

The Machine in the Text, and the Text in the Machine

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Abstract

"The Machine in the Text, and the Text in the Machine" is a review essay on *Electronic Literature: New Horizons for the Literary* (Notre Dame, IN: University of Notre Dame, 2008), by N. Katherine Hayles, and *Mechanisms: New Media and the Forensic Imagination* (Cambridge, Mass.: MIT Press, 2008), by Matthew G. Kirschenbaum. Both works make remarkable contributions for the emerging field of digital literary studies and for the theory of digital media. While Hayles analyses the interaction between humans and computing machines as embodied in electronic works, Kirschenbaum conceptualizes digitality at the level of inscription and establishes a social text rationale for electronic objects.

The emergence of electronic literature can be seen in a growing body of digitally born artifacts. Most of these works are now published online and they are produced, distributed, and executed by digital machines. The parallel evolution of electronic computers and communication networks during the past twenty years has transformed writing and reading practices, and has deeply altered the electronic landscape itself. Mutations in media technologies have originated not only new sets of relations between print codex and computer display, but they have also redefined the ecology of all other media. These momentous changes are part of a large cluster of social and cultural transformations that characterize contemporary culture, which can be accurately described as a software culture. In their new books, N. Katherine Hayles and Matthew G. Kirschenbaum refine our understanding of electronic literature and digital materiality. In this review essay I look at their critical approaches and try to explain why both books make outstanding contributions to the field of new media studies.

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Literature as Human-Machine Intermediation

Linking subjectivity with computational media is a highly contested project in which the struggle for dominance plays a central role: should the body be subject to the machine, or the machine to the body? The stakes are nothing less than whether the embodied human becomes the center for humanistic inquiry within which digital media can be understood, or whether media provide the context and ground for configuring and disciplining the body. [Hayles 2008, 87]

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In *The Language of New Media* (2001), Lev Manovich defined new media as the result of the combination of modern media and computers. He synthesized the features of new media in five principles: numerical representation, modularity (these are the two basic material principles of data processing upon which the other three depend), automation, variability, and cultural transcoding. Manovich's fifth principle — which describes the social effects of the intertwining of computer and cultural layers — provided a sound theoretical basis for the relatively new field of software studies, i.e., for the cultural analysis of the interactions between computer programs and human practices (cf. [Manovich 2008]). Software mediation is perhaps the main cultural aspect of digital culture because all human-machine interactions are enabled and shaped by features of the software.

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N. Katherine Hayles's approach in *Electronic Literature: New Horizons for the Literary* (2008) follows a similar software and cultural analytics rationale. A survey of contemporary electronic literature in English functions, at the same time, as a theoretical investigation into the aesthetic and cultural materiality of digital media. Hayles analyses digital genres and forms in order to understand the material and cultural specificity of the digital. Placed in the wider social and cultural context of human-machine intermediation, electronic literature becomes a particular domain for observing ongoing changes in technologies of meaning production. Close attention to literary digital practices is part of her long-term critical reflection upon a larger cluster of cultural transformations brought about

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by the ubiquity of computers.

This book continues her intellectual project of examining the interactions among digital media, literature, and posthuman culture (cf. [Hayles 1999], [Hayles 2002], [Hayles 2005]). Her new attempt at an integrated techno-social approach develops out of her two earlier works. *Electronic Literature* brings together, in a magnificent synthesis, her earlier theorization in *Writing Machines* (2002) — in which she analyzed the works Lexia to Perplexia, by Talan Memmott, A Humument, by Tom Phillips, and *House of Leaves*, by Mark Z. Danielewski, as examples of technotexts — and her reflection on the cultural effects of digital technology in *My Mother Was a Computer* (2005). My epigraph (above) is taken from the beginning of the third chapter ("Contexts for Electronic Literature: The Body and the Machine," 87-130), and it opens a pivotal moment in Hayles's attempt to articulate a context for digital literature and to propose a new digital media theory. Human-computer interaction is now so ubiquitous that it may be said to be changing the nature of human culture and the technologies of the self.

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Hayles contextualizes electronic literature within the present digital media ecology. As in her previous work, she selects and reads most of her examples as self-reflexive engagements with electronic materiality. She then uses the self-referential and metatextual elements in these works to interrogate the specific mediation introduced by networked computers in cultural, economic, and social transactions in contemporary information societies. As a methodological and interpretive move, it is critically and theoretically productive in the sense that it illuminates both the works themselves and the difficult questions concerning digitality. This broader contextualizing of electronic literature has far-reaching consequences for a deeper understanding of the social dynamics of digital culture. Its products and tools are now embedded in so many administrative, commercial, political, social, and cultural practices that we are increasingly becoming a software culture — a change so fast and so pervasive that the specific message of digital media seems to be that the posthuman human is/will be the extension of his/her software.

