Introduction

A Personal Chronology

Moscow, 1975. Although my ambition is to become a painter, I enroll in the mathematical ("matematicheskaya") high school, which in addition to a regular curriculum has courses in calculus and computer programming. The programming course lasts two years, during which we never see a computer. Our teacher uses a blackboard to explain the concepts of computer programming. First we learn a computer language invented in the Soviet Union in the late 1950s. The language has a wonderful Cold War name: "Peace-1" ("MiR-1"). Later we learn a more standard high-level language: ALGOL-60. For two years, we write computer programs in our notebooks. Our teacher grades them and returns them with corrections: missed end of the loop statement, undeclared variable, forgotten semicolon. At the end of the two-year course, we are taken—just once—to a data-processing center, which normally requires clearance to enter. I enter my program into a computer, but it does not run: Because I had never seen a computer keyboard before, I used the letter *O* whenever I need to input zero.

Also in 1975, I start taking private lessons in classical drawing, lessons that also last two years. The Moscow Architectural Institute entrance exams include a test in which the applicants have to complete a drawing of an antique bust in eight hours. To get the top grade, one has to produce a drawing that not only looks like the cast and has perfect perspective, but also has perfect shading. This means that all shadows and surfaces are defined completely through shading, so all the lines originally used to define them disappear. Hundreds of hours spent in front of a drawing board pay off: I get an A on the exam, even though out of eight possible casts I am assigned the most difficult one: the head of Venera. It is more difficult because, in contrast to casts of male heads such as Socrates', it does not have well-defined facets; the surfaces join smoothly together as though constructed with a spline modeling program. Later I learn that, during the 1970s, computer scientists were working on the same problem, that is, how to produce smoothly shaded images of 3-D objects on a computer. The standard rendering algorithm still used today was invented at the University of Utah in 1975—the same year I started my drawing lessons.[1]

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1. B. T. Phong, "Illumination for Computer Generated Pictures," *Communication of the ACM* 18, no. 6 (June 1975): 311–317.

New York, 1985. It is early morning, and I am sitting in front of a Tetronics terminal in midtown Manhattan. I have just finished my night shift at Digital Effects, one of the first companies in the world devoted to producing 3-D computer animation for film and television. (The company worked on *Tron* and produced computer animation for all of the major television networks.) My job is to operate the Harris-500 mainframe, used to compute animations, and also the PDP-11, which controls the Dicomed film recorder, used to output animation on 35mm film. After a few months I am able to figure out the company's proprietary computer-graphics software written in APL (a high level programming language), and begin work on my first images. I would like to produce a synthetic image of an antique bust, but the task turns out to be impossible. The software is able to create 3-D objects only out of primitive geometric forms such as cubes, cylinders, and spheres—so I am forced to settle for a composition made out of these primitive forms. Tetronics is a vector rather than raster terminal, which means that it does not update its screen in real time. Each time I make a change in my program or simply change a point of view, I hit the enter key and wait while the computer redraws the lines, one by one. I wonder why I had to spend years learning to draw images in perspective when a computer could do it in seconds. A few of the images I create are exhibited in shows of computer art in New York. But this is the heyday of postmodernism: The art market is hot, paintings by young New York artists are selling for tens of thousands of dollars, and the art world has little interest in computer art.

Linz, Austria, 1995. I am at Ars Electronica, the world's most prestigious annual computer-art festival. This year it drops the "computer graphics" category, replacing it with the new "net art" category, signaling a new stage in the evolution of modern culture and media. The computer, which since the early 1960s has been used as a production tool, has now become a universal media machine—a tool used not only for production, but also for storage and distribution. The World Wide Web crystallizes this new condition; on the level of language, this fact is recognized around 1990 when the term "digital media" comes to be used along with "computer graphics." At the same time, along with existing cultural forms, computers begin to host an array of new forms: Web sites and computer games, hypermedia CD-ROMs and interactive installations—in short, "new media." And if in 1985 I had to write a long computer program in a specialized computer language just to put a picture of a shaded cube on a computer screen, ten years later I can

choose from a number of inexpensive, menu-based 3-D software tools that run on ordinary PCs and come with numerous ready-made 3-D models, including detailed human figures and heads.

