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Electronic Media and Visual Knowledge

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The real challenge of today lies in exploring how computers will enable us to do what was not possible previously. The paper attempts to provoke thought about new frontiers of visual knowledge organization. Computers introduce the possibility of interchangeable media. They offer multiple nodes of access to a given term or object. They enable us to approach knowledge on different levels. A scheme of 10 levels is proposed and some consequences for visual knowledge at each of these levels is considered briefly. The final section of the paper considers four navigational tools: questions, maps, meters, and tracking. (Author)

1. Introduction

To date most computer projects in the visual arts have been focussed on the nitty-gritty of compatibility, standards of image quality, storage capacity, authority files for names, places and basic concepts. Some of the papers in this issue have offered detailed glimpses into the complexities of these problems which need to be solved before we can achieve anything serious. Even so, it is important to remember that these are interim problems, that they will be solved, and that the real challenge lies in exploring how computers will enable us to do that was not possible previously. This paper takes as its point of departure a project[1] that is being funded by BSO/Origin[2] and CHIN[3] and developed in conjunction with Greenfield Projects. It is partly visionary with the intent of provoking thought about new frontiers of knowledge. Why is the computerization of knowledge, particularly visual knowledge important? How will computers change our methods and horizons of research?

At the outset it should be noted that the term computers is actually a synecdoche where a part stands for a whole. The revolution is not just about a desktop PC. It is about a whole gamut of electronic devices ranging form camera recorders and scanning devices to smart cards and display screens in which the computer is merely the most familiar intermediary device. (Some now refer to this set of devices as a transputer). A first point we shall make is that computers in this wider sense introduce the possibility of interchangeable media. Computers offer multiple nodes of access to a given term or object. They enable us to approach knowledge in different levels. A scheme of ten levels is proposed and some consequences for visual knowledge at each of these levels is considered briefly. In the final section of the paper four navigational tools are mentioned: questions, maps, meters and tracking.

2. Interchangeable Media

In the past each new medium threatened to replace earlier media. The advent of printed books threatened the continued use of manuscripts and to exclude the use of visual material. This changed gradually as books translated the coloured originals into woodcuts, engravings, lithographs and line drawings, yet it was not until the second half of the twentieth century that full colour reproduction became possible, and even now costs remain prohibitive such that most printed images are black and white. Computers are fundamentally different because they do away with the need for intermediary forms of images. They permit viewing and printing of high level colour images directly. More significantly, they promise access to all media. A digital text can be displayed on a computer screen, as a video or as a television image, be printed in book form or read out orally. Instead of replacing earlier media it can use each of them interchangeably. Hence in addition to providing a new technology, it can reproduce the media of earlier technologies. In the past a single medium (uni-medium) was used at a time. The early twentienth century introduced dual media (bi-media). These remained either private or public. Multiple media also evolved but remained unintegrated. Computers permit the integration of many media (multi-media) which can be used both in private and in public (Fig. 1).

UNI-MEDIUM		
Aural (Unrecorded Verbal)	Speech	(Public, Private)
	Conversation	(Private)
Recorded Visual	Letter	(Private,Public)
	Manuscript	(Private,Public)
	Painting etc.	(Private,Public)
	Book	(Public) *
	Periodical	(Public) *
	Newspaper	(Public)
	Silent Film	(Public)
	Newsletter	(Public,Private)
	Photography	(Public,Private)
BI-MEDIA		
Recorded Verbal (Audio)	Radio	(Public,Private)
	Tape Recorder	(Private)
Verbal-Visual (Audio-Visual)	Film	(Public)
	Television	(Public)
	Video	(Public,Private)
MULTI-MEDIA		
Visual-Verbal Combinations	Computers	(Public,Private)

Fig. 1. Examples of types of communication. Asterisks indicate levels particularly associated with scholarship from the Renaissance until the mid-twentieth century.

Marshall McLuhan described shifts between hot and cold media. Computers offer a new integration of both hot and cold and thus challenge traditional boundaries between different media, between visual and verbal knowledge. As a result we need to rethink the boundaries of scholarship which in the past were limited to a small part of this spectrum (cf. asterisks in Fig. I).

