

Shall We Play a Game: Thoughts on the Computer Game Archive of the Future

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The Importance of the Topic

Now that the Pong and Pac-Man generations have aged and few Stanford undergraduates can remember a world without Mario, computer games have suddenly grown up. It is a good time to think about the place of games among media and how we can preserve their history.

Many would argue that the “medium of the video game” (the title of a recent book)¹ should be a prominent stop on any tour of late 20th-century mediascape, certainly of popular culture and art. The conventional approach cites statistics that measure the commercial success of computer games. Sales of computer and video games in the United States alone, including hardware and accessories, exceeded \$10 billion in 2001. By comparison, box-office receipts in the U.S. movie industry reached \$8.35 billion, itself a record total. Global sales of hardware and software are expected to exceed \$30 billion this year, with developed markets for PC or video games in Japan, Korea, Germany, and the U.K. rivaling the U.S. Dollar figures alone do not say enough about the attention our society devotes to computer games. Generally, games take more time to experience than media such as books and films. The publishers of *Half-Life: Counterstrike*, the most popular networked multiplayer game, report some 3.4 billion player-minutes per month in mid-2002, exceeding estimates based on Nielsen ratings for even the highest-rated U.S. television

shows. *Counter-Strike* frags *Friends* in the battle for screen time. About 1.5 billion movie tickets will be sold this year. We can calculate from this statistic that on average less than 15% of the U.S. population goes to the movies in a given week (down from 46% after World War II, by the way). By comparison, the Interactive Digital Software Association reports that roughly 60 percent of the U.S. population played "interactive games on a regular basis" in the year 2000. Yes, video and computer games have got our attention.²

There are reasons other than net profits and eyeball time for taking computer games seriously. Games are shedding their reputation for merely providing mindless amusement for young boys. Henry Jenkin's suggests that it is time to think about video games as the "art form for the digital age." Some of you may find this thought difficult to reconcile with faded memories of *Pong* and *Pokemon*, or the quietly muttered thanks as your kids stare vacantly into a Game Boy instead of fighting in the back seat. Allow Jenkins to rap your knuckles as he observes that such reactions "tell us more about our contemporary notion of art—as arid and stuffy, as the property of an educated and economic elite, as cut off from everyday experience—than they tell us about games."³ Indeed, anyone familiar with the narrative aspirations of interactive fiction, the social worlds of MUDs and massively multiplayer games, the technical mastery of id's first-person shooters, the visual storytelling of the *Final Fantasy* series, the strategic depth of Sid Meier's *Civilization*, or Will Wright's open-ended simulations from *Sim City* to *The Sims*, knows that game design has matured. Computer games cover an astonishing breadth of entertainment, simulation, artistic, competitive, and narrative experiences.

Computer games are beginning to put their stamp on academic media and cultural studies. It is sufficient for now to cite Bolter and Grusin's *Remediation* -- which is becoming to new media what Elizabeth Eisenstein's *The Printing Press as an Agent of Change* was to print.⁴

Remediation begins its list of the essential new media with a chapter on computer games. The bibliography of game studies is growing rapidly, fed by scholars in literary, media and cultural studies and the social sciences, as well as game designers. Let us agree then that computer games are and will be taken seriously. Today I want to talk about the problem of insuring that this new medium will have a history, one that future scholars can write about critically. In considering the construction of computer game archives, I will organize my thoughts into three sections: (1) What are some challenges we face in building historical collections of software and interactive media? (2) How will the characteristics of computer games define historical collections and who will be the curators of these collections? (3) What can we do now to advance the computer games archives of the future?