What else can be said about 1995? The Soviet Union, where I was born, no longer exists. With its demise, the tensions that for decades animated creative imaginations both in the East and the West—between freedom and confinement, interactivity and predetermination, consumerism in the West and "spirituality" in the East—disappear. What takes their place? A triumph of consumerism, commercial culture (based on stereotypes and limited clichés), megacorporations that lay claim to such basic categories as space, time, and the future ("Where Do You Want to Go Today?" ads by Microsoft; "Internet Time" by Swatch, which breaks twenty-four hours into 1,000 Swatch "beats"; "You will" ads by AT&T), and "globalization" (a term at least as elusive as "spirituality").

When I visit St. Petersburg in 1995 to participate in a small computer art festival called "In Search of a Third Reality," I see a curious performance, which may be a good parable of globalization. Like the rest of the festival, the performance takes place in the planetarium. Its Director, forced like everyone else to make his own living in the new Russian economic order (or lack thereof), had rented the planetarium to conference organizers. Under the black hemispherical ceiling with mandatory models of planets and stars, a young artist methodically paints an abstract painting. Probably trained in the same classical style as I had been, he is no Pollock; cautiously and systematically, he makes careful brushstrokes on the canvas in front of him. On his hand he wears a Nintendo Dataglove, which in 1995 is a common media object in the West but a rare sight in St. Petersburg. The Dataglove transmits the movements of his hand to a small electronic synthesizer, assembled in the laboratory of some Moscow institute. The music from the synthesizer serves as an accompaniment to two dancers, a male and a female. Dressed in Isadora Duncan–like clothing, they improvise a "modern dance" in front of an older and, apparently, completely puzzled audience. Classical art, abstraction, and a Nintendo Dataglove; electronic music and early twentieth-century modernism; discussions of virtual reality (VR) in the planetarium of a classical city that, like Venice, is obsessed with its past—what for me, coming from the West, are incompatible historical and conceptual layers are composited together, with the Nintendo Dataglove being just one layer in the mix.

What also arrives by 1995 is the Internet—the most material and visible sign of globalization. And by the end of the decade it will also become clear that the gradual computerization of culture will eventually transform all of it. So, invoking the old Marxist model of base and superstructure, we can say that if the economic base of modern society from the 1950s onward starts to shift toward a service and information economy, becoming by the 1970s a so-called post-industrial society (Daniel Bell), and then later a "network society" (Manual Castells), by the 1990s the superstructure starts to feel the full impact of this change.[2] If the postmodernism of the 1980s is the first sign of this shift still to come—still weak, still possible to ignore—the 1990s' rapid transformation of culture into e-culture, of computers into universal culture carriers, of media into new media, demands that we rethink our categories and models.

The year is 2005. . . .

Theory of the Present

I wish that someone in 1895, 1897, or at least 1903, had realized the fundamental significance of the emergence of the new medium of cinema and produced a comprehensive record: interviews with audiences; a systematic account of narrative strategies, scenography, and camera positions as they developed year by year; an analysis of the connections between the emerging language of cinema and different forms of popular entertainment that co-existed with it. Unfortunately, such records do not exist. Instead we are left with newspaper reports, diaries of cinema's inventors, programs of film showings, and other bits and pieces—a set of random and unevenly distributed historical samples.

Today we are witnessing the emergence of a new medium—the meta-medium of the digital computer. In contrast to a hundred years ago, when cinema was coming into being, we are fully aware of the significance of this new media revolution. Yet I am afraid that future theorists and historians of computer media will be left with not much more than the equivalents of the newspaper reports and film programs from cinema's first decades. They will find that analytical texts from our era recognize the significance of the com-

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2. Daniel Bell, *The Coming of Post-industrial Society* (New York: Basic Books, 1973); Manuel Castells, *The Rise of the Network Society* (Cambridge, Mass.: Blackwell Publishers, 1996).

