistic virtual world while periodically demanding quick actions: shooting at the enemy; changing the direction of a vehicle; and so on. In this art form, the roles of a viewer and an actant are blended perfectly — but there is a price to pay. The narrative is organized around a single and clearly defined goal: staying alive.

4. Riegl, Panofsky, and Computer Graphics: Regression in Virtual Worlds

The last feature of virtual worlds that I will address can be summarized as follows: virtual spaces are not true spaces but collections of separate objects. Or: there is no space in cyberspace.

To explore this thesis further, we can borrow the categories developed by art historians early in this century. The founders of modern art history (Alois Riegl, Heinrich Wölfflin, and Erwin Panofsky) defined their field as the history of the representation of space. Working within the paradigms of cyclic cultural development and racial topology, they related the representation of space in art to the spirit of entire epochs, civilizations, and races. In his 1901 "Die Spätrömische Kunstindustrie," Riegl characterized humankind's cultural development as the oscillation between two extreme poles, two ways to understand space, which he called "haptic" and "optic". Haptic perception isolates the object in the field as a

discrete entity, while optic perception unifies objects in a spatial continuum. Riegl's contemporary, Heinrich Wölfflin, similarly proposed that the temperament of a period or a nation expresses itself in a particular mode of seeing and representing space. Wölfflin's "Principles of Art History" (1913) plotted the differences between Renaissance and Baroque on five dimensions: linear — painterly; plane — recession; closed form — open form; multiplicity — unity; and clearness — unclearness. Finally, another founder of modern art history, Erwin Panofsky, contrasted the "aggregate" space of the Greeks with the "systematic" space of the Italian Renaissance in a famous essay "Perspective as a Symbolic Form" (1924-1925). Panofsky established a parallel between the history of spatial representation and the evolution of abstract thought. The former moves from the space of individual objects in antiquity to the representation of space as continuous and systematic in modernity; in Panofsky's neologisms, from "aggregate" space to "systematic" space. Correspondingly, the evolution of abstract thought progresses from ancient philosophy's view of the physical universe as discontinuous to the post-Renaissance understanding of space as infinite, ontologically primal in relation to bodies, homogeneous, and isotropic — in short, as "systematic".

We don't have to believe in grand evolutionary schemes but we can retain the categories themselves. What kind of space is a virtual space? At first glance, 3D computer graphics, the main technology of creating virtual spaces, exemplify Panofsky's concept of Renaissance "systematic" space which exists prior to the objects. Indeed, the Cartesian coordinate system is hardwired into computer graphics software and often into the hardware itself. When a designer launches a modeling program, she is typically presented with an empty space defined by a perspectival grid, the space that will be gradually filled by the objects she will create. If the built-in message of a music synthesizer is a sine wave, the built-in world of computer graphics is an empty Renaissance space, the coordinate system itself.

Yet computer-generated worlds are actually much more "haptic" and "aggregate" than "optic" and "systematic". The most commonly used 3D computer graphics technique to create 3D worlds is polygonal modeling. The virtual world created using this technique is a vacuum filled with separate objects defined by rigid boundaries. A perspective projection creates the illusion that these objects belong together but in fact, they have no connection

to each other. What is missing is space in the sense of space-environment or space-medium: the environment between objects; an atmosphere which unites everything together; the effects of objects on each other. In short, computer space is the opposite of what Russian art historians call prostranstvennaya sreda, defined by Pavel Florensky who taught in Vkhutemas in the early 1920s as follows: "The space-medium is objects mapped onto space… We have seen the inseparability of Things and space, and the impossibility of representing Things and space by themselves." It is also the opposite of space as it is understood in much of modern art which, from Seurat to De Kooning, tried to eliminate the notions of a distinct object and empty space as such. Instead, it proposed a kind of dense field which sometimes harden into something which we can read as an object — an aesthetics which mainstream computer graphics has yet to discover.

Another basic technique used in creating virtual worlds — compositing (superimposing, keying)— also leads to an "aggregate" space. It involves superimposing animated characters, still images, QuickTime movies, and other graphical elements over a separate background. A typical scenario may involve an avatar animated in real time in response to the user's commands. The avatar is superimposed over a picture of a room. An avatar is controlled by the user; a picture of a room is provided by a virtual world operator. Because the elements come from different sources and are put together in real time, the result is a series of 2D planes rather than a real 3D environment.

In summary, although computer-generated virtual worlds are usually rendered in linear perspective, they are really collections of separate objects, unrelated to each other. In view of this, commonly expressed arguments that 3D computer graphics send us back to Renaissance perspectivalism and therefore, from the viewpoint of twentieth-century abstraction, should be considered regressive, turn out to be ungrounded. If we are to apply the evolutionary paradigm of Panofsky to the history of virtual computer space, it has not even achieved its Renaissance yet. It is still on the level of Ancient Greece which could not conceive of space as a totality.

And, if the World Wide Web and VRML 1.0 are any indications, we are not moving any closer toward systematic space; instead, we are embracing "aggregate" space as a new norm,

both metaphorically and literally. The "space" of the Web in principle can't be thought of as a coherent totality: it is a collection of numerous files, hyperlinked but without any overall "perspective" to unite them. The same holds for actual 3D spaces on the Internet. A VRML file which describes a 3D scene is a list of separate objects which may exist anywhere on the Internet, each created by a different person or a different program. The objects have no connection to each other. And, since any user can add or delete objects, no one may even know the complete structure of the scene.

