Symmetry: Culture and Science

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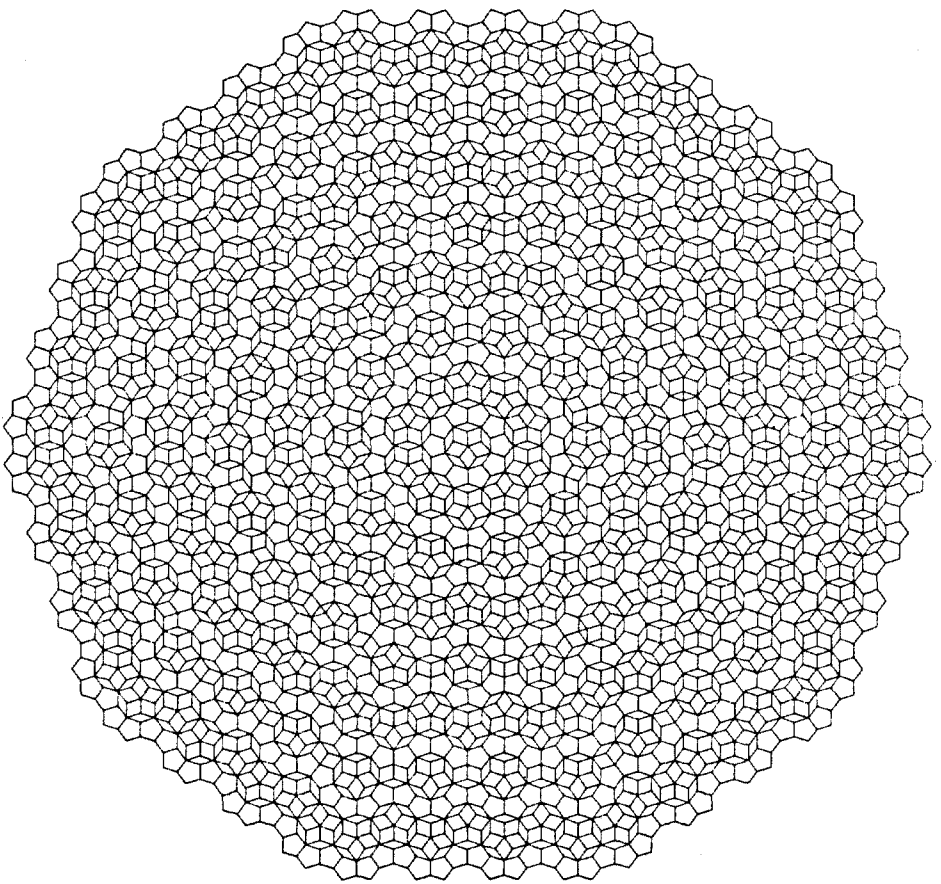

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BACKGROUND FOR AN ISIS-SYMMETRY WORKSHOP

KNOWLEDGE REPRESENTATION BY METASTRUCTURES

GENERAL BACKGROUND

These notes are intended as a brief background for and invitation to a brainstorming workshop to be held Friday afternoon. The background will be fleshed out somewhat in a session Thursday afternoon with the purpose of getting people thinking about the issues for Friday.

The idea is the use of periodic systems (with spatial analogies) to represent knowledge in the form of concepts and such. The two benefits that are expected are the ability to intuitively perceive extremely complex or subtle relationships, and a greatly enhanced ability for computers to manage such 'modelled' information. Symmetry plays a part in defining both the nature of the space (the way concepts can be related) and operations on the space (the way individual and grouped concepts can be transformed).

There is a great deal that can be said about the technical issues that can be raised by various disciplines which are involved. We hope to avoid such technical issues this week; instead, in the spirit of the interdisciplinary congress, we'd like to have a brainstorming session that takes advantage of the breadth of expertise that is here. We hope to avoid excluding anyone not familiar with discipline-specific formalisms. Everyone is invited.

The idea, in its present form, originated in some brainstorming between myself (Ted Goranson) and Haresh Lalvani some years ago, synthesizing prior work of each of us. It appeared as the novel basis of a proposal, presented in Hiroshima, for developing a 'federating' taxonomy for ISIS-SYMMETRY which was reported in the Journal. This project, which has yet to begin, is outlined below.

Because the approach promises radical benefits for knowledge representation, a US government-sponsored research program has gathered a few researchers to be here to participate. We hope that this project, which also is outlined below, can be the incubator for the first step in what we think could be a exciting future for symmetry in knowledge representation.

So the purpose of the session will be to explore the fundamental ideas and diverse perspectives of symmetry in knowledge representation. Although there are a couple potential applications described here (the ISIS-SYMMETRY taxonomy and the business metrics), we'd rather not spend time on the details of either project. That's for later attention.