puter's takeover of culture yet, by and large, contain speculations about the future rather than a record and theory of the present. Future researchers will wonder why the theoreticians, who had plenty of experience analyzing older cultural forms, did not try to describe computer media's semiotic codes, modes of address, and audience reception patterns. Having painstakingly reconstructed how cinema emerged out of preceding cultural forms (panorama, optical toys, peep shows), one might ask why they didn't attempt to construct a similar genealogy for the language of computer media at the moment when it was just coming into being, that is, when the elements of previous cultural forms shaping it were still clearly visible and recognizable, before melting into a coherent language? Where were the theoreticians at the moment when the icons and buttons of multimedia interfaces were like wet paint on a just-completed painting, before they became universal conventions and thus slipped into invisibility? Where were they at the moment when the designers of *Myst* were debugging their code, converting graphics to 8-bit, and massaging QuickTime clips? Or at the historical moment when a twenty-something programmer at Netscape took the chewing gum out of his mouth, sipped warm Coke out of the can—he had been at a computer for sixteen hours straight, trying to meet a marketing deadline—and, finally satisfied with its small file size, saved a short animation of stars moving across the night sky? This animation would appear in the upper right corner of Netscape Navigator, and become the most widely seen moving image sequence ever—until the next release of the software.

What follows is an attempt at both a record and a theory of the present. Just as film historians traced the development of film language during cinema's first decades, I aim to describe and understand the logic driving the development of the language of new media. (I am not claiming that there is a single language of new media. I use "language" as an umbrella term to refer to a number of various conventions used by designers of new media objects to organize data and structure the user's experience.) It is tempting to extend this parallel a little further and speculate whether this new language is already drawing closer to acquiring its final and stable form, just as film language acquired its "classical" form during the 1910s. Or it may be that the 1990s are more like the 1890s, in the sense that the computer-media language of the future will be entirely different from the one used today.

Does it make sense to theorize the present when it seems to be changing so fast? It is a hedged bet. If subsequent developments prove my theoretical projections correct, I win. But even if the language of computer media

develops in a different direction than the one suggested by the present analysis, this book will become a record of possibilities heretofore unrealized, of a horizon visible to us today but later unimaginable.

We no longer think of the history of cinema as a linear march toward a single possible language, or as a progression toward perfect verisimilitude. On the contrary, we have come to see its history as a succession of distinct and equally expressive languages, each with its own aesthetic variables, and each closing off some of the possibilities of its predecessor (a cultural logic not dissimilar to Thomas Kuhn's analysis of scientific paradigms.)[3] Similarly, every stage in the history of computer media offers its own aesthetic opportunities, as well as its own vision of the future: in short, its own "research paradigm." In this book I want to record the "research paradigm" of new media during its first decade, before it slips into invisibility.

Mapping New Media: The Method

I analyze the language of new media by placing it within the history of modern visual and media cultures. What are the ways in which new media relies on older cultural forms and languages, and what are the ways in which it breaks with them? What is unique about how new media objects create the illusion of reality, address the viewer, and represent space and time? How do conventions and techniques of old media—such as the rectangular frame, mobile viewpoint, and montage—operate in new media? If we construct an archeology connecting new computer-based techniques of media creation with previous techniques of representation and simulation, where should we locate the essential historical breaks?

To answer these questions, I look at all areas of new media: Web sites, virtual worlds,[4] virtual reality (VR), multimedia, computer games, interactive instal-

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3. Thomas S. Kuhn, *The Structure of Scientific Revolutions,* 2d ed. (Chicago: University of Chicago Press, 1970).

4. By virtual worlds I mean 3-D computer-generated interactive environments. This definition fits a whole range of 3-D computer environments already in existence—high-end VR works that feature head-mounted displays and photo realistic graphics, arcade, CD-ROM and on-line multi-player computer games, QuickTime VR movies, VRML (Virtual Reality Modeling Language) scenes, and graphical chat environments such as The Palace and Active Worlds.

Virtual worlds represent an important trend across computer culture, consistently promising to become a new standard in human-computer interfaces and computer networks. (For a

lations, computer animation, digital video, cinema, and human-computer interfaces. Although the book's main emphasis is on theoretical and historical arguments, I also analyze many key new-media objects, from American commercial classics such as *Myst* and *Doom, Jurassic Park* and *Titanic,* to the work of international new media artists and collectives such as ART+COM, antirom, jodi.org, George Legrady, Olga Lialina, Jeffrey Shaw, and Tamas Waliczky.

