"Thick & thin: 'direct manipulation'
& the spatial regimes of human-computer interaction"

Terry Harpold
Department of English
4008 Turlington Hall
University of Florida
Gainesville, FL 32611-7310

Abstract.

Consider a design trajectory, figured on one end by the screens of early command-line computer interfaces and ColecoVision's *Donkey Kong*™ (1981), and on the other, by the more complex and finely-rendered spaces depicted in *Tomb Raider® III: The Adventures of Lara Croft* (1999), and Apple's newly-released Mac OS X.

Lara Croft runs, jumps, tumbles, and blasts away at her opponents in visual fields which are more subtle and perspectivally sophisticated than those inhabited by Mario and Donkey Kong. The responses of the images shown on the screen to the user's keyboard, gamepad or joystick have been enormously enhanced, in both quickness and variety. But the fundamental spatial tropology – the tropology *of* space: abstract space, *empty* space, space that doesn't get in the way of the player or her agents on the other side of the glass – remains consistent, from the earliest to the most recent examples of both desktop computing interfaces and computer gaming. The conceptual and psychological commonplace that grounds play in the domains inhabited by Mario and Lara, and the principles of "direct manipulation" in the graphical user interface, is the assumption of *a permeable field of agency*, essentially free of substance or resistance – or marked only by the sorts of resistance which a more efficient gamepad, a faster processor, or a more "intuitive" visual metaphor, may eliminate.

In this paper, I propose that the "thin" spaces typical of the modern GUI and videogaming appear self-evident or "intuitive" to users and designers because they draw upon conventions of spatial thought which strategically foreclose traits of actual embodied encounters of human-computer interaction. It is desirable, I argue, to reconceive the forms

of space commonly presupposed by the contemporary discourses of the GUI: to grasp these spaces materially, not as empty domains, open to the user's purposive manipulations of objects sited within them, but rather as persistantly impermeable, resistant – "thick" – spaces, in which objects are only imperfectly manipulated, and incompletely detachable from the lived moment of the interaction.

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1. Knowledge on the Screen

Fig. 1. Donald Norman describes the advantages of the GUI, in his *Defending Human Attributes in the Age of the Machine* (1994). ©1994 The Voyager Company. Used by permission.

This is Donald Norman, from his 1994 CD-ROM for Voyager, *Defending Human Attributes in the Age of the Machine:*

> In the early days of computers,when you turned it on, there wasn't anything there. There was no way of knowing what it is you could do. You had to have it memorized. You had to have all the knowledge in your head. [TH: At this point, a black MS-DOS screen changes to a circa 1994 Mac Finder – Figure 1] Today we've changed that. We've put a lot of knowledge on the screen to help you. You don't have to remember as much. You can just look. So we have menu bars above us. We have icons on the

> screen. We have a trash can. All of these are visual aids, putting knowledge there that lets you easily recollect what you must do. (1089)

As Norman calls out the names of elements of the Mac OS's graphical user interface (GUI), a miniature Norman walks along the frame of a simplified computer screen, pointing to each element. This brief intervention in the mostly static pages of an "Expanded Book"[1] underscores his claim for the self-evidentiary qualities of the Mac OS, through a consciously cinematic gesture: recasting the on-screen field as an open, permeable domain, within which an agent (in this case, Norman) moves freely, and into which other objects are projected. "You can just look," Norman says, and the little Norman seems to prove the claim. The advantages of this new and better way of depicting knowledge on the screen are, well, obvious – so long, however, as nothing gets between between the eye and the things it regards.