Analogue	TV and Film	Computers	Digital
Mass	Publishing	Software	Personal
Passive			Interactive
Content	Databases	Telecommunications	Carriage

Fig. 2. Trends in the key industries according to Stursberg.

Stursberg (I) has drawn attention to other aspects of this interchangeability. Traditionally distinctions were made between industries which were analog(ue) or digital, mass orpersonal, passive or interactive, content based or carriage (pipeline) based. These distinctions are also being eroded. The new synthesis will integrate these industries into a single electronic nexus.

3. Multivalent Access

In traditional media such as books, reference material was typically arranged in alphabetical lists of names and terms, with 'see also references' in the case of variants. If, for instance, one was looking for Leonardo da Vinci and one looked under Vinci, Leonardo da, one might find a note telling one to look directly under Leonardo da Vinci. In the case of major libraries this entailed walking a number of feet from the catalogue for the letter V to the catalogue for the letter L. Computers require standardized terms and names and terms. Hence the great upsurge in authority files. At the same time computers permit one to add any number of 'see also references' each of which can become points of access to those standard names and terms. As a result a person who types in 'Vinci' or 'Da Vinci' in a computerized database can be directed immediately to Leonardo without needing to lose time walking to another catalogue or book. The same principle applies to paintings. The computer can direct a person who types in either Mona Lisa or La Gioconda to the same painting. In traditional printed media each time such a painting was compared in a new way the picture had to be reprinted in a new book. In a computer the same image can be called up any number of times in different contexts.

This principle of multiple entry points to a given name, term or object has enormous implications, particularly when extended to classification systems. In the past a classification system was used to class a given painting or other object and this was used to place them in some physical location. A book classed as mathematics was placed in one room. A book classed as art was placed in another room. This meant that a book on perspective which dealt with both mathematics and art was inevitably relegated to one or the other. If a librarian placed it in mathematics then someone looking for perspective only under art would not find that book. Once such a list is computerized the same book can be reached through both mathematics and art. If different classification systems class this book differently, then these further entry points can also be used. Indeed all variant names or terms potentially become further points of entry in the computerized version.

The advent of printing brought a specialization in kinds of knowledge which were classed according to their medium. Books went to libraries; artefacts went to museums; paintings to galleries; drawings went to drawing cabinets; engravings went to engraving cabinets and so on. Hence persons typically became experts in a medium rather than in subjects and as a result thorough histories of subjects across the various media have yet to be written. We know, for instance, that important themes in manuscript illustration often influenced paintings and in turn were influenced by paintings. Important paintings frequently inspired a visual equivalent of commentaries in the form of woodcuts, engravings and lithographs as well as other paintings (both as so called copies and as versions). Computerized access to the full corpus will make these strands of our cultural heritage visible in a new way.

4. Levels of Knowledge

The specialization of different kinds of knowledge had other consequences. In the case of books there was a further separation in terms of size. At Wolfenbüttel, for example, the Duke of Lower Saxony arranged the folio books (35cm.+) on the lowest shelves, the quarto books (c.25-35cm.) on higher shelves. Above these he placed the octavo books (c.I5-25cm.) and at the very top he placed the minimal formats 16° and 32°. This idea of size spread to many of the great European libraries. Gradually contents became another criterion for separation. Classification systems were arranged in one room. Dictionaries, encyclopaedias and bibliographies were arranged in reference rooms, while the books themselves were arranged elsewhere in terms of different classes.

In all this separation the basic links between these works were easily forgotten: I) classification systems provided authority lists of terms and names. These terms were then defined in 2) dictionaries, explained in 3) encyclopaedias and related to lists of books in 4) catalogues and bibliographies. These same terms recurred in the 5) title pages and indexes of books. Each of these five kinds of knowledge can be seen as a separate level and as pointers to the actual objects: books, paintings, instruments, buildings etc. which can be seen as a sixth level. With computers it is possible to relate these automatically and move from one level to the next on a screen without turning to a new set of books each time.

