Cyber Cartography

Peter Cho
December 10, 2003

In this paper, I discuss how mapmaking has changed in the context of database structures, networks, the Internet, and virtual worlds. I examine what the mapping of cyberspaces can show us by considering recent cartographic projects, especially within a media arts context. When we attempt to draw a map of an unseen or previously unexamined, digitally-mediated territory, we are giving a visual form to an abstract system. As with any map, selecting the territory and the viewpoint from which to chart the territory represents the first and most important step in creating the cyber map. This selectivity and subjectivity can often be the most interesting and useful aspect of the map.

Uses and motivations for maps

Considering traditional cartographic maps, we can see a number of uses and motivations for map making. Traditionally, a map is used to record space, to develop a "true" representation of a territory. The map purports to give an accurate, scale representation of locations, distances, orientations, names, and other data. We use this map for wayfinding or for orienting ourselves in the world, either in our neighborhoods or in foreign places. It tells us, you are here. Maps are often used to analyze space and topology: a "plan" view, both a flat two-dimensional architectural reduction and a plan, a stage for action. Another type of map shows you a specific path or story: a selective, perhaps distorted, map that someone might draw for you to show the path to a new place. This may be a very personal map, one showing a subjective representation of a particular viewpoint.

A map may be used to describe the unknown, say 15th century maps of the new world. This can be seen as an act of content generation, since by making a map, we are putting onto paper something we do not know. Clearly, these maps may be flawed, raising questions about the truth of a map and mapmaking in general. Making a map of uncharted terrain might also be intended or perceived as an act of aggression, a marking of territory.

Maps hold the power to inform or mislead, through ideological messages the maps' creators want to put across, or even inadvertently through the creators' choices. A map might label a body of water "Sea of Japan" or "East Sea," or may define a border for Kashmir, raising some contentious issues. Often a bias can occur through omission as well—for example, Iraqi maps which do not include Israel. In the creation of every map, it is not only the choice of the territory but also the viewpoint that defines the boundaries of the map. The viewpoint is not only physical, but political, cultural, or ideological. A map cannot represent a "view of God" or a vision of how things "really are." A map is subjective by nature, so

a map's true purpose is to tell a story from a specific point of view.

Psychogeographic maps, as suggested by the Situationists, might be an example of subjectivity taken to an extreme. Psychogeography is the study of conscious or subconscious effects of geographical settings on the mood and behavior of the individual. A map of this type represents an innately personal experience, one which may be useful in exploring the spaces we construct around ourselves.

Mapping the network

With the pervasiveness of digital telecommunications technologies, we have seen efforts to map the network infrastructures within physical space. Often the hardware infrastructures that supports network communications are hidden from our daily lives, whether it be the fiber optic cables below our feet or the satellites in orbit above our atmosphere. Maps of these physical networks show the physical presence of the connections between nodes. These maps also reveal concentrations and disparities of access at different levels—worldwide, nation-wide, city-wide—allowing us to assess the social and economic implications. Mapping the network, we should also be aware that the edges connecting nodes are not equivalent, since bandwidth varies along different pathways. Physical proximity is no prediction of the width of the pipe—a data packet can travel between New York City and Los Angeles more quickly than downtown LA and Echo Park.

According to a December 2001 Newsfactor report, the U.S. federal government was to begin work on drawing a "map of the Internet" in an attempt to improve the country's ability to respond to future cyber-attacks: "The National Infrastructure Simulation and Analysis Center will diagram the complex links between the country's critical Internet infrastructure, such as interdependent telecom and information technology networks, electric power grids, transportation systems, and gas and oil pipelines." Drawing a truly comprehensive map of network infrastructure would prove costly and problematic, if not impossible. This defense-funded research into mapping in anticipation of war activity seems a reflexive process, considering the military origins of ARPANET, a precursor to the Internet. In an opposite case, researchers at Lumeta Corporation looked at the effects of war on networks, mapping the network in Yugoslavia during the war of 1999.

