The Digital Space Shuttle, 3D Graphics, and Knowledge Management

Julian E Gómez*
Research Institute for Advanced Computer Science
NASA Ames Research Center

Paul J. Keller**
NASA Ames Research Center

Abstract

The Digital Shuttle is a knowledge management project that seeks to define symbiotic relationships between 3D graphics and formal knowledge representations (ontologies). 3D graphics provides geometric and visual content, in 2D and 3D CAD forms, and the capability to display systems knowledge. Because the data is so heterogeneous, and the interrelated data structures are complex, 3D graphics combined with ontologies provides mechanisms for navigating the data and visualizing relationships.

Introduction

Digital Shuttle will allow creation of a virtual Space Shuttle Orbiter model, based on intelligent Engineering Objects (EOs) and immersive display methodologies. The goal is to create semi-standalone encapsulated forms of knowledge of the Orbiter, with embedded graphical representations, providing accessibility through maintenance of relationship information external to a given application. This improves not just the Product Lifecycle Management of the system but also overall safety, as relationship information is made explicit as it is used within the lifecycle.

Since the Space Transportation System (STS) was designed before modern 3D CAD, largely there is no 3D data. Generating this information is an essential step for visualization of the Orbiter and its systems, and allows sustaining engineering and support activities to take better advantage of current tools.

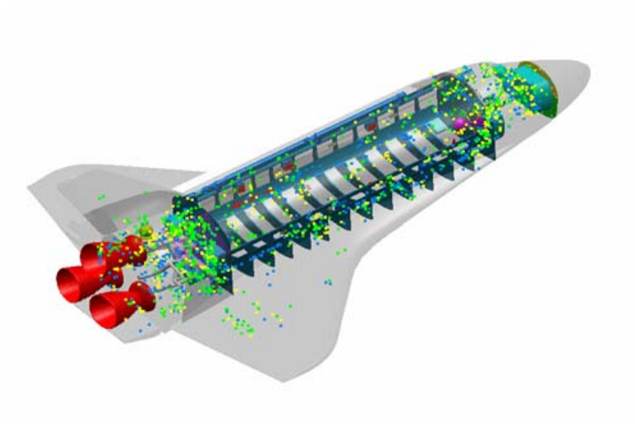
The EOs represent knowledge collections of entities within the Orbiter, and are defined in an ontological framework. The knowledge collection includes legacy data and documents such as drawings, mishap reports, materials requirements, stress profiles, etc., as well as data yet to be generated, such as the CAD models. Ontologies also include systems knowledge, e.g. a brake on the landing gear is connected to both the hydraulic system (for actuation) and the electrical system (for status/fault indicators).

Exposition

Digital Shuttle data is severely heterogeneous, meaning that there are many different types of primitive data beyond strings, dates, and numbers. 3D graphics will be used for content, display and interaction, and navigation. To some extent, the 3D data forms a basic unit of information within the knowledge base, as a peer to, for example, strings.

The CAD models currently being built are a good example of data heterogeneity. Drawings are 2D graphics, which are being laboriously converted to 3D. However, the drawings are annotated, and these notes form a critical part of the knowledge embodied in the drawings. Thus the 3D data must have some way of incorporating the annotations as essential structured data, but in a form that is both machine and human usable, such as RDF.

Conventional 3D display techniques, including stereo, provide different levels of image quality. Special purpose hardware, such as domes or head mounted displays, provide more immersive image generation. 3D audio is now available on all computer systems, and haptic devices are cheap enough to be relatively ubiquitous. These will augment the user experience so that it will be much more immersive. The addition of 3D audio and the haptic devices is expected to significantly differentiate Digital Shuttle from 3D systems that have come before it. A typical deskside computer currently provides enough power to drive it, so the average NASA engineer can expect to have access without a noticeable expenditure. More involved experiences may require labs or centers with larger investments.



In addition to content and display, 3D graphics is essential for dealing with the information architecture within Digital Shuttle. To begin with, the common concept of "drill down" becomes extended to "drill in any direction" and then on to "drill to another dimension or context". Whenever a user is working in any part of the system, it should be possible to quickly access or shift to another, probably related, part of the system. An example might be while looking at the CAD of a brake, to move over to the hydraulic system logical layout, and then to the stress profile display for the brake, and then to an animated display of that stress profile over time.

In a larger sense, the Orbiter contains a number of complex interacting systems. To develop ontologies requires some sophisticated tools; to make the ontologies co-exist with alternate data representations, such as 3D CAD, requires sophisticated tools with graphics. Again, the user should be able to switch context.

Working with the ontologies presents a problem by itself. Since they will use RDF, there is a question of how to work with the information structure of a dataset with the complexity of the Digital Shuttle. In this case, the ontologies present yet another part of the overall visualization problem in Digital Shuttle, which means that 3D can be used to navigate and work with the ontology data structures. In this way the ontologies present both data to be visualized and information structure to be visualized, and in both cases 3D provides a key mechanism for the solution.

---

* email: jgomez@mail.arc.nasa.gov ** email: Paul.J.Keller@nasa.gov