In the past a distinction evolved between the actual texts (primary sources) and commentaries on them (secondary sources). These commentaries were variously termed analyses, interpretations and the principles underlying these led to the field of hermeneutics. With the advent of computers, a need for greater clarity is leading

to further distinctions between four levels of interpretation: internal analyses, involving only the object itself; external analyses, that is, involving other objects as well; restorations and reconstructions. If each of these is also assigned a level, a scheme of ten levels of knowledge emerges (Fig. 3) consisting of pointers (levels 1-5), objects (level 6), and interpretations (levels 7-10). The advent of computers has implications for visual material at each of these levels.

Type	Other Names
1. Classification Systems	Containers of Containers
2. Definitions	Dictionaries
3. Explanations	Encyclopaedias
4. Bibliographies	Names of Containers
5. Partial contents	Tables of Contents, Indexes
6. Full Contents	Art, Books, Instruments
7. Internal Analyses	Descriptions of Object
8. External Analyses	Descriptions of Related Objects
9. Restorations	Conservation Reports
10. Reconstructions	Models, CAD, Virtual Reality

Fig 3. Ten levels and types of knowledge with alternative names.

In terms of classification systems the automated versions of Iconclass and the AAT, discussed elsewhere in this issue offer one obvious application of computers for readier access to visual knowledge. Such systems can be augmented by the use of visual material (e.g. diagrams, illustrations, including animations, images of paintings in video or on CD-ROM), which can further be used to demonstrate any term at the level of definitions (level 2) or clarify explanations in what was traditionally an encyclopaedia (level 3).

In the past, access to bibliographies (level 4) was usually limited to author, title and subject lists. Exceptional libraries such as the Herzog August Bibliothek (Wolfenbnttel) have created catalogues by place of publication. If this information is linked with a map, users can click on cities to check what publications they produced. Statistical spread sheets can be used to visualize publication rates of authors, publishers and their editions in graph form. In the past, partial contents (level 5) were mainly available from tables of contents and indexes within the actual book. The last century has seen the gradual rise of abstracts which can be searched in terms of names, and subjects. They are however still fragmented. One looks for dissertation abstracts in one databank, humanities abstracts in another, chemical and pyschological abstracts in other databanks. Search strategies by author, subject, period and image can be centralized. Books and articles (level 6) often contained poor reproductions of paintings and other works of art. Once these books and articles have been scanned in, one can study the history of editions in terms of which images are added or removed. The digitized versions of these books can also be supplemented with high level illustrations by downloading images from databanks of major art works, thus improving on the quality and effectiveness of the original publications.

5. Internal and External Analyses

For internal and external analyses (level 7), computers offer remarkable possibilities for the study of visual knowledge. To see the contents of a picture may seem easy, but to describe these contents was often very difficult. The question of access to these descriptions was even more problematic. In terms of publication two common forms were monographs with detailed descriptions of work by a given artist (the catalogue raison_e), and specialized articles describing a given painting, sometimes comparing its features to those in related paintings or drawings. These publications had the disadvantage that they were often in obscure journals. It was commonly assumed that scholars were fluent in Latin, Greek, German, French, Italian and English. Even so these publications represented only a small fraction of the available material concerning identifications and descriptions of paintings. Major projects such as the Princeton Index of Christian Art and the Marburg Archive contained hundreds of thousands of detailed descriptions but were not generally accessible. This was also the case with records in individual museums. All these projects are being computerized and within the near future this material will be available.

With respect to portraits and human figures it will be possible to study the history of their positions: which ones are depicted frontally, from the rear, in profile (facing right or facing left) or in three quarter view. The scholarly value of so doing will come into focus when individual images are compared with others in external analyses. For instance, in the late nineteenth and early twentieth centuries there was an enormous debate about the sequence of these views in the evolution of drawing techniques. With the help of computers the material can be studied systematically for the first time. This applies equally to descriptions of individual features such as hands or ears which formed a point of departure for Morelli's comparative method in the past century but which again remained unsystematic prior to computers.

