An Archeology of a Computer Screen

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1. A Screen

Contemporary human-computer interfaces appear to offer radical new possibilities for art and communication.[1] Virtual reality (VR) allows us to travel through non-existent three-dimensional spaces. A computer monitor connected to a network becomes a window through which we can be present in a place thousands of miles away. Finally, with the help of a mouse or a video camera, a computer is transformed into an intelligent being capable of engaging us in a dialogue.

VR, interactivity and telepresence are made possible by the recent technology of a digital computer. However, they are made real by a much, much older technology -- the screen. It is by looking at a screen -- a flat, rectangular surface positioned at some distance from the eyes -- that the user experiences the illusion of navigating through virtual spaces, of being physically present somewhere else or of being hailed by the computer itself. If computers have become a common presence in our culture only in the last decade, the screen, on the other hand, has been used to present visual information for centuries -- from Renaissance

painting to twentieth-century cinema.

Today, coupled with a computer, the screen is rapidly becoming the main means of accessing any kind of information, be it still images, moving images or text. We are already using it to read the daily newspaper, to watch movies, to communicate with coworkers, relatives and friends, and, most importantly, to work (the screens of airline agents, data entry clerks, secretaries, engineers, doctors, pilots, etc.; the screens of ATM machines, supermarket checkouts, automobile control panels, and, of course, the screens of computers.) We may debate whether our society is a society of spectacle or of simulation, but, undoubtedly, it is the society of a screen. What are the different stages of the screen's history? What are the relationships between the physical space where the viewer is located, his/her body, and the screen space? What are the ways in which computer displays both continue and challenge the tradition of a screen?

2. A Screen's Genealogy

Let us start with the definition of a screen.

Visual culture of the modern period, from painting to cinema, is characterized by an intriguing phenomenon: the existence of another virtual space, another three-dimensional world enclosed by a frame and situated inside our normal space. The frame separates two absolutely different spaces that somehow coexist. This phenomenon is what defines the screen in the most

general sense, or, as I will call it, the "classical screen."

What are the properties of a classical screen? It is a flat, rectangular surface. It is intended for frontal viewing (as opposed to, for instance, a panorama). It exists in our normal space, the space of our body, and acts as a window into another space. This other space, the space of representation, typically has a different scale from the scale of our normal space.

Defined in this way, a screen describes equally well a Renaissance painting (recall Alberti) and a modern computer display. Even proportions have not changed in five centuries, they are similar for a typical fifteenth century painting, a film screen and a computer screen. (In this respect it is not accidental that the very names of the two main formats of computer displays point to two genres of painting: a horizontal format is referred to as "landscape mode" while the vertical format is referred to as "portrait mode.")

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A hundred years ago a new type of screen became popular, which I will call the "dynamic screen." This new type retains all the properties of a classical screen while adding something new: it can display an image changing over time. This is the screen of cinema, television, video.

The dynamic screen also brings with it a certain relationship between the image and the spectator -- a certain viewing regime, so to speak. This relationship

is already implicit in the classical screen but now it fully surfaces. A screen's image strives for complete illusion and visual plenitude while the viewer is asked to suspend disbelief and to identify with the image. Although the screen in reality is only a window of limited dimensions positioned inside the physical space of the viewer, the latter is supposed to completely concentrate on what is seen in this window, focusing attention on the representation and disregarding the physical space outside. This viewing regime is made possible by the fact that, be it a painting, movie screen or television screen, the singular image completely fills the screen. This is why we are so annoyed in a movie theater when the projected image does not precisely coincide with the screen's boundaries: it disrupts the illusion, making us conscious of what exists outside the representation.[2]

Rather than being a neutral medium of presenting information, the screen is aggressive. It functions to filter, to screen out, to take over, rendering non-existent whatever is outside its frame. And although, of course, the degree of this filtering varies between cinema viewing (where the viewer is asked to completely merge with the screen's space) and television viewing (where the screen is smaller, lights are on, conversation between viewers is allowed, and the act of viewing is often integrated with other daily activities), overall, this viewing regime remains stable -- until recently.

This stability has been challenged by the arrival of the computer screen. On the one hand, rather than

showing a single image, a computer screen typically displays a number of coexisting windows. (Indeed, the coexistence of a number of overlapping windows has become a fundamental principle of modern computer interface since the introduction of the first Macintosh computer in 1984.) No single window completely dominates the viewer's attention. In this sense the possibility of simultaneously observing a few images which coexist within one screen can be compared with the phenomenon of zapping -- the quick switching of television channels that allows the viewer to follow more than program.[3] In both instances, the viewer no longer concentrates on a single image. (Some television sets now enable a second channel to be watched within a smaller window positioned in a corner of the main screen. Perhaps future TV sets will adopt the window metaphor of a computer.) A window interface has more to do with modern graphic design, which treats a page as a collection of different but equally important blocks of data (text, images, graphic elements), than with cinema.

