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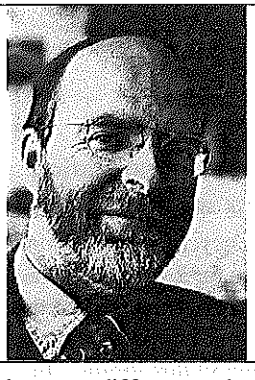
Envisaging the Art of Navigating Conceptual Complexity

In search of software combining artistic and conceptual insights



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This paper is concerned with approaches to the design and production of a software package to demonstrate the feasibility of enhancing comprehension, and navigating complexity, using features uniquely dependent upon the The concern here is with the design of a software package to demonstrate how the power of both "scientific" and "artistic" approaches may be integrated to enhance comprehension and navigation of complexity — as well as offering new forms of creativity in response to complex policy conditions. riches and subtleties of artistic insight.
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1. Introduction

It is usual to distinguish conventional software strategies for navigating relational databases from software for purely artistic representation. Database navigation has already been enhanced by the use of spatial metaphors (windows, landscapes, etc). Multi-media features may be possible (video clips, sound, etc). Data can also be converted into graphic form (diagrams, pie charts, graphs, etc). Quite distinct from these approaches are the facilities offered by the increasingly sophisticated painting programs used by artists to manipulate colour and shape, notably with the purpose of creating "special effects" (as in video-clips) designed to capture the attention. Also distinct is visual (or experimental) mathematics, namely the experimental use of computer graphics by mathematicians sensitive to insights emerging from the aesthetic properties of the unusual forms they are able generate.

It is no longer widely believed that society has the collective ability to organize collaborative projects of a scope capable of making the breakthroughs called for by current challenges. There is a suspicion that the challenge calls for quite another approach that makes greater, and more imaginative, use of the information tools that our society has created in order to counteract the tendency for collaboration to become tokenistic. Failing that, projects now run the significant risk of being undermined by dynamics with which many are already all too familiar.

The general concern here is that of obtaining an integrative perspective on any complex of social issues and potential responses, bearing in mind the need to zoom between levels of complexity and to effectively plan between different ordering systems. Issues of learning are then integral to any software specifications. Flexibility in reordering is fundamental -- in contrast to many systems based on somebody's "good idea at the time" (which later proves very costly to change in the light of new insights). There is a marked tendency for the replication of this kind of inadequate thinking in electronic conferences. There is every indication that there should instead be a heavy investment in moving towards what might be termed "conceptual scaffolding" that can facilitate higher orders of consensus -- using differences rather than becoming vulnerable to emergent differences.

A key question is whether valuable insights into complexity, vital to governance of social processes, may only be representable and comprehensible through presentations of an essentially artistic nature. It is then their aesthetic properties that have valuable ordering and integrative functions. Given the well-demonstrated weaknesses of current international policy-making, it would be unwise to assume that this is not the case. There is also merit in asking why such possibilities are repressed rather than explored. Even in those special meetings or journal issues where the bridge between science and art is the focus, there has been little ability to establish any relationship to new organizations of knowledge for policy purposes.

2. Scope

2.1 Interrelated modes

Briefly the requirement appears to be that users should be offered the possibility of:

(a) operating in an **artistic mode** to create, manipulate and contemplate colours and shapes (possibly drawn from a figure library), possibly over time and in relation to sound;

(b) operating in a **database mode** to build up relational data files;

(c) operating in a **bridging mode** to link specific features of the artistic representation (eg points, lines, shapes, etc) to data elements (whether records or files), thus effectively setting up a a new environment combining the "artistic" and "database" modes;

(d) operating in a **navigational mode** in which the artistic features can be perused and interrogated to reveal any data that they are effectively "holding". It is in this mode that creativity and insight are triggered by interaction with the aesthetically configured display.

The main purpose of this facility is to enable users to "hang" significant data elements onto memorable artistic representations which can be massaged and augmented over time to carry higher levels of ordered complexity. Features could be developed to enhance the ability of the user to reflect selected relational links between data elements into the features of the artistic representation. The software itself might be used to offer options to the user for "hanging" a range of data elements (files, programmes, relationships, images, etc) on an aesthetically dimensioned display.

2.2 Open Environment

The package envisaged is not intended as a closed or over-defined environment. Rather it is a tool that grows and adapts according to the development of the user's artistic and conceptual skills over the years. In a sense the artistic representations are selected and crafted by the user into a personalized knowledge display in order to embody the full range of issues with which he is dealing. Aesthetic priorities would be used to configure together apparently incommensurable insights, where any conventional classification would be unable to provide such integration.

