COMMENTS ON A PAPER

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Motivation Section

The topic you are addressing is central and important, though we may see the importance from different angles. For me, the structure of the underlying space in VR is a central "metaphor", since it determines the available activities and the mental model. Unfortunately, folks are real used to thinking in Cartesian metric spaces, and so assume that that should be the structure of cyberspace. It's a battle to convey the idea that *reality is a constraint on cyberspace*.

Incidentally, I'm trying to promulgate the distinction that a VR is a cyberspace with visual semantics, while a cyberspace is a more general concept of an inclusive information environment. You address visual semantics: databases that transcribe into models of reality. The central difference is whether or not we are *making up* the semantic map. The code example is cyberspace, there are no naturally occurring file structures. The architecture example is VR, we can find buildings in ER (external reality).

So the central issue of your paper is how to construct semantic cyberspaces. And I agree completely that the only principled way (well the way we must try first) is models of mathematical structures. Sure, deep knowledge of an information domain may make a visual semantic model readily available, someone may be able to represent stocks as fields of wheat. But the real issue is not representation, it is composability and transformation. Do wheat stalks "add" like stocks? Do we know how to add stocks in the first place? Composability is the abstract semantics of a representational space.

Here is another central concept: the representational space, the empty context within which we express a concept. This is a neutral way of saying *all types of spaces* without mentioning the semantics of space.

Ah, the English language leaves us with few non-Cartesian descriptors. To avoid the wrong impression, word choice is critical. So a small suggestion: *place* (to me) triggers *metric*. So does *location*. We need to be able to refer to a domain in non-metric space without implying that it has an associated *distance*. Maybe *place* is the best choice, I don't know.

Semantic Dimensions Section

Have a look at Brian C. Smith's work on Correspondence Theory (PARC memos). This discussion takes two paths: traditional semantics and inclusive semantics.

Traditionally, semantics is a function which maps representation onto value. I think what you are saying is that *arrangement* and *dimension* have both representational significance and meaning. This is certainly true for VR (visual semantics), the trivial case. It remains to be demonstrated for other abstract domains. Another way of thinking about this is: the map from place to meaning is not one-to-one. If many visual representations exist, we need to empirically identify the best, for the particular participant and for the particular application.

This line of thought (the necessity of empirical validation) moves us off mathematics and onto psychology. It is also the same shift from traditional to inclusive semantics.

"(top paragraph) The elements of meaning ..." seems to beg the question. Semantics cannot be derived. If it is intrinsic in properties and interactions, then we have visual semantics. My comment is not strong. I want to believe that information flow in a dataflow network has visual semantics, but after building lots of these, it doesn't make me comfortable. The issue seems to be that Yes, mathematical structures and processes are visualizable (equations to graphs, for eg), but No, there is no intuitive semantics. Visual representations of abstract formal systems are still abstract, and may require as much learning as their symbolic counterparts.

"(third paragraph) ...meaningful because of the arrangement of their elements." I believe that mapping non-metric concepts (such as file systems) onto metric spaces degrades meaning rather than enhances it, cause we are adding irrelevant concept structure (metric distance). Logical placement can be mapped onto purely logical visual structure, but it certainly isn't X,Y,Z. In the next section, you get to this point.

Kinds of Dimensions Section

The fundamental contribution of the paper. There are different spaces and we need them all. I recommend you cite work in measurement theory, and I strongly suggest you at least identify the traditional names for the concepts.

Nominal
Ordinal
Interval
Rational
Real

Personally, I would supply the traditional mathematical definitions and then link the math into the explanations and applications you provide. The hard job is implementing a cyberspace which can mix and match types of spaces.

Re relative/absolute: I personally believe that there are no unary properties, everything is a relation, at least, between an object and an observer. So I interpret your distinction to be saying that there are two fundamental perspectives, observer and participant. For eg: size is relative to the scale of the observer. Since scale is navigatable, cyber-objects don't have size properties, they have size relations. Ted Nelson will also argue that author is a relative idea. In a sense, absolute properties are those that choose to ignore the participant. In an inclusive environment, in quantum mechanics, in the twentieth century, it is impossible to ignore participation.

Your central idea is great: we want to display relations as spatial relations. Formally, though, each different relation is a different dimension. So 3space permits display of 3 relations. Have a look at Lenat's CYC. He says that about 400 relations are necessary for a basic world. The central problem, then, is how to display very large dimensional spaces, or how to conveniently select 3 from the many for focus.