On the other hand, with VR, the screen disappears altogether. VR typically uses a head-mounted display whose images completely fill viewer's visual field. No longer is the viewer looking forward at a rectangular, flat surface located at a certain distance and which acts as a window into another space. Now s/he is fully situated within this other space. Or, more precisely, we can say that the two spaces, the real, physical space and the virtual simulated space, coincide. The virtual space, previously confined to a painting or a movie screen, now completely encompasses the real space.

Frontality, rectangular surface, difference in scale are all gone. The screen has vanished.

Both situations (window interface and VR) disrupt the viewing regime which characterizes the historical period of the dynamic screen. This regime, based on the identification of the viewer with a screen image, reaches its culmination in the cinema which goes to the extreme to enable this identification (the bigness of the screen, the darkness of the surrounding space) while still relying on a screen (a rectangular flat surface).

Thus, as we celebrate a hundred years of cinema (the first paid public presentation of a film took place in December of 1895), we should also celebrate -- and mourn -- the era of the dynamic screen which began with cinema and is ending now. And it is this disappearance of the screen -- its splitting into many windows in window interface, its complete take over of the visual field in VR -- that allows us today to recognize it as a cultural category and begin to trace its history.

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The origins of the cinema's screen are well known. We can trace its emergence to the popular spectacles and entertainment of the eighteenth and nineteenth centuries: magic lantern shows, phantasmagoria, eidophusikon, panorama, diorama, zoopraxiscope shows, and so on. The public was ready for cinema and when it finally appeared it was a huge public event. Not by accident the "invention" of cinema was claimed by at

least a dozen of individuals from a half-dozen countries.[4]

The origin of the computer screen is a different story. It appears in the middle of this century but it does not become a public presence until much later; and its history has not yet been written. Both of these facts are related to the context in which it emerged: as with all the other elements of modern human-computer interface, the computer screen was developed by the military. Its history has to do not with public entertainment but with military surveillance.

The history of modern surveillance technologies begins at least with photography. From the advent of photography there existed an interest in using it for aerial surveillance. FŽlix Tournachon Nadar, one of the most eminent photographers of the nineteenth century, succeeded in exposing a photographic plate at 262 feet over Bi□vre, France in 1858. He was soon approached by the French Army to attempt photo reconnaissance but rejected the offer. In 1882, unmanned photo balloons were already in the air; a little later, they were joined by photo rockets both in France and in Germany. The only innovation of World War I was to combine aerial cameras with a superior flying platform -- the airplane.[5]

Radar became the next major surveillance technology. Massively employed in World War II, it provided important advantages over photography. Previously, military commanders had to wait until the pilots returned from surveillance missions and the film was developed. The inevitable delay between the time of

the surveillance and the delivery of the finished image limited its usefulness because by the time the photograph was produced, enemy positions could have changed. However, with radar, as imaging became instantaneous, this delay was eliminated. The effectiveness of radar had to do with a new means of displaying an image -- a new type of screen.

Consider the imaging technologies of photography and film. The photographic image is a permanent imprint corresponding to a single referent (whatever was in front of the lens when the photograph was taken) and to a limited time of observation (the time of exposure). Film is based on the same principle. A film sequence, composed of a number of still images, represents the sum of referents and the sum of exposure times of these individual images. In either case, the image is fixed once and for all. Therefore the screen can only show past events.

With radar, we see for the first time the mass employment (television is founded on the same principle but its mass employment comes later) of a fundamentally new type of screen, the screen which gradually comes to dominate modern visual culture -- video monitor, computer screen, instrument display. What is new about such a screen is that its image can change in real time, reflecting changes in the referent, be it the position of an object in space (radar), any alteration in visible reality (live video) or changing data in the computer's memory (computer screen). The image can be continually updated in real time. This is the third (after classic and dynamic) type of a screen -- the screen of real

time.

The radar screen changes, tracking the referent. But while it appears that the element of time delay, always present in the technologies of military surveillance, is eliminated, in fact, time enters the real-time screen in a new way. In older, photographic technologies, all parts of an image are exposed simultaneously. Whereas now the image is produced through sequential scanning: circular in the case of radar, horizontal in the case of television. Therefore, the different parts of the image correspond to different moments in time. In this respect, a radar image is more similar to an audio record since consecutive moments in time become circular tracks on a surface.[6]

What this means is that the image, in a traditional sense, no longer exists! And it is only by habit that we still refer to what we see on the real-time screen as "images." It is only because the scanning is fast enough and because, sometimes, the referent remains static, that we see what looks like a static image. Yet, such an image is no longer the norm, but the exception of a more general, new kind of representation for which we don't have a term yet.

