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VIRTUAL FACTORY – HIGHLY INTERACTIVE VISUALISATION FOR MANUFACTURING

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ABSTRACT

Funded by the Agency for Science, Technology and Research – A*STAR – Singapore, CAMTech is collaborating with a Singaporean research institute and two industry partners with the objective to improve electronics assembly processes. The goal of this project is to visualise the behaviour of an electronics assembly industry based on discrete events simulation. The traditional scenario - from the customer placing order for a product to delivery - goes through various phases including manufacturing the product. Several major electronics manufacturing stages can be addressed: fabrication, assembly, testing, and packing. Each of these stages accounts for set up, process, failure, and wait time periods. A delay in one process will accumulate over to the future delays. To simulate the discrete events a general-purpose simulation system has been employed. For modelling and visualisation CASUS (Computer Animation of Simulation Traces) system has been used and refined developed by Fraunhofer Institute for Computer Graphics (Fraunhofer-IGD).

1 INTRODUCTION

In collaboration with a Singaporean research institute and two industry partners CAMTech is conducting a research project in order to improve electronics assembly processes. Current approaches for analysing such complex processes include the use of simulation systems (Bowden 1998). But the interpretation of this event-oriented simulator output is very difficult, suited for experts only.

The visualization of simulation results from the areas of manufacturing and logistics simulations as 3-dimensional animations has been proven to be a promising approach. 3D animations are intuitively better understandable for the human observer than raw data in ASCII format or moving 2D pictograms. Through the 3D animations a user can verify assumptions and results of simulations on their probability. Results can be analyzed and easily presented to a wider audience of decision makers.

The goal of this project is to visualise the behaviour of an electronics assembly industry by simulating, visualising the discrete events of the entire manufacturing processes and observing the flow of materials, size of buffers, and line balancing. The vivid presentation of the simulated reality allows direct recognition of relationships inside the simulation models. In addition, easy checking and validation of the model accuracy is provided.

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In this work, the prototype interface between simulation trace file and CASUS animation scripts has been implemented. The animation script created using this interface is converted into a scene file and finally visualised. These discrete-event simulation software systems are adopting object-oriented approach for performing effective simulation. This system provides a 3-D animation from event-oriented simulator data building a library of reusable animation elements.

2 METHODS

The focus of this work is to provide an automatic pipeline starting with the conversion of simulation trace files into animation scripts and ending with the visualisation of the simulation. Moreover, the complex assembly process has to be considered divided in inbound, sub assembly, testing, packing, and outbound process. Based on the simulation and visualisation results the refinement of existing processes like minimal process time, reduced wait time or buffer size can be made.

To carry out the visualisation, a library of objects representing equipment used in manufacturing, inbound logistics and outbound logistics processes has been generated. These objects, where applicable, are defined by 3-D geometry and behaviour. The geometric modelling for each object were modelled in three levels of detail with respect to the model's complexity, i.e. simple, moderate and high. For the purpose of flexibility in using the animation elements, the objects have been built as basic building blocks where some objects has been divided into smaller and modular components.

The library that has been created serves as base library for CASUS Base, which is then used in the CASUS Layout Editor (see Figure 1). The CASUS Base allows a fast and realistic visualisation of complex scenarios where they have object-specific functionalities and independent intelligence (see Figure 2).

Usually, the description and representation of an factory and its inherent processes is very complex resulting in a rendering scene of several 100K polygons. By using an level-of-detail concept an adaptive visualisation is provided allowing the presentation of the simulation results with high performance on low-cost platforms (see Figure 3).

For the visualisation of discrete simulation events, 3-D animated geometric entities are required. To build animated scenes the entities do not only need to have the geometric data that defines their appearance. In addition methods are needed that perform the animation of the geometries. To make the geometric entities reusable for different visualisations and to avoid redundancies in the modelling of the animation behaviour, object oriented techniques like inheritance and data encapsulation are used. Associating the animation methods with the geometric objects rather than the animated scene, makes the objects utilisable for the reuse in other animations. The object-oriented technique of inheritance makes it possible to share the same behaviour methods among similar objects.

The animated scene is partially build of static objects, which will not be animated, and animated objects. The animation is created by the call of the objects behaviour methods. These calls will be triggered by the simulation events in the simulation trace output file.

Since the simulation defines not all details for the placement and movement of the animated objects, these

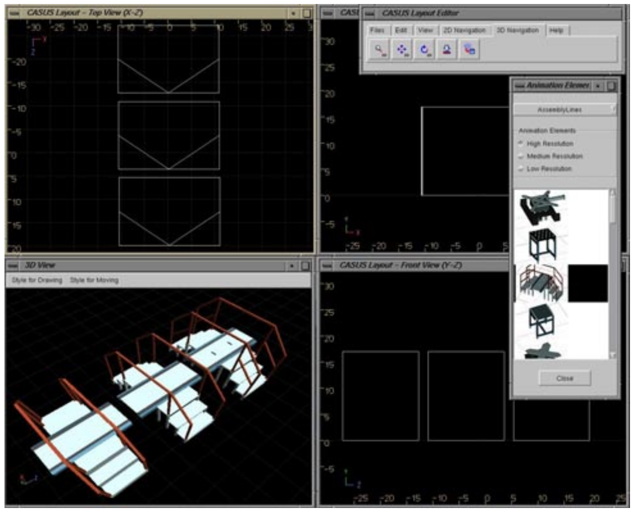

Figure 1: Modelling of Virtual Factory

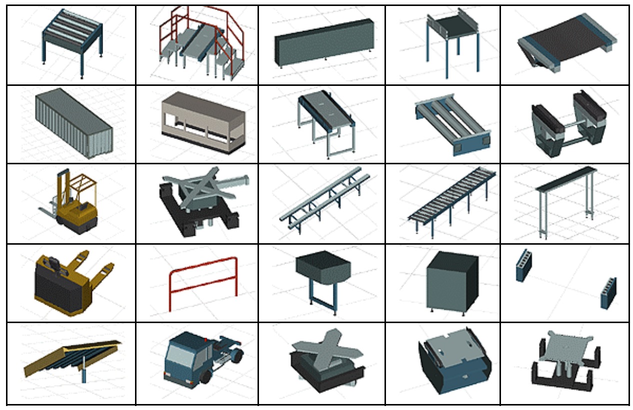

Figure 2: Library of 3D Factory Elements

Figure 3: Case Sealing System (Level-of-Detail)

