

Integrating Factory Floor and Human Simulations in a Portable Web-based Environment

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Abstract

Factory floor and human simulations are typically created using expensive proprietary systems. Users wishing to share the simulations or view-only versions of those simulation are faced with serious problems. In addition the defacto standard communications method used today is the World Wide Web. We present a methodology we have developed to integrate humans with a factory floor simulation suitable for Web-based display.

The Virtual Reality Modeling Language (VRML) soon to be an ISO standard (ISO/IEC 14772) is used as a highly portable method to display factory floor and human simulations. A VRML world under the control of Java code is created as a mechanism to “publish” proprietary simulations in a non-proprietary easily accessible format. VRML worlds output from proprietary systems can be used to integrate and display simulation results.

Introduction

We have built a factory floor simulation using Deneb’s QUEST software and can populate a VRML environment with humans from the University of Pennsylvania's (now Transom) Jack software. The geometry from both QUEST and Jack are converted into the geometry portion of VRML.

A simple simulation is run directly in the VRML world controlled by Java code. Simple human animation is introduced in the VRML world through the use of VRML behavior constructs which allow keyframe animation of geometry. The VRML human is triggered to perform an activity by the executing Java simulation. The VRML world represents a “view-only” version of the factory floor and human simulations. The Java simulations are much too simple to be considered a replacement for QUEST or Jack, rather the Java/VRML world is a non-proprietary read-only version of a complex simulation created by specialized simulation tools. Figure 1 illustrates a Java driven VRML world in the context of a Web browser.

Simply put people who create complex factory floor and human simulations can publish their work on the World Wide Web without requiring expensive software (Ressler et. al. 1997). The inherent integration of VRML and Java with the WWW provides a powerful publishing methodology.

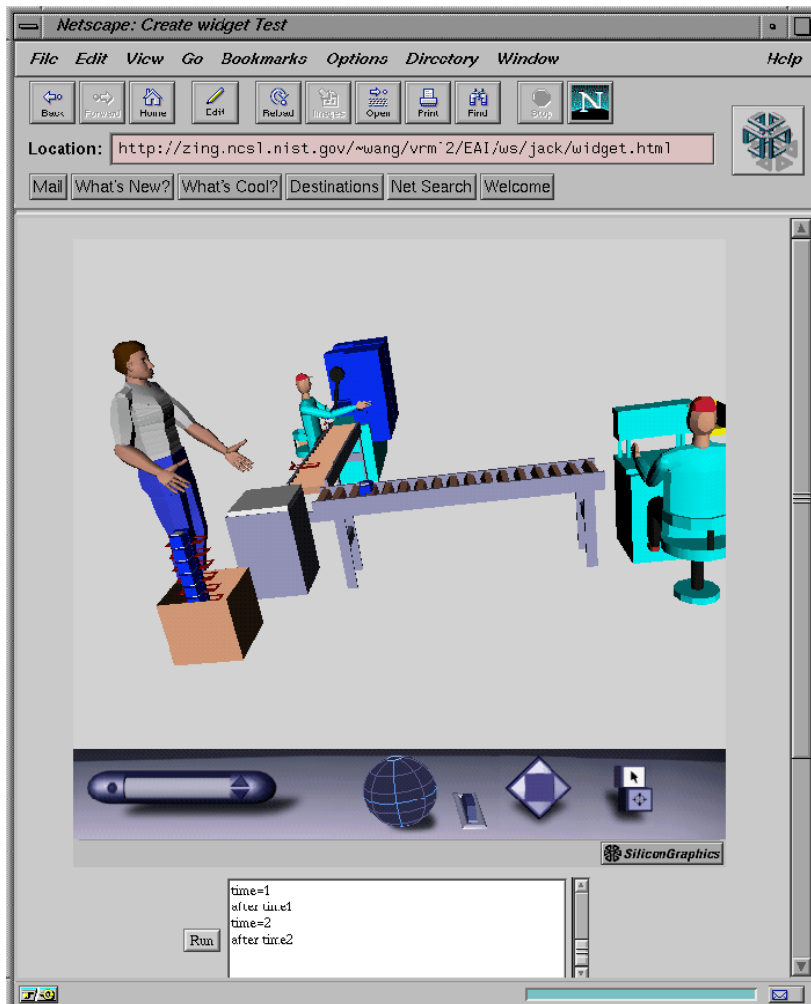


Figure 1: VRML simulation driven by Java code, with Deneb and Jack geometry.

Factory Floor Simulation Model

A Java simulation model has been defined which executes a simple simulation based on the same overall structure of a QUEST simulation (Deneb 1995). This model consists of widgets, workstations, source, sink and buffer areas. The model is visually represented with VRML geometry, a simply polygonal representation, which is controlled by the execution of Java code.

We have defined Java classes for a simulation model containing entities such as Widgets, Resources, Transports and Processing logic. A simulation model, defined via the class “Model” provides the overall semantics and organizational structure for the other entities of the simulation. A simulation-model includes Widgets, Resources, Transports and Processing Logic. The overall system architecture is illustrated in Figure 2.

