VIRTUAL REALITY ENGINEERING CONTENT ANALYZER FOR ENVIRONMENTAL SAFETY AND ACCIDENT CONSEQUENCES ANALYSIS APPLICATIONS

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Abstract

Profound engineering analysis of the safety related issues, especially using advanced computational technologies (multi-dimensional CFD, multi-step, heterogeneous chemical kinetics, complex GIS and CAD drawings, etc.) is impossible without easy-to-use engineering data management, intuitive visual modeling of the safety-critical physico-chemical processes and easy-to-comprehend simulation results representation and visualization. The last feature is especially important for customers of the safety and hazards analysis. Objective of this report is to present a set of the innovative high-end capabilities, which can be provided by Virtual Reality systems for the research and engineering communities in the industrial safety and loss prevention domains. The specific functionality and unique analytical features of the Virtual Reality Engineering Content Analyzer (VRECA), developed by Kinetic Technologies company in cooperation with Kurchatov Institute, are demonstrated for the basic example activities within hazard-lifecycle safety engineering workflow: navigation, safety-related data probing and metrology in the complex CAD environments, editing, safety report (or emergency planning report) compilation and communication via Internet.

Keywords

Industrial safety, Virtual Reality, 3D graphics, Environmental monitoring, Content management.

Introduction

A principal characteristic of computer modeling projects is the distributed nature of the project sources. During modeling it is necessary frequently to deal with the diverse data received as a result of computer modeling, experiments and engineering development representing the descriptions of processes and parts of simulated installation. There is a task how to connect in one system the scientific and engineering data from diverse sources. Those sources are usually the computer codes, which simulate the physico - chemical processes occurring inside (and outside) installations, codes for geometrical design and modeling (CAD) and other systems of three-dimensional modeling, for example – computer codes for architectural design of the sites, in which it is supposed to build the industrial installations.

Many of the commercial CAD systems used by the construction industry are primarily geometry modelers, rather than object modelers. Regardless of the file format used to export a model, they frequently export the 3D model as only a collection of surfaces representing the geometry that contains far too many polygons and unnecessary details. They also fail to preserve the aggregation of geometry elements into objects and the relationship between objects. There is no possibility of accessing and viewing information in the 3D model other than the geometry.

Traditionally, an enormous amount of information has been communicated by means of scientific author's documents, including 2D drawings and 3D scenes based on interpretation of source information. Certainly, the science

has embraced many kinds of web hypertext technologies, but information access continues to be based on the author's interpretation document metaphor (not on direct using of the original data).

True source-data-preserving information access can be achieved only in special cases where all the participants use proprietary software systems that understand a common data exchange protocol, or the shared data source. Aside mentioned features, a resulting project scene must be able to adapt to the information delivery method. Effective project delivery depends on making current and correct information available to the all project consumers, wherever they are and whenever they need it. In other words, it must be complex scientific data content, integrated with Virtual Reality environment.

PIEX - object library for scientific data content carrying out

In practice of scientific researches and engineering designing, results of research frequently are two or three-dimensional files. It can be both the results of the digital simulation calculations and results of the physical parameter measurements.

In order to give to the researcher the software tool, which combine the efficiency of direct access to numerical data without their distortion at visualization stage (which is implicit consequence of the generally accepted approach to data visualization in current graphing systems) the special data format and appropriate software library were developed.

The structure of the software library **PIEX** (Packed Information EXchange library) allows:

- To have an opportunity of access to the initial data whenever you need and data do not changed by the interpretation or post-processing.
- The data format is free from computer restrictions.
- The data can be visualized in a list of forms according to user's choice.

The **PIEX** data format has the following features:

- The numerical range for representation of the data is not limited.
- Accuracy for data storage and representation method is defined by the user.
- The size of data files is limited only by the storage media size.
- Initial or input data is any format of computer data, processed by specialized converting software.

Original "gridding" procedure is used for creating uniformly-spaced data volumes from irregularly-spaced and unstructured data.

The developed format of the data differs from popular formats of data storage (HDF, HAIF, netCDF, USGS DEM, ENVI etc.) by absence of restrictions on a dynamic range of representation of the data that is especially important for "differential" digital computations, and don't includes interpreting images into the initial data.