The Challenge of Preserving the History of Software and Interactive Media

The idea of playing games on computers is about as old as the computer itself. Initially, the payoffs expected from this activity were closely related to the study of computation. For example, the mathematician and engineer Claude Shannon proposed in 1950 that computers could be programmed to play chess, leading him to wonder if machines could think. Shannon's proposal stimulated decades of research on chess- and checkers-playing programs by computer scientists working in the field of artificial intelligence. Similarly, games have proven their value as a way of experimenting with computer technology and stretching its capabilities. Pioneering early games such as Willy Higginbotham's *Tennis for Two* (1958) or MIT's *Spacewar!* (1962) were designed to demonstrate what computers could do. Since the 1970s, connections leading from the lab to the living room have usually been mediated by military or industrial R&D and commercial game

developers. Indeed, Tim Lenoir and I would argue that understanding the relationship among these groups is an important and revealing research topic. Games exploit technology, they revel in pushing the technological envelope of personal computers, arcade and television consoles. Since the mid-1990s (one might say, since DOOM), it has been games primarily that have driven the need for high-end personal computers and 3D-graphics boards, for example. I will mention a few implications of the sturdy technology requirements for games when I talk about emulators later on.

In part, computer and video games are a sub-category of software, and it is instructive to contemplate the work of historians of software in ten or a hundred years. Since the 1970s, the emancipation of software from the closed and bundled world of computer engineering has led to our dependence on computers. While the scope of software's history has thus grown, our personal intimacy with evolving information technologies has intensified. In the last quarter-century, personal computer technology, graphical interfaces, networking, productivity software, electronic entertainment, the Internet, and the World Wide Web have made software part of our cultural environment, thus profoundly raising the stakes for being able to tell its history, our history.

It is important in this regard to recall the contributions of Doug Engelbart, Ted Nelson, Alan Kay and others in the 1960s and 1970s. They laid a foundation for digital media of communication and entertainment, not just for productivity and information management. They did this by establishing the computer as a communication machine rather than primarily a calculation engine. The monumental expansion of the nature of software that followed has led more recently to convergences of media and technology that

push software (and its historians) into nearly every medium of entertainment, art, recreation and story-telling. Software has become a condition of our lives; culture is embedded in the computer as much as the computer is embedded in culture. About ten years ago, the computer scientist Mark Weiser described the then future omnipresence of software in an article titled “The Computer for the 21st Century” published in *Scientific American*. This essay introduced Weiser’s research program, which he dubbed “ubiquitous computing,” to this magazine’s technologically literate readership, always eager to read about plausible visions of the future. Much of Weiser’s argument hinged on a straightforward observation, but one that nonetheless turned his views in an unexpected direction: “the most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.” He believed it significant not that in his future computers would outnumber people, but that they would have to become “invisible” in order to become useful. As he phrased it a few years after publishing the *Scientific American* article, the “highest ideal is to make a computer so imbedded, so fitting, so natural, that we use it without even thinking about it.”⁵ We have barely begun to address the long-term preservation of this ubiquitous, yet invisible technology.

Archives of Computer Game History: Collections and Curators

The Nature of the Medium

As we tag along behind Bolter and Grusin down the path of remediation, let us not limit our gaze to cinema, literary texts, and television as the role models for computer games. They are, of course, games. We should keep this in mind when we enter video games in the

genre catalog of new media. In *The Study of Games* (1971), the essential treatise of the anthropology of games, Elliott Avedon and Brian Sutton-Smith asked:

"What are games? Are they things in the sense of artifacts? Are they behavioral models, or simulations of social situations? Are they vestiges of ancient rituals, or magical rites? It is difficult and even curious when one tries to answer the question 'what are games,' since it is assumed that games are many things and at the same time specific games are different from one another--but are they?"⁶

They are asking two questions here. The first concerns the essential nature of games. Allow me to over-simplify and reduce the options to two: Either games are fixed objects – perhaps authored texts or built artifacts. Or, alternatively, they are the experiences generated by a framework of rules, codes or stories and expressed through interaction, competition, or play. Text or performance? Artifact or activity? I will return to this part of their question when I talk about preservation strategies. The second question is whether there are structural similarities among games. Answering this question is out of scope for us today. However, it is worth noting that the authors of *The Study of Games* conclude with “seven elements in games” distilled from studies by psychologists, mathematicians and others. These structural elements include "procedures for action," "roles of participant," "participant interaction patterns" and the like, taking games away from the notion that they are stable artifacts or texts. These elements underscore the importance of documenting interactivity as a historical phenomenon, something that predated computers (an obvious statement to any player of *Diplomacy* or *Dungeons and Dragons*). As fashionable as it has become to discuss games as cinematic or as narratives, let us not forget that actions and responses are fundamental. Games provide a structure within which players do something – whether the games is

baseball, D&D, or *Myst*—and this structure is not likely to be a linear narrative. Computer games provide a tailor-made opportunity to study interactivity.

