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A System for Universal Media Searching (SUMS)

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Abstract
This paper outlines a System for Universal Media Searching (SUMS), a software program which permits multi-dimensional navigation through knowledge. A starting point is in terms of basic questions: who, what, where, when, how, why? Three basic domains and ten levels of knowledge are defined. The use of meters for purposes of conceptual navigation is described. Strategies for addition of new materials, and access to other databases are outlined. It is foreseen that a later version of SUMS will integrate other shells for commentary, creation, publication and testing. It is also planned that SUMS will become one of three search strategies in the context of large scale searches.
Keywords: computers, database navigation, multimedia, search strategies.

1. Introduction

This project began formally as a standard bibliography on perspective in 1976. Titles of 8000 sources and 7,000 secondary sources were collected on file cards. These were entered into a computer using DbaseIII with support from the Getty Trust while the author was Canada's first Getty Scholar in 1986-1987. Dr. Richard Dolen acted as a consultant on problems of entering the material, preparing a draft printed version and charting a plan for database development. From 1987 through 1991 work progressed on a multi-dimensional bibliography[1] permitting access through a number of different points[2]. Work also continued on detailed access to manuscripts and paintings using Leonardo da Vinci as an example. In 1992 the basic DOS environment was transported to Windows for Multimedia linked with Toolbook for Multimedia. Using windows, materials were called from databases (Codebase, dBase, FoxPro, Freebase, and Superbase) and graphics packages (AutoCAD, Animator Pro, 3-D Studio). As this work advanced, plans unfolded

for a knowledge package[3] on perspective, whereby all material on this or potentially any other topic could be integrated. Plans also developed for a first electronic edition of Leonardo da Vinci's works. Hence, by the end of 1992 a new goal emerged: construction of an abstract shell or container into which knowledge from diverse topics could be entered. This shell is being called a System for Universal Media Searching (SUMS, Copyright 1992[4]) and is being written in C++ with a view to being both software and hardware independent.

SUMS uses a principle of conceptual navigation in an accepted corpus of knowledge which is divided into three basic domains and subdivided into levels of knowledge. An ancillary project is concerned with addition of new materials either manually or from other databases. Many recent efforts in software have been directed less at access to an existing corpus and more towards shells commenting, transforming, creating, publishing and testing knowledge. It is foreseen that shells will be built for these functions which will eventually be integrated with the basic shell of SUMS. Most software efforts have aimed at creation of shells which are entirely abstract, form without content, it being assumed that domain experts will then adapt these shells for their own needs. SUMS marks a departure from this approach insomuch that it adds navigational tools with implications for organization of content as well as form.

In the short term SUMS serves as a method for authoring and providing access to materials on a given topic. As such it is primarily of interest in education where teachers and professors have specialized knowledge in a given field. A next step will make SUMS into a multi-media authoring tool for CD-ROM production, and thus prepare the way for producing knowledge packages. The value of the navigation tools in SUMS is equally applicable to databanks of library and museum collections where its search strategems will be extended to a number of topics. In the case of small databanks and very large databanks other search strategems will be more appropriate and for this reason at least three major search strategies are suggested.

This is a period of transition during which the methods for storing and disseminating knowledge are changing yearly, some would say weekly or even daily. As of 1992 there has been increasing talk of an electronic highway. While this is frequently still merely rhetoric in political circles, the remarkable growth of (the) *Internet* in the past nine months attests to the practicability of this vision. Unprecedented agreements are linking the hitherto competing interests of cable and telephone companies. Cable is becoming fibre optic cable. New hardware such as 3-DO and Kaleida promises to resolve switching problems among different devices and media. Major corporations including IBM, Kodak and Time-Warner have reached agreements on image standards. As a result problems of pipelining are rapidly being overcome and already attention is turning from problems of form to content; from visions of an electronic highway to the electronic equivalent of cars on that highway, and new challenges of how one navigates with those cars and where one goes with those cars. By the time all this is in place, SUMS may provide a model for new methods of electronic navigation.

