Development of a Virtual Reality System: CompleXcope

Y. Tamura, A. Kageyama and T. Sato

Theory and Computer Simulation Center
National Institute for Fusion Science
Toki 509-5292, Japan
tamura@tcsc.nifs.ac.jp

Abstract

One of the most practical objectives to use virtual reality system in science is to make it easy to intuitively percept complex physical phenomena. At Theory and Computer Simulation Center (TCSC), National Institute for Fusion Science, a virtual reality system, called CompleXcope, was developed. This virtual reality system can represent “real” 3D environment, not pseudo 3D. Since attractive phenomena become more and more complex, it becomes unavoidable recognize by using “real” 3D visualization tools. In our CompleXcope system, OpenGL makes images and CAVE library makes virtual image (stereo image). Some applications produced by this system are presented.

1. Introduction

A virtual reality system for scientific visualization, that we call CompleXcope, is proposed. The CompleXcope system is based on CAVE system that is developed at Electronic Visualization Laboratory, University of Illinois at Chicago. In recent days, many tools to visualize various models have been developed and used in many fields. Above all, in physics field, such tools are indispensable to comprehend physical phenomena and cultivate the frontier science of complexity. But it becomes too uneconomical to analyze complex phenomena by using traditional 2D visualization tools, because they ought to be dealt with highly nonlinear, dynamic and large-scale simulation models. The output data generated by advanced supercomputers is huge. Moreover, it often happens that interesting phenomena occur locally, both in time and space. So it is highly required to recognize them in "real" 3D environment and in real time and explore their detailed evolutions. The purpose of this study is to develop a viable virtual reality system and to present scientific applications demonstrating the viability and practicability for comprehension of complex evolution of physical phenomena.

2. System Configuration

CompleXcope is a projection-based VR system based on CAVE system. This system has four screens whose size is 10 foot x 10foot. The screens are arranged in a cube made up of three rear-projection screens for walls and a down-projection screen for the ground. The correct stereoscopic perspective projections are calculated by a graphic workstation (SGI ONYX2) in real time. This workstation has four graphic pipelines to control four screens. A master viewer, who can only control 3D environment, wears stereo liquid crystal shutter glasses and a six-degrees-of-freedom head-tracking device. The workstation redraws images of each wall in response to change of head position. The glasses also have infrared sensor. The role of this sensor is to synchronize image with shutter timing. If the shutter of right eye is
opened, the images for right eye are projected. The reverse is also same. In this system there are input devices in order to change environment in CompleXcope. The sensor also has tracking device.

CompleXcope application is developed by OpenGL and CA VE library. The functions of CA VE library are to synchronize each image drawn by OpenGL and to redraw images when events occur. To take examples of events, the image is movable by pushing joystick and lines are drawn by pushing button. The following are the shape of CompleXcope system and the configuration of the system.

3. Examples

3.1 Application 1 LHD

LHD (Large Helical Device) is a large in size (major radius is 3.9m), doughnut-shaped experimental device of nuclear fusion plasma, constructed at National Institute for Fusion Science. High temperature hydrogen plasma is confined by a strong magnetic field generated by superconducting coils of helical shape. Since the LHD’s helical coils have complex spatial structure and magnetic field, it is too inefficient to analyze merely by 2D-visualization tool that is generally used to comprehend physical phenomena. Furthermore, it is necessary to investigate plasma behavior in real time. The real 3D virtual reality system is really useful for a complex structural function. Two examples of this application are shown here.
3.2 Application 2 Molecular Dynamics of Polymer Chains

Next we pick up a computer simulation of the structural formation of polymer chains. The purpose of this simulation is to clarify the mechanism of the structural formation of polymer chains at the molecular level. The model of polymer chain consists of a sequence of CH$_2$ groups, which are treated as united atoms. The simulation model consists of 100 chains and 2000 molecular. At first, the temperature of polymer chain is 700K. It is then quenched to 400K and subsequently it is cooled stepwise to 100K with the rate of 100K/2000ps. The positions of the molecular chains are random at first time, but as time goes on, these chains begin to coalesce into a large cluster and finally to form a hexagonally lined structure.

3.3 Application 3 Spherical Tokamak

Recently spherical tokamak has attracted attention of fusion researchers because of several favorable properties such as compactness and excellent stability in high-plasmas. With the progress of experiments, it has been shown that several unique features are observed in the dynamical processes of spherical tokamak plasmas. A phenomenon called Internal Reconnection Event (IRE) is one of such features. A simulation study of the TCSC group has successfully demonstrated the nonlinear evolution of the IRE instability. This phenomenon is very complex and it is difficult to grasp the whole evolution process by 2D visualization tools only. So we adapt this process to the CompleXcope system. Examples are presented here.
4. Conclusion and Future Projects

Simulation environments (simulation algorithms, supercomputers, graphics workstations, etc) have already matured so that almost any single complex phenomenon could be adequately solved. However, the perception technologies are yet premature. Now it becomes urgent to have an innovative tool to comprehend physical phenomena visually with ease. CompleXcope, we proposed here, is a powerful tool for comprehending complex evolutionary phenomena in 3D environment and in real time.

We are now only utilizing visual representation, but we sometimes feel something unsatisfied in grasping complex phenomena. To take example, we find difficulty in intuitively recognizing a transient change obtained in dynamic simulation in visual sense. So we are now planning to install an acoustic system in CompleXcope to recognize physical phenomena by auditory sense.

In the virtual reality space, also required is a conversation facility among plural researches who are working together for a simulation project. In the present system we have only one input device available. Under this circumstances we are investigating the “Speech Recognition System”. By using this system, we enable to order orally the virtual environment without using the input device (joystick). Thus, several persons will be able to join simultaneously the handling & the CompleXcope.

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