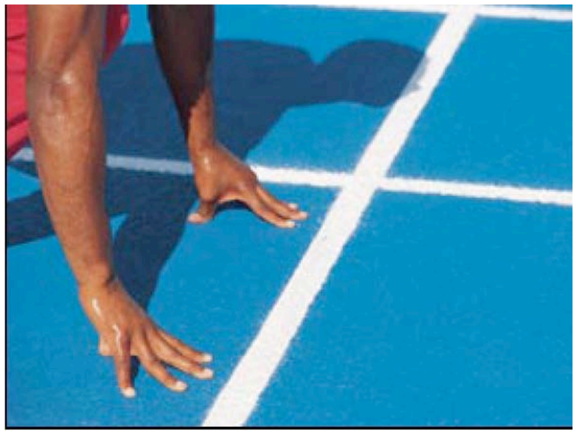
Vector Futures:
New Paradigms for Imag(in)ing the Humanities *



This image, an artifact of our age, is named SAMPLE.JPG and comes loaded with all Windows-based operating systems. If you use a Windows machine you already have your own copy. Why this particular image? Clearly it has certain aesthetic qualities, for example the chalked lines of the starter's box extending the strong limbs of the runner. The color palette is also conspicuous: red, white, and blue contrasted with the rich flesh-tones the of human body. And the image is thematically appropriate to the Microsoft ethos—Start! Go! There are good technical reasons for this choice of composition too, for it serves to test a system's capacity to simultaneously render both the subtle tonal gradations in the runner's arms and the clean, crisp color separation demanded by the white grid on

* This is the text of a paper I delivered at the 2002 Modern Language Association. I have not edited or updated the arguments or prose, so it is, especially in its specifics, an artifact of its moment. However I still stand by the core contention, namely that the fundamental characteristics of vector images--temporality, modularity, and programmability, as I gloss these terms below--are increasingly integral elements of image-based activities in the digital humanities as well as reflective of a more general paradigm shift from the documentary to the diagrammatic in terms of the role of the image. (Today's explosive rise in humanities GIS applications, which I mention in passing, seems especially significant in this regard.) Portions of the text previously appeared in my chapter on "Interface, Aesthetics, and Usability" in Blackwell's *A Companion to Digital Humanities*, eds. Susan Schreibman, Ray Siemens, and John Unsworth (2004).

the blue background. But I want to introduce my topic by proposing a broader significance for this, one of the most widely disseminated digital objects in the world today. Although it is a photographic image, its photorealism is tempered by the way the runner's body is cropped so as to be all but disembodied against the chalked asphalt. I am going to read this image as emblematic of two competing paradigms in digital imaging, both of which have been present since the origin of applied computer graphics in the 1960s, and both of which are now vying for authority on the Web. The outcome of this contest—if I may be so agonistic—could well determine the visible landscape of the Web for some time to come. The first of these two paradigms is photorealism, images typically delivered in raster or bitmap formats and represented here by the body of the athlete; the second and slightly older of the two paradigms are mathematically constructed images, delivered in vector formats and represented here by the same stark grid lines that have been the wire-frame support for some of our most influential imaginings of cyberspace. The history of these two competing image paradigms and their implications for the digital humanities today is the subject of my paper.

Let me begin with some context. Computers compute, of course, but the first use of CRT displays as output devices in the early 1960s also irretrievably situated computers within a cultural genealogy of screens, a genealogy which includes television, video, cinema, photography, and indeed, as Lev Manovich and others have argued, the full lineage of visual aesthetics in the West since the advent of perspective. This is important because it allows computer graphics and digital images to take their place alongside the other representational forms that have inhabited our many varieties of screens, frames, and windows. While there is no single origin story for computer graphics I want to briefly review two of the most important. The first belongs to Ivan Sutherland, whose work on a Ph.D. thesis at MIT in 1963 introduced Sketchpad, a system that allowed users to draw lines on a screen in real-time with what we would today recognize as a light pen. Sketchpad was a vector system, meaning that the lines and curves drawn by the user were stored as mathematical statements (vectors) that could be expressed visually on screen. Nicholas Negroponte has commented:

> The achievement was of such magnitude and breadth that it took some of us a decade to understand and appreciate all of its contributions. Sketchpad introduced many new concepts: dynamic graphics, visual simulation, constraint reduction, pen tracking, and a virtually infinite coordinate system, just to name a few. Sketchpad was the big bang of computer graphics. (103)