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In *Writing Machines*, Hayles defined *technotexts* as texts (executed electronically or printed on paper) that self-reflect upon their own material properties and operations as devices that allow meaning to emerge. The technotext is a material or textual machine, "a device capable of manipulating itself as well as the reader" [Hayles 2002, 24]. *Cybertext* (in Espen Aarseth's definition) is a related concept: cybertexts are (paper or electronic) texts that require a "non-trivial effort" on the part of the reader to co-generate the textual field. Aarseth calls this type of literature "ergodic" [Aarseth 1997]. While Hayles's definition highlights works that depend upon self-referential codes, Aarseth's concept captures the algorithmic potential of modes of textuality that call upon certain types of reader intervention in the textual field. What "technotexts" and "cybertexts" have in common is the fact they work as *self-conscious textual machines*, i.e., texts for generating texts. As a mechanism for generating texts, they establish a relation between *texton*, or scriptural algorithm, and *scripton*, or textual instance of that algorithm. Textual configuration and textual content can be emergent properties because textual fields are not entirely pre-constituted at their formal level. Interaction among the author's field, the reader's field, and the text's field develops in unpredictable patterns according to a network of intentions embodied in a code [Douglas 2000].

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In computerized technotexts/cybertexts, emergent readings are the result of this intermediation that connects author and reader to computer through automated formal processing of signs. Human and machine are seen as parts of an interlocking cognitive system. Hayles makes the point that at the present level of complexity of computers as quasi-autonomous sign machines, machine-human borders are less and less defined. Computers and humans become increasingly linked by recursive feedback loops. This process of machine-human intermediation gives rise to emergent behaviors which are a function of the systemic relation between machines and humans across a range of fields. In electronic literature, semiosis — i. e., the process according to which signs are interpreted and translated into other signs — partakes of cybersemiosis, i.e., the automated processing of signs that takes place in the machines themselves. According to Hayles, the result is a hybridization that brings together human cognition and the cognition of "intelligent machines." Thus a significant part of her study of electronic literature is dedicated to conceptualizing this human-machine interaction as the defining element of our contemporary mediascape.

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Hayles adopts the concept of human-machine *intermediation* — used here to account for emergent forms of cognition — as a literal and metaphorical description of the "dynamics of human-computer interaction" [Hayles 2008, 51]. "Intermediation" means the emergence of complex patterns from local interactions resulting from "recursive feedback and feedforward loops" [Hayles 2008, 48] in a dynamic heterarchy. Quoting research in the fields of artificial life, genetics, and computer programming, she argues for the co-evolution of embodiment and technology, rather than for any strict form of social or technical determinism. Human-machine intermediation is also modeled on what recent research has uncovered about human brain development. Hayles sees such intermediation as similar to the co-evolution of brain and language or to the synergy between neural plasticity and

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learning. The recursive loops that take place inside the machine and the recursive loops that constitute a human subject's cognition processes become linked in human-computer interaction. In electronic literature this dynamic between body and machine takes place both at the level of writing and reading. A series of cascading and interacting processes makes human and machines part of a single system of emergent cognition:

In electronic literature, this dynamic is evoked when text performs actions that bind together author and program, player and computer, into a complex system characterized by intermediating dynamics. The computer's performance builds high-level responses out of low-level processes that interpret binary code. These performances elicit emergent complexity in the player, whose cognitions likewise build up from low-level processes interpreting sensory and perceptual input to high-level thoughts that possess much more powerful and cognitive powers than the computer does, but that nevertheless are bound together with the computer's subcognitive processes through intermediating dynamics. The cycle operates as well in the writing phase of electronic literature. When a programmer/writer creates an executable file, the process reengineers the writer's perceptual and cognitive system as she works with the medium's possibilities. Alternating between writing modules and testing them to ensure they run correctly, the programmer experiences creation as an active dynamic in which the computer plays a central role. [Hayles 2008, 56]

Hayles's analysis of the intertwined role of electronic media and certain cultural patterns in global finance transactions [Hayles 2008, 94–102] makes an interesting case-study of intermediation as a non-deterministic explanation of the relations between technology and culture. By recontextualizing digital media works and media theory in wider social and cultural phenomena, we can see how certain practices get their content and forms from other fields (in this instance gendered practices and discourses) at the same time that they are transformed by the electronic capabilities of synchronous and constant communication. This approach suggests the need to integrate media models and cultural models in order to explain the specifics of technological embodiment in the digital age. Marshall McLuhan described media-culture interactions in terms of the sense ratios and participatory involvement that define each medium. Electronic media, because they combine participatory and audiovisual immersion, were seen as retribalizing agents that establish new forms of sociality within a general global media network. The interiorized, rationalized, and individualized subjectivity of print, challenged by 20th century mass media, has been further hybridized by the interactive and multisensory modalities of contemporary digital media.