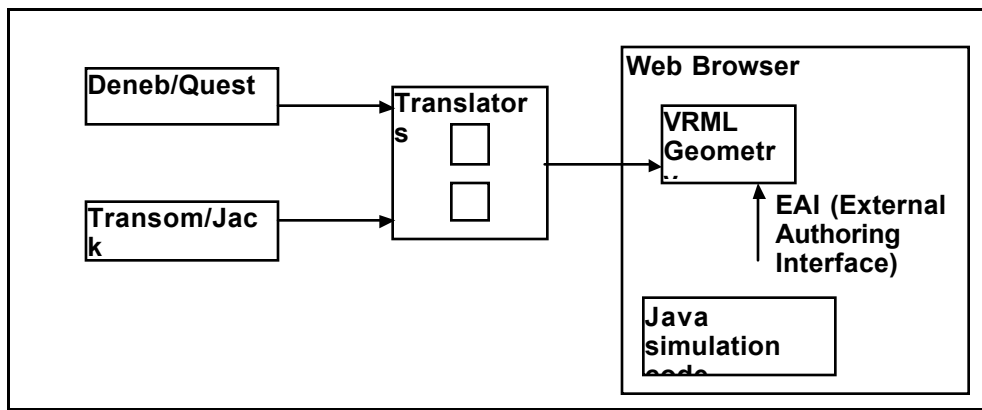


Figure 2: System architecture

Java Simulation Class Descriptions:

- Model, the container class in which all necessary information for the simulation is organized. The number of widget class, widget class names, number of resources, resource attributes, conveyor's length, speed and other required data are held. These data must match the data in main VRML file.
- Widgets are the material/parts/products that flow through the system. Widgets are the entities in the model which receive “services” from Resources, or are “Processed” by them. Instances of widget classes should be defined before the resources can generate, process or move widgets.
- Resources are agents in the model that define the structure and behavior of the model, such as Buffers, Conveyors, Sources, Sinks, Workcells.
- Workcells perform Processes on Widgets, and may consume, create or pass Widgets through.
- Transports are subset of Resources and indicate these entities whose primary service to Widgets is transport, such as Conveyors.
- Processes are time taking activities tied to Widgets through process logic, exclusively performed by the Workcells. They have a requirement for Widgets and produce Products.
- Logic are rules that govern the distribution of the Widgets among the Resources in the model and behavior of Resources. There are processing, routing and querying logic classes.
- Connections establish I/O Connection between Resources. An I/O Connection connects the output of one Resource to the Input of another.

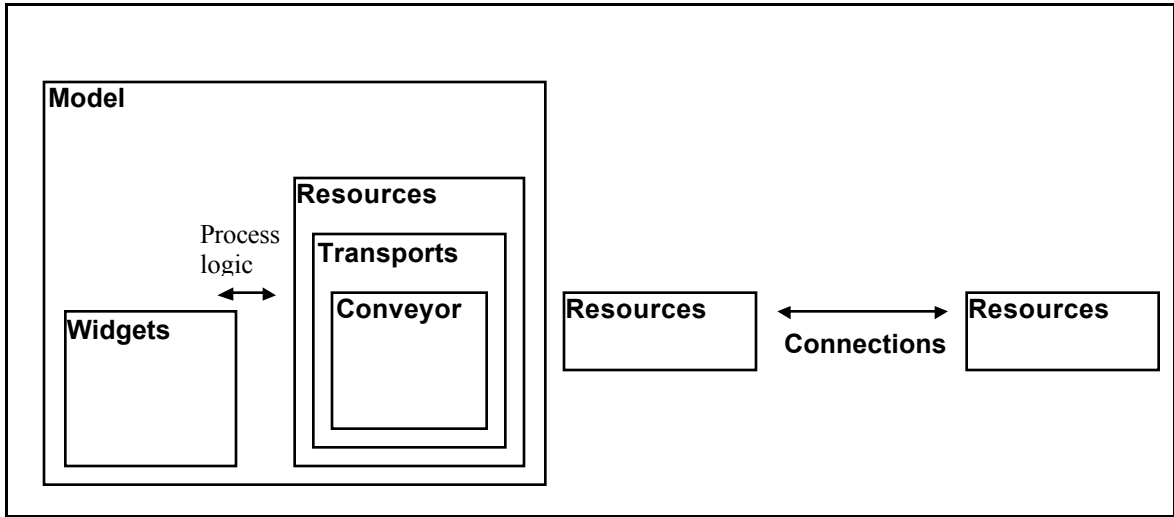


Figure 3: Java class relationships

Human Simulation Model

The primary representation we have chosen to use is based on the Humanoid Animation Working Group (HANIM) of the VRML Consortium (VRML Con.). The tool we are using is Transom's Jack (Transom 1997) along with custom software developed by staff at the University of Pennsylvania Center for Human Modeling and Simulation. The translation from Jack to HANIM is currently incomplete due to the evolving nature of the HANIM specification. Most of the work has concentrated on generating anthropometrically accurate visualizations based on a collection of data for children.