The active, performative aspect of games provides a special challenge for documentation strategies. As a thought experiment, think for a moment about the case of a game like basketball. Let's look at some records and try to choose between texts, artifacts, or records of performance. Do any of these sources alone tell us enough about the nature of the game? Don't we need all three?

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Computer and video games are both dynamic and interactive. Dynamic, in the sense that no matter how linear, how narrative-driven the game, each instance of it being played results in a different set of experiences. The text is never the same. The interactivity of games is the sine qua non of the definition of this new medium, the aspect without which computer games would lose their identity. Chris Crawford, the dean of American game designers, put it this way:

"Interactivity is not about objects, it's about actions. Yet our thought processes push us towards objects, not actions. This explains why everybody is wasting so much time talking about 'content.' Content is a noun! We don't need content; we need process, relationship, action, verb."⁷

Randall Packer, a media artist and museum curator, has described a similar quality in interactive art, particularly net-based hypermedia, noting the degree to which computer games embrace the loss of fixed content:

"While theater begins with the notion of the suspension of disbelief, interactive art picks up where theater (and film) leave off with branching, user-driven non-linear narrative. The letting go of authorial control has been the big dilemma of interactive works as an art and/or entertainment medium, games being the exception."⁸

The loss of authorial control is not a dilemma for game designers, because they embrace it as the foundation of a medium created by actions as much as content. Games exist somewhere between the text and the experience, confounding preservation strategies that rely on notions of content fixity taken from other media. Hardware and software objects alone cannot document the medium of the computer game. What is saved by preserving consoles, hardware, and software alone, without recording game play?

The nature of computer games as software leads to another sort of variability of content, one that does not yet apply so much to console and arcade-based games as it does to computer-based games. I am referring to what Lev Manovich has called the new "cultural economy" of game design, introduced in 1993 with the release of id software's *DOOM*.⁹ When a computer game is released today, it is as much a set of design tools as a finished design. Since the advent of level editors and the increasing popularity of modified games – "mods" – many designers ship game engines accompanied by a game, levels, and maps designed in-house. (Game engines are the software platforms for handling graphics,

game physics, artificial intelligence, the structure of game levels and file formats, editors, etc.) Then level, scenario and mod designers take over, creating their own games. Manovich contrasts modifiable games to the more traditional characteristics of a game like *Myst*, "more similar to a traditional artwork than to a piece of software: something to behold and admire, rather than take apart and modify." The contemporary game scene pulses with the energy of new content developers using game engines to design new games (such as *Dungeon Siege* "siegelets"), modding games and game engines, skinning characters, working up freeware utilities, changing art assets or even conflating media by using game engines to produce movie-like game experiences, such as game movies and Machinima. *Counter-Strike*, the most popular internet-based game of all, is of course a multiplayer modification of single-player *Half-Life*, demonstrating how mainstream the mod economy of game design has become.