Such comparative techniques can also fruitfully be applied to representations of a) human actions (such as drinking, eating, fighting, loving, playing, reading or sleeping); b) human motions (such as carrying, kneeling, leaning, lifting, lying, pulling, pressing, running, sitting, standing, being supported, being suspended and thrusting); and c) human emotions (such as anger, ecstasy, fear, joy, sorrow and suffering). Systematic study of these, comparing the extent to which they are reflected in the titles of drawings, paintings and other works of art could provide valuable materials for the history of society and psychology. Are there trends in the gradual diversification of depicted motions and exteriorization of emotions? To what extent do they vary from culture to culture? More could be learned by examining the depicted relations between/among persons in terms of simple descriptive adjectives such as to, from, with, against, at, towards and away from. This approach could also be extended to relations between/among objects such as

inside, outside, below, above, near, far, and beside as well as basic orientations in terms of North, East, South, and West.

The work of authors such as Brilliant (2), Kaftal (3), and Aronberg Lavin (4) has focussed attention on the importance of narrative for the development of mimetic art in the West. The sources of these narratives are both sacred (the *Bible* and lives of the saints such as Voragine's *Golden Legend*) and secular (mythologies such as Ovid's *Metamorphoses*). Prior to the advent of computers systematic links between all these verbal sources and visual examples posed insuperable difficulties. In the past decades computerized versions of many of these sources have been created including the *Bible*, effectively the whole of classical literature (*Thesaurus Graecum*) and the whole of patristic literature (*Patrologiae Graecae* and *Latinum*). There is every reason to believe that other sources such as later lives of the saints, post classical literature and fairy tales (e.g. Grimm) will become available within the next generation. When this occurs systems such as Iconclass will help to provide a front end for more ready access to this vast corpus.

Other examples of external analyses which have been discussed elsewhere are comparison (e.g. copies, versions, related images and other media), development (both genesis of an individual painting through preparatory drawings and evolution of styles over time), places and scales (also mentioned below under maps), relationships between practice and theory, concrete and abstract, universal and particular[4].

6. Restorations

Restorations involve a subtle form of analysis and interpretation the importance of which has only recently come into focus. Restoration sometimes plays an important part in the context of manuscripts. For instance, Leonardo's *Codice Atlantico* was altered by the process. Some new text and images came to light, while in rare cases lines were destroyed. Restoration applies particularly in the case of paintings. Leonardo's *Last Supper*, Masaccio's frescoes in the Brancacci Chapel and Michelangelo's work on the Sistine Ceiling are three dramatic examples of how restoration changes our very conception of the object of study. In earlier centuries the restorer carried out their task with little documentation. In the past generation restoration has developed complex methodologies. The computer plays an important part in these developments because simulations can now be made prior to interventions and very detailed records made of all actual interventions. Perhaps the best example to date of these possibilities is a program developed by Menci and Chimenti in connection with the restoration of Piero della Francesca's *Legend of the True Cross* (Arezzo). The database for this one fresco is over 600 megabytes.

7. Reconstructions

The idea of reconstructions as an aid to understanding is an old one. Physical models of wood are perhaps the most familiar form. Since the Renaissance there has also been a tradition of artists' reconstructions of partly ruined or no longer extant buildings. The advent of easily accessible CAD[5] packages such as Autodesk's AutoCAD and 3-D Studio has led organizations such as the Committee for the Study of Architecture (CSA) to make computerized models of ancient buildings. Even so, reconstructions are only gradually being recognized as an independent area of analysis and interpretation. For instance, in editions of mathematical texts it was customary to substitute a geometrical diagram for the original in the manuscripts. Manuscript variants in terms of diagrams were often not deigned worthy of mention. Similarly discrepancies between textual descriptions and diagrams were often not mentioned. The new edition of Piero della Francesca edited by Dalai Emiliani, Grayson and Maccagni is introducing a new standard where every diagram in the manuscript is reproduced and complemented by a critical version that draws attention to errors or discrepancies obtaining in the original.

