

Virtual Reality Laboratory for Robotic Systems

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Abstract: Modeling and analysis of robotic system is important to reducing system development time and increasing operational efficiency. Powerful software allows engineers to model and program a three-dimensional animated simulation of the robot system, allowing them to test a variety of designs and robot control programs, all without using the real robot and wasting its production time. Obviously, to run virtual reality applications it's required a laboratory provided by special devices. This paper describes the theoretical background of a Virtual Reality based simulation of Virtual Robotic Systems.

Keywords: virtual reality, laboratory, robotic systems

1 Introduction

Virtual Reality is a tool that is being utilized more often in the industry. Above all, the automotive industries, as well as the aerospace sector, apply this technology productively for their envelopment processes. The main fields of application at present are: evaluation of CAD data, visualization of draft designs, representation of production facilities and processes, installation and assembly analyses, ergonomic examinations and the visualization of numerical simulation results. VR can thus be regarded as a supplement to digital product-development tools and, in this respect; it can also be combined with modern information and communication technologies [1].

The use of virtual environments in robotic fields is becoming more and more prevalent as design and testing tools. Many companies are finding that virtual prototyping can be a fast, easy, and affordable way to develop products and manufacturing processes. Product designers can make virtual models that can easily be modified. The models can then be tested under various conditions that may be difficult or costly to create. Problems can be quickly found and fixed. Good designs can then be reviewed by a test group of users in a virtual environment that would approximate a real setting. All this can be done before a

single physical model has been created, thereby speeding up product realization and reducing the cost of creating and testing numerous models [2].

2 Virtual Reality

Virtual Reality can be understood as a computer generated environment. By using natural senses, the observer experiences an apparently real environment which allows interaction and inspires creative activities. Such an environment can be a depiction of reality (simulation), an environment which existed earlier or which has not yet come into existence, an environment which can not be perceived or accessed in "actual reality" or an environment which will not, and cannot, come into existence (artificial worlds, artificial reality). The characteristic features of Virtual Reality are [3]:

- interaction:
 - navigation: free movement of the user in the virtual world
 - manipulation of virtual objects
- natural, intuitive user interface:
 - three-dimensional input and output
 - multi-modality: incorporation of several senses visual, acoustic, haptic
- immersion (being immersed in the process).

3 Virtual Reality Laboratory

The laboratory is mainly involved in the modelling and animation of Three-Dimensional Inhabited Virtual Worlds.

The goal of the Virtual Reality Laboratory is to make the environments as natural as possible while allowing experimental control. One of the motivations for using naturalistic conditions is that the results have immediate applicability to the real world, with consequent applications in a variety of domains especially in robotics.

The Laboratory's devices are presented bellow.

3.1 Hardware Equipment

The Virtual Reality Laboratory contains a high-performance Silicon Graphics Prism™ Deskside System with Autostereoscopic display; six Pentium based PCs, a Phantom Desktop haptic device, a 5DT Head Mounted Display (HMD), a 5DT Data Glove 16, a InertiaCube 2.

Silicon Graphics Prism™ Deskside System (Fig. 1a) puts more visualization capabilities and greater memory capacity into the hands of power users. This deskside system is the bridge between traditional workstations and the successful rackmount Silicon Graphics Prism visualization systems, bringing large memory and world-leading I/O capabilities to power users at an even lower price point [4].

The SGI system has: 1.6GHz/3MB L3 Cache Itanium2, ATI FireGL X800 Graphics Card with 256MB Graphics Memory, 4GB DDR Memory (4x1GB), 250GB 7200RPM SATA Drive.

Autostereoscopic displays are direct view LCD-based devices which as well as performing as a normal monitor can also display an autostereoscopic 3D image (Fig. 1b), the user can see a stereoscopic 3D image in front and behind the plane of the screen without the need for any special glasses. The technology is state-of-the-art and makes use of a holographic illumination system combined with a conventional LCD panel [5].