Whatever non-pictorial or non-iconic signifiers they may include, digital artifacts in the era of the GUI are understood chiefly by being *seen*. Users' and designers' understanding and expectations of them are informed by largely unacknowledged schemes of space, visuality, and agency, which nonetheless are crucial to their function. Designers tend to ignore the influence of these schemes, I suspect, for two reasons. First, many of them take these forms of spatial representation to be natural or self-evident. They are unaware of the extensive critical and philosophical literature which asserts that relations of embodied

[1] Voyager's name for the HyperCard™-based CD-ROM series that includes Norman's text.

space and agency, and of seeing to knowing, are more complex, inconsistent, and contested than Norman's formula suggests. Second, designing interfaces in this way appears to work – and work very well – for a specific task domain, though the fact that the domain is specific is rarely acknowledged. The forms of spatial thought encoded in Norman's praise of the GUI are, as I will observe later, typical of dominant spatial regimes of our time.[2] What this means in practical terms is that the user of a GUI is predisposed to expect human-computer interfaces to work in much the way they aim to work, even if she is unaware that this predisposition may be produced by the artifacts which seem to support it.

Critics and designers of new media should be wary of the epistemological sleight of hand that makes this seem easy or obvious. To say that the GUI puts knowledge "on the screen" – a version of Norman's signature distinction between "knowledge in the head" and "knowledge in the world" – may be appropriate for pragmatic analysis of the GUI's dominance of desktop computing.[3] Nonetheless, it leaves little room for critical thinking about the spatiality of the digital field or the conditions of knowledge it presumes, because it too narrowly circumscribes the terms of investigation.

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[2] My use of the term, "spatial regimes" is a nod to Martin Jay's analysis of the "scopic regimes" of modernity [10]. See my discussion of Jay, below.

[3] That the icon- and window-laden fields of GUI screens are also called "desktops" demonstrates the remarkable efficacy of the GUI. As Ted Nelson pointed out more than a decade ago [16], these images don't look *at all* like the surfaces of desks. But the effect of a strong metaphor is such that it tends to eliminate from our awareness experience that doesn't fit that metaphor.

"You can just look," Norman promises of the GUI. But *just* looking is, strictly speaking, impossible for the intractably inconsistent consciousness we summarily describe as the "user." *Looking* will always be caught between moments of seeing and *not* seeing, bracketed and deformed by historical, cultural and technical practices which determine the viewer's grasp of what it means to *see* anything at all. Before we can carefully discuss the siting of something called knowledge "on the screen," we need to investigate the assumption, widely held by designers of human-computer interfaces, that the spaces of the screen within which looking happens start off as *empty*, and empty in a particular way.

An important clue that this is all more complicated than it may at first appear is the frequent and explicit conflation in descriptions of the GUI of the attitude of seeing and the relation of knowing or understanding. Norman's praise of the "visual aids" of the GUI is one example of this. Another is a distinction made by Bruce Tognazzini between (merely) "graphical" and "visible" interfaces:

> A visible interface is a complete environment in which users can work comfortably, always aware of where they are, where they are going, and what objects are available to them along the way. To be labeled a graphical interface, an interface need only make use of objects that have a distinct graphical representation. Many aspects of the graphical interface may remain invisible. ([23], xiii)[4]

[4] Tognazzini's use of the term "visible" is evocative of Norman's use of that word in *The Design of Everyday Things*: "The user needs help. Just the right things have to be visible: to indicate what parts operate and how, to indicate how the user is to interact with the device. Visibility indicates the mapping between intended actions and actual operations" ([17], 30).

The "visible" interface is a name for the ideal to which the GUI plainly aspires: it hides nothing that would be of interest or value to the user; nothing is missing; nothing is obscured; nothing gets in the way.[5] The much-touted usability and "intuitiveness" of GUIs depend on this myth of perceptual and conceptual transparency. If that transparency is impaired in any way, the interface will fail Tognazzini's benchmark. "When we set about to fool the senses through a very carefully constructed reality," he writes, "it becomes very important that we have no hidden rules that violate the user's sense of trust" ([23], 240).