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In chapter 4 ("Revealing and Transforming: How Electronic Literature Revalues Computational Practice," [Hayles 2008, 131–157]), Hayles proposes an alternative theory to Friedrich A. Kittler's technodeterminism ([Kittler 1990], [Kittler 1999]) and to Mark B. N. Hansen's affective embodiment of technology in human interfaces ([Hansen 2004], [Hansen 2006]). In Hayles's perspective, subjectivity and technology, body and machine are conceived in terms of an "open-ended recursivity with one another" [Hayles 2008, 130]. She argues for their coevolution, and she claims that electronic literature is exploring this intermediating dynamics between human and nonhuman cognition by means of random algorithmic permutations in the production of meaning. Electronic literature and digital art play an important role in our critical awareness of computational practices: "Through such intermediations, computation evolves into something more than a technical practice, though of course it is also that. It becomes a powerful way to reveal to us the implications of our contemporary situation, creating revelations that work both within and beneath conscious thought" [Hayles 2008, 157]. Her survey of electronic literature is powerfully linked with a media theory about the function of the digital computer in contemporary culture.

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A Recursive Dynamics for Emergent Cognition: Digitality, Performability, Readability

Hayles examines both the continuities and discontinuities between print and digital textuality: on the one hand, digital literary genres are dependent upon print conventions and print modes; on the other, they are close to contemporary networked media, such as "computer games, animations, digital arts, graphic design, and electronic visual culture" [Hayles 2008, 4]. Interaction between print and electronic forms (and a good example of a retroactive media loop) can be seen in print works that use electronic means of production to intensify the formal materialities of print. Conversely, the formal transformation of print literary forms can be seen in electronic works that combine alphabetic with non-alphabetic materialities: multimodality, characteristic of 20th-century experimental literature, has become a general feature of digital literature. The nature of reproduction in digital media fosters the convergence of forms that were once medium-specific and rhetorically distinct, such as moving images, recorded sounds and written words. Moving images and moving letters, for instance, are common tropes in electronic literature, due to the fact that digital machines can process all these different

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sensory outputs using the same processes and channels. Hybridity is the result of this recombination of print-born with digitally-born forms.

Whereas earlier surveys included web publication as part of the digital literature field, Hayles restricts her corpus to works that can only exist within the computer environment. Loss Pequeño Glazier defined three forms of electronic textuality (hypertext, visual/kinetic text, and works in programmable media), but he also examined web-based electronic writing as a distribution and publication platform for the dissemination of forms of innovative poetry [Glazier 2002]. Hayles defines electronic literature as "a first-generation object created on a computer and (usually) meant to be read on a computer" [Hayles 2008, 3]. Digitally produced, digitally distributed, and digitally received, electronic literature materializes within the networked environment of computer-assisted communication. A similar, but less restrictive definition, is provided by the Electronic Literature Organization on its website: "The term [Electronic Literature] refers to works with important literary aspects that take advantage of the capabilities and contexts provided by the stand-alone or networked computer." (Cf. <http://eliterature.org/about/>).

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Electronic works of literature come in many forms: network fiction (a term Hayles adopts from David Ciccoricco, who uses it to refer to hyperfiction); interactive fiction, which combines novelistic and game components (referred to as "playable media" by Wardrip-Fruin); exploration of three-dimensionality on the screen; immersion in three-dimensional spaces, as represented by works produced at Brown University's CAVE virtual reality laboratory; site-specific or online interactive dramas; generative literature, such as has been developed by Philippe Bootz, Jean-Pierre Balpe or Noah Wardrip-Fruin; exploration of the dynamics between programming codes and natural language codes, as in the genre called code work (Alan Sondheim; MEZ; Talan Memmott); and many others, such as animated poems, e-mail novels, locative narratives (dependent on GPS technologies), or short fiction for cell phone. Multimodality, a common property of networked and programmable media, explains the contiguity between electronic literature and digital art. The invention and dissemination of handheld mobile and networked devices, from i-pods to e-books to electronic paper, is likely to continue to multiply digital genres and forms.

