An XML Implementation for Data Exchange of Heterogeneous Object Models

X.Y. Kou and S.T. Tan

Department of Mechanical Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong, China
Email: 1kouxy@hku.hk, 2sttan@hku.hk

Abstract
Heterogeneous objects refer to objects with spatially different material compositions or structures. Tremendous research efforts have been devoted to modelling heterogeneous objects and many heterogeneous object representations have been proposed. Regardless of the diversity of these CAD models, there are needs to transport and exchange the included geometry, topology as well as material distribution between CAD modellers, CAE tools and CAM facilities. In literature and practical applications there have been lots of STEP (STandard for the Exchange of Product model data) based tools and implementations for the exchange of the geometric/topological data. However, there has been only limited research on the data exchange of material distributions. This chapter focuses on an XML implementation for data exchange of heterogeneous CAD models. The proposed heterogeneous CAD model is described by Extensible Markup Language and detailed approaches to represent the voxel based, explicit function based and heterogeneous feature tree based models are described. The idea is to introduce self-descriptive, customised tags/vocabularies to fit the specific needs of material modelling. The structure of the heterogeneous CAD model is specified with XML schemas and related data validations can accordingly be checked to ensure the model correctness. A prototype CAD module is developed to construct XML-based heterogeneous material model, and the XML model is then exported to SolidWorks to test the validity of the proposed approach. Results show the proposed XML based model can facilitate the data exchanges of heterogeneous material distributions.

19.1 Introduction

Heterogeneous object modelling [19.1,19.2] is a relatively new research direction in the CAD community. Different from traditional homogeneous solid modelling, in which the material distribution of an object is assumed uniform in geometric domain, heterogeneous object modelling incorporates and utilises spatially varying material distributions as additional design freedoms.

The advantages of using heterogeneous material distributions in CAD design have been getting increased recognition in recent years. One primary reason is that
the users’ design requirements are usually manifold and can seldom be fulfilled with a single homogeneous material. For instance, in artificial finger joint replacement, the implanted finger joint should be both strong and biocompatible. Homogeneous metals (stainless steel, for instance) can provide sufficient strengths; however, the bonding of the artificial joint with the human bones are not ideal. Using biocompatible materials (e.g. titanium, etc.) can enhance the bonding of the artificial joints with the fingers, but the wear resistance of the joint is relatively poor, which may deteriorate the finger movement accuracy and long life use. To alleviate the problems, a heterogeneous finger joint can be developed, as shown in Figure 19.1. In this heterogeneous finger joint, two primary materials are used: material A (cylindrical in shape) has good biocompatibility and can gradually grow into bones (thus offering enhanced integrity with the fingers); and material B (kidney shape) has good strength and wear resistance properties and can contribute to the long life use of the joint. The gradient material region in Figure 19.1 is designed to eliminate possible cracks due to abrupt material changes in the material interfaces.

Figure 19.1. An example heterogeneous object

The example shown in Figure 19.1 demonstrates a typical heterogeneous object application, in which the material heterogeneities contribute significantly to the object’s functionality and performance. In recent years, similar applications have also been found in mechanical, electrical, thermal and other interdisciplinary areas [19.1].

The wide applications of heterogeneous objects have aroused very active research in modelling, analysis and fabrication of heterogeneous objects in the past few decades. In the literature, many heterogeneous object models have been proposed [19.1,19.2]. These heterogeneous object models differ in their representational capacities, design intuitiveness, model exactness, compactness, etc. and many of them target to one or two specific application fields, for instance, visualisation or finite element analysis of heterogeneous objects.