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Webometry:

chronotopography

of the World Wide Web

by

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Abstract. This is the third progress report on the webometry project: acquisition of data regarding the density of links on the WWW. Here we discuss the mapping from geography to chronotopography of the web as a basis for the complexity and simplexity of cyberspace.

CONTENTS

1. Introduction. For over a century art and science have been defining a new space for western society, a space which will provide the schema of how we organize our universe. It is a visual space, a communication space, an organizational space, the space of how we imagine reality. This space has been anticipated by artists, defined by science, and made habitable by artists again as it is integrated into our cultural consciousness. The process in not complete, and will not be for another fifty years, but we have become conscious of it and are, therefore, capable of accelerating and directing it.

The space will function in time. It will not be a fixed static space but one whose evolution will be part of its definition. It will be interactive, containing multiple points of view. The observer as actor, actor as observer. Our cultural reality will be found in the collection and communication of those several points of view. The space-time geometry of this space is becoming clearer and will eventually replace the euclidean geometry of the past in the western imagination.

Every mode of communication has at one of its extremes a form of expression we call art. Art, being the densest form of communication, is often the supreme test of any means of communication. Each work of art contains the entire world view of the artist and, as such, demands of any means of expression the dimensions necessary to fulfill that need. Art is the means by which we test a communication system, and by doing so, the reality that it defines.

The technologies of communication today permit a full exploration of the potential of this new space making them an expression of the values that we are attempting to define as we reinvent our society according to the new artistic and scientific givens. The flux of civilization produces the ideas that produce the tools for the realization of the ideas. In the use of those tools we can see the organizational patterns that are becoming the institutional expression of our future society.

2. Webometry. Artists, futurists, and science fiction authors have predicted a move into cyberspace for years. Now, thanks to the Internet (and especially the World Wide Web) it is here, and we are moving into the new space. At the same time, a major cultural transformation is upon us, as the industrial and modern paradigms self-destruct. We must think of the emerging culture in this new cybersocial space as we experience it, artistically, not technically, as its technical infrastructure/ medium of wires and machines. We regard the new space, like the social and cultural space supported by older media, as a (fractal) continuum, an infinite field of consciousness, a culture, a space. And to understand the new universe, and our places in it as individuals and as social and political groups, we must make maps and models, like the earliest seafarers, geographers, and cartographers did with the physical and political globe. And thus, we are brought to *webometry*, the creation of cognitive maps and mathematical models of the network and the World Wide Web.

3. The fractal cybersociosphere. The network is a prototype of the socio-politico-cultural organization of the future. For that reason, it is important to understand its functioning, and to avoid applying to it outdated or irrelevant procedures derived from other media, technologies or cultural habits. A mathematical model may help us in this. The network is spherical, and its dimension is fractal. Finding its dimension may help us to develop a model for it.

We reason as follows. We have a number of connections on the surface of the globe, A to B, B to C, A to C, etc. At first glance, a large number of connections would give us a geodesic globe, a la Fuller, but that implies connections with only immediate neighbors. In a network everyone is connected more-or-less directly with everyone else, on a one-to-one basis, without going through any

other point. This multiplies the number of potential connections rapidly, and the addition of any new member increases enormously the number of those connections. As the number becomes larger, tending toward infinity, the pattern of connections slides away from that of a complex line on the surface of a sphere and approaches that of a spherical plane. An infinite numbers of connections contained in a finite space. My reasoning is similar to that of Koch's curve. The dimension must be a spherical one, between one and two, thus a fractal. In using the geodesic sphere as a model, we stay within the realm of classical geometry and completely cut ourselves off from the actual description of the functioning of the network that we find when using a fractal approach. And then, there is its strange attractor.

4. Chronotopography of the Web. The space-time perspective of general relativity theory and its model of the universe developed from the discovery of light speed: messages take time. And our experience of the Internet makes us very aware of this fact, as messages take rather long times over the Internet. The times are related to the distances, but not in a simple fashion. If we used message time as a measure of distance, then the geography of cyberspace would be revealed as a very distorted sphere, or perhaps, not even a sphere. This process, the creation of a topological model for cyberspace from experiential time data, we call the *chronotopology* of the Web, using a word coined by Charles Musès. We may use the notion of *isochrons*, from chaos theory and fractal geometry, which is the chronotopological equivalent of the *contour lines* of a topographic map. Fixing one point in cyberspace (for example, a Web server), A, and a message time, T, we consider the set of all other points in cyberspace, B, such a message from A to B takes the same time T. The set of all such points B, with A and T fixed, comprises the T-isochron centered at A. In our Euclidean minds, we think of a circle about A of radius determined by T. We call this process *chronotopography.*

5. Strategies for mapping the isochrons from one point. Now our mapping strategy seems simple.

Method #1. If I have a server, A, all I have to do is ask everyone in cyberspace to send me a message, and record the message times of each in a big file. But practically how can I ask even a small number of people to cooperate in this measurement? Here is another way, which I can do all by myself.

Method #2. I make a list of URLs in different cities, for which I know the latitude and longitude, world-wide. For example, I might ask Alta Vista to search for a common key word. For each URL on the list, I click the link, and time the response. All this could be done with a PERL script. Still, this is a bit of work. Here is another way, which is relatively effortless.

Method #3. On one of my webpages I write an appeal for participation in an experiment. All that is necessary for the participant is to press a button, and fill in a simple form. This will give me data with which to map some approximate isochrons around my server, and eventually make a chronotopographic map of the Web. Upon clicking the button by a the participant at the remote browser, B, a CGI script on my server, A, is called. It records the starting time, sends a form to B asking for the latitude and longitude (or city and province) of B, which (hopefully) B fills out and returns. Upon receipt of the data from browser B, A records the data and the finish time in a logfile. From this data, a mapping from geographical space to cyberspace may be made. For example, color coding different times T and placing T-colored dots on a map of the world, we may see the isochrons for a fixed cyberpoint, A.

One advantage of Method #3 is that it is automatic, and can be repeated at different points, A1, A2, A3, and so on, on different continents. Integrating the maps for different points will require some more advanced mathematics, and we hope to return to this point in a later publication.

6. Conclusion. We hope to actually carry out the strategy described here, presenting our results on the Web at *http://www.vismath.org/webwatch*. We are aware that the chronotopography of the Web changes from day to day, and we hope to present movies of this evolution.

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