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The principles and technology of radar were worked out independently by scientists in the United States, England, France and Germany during the 1930s. But, after the beginning of the War only the U.S. had the necessary resources to continue radar development. In 1940, at

MIT, a team of scientists was gathered to work in the Radiation Laboratory or the "Rad Lab," as it came to be called. The purpose of the lab was radar research and production. By 1943, the "Rad Lab" occupied 115 acres of floor space; it had the largest telephone switchboard in Cambridge and employed 4,000 people.[7]

Next to photography, radar provided a superior way to gather information about enemy locations. In fact, it provided too much information, more information than one person could deal with. Historical footage from the early days of the war shows a central command room with a large, table-size map of Britain.[8] Small pieces of cardboard in the form of planes are positioned on the map to show the locations of actual German bombers. A few senior officers scrutinize the map. Meanwhile, women in army uniforms constantly change the location of the cardboard pieces by moving them with long sticks as information is transmitted from dozens of radar stations.[9]

Was there a more effective way to process and display information gathered by radar? The computer screen, as well as all of the other key principles and technologies of modern human-computer interface -- interactive control, algorithms for 3-D wireframe graphics, bit-mapped graphics -- were developed as a way of solving this problem.

The research again took place at MIT. The Radiation Laboratory was dismantled after the end of the War, but soon the Air Force created another secret laboratory in its place -- Lincoln Laboratory. The purpose of Lincoln Laboratory was to work on human factors and new display

technologies for SAGE -- "Semi-Automatic Ground Environment," a command center to control the U.S. air defenses established in the mid-1950s.[10] Paul Edwards writes that SAGE's job "was to link together radar installations around the USA's perimeter, analyze and interpret their signals, and direct manned interceptor jets toward the incoming bee. It was to be a total system, one whose 'human components' were fully integrated into the mechanized circuit of detection, decision and response."[11]

Why was SAGE created and why did it require a computer screen? In the 1950s the American military thought that when the Soviet Union attacked the U.S., it would send a large number of bombers simultaneously. Therefore, it seemed necessary to create a center which could receive information from all U.S. radar stations, track the large number of enemy bombers and coordinate the counterattack. A computer screen and the other components of the modern human-computer interface owe their existence to this particular military doctrine.

The earlier version of the center was called the Cape Cod network since it received information from the radars situated along the coast of New England. The center was operating right out of the Barta Building situated on the MIT campus.

Each of 82 Air Force officers monitored his own computer display which showed the outlines of the New England Coast and the locations of key radars. Whenever an officer noticed a dot indicating a moving plane, he would tell the computer to follow the plane. To do this the officer simply had to touch the dot with the special

"light pen."[12]

Thus, the SAGE system contained all of the main elements of the modern human-computer interface. The light pen, designed in 1949, can be considered a precursor of the contemporary mouse. More importantly, at SAGE the screen came to be used not only to display information in real time (as in radar and television) but also to give commands to the computer. Rather than acting solely as a means to display an image of reality, the screen became the vehicle for directly affecting reality.

Using the technology developed for SAGE, Lincoln researchers created a number of computer graphics programs that relied on the screen as a means to input and output information from a computer. They included programs to display brain waves (1957), simulate planet and gravitational activity (1960), as well as to create 2-D drawings (1958).[13] The single most well known of these became a program called Sketchpad. Designed in 1962 by Ivan Sutherland, a graduate student supervised by Claude Shannon, it widely publicized the idea of interactive computer graphics. With Sketchpad, a human operator could create graphics directly on computer screen by touching the screen with a light pen. Sketchpad exemplified a new paradigm of interacting with computers: by changing something on the screen, the operator changed something in the computer's memory. The real-time screen became interactive.

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This, in short, is the history of the computer screen.[14] But even before a computer screen became widely used, a new paradigm emerged -- the simulation of an interactive three-dimensional environment without a screen. In 1966, Ivan Sutherland and his colleagues began research on the prototype of VR. The work was cosponsored by ARPA (Advanced Research Projects Agency) and the Office of Naval Research.[15]

"The fundamental idea behind the three-dimensional display is to present the user with a perspective image which changes as he moves," wrote Sutherland in 1968.[16] The computer tracked the position of the viewer's head and adjusted the perspective of the computer graphic image accordingly. The display itself consisted of two six-inch-long monitors which were mounted next to the temples. They projected an image which appeared superimposed over viewer's field of vision.

The screen disappeared. It completely took over the visual field.

3. The Screen and the Body

I have presented one possible genealogy of the modern computer screen. In my genealogy, the computer screen represents an interactive type, a subtype of the real-time type, which is a subtype of the dynamic type, which is a subtype of the classical type.