In this context, the user's mastery of objects on the screen – the formal term is "direct manipulation" or "direct engagement" [9, 20] – is strictly determined by the GUI's substitution of visuality for other orders of relation. In 1982, David Canfield Smith described this substitution as the signal achievement of the new "desktop" interface of the Xerox STAR, the first commercial implementation of a GUI (Figure 2):

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[5] Neal Stephenson's criticism [22] of the pervasiveness of the GUI and the decline of the command-line interface – that the former oversimplifies what the latter reveals to be complicated – differs from Norman and Tognazzini's celebration of the GUI only in Stephenson's preference for text and syntagm over window and menu. All three critics begin with the assumption that human-computer interaction may be (or *should* be) exhaustively encoded in forms of the screen, that the secrets of the system's inner domains may be revealed to the user who is able to interpret the appropriate glyphs.

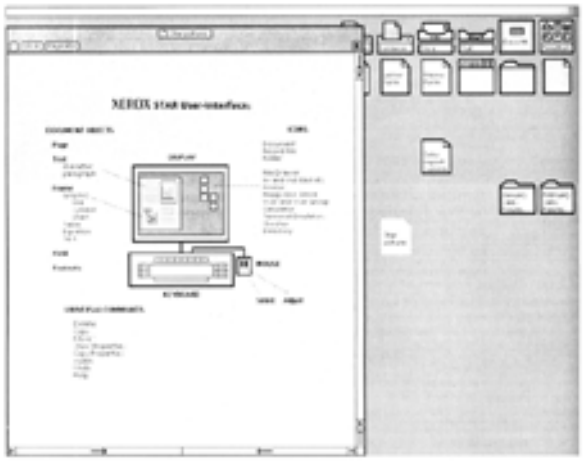

Fig. 2. The Desktop of XEROX's Star Information System (1981). (From Smith, *et al.*, "Designing the Star User Interface," 256). ©1981 XEROX Corp. Used by permission.

> A subtle thing happens when everything is visible: *the display becomes reality*. The user model becomes identical with what is on the screen. Objects can be understood purely in terms of their visible characteristics. Actions can be understood in terms of their effects on the screen. This lets users *conduct experiments* to test, verify, and expand their understanding – the essence of experimental science ("Designing the Star User Interface," 260).[6]

Smith's enthusiasm for visual catachresis – the iconic, figurative ambiguities of the interface collapse into a way of simply naming what is seen on the screen – is echoed in Hutchins, Holland, and Norman's 1986 still broader claims for the transformative experience of direct manipulation:

> The point is that when an interface presents a world of action rather than a language of description, manipulating a representation can have the same effects and the same feel as manipulating the thing being represented. The members of the audience of a well-staged play will fully suspend their beliefs that the players are actors and become directly engaged in the content of the drama. In a similar way, the user of a well designed model world interface can willfully suspend belief that the objects depicted are artifacts of some program and can thereby directly engage the world of the objects.

[6] For discussion in a similar vein, see [11].

([9], 99)

This alchemical metamophosis from a "language of description" to "a world of action" is not effected simply by a technical a shift from a command-line interface to a GUI (as a common misreading of Norman's "you can just look" might suggest). A command-line interface easily can be, as Douglas Engelbart's NLS demonstrated as early as 1968 [4], constructed on design principles similar to those voiced by Tognazzinni, Hutchins, Holland, and Norman. The thread of conceptual continuity across all these interface strategies, and the basis of any claim that an interface approaches the idealized encounters of direct manipulation, is the consistency with which they address the fields in which looking, naming, and doing take place.

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2. Thick and Thin Spaces

Personal computing has undergone innumerable changes in the last twenty years, but in this area, most of the effort seems to have gone into technical refinement rather than critical investigation of reigning scopic and spatial conventions. Aqua, the interface of Apple's recently-released OS X (Figure 3), may be the most programmatic encoding to date of these conventions.[7]

[7] OS X is not unique among GUIs in using translucent widgets and antialiased shadows to suggest visual depth on the monitor screen – though Apple's new GUI may be the most complete and consistent implementation of these schemes. Recent releases of the K Desktop Environment for Linux (KDE), for example, have incorporated some translucent elements. Windows XP, Microsoft's recently-announced GUI

Fig. 3. Aqua, the desktop interface for Apple Computer's OS X (2001). ©2001 Apple Computer, Inc. Used by permission.