Curatorship Issues

Curatorship of interactive digital media collections confronts the growing volume, diversity, and importance of impermanent and invisible software, even for its own preservation. The cat we are trying to put in the bag is ripping our heirloom luggage to shreds. The history of software diverges from the history of print culture, not just in the impermanence of its media – an issue upon which the dust has not yet settled – but in the flexibility of its use and capacity for converging previously separated realms: texts, stories, audio-visual experiences, interactive simulations, data processing, records management, and metadata applications such as indexing, among them. Traditional institutions and professional identities provide uncertain guidance in deciding who should be responsible for the custodial care of software and new media collections, given such a diverse range of

contents and associated knowledge. As Doron Swade points out from the perspective of a museum curator:

“Some software is already bespoke: archivists and librarians have ‘owned’ certain categories of electronic ‘document’: Digitised source material, catalogues, indexes, and dictionaries, for example. But what are the responsibilities of a museum curator? Unless existing custodial protection can be extended to include software, the first step towards systematic acquisition will have faltered, and a justification for special provision will need to be articulated ab initio in much the same way as film and sound archives emerged as distinct organisational entities outside the object-centred museum.”¹⁰

Swade considers the problem as one of “preserving information in an object-centred culture,” the title of his essay; that is, he ponders the relevance of artifact collections of software and the various methods of “bit-perfect” replication of their content. Libraries, and within libraries rare books and manuscript librarians, are coming to grips with related issues that might be described as “preserving information in a text-centred culture.” In saying this, I realize that these librarians are often the chief protectors of artifact-centered culture in American libraries. Nonetheless, their *raison-d’être* is the preservation of special categories of original source materials – primarily texts. This is one of the rubs in formulating institutional approaches to the preservation of software and related digital media, for software defines a new relationship between media objects and their content, one that calls into question notions of content preservation that privilege the original object. Current debates about the best methods for preserving software are hung up to some degree on different institutional and professional allegiances to the preservation of objects, as well

as data migration, archival functions, evidentiary value, and information content. These issues are not likely to be sorted out in time to make serious commitments even to the stabilization, let alone the long-term preservation, of digital content and software. Brewster Kahle's Internet Archive demonstrates what can be done outside these institutional constraints, but it is an exceptional case, rather than providing a new rule.¹¹

The historical preservation of games and other interactive multimedia will depend on the development of new models of curatorship and collections. Jürgen Claus, now Professor of Media Art at the Kunsthochschule für Medien in Cologne, introduced this topic in his 1985 essay on the "Expansion of Media Art: What Will Remain of the Electronic Age?" He said simply, "If media art does constitute a new stage of development, then we have to ask for adequate spaces to display and store this art, that is, we have to ask for media museums."¹² Claus insisted that "The Museum must not be relieved of its duty of being a place of reference for works of remaining value. Certainly, film, photography, video, disc, tape, etc. are media to store events of art. Where should they be collected, examined, and passed on if not in an adequate museum, that is, a media museum?"¹³ More recently, Matthew Kirschenbaum, a literary scholar who has written particularly about hypertext, has asked what it means to treat electronic texts such as Michael Joyce's *afternoon* as a textual artifact "subject to material and historical forms of understanding."¹⁴ He calls into question the duality that sees printed texts as durable and fixed, electronic texts as "volatile and unstable." Perhaps Eisenstein's notion of the "fixity of print" has obscured counter approaches best exemplified in such disparate scholarly worlds as editorial and reader studies. Kirschenbaum points out the equally dangerous position of a post-modernist embracing of the ephemeral qualities of electronic media. He concludes that a kind of

bibliographic/textual scholarship can be applied to the “authorial effort to create links, guard fields, and so forth,” as long as the network of code, technology and documentation that underlies the creation of hypermedia is preserved. I would add to this that these artifacts cannot be adequately interpreted without establishing contexts of design, creation, and technology, and for this we need documentation, texts, source code, artwork and so on. A brochure published by the History of Computing Committee of the American Federation of Information Processing Societies (AFIPS) over two decades ago recommended that:

“If we are to fully understand the *process* of computer and computing development as well as the end results, it is imperative that the following material be preserved: correspondence; working papers; unpublished reports; obsolete manuals; key program listings used to debug and improve important software; hardware and componentry engineering drawings; financial records; and associated documents and artifacts.”¹⁵

The media museum will be equal parts museum, library, and archives.