We'd ask your cooperation in helping make this difficult type of meeting work well. If you want extended explanation of the aspirations of the projects, seek one of us out individually. In the meetings, please do not monopolize the discussion, and help us prevent others from doing so. Remember to keep jargon and discipline-specific terms to a minimum. Finally, remember that many of us are not native English speakers.

Please come.

THE TAXONOMY PROJECT

An attractive feature of the ISIS-SYMMETRY community is its extreme diversity. Many of us not only enjoy hearing about work in other disciplines, we also hope to gain deeper professional insights. But there is a problem with interdisciplinary efforts, because there are many world views. By picking one as the basis for common discussion, you lose much of the power of different views.

Part of the problem is in different notations and jargon, but there are deeper differences as well. We won't discuss these here. The bottom line is that the ISIS-SYMMETRY congresses, journal, and especially the bibliographies could benefit from a taxonomy which incorporated and preserved the diversity of the taxonomies of contributing disciplines. So that, for example, a chemist could 'search' in terms that are familiar to her across the same information against which a linguist might also search, in terms familiar to him.

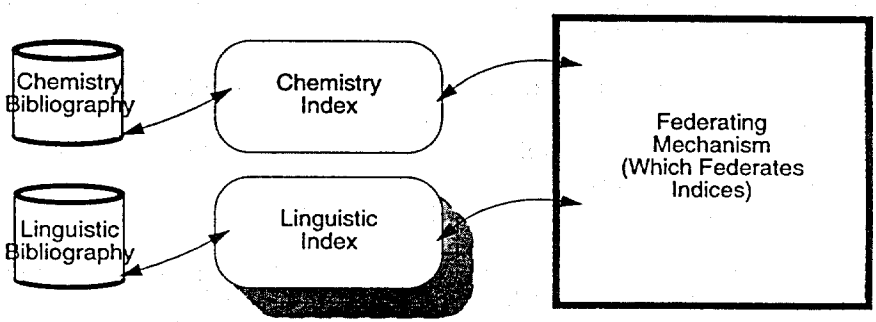

Figure 1

Figure 1 shows how this might work, The chemist uses an indexing scheme specific to chemistry, which also has references to many chemistry-related databases. But through some sort of a 'federating mechanism,' she can see linguistic information

which appears to be indexed according to the rules of the chemical index. The linguistic references are in their own native databases, having been indexed according to a presumably quite different linguistic world view.

Note that each discipline maintains its own data and index without change. Nothing is copied into a central database, nor indexed according to a comprehensive scheme. Such a federating mechanism has been a holy Grail of information scientists for some time. But it appears that symmetry principles, when applied to concept indexing, may provide a way to eliminate the most vexing barriers to success.

The ISIS-Symmetry taxonomy was proposed as a simple first case, of limited scope. It has the benefit that users are presumed to understand the principles of symmetry so that the first generation tools need not hide so much of the underlying, symmetry-based mechanics. And it seems, well, symmetrical to index symmetry ideas using symmetry ideas.

THE METRICS PROJECT

There is a similar problem in industry and commerce. Large, complex products require collaboration of many different kinds across different companies and disciplines. Supporting, coordinating and fixing this collaboration are turning out to comprise the lion's share of many products, and that share is growing. The biggest villain is how fast all sorts of things change. So a group of researchers has turned to ways of looking at how someone can understand the impact of all the diverse pieces in an organization and see a big picture.

Figure 1 is still good for this problem, because we know that inventing and maintaining central databases and comprehensive indices don't work for a variety of reasons. So we have to federate among information held by each group or company. What's different is that instead of just indexing information (qualitative models), we are interested in metrics information (quantitative models). And one of the things that is of interest is the active content (behavior) of what we are modeling as opposed to the passive content (the knowledge), required by the taxonomy application.

We think that the federating mechanism could be the same in both cases, but there is much interest from industry for the second case, the metrics problem. Therefore, the US Advanced Research Projects Agency is sponsoring a project in "Metrics for the Agile Virtual Enterprise," which is including in its scope the study of the promise of symmetry-based federation. At least a half-dozen people are attending the congress who are involved in this project in some way.

This million-dollar effort is a key part of a larger government initiative of two orders of magnitude larger funding. The exploratory session of Friday will help indicate promising areas for future attention, we hope.

THE REPRESENTATION IDEAS

There are three ideas which could, as they are fleshed out, work together to make this possible. The first should just be taken as background, as the latter two will form the basis for the workshop.

(1) Capturing Ideas in a Representation Space

Knowledge representation workers have a few ways of breaking concepts into parts and linking those parts in a meaningful way. One of these is a semantic network, which can be visualized as a collection of nodes connected by relationships. These networks can get quite complex and involved; often, they become complex more quickly than the information that they are representing. But for our federation mechanism, we do not want to represent the ideas themselves, since they are presumed to already be represented somewhere else. Instead, we want to represent some structural information about what the information is about, how it is represented, and where it is.