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Hayles underlines *hybridity* and *eventuality* as two fundamental features of contemporary electronic literature. Both features are a consequence of digitality. Once forms are digitally produced and reproduced, they become part of a large database whose elements may be recombined *ad infinitum*. Under the new conditions of technical reproduction, the combined materialities of previous media originate hybrid forms of textuality that interweave verbal text, still image, moving image, and sound in multimodal genres and forms. Eventuality is a consequence of the fact that works have to be performed by the code before they are performed by reading: "electronic text (...) cannot be accessed until it is performed by properly executed code" [Hayles 2008, 5]. Software (i.e., the ensemble defined by operating system, computer application, and work's programming code) becomes a structural element in a work's signifying field. Since works depend upon the specific codes and machines that generate them, electronic genres may be partially defined by the kind of software and hardware used to produce and execute them.

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Thus certain generic properties of a digital work will derive from the structural and formal properties of its particular code and application, even when they originated in graphical conventions of print genres. This is clear when we look at kinetic poems: conventional features of the ideogrammatic visual poem have been re-inscribed by properties of animation programming, such as the Actionscript language used in Flash. A similar specific software inscription can be seen also in the contrast between early CD-ROM hypertext fictions — that depended upon the formal capabilities of the lexia-and-link structure of hypertext programs such as *Hypercard* or *Storyspace* — and later hypertext fiction, generally web-based, hypermedially structured, and multimodal. The digital medium inscribes its material and formal features in a work's material form. "Code work" — a genre of digital text that plays with the relations between natural languages, alphabetic writing, computer codes or pseudo-codes, and various processes of verbal and visual translation — is one good example of the self-reflective work that explores the recodings and remediations in electronic literature. Such works probe into the nature of natural and programming languages, directing our attention to the formal materiality of writing as code and inscription.

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Hayles lists four major characteristics of digital text: "computer-mediated text is layered"; "computer-mediated tends to be multimodal"; "in computer-mediated text, storage is separate from performance"; and "computer-mediated text manifests fractured temporality" [Hayles 2008, 163–164]. The layered nature of digital text has to do with cascading processes of abstraction that link the deep layer of alternating voltages to the screen layer of symbolic representations. Kirschenbaum's distinction between forensic and formal materiality is another way of conceptualizing the layered nature of computational media. Multimodality and multimediality are consequences of binary code, which enables the integration of all other media. Separation between storage and performance is another fundamental element of digital textuality: the work cannot be accessed unless it is performed by the

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code, i.e., executed by a machine, and files played locally can be assembled from different locations. Finally, the fracturing of time describes the fact that in electronic display the timing of texts is variable and not entirely controlled by the reader. While the first and third properties follow from the ontology of the computer as a binary machine, the second and the fourth describe specific aspects of its formal materiality as phenomenologically experienced by a human subject.

Hayles analyses a number of digital works in order to clarify the material specificities of electronic embodiment and the formal workings of intermediation. Her model for digitality in *Electronic Literature* comes mostly from technotexts, i.e., from those textual embodiments of text as a machine to generate texts. Self-reflexive operations in these works are read as ways of probing the cultural and technological specifics of the medium itself. The selected works self-consciously engage with their formal and material condition, and this engagement is used, in turn, as a critical examination of the situation of contemporary culture. This is what happens when she reads Talan Memmott's *Lexia to Perplexia* (2000) as a reflection on the "mergent subjectivity inside the machine" and as a "metaphor for the co-construction of embodiment and media technologies" [Hayles 2008, 122]. Or when she reads works by Young-Hae Chang and Marc Voge (Young-Hae Chang Heavy Industries) as "an interrogation of global microsociality and temporality as a place to inhabit" [Hayles 2008, 126]. A similar reading protocol is applied to *Translation* (2004-2005), a work by John Cayley and Giles Perring, whose transliteral morphings are read as examples of "recursive interaction" between machine and linguistic codes. Several other works are read as explorations of the codeterminations between body and machine that define contemporary cultural formations.

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By using electronic works as tools for her interrogation of computation and digitality, Hayles is sometimes close to the point where her readings turn into allegories of her own media theory — a reading practice that is all too frequent in professional readers. This can be a productive conceptual move — as she has brilliantly demonstrated here and elsewhere — but it can also obscure other issues, particularly if the works are read as symptoms of a certain media regime or if they are treated as autonomous objects. This mode of reading plays down the role of heterogeneous discursive fields as sources for their signifiers. A self-referential reading can be illuminating in grasping the specific formal dialectics of a given work, but at the risk of extrapolating, as medium-specific, properties that are in fact the result of certain formal manipulations upon a given material and its discursive basis. It also tends to ignore the actual conditions of production, circulation, and reception of those works, conditions which cannot be accessed by close reading the works themselves.