There are different kinds of reconstruction. A simple type attempts to establish underlying patterns in an existing object. For instance, such a reconstruction may involve the imposition of lines of perspective or proportion onto drawings and paintings. More complex reconstructions typically use patterns at different levels of abstraction. Reconstructions in this sense involve many types, ranging from physical models to Computer Aided Design and virtual reality. This involves a spectrum linking concrete and abstract. Many assumed that knowledge was a function of how close we could get to the abstract side of the spectrum: i.e. a physical model was better than the original aspect of nature it represented; a geometrical diagram was better still and an algebraic formula was best of all. Some persons are now conscious that knowledge lies not just in this abstract end but rather in the whole spectrum from concrete to abstract. Hence reconstructions play a central role in our concepts of knowledge.

In addition to these reconstructions within objects, there can also be reconstructions between objects in isolation and among objects in sites, particularly in the context of architectural ruins. Such reconstructions are more complex because they typically involve combinations of parts of existing objects with objects that no longer exist (and indeed may never have existed physically). Such reconstructions are invariably influenced by national ideals and ideologies. For instance, a Greek reconstruction of the Acropolis may look quite different from a German, French or American version and as such reconstructions offer unexpected avenues into visualizing the consequences of -isms.

Using CD-ROM technology we could collect images from different cultures and from different times of the same scene and thus make visible the way in which society shapes our views of culture. Rather than telling children in abstract terms that they should not accept communism, fascism or other -isms it would be much

more effective simply to show them what certain -isms do to our views of familiar places and particularly with our cultural heritage. At the moment, especially in countries such as Canada there is a great concern with teaching children multiculturalism. In the United States this term has become almost synonymous with relativity, which is misleading. If we use computers to show children how different cultures image their historical landmarks and beliefs (or consciously do not use images for this) we can help children and adults understand visually the complexities of cultural variety.

8. Questions

Such integration of knowledge poses new problems of navigation[6]. How can a user move through vast amounts of facts without getting hopelessly lost? The concept of levels of knowledge as discussed above offers one tool for this purpose. Four other navigation tools will be considered briefly here: questions, maps, meters and tracking. In school we all learned to ask basic questions each of which has corresponding answers or types of knowledge (Fig. 4). Through author and subject lists, both book catalogues in libraries and image catalogues in art galleries, museums and photo archives have traditionally been limited to the first two of these questions. Computers will give us access to 'where' questions in terms of maps (see next section) and 'when' questions through both simple chronological lists and electronic versions of the universal history books with their lists of key events in politics, culture etc. 'How' questions can largely be answered through access to how to do it books after distinguishing whether the interest is as a hobby, a trade, or a profession. Why questions can be answered through Boolean searches combining a given subject (what) with terms such as reasons and causes.

Each of the questions can be seen as an aid in focussing or delimiting the scope of that which is being searched. A person asking only 'who?' will simply be given an alphabetical list of all extant biographical names. A person asking for 'who? and typing in the letter 'L' will enter the same list at the beginning of this letter. If a person types Leonardo they are given a list of all Leonardos including Leonardo Pisano (Fibonnacci) and Leonardo da Vinci. A person typing in Leonardo da Vinci under 'who', flight under 'what', and 1490-1500 under 'when' would be given the relevant pages of Leonardo da Vinci's *Manuscript B* (Paris, Institut de France). As a result an expert who begins their search by knowing parameters to a majority of types of questions can avoid a series of steps that would otherwise be required to define a problem.

9. Maps

As was suggested above, physical maps such as those found in atlases are particularly useful in answering the question where (is)? In electronic form physical maps of the world can have the equivalent of hotwords for each continent, maps of each continent can have hotwords for each country; country maps can have hotwords for provinces, provincial maps hotwords for cities, city maps hotwords for buildings, buildings hotwords for ground-plans, ground-plans can have hotwords for rooms, rooms can have hotwords for objects. In this way one can move visually from a map of the world to any (significant) object in the world in ten simple stages (cf. Fig. 6 below). At present Geographical Information Systems (GIS) are being developed particularly in the case of municipal and local government to establish the locations of power lines, cables, sewage pipes and other features of the environment. The challenge is to apply these principles to our cultural heritage, such that the layers can include different levels of archaeological materials and different periods of history.