2. Questions

Traditionally, a person wishing to find things in a library or a museum had very limited questions they could ask. They turned to catalogues of authors, titles, subjects and in rare cases as at the Herzog August Bibliothek in Wolfenbuttel, of publishers and of places. Great libraries often had an alarming number of different catalogues. Typically there was a different catalogue for each medium (e.g., manuscripts, books, maps, drawings, engravings) each of which was in turn stored in a different room (e.g. the manuscript room, the map room etc. at the British Library) or even in different buildings. Another criterion was subjects which were often very broad categories such as theology, law, medicine, mathematics or physics. Within these subjects the only other criteria for arrangement were size (folio, 4o, 8o) and accession date: hence the order on the shelf often reflected literally the sequence in which books were acquired. As a result it took weeks or even months to know precisely where to look. One aspect of the revolution that is taking place is that these traditional catalogues and card files are being automated such that one can theoretically get at these hitherto disparate materials much more quickly. In computerized databases such as SUMS, searches can now be made using variant names--a point explored in a previous article in this journal[5]-- and a variety of indexes which permit multivalent access to materials. Much more is involved, however.

As a point of departure SUMS uses the principle of basic questions: who?, what?, where?, when?, how?, why? *Who* questions lead to knowledge of persons. *What* questions lead to objects; *where* questions lead to places, *when* questions lead to events and chronological charts; *how* questions lead to instructions; *why* questions lead to reasons and causes. Choosing a question leads to lists, subsets of which are then chosen in order to reach both other lists and sequences.

For example, if one chooses *who* there is a long list of names (authors, inventors, etc.). The next step depends on the user's needs. They may wish to do general study or research and therefore choose to limit this initial list by profession (who?) , topic (what?), place (where?) and time (when?): e.g. they may choose to study artists who were concerned with perspective in Europe from 1500 to 1800 and will hence receive a subset of the original list. This will include both practitioners (who may have used perspective but did not write on the subject) and theoreticians (persons who practiced perspective and/or wrote books on the subject). This list can be limited to display only practitioners, only theoreticians or changed again to include both. A user can browse through these lists to learn, or sometimes simply remind themselves of the names of individuals active in a given field. Choosing an individual leads to a very brief biographical sketch and lists of their writings etc. Alternatively if the user knows at the outset that they wish to study Leonardo da Vinci they can type in his name immediately in order to arrive at lists of his paintings and writings, then view key words concerning the contents of those writings and so on.

What questions lead to lists of subjects and objects. Users can again choose a very long composite list, or choose subsets thereof in the form of classification systems which serve as different cubbyholes for organizing basic terms of knowledge. In the past a classification system served specifically for determining the physical location of books on a shelf which meant choosing one system to the exclusion of others. In computerized

form, this remains, but other classification systems can function as see also references. At present, SUMS uses eight basic classification systems, namely: the Art and Architectural Thesaurus (AAT), Bliss, Dewey, Gottingen, Iconclass, Library of Congress, Ranganathan, and Riders International. Classification systems also have relevance for other kinds of questions: who, where, when etc. and will eventually be integrated within the system for all of these.

In terms of *where* questions two approaches are foreseen. A first again begins with a long list of places, subsets of which will provide places in a given continent, country, province or state etc. Alternatively one can choose a map of the world, use a mouse to click on a continent, then on a country, province, city, building, plan, room, wall in order to arrive at an object in ten steps using a scaleometer. This will be primarily for purposes of general orientation. A more specialized meter will allow one to choose scales in between these basic ones, and permit integration with work being done in the realm of Geographical Information Systems (GIS) and Facilities Management (FM). Further meters will deal with larger scales (macro-scaleometer) for astronomical contexts and smaller scales (micro-scaleometer) for microscopic environments. Hence computers will provide systematic access to maps, pictures and interplay of space and time generally.

In the case of *when* questions the user begins with a list of historical periods or with a simple chronological list. With respect to the subject of perspective this entails all books on perspective for that particular year. As a next step a user can choose between vertical (internal), and horizontal (external) history. If vertical history is chosen the user has to decide on a person (who?), subject (what? i.e. a key word related to perspective) or place (where?), which then leads to chronological lists of all works by an author, of a given key-word, or of publications in a given city. In future, if horizontal history is chosen a general list of events for that year will be given. This approach will subsequently be expanded such that a user can choose to learn more about the art, law, medicine, politics or theology of that particular year or general period.

If a user chooses *how* questions, they will basically be interested in books of instructions and techniques. In the case of perspective they will be given a subset of the bibliography that deals with *how-to-do-it* books. *Why* questions are in some senses the most intriguing. They are also the most elusive to track down electronically. In the case of perspective this would entail literature that explores the causes, reasons, conditions that led to its discovery and development.