Our other origin story belongs to Stanford's Douglas Engelbart, who five years later, in 1968, demonstrated the first functioning graphical user interface to a standing-room-only audience in San Francisco. Engelbart's demo, which is the stuff of legend in computer science circles, included the first public display of the mouse, windows, hyperlinks, and, most importantly for my narrative, bitmapped raster graphics (subsequently perfected at Xerox PARC). A "bitmap," as many will know, is a grid or matrix of pixels ("picture elements"), which, not unlike a Seurat painting or a photographic halftone, yield a coherent visual image through the optical interpretation of the aggregate composition. This was to prove an enormously successful technique, and until recently bitmapped formats accounted for nearly all of the digital images one encountered on the Web.[1] If vector images were the graphical inheritance of the computer's mathematical roots, bitmapped images, I would argue, were the visual realization of Turing's ideal of the universal machine: bitmaps enabled the computer screen to function as a representational surface capable of emulating *other* representational surfaces. Through bitmapping, the computer screen was transformed into a second-order or "meta" representational venue. This transformation quickly gave rise to intensive research into photorealistic rendering techniques in computer graphics as well as the advent of hardware devices like scanners and digital cameras—which enable the computer screen to function in the service of photographic media. (JPEG compression algorithms, it is worth noting, were introduced precisely to provide an image format that lent itself to reproducing photographic images.) William M. Ivins, in *Prints and Visual Communication*, his landmark survey of print-making technologies in the West, argues eloquently for the importance of what he terms "exactly repeatable visual statements" in enabling the dissemination of scientific knowledge. Bitmapping, I would argue, endows the computer screen with much those same qualities and capabilities, and although Manovich is right to point to the origins of computer graphics in the vector images of Cold War radar displays, the visual authority of the computer as we know it today probably owes more to the refinement of bitmapping. Taken together, however, Sutherland and Englelbart, about five years apart, laid the foundations for contemporary computer graphics and today's graphical user interface through their competing paradigms of vector and bitmap imaging; "competing" not in a strict commercial sense, but rather in that they offer different visions of the computer as a representational medium and as an information space.[2]

For those who know something about printmaking and the graphic arts—the tradition documented by Ivins, Estelle Jussim, and Gascoigne Bamber—the contrast between vector and raster imaging will likely be a familiar story, prefigured by the history of techniques such as line engraving and halftone screens. I do not have time to tease those correspondences out further here. Perhaps the most rigorous way of articulating the differences between raster and vector representations is by way of Nelson Goodman's painstaking distinction between "dense" and "finitely differentiated" symbolic systems. Goodman's vocabulary is drawn from the language of analytic philosophy, but the basic concepts are quite accessible. Dense or replete systems are those in which every constituent component contributes to the ontological whole; each brushstroke of an oil painting, for example. Finitely differentiated systems are those in which there are discrete elements that can be added or subtracted from the ontological whole; examples would be the text of a novel or a musical score. What's really at issue here is the way in which a given symbol system encourages or inhibits formal manipulation of its components. For purposes of my discussion here, I want to align bitmap images with Goodman's dense or replete systems, and vector images with Goodman's finitely differentiated systems.[3] Though both are susceptible to formal manipulation by virtue of their status as computational objects, vector images, which in fact exist as mathematical statements, are scalable and modular in ways that bitmaps are not. A vector image is not subject to the phenomenon of pixellation, for example; as the viewer zooms in on the image, its coordinates are simply extrapolated to generate the illusion of a closer view.[4]

Today the most popular vehicle for vector graphics is the animation tool Flash, which, characterized by its colorful, dynamic displays, is rapidly colonizing large segments of the Web; indeed, there are those who believe that at the level of interface design the Web itself will eventually be made over as an animated Flash-based environment, with static HTML (or more likely, dynamic and database-driven XML) documents existing as subsidiary, special-purpose content. Interestingly for our purposes, Flash is also capable of supporting embedded bitmapped images, suggesting that the representational field I described earlier has receded by one full order of magnitude and that vector graphics are now the true heir to Turing's universalism. (On the other hand, it remains true that all general purpose screen displays, whether LCD or CRT, are rendered as bitmaps.) To build a Flash animation, the designer creates a so-called "movie" consisting of a series of timed, sequenced, or triggered events. For some this may suggest that the Web is evolving into a medium that owes more to television than the now-familiar (and comfortably humanistic) conceit of the "page." I would cast the argument differently. Unlike bitmap or raster graphics, vector graphics are not well suited to representing continuous tone (especially photographic) images. Consequently, they may seem of little use in the digital humanities, where much of our work chiefly consists in providing high-quality facsimile renderings of documents, artwork, and other artifacts of cultural heritage. But vector images bring at least three important instruments to our humanist toolkit: temporality, modularity, and programmability. I want to briefly consider each of these in turn.