Hard-core fans of the command line are likely to dismiss the extravagance and graphical nuances of the Mac OS X desktop as so much eye candy, a constrained computing environment masquerading as an interactive space by virtue of putting on an especially showy dress.[8] But this complaint, I would argue, misses the real aim of Mac OS X's lush visual redesign, which is to bind cultural conventions of spatial complexity, depth, and transparency to practices of computing which don't fully conform to those conventions. The masquerade of visual depth is, in an important sense, precisely candy for the eye, a self-conscious artifice. No user would mistake the overlapping and translucent frames of this desktop for "real" – that is, embodied – spatial fields, just as no viewer schooled in

for future versions of the Windows OS, also appears to incorporate similar elements. Given Apple's traditional role as a pathbreaker in the personal computing industry, it is probable that other OSes will adopt traits of OS X, and widget translucency is likely to be among them. On the use of transparent and transluscent interface widgets in general, see [1].

[8] This is, in a somewhat caricatured form , Stephenson's complaint [22].

these matters would mistake pictorial or filmic spaces for those of the world off the canvas or the screen.[9] Since the invention of linear perspectival method in Italy in the early 15th century, a lexicon of specific visual cues (projection lines, vanishing points, lengthening shadows, etc.) has informed the discourses of verisimilitude in traditions of scientific visualization, industrial and commercial graphic design which have most shaped the visual toolbox of the GUI.[10] This reliance on perspectival technologies as the privileged measures of an image's "realism" was extended and solidified by practices of modern photography and cel animation, as the simple convex lens appeared to concretize and objectify scopic relations of linear perspective. The nearly direct line of descent from the camera obscura to the cathode ray tube has embedded these conventions in the visual and spatial logic of the computer display.

But our responses to these visual conventions are always – if not always consciously – adaptable. We take them to be markers of a reliable representation of the realms of the eye. Yet we also understand implicitly that they belong to a domesticated, geometrically sanitized version of those realms. In this way, the "visibility" of a GUI's spatial forms –

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[9] Contrary to often-repeated claims that early cinema goers naively confused images on the screen with "real" objects and events, this was clearly not the case [5].

[10] See Mullett and Sano [14]. On the larger historical question of the role of perspectivalist technique in Western spatial thought, Damisch and Panofsky [2, 18] are valuable sources. But see also Elkins [3] for a more subtle imbrication of spatial thinking and artistic practice. He argues (convincingly) that the Renaissance inventors of linear perspective never mistook it for a unifying optical practice (as Enlightenment critics would have it, and as perspective is now widely understood), but accepted it as only one of the tools available to the painter. Jay [10] emphasizes that the varieties of scopic and spatial technique in Western art and science have been far more varied and inconsistent than claimed by historians of what he terms "Cartesian perspectivalism."

"visible" as Tognazzini might use the word – is a function of both a tacit acceptance of visual conventions, and a pragmatic willingness to suspend some of them, if circumstances require it.

Fig. 4. Left: Microsoft's Bob™ interface for home computing. ©1995 Microsoft Corporation. Used by permission. Right: General Magic's Magic Cap™ interface for PDAs. ©1995 General Magic, Inc. Used by permission.

Thus, the history of the GUI suggests that overly-rigid implementations of screen-based interaction in "real-world" forms are destined to fail – Microsoft's Bob™ interface for desktop computers and General Magic's Magic Cap™ interface for handheld communicators are good examples of this fatal strategy (Figure 4). Mullet and Sano argue that these schemes must fail, not because they aren't "real" enough to fool the eye, but because their crude literalism works against the need for some kinds of digital data to be manipulated in ways not tied to visual depth ([15], 36). The fictions of the "real-world" interactive spaces in Figure 4, for example, fracture as soon as the user "opens" her check register or address book, where she is confronted by visual fields that (at best) relegate drop shadows, translucency, and the like to the margins. Successful GUIs thereform tend to

apply strategies of frank spatial hybridity, mixing flat and deep visual fields. For example, a drop-down menu will cast a subtle shadow on the objects "behind" it, but the menu items are displayed on the plainest of fields, and the letterforms will have no dimensionality.[11] These hybrid approaches do not, however, challenge the basic spatial production which acts as the conceptual and procedural support for the rest of the interface. Whatever inconsistencies appear in the visual framework of the desktop remain subject to an overarching representational logic that fuses spatial depth – more precisely, spatial emptiness – and the user's efficient manipulation of the desktop.