My discussion of these types relied on two ideas. First, the idea of temporality: the classical screen displays a static, permanent image; the dynamic screen

displays a moving image of the past and finally, the real-time screen shows the present. Second, the relationship between the space of the viewer and the space of the representation (I defined the screen as a window into the space of representation which itself exists in our normal space).

Let us now look at the screen's history from another angle -- the relationship between the screen and the body of the viewer.

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This is how Roland Barthes described the screen in "Diderot, Brecht, Eisenstein," written in 1973:

Representation is not defined directly by imitation: even if one gets rid of notions of the "real," of the "vraisemblable," of the "copy," there will still be representation for as long as a subject (author, reader, spectator or voyeur) casts his gaze towards a horizon on which he cuts out a base of a triangle, his eye (or his mind) forming the apex. The "Organon of Representation" (which is today becoming possible to write because there are intimations of something else) will have as its dual foundation the sovereignty of the act of cutting out [dŽcoupage] and the unity of the subject of action... The scene, the picture, the shot, the cut-out rectangle, here we have the very condition that allows us to conceive theater, painting, cinema, literature, all those arts, that

is, other than music and which could be called dioptric arts.[17]

For Barthes, the screen becomes the all-encompassing concept which covers the functioning of even non-visual representation (literature), even though he does make an appeal to a particular visual model of linear perspective. At any rate, his concept encompasses all types of representational apparatuses I have discussed: painting, film, television, radar and computer display. In each of these, reality is cut by the rectangle of a screen: "a pure cut-out segment with clearly defined edges, irreversible and incorruptible; everything that surrounds it is banished into nothingness, remains unnamed, while everything that it admits within its field is promoted into essence, into light, into view."[18] This act of cutting reality into a sign and nothingness simultaneously doubles the viewing subject who now exists in two spaces: the familiar physical space of his/her real body and the virtual space of an image within the screen. This split comes to the surface with VR, but it already exists with painting and other dioptric arts.

What is the price the subject pays for the mastery of the world, focused and unified by the screen?

"The Draughtsman's Contrast," a 1981 film by Peter Greenway, concerns an architectural draftsman hired to produce a set of drawings of a country house. The draughtsman employs a simple drawing tool consisting of a square grid. Throughout the film, we repeatedly see the draughtsman's face through the grid which looks like

the prison bars. It is as if the subject who attempts to catch the world, to immobilize it, to fix it within the representational apparatus (here, perspectival drawing), is trapped by this apparatus himself. The subject is imprisoned.

I take this image as a metaphor for what appears to be a general tendency of the Western screen-based representational apparatus. In this tradition, the body must be fixed in space if the viewer is to see the image at all. From Renaissance monocular perspective to modern cinema, from Kepler's camera obscura to nineteenth century camera lucida, the body had to remain still.

The imprisonment of the body takes place on both the conceptual and literal levels; both kinds of imprisonment already appear with the first screen apparatus, Alberti's perspectival window. According to many interpreters of linear perspective, it presents the world as seen by a singular eye, static, unblinking and fixated. As described by Norman Bryson, perspective "followed the logic of the Gaze rather than the Glance, thus producing a visual take that was eternalized, reduced to one 'point of view' and disembodied."[19] Bryson argues that "the gaze of the painter arrests the flux of phenomena, contemplates the visual field from a vantage-point outside the mobility of duration, in an eternal moment of disclosed presence."[20] Correspondingly, the world, as seen by this immobile, static and atemporal Gaze, which belongs more to a statue than to a living body, becomes equally immobile, reified, fixated, cold and dead. Writing about DŸrer's famous print of a draftsman drawing a nude through a

screen of perspectival threads, Martin Jay notes that "a reifying male look" turns "its targets into stone"; consequently, "the marmoreal nude is drained of its capacity to arouse desire."[21] Similarly, John Berger compares Alberti's window to "a safe let into a wall, a safe into which the visible has been deposited."[22] And in "The Draughtsman's Contrast," time and again, the draughtsman tries to eliminate all motion, any sign of life from the scenes he is rendering.

With perspectival machines, the imprisonment of the subject also happens in a literal sense. From the onset of the adaptation of perspective, artists and draftsmen have attempted to aid the laborious manual process of creating perspectival images and, between the sixteenth and nineteenth centuries, various "perspectival machines" were constructed.[23] By the first decades of the sixteenth century, Durer described a number of such machines.[24] Many varieties were invented, but regardless of the type, the artist had to remain immobile throughout the process of drawing.

