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Using Virtual Reality Technology in Oil and Gas Industry

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ABSTRACT

This article introduces the research of virtual reality technologies used in the oil and gas industry. The industry is so vast that the technologies used there are radically different. Various aspects of oil and gas production were considered, such as geodata modeling, real-time production visualization technology. The problems and possible solutions for translating CAD models into virtual reality applications are indicated. Also, using virtual reality technology, can increase the speed of work and reduce the risk of errors, which is extremely important in the oil and gas industry. As well as the benefits of learning and using virtual reality to improve learning and understanding of production processes.

Keywords— Virtual Reality, Oil and Gas Industry, Computer-Aided Design

I. INTRODUCTION

Using virtual reality technology in Oil and Gas industry is a new direction of industry development. A person receives 80% of information about the world through vision. Therefore, achieving realistic three-dimensional visualization of data is important when working with large arrays of geological information when designing the development of oil and gas fields.

The use of the entire complex of 3D seismic technologies in the design of drilling allows us to increase the probability of drilling for oil by more than 2 times compared with the old approaches, i.e. these technologies are already paying off when designing drilling 1–2 wells. Also, 3D stereoscopic visualization is actively used in photogrammetry, remote sensing of the Earth and other geo-information tasks.

There is an acute question about the transformation of CAD models into virtual reality models. Such as lack of realism, low productivity and frame rate, inadequate processing of complex surfaces. There is still no such integrated system in which it would be possible to convert a VR model into a CAD model and vice versa. But with the development of technology, applications are being developed that gradually facilitate this process[1].

Intuitive and volumetric representation of geological data allows an interdisciplinary team of specialists to quickly process the field information, analyze and develop the best solution for the development of this field. This significantly speeds up development and allows you to optimally plan the well trajectory and reduce the number of drilling errors. There is a research investigated the benefits of immersive VR for editing the trajectory of the well[2].The research presents a quantitative assessment of the use of immersion technologies on the example of planning the trajectories of oil wells. An experiment was developed in which the quality of tasks performed by people was compared between immersive virtual environment and the desktop workstation.

The use of additional equipment (interactive 3D devices, video conferencing systems, sound equipment, communication channels, etc.) allows to combine the efforts of various specialists from the well to the central office in real time.

II. GEOLOGICAL DATA

Oil and gas exploration is based on data from two sources - well logging and seismic exploration. Seismic surveys provide a broad overview of large formations, well log data provide detailed information on sampling sites down the wellbore.

Seismic exploration is the leading method of field geophysical surveys of the earth's crust. The principle of its application is based on the ability of rocks of different composition to conduct oscillations of elastic waves with different speeds. Mainly, elastic waves are artificially excited on the surface of the earth using explosive charges explosions during seismic prospecting. In the process of propagation in the earth’s crust, elastic waves, interacting with heterogeneities of the geological environment, undergo processes of reflection, refraction and diffraction. As a result, part of the seismic energy returns to the surface of the earth, where it is captured by special devices called seismic receivers, or seismographs. Analysis and interpretation of the results obtained after processing allows to determine the depth, shape and petrophysical properties of the properties of researchable objects and, therefore, their structural features, reservoir properties and fluid saturation.

Logging includes a variety of geological well survey methods. As a rule, the procedure is accompanied by the preparation of the necessary documentation necessary for the detailed study of wells. Such research is usually based on the study of geophysical fields. To unveil physical reserves of wells, well logging is carried out using various methods that have different efficiencies, not only depending on the terrain and tasks set for logging, but also on many other factors. Well logging is carried out in various ways, but they are united by one

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common task: the study of artificial and natural physical fields of various nature. The intensity of the cutting depends on the properties of the soil.

There are several well logging methods. The method of electrical research is based on changing the magnetic field of the soil layer. The principle of operation is as follows: using a special probe in the mine, measurements of the electric field are made. Using the method of nuclear-geophysical logging, find out what the density of the well, its porosity, the amount of coal, whether there is hydrogen or other gases in the soil. There are the following subtypes of this research method: gamma-ray; gamma-gamma logging; the neutron method. Acoustic logging measures the speed of the sound signal, which is necessary for him to pass the soil in the space near the well.

III. VISUALIZATION IN VIRTUAL REALITY

Investigating seismic data, experts determine areas of interest that are compared with log data. Based on this information, they model subsurface structures, such as rock layers and boundaries between materials. Then, using the software, three-dimensional modeling of underground structures is performed. To facilitate the work with three-dimensional models of underground layers, in German National Research Center for Information Technology[3] have developed a cubic mouse for navigation in a seismic cube and for placing three layers. This device tracks input in the form of a cube that simulates the shape of a seismic cube. The mouse-cube is controlled by a sensor with 6 degrees of freedom, and the orientation of the seismic cube is synchronized, effectively placing the seismic cube in your hand. The mouse rotates the seismic cube. Because other structures, such as horizons, faults, and wells, are defined relative to the seismic cube like in figure.1, and they move with it. Analyzing these 3D maps, experts estimate the probability of finding hydrocarbons there and their expected volume, after which further work is planned [4]. Geologists have to work with large amounts of data, analyze them and draw conclusions that require a lot of time and effort.