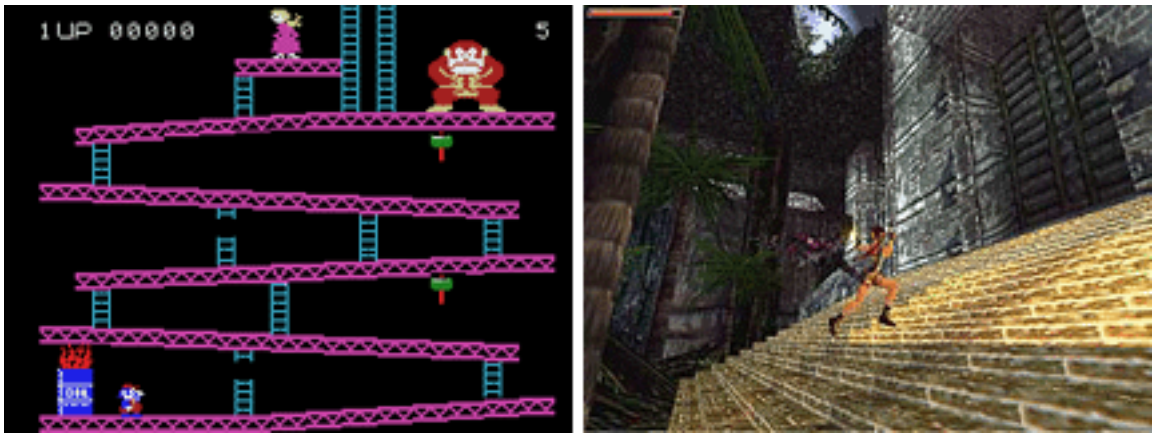

Fig. 5. Left: ColecoVision's release of the Nintendo classic, *Donkey Kong*™ (1981). Right: *Tomb Raider III: The Adventures of Lara Croft* (1999). ©1999 Core Design. Used by permission.

Visual conventions of spatial depth and manipulation have played a more conspicuous role in the evolution of videogaming during the period of the GUI's rise to dominance.[12]

[11] The use of anti-aliased screen fonts in menus and window titles aims at improving their readability, not creating an illusion of depth.

[12] For the purposes of simplifying this (very schematic) historical overview, I won't distinguish between spatial discourses specific to coin-operated arcade, television console, and desktop computer games. I follow Poole's lead in labelling all of these forms, "videogames" [19].

Consider a design trajectory, figured on one end by the screens of ColecoVision's 1981 release of *Donkey Kong*™, one of the first videogames to move beyond the purely planar schema of early games like *Pong*, *Space Invaders*, or *Pac-Man*,[13] and on the other, by the more complex and finely-rendered spaces of the 1999 release of *Tomb Raider® III: The Adventures of Lara Croft* (Figure 5). Lara runs, tumbles, and blasts away at her opponents within spaces more elaborate and subtle than those inhabited by Mario and Donkey Kong.[14] The responsiveness of objects depicted on the screen to the user's keyboard, gamepad, or joystick has increased enormously, in both quickness and variety. But the fundamental spatial tropology – the tropology *of* space: abstract space, *empty* space, space that doesn't get in the way – is consistent from the earliest to the most recent examples of gameplay.

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[13] See Le Diberder and Le Diberder, and Wolf [11, 24] for differing taxonomies of spatial representations in these early video games. See also Poole's discussion [19] of the early history of videogaming, and the evolution of three-dimensional gameplay.