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Some of the properties Hayles equates with digital materiality in these works are the result of certain operations with the code that translate into certain types of display and interaction. They are not inherent in digitality, or they are only in so far as digitality may be redefined in a given work by a specific formal operation. In fact, similar self-reflexive features (and the ensuing recursive dynamics) would equally apply to works in print, cinema, or other media. And this is particularly true for the semiotic and semantic import of those operations. Such properties have to be seen as particular instantiations of digital materiality achieved by certain formal operations. This means that their self-reflexivity is work-specific rather than medium-specific. Digitality is retroactively redefined by a formal intervention, as much as printness has been re-enacted and re-displayed by specific printing codes in novels such as Laurence Sterne's *Tristram Shandy* (1759-1767) or Mark Z. Danielewski's *Only Revolutions* (2006). Such metatextual and metamedial processes are a function of those particular interventions and of the semiotic loop they help to sustain.

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Most of the works Hayles has chosen can be read in meaningfully self-reflective ways ("a growing body of work that interrogates networked and programmable media as the material basis for artistic innovation and creation" [Hayles 2008, 20]), whether their self-reflexivity was intended by the authorial algorithm, or if it was mainly the result of an ergodically enhanced readerly/ writerly intentionality. Again, the fact that many works concern themselves with the ergonomics and mechanics of reading, using digital forms to probe into the nature of meaning production, would suggest that certain features that are being explored by electronic literature should be accounted for within a more general theory of multimodality of contemporary literacies. Many of these operations have been used in the 20th-century experimental tradition of challenging and redefining the media boundaries of literary art. In their archaeology of forms, Loss Pequeño Glazier and Chris Funkhouser have read electronic text as both a continuation of experimental print literature and a new practice grounded in the materiality of the medium ([Glazier 2002], [Funkhouser 2007]).

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Generating text by the use of algorithms as a way freeing discourse from certain syntactic and semantic structures for producing textual coherence and textual cohesion is one example of such experimental procedures. Textual constraints, as defined and practiced by Oulipian authors since 1960, already contain the basic principles of computational literature. The text as potential textual field, i.e., its eventuality, has been perceived and explored as a function of the generative codes of language and writing. Similar perceptions and experiments with the generative features of programming codes have originated certain types of self-referential and metatextual

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forms of digital works. These properties, as far as they bear upon the medium itself, result from a particular formal and aesthetic engagement with its material basis.

The possibility of semiotic interaction, that is, of an interference that alters sequence and outcome of display or narrative, is one of the formal operations being explored in digital texts. Iterations of algorithms that respond to readers' interventions result in unpredicted automatic semiotic permutations of file components and display elements, but all other textual features, particularly when considered as reading fields, are not unlike print, film, or sound textuality. The crucial phenomenological question is what is the nature of eventuality in digital media as opposed to, or different from, other forms of eventuality? The fact that files have to be executed and performed by specific programs in specific machines, and reassembled instantaneously from across a network, produces a new kind of eventuality, and thus a new kind of textuality? A textuality that can be said to be different from the general eventuality of reading acts as specific instantiations of the symbolic transaction that defines all textual fields?

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Hayles is right in pointing to certain limitations of the early technophile hypertext theory in representing digital media (and hypertext in particular) as a material embodiment of the post-structuralist theory of infinite text and deferral of meaning. Landow, Bolter and others certainly overstressed the liberatory effects of hyperlinks as reader-oriented structures and mis-represented codex dynamics. Bolter and Grusin's conceptualization of the electronic writing space as a remediation of print and other media is much more accurate. In fact, many digital works (both in poetry and fiction) foreground this metamedial dimension of the digital, i.e., the use of its new material properties as formal investigations into mediality (i.e., graphicality or kineticity or aurality) in meaning production in general. Print is thus re-represented within digital textuality in forms that replicate, transform, and interrogate its topographic and typographic materiality. Even when they are not digitally born, as is the case with many digital archives that migrate print and manuscript works to a digital space, such literary works are redefined by the digital dynamics created by their hypermedia structure of networked marked-up files.

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N. Katherine Hayles's overview of the field is accompanied by Volume One of The Electronic Literature Collection, one of the first attempts at producing an executable, interpretable, critical, and teachable canon of electronic literature. This anthology (available as a CD-ROM appendix to this book, and also as an online archive, at <http://collection.eliterature.org/1/>) contains many remarkable works in new media. Selected titles include Michael Joyce's *Twelve Blue* (1996), Shelley Jackson's *My Body: A WunderKammer* (1997), Stuart Moulthrop's *Reagan Library* (1999), Jim Andrews' *Nio* (2001), Talan Memmott's *Self-Portrait(s) [as Other(s)]* (2003), Millie Niss's *Oulipoems* (2004), and Jason Nelson's *Dreamaphage* (2004), among others. One criticism to be made is that this anthology is entirely English-speaking and, with a few exceptions, North-American-centered. Even if the development of information technology has meant that the U.S.A. has led the electronic communication of the world, one would expect to see more works in other languages, such as French, German, Italian, Spanish, and Portuguese — languages in which there has been a tradition of experimenting with new media since the 1960s and 1970s. Universities have become major players in the networked media environment that defines contemporary culture. Reflecting the dominance of English-speaking institutions in contemporary knowledge production, critical work on new media replicates the cultural and linguistic hierarchies characteristic of other fields and modes of knowledge production and distribution. As a post-WWW electronic canon, *Electronic Literature* both reflects and reinforces the technological and institutional asymmetries of cultural and political power in the techno-scientific digital age.