parameters have to be set during the animation-modelling phase. For this purpose a so-called dynamics editor was developed.

When visualising the discrete events of the entire manufacturing processes and observing the flow of materials and line balancing, user needs to adjust positions of some objects visually to analyse, test and optimise the main electronics assembly process. Dynamic Layout Editor is provided as one part of the modelling and visualisation system. User can select and define paths and distances with it. After all the adjustments are done, files exported can be used by CASUS animation script.

The current version of Dynamic Editor provides the following functions: opening of a layout file with 3-D view, object selection and information viewing, object path definition, 3D replay of the results and output of animation script. This environment allows the definition of animations in an intuitive way with immediate visual feedback.

3 CONCLUSIONS AND FUTURE WORK

A system for modelling virtual prototypes, verifying the existing manufacturing processes by animating the behaviour has been developed (see Figure 4). Moreover, a reusable library of manufacturing, inbound and outbound animation elements was generated (more than 100 objects were modelled in 3 levels of detail).

The system presented herein allows the rapid creation of 3D animations from simulation output. It supports the reuse of existing 3D animation objects as well as the development of new 3D animation objects by composition of 3D models and animation components. Through the deployment of visual assembly tools for all parts of the visualization system its use becomes fast and easy. Through the connection of simulation parameters and component properties, changes at one end of the connection will be automatically reflected at the other end.

Currently, besides the integration of these simulation results into immersive virtual environments (see Figure 5) there are some promising visualisation results on low-cost platforms. The visualisation component is based on OpenSG, a scenegraph-based rendering API. (Reiners, Voss, and Behr 2002, Voss, Behr and Reiners 2002) It consists of a library of routines necessary for the representation of computer-generated scenes and is especially designed for Virtual Reality realtime applications. It is developed following Open Source principles and can be usedfreely. It runs on IRIX, Windows and Linux and is based on OpenGL.

The immersive presentation of the simulation results in high quality virtual environments is interesting. But the need for more information is one the essential results of discussions with the industry partners. Consequently, first work started to offer appropriate context-dependent presentation of information (see Figure 6). The manager should be able to see on a glance what is happening on the shop floor. Certainly, more validation is necessary to provide an optimised human computer interaction.

Besides this future work will focus on the realisation of complex manufacturing processes including the handling of very complex simulation data (e.g., simulation time of several weeks integrating manufacturing, inbound and outbound processes is typical).

In general, this rapid 3-D visualisation of assembly processes based on simulation models has the potential to

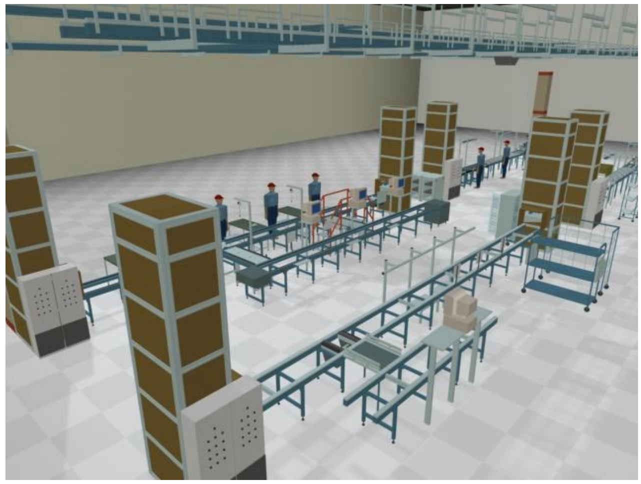

Figure 4: Virtual Assembly Lines

Figure 5: Semi-immersive Presentation of Virtual Factory

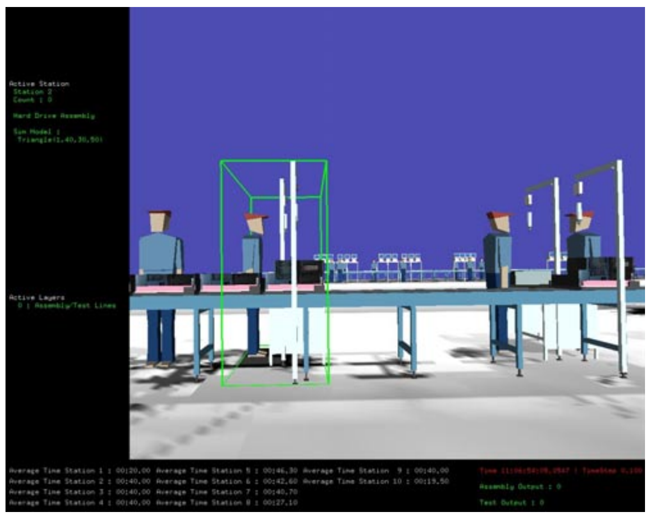

Figure 6: Presentation of Additional Information

support in decision management allowing the identification and removal of bottlenecks to avoid costly errors.

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