Besides, it is possible to use a "logic weights" matrix for each node point of the data field, depending on a nature of the initial data for marking of environment (wall, liquids, gases media, terminals…), or for division on data "logic layers " for operations with the different series of the data.

PIEX software library is released as MS Windows ActiveX component and useful for embedding into MS Windows applications. Any MS Windows application with "container" properties (like MS Internet Explorer, Word, Excel etc…) can be used as scientific content carrier application.

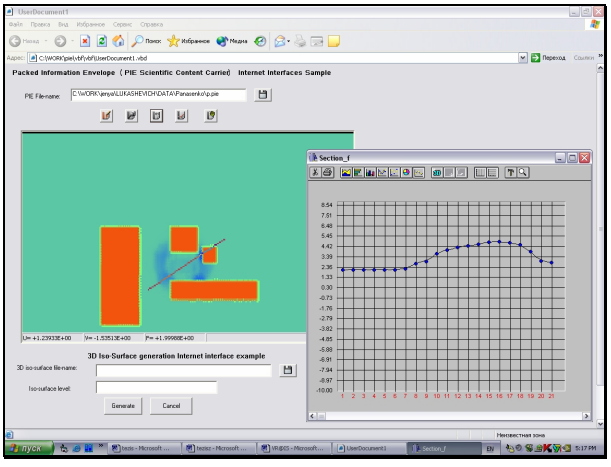

Fig.1 Using of MS Internet Explorer as scientific data content container

VPPR – two dimension data fields analyzer and post-processor

As the interactive graphic interface for the researcher was developed **VPPR (Visual Post Processor)**. It is utility program for visualization and detailed scientific analysis of a **PIE** (Packed Information Envelope) format files.

The program works in operational environment **WINDOWS 9X/2000/XP** for **Intel**-platforms. If compare with the majority of the graphic images editors, this program works with real "user's world units " i.e. with values of function expressed in real physical sizes and in real spatial coordinates.

The **VPPR** program allows:

- To analyze any quantity of data arrays (time or spatial sections).
- Choose one or several (included in a combination) forms of the analysis of the data.

- Construction of cross-sections through a data field.
- Selective testing of data element.
- Definition the coordinates of the chosen point on a data field.

The cross-sections processor gives a wide range of analysis methods of one-dimensional dependencies

- Various forms of knot points,
- Spline-interpolation of dependences,
- Three-dimensional representation of dependences.

The program functionality can be easily extended by implementation of the specialized modules focused on concrete kinds of the data analysis and data processing.

Virtual Reality Engineering Content Analyzer (VRECA)

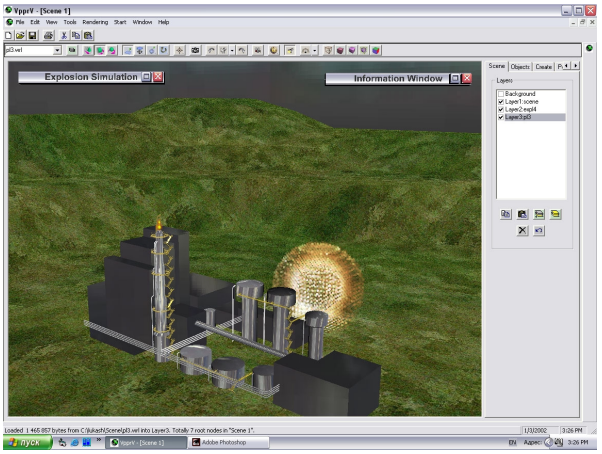

Fig.2 Example of 3-dimensional simulation for blast wave and thermal radiation from fire-ball.

Virtual Reality Engineering Content Analyzer is complex multi-language package based on Virtual Reality Modeling Language (VRML) as a basic data main-stream. The modeling of environment and equipment has objects to combine physical, chemical and dynamic models. The ultimate goal of virtual realty data modeling is to provide three-dimensional web-based modeling information for managing, accessing, and viewing of complex processes.
Virtual Reality Engineering Content Analyzer is a standalone application for MS Windows 95/98/ME/200/XP operation environment, capable of browsing and analyzing virtual worlds written in Virtual Reality Modeling Language and CAD drawing format description files. Virtual Reality Shell provides navigation paradigms (such as walking or flying), which enable the user to move the viewer through the virtual world. Additionally, it provides a mechanism that allows the user to interact with the world.
Virtual Reality Shell is designed on the basis of the universal component technology that provides the opportunity to create a wide range of 3D applications: from graphical processors to complex multi-user Internet-services.