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A Grammatology of Digital Inscriptions

My argument, then, is this: computers are unique in the history of writing technologies in that they present a pre-meditated material environment built and engineered to propagate an illusion of immateriality; the digital nature of computational representation is precisely what enables this illusion — or else call it a working model — of immaterial behavior.
[Kirschenbaum 2008, 135]

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At the present transitional moment, file structures modeled on book structure and book surfaces are challenged by specifically digital forms of inscription and organization, both in literary and artistic production, and in scholarly work of all kinds. Matthew G. Kirschenbaum's *Mechanisms* is the ideal companion for N. Katherine Hayles's *Electronic Literature*. While Hayles is more interested in electronic textuality as it manifests itself at the formal materiality level, and in what it tells about its own signifying process, Kirschenbaum offers an infrastructural approach to digital materiality. He sees digital technology as a technology of inscription at the multiple material levels that define the computer, from electromagnetic forces to semiotic effects. Digital objects are thus brought under the scrutiny of textual studies as a mode of inquiry historically concerned with the analysis of physical marks of inscription and re-inscription.

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For Kirschenbaum, the fungibility and the volatility of screen display should not be essentialized as the phenomenological manifestation of the electronic writing space. Like Espen Aarseth [Aarseth 2003] or Alan Liu [Liu 2004], he offers a critique of this form of new media ideology. The electronic writing space has a microscopic dimension susceptible to being described as an inscriptional space. Kirschenbaum wants to start with the mechanism and refocus our attention in the computer's physicality and materiality as an electronic device:

The hard drive, and magnetic media more generally, are mechanisms of extreme inscription — that is, they offer a limit case for how the inscriptive act can be imagined and executed. To examine the hard drive at this level is to enter a looking glass world where the Kantian manifold of space and time is measured in millionths of a meter (called microns) and thousands of second (called milliseconds), a world of leading-edge engineering rooted in the ancient science of tribology, the study of interacting surfaces in relative motion. [Kirschenbaum 2008, 74]

Kirschenbaum distinguishes the forensic materiality level of magnetic inscription on the disk from the formal materiality level of executed code as presentation. Computational materiality is seen as a series of cascading physical processes of storage and deletion, writing and overwriting. He describes this process in terms of a tension between inscription and abstraction, and between digitality and volatility. Digital information becomes abstract because it is susceptible to allographic manipulation of discrete units (substitution, deletion, insertion, transposition, relocation and repetition) — the property described by Lev Manovich [Manovich 2001] as modularity.

In the chapter "Extreme Inscription: A Grammatology of the Hard Drive" [Kirschenbaum 2008, 73–109], the author attributes eight characteristics to the mechanism for computer inscription (88-96): *random access* ("instantaneous access to any portion of the physical media"); *signal processor* ("writing and reading to and from the disk are ultimately a form of digital to analog and analog to digital signal processing"); *differential* ("the read/write head measures reversals between magnetic fields rather than the actual charge of an individual magnetic dipole"); *volumetric* ("a hard-disk drive is a three-dimensional writing space"); *rationalized* ("the volumetric space of the drive" is mapped "by an intricate planar geometry comprised of tracks and sectors"); *motion-dependent* ("motion and raw speed are integral aspects of their operation as inscription technologies"); *planographic* ("the surface of the disk, in order to fly scant nanometers beneath the air bearings, must be absolutely smooth"); and *nonvolatile but variable* ("just as important as magnetic disk storage's nonvolatility was the fact that its same volumetric area could be overwritten"). It is this forensic description of the mechanism for electronic writing that is absent from most accounts of electronic textuality.