The computerization of culture not only leads to the emergence of new cultural forms such as computer games and virtual worlds; it redefines existing ones such as photography and cinema. I therefore also investigate the effects of the computer revolution on visual culture at large. How does the shift to computer-based media redefine the nature of static and moving images? What is the effect of computerization on the visual languages used by our culture? What new aesthetic possibilities become available to us?

In answering these questions, I draw upon the histories of art, photography, video, telecommunication, design, and, last but not least, the key cultural form of the twentieth century—cinema. The theory and history of cinema serve as the key conceptual lens though which I look at new media. The book explores the following topics:

- the parallels between cinema history and the history of new media;
- the identity of digital cinema;
- the relations between the language of multimedia and nineteenth century pro-cinematic cultural forms;
- the functions of screen, mobile camera, and montage in new media as compared to cinema;
- the historical ties between new media and avant-garde film.

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discussion of why this promise may never be fulfilled, see the "Navigable Space" section.) For example, Silicon Graphics developed a 3-D file system that was showcased in the movie *Jurassic Park.* Sony used a picture of a room as an interface in its MagicLink personal communicator. Apple's short-lived E-World greeted its users with a drawing of a city. Web designers often use pictures of buildings, aerial views of cities, and maps as interface metaphors. In the words of the scientists from Sony's The Virtual Society Project (www.csl.sony.co.jp/project/VS/), "It is our belief that future online systems will be characterized by a high degree of interaction, support for multi-media and most importantly the ability to support shared 3-D spaces. In our vision, users will not simply access textual based chat forums, but will enter into 3-D worlds where they will be able to interact with the world and with other users in that world."

Along with film theory, this book draws theoretical tools from both the humanities (art history, literary theory, media studies, social theory) and computer science. Its overall method could be called "digital materialism." Rather than imposing some a priori theory from above, I build a theory of new media from the ground up. I scrutinize the principles of computer hardware and software and the operations involved in creating cultural objects on a computer to uncover a new cultural logic at work.

Most writings on new media are full of speculation about the future. This book, in contrast, analyses new media as it has actually developed until the present moment, while pointing to directions for new media artists and designers that have yet to be explored. It is my hope that the theory of new media developed here can act not only as an aid to understanding the present, but also as a grid for practical experimentation. For example, the "Theory of Cultural Interfaces" section analyzes how the interfaces of new media objects are being shaped by three cultural traditions: print, cinema, and human-computer interface. By describing elements in these traditions that are already being used in new media, I point toward other elements and their combinations still awaiting experimentation. The "Compositing" section provides another set of directions for experiments by outlining a number of new types of montage. Yet another direction is discussed in "Database," where I suggest that new media narratives can explore the new compositional and aesthetic possibilities offered by a computer database.

Although this book does not speculate about the future, it does contain an implicit theory of how new media will develop. The advantage of placing new media within a larger historical perspective is that we begin to see the long trajectories that lead to new media in its present state, and we can extrapolate these trajectories into the future. The section "Principles of New Media" describes four key trends that, in my view, are shaping the development of new media over time: modularity, automation, variability, and transcoding.

Of course we don't have to accept these trends blindly. Understanding the logic that is shaping the evolution of new media language allows us to develop different alternatives. Just as avant-garde filmmakers have offered alternatives to cinema's particular narrative audio-visual regime throughout the medium's history, the task of avant-garde new media artists today is to offer alternatives to the existing language of computer media. This can be better accomplished if we have a theory of how "mainstream" language is now structured and how it might evolve over time.

Mapping New Media: Organization

This book aims to contribute to the emerging field of new media studies (sometimes called "digital studies") by providing one potential map of what the field can be. Just as a literary theory textbook might feature chapters on narrative and voice, and a textbook of film studies might discuss cinematography and editing, this book calls for the definition and refinement of the new categories specific to new media theory.

I have divided the book into a number of chapters, each of which covers one key concept or problem. Concepts developed in earlier chapters become building blocks for analyses in later chapters. In determining the sequence of the chapters, I considered textbooks on various established fields relevant to new media, such as film studies, literary theory, and art history; much as a textbook on film may begin with film technology and end up with film genres, this book progresses from the material foundations of new media to its forms.