Access to historical collections of digital files and software strikes me as urgently requiring new institutional and curatorial models. The roles of archives, libraries, and museums will converge rapidly in the realm of new media collections such as the computer game archives of the future. W. Boyd Raymond has written about this convergence, arguing that electronic information is reshaping the roles of these institutions. He points out that “the functional differentiation of libraries, museums and archives as reflected in different institutional practices, physical locations, and the specialist work of professional cadres of personnel is a relatively recent phenomenon. This functional differentiation was a response to the exigencies of managing different kinds of collections as these have grown in size and have had to respond to the needs and interests of an ever enlarging body of actual and

prospective users.” Raymond’s view is that individual scholars continue to favor the ideal of a “personal cabinet of curiosities” finely tuned to specific research, an ideal that considers format of artifacts and media as irrelevant, while stressing content. This was the “undifferentiated past” that these institutions hold in common.¹⁶ Computer game archives, as cabinets of new media curiosities, will need to consolidate access to media collections, digital libraries and software archives in this way.

A Plan for Action

I have argued that in the realm of digital, interactive software and multimedia, preservation strategies limited to the long-term stabilization of fixed content provide only partial solutions, whether this fixed element is defined as a kind of text, an artifact, or software code itself. Similarly, existing institutional and curatorial models – museums, libraries, special collections departments and archives – provide only partial models for the care and feeding of the kinds of collections we will need to build.

It seems to me that as we begin building the computer game archives of the future in the present, we should be guided by three notions. The first is careful revision of institutional and curatorial roles for historical new media collections. The second is to begin definition now of the technical foundations of these archives, focusing on how to capture and preserve the "look and feel" of interactive media, interactivity itself, and the social and personal experiences made possible by computer games. At the same time, we should keep our eyes on the ball of preserving existing documentation, hardware, data and metadata in the full variety of their formats. The third notion is simply that the lynchpin of all that

follows will be to solve these problems in collaborative, multi-institutional projects. No single institution owns the resources or expertise under one roof to go it alone in this realm. But a network of museums, libraries, and new digital repositories (such as the Digital Game Archive or the Internet Archive) would make a good start. Moreover, without the cooperation of industry groups such as the International Game Developers Association, game designers and publishers we cannot make progress on the sticky social, business and legal issues that hinder the building safe harbor collections relying on voluntary participation and provide access to collections to as wide a community of users as possible.

Now I will propose five salient tasks and challenges facing such a an alliance of interested parties:

1. **Build emulation test-beds.** We are only at the beginning of the technology debate about the best way to preserve bits of culture – born-digital content and software. Strategies based on migration, hardware and media preservation, emulation, and Rothenberg’s “encapsulation” have been debated at great length, though there are few tests of the options. In fact, the application of any one of these methods depends to some degree on one or more of the others. For example, it is difficult to imagine an emulation strategy that does require migration of emulation software to new hardware platforms. It is likely that all of these methods will play some role in the preservation of software history, but at the same time we can agree that in the case of games, a method that preserves “look and feel” is particularly attractive. However, as noted at the beginning of this talk, the technology requirements for running games are evolve rapidly to take advantage of new means for enhancing graphics and game play. Emulation design must take account not just

of operating systems and software, but also the requirements built into games for audio and graphics boards, 3D programming interfaces (APIs) such as OpenGL and Direct3D, networking protocols (and speeds!), displays and controllers. For this reason, I propose that we fund and implement a very small number of complete test-beds to develop emulation as a long-term archival strategy. “Complete” means that these test-beds not only deliver technology, but also architect repositories that address intellectual property rights, access, cost control, and collection development. These problems are complex, and I propose the following mix of test-beds: (1) a system whose software is largely or completely in the public domain (such as the Vectrex); (2) a single console platform and publisher (such as Atari’s titles for the 2600 or Nintendo’s for the NES); (3) the games published as computer or personal computer software by a single publisher or in a single genre (Infocom’s interactive fiction titles, SSI’s military simulations, or id’s 3-D shooters come to mind); (4) a game produced outside the commercial sphere (such as MUD or games produced by the PLATO project).