Clearly those with less artistic competence may draw on libraries of complex artistic figures (or have them specially crafted by specialists). These may be used as such or modified at will (as in many standard packages). Information may however be „fed" into (or onto) them by the user (possibly with the assistance of a consultant specialist — a future role in the knowledge ordering sciences).

Over time the user would effectively be equipped with a highly personalized interface to the complex of data elements with which he deals — effectively a personal „insight mirror". Personal preferences and challenges would govern whether this interface, like the decoration of a room or house, changed frequently or seldom. The package would not confine the user to a single representation. The same data might be hung onto one or more alternate artistic representations, each with their own advantages.

2.3 Conceptual Keystones

Many documents of fundamental importance to patterns of collaboration within societies, organizations and groups (or even to an individual's creative processes) are based on sets of principles, values, qualities, policies, initiatives or other points (eg declarations, charters, action plans). These are usually listed out as a numbered sequence, possibly with nested sub-points. The conventional method of producing such documents favours (and reinforces) linear thinking at a time when non-linear, contextually-oriented approaches are often believed to be more appropriate to ensure higher levels of integration amongst the elements of the set.

The software required would aim to facilitate the ability to envisage viable configurations of functions based on structures more complex than those reinforced by hierarchical organization charts and the like. It responds to the need for potential collaborators to design „conceptual keystones" essential to the coherence and viability of unforeseen coalition possibilities in difficult situations of governance. This contrasts with the functions of hypertext which in no way aspires to offering integrative insights into the map of hypertext relations, even if this can be displayed.

The assumption made is that aesthetic representations may prove to have considerable advantages over conventional approaches to organization of knowledge in offering understanding of such keystones. But the relationship to such conventional representations may be preserved. New significance might even be given to the notion of an „artifact", without needing to coin an ugly neologism such as „artyfact".

2.4 Conceptual Scaffolding

The key feature sought from this package might be described by phrases such as „conceptual scaffolding" and „insight capture". The progressively refined artistic representation would serve as a form of scaffolding for an evolving pattern of insight. The artistic dimensions provide a form of order through many patterns of associations which may be of a most tentative and even playful quality. Understanding and creativity are supported and challenged by the relation between the representation and the data held by it.

As with the construction of any building, there is a basic need for „scaffolding" to hold the conceptual and organizational elements in place, especially during the early phases of „imaginative, interdisciplinary" interconnection. It may be argued that it is the lack of this scaffolding feature which prevents many potentially useful initiatives from „getting off the ground" — and staying up. And the more complex the psycho-social structure, and the more communication space it spans, the greater the need for more complex scaffolding.

A typical function of scaffolding in a conference is to provide a framework within which complementary perspectives can be articulated, especially when there is a major tension between them. For example, when Concept A is formulated, the scaffolding holds a space for Concept B to counter-balance it. Such scaffolding is even more essential when more than two concepts have to be held in balance. As with buildings, the scaffolding provides a protection against disruptive forces in the conference process. A typical disruptive force in a contemporary conference might focus narrowly on „industry is exploitative", when the larger issue is to provide a sustainable framework in which to balance the exploitative character-

istics of industry against the socio-economic benefits that it provides in the light of environmental constraints. The more complex the balance, the more vulnerable is the conference to disruptive forces.

The challenge is how to allow different category structures, and the groups advocating them, to mesh before their incompatibilities tear each other apart. This is a major issue when dealing with the strong, creative, and often idiosyncratic, personalities (and groups) whose collaboration is ideally required. It is seen in its most dramatic form in the Middle East peace process and in negotiations among the warring parties in Bosnia. The apparently disproportionate importance attached to „table layout" in any negotiation procedure is a physical indication of the nature of the conceptual challenge.

Failure to respond to this issue leads to project outputs whose only real integrative feature is the physical binding of a document containing unrelateable „integrative" contributions — however skilfully worded the introduction may be (In German: Buchbindersynthese!).

The scaffolding required not only has implications for elaboration of new structures. It also supports the learning processes through which others subsequently come to grasp the scope of such structures as viable alternatives to the simpler conventional patterns that have proven so inadequate to the challenges of the times.