One could also draw an analogy between the "bottom-up" approach I use here and the organization of computer software. A computer program written by a programmer undergoes a series of translations: high-level computer language is compiled into executable code, which is then converted by an assembler into binary code. I follow this order in reverse, advancing from the level of binary code to the level of a computer program, and then move on to consider the logic of new media objects driven by these programs:

1.   "What Is New Media?"—the digital medium itself, its material and logical organization.
2.   "The Interface"—the human-computer interface; the operating system (OS).
3.   "The Operations"—software applications that run on top of the OS, their interfaces, and typical operations.
4.   "The Illusions"—appearance, and the new logic of digital images created using software applications.
5.   "The Forms"—commonly used conventions for organizing a new media object as a whole.

The last chapter "What Is Cinema?" mirrors the book's beginning. Chapter 1 points out that many of the allegedly unique principles of new media can already be found in cinema. Subsequent chapters continue to employ film history and theory as a means of analyzing new media. Having discussed

different levels of new media—interface, operations, illusion, and forms—I then reverse my conceptual lens to look at how computerization changes cinema. I analyze the identity of digital cinema by placing it within the history of the moving image and discuss how computerization offers new opportunities for developing the language of film.

At the same time, the last chapter continues the "bottom-up" trajectory of the book as a whole. If chapter 5 looks at the organization of new cultural objects, such as Web sites, hypermedia CD-ROMs, and virtual worlds, all "children" of the computer, chapter 6 considers the effects of computerization on an older cultural form that exists, so to speak, "outside" computer culture proper—cinema.

Each chapter begins with a short introduction that discusses a concept and summarizes the arguments developed in individual sections. For example, chapter 2, "The Interface," begins with a general discussion of the importance of the concept of the interface in new media. The two sections of chapter 2 then look at different aspects of new media interfaces: their reliance on the conventions of other media and the relationship between the body of the user and the interface.

The Terms: Language, Object, Representation

In putting the word *language* into the title of the book, I do not want to suggest that we need to return to the structuralist phase of semiotics in understanding new media. However, given that most studies of new media and cyberculture focus on their sociological, economic, and political dimensions, it was important for me to use the word *language* to signal the different focus of this work: the emergent conventions, recurrent design patterns, and key forms of new media. I considered using the words *aesthetics* and *poetics* instead of *language,* eventually deciding against them. *Aesthetics* implies a set of oppositions that I would like to avoid—between art and mass culture, the beautiful and the ugly, the valuable and the unimportant. *Poetics* also bears undesirable connotations. Continuing the project of the Russian formalists of the 1910s, theoreticians in the 1960s defined *poetics* as the study of the specific properties of particular arts, such as narrative literature. In his *Introduction to Poetics* (1968), literary scholar Tzvetan Todorov, for instance, writes:

In contradistinction to the interpretation of particular works, it [poetics] does seek to name meaning, but aims at a knowledge of the general laws that preside over the

birth of each work. But in contradistinction to such sciences as psychology, sociology, etc., it seeks these laws within literature itself. Poetics is therefore an approach to literature at once 'abstract' and 'internal.'[5]

In contrast to such an "internal" approach, I neither claim that the conventions, elements, and forms of new media are unique, nor do I consider it useful to look at them in isolation. On the contrary, this book aims to situate new media in relation to a number of other areas of culture, both past and present:

•   other arts and media traditions: their visual languages and their strategies for organizing information and structuring the viewer's experience;
•   computer technology: the material properties of the computer, the ways in which it is used in modern society; the structure of its interface, and key software applications;
•   contemporary *visual culture:* the internal organization, iconography, iconology, and viewer experience of various visual sites in our culture—fashion and advertising, supermarkets and fine art objects, television programs and publicity banners, offices and techno-clubs;
•   contemporary *information culture.*

The concept "information culture," which is my term, can be thought of as a parallel to another, already familiar concept—visual culture. It includes the ways in which information is presented in different cultural sites and objects—road signs; displays in airports and train stations; television on-screen menus; graphic layouts of television news; the layouts of books, newspapers, and magazines; the interior designs of banks, hotels, and other commercial and leisure spaces; the interfaces of planes and cars; and, last but not least, the interfaces of computer operating systems (Windows, Mac OS, UNIX) and software applications (Word, Excel, PowerPoint, Eudora, Navigator, RealPlayer, Filemaker, Photoshop, etc.). Extending the parallels with visual culture, information culture also includes historical methods for

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5. Tzevan Todorov, *Introduction to Poetics,* trans. Richard Howard (Minneapolis: University of Minnesota Press, 1981), 6.

organizing and retrieving information (analogs of iconography) as well as patterns of user interaction with information objects and displays.