At present maps are already being used in the Micro-Gallery at the National Gallery (London) to show visitors in which room a given painting is hanging and to help visitors plan an itinerary which will include a number of paintings of their choice. Maps offer many other potentials. A person studying Leonardo could trace the itinerary of his various travels on maps. A map could show the present locations of all paintings by Leonardo and his school and also trace the history of locations of a given painting. In the nineteenth century maps were used to illustrate the spread of major movements such as Romanesque or Gothic architecture. With an adaptation of the hypertext concept this could be developed greatly.

One of the regular objections to such proposals is that the idea is splendid but since it is not a money making proposition, it is entirely utopian to believe that it could ever happen. By way of reply, two comments should be made. First, in fields which are thought of as business, the essential framework for these approaches has already been developed. For example, if one flies across the Atlantic on Air Canada, there are now maps that allow one to see exactly where one is at every point of one's journey. Similarly, at Rome airport, there are maps that trace weather patterns in the past 24 hours and predict them for the next day. In the realm of tourism, computers are being used to give pictures of hotels. In real estate, computers are being used to give pictures of available houses. So, not only the hardware but also the software is already there. It "merely" needs to be integrated and applied to cultural objects. Second, it should be noted that such seemingly uncommercial applications will actually have enormous commercial potentials in the long term. The experience of television has confirmed that there is a certain amount of interest in cultural and educational programs. Persons want to see an excellent tour of the Louvre or the Prado. They are interested in seeing the great architectural, artistic and cultural monuments of Europe and more exotic countries. This interest will increase when the access is potentially interactive and will awake at least two quite different responses. Some will find in these developments a greater excuse to stay at home and will focus on getting the best possible images there. This group will bring new sales in equipment and to the communications industries (be they telephone companies

or cable TV, who offer fibre optic or other pipelines). Others will find in these developments new incentives for ex- and in-tensive travel. Hence this second group will also bring new business to travel agents, airlines, hotels and the tourist industry at large. Both groups will want reproductions of their experiences which will aid imaging companies (e.g. Kodak and Polaroid) as well as the owners whose works are being reproduced (museums, art galleries, artists). Thus if a longer view be taken there are no insuperable obstacles to applications in areas that have traditionally been considered unprofitable.

Maps are of two kinds, physical and conceptual. By conceptual maps we mean tables which establish relations between different elements. Such tables have their origins in late medieaval scholastic philosophy when thinkers were attempting to establish hierarchies of being and knowledge. As Ong has shown (7), during the Renaissance these structural tables or trees were taken up and developed by Ramus (Pierre de la Ramée) particularly in the context of logic. In the nineteenth century such trees were applied to the life sciences in order to visualize connections between genus and species. Their modern equivalent in the realm of computers is a tree which shows relationships between directories and contents. At the frontiers of computational linguistics such trees are being used to visualize grammatical structures.

These conceptual maps can be applied locally (i.e. one level at a time) or globally (all levels together). If I wish a local map in terms of classification (level 1), then I am given the hierarchical relation of my term, or if it be in a nested system, the level at which it is nested. A local map in terms of explanations (level 3) will give me a chart showing other concepts with which it is related. A global map will give me all hierarchical links that have been proposed. If more than one series of links exists, then the alternative explanations will be presented.

10. Meters

Another navigation tool is the use of pop-up tables or meters with a variety of options that function in a manner analogous to the toolpalette in Toolbook or the menu items in Windows environments. For the purposes of this paper five such meters will be mentioned. A first incorporates the basic types of questions and answers outined above in the form of a questionometer (Fig.4).

1. Who	Persons
2. What	Objects
3. Where	Places
4. When	Events
5. How	Instructions
6. Why	Reasons

Fig. 4. Questionometer for basic types of questions and answers.

A second incorporates the potential interchangeability of media discussed earlier such that a user can decide the medium in which they wish to see their message (Fig. 5).

1. Animation
2. Diagram
3. Film
4. Photograph, black-white
5. Photograph, colour
6. Sound
7. Television
8. Text
9. Video
10. Virtual Reality

Fig. 5. Mediaometer with ten options.