Fig 1: Cable & Wireless "Great Circle" map, a marketing map showing the global connectivity of C&W, with Britain representing the "hub of the world"

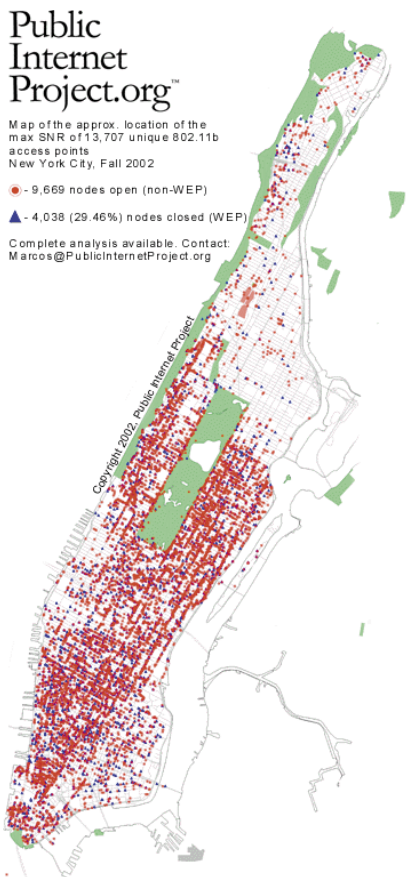

Fig 2: Public Internet Project.org's map of Manhattan, showing 802.11b access points throughout the city

With the recent spread of wireless networks in urban environments, we see maps of another type of network within a physical space. The Public Internet Project has created maps of Manhattan which indicate open and closed Wi-Fi nodes throughout the city. In one map, economic data from the census is layered onto the map to show that Wi-Fi access is greater in wealthy neighborhoods. This organization uses mapping for social advocacy: their mission statement is "to promote open access to the Internet for the benefit of all people." Warchalking, or the practice of marking a series of symbols on sidewalks and walls to indicate nearby wireless access, can be seen as a real-space mapping effort, also with the interest of bringing Internet access to the people.

Some mapping efforts look at the physical pathways of data travelling across the network. These mapmakers use lookup tables and other techniques to approximate the physical locations of IP addresses, then superimpose this information onto maps of physical space. Other visualizations also track the actual paths of network traffic by looking at traceroutes, which record the route and times that data packets travel through the Internet to reach a destination.

Mapping cyberspace

We move from the previous section, which looks at intersections between physical and virtual characteristics of the network, to maps which consider only the virtual space. The web space of pages, hyperlinks, hosts, and back-end databases is a complex, rhizomatic system. As Umberto Eco describes the model of these inter-connected structures, such as hypertext, as "not so much a straight line as a real galaxy where everybody can draw unexpected connections between different stars to form new celestial images at any new navigation point." Cyberspace is not a static terrain, but a multi-dimensional space that is always in flux. A digital map may need to respond in realtime to changes in the landscape.

Researchers at the Internet Archive estimate the average life span of a web page to be 100 days, while an estimated 7 million new pages are added to the Web every day. A map of all the nodes and links on the Web, even if such a map were possible, would serve only as a historical trace, immediately becoming obsolete as a wayfinding tool. As of November 2003, the Internet Archive already contained 200 terabytes of information, archived snapshots of webpages dating back to 1996. Lost pages and changed locations becomes a concern for researchers who rely on footnotes and links in their online

documents. One indexing and retrieval system currently in development assigns a permanent DOI, digital object identifier, to participating webpages, so that even if the page moves to a new address, it can always be found via its unique DOI. This serves as a virtual-space analog to RFID tags, devices which identify and encode the items in physical databases such as warehouses so that each product can be identified, located, and catalogued.