The different questions are not mutually exclusive. They are different ways of getting at the same information. For instance, if a user wants to find a particular treatise by Leonardo on perspective, say the *Manuscript A*, they could choose *who*, find Leonardo, a list of his books and choose the work. If they knew the date they could choose *when*, go to 1492 and find it. Or they could choose *what*, find perspective, ask for Leonardo's writings on perspective and find it that way. If the user is an expert in the field and knows the precise name of the author, title and date at the outset they can type this in and get at the manuscript directly. The choice of question will depend on whether a user is interested in a particular record in isolation, or wants to learn something about its

biographical (who?), contemporary (what? and when? in the sense of horizontal history) or chronological (when? in the sense of vertical history) context. Polyvalent access gives many ways of getting at the same facts, but each approach presents those facts in a different context. The nature of the problem will determine which kind of question is the most efficient way of getting at those facts.

3. Domains and Levels of Knowledge

Particularly with respect to *what* but also with respect to other questions, a distinction is made in SUMS between three basic domains of knowledge: pointers, objects and interpretations. Pointers are the tools used to get at objects. Five basic kinds of pointers are identified: classification systems, which give basic cubbyholes and terms in different cultures; dictionaries, which define those terms; encyclopaedias, which explain those terms; bibliographies, which give titles of articles and books concerning those terms and partial contents which give indexes, abstracts and other summaries of those publications. A second domain provides the objects themselves in some form approaching facsimile. At present traditional limitations of reproducing text and pictures mean that these are usually representations of the originals or second-hand descriptions thereof. The latest developments in auto stereographic 3-D flat panel displays and virtual reality will soon enable users to enter into the three dimensional images of the objects they are studying[6]. A third domain involves interpretations. Here four different levels are identified: internal analysis, when a text or picture is studied in isolation; external analysis, when it is studied with respect to other objects; restoration, when the object to be interpreted has built into it the earlier interpretation(s) of a restorer; and reconstructions, when the object has within a greater amount of interpretation by an earlier reconstructor (fig. 2). Taken together these three domains thus entail ten basic levels which should not be taken in a simple hierarchical sense.

Pointers	1. Classification Systems
	2. Dictionaries
	3. Encyclopaedias
	4. Bibliographies
	5. Partial Contents (Abstracts, Indexes)
Objects	6. Full Contents (Books, Paintings, Instruments etc.)
Interpretations	7. Internal
	8. External
	9. Restorations
	10. Reconstructions

Fig. 2. Basic domains and levels of knowledge.

4. Navigation

Basic to SUMS is the idea of meters as tools for conceptual navigation. In the case of maps the use of a scaleometer has already been mentioned. This will be complemented by a cartometer listing different kinds of maps. The different questions mentioned in an

earlier section will be accessible through a questionometer. Similalry different levels of knowledge will be reached using a levelometer (cf. fig. 3). For purposes of ready orientation these meters are usually limited to ten levels or choices. But subsets thereof can be expanded as necessary.

Accessometer	Levels of Access
Cartometer	Types of Maps
Chronometer	Time Frames
Levelometer	Kinds of Knowledge
Mediaometer (Objectometer)	Media and Objects
Questionometer	Questions
Scaleometer (Micro-Scaleometer)	Scales

Fig. 3. Basic meters and their uses for conceptual navigation[7].

Each major advance in the world of learning has entailed a more detailed documentation of the contents of knowledge[8]. The shift from manuscript to book culture brought not only the triumph of alphabetical lists but also new criteria for the description of the physical world. Since the sixteenth century the criteria for recording such information has been improving as has the subtelty of the categories involved. For this reason we know a great deal more about the history of sixteenth century printing than any individual in the sixteenth century, just as we know more about ancient inscriptions through the *Athenians Project* than did Aristotle, Plato or any other Greek living in Antiquity. Likewise the fundamental importance of computers lies less in making accessible what was catalogued previously than in constraining, some would say challenging us, to catalogue new aspects of the corpus of knowledge.

For example, in the past there has been nothing to indicate the level of reader for whom a book was intended, whether it was a children's book, an introductory textbook or a work intended for scientists or scholars at the frontiers of research. Such information was sometimes suggested in the long titles of books which meant that, in rare cases where a library catalogue recorded most or all of a title, it was available indirectly. For the most part however this information remained undocumented. The grade one teacher knew which books were appropriate for Sally and Johnny, just as the research physicist knew which books and journals were relevant for their students. Everyone agreed that it was important to be aware of the readership or so-called audience for which a work was intended. The rise of reception theory heightened this interest but even so such knowledge remained primarily within the oral tradition.