Kirschenbaum's analysis thus adds an important layer to media-specific analysis: the consideration of the relation between hardware inscription, on the one hand, and software configurations, formal modeling, and presentational display, on the other, i.e., between forensic materiality and formal materiality. A series of multiple-order representations (or translations) allow for the inscription, processing, and presentation of data. His analysis of digital image representation as a data set provides a clear example for the particular nature of the cascading inscriptions that define digitality. He explains, "The tendency to regard one image as correct and the other as deviant is to misapprehend the nature of computers as digital systems, and indeed allographic sign systems in general" [Kirschenbaum 2008, 148]. Modeling documents in electronic environments [Kirschenbaum 2008, 149] shows how at the formal materiality level text is modeled with more text, which defines access, representation and searches that result in different renderings of what is and isn't an object: "an electronic document is being modeled by a cascade of formal or semantic values that materialize it in relation to the electronic environment or system that supports it" [Kirschenbaum 2008, 154–155].

Understanding the modeling and metatextual function of computer programs and coding languages in general, particularly as they manifest themselves in certain formal properties, is crucial for understanding the ideological dimension of data structuring and data representation [Drucker 2007]. Many features we tend to attribute to digitality are, in fact, the result of specific formal operations designed to produce and represent data in a certain configuration. Graphic user interfaces and other software tools have been naturalized, and we often fail to notice the conventionality that produces certain digital structures and behaviors. With the concept of formal materiality, Kirschenbaum captures this level of modeling that produces specific instantiations of digital materiality: "My word processor presents me with a certain document model, and while its formal behaviors ultimately come to rest in the forensic materiality of chips, memory, and other spaces of the hardware configuration, much of what we tend to essentialize about new media is in fact merely the effect of a particular set of social choices implemented and instantiated in the formal modeling of the digital environments in question" [Kirschenbaum 2008, 133].

Textual Studies for Digital Objects

Kirschenbaum applies procedures of textual criticism and analytical bibliography to the study of new media objects. His book signals a much-needed departure from studies of digitality that only address the semiotic level of presentation. Instead, he examines the whole material and social process through which digital texts are produced, transmitted, and transformed: "Crystallizing at the nexus of storage, inscription, and instrumentation, the forensic imagination stands in contrast to the medial ideology and screen essentialism that has held sway in the theoretical conversation's critical formative years for new media as a field" [Kirschenbaum 2008, 254]. *Mechanisms* thus sets a new research standard by succeeding not just in the theoretical integration of the multiple levels of electronic inscription, but also for treating electronic texts as social texts that disseminate in particular ways. Textual variation in electronic works, for instance, is not a mere function of the flickering material circumstances that condition code execution. It results from material changes in operating system or in the software that supports and executes the code, and these can be formally described in much the same way as versions or editions in textual studies. The eventuality ascribed to the digital medium *per se* is, in fact, formally determined by the specific electronic coding that generates a certain material instantiation of the executable work.

Kirschenbaum recalls McGann's description of the double helix of linguistic and bibliographic codes in bibliographic objects, and he explains the interdependence of formal and forensic materiality by referring to the "unique monodimensionality of the Möbius strip, at once separate and coextensive" [Kirschenbaum 2008, 156]. Textual fluidity in computational environments results from the fact that autographic discrete units at the forensic level are susceptible of allographic manipulation at the formal level. The abstract nature of information ultimately depends upon the specific mode of electronic inscription at its various storing and coding levels — from data addresses on disk sectors to topographic and typographic coding and marking-up of graphic display. Electronic textuality gains its specific properties from this tension between "the forensic principle of individualization" and the formal principle of identity:

Formally or allographically identical, forensically or autographically individualized and discrete: this conundrum becomes the methodological lever with which to pry open the relentless symbolic cascade of computation and understand what is unique about computers as writing technologies — that they are material machines dedicated to propagating an artificial environment capable of supporting immaterial behaviors. [Kirschenbaum 2008, 158]

Thus Kirschenbaum's electro-bibliographic perspective refines our notion of what an electronic object is, and refocuses our perception of computation and digitality by pointing to the manifold negotiations that constitute electronic texts as material and social objects. His extreme materialism is thoroughly tested in his detailed analyses of the textual and reception history of Michael Joyce's *Afternoon: A Story* (chapter 4) and William Gibson's *Agrippa: A Book of the Dead* (chapter 5). Social and cultural setting, platforms and operating systems, hypertext programs and electronic networks, various kinds of physical artifacts at both genetic and social levels (reflecting intentions, variations, versions, editions, porting or versioning) — all of these spell out the textual condition of the electronic object. Both analyses assert a fundamental similarity in the way bibliographic codes and electronic codes work in relation to their respective textual fields, and how these fields in turn are shaped by social interactions. Consideration of the forensic materiality of electronic objects — which brings "difference" to the theory of electronic textuality [Kirschenbaum 2008, 158] — implies the use of new tools for textual criticism and bibliographic analysis, such as hex editors, hashes, or magnetic force microscopy. At the same time, a social text approach is indispensable if we are to fully grasp the dynamics of digital objects as cultural artifacts.