Along with perspectival machines, a whole range of optical apparatuses was in use, particularly for depicting landscapes and conducting topographical surveys. The most popular optical apparatus was camera obscura.[25] Camera obscura literally means "dark chamber." It was founded on the premise that if the rays of light from an object or a scene pass through a small aperture, they will cross and re-emerge on the other side to form an image on a screen. In order for the image to become visible, however, "it is necessary that the screen be placed in a chamber in which light levels

are considerably lower than those around the object."[26] Thus, in one of the earliest depictions of the camera obscura, in Kircher's Ars magna Lucis et umbrae (Rome, 1649), we see the subject enjoying the image inside a tiny room, oblivious to the fact that he had to imprison himself inside this "dark chamber" in order to see the image on the screen.

Later, smaller tent-type camera obscura became popular -- a movable prison, so to speak. It consisted of a small tent mounted on a tripod, with a revolving reflector and lens at its apex. Having positioned himself inside the tent which provided the necessary darkness, the draftsman would then spend hours meticulously tracing the image projected by the lens.

Early photography continued the trend toward the imprisonment of the subject and the object of representation. During photography's first decades, the exposure times were quite long. The daguerreotype process, for instance, required exposures of 4 to 7 minutes in the sun and from 12 to 60 minutes in diffused light. So, similar to the drawings produced with the help of camera obscura, which depicted reality as static and immobile, early photographs represented the world as stable, eternal, unshakable. And when photography ventured to represent the living, such as the human subject, s/he had to be immobilized. Thus, portrait studios universally employed various clamps to assure the steadiness of the sitter throughout the lengthy time of exposure. Reminiscent of the torture instruments, the iron clamps firmly held the subject in place, the subject who voluntarily became the prisoner of the

machine in order to see her/his own image.[27]

Toward the end of the nineteenth century, the petrified world of the photographic image was shattered by the dynamic screen of the cinema. In "The Work of Art in the Age of Mechanical Reproduction," Walter Benjamin expressed his fascination with the new mobility of the visible:

> Our taverns and our metropolitan streets, our offices and furnished rooms, our railroad stations and our factories appeared to have us locked up hopelessly. When came the film and burst this prison-world asunder by the dynamite of the tenth of a second, so that now, in the midst of its far-flung ruins and debris, we calmly and adventurously go traveling.[28]

The cinema screen enabled audiences to take a journey through different spaces without leaving their seats; in the words of Anne Friedberg, it created "a mobilized virtual gaze."[29] However, the cost of this virtual mobility was a new, institutionalized immobility of the spectator. All around the world large prisons were constructed which could hold hundreds of prisoners -- movie houses. The prisoners could not neither talk to each other nor move from seat to seat. While they were taken on virtual journeys, their bodies had to remain still in the darkness of the collective camera obscuras.

The formation of this viewing regime took place in parallel with the shift from what film theorists call "primitive" to "classical" film language.[30] An important

part of the shift, which took place in the 1910s, was the new functioning of the virtual space represented on the screen.

During the "primitive" period, the space of the film theater and the screen space were clearly separated much like those of theater or vaudeville. The viewers were free to interact, come and go, and maintain a psychological distance from the cinematic diegisis.

In contrast, classical film addressed each viewer as a separate individual and positioned her/him inside the diegetic space. As noted by a contemporary in 1913, "they [spectators] should be put in the position of being a 'knot hole in the fence' at every stage in the play."[31] If "primitive cinema keeps the spectator looking across a void in a separate space,"[32] now the spectator is placed at the best viewpoint of each shot, inside the virtual space.

This situation is usually conceptualized in terms of the spectator's identification with the camera eye. The body of the spectator remains in the seat while her/his eye is coupled with a mobile camera. However, it is also possible to conceptualize this differently. We can imagine that the camera does not, in fact, move at all, that it remains stationary, coinciding with the spectator's eyes. Instead, it is the virtual space as a whole that changes its position with each shot. Using the contemporary vocabulary of computer graphics, we can say that this virtual space is rotated, scaled and zoomed to always give the spectator the best viewpoint. Like a striptease, the space slowly disrobes itself, turning, presenting itself from different sides,

teasing, stepping forward and retracting, always leaving something unrevealed, so the spectator will wait for the next shot ... the endless seductive dance. All spectator has to do is remain immobile.

Film theorists have taken this immobility to be the essential feature of the institution of cinema. Friedberg wrote: "As everyone from Baudry (who compares cinematic spectation to the prisoners in Plato's cave) to Musser points out, the cinema relies on the immobility of the spectator, seated in an auditorium."[33] Jean-Louis Baudry has probably more than anyone put the emphasis on immobility as the foundation of cinematic illusion. Baudry quoted Plato: "In this underground chamber they have been from childhood, chained by the leg and also by the neck, so that they cannot move and can only see what is in front of them, because the chains will not let them turn their heads."[34] This immobility and confinement, according to Baudry, enables prisoners/spectators to mistake representations for their perceptions, regressing back to childhood when the two were indistinguishable. Thus, rather than a historical accident, according to Baudry's psychoanalytic explanation, the immobility of the spectator is the essential condition of cinematic pleasure.