This same idea can be applied to the problem of spatial orientation using a scaleometer. If reconstruction shows how computers can help us see an object in its cultural context, scale illustrates how computers can help us see objects in their spatial context. Traditionally scale has been one of our chief criteria for separating objects: small pictures or maps go somewhere, large pictures and maps go somewhere else. The computer offers a possibility of relating all these images of different scales. Indeed if these images be organized systematically using a scaleometer one can move from any object, to the room it is in and finally a map of the world in ten easy steps (Fig.6). The sceptic may again say that this is a wonderful idea but quite impossible to achieve. Through the development of Facilities Management (FM), methods have already been developed for the systematic cataloguing of objects relative to walls and ground plans. Older museums have long had their own general methods for the same problem. The location of each museum or other building is already known through address books. The locations of cities within countries and countries within continents is known through atlases and gazeteers. Hence, by co-ordinating museum catalogues, address books and atlases, the process of estabishing a spatial orientation system can effectively be automated.

1. World
2. Continent
3. Country
4. Province, State
5. City
6. Building
7. Ground Plan
8. Room
9. Wall
10. Object

Fig. 6. Scaleometer for spatial orientation and coordination.

The full potentials of such an approach are staggering. A first stage would entail digitizing standard local and world atlases. A second stage would entail relating this to digitized satellite images of the world which could (if the military permitted it) permit us to view any part of the world in "real time". A third stage would entail digitizing historical maps. With the use of morphing techniques these could then be animated such that one could effectively watch how cities grow and how borders change with time. Many paintings since the fourteenth century depict

real places. For example, Ghirlandaio's fresco of the *Pope giving Saint Francis the Rights to his Order* (Santa Trinita, Florence, painted 1480 showing an event in 1223) depicts the Palazzo Vecchio and the Piazza della Signoria in the background. Given a historical version of the scaleometer one could call up the relevant illustrations and maps around 1480 and in this way gain further insights into cultural context.

This same principle of different scales can be applied to chronology in order to provide temporal orientation (Fig. 7). For most historical subjects the emphasis will be on decades, years, months and days. Those concerned with paleontology and related subjects will tend to use the scale of millions of years. At the other extreme those concerned with chemical or physical processes will usually prefer minutes and seconds.

1. Millions of years
2. Millenia
3. Centuries
4. Decades
5. Years
6. Months
7 Days
8. Hours
9. Minutes
10. Seconds

Fig. 7. Chronometer for different time frames.

The explosion of available information has made it increasingly apparent that there are different levels of discourse needed in the description of an object, a technique, process or other realm of knowledge. Physicists explaining a problem to their colleagues will use very technical language; explaining the same problem to a student they will use less technical terms and explaining it to a layperson they will use a quite different method of explanation. These different levels of discourse apply to visual images as well as mathematical formulae and technical terms. Eventually one will wish to have what might be termed an accessometer to guide users in choosing differing amounts of detail concerning a given level of knowledge (Fig. 8).

1. Pre-School
2. Junior
3. Intermediate
4. Senior
5. General
6. Craftsman
7. Professional
8. B.A.
9. Postgraduate
10. Research

Fig. 8. Accessometer for different levels of discourse.

These are but some instances of a principle that could readily be extended. For instance the scaleometer is designed specifically for the co-ordination of cartographical or geographical scales. These range from original objects (1:1) to maps of the world (1:5,000,000). The scaleometer is designed mainly as a tool for orientation. Hence the limit to ten steps. Persons wishing to explore geographical material in more detail would study interim scales and thus arrive at a deeper understanding of context. For astronomy one would wish to have a macro-scaleometer with scales well above 1:5,000,000. For mineralogy, cell-biology and other fields using (electron-) microscopes, one would want a micro-scaleometer with downward scales beginning from a maximum of 1:1. A further resolutionometer could be used to indicate different levels of resolution (ranging from 100 dots per inch to 4000 dots per inch) for purposes of viewing and printing high level images.

11. Tracking

Tracking offers a third essential tool for navigation. I may begin a search looking for a term. While reading the definition of that term I encounter another term which is unfamiliar to me. So I search for a definition of that term and may go on to search the bibliography of that term. My search takes me through a series of terms and levels. Suddenly I become conscious that I have forgotten the original purpose of the search. Fortunately each step of my inquiry has been recorded by a tracker, which I can now consult and print out if I so wish. This has the added advantage of making visible for me my own search strategies. In an educational situation a teacher can ask students to record their searches and suggest how their approaches can be improved.