The advent of computers makes it practical to record information concerning different levels of access using an accessometer. It is foreseen that SUMS will entail ten such levels. Each lower level is a subset of the levels above it, thus making clear the cumulative nature of the process. Hence a pre-school dictionary of perspective has only a handful of terms including point, line, ground, and horizon. A junior dictionary has a few more terms including (central) vanishing point, picture plane and line of sight. In traditional education children were often asked to forget what they had learned

previously in order to learn a new approach. Using an accessometer a child or student becomes aware of the cumulative nature of learning.

In the long term the role of the accessometer will be extended enormously. For the professional level, the domains of knowledge will be different for theologians, lawyers and medical doctors. At a research level, there will be significant differences within a profession: a brain surgeon, an ear, nose and throat (E.N.T.) specialist and bone-marrow expert will have their own specialized knowledge. Hence navigation will increasingly involve knowledge of the navigator as well as of the knowledge bases to be navigated[9].

5. Addition

Traditional printed bibliographies suffered from the problem that they were almost out of date the moment they were published because they could only include new titles by way of supplements and new editions. SUMS has a built in function that allows one to choose a database of a library or museum and choose a topic such as *perspective*. The titles under this term are downloaded from a remote database into the local database where a check is made against the titles there. In the case of authors and titles already in the local database a note is made of their presence in the library or museum in question. In the case of authors and titles not yet in the local database, these are added to the list. An extension of this principle applies in the case of library networks (such as RLIN and OCLC). Using these techniques a local bibliography on perspective or any other topic can be electronically updated using records from other libraries and databases. Since an increasing number of these libraries are available on Internet, it is foreseen that an algorithm will eventually permit automatic access to and updating from a series of libraries.

6. Access

At present the code for SUMS constitutes only about a megabyte and can be run from a Windows environment on an IBM compatible PC 386 or higher. For graphics display a 24 bit card is highly recommended. It is foreseen that SUMS will become an authoring tool for the creation and searching of CD-ROMs. The plan is that knowledge packages containing all the materials in a given subject such as perspective would be collected on a series of CD-ROMs and searched using SUMS. At a subsequent stage it is hoped that an online version of SUMS, or a related product, Knowledge Engine (cf. below), could be used for searching databases directly on Internet.

7. Publication, Commentary, Transformation, Creation and Testing

Most readily available software programs have been concerned with creating shells for dissemination of and appendages to knowledge rather than with the corpus of knowledge per se. Some of these features are being integrated directly into software programs. With respect to publication, for example, a print function is almost always available. In addition there are of course specialized software packages for desktop publishing such as *Aldus Pagemaker* and *Ventura Publishing.* Similarly in the case of adding notes and

making commentaries many operating systems and packages have a notepad or bookmark function. In the case of transformation there are a number of specialized packages for adapting, manipulating or playing with images such as *PhotoShop, Corel Photo, Corel Draw , Photostyler,* and *T-Base* as well as more specialized morphing programs.

Software programs are also concerned with the creation of new text and images. In the case of text, this is the aim of word-processing packages such as *Microsoft Word* or *Word Perfect*. In actual fact they are shells for recording creative writing rather than tools for creativity. A non-creative person can sit in front of the screen all day and produce as little as they would if they were sitting in front of a blank piece of paper and a pen. This applies equally in the case of graphics packages intended to aid in the creation of new images such as *AutoCAD, 3-D Studio*[10], *Corel Draw* or the like. What these programs do offer, however, is an immense reduction in the tedious aspects of rendering basic shapes such that someone with talent and creativity can accomplish much more than was previously possible. As such they are immensely valuable.

Some features which are being explored are not yet readily available. For instance, most translation packages are still limited to individual words, but more complete packages for major European languages as well as Chinese and Japanese are becoming available. Some of these new techniques presently involve hardware rather than software as in the case of sensory extenders. Hence a person can now see at night by using special glasses, such as those of the villains in *Cliffhanger*, which extend sight into the infra-red frequencies. (Stereoscopy, holography and virtual reality can also be seen as sensory extenders).