[14] Though that distinction may not be true of *SuperMario 64* (1996), which discarded the platform architecture of the classic Mario games in favor of more complex spatial representations – in many ways, resembling those of "serious" action games, like the *Tomb Raider* series. Many Mario purists have complained that the newer, more spatially "realistic" variation of the game has sacrificed much of the charm and conceptual simplicity of the original.

Fig. 6. Left: *Space Invaders*. ©1979 Taito. Right: *Oni*. ©2001, Bungie Software. Used by permission.

As is true of most GUIs, the visual fields of videogames are typically hybridized in certain ways. The game's action ostensibly takes place in two- or three-dimensional domains in which objects, people, monsters, etc., look pretty much as they might in a "real" world – that is, they aren't emblazoned with titlebars, menus, buttons, and the like. But game designers, facing the need to communicate vital information to the player that can't be gleaned from action on the screen – how many lives does a character have remaining, how many bullets are in her gun, what's the current score? – resort to the use of counters or controls displayed over the gameplay, in the margins, or called up with a special keystroke (Figure 6). These visual inconsistencies don't programmatically challenge the overall fiction of spatial openness – their usual position in the foreground or periphery of the game window or screen reinforces the illusion that the events of gameplay somehow take place *behind* them. They are almost always a minor element in the game's graphic design, which is overwhelmingly dimensional; and designers will go to great lengths to

give these violations of the space of the game a look and feel that evokes the game's visual sensibilities.[15]

The principles of direct manipulation in the modern GUI and play in the spaces peopled by Mario and Lara are grounded by a single conceptual commonplace: the assumption of *a prior permeable field of agency*, free or nearly free of resistance – or marked only by the sorts of resistance that a more efficient keypad, a faster processor or video card, or a more "intuitive" or "natural" visual metaphor, might eliminate. I've been referring to this field of agency as "empty" or "transparent" space (its idealized instance), but a more accurate term would be "thin" space – a form of space which is *very nearly* emptied out beforehand, so that movement within it and mastery of the objects it contains is minimally challenging to the user. In an important sense, the user is constituted *as* a user by her successful penetration into and traversal of this space. This is what the startup screen of the GUI signals; the desktop icon zooming out into a directory window; the expressly cinematic full-motion video sequence that "sets up" the story of the game; the constant running, tumbling, flying down corridors, tunnels, and narrow alleyways: the first effect of the graphic interface *cum* visible interface is to open up a space before you, already thinned out, ready for your purposive movement *inside*.

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[15] The cognitive significance of these interruptions in the game's visual orders – they are signals to the user that the events on the screen are embedded in a larger psychic and cultural dynamic – has been, I think, underestimated. See [7].

Thin space will take on different casts, depending on the contexts of its production. It will be shaped and bounded by requirements of input devices, screen sizes, rendering speeds, and OS conventions and fashions. But its underlying structure is consistent and decisive. Putting "knowledge on the screen" (Norman really means "behind" the screen – the distinction is not inconsequential) is possible – that is, conceivable – only if the shared domain of the user's eye and objects she observes may be freely traversed by her or the avatars who act in her place. Norman misses something vital to understanding the spatial regimes of the human-computer interface when he observes that there was "nothing" in the black void of the C-prompt, until the GUI revealed its secrets. There was – there is – a very *particular* sort of nothing, a nothing which prepared the way for the expectation that something may come to be in its place.

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3. The Spatial Regimes of Human-Computer Interaction

