LATTICE REPRESENTATIONS AND DESIGN DESCRIPTIONS

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Designers work with multiple design descriptions. In making design transformations, engineers use different design structures (which themselves are design descriptions) to support specific tasks. Design structures, such as Bills of Materials (BoMs), are used to tailor design descriptions, including shape models, for particular tasks. For example, an engineering BoM defines the as-designed product whereas a manufacturing BoM defines the as-built state and a service BoM includes its maintenance history. All of these BoMs relate to the same designed product. However in practice, because of restrictions arising from current computer aided design technologies and associated business systems, different BoMs are usually related to separate digital definitions of the same product. This creates data management problems that add cost, time and rework into product development processes. If resolved, substantial business benefits could be achieved.

The purpose of this poster is to explore the potential of lattice theory (Szász 1963) as an approach that could be used to embed design structures in product information. Embedding allows one instance of a mathematical construct to be superimposed on another. It has been documented since the 1930s and descriptions of concrete applications, though uncommon, do occur in, e.g., the shape computation literature (March 1996). However, methods to enable the robust implementation of embedding for use in real-world applications remains an open research issue. Early research exploring the potential of lattice theory as a means of embedding design structures into shape models, without the need to replicate the shape models themselves, is presented (da Silva 2001, p15; Spivak 1979, p65). In addition to the benefits of reducing duplication of data, this provides the potential to revolutionize the way designers use multiple descriptions that could lead to opportunities for using shape as a means of mediating across design definitions and structures. A practical engineering example is used to show how lattice representations may support design tasks. In addition to the business benefits, embedding can facilitate a radical shift in the way designers use multiple descriptions in their creative processes with shape models acting as mediators.

Early results indicate that it is feasible to use lattice theory to superimpose multiple BoMs (i.e. parts related to each other through part-whole relationships) into a given physical design description. This is because, for a given collection of parts, there is a complete lattice that contains every possible combination of parts, i.e., every possible BoM. In addition, given two objects, e.g., two BoMs, there is a unique biggest lattice (the supremum) that contains both and a unique smallest part (the infimum) that is part of both. As a result, new BoMs for a given product can be traced through a lattice generated from another BoM. However, further software prototyping is needed to explore usability issues related to the size of lattices generated for even relatively few parts, and implementation issues related to the potential of a newly defined BoM to corrupt the underlying shape model, e.g., by changing the part hierarchy and so permitted assembly mating relationships. For embedding different kinds of structure into each other, such as function structures into physical structures, further theoretical work is needed to identify ways in which non-physical structures are defined and how they are related to physical design descriptions.

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References

da Silva AC (2001) Lectures on Symplectic Geometry. Lectures Notes in Mathematics, volume **1764**. Berlin: Springer.

March L (1996) The smallest interesting world? Environment and Planning B: Planning and Design **23**(2):133-142.

Spivak M (1979) A Comprehensive Introduction to Differential Geometry, volume **1**. 2nd ed, Berkeley, CA: Publish or Perish, Inc.

Szász G (1963) Introduction to Lattice Theory. Budapest: The Publishing House of the Hungarian Academy of Sciences.