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Alberti's window, Durer's perspectival machines, camera obscura, photography, cinema -- in all of these screen-based apparatuses, the subject had to remain immobile.

In fact, as Friedberg perceptively points out, the progressive mobilization of the image in modernity was accompanied by the progressive imprisonment of the viewer: "as the 'mobility' of the gaze became more 'virtual' -- as techniques were developed to paint (and then to photograph) realistic images, as mobility was implied by changes in lighting (and then cinematography) -- the observer became more immobile, passive, ready to receive the constructions of a virtual reality placed in front of his or her unmoving body."[35]

What happens to this tradition with the arrival of a screen-less representational apparatus -- VR?

On the one hand, VR does constitute a fundamental break with this tradition. It establishes a radically new type of relationship between the body of a viewer and an image. In contrast to cinema, where the mobile camera moves independent of the immobile spectator, now the spectator has to actually move around the physical space in order to experience the movement in virtual space. The effect is as though the camera is mounted on user's head. So, in order to look up in virtual space, one has to look up in physical space; in order to "virtually" step forward one has to actually step forward and so on.[36] The spectator is no longer chained, immobilized, anesthetized by the apparatus which serves him the ready-made images; now s/he has to work, to speak, in order to see.

At the same time, VR imprisons the body to an unprecedented extent before. This can be seen clearly with the earliest VR system designed by Sutherland and his colleagues in the 1960s to which I have already

referred. According to Howard Rheingold's history of VR, "Sutherland was the first to propose mounting small computer screens in binocular glasses -- far from an easy hardware task in the early 1960s -- and thus immerse the user's point of view inside the computer graphic world."[37] Rheingold further wrote:

In order to change the appearance of the computer-generated graphics when the user moves, some kind of gaze-tracking tool is needed. Because the direction of the user's gaze was most economically and accurately measured at that time by means of a mechanical apparatus, and because the HMD [head-mounted display] itself was so heavy, the users of Sutherland's early HMD systems found their head locked into machinery suspended from the ceiling. The user put his or her head into a metal contraption that was known as the 'Sword of Damocles' display.[38]

A pair of tubes connected the display to tracks in the ceiling, "thus making the user a captive of the machine in a physical sense."[39] The user was able to turn around and rotate her/his head in any direction but s/he could not move away from the machine more than few steps. Like today's computer mouse, the body was tied to the computer. In fact, the body was reduced to nothing else -- and nothing more -- than a giant mouse, or more, precisely, a giant joystick. Instead of moving a mouse, the user had to turn her/his own body. Another comparison which comes to mind is the apparatus built in

the late nineteenth century by Etienne-Jules Marey to measure the frequency of the wing movements of a bird. The bird was connected to the measuring equipment by wires which were long enough to enable it to flap its wings in midair but not fly anywhere.[40]

The parodox of VR that requires the viewer to physically move in order to see an image (as opposed to remaining immobile) and at the same time physically ties her/him to a machine is interestingly dramatized in a "cybersex" scene in Hollywood's "Lawnmower Man." In the scene, the heroes, a man and a woman, are situated in the same room, each fastened to a separate circular frame which allows the body to freely rotate 360 degrees in all directions. During "cybersex" the camera cuts back and forth between the virtual space (i.e., what the heroes see and experience) and the physical space. In the virtual world represented with psychedelic computer graphics, their bodies melt and morph together disregarding all the laws of physics, while in the real world each of them simply rotates within his/her own frame.

The paradox reaches its extreme in one of the most long standing VR projects -- the Super Cockpit developed by the U.S. Air Force in the 1980s.[41] Instead of using his own eyes to follow both the terrain outside of his plane and the dozens of instrument panels inside the cockpit, the pilot wears a head-mounted display that presents both kinds of information in a more efficient way. What follows is a description of the system from Air & Space magazine:

When he climbed into his F16C, the young fighter jock of 1998 simply plugged in his helmet and flipped down his visor to activate his Super Cockpit system. The virtual world he saw exactly mimicked the world outside. Salient terrain features were outlined and rendered in three dimensions by the two tiny cathode ray tubes focused at his personal viewing distance...His compass heading was displayed as a large band of numbers on the horizon line, his projected flight path a shimmering highway leading out toward infinity.[42]

If in most screen-based representations (painting, cinema, video) as well as in typical VR applications the physical and the virtual worlds have nothing to do with each other, here the virtual world is precisely synchronized to the physical one. The pilot positions himself in the virtual world in order to move through the physical one at a supersonic speed with his representational apparatus which is securely fastened to his body, more securely than ever before in the history of the screen.