The Web has already been compared to the American Wild West. The spatialized Web as envisioned by VRML (itself a product of California) even more closely reflects the treatment of space in American culture: the lack of attention to space which is not functionally used. The territories that exist between privately owned houses and businesses are left to decay. The VRML universe pushes these characteristics to the limit; it simply does not contain space as such — only objects which belong to different individuals.

And what is an object in a virtual world? Something which can be acted upon: clicked; moved; opened — in short, used. It is tempting to interpret this as another case of regression — in this case, to the world view of an infant. A child does not think of the universe as existing separately from herself — it appears as a collection of unrelated objects with which he can enter in contact: touch; suck on; grab. Similarly, the user of a virtual world tries to click on whatever is in front of him; if the objects do not respond, he is disappointed. In the virtual universe, Descartes' maxim can be rewritten as follows: "I can be clicked on, therefore I exist."

According to a well-known argument of Jean-Louis Baudry, immobility and confinement of cinema's viewers leads them to mistake representations for their perceptions; they regress back to childhood when the two were indistinguishable. Paradoxically, although interactive virtual worlds may appear to turn us into active adults, they actually reduce us once again to children — helplessly clicking on whatever is in front of us; participation becomes yet another kind of regression.

Epilogue

Quantification of all visual and experiential dimensions; ready-made ontology; oscillation between illusion and its suspense; "aggregate" space — these are some of the features which distinguish reality as simulated by a computer.

It should not be surprising that the same features characterize the "larger" reality beyond the computer screen. RealityEngine only caricatures, exaggerates, highlights the tendencies defining the experience of being alive in an advanced capitalist society, particularly in the U.S. The assumption that every aspect of experience can and should be quantified; the construction of one's identity from the menus of tastes, objects, affiliations; constant shifts between illusion and its suspense, be it commercial breaks on TV or endless "scandals" and "investigations" which disrupt the surface of an ideological field; the space lacking a unifying perspective, whether it is a space of an American city or the space of public discourse more and more fragmented by the competition of separate interest groups — all these experiences are transferred by computer designers into software and hardware they create. Rather than being a generator of new alternative reality, RealityEngine is a mirror of existing reality, a lens which focuses the culture around it.

To the extent that Southern California, and particularly Los Angeles, brings to the extreme these tendencies of RL (real life) under American capitalism, we may expect L.A. to offer us a precise model of a virtual world, a physical equivalent to the fictions pumped out by the RealityEngines.

This is exactly the case. If you keep your visit to L.A. short and follow the standard tourist itinerary, you will discover a virtual world with all its features. There is no center, no hint of any kind of centralized organization, no traces of the hierarchy essential to traditional cities. One drives to particular locations defined strictly by their street addresses rather than by spatial landmarks. A trendy restaurant or club can be found in the middle of nowhere, among the miles of completely unremarkable buildings. The whole city feels like a set of particular points suspended in a vacuum, similar to a bookmark file of Web pages. You are immediately charged on arrival to any worthwhile location, again like on the Web

(mandatory valet parking). There you discover the fashionable inhabitants (actors, singers, models, producers) who look like some new race, a result of successful mutation: unbelievably beautiful skin and faces; fixed smiles; and bodies whose perfect shapes surely can't be the result of human evolution. They probably come from the Viewpoint catalog of 3D models. These are not people but avatars: beautifully rendered with no polygons spared; shaped to the latest fashion; their faces switching between a limited number of expressions. Given the potential importance of any communicative contact, subtlety is not tolerated: avatars are designed to release stimuli the moment you notice them, before you have time to click to the next scene.

The best place to experience the whole gestalt is in one of the outdoor cafes on Sunset Plaza in West Hollywood. The avatars sip cappuccino amidst the illusion of 3D space. The space is clearly the result of a quick compositing job: billboards and airbrushed cafe interior in the foreground against a detailed matte painting of Los Angeles with the perspective exaggerated by haze. The avatars strike poses, waiting for their agents (yes, just like in virtual worlds) to bring valuable information. Older customers look even more computer generated, their faces bearing traces of extensive face-lifts. You can enjoy the scene while feeding the parking meter every twenty minutes.

A virtual world is waiting for you; all we need is your credit card number. RealityEngines are tirelessly cranking out the images, pushing pixels around to assure the smoothest possible experience. Enjoy RealityTM!

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[3] Quicktime VR is a software-only system which allows the user of any Macintosh computer to navigate a spatial environment and interact with 3D objects.

[4] VRML stands for The Virtual Reality Modeling Language. Using VRML, Internet users can construct 3D scenes and link them to other Web documents. For examples, see http://www.worlds.net/info/aboutus.html; http://www.ubique.com; http://www.thepalace.com; http://www.blacksun.com; http://www.worldsaway.ossi.com; http://www.fpi.co.jp/Welcome.html; http://www.wildpark.com.

[5] For instance, Silicon Graphics developed a 3D file system which was showcased in the movie Jurassic Park. The interface of Sony's MagicLink personal communicator is a picture of a room while Apple's E-World greets its users with a drawing of a city. Web designers often use pictures of buildings, aerial views of cities, and maps as front ends in their sites. In the words of the scientists from Sony's The Virtual Society Project http://www.csl.sony.co.jp/project/VS/, "It is our belief that future online systems will be characterized by a high degree of interaction, support for multi-media and most importantly the ability to support shared 3D spaces. In our vision, users will not simply access textual-based chat forums, but will enter into 3D worlds where they will be able to interact with the world and with other users in that world."

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[7] Michael Baxandall, Painting and Experience in Fifteenth-century Italy, 2nd ed. (Oxford and New York: Oxford University Press), 8.

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[9] Ibid., 37.

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