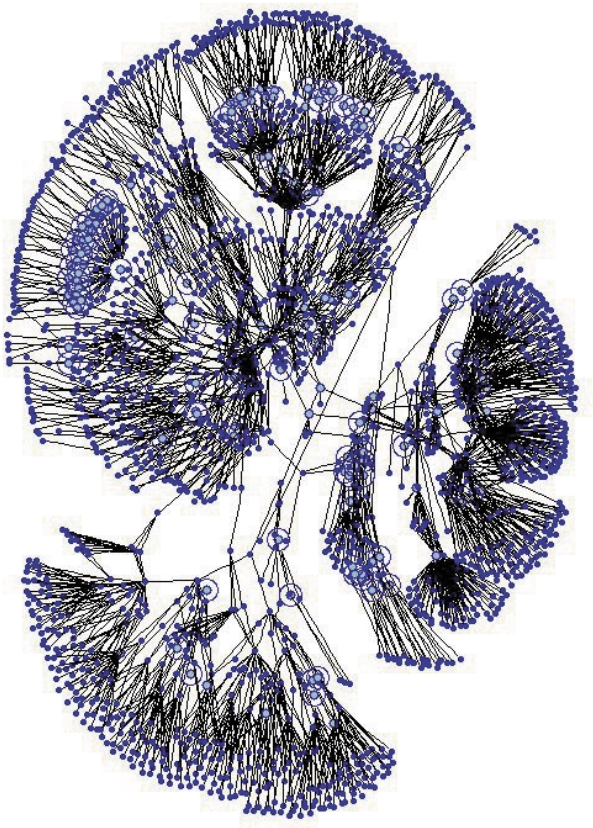

Fig 3: A November 2003 map from the Opte project visualizing "one-fifth of the Internet"

Some recent and ongoing efforts to map the cyberspace of the Internet deal with sending web crawlers to follow links between web pages, then drawing the results as a two-dimensional diagram of nodes and edges. Lumeta Corporation's Internet Mapping Project, the Cooperative Association for Internet Data Analysis (CAIDA) at UCSD, and the Opte project all produce intricate diagrams showing this root-like graph structure. According the Opte project home page, the project was born from a techno-machismo challenge, "I can write a program that can map the entire net in a single day." Peacock Maps even features the "Whole Internet Poster: 2002" on their website, though it is now discontinued, whether for its immense popularity or its obsolescence, it is unclear. By visualizing these systems, these maps give physical locations, cardinal directionality, and spatial relationships to a space with none of these properties.

The efforts to map cyberspace mentioned above attempt to draw a comprehensive picture of the space. This focus perhaps resembles the drive in the digital technology and motion picture industries to create simulations which are as "real" and life-like as possible. This optimistic, technological fetishism can divert our attention toward the how and away from the why of mapmaking. This desire for realistic representation of the entire space we find is also problematic since cyberspace does not exist in a two- or three-dimensional plane, but a "plane of consistency of multiplicities" where "the dimensions of this 'plane' increase with the number of connections that are made on it," to reference Deleuze and Guattari (p.9). Maps of cyberspace and the Internet attempt to make a trace of the rhizomatic space, but as Deleuze and Guattari describe:

> The rhizome is altogether different, a map and not a tracing. Make a map, not a tracing. The orchid does not reproduce the tracing of the wasp; it forms a map with the wasp, in a rhizome. What distinguishes the map from the tracing is that it is entirely oriented toward an experimentation in contact with the real. (p. 12)

What is missing from these tracings—for example, media reports of a 1999 research study which found the Internet to be shaped like a "bow tie"—is a reflexive, reactive, and interactive process between the map and the space it describes, a transcoding of sorts.

The task of mapping cyberspace as a territory may in fact be problematic, if we consider cyberspace already to be a one-to-one map of itself. In a short story from "Of exactitude in science" in A Universal History of Infamy, Jorge Luis Borges describes a mythical empire in which cartographers created a map at "the same Scale as the Empire and that coincided with it point for point," so that the real territory underneath the map was obscured. Baudrillard appropriates this story to illustrate the concept of simulation, that in fact the world we live in is a simulation of images and media: "The real is not only what can be reproduced, but that which is always already reproduced: that is the hyperreal . . . which is entirely in simulation." Lev Manovich considers the Web to be "in a way its own map—its own reality. It's not like a painting, which is a representation of reality." According to Peter Anders in "Anthropic Cyberspace," what we experience as space is actually the product of complex mental processes, and cyberspace is in fact an extension of our consciousness. Retreating a bit from this line of thinking, we might consider cyberspace to be a map of our collective consciousness, and a reflection of humanity. Or we could return to our original thought and consider cyberspace simply to be a one-to-one map of its own inner workings.