Sensory transducers take information from one sensory mode and transduce or translate (in a special sense) them to another. IBM's *Personal Science Instructor* (PSI) which takes the kinesthetic motions of a person and translates this into a graph is a case in point. Voice recognition packages which take oral messages and translate them into visible written messages are another example of this process. Still in their initial stages of development are more complex sensory transducers, whereby information gathered by one sense is translated into that of another sense. Warren Robinett at the University of North Carolina, Chapel Hill has proposed more dramatic examples of this principle whereby one could take the information gathered by an ultra-sound scan and and transduce it into a visual image, such that a medical doctor could literally see what they hear[11]. All of these features which are now appendages to operating systems, independent software programs or linked with specific hardware are effectively tools for adding to the corpus of knowledge and as such should eventually be integrated as extras to the shell for SUMS (fig. 4).

Commentary	note(pad)
Transformation	adaptation, manipulation, play
Translation	adaptation into another language
Extension	extension of a sense to other parts of the spectrum
Transduction	adaptation into another sensory mode

Creation	new text, images
Publication	printing

Fig. 4. Functions of other shells to append to the corpus.

It is important to be aware that these tools could also be misused to edit, transform and generally tamper with the existing knowledge by persons who would like to see the principles of *new speak* applied to written documents and other historical records. This has enormous legal and political implications. For instance, if digital versions of photographs can be emended and manipulated, what then is the legal status of photographic evidence? To insure against this companies such as Kodak are introducing new photographic versions of watermarks, originally developed by the paper industry, and encryption techniques that will permit experts to determine whether photographs are based on a physically real scene. Such precautions need to be extended to the whole corpus of historical knowledge, if twenty-first century versions of the Donation of Constantine[12] are to be avoided.

Aside from such obvious dangers of simple fraud, deeper problems of a philosophical nature are also entailed. Knowledge is not static. New things are being discovered and invented almost daily. Moreover, commentary on the existing corpus also continues as scholars have fresh insights into texts, paintings and other records. Anyone is free to make their own translation of Dante or make comments in their personal notepad on Shakespeare, Michelangelo, Plato or any other figure. Should these be treated equally and entered indiscriminately alongside the translations and commentaries of recognized masters? No. In the case of printed texts there are review committees to referee which books and articles are worth publishing. This principle could be extended to electronic commentaries, editions, translations and other potential contributions. Those accepted by panels of experts would be included as part of the official corpus of knowledge. Unsuccessful candidates would remain free to make their comments available via bulletin boards and produce electronic equivalents of underground literature.

Even within the accepted corpus there are mechanisms for distinguishing levels of quality. Traditionally this was the main purpose of reviews. The prototype of SUMS applied to perspective relates reviews directly to bibliographical references of titles. In future, regular bibliographies could be integrated with bibliographies of review literature to provide much more systematic access to these indicators of quality. More recently citation indexes are also used. With the enormous increase in computing power this could be applied retrospectively to (all) earlier literature. This would open up new studies of how key authors influenced both their specific discipline and other fields. Hence, notwithstanding the dangers they entail, the tools or shells used for adding to the corpus of knowledge can also add new avenues for understanding traditional knowledge.

Related to these tools are other functions that are being developed in the context of training and education which are also being developed into shells. At the simplest level are software packages that help students to memorize things in fields where rote-learning is important. For instance, an air force student needs to memorize various kinds of

aircraft so that they can distinguish enemy aircraft from those of their allies. Or a medical doctor needs to know precisely what the basic organs of the body are. (We would not be happy with the thought that a surgeon would need to consult his manuals half-way through a delicate operation). Other problems for which specialized software is being developed include excerpting, which is another application of the notepad or notebook function, experimenting, imitation, simulation and various types of testing (fig. 5).

Memorizing	rote learning
Excerpting	study, notes, notepad
Experimenting	attempted repetition in science
Imitation	personal adaptations and versions
Simulation	possible interventions, scenarios
Testing	examination

Fig. 5. Some aspects of training and education.

A project directed by Professor Spero (Toronto) is creating a generic shell for educational testing. This could be expanded to include other aspects of study. It is hoped that these functions might eventually be integrated within the SUMS package.

