MODELING AND VISUALIZATION OF A 3D MECHANICAL WORKSHOP

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INTRODUCTION

Computer simulation is now-a-days becoming popular in evaluation of complex motion of mechanical systems. To date there are several 3D simulation packages which gives a good feel and quite realistic effect of the actual real product that they are modeling[1]. Industrial construction and planning is a very important application area for Virtual Reality. The idea is to exploit a 3D-model (including both, product information and process data) through the whole process of design, styling, construction, assembly or disassembly, training, sales, recycling, etc., thereby supporting the whole product life cycle. With the tools provided by virtual reality technology, design and construction engineers are enabled to work with a digital prototype (also called digital mock-up) in an efficient manner similar to working with physical mock-ups. This includes collaborative environments where groups of engineers from different locations can meet in a virtual scenario. A picture is worth thousand words, according to an old Chinese proverb; if this is so, a graphical animation should be worth at least a thousand pictures. Animated graphical simulations enhance our understanding of abstract concepts, aid analysis, increase human productivity and reduce design cost. Creation of a 3D Machine shop using 3-D solid modeling and animation based simulation system can provide a fast, effective method of visualizing and 'experiencing' new designs which can be easily modified to consider design alternatives.

Using animation, the various entities within a process can be seen moving around the simulation system, the status of the resources within the system be clearly displayed, and interaction between sub process easily visible. The most important aspect is its economical impact in design for manufacturing. It can be easily imagined that it is desirable to use a simulation system to have an opportunity of watching a new mechanical system on a computer screen first, when it is just finished in design stage. One of the important applications of computer technology in the field of manufacturing is to construct a workshop on a computer memory and to operate it as if it were real. This idea is called a virtual workshop.

Traditional design methods and mock-ups for workshop facilities planning can be time consuming and costly. One perceived advantages of 3D environment in this use is a "feel good" factor resulting from the fact that everyone is able to relate to and understand what they are seeing. A 3D workshop built in a computer will be conveniently applied to a lot of purpose. At the design stage of a workshop, designers can evaluate the feasibility such as space, storage and other facilities. At the stage of operations, a virtual workshop built in a computer is considered to be a replica of the real workshop and it can be used for workshop management. The development of a virtual workshop is expected to be valuable for the education and training of engineering personnel of manufacturing, as well as for industrial workshop design automation.

This paper describes one approach to a virtual workshop by means of a three-dimensional modeling system and animation based simulation package (PC version of animation package 3D Studio Max). It also discusses how 3-D solid modeling and animation-based simulation can aid engineers in designing the virtual workshop's layout with a view to (i) have a walkthrough and (ii) proper utilization of space and other facilities.

3D GEOMETRY MODELING TOOL

3D geometry modeling CAD systems such as AutoCAD are widely used in engineering design. AutoCAD is very suitable as a graphics editor for geometric modeling, especially for 3D geometric modeling. Although it is powerful for geometry modeling, it cannot be used as the tool for complex system motion verification. It does not have the dynamic simulation capabilities. It provides some primary 3D objects, such as box, cone wedge, ball etc., which are often used in 3D modeling. In order to create a realistic virtual model of the machines, an AutoCAD model was imported into 3D studio as a 3DS file. Similarly the virtual model for modification was imported into AutoCAD as a DXF (Data Interchange Format) file. A DXF file is an ASCII (American Standard Code for Information Interchange) coded file, of an AutoCAD drawing for importing and exporting to and from other software packages[2]. Figure 1 illustrates the process of converting a realistic AutoCAD model into 3D Studio virtual model.

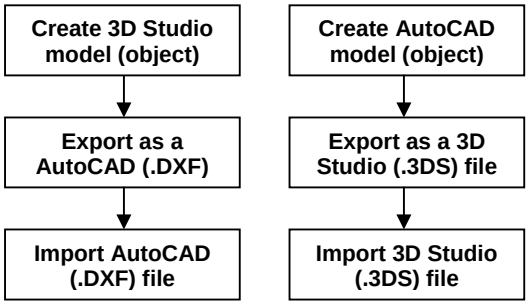

Figure 1: Conversion process of a 3D studio virtual model to an AutoCAD model (left) and that of an AutoCAD model to a 3D studio Virtual model (right).

REQUIREMENTS FOR VIRTUAL MACHINE-SHOP MODELING

In order to build the virtual workshop, which is similar to a real workshop, there might be many requirements in modeling the elements of manufacturing system. Among a number of requirements, the authors emphasize that the following three are most important to develop a modeling system for virtual workshops[3].

(i) *Visualization:* The most important requisite is that a virtual workshop should be visualized with reality. With good visualization, one can easily understand the constitution of a virtual workshop and observe how elements of each system work.

(ii) *Detailed descriptions:* Each element needs its detailed description, not only for its visualization, but also for calculating a number of its attributes, for example, when a workpiece needs to be placed into a box, the shape and dimensions of the workpiece and the box have to be known in order to check whether the box can contain the workpiece or not.

(iii) *Flexibility:* The modeling system should present a flexible way a modifying a virtual workshop in order to cope with the change of machines, layout and other facilities.