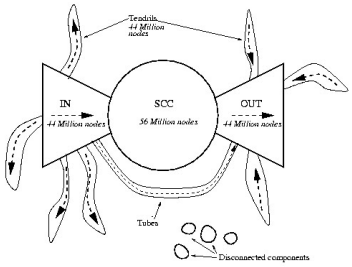

Fig 4: A 2000 study from IBM Research, Compaq Corporate Research Laboratories and AltaVista Company presents a "bow tie" theory of the Internet

Our most common contact with what we think of as cyberspace is through software we call a web browser. The conventional browser could also be thought of as a selective map of cyberspace, showing one location at a time and recording the viewer's trail over time. Next-generation browsers by TouchGraph allow users also to browse "horizontally," using the "see related" functionality of sites such as Google to visualize a network of related information. Members of the open source community have used the TouchGraph technology to draw interactive, associative maps of LiveJournal, Friendster, Amazon, and other database-driven sites. We will see in the next section that manipulating

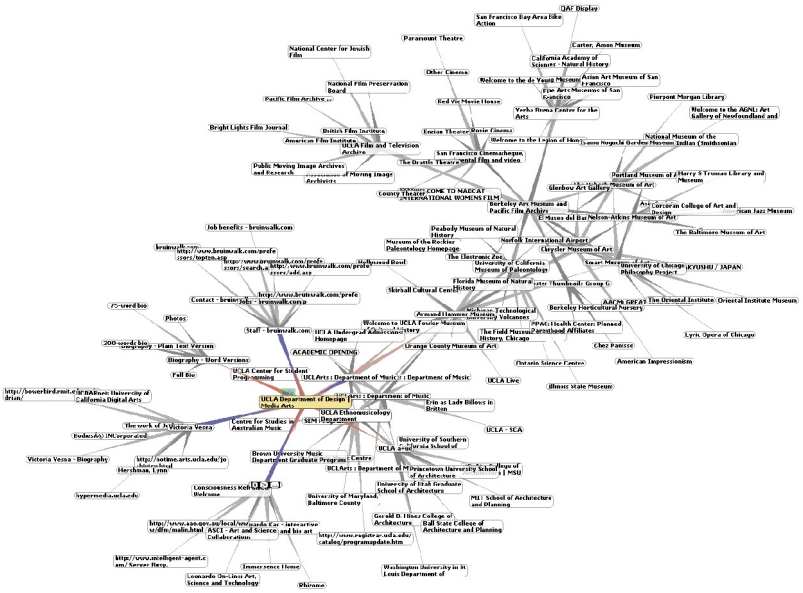

Fig 5: TouchGraph Google browser visualizes horizontal links originating from the UCLA Design | Media Arts Department

the browser and what it feeds to the user is one genre of media art that has surfaced over the past decade. A list of bookmarks or favorites serves as an index of starting points into the space, but could also even be considered a subjective, one-dimensional map. Any graphical user interface might in fact be thought of as a content map, one which allows a user to act on the selected territory.

Maps of cyberspace differ from maps of physical territories in a number of ways. One point in particular is that the space of cyberspace exists without the quality of "place." While the nature of place is not fully understood, contemporary geographers such as Nigel Thrift believe that "place" is somehow more "real" and "human" than space. Thrift contends, "Place (understood as a part of this complex process of embodiment) is a crucial actor in producing affects because, in particular, it can change the composition of an encounter by changing the affective connections that are made" (p. 8). The Situationist's take on psychogeography suggests that mapping our sensual experiences, memories, and emotions back onto a map of an environment creates a reflexive process which changes our relation to the space. It is unclear whether cyberspace may produce the same affects as physical space, but this is a subject of study which could lead to interesting map-related explorations.