Providing means for higher and subtler degrees of order to be carried by aesthetically organized displays, allows otherwise incommensurable positions in conferences to be related in ways which the present hierarchical and legalistical approaches to order render impossible. This is also true for any emergent agreements and communication protocols. Ironically this recalls some of the underlying functions of heraldic devices and seals that still carry significance in secret societies.

Whether for a coalition of forces or for an individual, the computer-held aesthetic display could become a fundamental asset as intellectual property. It is potentially of greater value than patents or copyright because it is effectively the generative aesthetic (or template) that holds the pattern of insights through which products of lower order are created.

Where different coalitions represent their respective ordering through contrasting aesthetic displays, many opportunities then attach to the significance of the transformational pathways between them (eg through morphing). This is of special relevance to any negotiation process.

2.5 Users

A package of this kind would be most attractive to those who have a broad range of interrelated interests. Typically it would respond to the needs of those who are ill-served by normal filing systems and databases — and find themselves constantly striving for some more significant pattern to order the complexity with which they are dealing. It would offer few advantages to those whose tasks are already well-defined by sets of files and conventional relational databases.

From an "arts" perspective the package would be most appreciated by those experimenting with new forms with which they seek to challenge conventional approaches to organization. It would provide an arena or bridge that would explicitly establish the relevance of the arts to the organization and comprehension of knowledge. But clearly it would be of very limited interest to those who are well-satisfied by more conventional software packages for artists. However it would incidentally allow those more concerned with providing commentary on details of specific works of art (eg symbolism) to attach text comments to any portions of a picture for later user interrogation.

2.6 Diversity of User Preferences

It should not be expected that users would in general favour one art form over another. For the package to be of value it would have to respond to the needs of users with quite different artistic tastes — including individuals who might alternate between different forms. Five extremes might be considered as examples:

(a) **Freeform:** Here the user would employ an idiosyncratically composed combination of shapes and colours (typical of any novice user of drawing packages). Relatively little would be invested in a particular figure, and frequent changes and adjustments would be expected in order to contain the range of data elements. As with maps of a fantasy land, features would be added or eliminated as required. Emphasis is placed on the familiarity the user acquires from having made it himself.

(b) **Classic designs:** Here the user would typically make use of a well-known, or favourite, painting as a template onto which to hang the data elements. Existing software tools (including "morphing") could be applied to enable the user to transform the image in different ways, but with the expectation that the relationships between the attached data elements would be maintained through the transformation.

(c) **Geometric symmetry:** Here the user would select from a library of geometric forms in two (polygons), three (polyhedra), or more dimensions. A form of adequate complexity would be offered and/or chosen as a function of the number of data elements to be held in relationship. Typically these would be associated with differently coloured points, lines, areas, possibly with particular attention to symmetry features (great circles, poles, etc). Advantage might be taken of the inter-transformability of symmetric polyhedra to explore zooming between different levels of complexity, with the data clustered more coarsely or more finely according to level of complexity (on the associated polyhedron).

(d) **Rotatable spherical surface**: For example, data might be distributed over the surface of a sphere articulated into (coloured) zones by the projection of a symmetric polyhedron onto it. The concept is very simple. The globe is cut up into segments by lines (possibly based on regularly polyhedral projections onto the sphere). The user then simply links lines, intersections or areas to directories or files, possibly zooming into parts of the surface to get more structural detail onto which to hang such links. Clicking onto any part of the surface then brings up file name and/or content. The advantage of this approach is that the user is responsible for the "geography" of the surface and can redesign it according to need or fantasy -- even using freehand islands and continents. The globe then holds the full range of the user's concerns. The user is free to introduce as many integrative and mnemonic dimensions as seem appropriate. This seems very do-able and way ahead of the way users are all obliged to structure our many areas of interest in computer files. Hierarchical sets of directories and sub-directories become severely counter-productive after a certain point. The user can rotate the sphere, zooming between alternate polyhedral projections, to focus in on the location of details. The use of such a device can perhaps be understood as "pigeon-holes" distributed in a non-linear but organized fashion over the surface of sphere. Each feature offers the ability to store data, but the modifiable non-linear geometry of the whole offers new ways to contextualize and understand the relationship between such data elements. Known systemic feedback loops might for example be associated with pathways around the surface.

(e) **Music:** The above cases all rely on essentially static forms. It is probable that some forms of complexity can only be effectively understood through a dynamic relationship between artistic forms subject to cyclic transformation over time. In this sense music introduces a fourth, and possibly fifth, dimension — whilst maintaining the comprehensibility of the whole.

