Distributed Virtual Environment Applications in Science, Education, and Industry based *on* PC-Linux-clusters and Standard Components: case of experience

by Prof Dr. Stanislav Klimenko IHEP, Protvino Russia

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Abstract

Since Virtual Environment has become a major R&D area worldwide within the recent decade, it can be noticed that this human-machine interface technology Is of high advantage for a large number of application areas, and therefore is already exploited by users as from, science or industrial domain. With the availability of less expensive infrastructure for performing VE research it must be expected that research in VE at the universities will significantly increase and that this technology will be established in the educational area as a basic tool for communication and teaching. Today fast development of the PC architecture allows to create computer systems with high performance for simulation and visualization, using distributed (cluster) systems and parallel computing, Advantages of such systems consist in the effective cost/performance rate that provides with the perspective of wide application.

The talk presents some results of cooperative project performed by Fraunhofer Institute of Mediacommunication, Germany and Institute of Computing for Physics and Technology, Russia. This research project is aimed at the development of new technology which can be extensively used in different branches of science, industry and education. We offer to create contemporary VE installation for physical modeling, industrial design and rapid. prototyping, and educational purposes using widely available standard components of high performance PC, low-cost projection systems, and proprietary tracking and interactive devices.

Our experience shows that VE technology provides a great benefit in fundamental research, and in practical problem solving when one concerns complex phenomena and extremely big data sets, using immersive visualization technique and direct data manipulation in virtual space.

Visualization can be of great significance in mathematics and physics issues where new insight may be inferred from images showing hidden properties. In the last several years, there has been numerous examples of topologically complex objects visualization. Nevertheless, the different panels on MathVis at Visualization'xx conferences have shown a permanent interest in this area, because non-trivial objects might serve for educational aims and as a pretty good test-bed for visualization tools.

In this talk we present a several topics in visualization and animation of topologically non-trivial objects: the open string in 3D space; a process of un-coupling of 2 coupled handles on a sphere in 3D space by means of a horaotopv in the class of embedding; the protective plane and the projective 3D space; the virtual planetarium in CyberStage

Various properties of these basic objects are visualized; their non-orientability and non-trivial connectivity, and two representations of the protective plane in 3D space are examined; the cross-cap and the Boy immersion.

As an example for the scientific research application of topologically complex objects we present visualization in siring theory and some results obtained from visual study of strings.

As an example for the educational application in virtual environment, intended for teaching and demonstration of basics of astronomy, we present the virtual planetarium in CyberStage. The application includes 3D models of-3C objects in the Solar System, 3200 nearby stars, a large database, containing textual descriptions of ail objects in r scene, interactive map of constellations and tools for search and navigation.

As an example of industrial application we present a new approach for the simulation of elastic objects in VI under real-time conditions- Simulating an object's elastic deformation is one of the most important features ii application fields, where 3D object behavior is explored, Especially in the case of user-object interaction it is desirable to compute these deformations as fast as possible, The approach makes use of the method of finite elements and precomputed Green's functions. The simulation is interactively visualized in fully immersive rear projection based VE such as the CyberStage and semi-immersive ones such as the Responsive Workbench, Using pick-ray interaction techniques the user can interactively apply forces to the object causing its deformation.

We conclude that Virtual Environment has successful applications in various fields of science, education and technology. Future use of VE will be widespread in different domain of Science, Industry and Education.