Useful comparisons can be made between the efforts to map cyberspace and those to map the genome, perhaps one of the most loaded of mapping projects. Comprising 3.1 billion nucleotide letters, the human genome has a scale on a similar order to the number of web pages on the Internet, which latest studies estimate at over 8 billion. Efforts to map the entire genome, like cyberspace, are meant to give viewers a "feel for the data—a sense of what a genome 'looks' like" (Fry, p. 1). Spatializations of web spaces or infrastructure might reveal connectivity and routing issues, while genomic maps might be used, for example, to compare the genomes of two species visually to find similarities and differences between the two.

Mapping within a Media Arts context

While digital technologies give us new regions for mapping, the same technologies also allow media artists new means for display, data mining, interaction, and real-time access. Considering recent works in cyber-cartography, we find that many interesting projects use the technology in combination with a concept or message to show the viewer something new about an uncharted territory.

Several recent projects use visualization techniques to revitalize the basic node graph. Ben Fry's Valence (1999) represents a system which reads in a stream of data—words from a book, or letters from a genomic code—and animates how the new information affects the system. Using general heuristics, for example, sending more common words to the exterior of the space and less frequently words to the center, Valence sets up relationships between data elements that might not be immediately obvious. Fry's software Anemone (2000) reads a weblog, visualizing and interpreting the data in an

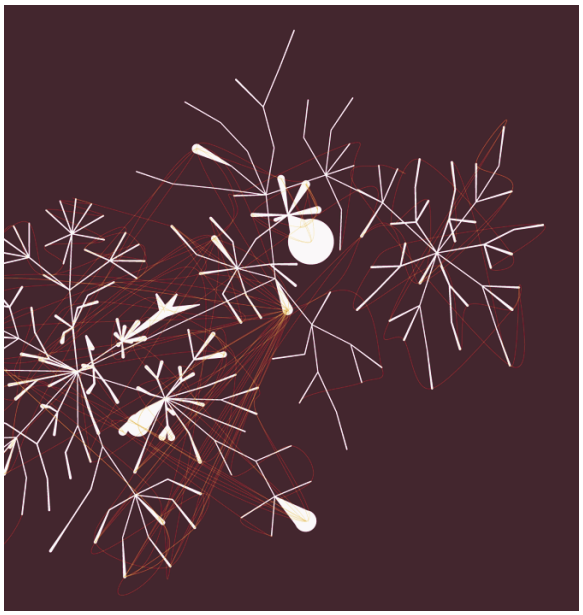

Fig 6: Anemone, Ben Fry, 2000

organic, animated node graph structure. W. Bradford Paley's TextArc (2002) visualizes a text, for instance, Alice in Wonderland, within an ellipse, using a set of rules to highlight and position words based on their usage within the story. Paley's site describes three goals for his work: "to create visual filters which let different subjects express their differences; to make the work readable enough that the viewer can gain specific insights; and to reveal complexity in a way that's matched to human perceptual abilities." Another visualization exercise, Ride the Byte (1998) by the Berlin-based collaborative ART+COM, focuses on the tracking of information flow through the global communication network. In the installation piece, viewers could choose a website, then watch the traceroute the data packet takes to retrieve the information. The visualization's glowing lines and wireframe globe refer to a decidedly optimistic, sci-fi, "cyber" aesthetic.

A media art project that also uses the temporal qualities of the network is Ping (2001) by Chris Chafe and Greg Niemeyer. Ping sonifies rather than visualizes ping connections across the Internet, translating the time lag of the data flow into sounds. Stelarc's Ping Body (1996) interprets ping data in a very different manner, by sending current into the muscles of Stelarc's body based on the time delay of the signal. While Chafe and Niemeyer's piece maps the data to audio throughout a physical space, Stelarc's internalizes the data, establishing an intimate, inverse relationship between Internet activity and the physical body.