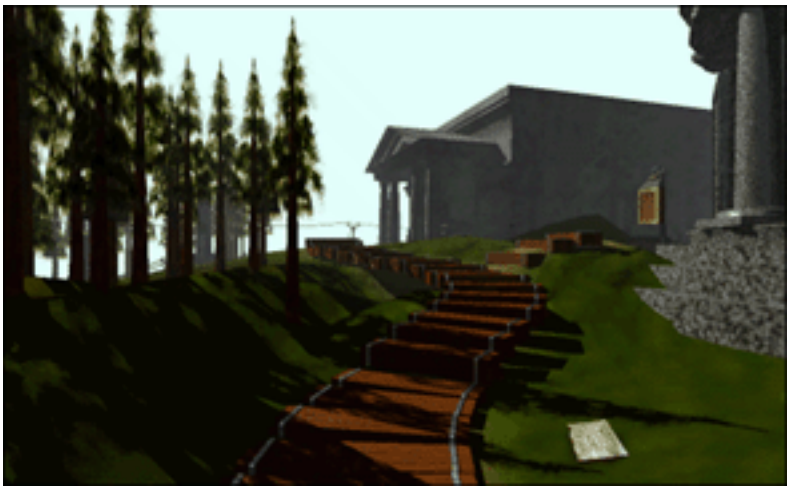

Fig. 7. *Myst* (1993). ©1993 Cyan Interactive. Used by permission.

> The real world is the best user interface there is. And it's an invisible interface. Or at least it's something we've all learned. So we tried to make something that was as close to the real world as possible, and that meant the absence of any kind of computer interface, like buttons and things like that.
>
> – Robyn Miller, "The Making of *Myst*," 42.

Robyn Miller's claim that the "real world" is an "invisible" interface is not a contradiction of Tognazzini's praise of the "visible" interface. Both are, I would argue, versions of an epistemic scheme, which also undergirds the exuberant rhetoric of direct manipulation: the ideal interface would be the *thinnest* of interfaces – that is, the interface in which manipulation is *direct* manipulation because its field has been conceptually and procedurally emptied out before the interaction begins.This form of space is not, however, an *a priori,* given condition of interaction: it is produced and sustained by historically- and culturally-bracketed understandings of visuality and spatial form. Discursive practices of

spatial emptying are among the most privileged methods of psychic and political coercion of the post-Enlightenment period [9, 13]. They are also, as I have noted elsewhere, among the methods by which specifically cybercultural regimes of spatiality pattern themselves on pernicious traditions of scientific positivism, national-political identity, and social normativity [6, 8].

An important step toward a critical-theoretical understanding of the peculiar spaces of human-computer interaction lies, I suggest, in learning to think carefully about the forms of space presupposed by the GUI and the fields of gameplay. These are not uncontested domains – as Martin Jay has observed of practices of visuality of the modern era, it is most accurate to say that there are multiple, overlapping, and inconsistent scopic regimes at work in the art and science of our time. This is true as well, I think, of the spatial regimes of the GUI. The history of contested spatiality in art, science, and politics *off* the computer screen, can point the way toward a careful spatial practice *of* the computer screen. Those debates may even provide strategies of design that break the epistemic confines of direct manipulation. The visual fields of contemporary GUIs are irreducibly hybrid; their inconsistencies demonstrate technical and conceptual limits of the common instances of this odd sort of place we call "cyberspace." Every space – and this includes the spaces of the human-computer interaction – will be at least a little thick: impermeable, imperfectly or incompletely manipulable, stuck in an historical, cultural, and psychic materiality that

stops up efforts to empty it out. We need better ways of looking, where the space of looking and knowing thicken.

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4. References

[1] Bier, Eric M., *et al.* "A Taxonomy of See-through Tools." *Readings in Human-Computer Interaction: Toward the Year 2000*. Eds. Ronald M. Baecker, *et al.* 2d ed. San Francisco: Morgan Kaufman Publishers, 1995. 517–23.

[2] Damisch, Hubert. *The Origin of Perspective*. Trans. John Goodman. Cambridge, MA: MIT Press, 1994.

[3] Elkins, James. *The Poetics of Perspective*. Ithaca: Cornell University Press, 1994.

[4] Engelbart, Douglas C., and William K. English. "A Research Center for Augmenting Human Intellect." Stanford Research Institute, Menlo Park, CA, December 9, 1968. RealVideo™ streaming video. <http://sloan.stanford.edu/MouseSite/1968Demo.html>.