Semantic networks, which have typed arcs, have been shown not to work. Look at Kim Fairchild's work at MCC.

"(page 3 second last paragraph) "...location may have precise meaning...". What you are saying is that a real space has an origin. A relative dimension has a movable origin, or more accurately, each object has its own origin. This is the same model as Turtle Geometry, (Abelson and DiSessa).

Types Section

Types seem to be a mix of measurement categories and mathematical properties. I don't understand why the mix you have identified has organizational value. In addition to list and describe, it would be nice to see a discussion of why these and why they form a category.

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Linear = real
Ray = bounded real
Quantum = interval
Enumerated = nominal
Functional = functional
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Re ordering: You have made ordering a property, but not included the Ordinal Type. Eg: Messages in a buffer.

I'd also add the Rational Type, which is the metric analogy of the point you make about relative dimensions (comparative but not irrational).

And to complete the list, there are two other measurement types which are non-traditional. Beyond Real is Imaginary, which includes waveforms and paradoxes. Before Nominal is Indicative, which includes topologies.

The complete type structure of measurement theory covers form, category and metric, a nice toolkit for building spaces. You should check out Osgood's work on the Semantic Differential, and neo-Osgood models, including Tim Leary's mental modeling programs. They are building semantic spaces for cognitive descriptors. There is actually a very broad literature in Social Psychology on applying measurement theory and types to human judgment.

Semantic Spaces Section

Spaces are sets of dimensions. The technical problem we will face is how to build non-homogeneous spaces, spaces which mix types of dimension. I don't know how to do this which maintaining visual intuition. In fact, I'd guess that any non Real space will be confusing. An empirical question.

There are two issues: tuple-spaces (which I agree with your approach to) and visualization of tuple-spaces, i.e. meaningful locations in cyberspace. If location is used for tuple display, we loose our ability to put other properties on the space, such as distance. So it's not obvious that tuple display is the best solution to visualization. When you map it onto X,Y,Z, you seem to say that the map from tuple-space to Real-space is intuitive, that we can treat tuple space as a terrain. This is a good idea that needs to be tested, but not yet a solution.

Navigation Section

I like your conceptualization of movement, it rings cyber-true. You seem to be addressing objective/reductionalist models only though. In a boundary model, in contrast, movement of a boundary is a change in self-territory that is also a change in other-territory. The computational analog is shared memory systems.

I have difficulty following your suggestion that semantic space has meaning but traditional spaces do not. The dimensional type is where the semantics is established for any space. And in a more philosophical sense, meaning requires the presence of an observer, presence means the space is not empty. Yes, a space can be devoid of objects (or more properly, representations), but a meaningful space is never empty. Newton and Leibniz hashed this issue out.

That moving focus of attention is the "cyber-cursor" is brilliant, I'd make explicit the link to relative Kind. This idea really is the core of cyber-navigation.

Manipulation Section

Again, movement changing meaning is brilliant, another cornerstone of cyberspace.

I believe functions are within objects, and not a Type of space.

Reification is also central. We are implementing it as self-similarity. The edit object is organizationally identical to the edited object, so editing becomes an inhabitation action.

Phase Section

It's probably not a good idea to ever consider cyberspace as static, to be viewed. The participant is inside, so navigation is a dynamic change of the space. To suggest that viewing and the space are separate is reify the reductionalist perspective and negate the concept of cyberspace.

In essence, viewing, the ability to see, is interaction. The stars are one look away, the dimensional type is Enumerated over visible objects.

I guess I'm strongly disagreeing that we can imagine cyberspace as phase space. In my mind, its a contradiction, the rules of imagination are not analogous to those of physical space. I can imagine moving the physical book, but purely, imagining in cyberspace is creating, interacting. This is a rather fine philosophical disagreement. But recall the fundamental result from Mandelbrot: measurement is a relation between world, participant and standard.

Conclusion Section

I'd feel more comfortable saying that semantic space provide a reasonable model for testing visualization. This is only a presentation issue, but I get very uncomfortable with claims based on words rather than experience. It is possible to be sure of words when they have a formal mathematics, and I think that is what you are heading toward, but there is a way to go.

Well, I hope this is what you wanted. Of course, it's risky to do a technical dump on a completed paper. Please take my comments in the spirit of discussion.