Virtual Reality Shell supports: OpenGL; Direct3D; Java language; Splines and NURBS; external Task Interface (ETI). The Virtual Reality Shell uses the ActiveX Automation technology for external modules implementation.

Unique analytical features of the Virtual Reality Engineering Content Analyzer (VRECA) are demonstrated for the basic example of 3-dimensional simulation for blast wave and thermal radiation from the fire-balls.
Here are explained the activities within hazard life cycle safety engineering workflow: navigation (Fig.2), safety-related data probing and metrology in the complex CAD environments, safety report (or emergency planning report) compilation and communication via Internet (Fig.3-5).

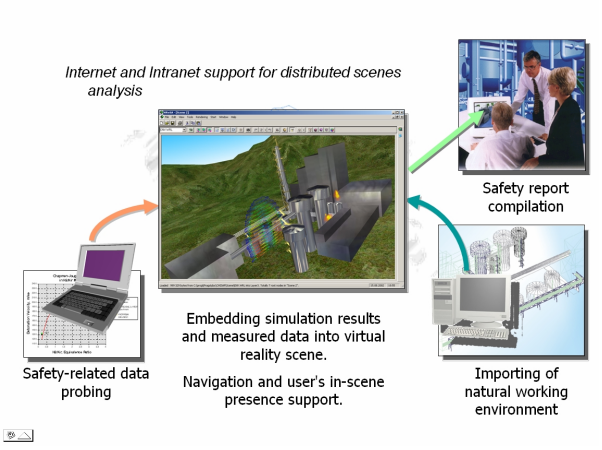

Fig.3 Hazard lifecycle safety engineering workflow

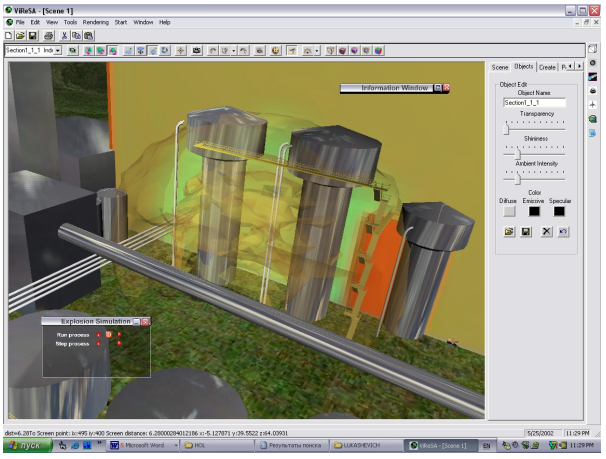

Fig4. 3D Data field cross-section and iso-surface capabilities sample.

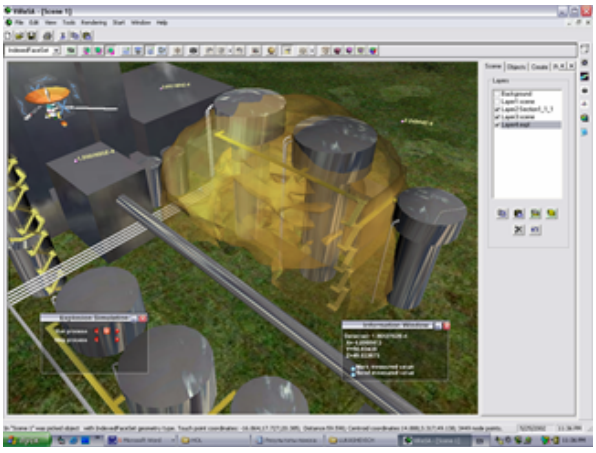

Fig.5 Detailed explosion zone analysis and time-slices processes simulation.

Conclusions

The research described in this paper has shown that scientific data content, based on Virtual Reality Modeling Language (VRML) can successfully be used in environments safety and accident consequences analyses applications.

Future work will extend the applicability of the complex scientific data content in physico-chemical dynamic modeling of the hazardous phenomena.

Post-processing information assembling from any of scene components into an intelligent VRML model scene (scientific content), making VRML a natural choice for representation and analyzing accident models created for environments safety analyses in the new and existing industrial safety analysis systems.

References

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