2.7 Related Frames of Reference

The envisaged package may be seen as combining initiatives already explored and justified in other contexts:

(a) **Computer-aided design** (CAD): There is much experience with CAD packages which have many features of interest to this new initiative. However CAD packages treat artistic features as a consequence of design rather than as essential to the comprehension of the whole. Although skilled at manipulating complex forms and linking them to databases (on materials, suppliers, etc), complexity is essentially handled by machine rather than calling for new approaches to comprehension.

(b) **Spatial metaphors in computer environments**: This is a central concern to some features of software development and interface design as is illustrated by a recent ACM-ECHT workshop on spatial metaphors for information systems (Edinburgh, 1994).

(c) **Multi-media**: It is unnecessary to make detailed comments on the way in which these techniques are now developing rapidly, or on the arguments made for them. It is however necessary to point out that the approach advocated here emphasizes "embedding" one form of representation within another rather than relying on the association or juxtaposition of text with relevant illustrations (or sound) as in multi-media. Indeed the "illustration" selected by a user in this project may have absolutely no subtantive relationship to the content that it holds. Although its underlying pattern may be fundamental, as a metaphor, to any higher conceptual integration of the elements so related.

(d) **"Memory palaces"**: There is a long tradition of mnemonic aids (Luria, Spence, Yates). The mnemonic challenge has been obscured in recent decades because of increasing reliance on paper and computer environments. The challenge of holding configurations of information in memory, as a platform for higher orders of creativity, nevertheless remains where the linear context needs to be transcended. Embedding information onto memorable surfaces is an old skill which has been most recently studied in relation to those with unusual memory and calculating skills (notably idiot savants).

(e) **Symmetry**: Major cross-disciplinary studies have shown symmetry to be both ubiquitous and fundamental to organization in many areas. Work on this topic has not yet been related through computers to that of the organization of knowledge.

(f) **Computer games**: Considerable resources are currently invested in sophisticated computer games — far more than in any innovative use of computers for knowledge organization. Many of these games endeavour to offer the exploration of complex, multi-plane, realities that require the solution of challenging conceptual and symbolic puzzles. The newer ones increasingly place considerable emphasis on artistic quality (eg Myst). A common feature is the ability of the user to "interrogate" parts of any image (symbols, drawers, etc) for clues enabling the user to then continue his exploration. The interrogation may result in the display of text or symbols. The architecture may be decorated so as to offer clues as to where such interrogation may be fruitfully made.

(g) **Virtual reality environments:** Although of immediate relevance to standalone-PC and Internet environ-

ments, it is clear that a package of this kind is equally relevant to virtual reality environments. Indeed it is the special combination of artistic and database information that could make such a package of unique importance in opening up new virtual reality applications — for a technology that is more likely to be constrained by lack of applications than other constraints.

The similarity to virtual reality applications under development may be seen from a recent UK innovation which converts engineering drawings of oil rigs into a walk-through virtual reality environment. At any point in the walk-through, portions of the architectural display may be interrogated to bring up technical information.

But again the emphasis in the required package is on the ability to "walk through" conceptual environments whose complexity is such that it can only be approximated by creative visualization using the full riches of the arts. This is way beyond the scope of mechanistic configurations of piping — and yet as a piece of "art" such a configuration could indeed serve to "carry" much knowledge that might be quite unrelated to the pipework.

2.8 Range of Applications

The major emphasis in each of the following cases is to enable the user to articulate a complex pattern whilst maintaining a sense of coherence and ensuring a configuration of functional checks and balances.

(a) Functional units in organizations: organization chart; complementarity and balance of functions; lines of communication.

(b) Principles in a declaration: articles; complementarity and balance of principles.

(c) Action plan or policy: policy elements; highlighting policy integration.

(d) Classification system (books, information, etc): filing codes; tracking disparate interests.

(e) Mind mapping: clarifying systems; creativity; philosophical organization; integrating incoherent patterns.

(f) Exploring structural transformation pathways: introduction of new elements; restructuring (simplification / complexification).

3. Structural Outliner

3.1 The package as described might usefully be associated with another feature. "Text outliner" is a term used in word-processing packages to describe the ability to organize complex documents into nested hierarchies of chapters, sections, paragraphs and sub-elements. These hierarchies may be optionally "collapsed" to allow the user to focus on those levels of interest and to navigate around a complex document. Text may be added at any level, but kept from view until requested. An index to the whole may be prepared from the outline down to whatever level of detail is required.