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In summary, on the one hand, VR continues the screen's tradition of viewer immobility by fastening the body to a machine, while on the other hand, it creates an unprecedented new condition, requiring the viewer to move. We may ask, in conclusion, whether this new

condition is without an historical precedent or whether it fits within some other alternative tradition we so far have not noticed.

In Ancient Greece, communication was understood as an oral dialogue between people. It was also assumed that physical movement stimulated dialogue and the process of thinking. Aristotle and his pupils walked around while discussing philosophical problems. In the Middle Ages, a shift occured from a dialogue between subjects to communication between a subject and an information storage device, i.e., a book. A Medieval book chained to a table can be considered a precursor to the screen.

The screen, as I defined it (a flat rectangle that acts as a window into the virtual world), makes its appearance in the Renaissance with modern painting. Previously, frescoes and mosaics were inseparable from the architecture. In contrast, a painting is essentially mobile. Separate from a wall, it can be moved anywhere.

But at the same time, an interesting reversal takes place. The interaction with a fresco or a mosaic, which can't be moved anywhere, does not assume immobility on the part of the spectator, while the mobile Renaissance painting does presuppose such immobility.

Do frescoes, mosaics and wall paintings, which are all part of the architecture, represent this alternative tradition I am searching for, the tradition which encourages the movement of the viewer?

I began my discussion of the screen by emphasizing that a screen's frame separates two spaces, the physical and the virtual, which have different scales. Although

this condition does not necessarily lead to the immobilization of the spectator, it does discourage any movement on her or his part: Why move when s/he can't enter the represented virtual space anyway? This was very well dramatized in "Alice in Wonderland" when Alice struggles to become just the right size in order to enter the other world.

The alternative tradition of which VR is a part can be found whenever the scale of a representation is the same as the scale of our human world so that the two spaces are continuous. This is the tradition of simulation rather than that of representation bound up to a screen. One example is mosaics, frescoes and wall paintings which create an illusionary space that starts behind the surface. The nineteenth century, with its obsession with naturalism, pushes this trend to the extreme with the wax museum and the dioramas of natural history museums. Another example is a sculpture on a human scale (for instance, Auguste Rodin's "The Burghers of Calais"). We think of such sculptures as part of post-Renaissance humanism which puts the human at the center of the universe, when in fact, they are aliens, black holes within our world into another parallel universe, the petrified universe of marble or stone, which exists in parallel to our own world ...

VR continues this tradition of simulation. However, it introduces one important difference. Previously, the simulation depicted a fake space which was continuous with and extended from the normal space. For instance, a wall painting created a psuedo landscape which appeared to begin at the wall. In VR, either there is no

connection between the two spaces (for instance, I am in a physical room while the virtual space is one of an underwater landscape) or, on the contrary, the two completly coincide (i.e., the Super Cockpit project). In either case, the actual physical reality is disregarded, dismissed, abandoned.

In this respect, nineteenth century panorama can be thought of as a transitional form from classical simulations (wall paintings, human size sculpture, diorama) toward VR. Like VR, panorama creates a 360 degree space. The viewers are situated in the center of this space and they are encouraged to move around the central viewing area in order to see different parts of the panorama.[43] But in contrast to wall paintings and mosaics which, after all, acted as decorations of a real space, the physical space of action, now this physical space is subordinate to the virtual space. In other words, the central viewing area is conceived as a continuation of fake space (rather than vice versa as before), and this is why it is empty. It is empty so that we can pretend that it continues the battlefield, or a view of Paris or whatever else the panorama represents. From here we are one step away from VR where the physical space is totally disregarded and all the "real" actions take place in virtual space. The screen disappeared because what was behind it simply took over.

* * *

And what about the immobilization of the body in VR which connects it to the screen tradition? Dramatic as

it is, this immobilization probably represents the last act in the long history of the body's imprisonment. All around us are the signs of increasing mobility and the miniaturization of communication devices -- cellular telephones and modems, pagers and laptops. Eventually VR apparatus will be reduced to a chip implanted in a retina and connected by cellular transmission to the Net. From that moment on, we will carry our prisons with us -- not in order to blissfully confuse representations and perceptions (as in cinema), but to always "be in touch," always connected, always "plugged-in." The retina and the screen will merge.

This futuristic scenario may never become a reality. For now, we clearly live in the society of a screen. The screens are everywhere: the screens of airline agents, data entry clerks, secretaries, engineers, doctors, pilots, etc.; the screens of ATM machines, supermarket checkouts, automobile control panels, and, of course, the screens of computers. Dynamic, real-time and interactive, a screen is still a screen. Interactivity, simulation, and telepresence: like centuries ago, we are still looking at a flat rectangular surface, existing in the space of our body and acting as a window into another space. Whatever new era we may be entering today, we still have not left the era of a screen.