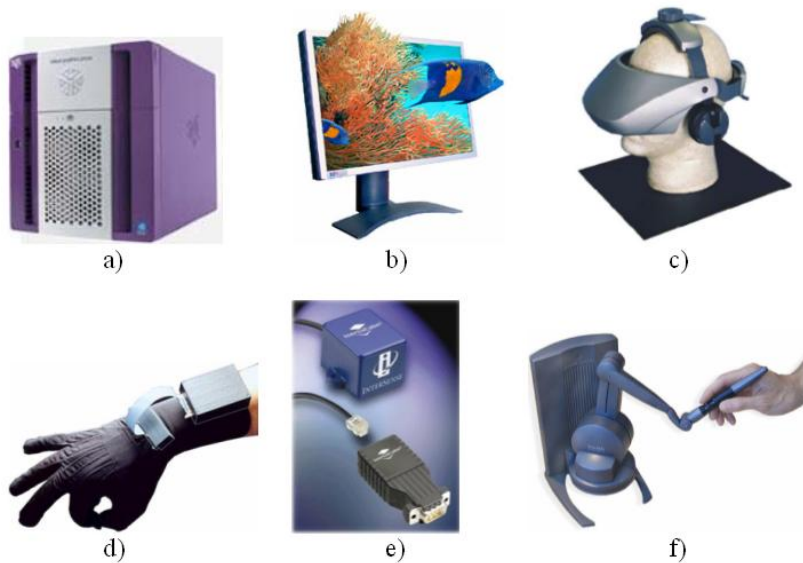


Figure 1
Hardware equipment

The 5DT Head Mounted Display (HMD), 3D version (Fig. 1c), offers the user affordable quality, high resolution (SVGA), a crisp image and superior sound quality packaged in a sleek, comfortable and extremely light headmount design. Head Mounted Displays, as popularized by virtual reality systems, offer the opportunity to immerse a user in a synthetically generated environment. Other features are adjustable top/back ratchets, a mounting base for head trackers and a flip-up mode for reality checks [6].

The 5DT Data Glove 16 (Fig. 1d) measures finger flexure (2 sensors per finger) as well as the abduction between fingers. Data Gloves are suitable for a wide variety of applications such as: control and manipulation of virtual worlds, gesture and cognitive media, physiotherapy rehabilitation, control device for actors in tele-robotics, etc. [6].

The InertiaCube 2 is the World's smallest inertial orientation reference system. The InertiaCube2 is a high fidelity, source less tracker that provides 3 degrees of freedom (3DOF). The InertiaCube2 tracker (Fig. 1e) virtually eliminates the jitter common to some other systems. It provides superior precision, stability and wide sensing range at a low cost. The small size and robustness of the InertiaCube2 makes it easy to use [5].

The Phantom Desktop (Fig. 1f) is a haptics device from SensAble Technologies that provides you with the sensation of touching and moving objects in a 3D environment. This is achieved through force-feedback output that is completely customizable. It has six degree-of-freedom positional sensing and provides precision positioning input and high fidelity force-feedback output. Make it possible for users to touch and manipulate virtual objects [7].

3.2 Software

There is various Software including: Modeling Software and Simulation Software, OpenGL, OpenInventor, SGI Performer, Pro/Engineer, SGI Advanced Linux Environment with SGI ProPack, OpenHaptics toolkit, etc.

4 Applications

The use of VR to support industrial applications is rapidly increasing. BMW uses VR to explore the visualisation of new car layouts to enhance communication and the simulation of processes, while Rolls Royce Aeroengines and Associates use VR technology in their early verification of maintenance procedures, training maintenance engineers in these procedures, enhanced visualisation of complex environments and rapid prototyping of plant control and instrumentation.

Several commercial software toolkits, such as dVise [8], Superscape [9], and the Deneb Robotics' package [10] are available to support the creation of virtual environment. These tools provide a VR environment to support existing CAD technology, such as modelling and database construction. A user can generate a synthetic virtual environment which can make the user have the feeling of immersion through a wide variety of VR hardware. Deneb Robotics has developed several VR tools to support machining and robot environments [10].

4.1 A Virtual CAPP System

A virtual CAPP system can be defined as a computer system that can generate the same information about machining process planning as we can observe in a real workshop. A virtual CAPP system has been constructed by the authors based on the Deneb Robotics VR toolkit (see Fig. 2a). An example of 3D machining simulation of a component is shown in Fig. 2b.

