Integrated Virtual Factory and Logistics

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German Abstract

Gefördert von NSTB und NTU kooperiert CAMTech mit einem singapurischen Forschungsinstitut und zwei Industriepartnern in diesem Projekt, dessen Ziel es ist, die Wettbewerbsfähigkeit der Elektronikindustrie zu verbessern. Simulations- und Visualisierungstechnologien werden entwickelt, um die Fabrik- und Logistikaktivitäten effizienter zu integrieren. Hierzu werden die Abläufe einer Elektronikmontagefabrik (bspw. Montage von Computern, Festplatten, Mobiltelephone, o.ä.) simuliert und visualisiert. Der gesamte Produktionsprozess wird in einer idealisierten Darstellung in diskrete Ereignisse untergliedert, um den Materialfluss, die Puffergrößen und die Lastverteilung zu analysieren. Ein System wird benötigt, um eine virtuelle Fabrik zu modellieren, die vorherrschenden Arbeitsabläufe durch Animationen zu verifizieren und schließlich Prozessverbesserungen abzuleiten, damit die Effizienz der Produktion gesteigert werden kann. Hierbei wird nicht nur der Produktionsprozess analysiert, sondern auch sein Zusammenwirken mit der Logistik, insbesondere der Materialbeschaffung (bspw. Bereitstellung der Montagebauteile) und dem Produktabsatz (bspw. Versand der Endprodukte).

Introduction

Funded by the Singapore National Science and Technology Board (NSTB), CAMTech collaborates with a Singaporean research institute and two industry partners with the objective to improve the electronics assembly processes. Current approaches for analysing such complex processes include the use of simulation systems. But the interpretation of this event-oriented simulator output is very difficult and suited for experts only.

To overcome these drawbacks, the goal of this project is to visualize the behavior of an electronics assembly industry by simulating and visualizing 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 model accuracy is provided.

The traditional scenario – from the customer issuing an order to product delivery- goes through various phases including manufacturing the product. Several major electronics manufacturing stages can be addressed: fabrication, assembly, testing, and packaging. Each of these stages include set up, process, failure, and wait time periods. A delay in one process will accumulate future delays. To simulate the discrete events, a general-purpose simulation system has been employed. For modeling and visualization, the CASUS (Computer Animation of Simulation Traces) system developed by Fraunhofer-IGD has been used.

In this work, the prototype interface between the simulation trace file and CASUS animation scripts has been implemented. The animation script created by using this interface is converted into a scene file and finally visualized. These discrete-event simulation software systems adopt object-oriented approaches to perform effective simulation. The system provides 3-D animation from event-oriented simulator data by building a library of reusable animation elements.

Figure 1: Virtual assembly lines

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 visualization 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 visualization results, existing processes like minimal process time, reduced wait time or buffer size can be refined.

To carry out the visualization, a library of objects representing equipment used in manufacturing, inbound, and outbound logistics processes is generated. These objects are defined by 3-D geometry (three levels-of-detail) and behavior where applicable. For the flexible use of animation elements, the objects were built as basic building blocks and some objects were divided into smaller and modular components.

The library that was created serves as base library for the CASUS Base, which is then used in the CASUS Layout Editor. The CASUS Base allows for a fast and realistic visualization of complex scenarios with object-specific functionalities and independent intelligence.

Usually, the description and representation of a factory and its inherent processes is very complex resulting in a rendering scene of several 100K polygons. By using a level-of-detail concept, an adaptive visualization allows a presentation of simulation results assuring high performance on low-cost platforms.

For the visualization 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 visualizations and to avoid redundancies when modeling the animation behavior, object-oriented techniques like inheritance and data encapsulation are used. Linking the animation methods to the geometric objects rather than to the animated scene, makes the objects reusable for other animations. The object-oriented technique of inheritance makes it possible to use the same behavior methods with similar objects.

Figure 2: Semi-immersive presentation of Virtual Factory

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

Since the simulation does not define all the details for the placement and movement of the animated objects, these parameters have to be set during the animation modeling phase. For this purpose, a so-called Dynamics Editor was developed.

When visualizing the discrete events of the entire manufacturing processes and observing the flow of materials and line balancing, the user needs to adjust positions of some objects visually to analyze, test, and optimize the main electronics assembly process. Dynamics Editor is provided as part of the modeling and visualization system. Users can select and define paths and distances with it. After the adjustments are done, exported files can be used by the CASUS animation script.

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

Conclusions and Future Work

The rapid 3-D visualization of assembly processes based on simulation models allows the identification and removal of bottlenecks avoiding costly errors. Future work will focus on the realization of complex manufacturing processes and the integration of these simulation results into immersive virtual environments (cf. figure 2).

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