The proposed package in many ways functions as a structural equivalent to the text outliner. Hence the expression "structural outliner". Users are free to zoom between levels of structural complexity (as in CAD applications) — each with text or other information associated with their structural features.

The package envisaged suggests the need for a **computer-based structural "outliner"** to facilitate a non-linear approach to the creative production of such "conceptual keystones". The need for a more integrative approach may be seen in the occasional efforts to group conceptual elements, basic to a strategy, into a table, a pie-chart, a diagram, or even into a form of mandala. Although currently simplistic, the structure provides **an integrative perspective that links a variety of disparate, bnt complementary, elements** that together ensure the viability of the larger pattern.

The required package therefore focuses initially on the design of computer software (possibly adapting an existing package) for which an appropriate database is then developed in collaboration with a number of bodies. The intention is then to use these tools to provide a "catalytic context" from which **new patterns of group and institutional action** could emerge. The principal output would not therefore be any form of "report" but rather a piece of software (possibly a prototype). It is the dissemination of this software, ultimately through commercial channels, which would enable many people to explore the tool as a "collaboration enhancing" device. In this sense the real objective of the package is new forms of collaboration. In subsequent use the database would be receptive to user-enhancement, notably to patterns of concepts from non-western cultures.

It is envisaged that such a PC-based structural outliner would be used in a manner somewhat similar to the conventional text outliners and mind mapping aids. However the software would offer many ways of configuring the evolving set of elements within a variety of non-linear structural frameworks, whether in two or three dimensions. The geometric and symmetric properties of these would be used to suggest levels of coherence and integration absent from conventional presentations.

Its claim to originality would lie in its ability to open up (and mid-wife) new and alternative patterns of collaboration — especially across discipline and faction boundaries. In creating this device, the purpose of inter-institutional collaboration would be to enrich its scope (as represented by the database) and explore opportunities it opened up (specifically in relation to institutional arrangements for sustainable development).

In the light of a number of collaborative international exercises (and notably the design of a collaborative process culminating in the Inter-Sectoral Dialogue in Rio de Janeiro on the occasion of the Earth Summit), it is legitimate to consider whether there is not a strategically more appropriate approach to encourage imaginative, interdisciplinary work of relevance to the policy.

3.2 Scaffolding Possibilities

Many of the geometric operations basic to fruitful exploration of such a structural outliner are detailed in a classic study by Robert Williams: *The Geometrical Foundation of Natural Structure; a source book of design* (New York, Dover, 1979). Part 3 of that work details 10 principal methods through which polygons and polyhedra can be generated or have identity changes. These include: vertex motion, fold, reciprocation, truncation, rotation-translation, augmentation-deletion, fistulation, distortion, dissection, symmetry integration. It is such operations which are required to explore transformations between structures whose features are used to carry the conceptual (and even symbolic) significance basic to any new patterns of collaboration.

Structurally an agenda or a conference programme, even a multi-track program, is rather simple — even simplistic — especially when considered in relation to the complex ecology of problems and organizations which are supposedly to be interrelated effectively through it. Is it any wonder that conferences are relatively ineffective at coming to grips with complex issues? What is being attempted is in defiance of Ashby's Law of Requisite Variety.

The issue is therefore how to enable users to collectively design more complex forms of conceptual scaffolding to hold in place embryonic or unstable concepts until other concepts can be fitted into the pattern to lock them into place. Ideally, of course, it is the conferencing software which should provide such scaffolding. And, like the scaffolding for buildings, it should be adjustable to different structural configurations as the building grows.

Four forms of scaffolding are especially interesting: symmetrical structures; tensegrity structures; resonance hybrids; embedding data in images.

3.3 Dynamic Scaffolding and Structural Transformation

The need for conceptual scaffolding is clear given the kinds of complexity with which society has to work. The challenge of making the more complex structures comprehensible is also clear — those most appropriate to the challenge of sustainable development may be beyond the ability of any single human mind to grasp. But **any form of development implies structural transformation**. Whilst transforming simplistic structures like conference agendas and organization charts may pose little challenge, the transformation of the complex structures described earlier are quite another matter.

The process of conceptual or social transformation appears to call for a form of **dynamic scaffolding** which provides some form of continuity — from stage to stage — through the transformation process. What we are looking for is a form of scaffolding onto which the conference's insights can be mapped at Stage I. The relationships in this mapping would then be stretched or changed in the transformation to Stage II, which might be some very different kind of structure — suggesting new kinds of relationships between the concepts so bound (and between their proponents in the conference).