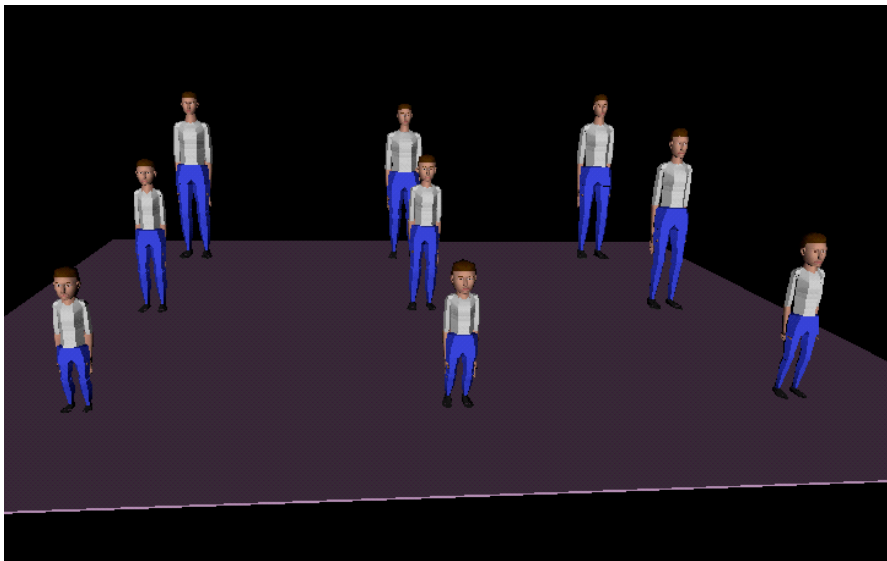


Figure 4: A collection of children in a VRML world generated in Jack from anthropometric data

Along with the standard anthropometric models that come with the Jack product we have also developed a set of anthropometric data for children. This data published on the "AnthroKids" web site can also be brought into Jack as a visualization method. Staff of University of Penn. have created some prototype software called GenFig which can

generate Jack figures for the individuals selected from the database according to some anthropometric criteria.

Factory Floor and Human Integration

By creating a series of translators all of which output VRML2 compliant code we can integrate the results of several applications. The sample world illustrated in this paper contains the output of three very different systems. A Deneb IGRIP workstation, a Knowledge Revolution Working Model 3D dynamics simulation (Godil 1997), and a Transom Jack human have all been integrated into a single VRML world. Currently all of the integration between VRML worlds and human simulations are performed by hand using text editors or VRML editors. In addition the Jack figure animation is hand generated and not the result of the Jack system, it is effectively a place holder awaiting completion of a VRML2 animation utility from Jack. The geometry of each world can be aligned simply using the capabilities of a VRML editor, in our case we used CosmoWorlds.

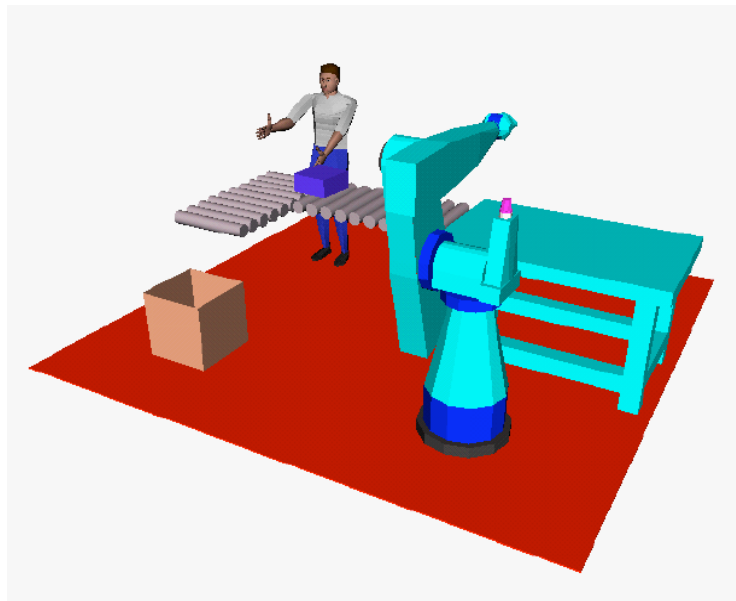


Figure 5: Jack in a VRML world with a Deneb robot and Knowledge Revolution conveyor belt.

The VRML world illustrated in Figure 5 contains a robot, generated in a Deneb IGRIP environment which picks up a box, places it on a conveyor belt. The box is moved along the conveyor belt and falls to the box on the floor according to the dynamics computed in Knowledge Revolution's Working Model 3D. While on the conveyor belt the Jack figure reaches out and touches the box at an appropriate time. The integration of the output of three very different and proprietary systems into a single non-proprietary VRML world demonstrates a promising integration methodology.

Conclusions and Future Work

One of the main tasks in the future is to define a set of conventions for how VRML translators should produce VRML that is easily integratable with other VRML worlds. Some of the issues to be examined include what types of integration hooks should be included with the code. These would include such things as code structuring and naming

conventions. In addition conventions for how worlds created in disparate systems can communicate with each other must be examined.

Acknowledgments

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