Another word deserving comment is *object.* Throughout the book, I use the term *new media object,* rather than *product, artwork, interactive media* or other possible terms. A new media object may be a digital still, digitally composited film, virtual 3-D environment, computer game, self-contained hypermedia DVD, hypermedia Web site, or the Web as a whole. The term thus fits with my aim of describing the general principles of new media that hold true across all media types, all forms of organization, and all scales. I also use *object* to emphasize that my concern is with the culture at large rather than with new media art alone. Moreover, *object* is a standard term in the computer science and computer industry, where it is used to emphasize the modular nature of object-oriented programming languages such as C++ and Java, object-oriented databases, and the Object Linking and Embedding (OLE) technology used in Microsoft Office products. Thus it also serves my purpose to adopt the terms and paradigms of computer science for a theory of computerized culture.

In addition, I hope to activate connotations that accompanied the use of the word *object* by the Russian avant-garde artists of the 1920s. Russian Constructivists and Productivists commonly referred to their creations as *objects* (*vesh, construktsia, predmet*) rather than works of art. Like their Bauhaus counterparts, they wanted to take on the roles of industrial designers, graphic designers, architects, and clothing designers, rather than remain fine artists producing one-of-a-kind works for museums or private collections. *Object* pointed toward the factory and industrial mass production rather than the traditional artist's studio, and it implied the ideals of rational organization of labor and engineering efficiency that artists wanted to bring into their own work.

In the case of new media objects, all these connotations are worth invoking. In the world of new media, the boundary between art and design is fuzzy at best. On the one hand, many artists make a living as commercial designers; on the other hand, professional designers are typically the ones who really push forward the language of new media by being engaged in systematic experimentation and also by creating new standards and conventions. The second connotation, that of industrial production, also holds true for new media. Many new media projects are put together by large teams (although, in contrast to the studio system of the classical Hollywood era, single producers or small teams are also common). Many new media objects, such as

popular games or software applications, sell millions of copies. Yet another feature of the new media field that unites it with big industry is the strict adherence to various hardware and software standards.[6]

Finally, and most important, I use the word *object* to reactivate the concept of laboratory experimentation practiced by the avant-garde of the 1920s. Today, as more artists are turning to new media, few are willing to undertake systematic, laboratory-like research into its elements and basic compositional, expressive, and generative strategies. Yet this is exactly the kind of research undertaken by Russian and German avant-garde artists of the 1920s in places like Vkhutemas[7] and Bauhaus, as they explored the new media of their time: photography, film, new print technologies, telephony. Today, those few who are able to resist the immediate temptation to create an "interactive CD-ROM," or make a feature-length "digital film," and instead focus on determining the new-media equivalent of a shot, sentence, word, or even letter, are rewarded with amazing findings.

A third term that is used throughout the book and needs comment is *representation.* In using this term, I want to invoke the complex and nuanced understanding of the functioning of cultural objects as developed in the humanities over the last decades. New media objects are cultural objects; thus, any new media object—whether a Web site, computer game, or digital image—can be said to represent, as well as help construct, some outside referent: a physically existing object, historical information presented in other documents, a system of categories currently employed by culture as a whole or by particular social groups. As is the case with all cultural representations, new media representations are also inevitably biased. They represent/construct some features of physical reality at the expense of others,

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6. Examples of software standards include operating systems such as UNIX, Windows, and MAC OS; file formats (JPEG, MPEG, DV, QuickTime, RTF, WAV); scripting languages (HTML, Javascript); programming languages (C++, Java); communication protocols (TCP-IP); the conventions of HCI (e.g., dialog boxes, copy and paste commands, the help pointer); and also unwritten conventions, such as the 640-by-480 pixel image size that was used for more than a decade. Hardware standards include storage media formats (ZIP, JAZ, CD-ROM, DVD), port types (serial, USB, Firewire), bus architectures (PCI), and RAM types.

