POPULATING AND INTERACTING WITH LARGE DESIGN KNOWLEDGE-BASES

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1. EXTENDED ABSTRACT

The central role of information technologies in the engineering enterprise has created an unprecedented opportunity to archive the output of the design process. Present Product Data Management systems are the forerunners of future Design Knowledge-Bases, which will be digital libraries that archiving CAD data, workflows, designer notebooks, collaborative exchanges and design intent and rationale. Interacting with large-scale design knowledge-bases requires we develop new approaches to interacting with and interrogating CAD databases which allow designers, or teams of collaborating designers, to work effectively amid an often overwhelming mass of information.

Our goal is to develop software tools to help designers navigate complex design knowledge-bases of engineering data. This paper presents our research toward developing intelligent systems that enable users to interact with large, CAD-centric design knowledge-bases. We have been building the National Design Repository (http://repos.mcs.drexel.edu), a collection of over 50,000 CAD models and assemblies. We propose an approach to use Conceptual Design as a interaction paradigm for the Repository: designers can sketch out, at a high level, structural and functional relationships to be used as a query to the knowledge-base. In the long term, we are working toward creating agents which can automatically (or semi-automatically) index CAD knowledge for archival in design Repositories and tools that support the information seeking behavior of designers.

This paper will briefly describe a system, Conceptual Understanding and Prototyping (CUP), that allows design engineers to develop a high-level structure-behavior-function (S-B-F) description of an assembly in a Java3D/VRML-
based virtual environment. Our goal is to enable users to navigate intricate product data management (PDM) and case-based design knowledge-bases, providing the ability to perform design at the conceptual level and have intelligent CAD tools that can access details from large repositories of previously archived designs.

This work furthers research efforts in supporting collaborative design, in particular drawing on work in Computer-Aided Design (CAD) and Computer Supported Collaborative Work (CSCW). We envision CUP to be a network interface to next-generation engineering PDM systems and CAD databases. We are currently deploying CUP as a query interface to the National Design Repository (http://repos.mcs.drexel.edu). This will enable CAD users to interrogate large legacy databases (models and assemblies) and identify artifacts with structural and functional similarities, aiding designers during case-based and variant design.

To accomplish this, we use an approach that draws on current Software Engineering practice for developing interactive software environments. Supporting Conceptual Design for mechanical assemblies means providing the ability to model these assemblies without having to define in detail every component or feature, while still being able to specify design intent and the interrelationships between each component and feature. Therefore we propose certain characteristics which any conceptual design tool should possess: a basis in CAD, in order to allow users to create the models in a manner familiar to most engineers; a Java 3D-based VRML environment, in order to give the user spatial placeholders in relating to the designs she or he creates; and platform portability, in order to support the wide range of machines and operating systems in use today by engineering professionals.

Other researchers have approached conceptual design as a freehand sketching problem. A novel aspect of CUP is that we have developed a three-dimensional modeling approach to conceptual design that enables teams of designers to embed semantic structure-behavior-function (S-B-F) information in their models. We believe that our approach offers several unique benefits. First, it is the structure-behavior-function knowledge, more than the geometry and topology, that encodes the designers’ intent. By capturing this intent, we can search design knowledge-bases for related information and create pro-active design tools that can guide the search of the design space. Second, this approach liberates the designer from the usual restrictions of exact measurements, or precise positioning and orientation. CUP will allow the designers to create a three-dimensional “freehand” sketch and the general structure of the artifact without performing detailed CAD.

CUP itself introduces several novel features. Embedding structure-behavior-function information in CUP’s model files will enable the addition of abstract design intent and purpose to the simple concrete objects and groups represented
in each design world. Import integration with major CAD suites’ model files will give CUP a wider applicability, allowing it to be used with pre-existing geometries as well as as a stepping stone to further, more detailed design phases. CUP will also be a query interface to the National Design Repository and used as a method of creating a logical query model for searching vast compilations of design data and metadata—searching CAD knowledge-bases for similar designs, process plans and S-B-F relationships.

CUP offers a unique combination of 3D conceptual sketching and layout, as well as a comprehensive set of functional and behavioral modeling actions. We believe that CUP is a component in an overall conceptual design environment, enabling users to create a knowledge-level description of the design without having to perform detailed CAD and solid modeling.

We are currently extending CUP in several significant ways. Most significantly, toward access to design repositories. Increasingly, engineers depend on Product Data Management (PDM) systems, large-scale engineering digital libraries, and knowledge-bases of CAD solid models to perform their job. This involves searching through vast amounts of corporate legacy data and navigating manufacturers’ catalogs to retrieve precisely the right components to assemble into a new product. Presently, however, design storage and retrieval systems are limited in their ability to capture design intent and to reason about CAD knowledge, often relying on the textual annotations of the designer, or the part’s filename, for storage and retrieval purposes. It is our eventual goal to integrate CUP with the National Design Repository (http://repos.mcs.drexel.edu) and provide facilities for users to add their own ontology information to the repository’s knowledge-base.

It is our hope that this research expands our understanding of how software tools can be developed to support computer-aided conceptual design (CACD) and that it lays a foundation for exploring new techniques to enhance our ability to query 3D solid model data based on form and function. Further, we believe that existing approaches to multimedia libraries can be augmented with geometric reasoning techniques that are tightly coupled with engineering knowledge and solid models, such as those developed in the future as part of this research.

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