Design and Engineering Data Semantics

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This research issue addresses the semantics of defining and exchanging high-level structures and behaviors across computer applications.

Problem

Today, an important goal is the integration of individual engineering tools into a workbench or suite, allowing integration across design, engineering and product life cycles. The ISO-STEP technology, developed in the 1980s, is almost universally used to develop data models to which translators are written. The name of this work is *product modeling*.

The current ISO-STEP approach, also used for most other forms of engineering data integration, relies on manual, group definition of a neutral data model representation that captures the important semantics of a related set of applications. This process is approached as a standards-making activity, heavy on public input, low on technology and science. The total time from beginning to end to develop a product model using ISO-STEP technology is usually about 5 years. Of course the technology on which the applications being developed often change within that timeframe; product models are a live (that is, evolving capability) requiring frequent revision and change, faster than a product model can be defined today.

A New Science of Engineering Semantics

Many of the structures embedded in these product models are amenable to a classification. That is, I want to define the *domain* of a representation (such as a solid model, or a finite element model, defined at the class level) based on the constrained Cartesian product of its individual data types. I wish to define the domain of all legal representations a particular representation allows. I use *subsumption* to refer to the relation between two representations, where the domain of one representation includes the domain of the other representation. For example, I can show that a triangular mesh

facetted representation subsumes all planar polyhedral solid models. From this we can define the concepts of *inclusion* and *equivalence*.

Development of a new paradigm for defining engineering semantics would allow significant movement toward a science of design, that goes far beyond product modeling:

1. new product modeling, modeling languages based on these theories could be used to define the data export and import capabilities of different engineering applications. This would allow the data structures to be ordered by subsumption. The mapping relations across srelations can be formally defined, providing the potential of automatic mappings between such related structures, allowing the possibility of automatic generation of translators.
2. by defining a set of precise semantic structures for aspects of engineering design, these become readily available for study, extension and automation. Software libraries of such structures could be used like those for geometric modeling, allowing faster development of engineering applications. Object modeling would become available for such areas as assemblies, embedded components, combined sets of behaviors, etc.
3. well-defined semantic structures is an open set, with new technologies adding to the set of possible semantic structures. However, such a formalism of models would allow continued classification of new ideas, and their analysis, reducing the reinvention of old ideas because their concepts were represented ambiguously.

Today, product modeling is a craft. It should be a science. What is needed to develop a science of engineering semantics!

Chuck Eastman is an architect and computer scientist, with appointments in both colleges at GA Tech (and earlier at Carnegie-Mellon University). He participated in the Oakland, California meeting leading to the development of the Design Theory program at NSF in 1987 and was on multiple NSF Review Panels for that program. . He was one of the original developers of solid modeling and made early contributions to parametric modeling. He has many papers in both computer science and CAD journals dealing with computer-aided design, solid modeling, engineering databases and product modeling.