2. Build a game performance archive. Games are about interactivity, and as Crawford has told us, interactivity is about actions, not just content. I do not mean to underestimate the difficulties of documenting performance, but the nature of computer game technology is conducive to creating collections that document game play. They are played on screens and computers, opening up the possibility of video capture. Even better, a number of competitive multiplayer games, such as Command & Conquer, Warcraft and some shooters, are capable of displaying spectator modes or saving game replays, although playing these replays will require either conversion to digital video files or emulation software.

The new genre of machinima provides a model. Machinima films borrow from the computer graphics technology developed for games, often using game engines such as Quake to make films inexpensively on personal computers. They are then distributed over the Internet either as game files or in versions rendered to display on another a computer. The website machinima.com describes the work of the Quake done Quick team, a maker of machinima films as “to get through Quake and its various mission packs, additional levels and various difficulty settings as fast as possible, and then to make an enjoyable Machinima film of the ‘demo’ recordings of their runs.” Note that in its dependence on game engines, a performance archive of game replays, game movies, and machinima depends to some extent on the success of emulation, unless all such formats are to be captured and encoded as digital video files. I propose that a working group formulate a strategy for creating, collecting and securing rights to collect game performance, then work with a digital repository to build a small demonstration collection within one year.

3. Launch an initiative to build archives of design document, source code, art assets, and ancillary documentation of the history of game design. Even if the application of concepts of authorship is problematic with respect to games, computer games are designed, coded, drawn, built, tested, and published. Design and programming history are important. Games designed by luminaries such as Shigeru Miyamoto, Sid Meier, Will Wright or Peter Molyneux have their own distinctive style and content. Others, notably the Infocom team or John Carmack, have shaped the technology of game design. At present, it is difficult to write a history of game design and technology, because documentation for the work of game designers – particularly for arcade and video game console games – is sorely lacking. I

propose that a working group design a documentation survey. This group should draw on experts in the IGDA, the Game Developers Conference, or other industry groups, together with academic repositories developing programs of new media studies (Stanford, MIT, Carnegie-Mellon, Georgia Tech). This survey strategy should be tested by applying it to a short list of significant game designs and designers.

4. Stabilize representative artifact collections in Museums and Archives. Build collections of packaged game software, documentation, and marketing materials to accompany these materials. This is probably the area in which the most progress has already been made. The collection of game software in Stanford's Stephen M. Cabrinety Collection in the History of Microcomputing (along with materials in the Martin Gardner papers and Apple History collection at Stanford), and the marvelous hardware collections of the Computer History Museum provide two examples of significant manuscript and artifact repositories. Conservators and preservation specialists, some of them in this audience, are already hard at work as they seek to insure the long-term availability of these collections. In the worst-case scenario, if game software can no longer be run in 100 years, these collections will still have value as archival resources for assessing the impact and marketing of games and evidence of their structure and play through documentation. They will also prod historians of technology and media to encourage their students to recreate lost technology, much as the Science Museum of London has done for Charles Babbage's difference engine.

5. Collaborate. Again, no single institution can carry out these tasks. This fact alone demands a collaborative approach. However, there are other reasons that competent institutions must join together to build archives of computer game history. Some of you

realized that lay historians of computer games, in web sites and communities of game players, have already contributed to the first two tasks on this list by making emulators and game movies available. So let's see if we can enlist these pioneers in the effort to create more permanent historical resources. The participation of the game industry, museums and academic institutions in this project can help to defuse the adversarial relationship between, say, the emulation community and publishers by developing mutually acceptable practices with respect to intellectual property and access.

James Cortada, an IBM executive and historian, made an interesting point in the preface to *Archives of Data-Processing History*, published in 1990:

“The first group of individuals to recognize a new subject area consists usually of participants followed closely after by students of the field and finally, if belatedly, by librarians and archivists. It is very frustrating to historians of a new subject, because it takes time for libraries to build collections or to amass documentary evidence to support significant historical research. This situation is clearly the case with the history of information processing.”¹⁷

I hope we can begin work on archives of computer games that anticipate the research needs of the future.