Another kind of mapping, alternate browsers could safely be considered an entire genre of media art. The British collective I/O/D established the alternative browser "medium" with WebStalker (1997-present), an application that allows users to build windows to perform different functions: a crawler to parse documents, a local dynamic map with circles and lines to represent URLs and links, an extractor to grab text from a particular document, and a dismantler to list the components of a page. Lisa Jevbratt's 1:1 (1999) also represents an early example of alternate browsing. In this interface, every IP address on the Internet is represented in a single graphical image-map. Carnivore, a project beginning in 2001 by RSG (Radical Software Group), is a surveillance tool, listening to Internet traffic on a local network. This data stream is sent to a client—created by various artist/programmers, or by users themselves—which interpret the traffic in various ways, from Mark Napier's representation of the bits from CNN.com as a black and white graphic study to Jonah Brucker-Cohen's Police State installation using radio-controlled miniature police cars directed by surveillance-related data from the network.

Napier's alternative Web browser Riot (1999) blends content from different web pages at separate domains into a collage in a single window. Napier suggests that the project exposes the fragility of territorial boundaries, writing that "the alternate space of the Net resists our traditional, physical model of ownership, copyright, and branding." Maciej Wisniewski's netomat(TM) (1999-present) transforms the Internet into an animated stream of images and words as the user navigates by typing words and phrases. A description at the netomat.net web site discusses the project: "In today's world of internet browsers, netomat(TM) has the feel of an anti-browser. netomat(TM) eschews the anachronistic page structure of today's web by not privileging layout and design. It atomizes text, images and audio loosening them from web sites and web pages. This allows the data to be recombined or viewed independently in a context determined by you."

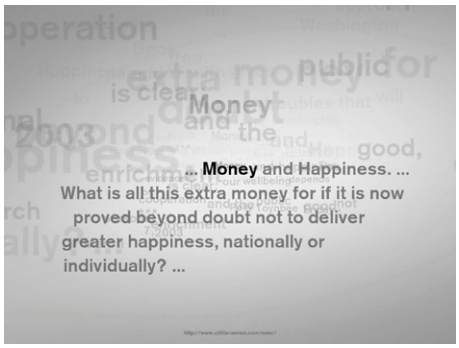

Fig 7: Money Plus, Peter Cho, 2003

The concept of recontexualization runs through several other selective mapping projects. Josh On's online project, They Rule (2001), diagrams the board of directors of major corporations, revealing the relationships among the US ruling class elite. My own project Money Plus (2003) could also be considered a selective mapping piece, displaying the results from a Google search for "money" plus another word as a dynamic typographic environment. Listening Post (2002), a work by artist/sound designer Ben Rubin and statistician Mark Hansen, culls text fragments from Internet chat rooms, forums, and bulletin boards in real time, sonifying the results using a voice synthesizer and displaying them on a large grid of LED screens. Especially effective about this piece is the way selective data-mining rules are used across six movements of a score. One section of the piece, for instance, features sentences beginning with "I am," building the results over time in a musical crescendo. In an NPR report about Listening Post, a visitor described the piece as "like the first astronaut who saw the planet from outer space and said it's really the most beautiful thing, and it's one planet." Rubin agrees that the work tries to capture a "zoomed-out" picture but says that "it also tries to zoom in and keep it rooted in the specifics of what people are saying." This duality, both specific and general, is

Fig 8: Listening Post, Ben Rubin and Mark Hansen, 2002

afforded through data-mining technology that can analyze the breadth of data and pick out thin slices of the space to represent the whole. While the work can be seen to derive from a tradition of Cage's indeterminacy and performance-based Happenings, the technology allows Rubin and Hansen to work with real-time information from cyberspace and let it speak mostly for itself.