There are few examples of this kind of structure: image transformation or "morphing"; vector equilibrium.

3.4 "Structural outliner" Library

Of greater potential interest is the possibility of building up and maintaining a structural library of concepts organized into sets. Whether in cultural or spiritual traditions, or in the theories of the natural and social sciences, there are a multitude of clearly defined sets of concepts. These range from religion (eg 3-fold trinity, 8-fold way), psychology (eg 4-fold Jungian types), to chemistry (8-group periodic table), and the principles of many international programmes of action.

The user would be able to draw upon a library of such structural templates based on symmetric or aesthetically balanced designs whether: tables (matrices) in 2D and 3D; polygons; polyhedra; or tensegrities; traditional forms (mandalas, etc).

In each case there is merit for a user to be able to scan through a library on the basis of:
(a) the range of sets (of a given discipline or area) having a given specified number of elements
(b) the range of forms (symmetric or otherwise) through which sets of a given number can be suitably displayed

The user can then select the set and/or the form as a basis for the organization of his own data. Note that it could be fed into some more comprehensive display as a detail that is accessible by zooming.

An associated thesaurus would be designed to provide facilities beyond those usually provided by such a function in a word-processing environment:

(a) Complements: Its main function would be to facilitate selection of complementary sets of terms, depending on the size of the set with which the user was working. With respect to a single element set, the synonym function is all that is called for. As usual, synonyms and antonyms are required for what amounts to two element sets. But what is also required is the ability to process items in 3-part, 4-part sets.

(b) Broader/Narrower: The thesaurus would also be used to enable identification of terms corresponding to broader or narrower terms, especially the contextual terms appropriate to the set as a whole.

(c) Traditional sets: This feature would enable users to browse relevant traditional sets of differing numbers of elements corresponding to the size of the set being worked (tertiaries, quaternaries, etc).

(d) Academic sets: This feature would offer access to sets elaborated in contemporary academic studies.

(e) User modified: The user would of course need to be able to amend the thesaurus in the light of specialized interests and evaluation of the library versions. The user would build up a library of complementary sets reflecting his/her specialized concerns and sense of the balance between the elements.

3.5 Restructuring (by rules, by library, or by indicatious)

Many features could be developed in the light of existing packages to restructure displays, maintaining the relationships to data. They might include:

(a) Text reveal / hide: This feature would suppress or reveal the text associated with particular structural features.

(b) Structure hide / nest / pack / simplify: This feature (as in text outliners) would be used to conceal levels of detail. In the case of complex structures, this would be achieved by a transformative reduction to a simpler structure (eg from a complex polyhedron to a simpler polyhedron). This reduction would conceal the text associated with the suppressed detail.

(c) Structure reveal / unpack / complexify: This feature would unfold levels of structural detail. A simple structure could thus be unfolded (from a simple polyhedron to a complex polyhedron). This could follow a previously chosen transformation pathway or offer transformative options at each stage. In an edit mode, text could then be input directly (or called in from the thesaurus) into the different facets of the revealed structure.

(d) Other features: optimize existing; duals; propose alternatives; indicate complementaries; switch from 2D to 3D presentation; rotation; contextualize; potential complementaries; structural families / periodic tables; user additions / indications.

4. Implementation and Practicalities

It is clearly possible to design and produce such a package without reference to existing packages. This could prove to be expensive and inappropriate, especially for a demonstration package.

Given the number of features common to other existing applications, there could be considerable merit in adapting or "piggy-backing" on such initiatives.

There is also merit in reflecting on the possibility of specifically designing the package as an interface to other packages. In the simplest case it might be of immediate value as an interface through which to order a complex set of word-processing documents that would normally be held in a nested hierarchy of sub-directories.

References

(Indicative Bibliography)

(1) Abraham, Ralph et al: Dynamics: the geometry of behavior. Santa Cruz: Aerial Press 1981. (Visual Mathematics Library)

(2) Aida, S et al.: The Science and Praxis of Complexity (Contributions to the symposium held at Montpellier, 1984). Tokyo: United Nations University 1985.

(3) Axelrod, Robert (Ed): The Structure of Decision: the cognitive maps of political elites. Princeton: Princeton University Press 1976.

(4) Barlow, H, Blakemore, C., Weston-Smith, M.: Images and Understanding. Cambridge, Cambridge University Press 1990.

(5) Beare, H., Slaughter, R.: Education for the 21st Century. London: Routledge 1992.