The study of transmissive variation in electronic objects — greatly facilitated by the self-documenting nature of electronic media — brings textual studies into the field of digital media. Diachrony, i.e., historical temporality (and not just the temporality of its machine execution), is part of a digital object. Kirschenbaum's careful consideration of the historicity of electronic reproduction offers a critical model for studying electronic literature that integrates the forensic and the formal at both material and social levels. He shows how electronic objects are never entirely and simply electronic. They partake in many other social and physical materialities, as is amply and brilliantly demonstrated by his case-studies of Joyce and Gibson. In *Mechanisms*, McKenzie and McGann's powerful social editing theory has been applied to new media objects, showing that critical tools developed for studying print textuality can, in new formulations, be applied to digital textuality. Diachronic awareness of electronic textuality is one way of bridging the gap between traditional critical practices and the specifics of networked and programmable media. There are many passages in *Mechanisms* where one can have a taste of this fruitful encounter for new media theory, as when Kirschenbaum looks at the scenes of production, transmission, and reception of those two classics of electronic literature:

In my view a fully adequate scholarly citation for *Afternoon* would specify the text's edition (according to the colophon), Storyspace software version, platform, and operating system; for example, *Afternoon, a story*, 5th edition (1992), Storyspace Reader 1.0.7, Windows XP. [...]

The general flattening effect whereby all versions and editions of *Afternoon* are assumed to be more or less homogenous is, in my view, symptomatic of still commonplace attitudes toward electronic textuality among the critical community, which assumes electronic objects exist absent of any meaningful diachronic dimension. [Kirschenbaum 2008, 196]

"Agrippa's" trajectory from text file to the commercial matrix of the Web is also perhaps loosely analogous to scribal publication of the seventeenth and eighteenth centuries, whereby poems in manuscript achieved widespread circulation from one reader to another in commonplace books before being acquired and printed as a saleable edition. Of course, vastly greater numbers of readers have read "Agrippa" for free on the Internet than have ever paid for one of the e-book distributions. But the key point is that "Agrippa's" afterlife as an e-book should remind us that the term *electronic text* is never rendered homogenous merely by virtue of a text's electronic pedigree, and should instead be understood as a thick constellation of historically visible inscriptive practices, determined both by technical considerations and by market forces. [Kirschenbaum 2008, 232]

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Projects such as The Rossetti Archive (1993-2008), The William Blake Archive (1996-), and Artists' Books Online (2004-) have created multi-layered semiotic systems around digital facsimiles. As electronic editing environments, they simulate their objects' graphic and visual materiality as a function of the difference between bibliographic and electronic codes. Such operations are performed within a critical and institutional apparatus which is built into the digital archive as an edited space and a technocultural practice. By stressing the configured nature of signifying marks, documentary editing in digital form reengages scholars and readers with the visual and bibliographic materiality of literary signifying processes. Heightened awareness of the medium caused by remediation results in a de-naturalization of familiar print forms and genres. Differences between codex codes and computer codes reveal the complex topology of bibliographic inscriptions. Recursivity works both at the level of language structure and at the level of visibility, producing feedbacks between visual and linguistic forms as reading acts map onto the writing space. Bibliographic recursive operations are now being simulated in the electronic space, as a way of exploring its inscriptional potential for cognition. If Jerome McGann [McGann 2001] discovered an electronic rationale for the study of bibliographic objects, Matthew G. Kirschenbaum has discovered a bibliographic rationale for the study of electronic objects.

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Hayles's and Kirschenbaum's new books offer critically rigorous, intellectually provocative, and highly productive perspectives on new media literary objects. Their technical, sociotextual, and interpretive analyses raise our critical awareness of the specifics of digital materiality and electronic literature to a new theoretical and analytical level. Hayles's readings of electronic works are exemplary in the way they relate electronic performability to interpretability. Using tropes such as "recursive dynamics," "intelligent machines" and "emergent cognition," she has tried to capture the embodied nature of technology and the distributed nature of subjectivity in human-computer interactions. Kirschenbaum's approach, in turn, opens up electronic objects to textual criticism, extending the genetic and social text approach of the last two decades to digitally born artifacts. He offers a critically nuanced and technically rigorous description of the multiple layers of formal and forensic materiality, and stresses their interdependence. Taken together, the "electronic" in *Electronic Literature* and the "mechanism" in *Mechanisms* clearly resonate in the way they both attempt to link the deep level of machine code to the formal level of textual and metatextual code to the social level of cultural code. The machine in the text and the text in the machine — quintessential expressions of our present postmodern technotextual condition — are now more fully conceptualized in their technical, aesthetic, and social materialities.

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