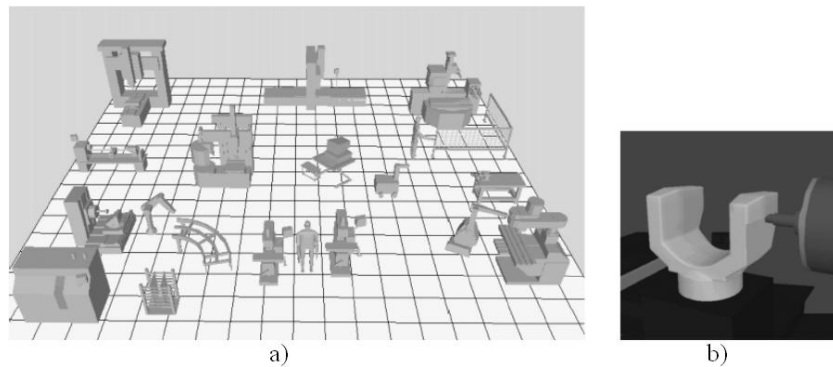


Figure 2

a) a virtual manufacturing environment produced by Deneb Robotics toolkit; b) an example of 3D machining simulation of a component

4.2 Offline Programming to Prevent Robot Collisions

Visualization of the newly created robot program and work cell verified no equipment, worker or workplace interferences (see Fig. 3). All elements of the work cell were able to be viewed from unlimited angles to verify compliance to process parameters, ensure programming accuracy, and eliminate safety hazards to employees [11].

The ability to program offline and simulate a robot path prior to production will save us an enormous amount of time and eliminate the potential for collisions between robots, parts, tools and fixtures [12].

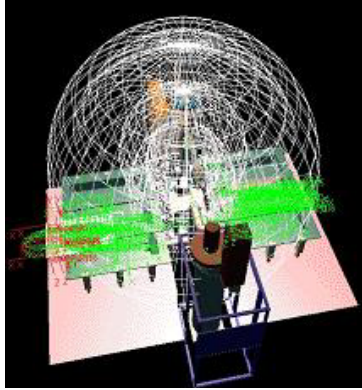


Figure 3

Simulation with graphical robot work envelope to indicate “unsafe zones”

4.3 Simulation in the Classroom

Simulation and offline programming has been used for decades in the classroom to teach students about robotic automation. At the Oakland Community College (OCC) robot lab in Auburn Hills, simulation has been a part of their robot curriculum for more than five years.

Students use Workspace not only to learn about simulation, but also how to use and apply robots offline in a virtual environment. Mistakes, which are a normal part of the learning process, can be made safely and without costly damage to equipment. Robot programs created by the students offline can be taken into the lab and run them on the real machines [11].

4.4 Other Applications

To further improve efficiency, tooling, equipment, and part designs created in an electronic CAD environment can be quickly and easily imported into the simulation package for use in simulations. Some packages allow users to create their own mechanisms with behaviors (motion algorithms) such as conveyors, presses, or other devices that can be stored in libraries for re-use. In addition to time savings, users also benefit from working offline with increased safety, improved resource utilization, higher process efficiency, and overall better cost effectiveness [11].

In a flexible automated manufacturing system such as a robot system, the time to make a switch-over for a new product and the quality of the resulting process

application are key factors of the system. To minimize the down-time, off-line programming and simulation of the process is an attractive approach [13].

5 The Benefits

The benefits of robot simulation are: reduce technical risk; promote common understanding; identify critical issues; create working scenarios; test, verify, benchmark proposed solutions; virtual implementation of products; plan and prepare for manufacturing; train personnel; programming, virtual test runs, etc; optimization tool; keep a coupling between CAD models and robot programs; test the impossible in a virtual world [14].

The Future Work

Further work will be made in areas such as: software, case studies, simulation of manufacturing processes, training.

Conclusions

The goal of the laboratory „Virtual Reality“ is to teach the procedures and available tools for producing VR-based simulations as well as the performance of modern VR hardware.

VR is becoming an important method to solve engineering problems because of its special simulation features, such as immersion, real-time interaction, and 3D graphics. Its further application will not only depend on the development of VR technology, but more on its capability to provide cost-effective solutions to real industrial problems [15].

VR technology has shown its advantages over conventional simulation processes where it can aid the understanding of sophisticated engineering problems. AVR system can provide not only basic computerised functions, but also an efficient way to utilise human sense and interaction to engineering applications in a virtual environment [15].

Acknowledgements

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