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Development of cost effective 3D stereo visualization software suite for manufacturing industries

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Abstract

The computer based visualization techniques plays an important role in the manufacturing industries. These techniques are especially useful for developing high-performance mechanical products. It allows acquisition of important information that can aid the designer in correcting and controlling the product right from the early conceptualization to the final assembly design stage. The design industry severely suffers from the productivity bottlenecks posed due to the physical prototyping. The time to market degrades drastically and the effective revenue far lessens than the expected due to late entry of the product in the market. In the present communication, emphasis is given on development of cost effective software suite for rapid simulation of the performance of mechanical systems in a virtual prototyping environment. This facilitates early troubleshooting of the problems within existing designs and to significantly reduce the risk associated with manufacturing them. The paper compares the developed software suite with the existing systems embodying active stereoscopic techniques. While the later requires a highly expensive setup comprising of Crystal eye ware, standard emitter, and stereo capable graphics card, the one reported in this paper resorts to a low cost passive stereo technique that simply requires a red blue eye ware. The main focus of the development is development of an effective low cost passive stereo based visualization technique that would run on a fairly general-purpose computer used in manufacturing industries for virtual prototyping. The paper elaborates the benefits of the low end, inexpensive visualization technique developed by the authors for manufacturing industries.

Keywords: Virtual reality, stereo vision, virtual prototyping, visualization, passive stereo, OpenGL

Introduction

Scientists in numerous disciplines use sophisticated computer techniques to model complex events and visualize observable facts that are not directly pragmatic. In case of the mechanical industry, advantages of the computer based visualization techniques are more realized (Ma *et al*., 2001; Seth Abhishekh, 2005; Yusuf Arayici, 2008). These techniques are especially useful for developing high-performance mechanical and electro-mechanical products. They allow acquisition of important information that can aid the designer in correcting and controlling the product right from the early conceptualization to the final assembly design stage. In order to improve competence and reduce the product weight and volume, designers need to bundle a large number of components in a very miniature space. At the same time, in order to make products easier to assemble and service, designers need to go away with the adequate room for carrying out assembly and disassembly operations. These requirements are quite often in conflict and make design of electro-mechanical products a highly iterative process. In the absence of high fidelity visualization techniques most product development teams are forced to include physical prototyping in the design loop to verify proper functioning and ease of assembly. Physical prototyping is a major bottleneck in rapid product design and results into more time to market. It slows down the product development process and seriously constrains the number of design alternatives that can be examined (Satyandra *et al*., 2009).

The way-out to alleviate bottlenecks posed due to the aforesaid problems is Virtual Reality based techniques for early visualization. By facilitating collaborative decision-making and inter departmental communication, the Virtual Reality visualization solutions enable teams to identify and resolve design and manufacturing problems earlier (Runar Ostones *et al*., 2004). By making the right decisions based on digital data, companies can optimize their designs and reduce the number of physical prototypes built, thus saving both time and money (Toledo, 2004). The 3D visualization suite reported in the present communication demonstrates how a low end, inexpensive viewing technique can be used as a quick trick to produce many of the same affects as high-end stereo viewing.

Pitfalls of the sate of art visualization software platforms

There are number of 3D visualization software suites such as like Cad/Cam, Catia, Pro/E, I-deas, and Solid Works available in the market. Although readily available in the market, they require sophisticated computing platforms that are out of the reach of the small firms and independent designers. It is observed that most of the large mechanical industries make heavy use of the

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modeling software to facilitate a concurrent engineering approach for the product design, 3D modeling, analysis and manufacturing applications (Jones *et al.*, 2001). The main reason why the small firms or independent designer find it difficult to compete with the big players is lack of such software. The software suite reported in the present communication attempts to bridge this gap. It aims at designing a general-purpose software platform for visualization of the mechanical assembly executable on fairly available computer architecture. This makes the proposed software unique, as the state of art software requires at least a workstation or powerful computers or clusters for their execution. Moreover it is planned to empower the designer with few additional tools not available in the existing software. This can be achieved by adopting a new methodology described below.

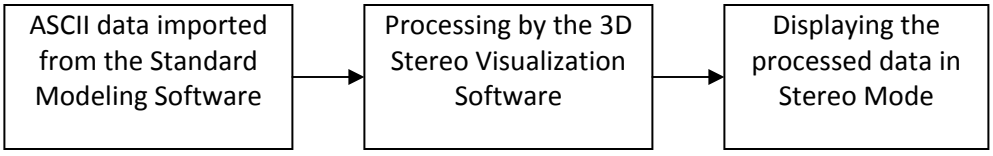
Key themes of software development

The key theme of the proposed software is parsing the ASCII files generated by any modeling software and to render the corresponding image. Even though this file contains huge details about the model, the software suite developed fetches only the data required for visualization. This leads to faster execution as contrasted with the existing software manipulating the entire file for visualization. The software suite supports both active and passive stereo. Active stereo is highly expensive which requires Crystal eye ware, standard emitter, and stereo capable graphics card. Where as passive stereo is a low cost technique, which requires only red blue eye ware. Therefore, the main focus of this software is to develop an effective low cost passive stereo executable on a fairly general-purpose computer used in day-to-day life.