Any facility to create computer-generated models of virtual objects and environments that can be interactively explored in 3D and modified and recreated offers enormous potential for concurrent engineering, and for integrating of manufacturing activities in general[4]. The designer would be able to quickly visualize the product concept and represent alternative design solutions.

DETAILED DESCRIPTION OF 3D MECHANICAL WORKSHOP

The virtual workshop considered in this work is for workshop (machine shop and class room) and is made up of two different sections. One section consists of class. The second section is the machine shop. To visualize the different activities on the workshop floor several viewing points have been set. Thus, it is possible to view different machines in operation and observe existing layout of different sections of the workshop. The user has the option to modify different design of facilities in dimensional and aspects and could test the machineries and other production facilities for better positioning thus making space available for future allocation of new production machineries and other machine tools. The system development was divided into two main parts[4]:

(i) Construction of a virtual environment: This part provides experience of creating virtual objects and placing them in the virtual environment with associated real world properties in order to illustrate how model are created.

(ii) Use of virtual environment: This part encourages exploring different attributes of the virtual environment within two broad categories which are workshop walk through and visualization of different sections of the workshop.

3D walk through

This feature demonstrates how the participant can navigate through virtual environment and examines it from different viewing points. Several viewing points were set up at different location around the workshop. Appropriate directional control inputs were responsive according to the type of object being manipulated. Two different types of object manipulation were represented in the virtual environment:

(i) 'Ghost mode' in which viewing point is placed in the ceiling above the room (Fig. 2).

(ii) Human walking (egocentric view) in which eye level is set at approximately 1.6m height (Fig. 3 and Fig. 4).

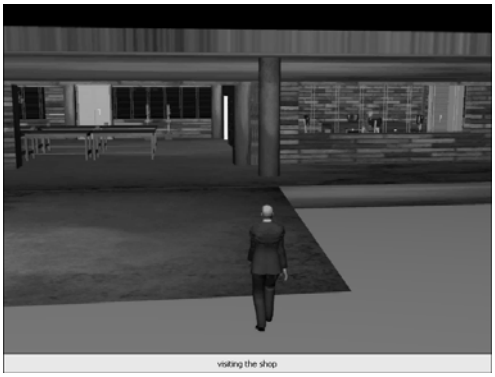

Figure 2: Workshop Entrance.

Figure 3: Human walking (Egocentric View).

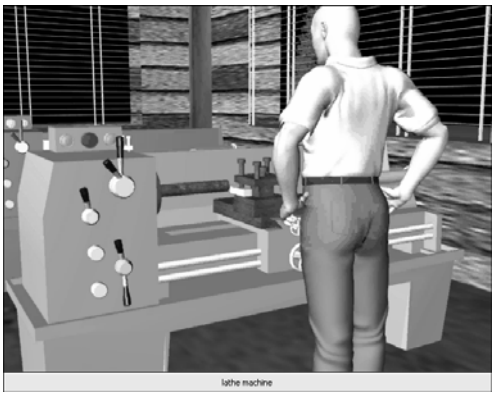

Figure 4: Human at Work.

Visualization of different facilities of the workshop

This feature demonstrates the effect of simulation operations and visualizing interactions between different objects and related functions. It was possible to observe operations from unusual viewing points.

DISCUSSION

The objective of creating the virtual workshop environment was to explore the potential use of 3D modeling and animation package for industrial application. A workshop could be represented in a virtual environment such that the operators could virtually see, hear and feel the system and components to determine status. After visualizing different sections of the workshop using viewing points it is considered that both the factory walkthrough and visualization facilities are useful for design and planning activities in virtual environment. Visualization gives information about the minimal needed workspace or the optimized production sequence for products or planning production facilities. In a virtual workshop, various variants can be simulated, stored and repeated. It is also possible to visualize the moving parts of materials. This path can be used as a real material-handling path.

Applicability of the 3D Studio Max system was assessed for its user friendliness for the user to perform specific operations. The 3D Studio Max gave a good feel and quite realistic effect of the actual real workshop. The user found some design operations easy to perform. In visualization of the machines "Flying into the machine and recognizing where one is" was found to be difficult. The most important feature is that any changes made by the user within one part of the would (e.g. design modification) influence the activities or results in another (e.g. production visualization).

The relation between multiple systems could be shown in a natural way. The primary advantage of designing a product in virtual environment is that it provides a good medium for visualization of the prototype. Virtual prototyping is a method to be used to evaluate different design alternatives very quickly[5]. In contrast to physical prototypes, a virtual prototype is made very rapidly, can be manipulated and modified directly and the data is reusable.

CONCLUSIONS

In this paper, an attempt to construct a virtual workshop is described. It has been shown that the designer can build up a virtual workshop just like constructing a miniature model of the real workshop. Thus 3-D solid modeling and animation based simulation technique provides a fast, effective method of visualizing and experiencing new designs which can be easily modified. Virtual environments have great potential to allow some thing to be done in industry in future. Knowledge and skill of VR designer includes conceptual skill, analytical skill, modeling skill, knowledge of hardware, knowledge of solution and their uses.

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