(6) Benking, Heiner, Judge, Anthony: Design considerations for spatial metaphors; reflections on the evolution of viewpoint transportation systems. (Paper for ACM-ECHT Conference, Edinburgh, September 1994)

(7) Berger, René: Téléovision: le nouveau Golem. Lausanne, IDERIVE (Institut d'étude et de recherche en information visuelle) 1994.

(8) Bertin, Jacques: Semiologie Graphique: les diagrammes, les reseaux, les cartes. The Hague: Mouton 1973.

(9) Boulding, Elise: Image and action in peace building. *Journal of Social Issues* 44(1988)2, p. 7-37

(10) Caglioti, Giuseppe: Ambiguity in art and science. *World Futures* 40(1994)3-4, p. 63-74

(11) Card, S K., Robertson, G., Mackinlay, J D: The Information Visualizer; an information workspace. Palo Alto: Xerox Palo Alto Research Center, (1991?)

(12) Callon, Michel, Law, J., Rip, Arie: Mapping the Dynamics of Science and Technology; sociology of science in the real world. London: Macmillan 1986.

(13) Dahlberg, Ingetraut: Guidelines for the establishment of compatibility between information languages. *International Classification*, 8(1981)2, p. 86-91

(14) Ehrenzweig, Anton: The Hidden Order of Art: a study in the psychology of artistic imagination. London: Paladin 1970.

(15) Emmer, Michele: Artistic and mathematical creativity. *World Futures* 40(1994)1-3, p. 49-61.

(16) Emmer, Michele (Ed): Visual Mathematics. *Leonardo* 24(1992)3-4 (special issue)

(17) Engelbart, Douglas: Augmenting Human Intellect; a conceptual framework. Menlo Park: Stanford Research Institute 1962. (AFOSR-3223)

(18) Fairchild, K M, et al.: SemNet: three-dimensional graphic representations of large knowledge bases. In: R Guindon (Ed): Cognitive Science and its Applications for Human-Computer Interaction. New Jersey: Erlbaum 1988.

(19) Fuller, R Buckminster: Synergetics; explorations in the geometry of thinking. 2 vols. New York: Collier 1975/1982

(20) Garfield, Eugene: Discipline-oriented citation indexes and data bases: bridging the interdisciplinary gap via multidisciplinary input. *Current Contents* (1981)3, p 5-8.

(21) Gentner, Donald, Stevens, A L (Eds): Mental Models. Hillsdale NJ: Lawrence Erlbaum 1982.

(22) Herdeg, Walter: Graphis Diagrams; the graphic visualization of abstract data. Zurich: Graphis Press 1974.

(23) Horn, Robert E.: Mapping Hypertext: the analysis, organization, and display of knowledge for the next generation of on-line text and graphics. Waltham MA: Information Mapping 1989.

(24) Judge, Anthony J N: (1994) Spherical configuration of categories to reflect systemic patterns of environmental checks and balances. In: Stancikova, P., Dahlberg, I. (Eds): Environmental Knowledge Organization and Information Management (1st European Conference of the International Society for Knowledge Or-