Architecture

The architecture of the modeling software is covered in this section. Components drawn using any state of art CAD software serves as the input for the present software suite. The Modeling software used for drawing the components exports the data into the files in ASCII format. The software suite developed imports the above said datasets and processes the same for visualization. The key component of this visualization software is parsing the ASCII files generated by modeling software and to render the corresponding image on screen. Even though these files contain huge details about the model, visualization software imports only the required data, required for visualization. The conceptual model of visualization software is as shown in Fig.1.

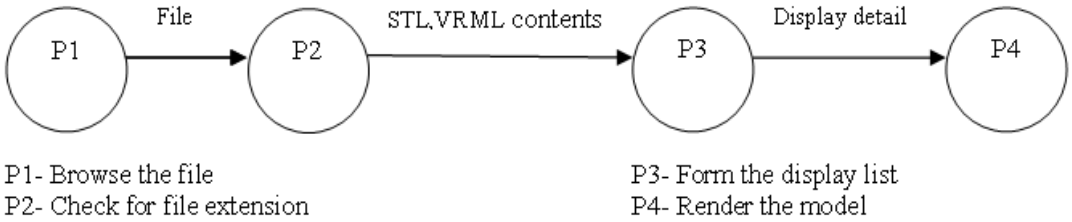
Fig.1.Conceptual Model of the developed Software Suite for 3D Visualization



Intrinsic details of 3D visualization software

This section presents the details of processing inculcated in the reported software suite. Fig.2, shows the process diagrams for the software suit of the overall system in which data flows, structure how the software works. The steps carried out by visualization software are:

Fig.2. Process diagram of software suite



1. The components are drawn by using a state of art CAD software. These software stores the model's data in ASCII format (Rikk Carey & Gavin Bell, 1997). These ASCII files, with codified information of the component serve as an input to the visualization software.
2. The 3D models designed using modeling software leads to the heavy file size since it holds geometric as well as topological information. All these details are not required for visualization. A Parser module goes through the ASCII file details, imports only the required information (pertaining to description of the object's surface in-terms of triangles, details about material, color, light etc required for display operation) which is subsequently stored in a data structure.
3. Display module refers the contents of data structure and renders the model on the screen. It support the additional properties like,
   - translation, scaling, rotation of model
   - applying various lights, material color
   - options for solid, wire frame, points, lines, transparency viewing
   - various views of an object (front, back, left, right, top, bottom, isometric)
   - texture mapping, fog effect
   - walk through the object with viewer being at the place itself, only the object is made to come closer or go away
   - cutting the object either along XY-plane, XZ-plane and YZ-plane or with any angle
   - background color selection
   - mark up features

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- Copy the rendered object to the clipboard and enabling to view more than one model through either tiling or cascading the windows.

4. Stereovision is an important feature of this software. It supports both active and passive stereo thereby enabling user to enter a world of virtual reality. Both of these methods use eye ware, "active" refers to glasses with electronic components; "passive" refers to no electronics. The largest benefit of passive stereo is its low cost.
5. OpenGL tool is used for displaying the processed dataset on the screen. The OpenGL constructs 3D rasterization information from geometric primitives- points, lines & polygons, thereby creating mathematical descriptions of objects with due calculation of calculation of color, material, light and texture of the object (Wright *et al*., 2007).
6. In order to view the image user has to wear special filtering glass. The two most common passive stereo techniques are anaglyph and polarized (Beier, 2008).

Conclusion

The primary goal of the development of the 3D Visualization software suite reported in the present communication is to empower the designers with a fully functional stereovision and facilitating them to explore their datasets in a graphical manner that too at low cost. This will realize the collaborative decision-making and interdepartmental communication.

The key theme of the reported software suite is parsing the ASCII files generated by any modeling software and to render the corresponding image. Even though this file contains huge details about the model, the reported software imports only the data, which is required for visualization. This leads to faster execution as contrasted with the existing software manipulating the entire file for visualization. The main feature of the reported software is support for both active and passive stereo besides the ease of execution on fairly general purpose computing platform. Thus, the development reported in this communication can be very useful for the small industries to foresee their component database in 3D ahead of prototyping.

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