This is a sort of 'meta-knowledge', or knowledge about knowledge. The technique of figuring out what is the metaknowledge of interest is called category-theoretic abstraction, somewhat of a black art. But the details don't concern us here, only that we are capturing knowledge about knowledge, for example we want knowledge about how chemists index bibliographies, and some information about some specific chemical bibliographies.

What is interesting however is that we want to put this knowledge in a network that can be expressed in terms of lines and nodes, that these lines and nodes form a fabric, a concept lattice, and that the lines can be treated to some extent like vectors. Needless to say, the lattices can be complex and multidimensional.

But as we say, this first step need not be understood well. We can assume that there are at least workable theories in existence. But there is a real problem in how complicated it is to reason with these kinds of structures. As we've said, this can work as a federating mechanism, but the 'overhead' costs too much. The complexity of the approach is too high. Two novel applications of symmetry can make this complexity manageable: the application of symmetry to order the lattice and its contents; and the employment of symmetry in how the contents of the lattice can be manipulated. These ideas are briefly expanded below.

(2) Making the Concept Lattice Regularly Periodic

Most representation networks have an ad hoc structure; their graphical representation. The more interesting ones have a formal local structure of each entry because the rules of entry have local structure. But virtually none of these networks have a global structure.

We think that if there were a global structure, essentially a periodic space-filling, concepts could be easily 'mapped' onto the substrate. It appears that all semantic networks have at least one type of regular substrate onto which it can be mapped. But the detailed topological science, sort of a syntactic topology, has yet to be worked out.

We'd like to brainstorm on ways to approach this 'science'.

3. Using a 'Symmetry Language' to Manipulate the Contents of the Symmetry Lattice

Once concepts are in the regular substrate, then the results of transform to those concepts made for, say, artificial intelligence reasoning, would also be mapped onto that substrate. It appears that all operations on the concepts can be mapped onto operations on nodes of the regular substrate. But the details of this symmetry-based concept grammar have yet to be fully explored.

We'd like to brainstorm on ways to approach this new language.

SOME NAMES

During the congress, you may want to talk to some people about some of these ideas or the metrics project. Here are the briefest of introductions of some who will be here, listed in alphabetical order:

Lee Bloomquist (Steelcase) is the guiding light for the theory of capturing implicit, social/cultural, and learning knowledge within the metrics project.

Ted Goranson (the writer of this overview, from Sirius-Beta) will be here through Friday night. He is the principle investigator of the metrics project and will chair the brainstorming session.

Haresh Lalvani (Pratt Institute) will attend the Friday session it is hoped. He is a morphologist who has done pioneering work which is applicable to the symmetry metaphor for metamodeling.

Jamie Rogers and *Adrian Presley* (Automation and Robotics Research Institute at the University of Texas, Arlington) are industrial enterprise modeling gurus who are concerned with delivering practical technologies within the project.

Jeff Weeks (University of Minnesota Geometry Center), a mathematician, has created some 'idea software', which helps to focus the ideas for the metrics project. This software will be shown by Goranson from time to time (as well as being available to take home). It leverages some ideas in analyzing and visualizing complex physical phenomenon developed by Sandia National Labs that can form a basis for

practical use of the federating mechanism (presuming that we can find a formally robust way to capture concepts in a normal vector space).

Jim Yoder (Sandia National Labs) is the behind-the-scenes interdisciplinarian and extraordinary brainstormer who has been advising the project. Jim is responsible for seeing the link between Sandia's scientific visualization tools and the federating mechanism that is sketched in the 'idea' software.

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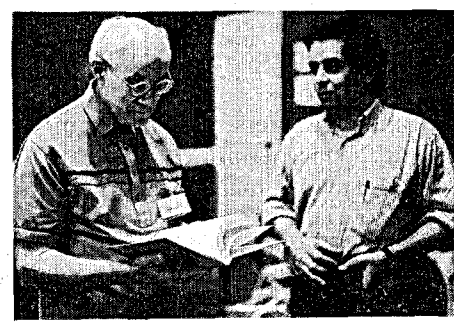
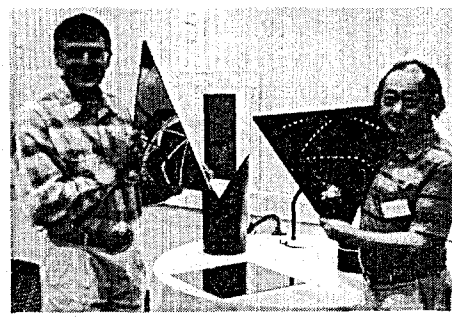
Haresh Lalvani and Robert A. Wiggs
(Photo: R. A. Wiggs)



Vladimir A. Koptsik and Emanuel D. M. Pimenta
(Photo: C. Schwabe)

Klara Kuchta and her light installation
Berenice No. 3 (Photo: R. A. Wiggs)



Quasicrystalists
Dan Shechtman and Tohru Ogawa
with the kaleidoscopes by Caspar Schwabe
(Photo: C. Schwabe)