ganization, Bratislava, 1994). Frankfurt/Main: INDEKS 1994. p 1-21
(25) Judge, A.J.N.: (1993) Poetry-making and Policy-making: arranging a marriage between Beauty and the Beast. Brussels: Union of International Associations 1993.
(26) Judge, A.J.N.: (1992) Configuring Globally and Contending Locally; shaping the global network of local bargains by decoding and mapping Earth Summit inter-sectoral issues. Geneva: International Faciliating Committee for the Independent Sector in the UNCED Process.
(27) Judge, A. J.N. (1992): Visualizing Relationship Networks: international, interdisciplinary, inter-sectoral (collection of pre-1991 papers). Brussels: Union of International Associations 1992. 60p.
(28) Judge, A.J.N. (1991): Guiding Metaphors and Configuring Choices. Brussels: Union of International Associations (Paper for the UN Department of Technical Cooperation for Development)
(29) Judge, a.J.N. (1991): Metaphors as Transdisciplinary Vehicles of the Future. (Paper for the UNESCO Conference on Science and Tradition: Transdisciplinary perspectives on the way to the 21st century, Paris)
(30) Judge, A.J.N. (1990): Through Metaphor to a Sustainable Ecology of Development Policies. In: Trzyna, T.C., Gotelli, I (Eds): The Power of Convening; collaborative policy forums for sustainable development. Sacramento CA: California Institute of Public Affairs 1990. p. 64-81.
(31) Judge, A.J.N. (1990): Transformative Conferencing; the re-enchantment of networking through conceptware. (Paper for the 5th Conference of the Electronic Networking Association, San Francisco) Brussels, Union of International Associations
(32) Judge, A.J.N. (1986): Comprehension of Appropriateness : Project on Economic Aspects of Human Development (EAHD) of the Regional and Global Studies Division of the United Nations University. Paper for Rome workshop, September 1986. Brussels, UIA.
(33) Judge, A.J.N. (1984): Forms of Presentation and the Future of Comprehension. (Collection of papers relevant to the GPID project of the United Nations University) Brussels: Union of International Associations.
(34) Judge, A..J.N. (1984): Patterns of Conceptual Integration (Collection of papers relevant to the GPID project of the United Nations University). Brussels, Union of International Associations
(35) Judge, A.J.N. (1979): Representation, Comprehension and Communication of Sets; the role of number. *International Classification*, 5 (1978)3, p 126-133; 6(19791, p 15-25; 6(1979)2, p 92-103
(36) Judge, A.J.N. (1979): Implementing Principles by Balancing Configurations of Functions: a tensegrity organization approach. *Transnational Associations*, 31(1979)12, p 587-591.
(37) Judge, A.J.N. (1977): Knowledge-representation in a computer-supported environment. *International Classification*, 4(1977)2, p.76-81.
(38) Klein, Julie Thompson: Interdisciplinarity; history, theory and practice. Detroit: Wayne State University 1990. bibl. (pp 231-325)
(39) Lamson, Robert W.: Mapping Policy Dialogues: a role for computer graphics. In: National Computer Graphics Association. Proceedings of the Third Annual Conference. Fairfax VA: NCGA 1982. Vol. 1, pp 459-465
(40) Laszlo, Ervin: The alliance of science and art for human survival. *World Futures* 40(1994)3-4, p 105-110
(41) Luria, A R.: The Mind of a Mnemonist. Cambridge: Harvard Univerity Press 1987.
(42) Mackinlay, J D.: Automating the Design of Graphical Presentations of Relational Information. ACM Transactions on Graphics, 5(1986)2, p 110-141
(43) Mackinlay, J D., Robertson, G G., Card, S K.: The Perspective Wall: detail and context smoothly integrated. ACM CHI '91 Conference on Human Factors in Computing Systems. New York, ACM, 1991.
(44) Masini, Eleonora Barbieri (Ed): Art and Science: studies from the World Academy of Art and Science. *World Futures*, 40(1994)1-3 (special issue)
(45) Michon, John A.: How to connect a library with a mind. In: C Reedijk, C K Henry, W R H Koops (Eds): Large Libraries and New Technological Developments. München: Saur 1984. p 137-152
(46) Miller, Arthur I.: Imagery in Scientific Futures in the 20th Century. *Futures*, 23(1991)5, p 499-515
(52) Spence, Jonathan D.: Memory Palace of Matteo Ricci. London: Penguin 1985 Thought: creating 20th century physics. Cambridge: MIT Press 1986.
(47) Pickover, Clifford A.: Computers and the Imagination. New York: St Martin's Press 1991.
(48) Richardson, Jacques (Ed): Creativity and Innovation in the Arts and Sciences. *Impact of Science on Society* (UNESCO) 34(1984)2-3
(49) Rohrbaugh, J.: Cognitive maps: describing the policy ecology of a community. *Great Plains-Rocky Mountain Geographical Journal* 6(1977)1, p 64-73
(50) Schattscheider, D.: Visions of Symmetry. New York: Freeman 1990.
(51) Slaughter, Richard A.: Changing Images of.
(53) Union of International Associations (1992): Yearbook of International Organizations. München: Saur. 3 vols. 29th ed.
(54) Union of International Associations (1994): Encyclopedia of World Problems and Human Potential. München: Saur. 2 vols. 4th ed. (notably Section TZ)
(55) Widener, W Robert: Computer Graphics in Decision Making. New York: Intelligence Interlink Corporation 1980.
(56) Williams, Robert: The Geometrical Foundation of Natural Structure: a source book of design. New York: Dover 1979.
(57) Yates, Frances: The Art of Memory. London: Penguin 1969.
(58) Young, Arthur: The Geometry of Meaning. Boston: Delacourt Press / Seymour Lawrence 1978. (Republished by Robert Briggs Associates, Portland OR)

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