8. Three Search Strategies

The appropriate search strategy is very much a function of the size of the database being used. When electronic versions of a single book or a relatively small number (up to c. 1000) of books are entailed it makes sense to search for every occurence of a term. When large libraries are involved other methods are needed. A person who searches for *liberty* in the Library of Congress or *God* in the Vatican will be overwhelmed with examples. In such cases an approach using the concept of domains of knowledge as in SUMS makes much more sense. In cases involving large libraries where an individual is not familiar with a topic and hence needs to browse and explore, constantly changing levels, more than SUMS is needed, namely a system which tracks a user's path such that one can retrace one's earlier steps at will. A prototype of such a system, termed Knowledge Engine, is being developed at the McLuhan Program in conjunction with Greenfield Projects. Hence quantity of material to be studied is one important factor in determining the method to be used (fig. 6).

Quantity	Search Methods	Tool
1-1000	Every word	Existing Software
1000-1,000,000	Domains of knowledge	SUMS
1,000,000+	Domains of knowledge plus tracking	Knowledge Engine

Fig. 6. Three fundamental strategems for searching.

9. Conclusion.

The background for and chief characteristics of a System for Universal Media Searching (SUMS) have been described: how basic questions are used as a starting point; how the concepts of basic domains and levels of knowledge are used for basic orientation; how meters can be used as tools for conceptual navigation, as are strategems for addition and access. In the software industry there has been great emphasis on creating shells for commenting on existing knowledge, creating new text and images and publishing the results. In the fields of training and education other shells for testing knowledge have also been produced. In the longer term it is foreseen that SUMS, which provides a shell for an existing corpus of knowledge, could have appended to it some of these ancillary shells. Finally three search strategies for different amounts of information were identified in order to clarify where the methods of SUMS are most appropriate and useful.

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Notes

[1] For a description of this part of the project see the author's "Multidimensional Bibliography and Classification: Inaugural Address": *Anwendungen in der Klassifikation. Proceedings 8 Jahrestagung der esellschaft fur Klassifikation eV*, ed. Rolf G. Hensler (Teil 1), Hof Geismar, 1984, Frankfurt, Indeks Verlag, 1984, pp. 57-75, and "A Databank on Perspective", *Metodologia della ricerca: orientamenti attuali. Congresso internazionale in onore di Eugenio Battisti* (Milan, 1991), *Arte Lombarda*, Milan, 1993, (In press).

[2] Programming was done by Alan Brolley, a student at the University of Waterloo; Paul Chvostek, a high school student and Eric Dobbs, a student from the University of Colorado at Boulder, who also produced a series of diagrams and animations using AutoCAD. More recent programming in C++ has been led by Jonathan Shekter and Eitan Grinspun, working with Effi Ofer. Programming on links with other libraries is being developed by Wen Yen Chan and Sanjeev Luthra. Further illustrations in Autodesk's 3-D Studio are being made by Darren Kraemer. Further titles are being added by Rani Talat Kharbutli.

[3] See: "Knowledge Packages", *The 12th E.C.O.O. and the 8th I.C.T.E. Joint Conference*, Toronto, May 1991, pp. 757-759.

[4] From 1987 to 1991 this project was supported by a Canada Research Fellowship and small grants from the SSHRCC. From 1991 through 1994 the project is being sponsored by BSO/Origin with some contributions from the Canadian Heritage Information Network.

[5] See: "Past Imprecision for Future Standards: Computers and New Roads to Knowledge", *Computers and the History of Art*, London, 1993, pp. , (in press).

[6] For a further discussion of this theme see the author's: "Conceptual Navigation: Views beyond Windows", *Sistema Terra*, Rome, September 1993 (in press).

[7] These have been discussed at greater length in the author's: "Electronic Media and Visual Knowledge", *Knowledge Organization* (formerly *International Classification*), Frankfurt, vol. 20, no. 1, 1993, pp. 47-53.

[8] For another discussion of these developments see the author's: "Computers and a new Philosophy of Knowledge", *International Classification*, Frankfurt, vol. 18, 1991, pp. 2-12.

[9] See the article cited in note 6 above.

[10] The Perspective Unit of the McLuhan Program where SUMS is being developed is very grateful to be a test site for the GIS technology of Cartologix, (formerly Generation 5), Autodesk's AutoCAD's 11, Animator Pro and 3-D Studio; Softdesk's AdCADD, Superbase and Freebase.

[11] See, for instance, Warren Robinett, "Electronic Expansion of Human Perception", *Whole Earth Review*, May 1991.

[12] A document purportedly written by the Emperor Constantine gave the Church claims over considerable state lands. In the fifteenth century the careful philological work of Lorenzo Valla established that this document had in fact been forged in the ninth century.