Automatic Learning of User Design Rationales from Examples

Yao-Yi Chiang, Abhishek Jain, Bhaskar Bandyopadhyay, Craig A. Knoblock
Spatial Sciences Institute
University of Southern California

The difficulties in CAD data interoperability arise from the need for using heterogeneous CAD systems and the lack of a proper notion for describing CAD designs [Raghothama and Shapiro, 2002]. Existing CAD systems each have their data formats, and the information recorded in these formats vary significantly. Some systems have the ability to record design histories for representing the design rationales, but others do not.

An emerging direction that enables a flexible approach for storing, querying, and exchanging design knowledge is to develop new methods for representing CAD designs (e.g., Raghothama and Shapiro, 2002). Along with this direction, some existing approaches employ the Semantic Web technologies to create semantically rich representations of CAD designs. These approaches start from a neutral format and create an ontological representation of the data (e.g., the OntoSTEP model [Krima et al., 2009]). These approaches focus on designing a representation that is a direct mapping from one of the neutral data formats (STEP or IGES). This type of CAD-to-ontology translation process requires the information in the CAD file to be explicitly defined in the current standards, which does not include information that is not defined in the standards (e.g., design rationales).

We will present a semi-automatic system that gives the user 1) the flexibility to define and use a rich semantic model that can go beyond the current standards and 2) the capability to efficiently "teach" the system to learn design intent and objectives. Given a user-defined semantic model (e.g., a set of relations between CAD sketches) and a few examples of the desired variations of a CAD design, our system learns the design rationales automatically and selects the semantic descriptions that best represent the design rationales. We recreated the ambiguous CAD designs described in Raghothama and Shapiro's previous work (Raghothama and Shapiro, 2002) and tested our system with these CAD designs using a set of user-defined relations between CAD sketches (e.g., dimensions). In the experiment, our system successfully learned the design rationales from a few examples of design variations and generated constraints between sketches in the CAD models to prevent possible ambiguities.

References:

Krima, S., Barbau, R., Fiorentini, X., Sudarsan, R., & Sriram, R. D. (2009). Ontostep: Owl-dl ontology for step. In Proceedings of 6th International Conference on Product Lifecycle Management.

Raghothama, S., & Shapiro, V. (2002). Topological Framework for Part Families. Journal of Computing and Information Science in Engineering, 2(4), 246–255. https://doi.org/10.1115/1.1558073