12. Conclusions

Some persons remain sceptical that computers are merely an expensive technology for seeing on a screen what we know already. This paper has offered reasons to challenge that view. Whereas earlier innovations in media sought to replace their predecessors, computers introduce a) interchangeable media; b) multivalent access via variant names that function as automated see also references, c) systematic access through levels of knowledge which is made the more efficient through d) navigational tools such as questions, maps, meters, and tracking. We have explored some ways in which computers entail a new integration of visual knowledge. We suggested that computers offer new horizons in our understanding of cultural history and ultimately in the interpretation of knowledge in general. These ideas, partly inspired by the intuitive suggestions of McLuhan himself, have grown out of a long term project. In conjunction with Greenfield Projects, work has begun on two products (Copyright 1992) termed System for Universal Media Searching (SUMS) and Knowledge Engine. As is so often the case these do not fit into any of the familiar cubbyholes of the university and hence remain underfunded. It is our hope that the power of these ideas will be recognized in time to ensure their continuity, and make our vision of visual knowledge a new reality.

Notes

1 This project would not have been possible without long term support from the Social Sciences and Humanities Research Council of Canada (Ottawa) and foundations including Volkswagen, Humboldt, Thyssen, Getty, whose contributions are gratefully acknowledged. The project also serves as a test site for software packages. These include Autodesk products such as AutoCAD, Animator Pro and Three-D Studio, those of third party developers such as Cartologix and Softdesk and products by other companies such as Freebase and Superbase).
2 BSO/Origin: the Dutch software firm: Burovoor Systeemontwikkeling)
3 CHIN: The Canadian Heritage Information Network
4 See, for instance (5)
5 CAD: Computer Aided Design
6 There are other projects in this direction. See, for instance (6). It is noteworthy that such projects apply number crunching techniques to words with no attention to historical experience gained in the library world.

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Reports and Communications

The CODART-System

A Computerized System for Registration, Documentation and Information of East-Christian Art

by Frank de Jongh and Leendert D.Couprie

Around the world there are several long-term artistic developments for which a great amount of iconographic standardization is characteristic; in which, over the centuries, themes and subjects remain more or less the same. This applies to East-Christian art to a high degree: in icons, mosaics, mural paintings, and in decorative art as well, the same motifs and scenes are repeated over and over again.
Another feature of standardized art forms is that, at least at first sight, stylistic changes tend to be very subtle and unobtrusive.
These two observations lay at the basis of a plan to develop a computerized documentation system for East-Christian art. The acronym CODART refers to 'Christian-Orthodox Data of Art', the sub-title of CODART explains the developers' intention to build a threefold implementation, that may serve the needs of a variety of audiences.
For persons engaged in documentary activities concerning Christian-Orthodox art, CODART's registration module should be an indispensable aid, as the system's data can serve as a blue-print for object records.
Scholarly publications may profit from a set of computerized 'productivity tools': authority files, thesauri, and bibliographical data. Interested laymen may have access to those parts of CODART's data which constitute an 'electronic encyclopedia'. The information is presented both in textual and in visual form.
Of foremost importance is the development of the envisaged set of productivity tools, which have been called 'CODART-Thesauri'. The most comprehensive one, which is presently under construction, has been named 'Iconoclatura'. This indication refers to its function as 'name-giver of icons': it will contain authorized, unique titles for all representations known in Christian-Orthodox art, and to each of these titles a score of supplementary data: feastday(s) in the ecclesiastical calendar, information about the represented holy persons, visualization of typical examples, and so on.
Scholars of East-Christian art will find this Iconoclatura useful to arrive at unequivocal standardized titles of iconographical entities - in a field of study where thus far it is liberty above all things. As the titles are supplied in seven languages (Russian, Church Slavic, Greek, French, English, German, and Dutch), the Iconoclatura can be used as a translation tool.