¹ Mark J. P. Wolf, ed., *The Medium of the Video Game* (Austin: Univ. of Texas Press, 2001)

² The IDSA statistics were gathered from a study. See: Interactive Digital Software Association, *Essential Facts about the Computer and Video Game Industry* (Washington, D.C.: IDSA, 2000): 5. See also: Khanh T. L. Tran, "U.S. Videogame Industry Posts Record Sales," *Wall Street Journal* (Feb. 7, 2002); Valve L.L.C., "Valve Unveils Steam At 2002 Game Developer's Conference," (Press Release, March 21, 2002); Sharon Waxman, "Hollywood's Great Escapism; 2001 Box Office Receipts Set a Record," *The Washington Post* (Jan. 4, 2002); Anne Valdespino, "The Big Screen Keeps Pulling Us In," *Los Angeles Times* (July 1, 2002).

³ Henry Jenkins, "Art Form for the Digital Age," *Technology Review* (Sept.-Oct. 2000). Available here: <http://www.techreview.com/articles/oct00/viewpoint.htm>

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- ⁴ Jay David Bolter and Richard Grusin, *Remediation: Understanding New Media* (Cambridge, Mass.: MIT Press, 1999), esp. "Computer Games," pp. 88-103.
- ⁵ Mark Weiser, "The Computer for the Twenty-First Century," *Scientific American* (Sept. 1991): 94-100.
- ⁶ Elliott Avedon and Brian Sutton-Smith, *The Study of Games* (New York: Wiley, 1971): 419.
- ⁷ Chris Crawford, "Why is Interactivity So Hard?," *Interactive Entertainment Design* 9 (1995-1996). URL: http://www.erasmatazz.com/library/JCGD_Volume_9/Why_so_Hard.html.
- ⁸ Randall Packer, "Net Art as Theater of the senses: A HyperTour of Jodi and Grammatron," in: *Beyond Interface*. URL: http://www.archimuse.com/mw98/beyond_interface/bi_frpacker.html. This is the introduction to Mark Amerika's Grammatron, a work of hypertext web art.
- ⁹ The term is found in Lev Manovich, "Navigable Space" (1998). URL: http://jupiter.ucsd.edu/~manovich/docs/navigable_space.doc
- ¹⁰ Doron Swade, "Collecting Software: Preserving Information in an Object-Centred Culture," in: Seamus Ross and Edward Higgs, eds., *Electronic Information Resources and Historians: European Perspectives* (St. Katharinen: Scripta Mercaturae, 1993): 94.
- ¹¹ My talk was followed by Brewster Kahle's presentation on The Internet Archive, which is located at: <http://www.archive.org/>.
- ¹² Jürgen Claus, "Expansion of Media Art: What Will Remain of the Electronic Age?" (1985?), reprinted in *Arx Electronica: Facing the Future, a Survey of Two Decades*, ed. Timothy Druckrey (MIT Press, 1999). (Source: Books24x7.com electronic edition)
- ¹³ Claus, *op cit*.
- ¹⁴ Matthew Kirschenbaum, "Materiality and Matter and Stuff: What Electronic Texts are Made Of," *ebr* 12 (2002), URL: <http://www.altx.com/ebr/riposte/rip12/rip12kir.htm>.
- ¹⁵ "Preserving Computer-Related Source Materials" (1979). This brochure was later reproduced in the *IEEE Annals for the History of Computing* 2 (Jan. 1980). The text of this brochure is available via the website of the Software History Center at URL: <http://www.softwarhistory.org/>.
- ¹⁶ W. Boyd Raymond, "Electronic Information and the Functional Integration of Libraries, Museums, and Archives," in: Seamus Ross and Edward Higgs, eds., *Electronic Information Resources and Historians: European Perspectives* (St. Katharinen: Scripta Mercaturae, 1993): 227-43, esp. 232.
- ¹⁷ James W. Cortada, "Preface," in: *Archives of Data-Processing History: A Guide to Major U.S. Collections* (New York: Greenwood, 1990): ix.