First, temporality. Flash and other vector formats will, I predict, encourage an explosion in the use of time-dependant data in digital humanities research. Every major humanistic discipline, certainly including literary studies, is four-dimensional in the sense that time is an integral component of the subject. If throughout the 1990s digital humanities research was dominated by the spatial paradigm of the Archive, this next decade may well be devoted to studying the way texts and other artifacts of cultural heritage forge and maintain their networks of dynamic temporal relations. This work will demand new forms of questions and new forms of representation. The Temporal Modeling project, under the direction of Johanna Drucker at the University of Virginia, is engaging that opportunity head-on by designing experimental Flash-based interfaces for the time-based representation of humanistic data.[5] Likewise, Nelson Hilton, at the University of Georgia, has been using Flash to animate sequences of illuminated prints by William Blake. Second, modularity. By modularity I mean the way in which vector representations can be assembled and disassembled out of discrete data structures in an object-oriented fashion. The traditional stronghold for vector imaging has been in fields like CAD and GIS, where images serve as something more akin to models or diagrams than as mimetic or documentary constructs. I predict that with the resurgence of vector imaging the humanities will find greater applications for CAD and GIS techniques, which are well-established in the social sciences. Projects at both Virginia's Institute for Advanced Technology in the Humanities and the University of Maryland's Institute for Technology in the Humanities (MITH) have already used Flash-based vector displays to this end. Virginia's Salem Witch Trials project, for example, permits users to access a dynamic map across which they can choose to layer a variety of different data structures to trace the history of witchcraft accusations in Eastern Massachusetts over four weeks in 1692.[6] Finally, programmability. Lev Manovich (2002), writing of the recent outpouring of activity in the digital arts community around Flash and other vector tools has characterized their delicate mathematical line structures as a kind of "soft modernism," with conspicuous debts to Bauhaus. These algorithmic designs, Manovich suggests, serve to remind us that the computer is ultimately a programmable machine at precisely the moment we seemed most in danger of being overwhelmed by its enormous representational capacity. Today much of the most exciting work in the digital arts and electronic literature is being done in vector-based animation formats, with software artists and multimedia authors positioning the arts and letters as genuine contenders to the game culture that currently dominates the bleeding technocultural edge.[7]

I want to close by very briefly sketching some of the broader theoretical implications of vector graphics. It's fascinating, for example, for those of us interested in word/image relationships, that vector imaging enfolds graphical representations within textual data structures; the Scalable Vector Graphics (SVG) standard, an XML-based spec which currently has the status of a Recommendation to the World Wide Web Consortium, would enable visual data to be expressed as machine-readable text.[8] Likewise, as the Salem project above demonstrates, the scalable and modular properties of vector formats lend themselves extremely well to integration with databases and encoded texts. But the point I most want to emphasize here is that the greatest significance of vector graphics in the humanities, is that they will, I believe, force us to confront head-on our dependence upon documentary forms of knowledge, a guilty habit which we have rushed to indulge in our digital embrace of elaborate archival shrines to the documentary ideal, loaded with 24-bit color high-resolution raster representations.[9] Vector images, and the conceptual freedom they instantiate, will lead to new ways of imaging and imagining the humanities, presenting us with challenges and opportunities that lie outside our archival walls.

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Notes

[1] The term "bitmap" as it is used here (interchangeably with "raster") should not be confused with the specific BMP or BitMap image format, a popular but proprietary bitmap format introduced by Microsoft.

[2] William J. Mitchell, in *The Reconfigured Eye: Visual Truth in the Post-Photographic Era,* his important 1992 study of computer graphics, gives no extended attention to vector imaging, suggesting that a decade ago raster techniques had succeeded in supplanting vector except in a handful of specialized communities.

[3] I am aware that Mitchell has also deployed Goodman's terminology in a similar context, arguing that bitmapped digital images, contrasted with their (dense) analog counterparts, are allographic (in Goodman's use of the word) and therefore (by extension) exhibit the characteristics of Goodman's finitely differentiated systems. I would in fact agree with this formulation, but I would also argue that vector images, contrasted with their bitmapped counterparts, serve to demonstrate the relativity of Goodman's terms. That is, a symbol system may be dense in one symbolic economy, and finitely differentiated in another. See Mitchell 50-51.

[4] Fonts are another common data type stored in vector formats, which is what allows them to scale up and down in point sizes. Thus, all of us use vector formats all the time.

[5] See http://jefferson.village.virginia.edu/time.

[6] See http://jefferson.village.virginia.edu/salem.

[7] See, for example, Rhizome's Artbase (http://www.rhizome.org) and the Electronic Literature Organization's Directory (http://www.eliterature.org).

[8] See http://www.w3.org/TR/SVG/.

[9] See, for example, *Computers and the Humanities* 36.1 (2002), a special journal issue on image-based humanities computing, guest edited by Matthew G. Kirschenbaum, with contributions from practitioners of several leading archival projects. Examples of electronic scholarship in the documentary archival mode include the *Dante Gabriel Rossetti Hypermedia Archive*

(http://www.iath.virginia.edu/rossetti), the *William Blake Archive* (http://www.blakearchive.org), the *Walt Whitman Archive* (http://www.iath.virginia.edu/whitman), the *Dickinson Electronic Archives* (http://www.emilydickinson.org), and the *Electronic Beowulf* (http://www.uky.edu/~kiernan/).