Some media arts mapping efforts make connections between cyberspace and physical space. The alpha series by Singapore-based tsunamii.net explores this relationship. In alpha 3.4 (2002), the artists Charles Lim Yi Yong and Tien Woon traced the journey from the Documenta XI installation in Kassel, Germany to the physical location of the website's server in Kiel. Along the way, the artists sent GPS data by mobile phone, initiating a sequence of web browsing at the installation. In their current project, alpha 3.8, the contents of their tsunamii.net website are migrated from webserver to webserver in 44 countries around the world over the course of a year. As the content does not change, the differences are visible to the user only through a ping/traceroute tool available on the site. A project by Waag Society in Holland, the RealTime Amsterdam map makes a more explicit relationship between physical space and virtual representation. During two months in the fall of 2002, residents of Amsterdam volunteered as "tracers"—as they moved throughout the city, a GPS unit would send their location data to a central source. Partial, personal maps of the city were created by visualizing only the traces on a blank background. Composite city maps were also developed by layering individuals' traces on top of each other. These maps suggest the Situationists' dérive: by applying our personal map back onto a map, we change our understanding of, experience with, and relationship to the space. The RealTime Amsterdam map also has a "Big Brother Is Watching" feel to it since the volunteers' movements were tracked and recorded (though not visualized or broadcasted) in real-time. Two projects, iSee, by the Institute for Applied Autonomy, and X-report, by Mongrel, speak to this increasingly authoritarian surveillance climate. These projects create maps that allow users to find routes avoiding closed-circuit television surveillance cameras in an urban environment. A statement by the first group describes their motivation:

Fig 9: RealTime Amsterdam map, week 2 composite, 2002

> As spytech dealers stumble over themselves in their haste to auction off our civil liberties—wrapped in the stars and stripes, tied up tight with memorial ribbons—to right-wing politicos who drool and salivate in anticipation of railroading their own Orwellian wet-dreams of social control through our

> legislative bodies, there is a vital need for independent voices that cry out against such cynical exploitation of legitimate human fear and suffering for political power and monetary gain. http://www.appliedautonomy.com/isee/info2.html

Mongrel's X-report also relies on the citizenry of London to report the locations of cameras, creating a reflective loop in their process of mapmaking.

We can also consider maps which do not relate directly to physical space or cyberspace but instead try to interpret something about ourselves or the interactions and communications between us. Two installation projects, George LeGrady's Pockets Full of Memories (2001) and Rachel Strickland's Personal Effects (1996), can be viewed as maps of the personal objects people carry with them in relation to others. In both cases, a database of images collected from gallery-goers are visualized in a display. Collections from LeGrady's piece appear online at his site as well, positioned in a two-dimensional map by a self-organizing algorithm. Other interesting maps include Warren Neidich's 'conversation maps' and Jochem Hendricks's 'eye drawings.' At first glance, Neidich's maps appear to be abstract paintings, but in fact were created by attaching lights to sign language speakers' arms and fingers, photographing the conversations with long exposures, then using software to color and superimpose the images. For his 'eye drawings,' Hendricks uses eye-tracking technology to scan the motion of the eye, record the paths, then output them as static drawings. His work EYE (2001) is a trace of the artist's eye movements while reading the 'Eye' entertainment section of the San Jose Mercury news. Both Neidich's and Hendricks's works map unseen processes, of reading or sign language speech. These works succeed on a formal level but also give insight into how we perceive the world.

Fig 10: Newspaper, Jochem Hendricks, 1994

In media art, we see a number of mapping-related projects which use technology to record and visualize uncharted territories. Maps can function as lens or filter to unseen worlds of cyberspace, as in Rubin's and Hansen's Listening Post. Maps can also record our daily activities and environments, giving us a higher-level picture of our movements, as in the RealTime Amsterdam Map. Maps can be created to show us something very specific, as in They Rule, or help us make conclusions from the data on our own, as in Anemone. Regardless of the intent, we find that maps in media art are most useful when they do not attempt to capture the entirety of the space but instead present a selective and subjective viewpoint.

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