[5] Gunning, Tom. "An Aesthetic of Astonishment: Early Film and the (In)Credulous Spectator." *Viewing Positions: Ways of Seeing Film*. Ed. Linda Williams. New Brunswick, NJ: Rutgers University Press, 1994. 114–33.

[6] Harpold, Terry. "Dark Continents: Critique of Internet Metageographies." *Postmodern Culture* 9.2 (1999). <http://muse.jhu.edu/journals/pmc/v009/9.2harpold.html>

[7] Harpold, Terry. "The Misfortunes of the Digital Text." *The Emerging Cyberculture: Literacy, Paradigm, and Paradox*. Ed. Stephanie B. Gibson and Ollie O. Oviedo. Cresskill, NJ: Hampton Press, 2000. 129–49.

[8] Harpold, Terry, and Kavita Philip. "Of Bugs and Rats: Cyber-Cleanliness, Cyber-Squalor, and the Fantasy-Spaces of Informational Globalization." *Postmodern Culture* 11.1 (2000). <http://muse.jhu.edu/journals/pmc/v011/11.1harpoldphilip.html>.

[7] Hutchins, Edwin L., James D. Hollan, and Donald A. Norman. "Direct Manipulation Interfaces." *User Centered System Design: New Perspectives on Human–Computer Interaction*. Eds. Donald A. Norman and Stephen W. Draper. Hillsdale, NJ: Lawrence Erlbaum, 1986. 87–124.

[9] Jay, Martin. "Scopic Regimes of Modernity." *Vision and Visuality*. Ed. Hal Foster. Seattle: Bay Press, 1988. 2–23.

[10] Johnson, Jeff, *et al*. "The Xerox Star: A Retrospective." *Readings in Human-Computer Interaction: Toward the Year 2000*. Eds. Ronald M. Baecker, et al. 2d ed. San Francisco: Morgan Kaufman Publishers, 1995. 53–70.

[11] Le Diberder, Alain, and Frédéric Le Diberder. *L'univers des jeux vidéo*. Paris: Éditions La Découverte, 1998.

[12] Lefebvre, Henri. *The Production of Space*. Trans. Donald Nicholson-Smith. Cambridge, MA: Blackwell, 2000.

[13] Milano, Dominic, and Jim Aikin. "The Making of *MYST*: An Interview with Robyn Miller." *Interactivity* 1995: 37–45.

[14] Mullett, Kevin, and Darrell Sano. *Designing Visual Interfaces: Communication-Oriented Techniques*. Mountain View, CA: Sun Microsystems, 1995.

[15] Nelson, Theodor Holm. "The Right Way to Think About Software Design." *The Art of Human-Computer Interface Design*. Ed. Brenda Laurel. Reading, MA: Addison-Wesley, 1990. 235–43.

[16] Norman, Donald A. *Defending Human Attributes in the Age of the Machine*. Santa Monica, CA: The Voyager Company, 1994.

[17] Panofsky, Erwin. *Perspective as Symbolic Form*. Trans. Christopher S. Wood. New York: Zone Books, 1991.

[18] Poole, Steven. *Trigger Happy: Videogames and the Entertainment Revolution*. New York: Arcade Press, 2000.

[19] Shneiderman, Ben. "Direct Manipulation: A Step Beyond Programming Languages." *Readings in Human-Computer Interaction: A Multidisciplinary Approach*. Eds. Ronald M. Baecker and William A.S. Buxton. San Francisco: Morgan Kaufman Publishers, 1987. 461–67.

[20] Smith, David Canfield, *et al*. "Designing the Star User Interface." *Byte* 7.4 (April, 1982): 242–82.

[21] Stephenson, Neal. *In the Beginning Was the Command Line*. New York: Avon Books, 1999.

[22] Tognazzini, Bruce. *Tog on Interface*. Reading, MA: Addison-Wesley, 1992.

[23] Wolf, Mark J. P. "Inventing Space: Toward a Taxonomy of On- and Off-Screen Space in Video Games." *Film Quarterly* 51.1 (1997): 11–23.