NOTES

1 The earlier versions of this essay have been presented at the "Generated Nature" symposium (Rotterdam, November 1994) and the "NewMediaLogia" symposium (Moscow, November 1994). I am grateful to the participants of

both symposia as well as to the students in my "Visual Theory" seminar for their many very useful comments and suggestions.

2 The degree to which a frame that acts as a boundary between the two spaces is emphasized seems to be proportional to the degree of identification expected from the viewer. Thus, in cinema, where the identification is most intense, the frame as a separate object does not exist at all -- the screen simply ends at its boundaries -- while both in painting and in television the framing is much more pronounced.

3 Here I agree with the parallel suggested by Anatoly Prokhorov between window interface and montage in cinema.

4 For these origins, see, for instance, C.W. Ceram, _Archeology of the Cinema_ (New York: Harcourt, Brace & World, Inc., 1965).

5 Beaumont Newhall, _Airborne Camera_ (New York: Hastings House, Publishers, 1969).

6 This is more than a conceptual similarity. In the late 1920s John H. Baird invented "phonovision," the first method for the recording and the playing back of a television signal. The signal was recorded on Edison's phonograph's record by a process very similar to making an audio recording. Baird named his recording machine "phonoscope." Albert Abramson, _Electronic Motion Pictures_ (University of California Press, 1955), 41-42.

7 _Echoes of War_ (Boston: WGBH Boston, n.d.), videotape.

8 Ibid.

9 Ibid.

10 On SAGE, see Paul Edwards, "The Closed World. Systems discourse, military policy and post-World War II U.S. historical consciousness," in _Cyborg Worlds: The Military Information Society_, eds. Les Levidow and Kevin Robins (London: Free Association Books, 1989); Howard Rheingold, _Virtual Reality_ (New York: Simon & Schuster, Inc., 1991), 68-93.

11 Edwards, 142.

12 "Retrospectives II: The Early Years in Computer Graphics at MIT, Lincoln Lab, and Harvard," in _SIGGRAPH '89 Panel Proceedings_ (New York: The Association for Computing Machinery, 1989), 22-24.

13 Ibid., 42-54.

14 I will address important later developments such as bitmapped display and

window interface in a future article.

15 Rheingold, 105.

16 Qtd. in Rheingold, 104.

17 Roland Barthes, "Diderot, Brecht, Eisenstein," in _Images-Music-Text_, ed. Stephen Heath (New York: Farrar, Straus and Giroux, 1977), 69-70.

18 Ibid.

19 As summarized by Martin Jay, "Scopic Regimes of Modernity," in _Vision and Visuality_, ed. Hal Foster (Seattle: Bay Press, 1988), 7.

20 Qtd. in Ibid, 7.

21 Ibid, 8.

22 Qtd. in Ibid., 9.

23 For a survey of perspectival instruments, see Martin Kemp, _The Science of Art_ (New Haven: Yale University Press, 1990), 167-220.

24 Ibid., 171-172.

25 Ibid., 200.

26 Ibid.

27 Anesthesiology emerges approximately at the same time.

28 Walter Benjamin, "The Work of Art in the Age of Mechanical Reproduction," in _Illuminations_, ed. Hannah Arendt (New York: Schochen Books, 1969), 238.

29 Anne Friedberg, _Window Shopping: Cinema and the Postmodern_ (Berkeley: University of California Press, 1993), 2.

30 See, for instance, David Bordwell, Janet Steiger and Kristin Thompson, _The Classical Hollywood Cinema_ (New York: Columbia University Press, 1985).

31 Qtd. in Ibid., 215.

32 Ibid., 214.

33 Friedberg, 134. She refers to Jean-Louis Baudry, "The Apparatus: Metapsychological Approaches to the Impression of Reality in the Cinema," in _Narrative, Apparatus, Ideology_, ed. Philip Rosen (New York: Columbia University Press, 1986) and Charles Musser, _The Emergence of Cinema: The American Screen to 1907_ (New York: Charles Scribner and Sons, 1990).

34 Qtd. in Baudry, 303.

35 Friedberg, 28.

36A typical VR system adds other ways of moving around, for instance, the

ability to move forward in a single direction by simply pressing a button on a joystick. However, to change the direction the user still has to change the position of his/her body.

37 Rheingold, 104.

38 Ibid., 105.

39 Ibid., 109.

40 Marta Braun, _Picturing Time: The Work of Etienne-Jules Marey (1830-1904)_ (Chicago: The University of Chicago Press, 1992), 34-35.

41 Rheingold, 201-209.

42 Qtd. in Ibid., 201.

43 Here I disagree with Friedberg who writes, "Phantasmagorias, panoramas, diaramas -- devices that concealed their machinery -- were dependent on the relative immobility of their spectators." (23)