7. Vkhutemas was a Moscow art and design school in the 1920s that united most leftist avant-garde artists; it functioned as a counterpart of the Bauhaus in Germany.

one worldview among many, one possible system of categories among numerous others. In this book I will take this argument one step further by suggesting that software interfaces—both those of operating systems and of software applications—also act as representations. That is, by organizing data in particular ways, they privilege particular models of the world and the human subject. For instance, the two key ways to organize computer data commonly used today—a hierarchical file system (Graphical User Interface from the 1984 Macintosh onward) and a "flat," nonhierarchical network of hyperlinks (1990s World Wide Web)—represent the world in two fundamentally different and in fact opposing ways. A hierarchical file system assumes that the world can be reduced to a logical and hierarchical order, where every object has a distinct and well-defined place. The World Wide Web model assumes that every object has the same importance as any other, and that everything is, or can be, connected to everything else. Interfaces also privilege particular modes of data access traditionally associated with particular arts and media technologies. For instance, the World Wide Web of the 1990s foregrounded the page as a basic unit of data organization (regardless of which media types it contained), while Acrobat software applied the metaphor of "video playback" to text-based documents. Thus interfaces act as "representations" of older cultural forms and media, privileging some at the expense of others.

In describing the language of new media, I have found it useful to use the term *representation* in opposition to other terms. Depending on which term it is opposed to, the meaning of *representation* changes. Since these oppositions are introduced in different sections of the book, I will summarize them here:

1. *Representation—simulation* ("Screen" section). Here, *representation* refers to various screen technologies such as post-Renaissance painting, film, radar, and television. I define *screen* as a rectangular surface that frames a virtual world and that exists within the physical world of a viewer without completely blocking her visual field. *Simulation* refers to technologies that aim to immerse the viewer completely within a virtual universe—Baroque Jesuit churches, nineteenth-century panorama, twentieth-century movie theaters.

2. *Representation—control* ("Cultural Interfaces" section). Here I oppose the image as a representation of an illusionary fictional universe and the image as a simulation of a control panel (for instance, GUI with its different icons and menus) that allows the user to control a computer. This new type of im-

age can be called *image-interface.* The opposition representation—control corresponds to an opposition between depth and surface: a computer screen as window into illusionistic space versus computer screen as flat control panel.

3.   *Representation—action* ("Teleaction" section). This is the opposition between technologies used to create illusions (fashion, realist paintings, dioramas, military decoys, film montage, digital compositing) and representational technologies used to enable action, that is, to allow the viewer to manipulate reality through representations (maps, architectural drawings, x-rays, telepresence). I refer to images produced by later technologies as *image-instruments.*

4.   *Representation—communication* ("Teleaction" section). This is the opposition between representational technologies (film, audio, and video magnetic tape, digital storage formats) and real-time communication technologies, that is, everything that begins with *tele-* (telegraph, telephone, telex, television, telepresence). Representational technologies allow for the creation of traditional aesthetic objects, that is, objects that are fixed in space or time and refer to some referent(s) outside themselves. By foregrounding the importance of person-to-person telecommunication, and *telecultural* forms in general that do not produce any objects, new media force us to reconsider the traditional equation between culture and objects.

5.   *Visual illusionism—simulation* (introduction to "Illusions" chapter). *Illusionism* here refers both to representation and simulation as these terms are used in the "Screen" section. Thus illusionism combines traditional techniques and technologies that aim to create a visual resemblance of reality—perspectival painting, cinema, panorama, etc. *Simulation* refers to various computer methods for modeling other aspects of reality beyond visual appearance—movement of physical objects, shape changes occurring over time in natural phenomena (water surface, smoke), motivations, behavior, speech and language comprehension in human beings.

6.   *Representation—information* (introduction to "Forms" chapter). This opposition refers to two opposing goals of new media design: immersing users in an imaginary fictional universe similar to traditional fiction and giving users efficient access to a body of information (for instance, a search engine, Web site, or on-line encyclopedia).