The oil and gas industry use three-dimensional geometric models that are created using CAD systems to interact with information systems. This is due to the fact that CAD systems have evolved from drawing programs into collaborative design tools. It combines geometric modeling with specialized tools for managing engineering documents and computer visualization. This combination reflects the need for enterprise information management systems-data warehouses that help reduce costs and increase efficiency by improving control over the entire project life cycle.

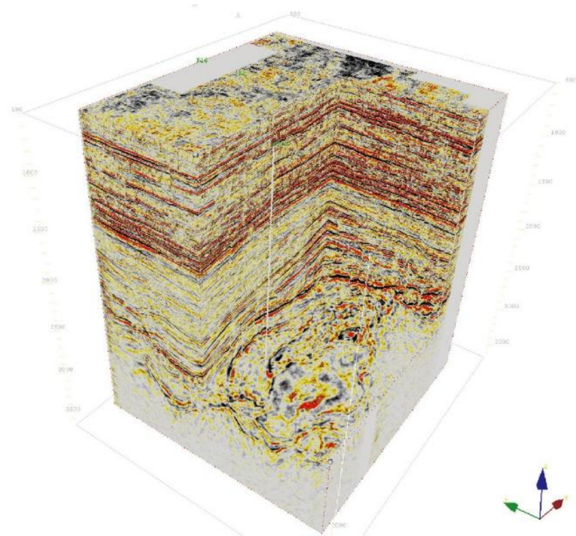

Figure:1 A 3D seismic cube

There is a significant gap between VR and CAD models due to different VR tools and CAD goals. VR tools support actions with high visualization requirements to provide better immersion in physical conditions using a virtual model. While CAD tools create detailed, performance-oriented models.

There are two main methods for integrating VR technology into a CAD system. The first is when virtual reality is a form of human-computer interaction that uses CAD systems to perform common tasks, such as collecting and drawing. The second considers VR as an improved form of visualization of the CAD model in real time and interaction with it.

But in the implementation of both of these approaches there are problems and difficulties. One of them is the complexity of CAD models that were not intended for real-time visualization. This leads to an unsatisfactory frame rate, which reveals the entire geometry and increases the complexity of the model. Another problem is incorrect processing of geometry. During the conversion of CAD to VR, there is usually a loss of accuracy and geometry. Because of this, virtual reality models are not of high quality and contain many geometrical errors. Active research is underway to solve these problems. For example, some CAD tools are developed taking into account virtual reality technology, but there is no possibility to integrate them with virtual reality resources. Or they may work with several project environments, but because of this, it is difficult to create complex models.

An application that tries to solve some of these problems is Environment for Virtual Objects Navigation (Environ)[5]. One of the goals of ENVRON is to create an infrastructure for optimizing the generation of a virtual reality environment based on CAD models. This application contains a 3D environment for real-time visualization and plug-ins that convert models from third-party applications to the Environ's format. This format extracts and exports semantic information such as

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databases (external) and attributes (internal) for models. Environ imports Aveva's PDMS (Plant Design Management System) and Intergraph's PDS (Plant Design System) formats. Since the virtual reality model supports semantic information, these methods become effective for analyzing projects.

ENVIRON supports the design of drawing areas, which is useful when modeling offshore oil platforms, where material, material supply and overloading are complex and expensive. Using the CAD platform model, users can correctly draw areas for drawing, given the location and shape of objects. The screenshot of platform in EVNIRON application is shown in figure.2. The application also provides the ability to rotate, move and scale, and also provides an accurate measurement of the distances between different objects. Another advantage that ENVIRON users can afford is to embed real terrain data, combine it with images from space and easily convert it to a three-dimensional grid. And then use this data in a virtual reality environment in real time.

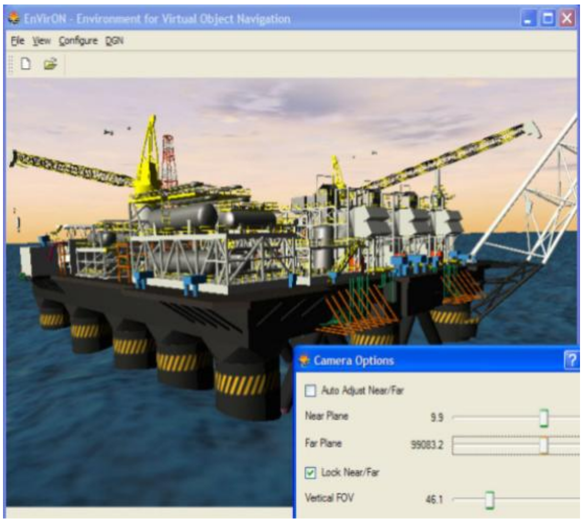

Figure:2 ENVIRON Screenshot

IV. TRAINING AND BENEFIT

Virtual reality, being a training and familiarization tool, is ideal for helping professionals in the energy sector understand their craft better. Many interesting applications are being worked on that can allow energy companies to develop use cases, train employees in "virtually identical" workplace environments, increase productivity and decrease risks.

The VR training can offer oil and gas companies numerous benefits. Oil drilling platforms, refineries and processing plants are some of the most complex pieces of machinery that are managed by highly trained professionals, who sometimes have to work in harsh conditions. As even routine operations require thousands of expertly executed man-hours, the importance of proper training cannot be undervalued. Creating a virtual replica of a rig is a lot cheaper than constantly ferrying students back and forth from one. Since VR technology was developed enough to provide the virtual experience as good as the real one, students can graduate with a good grasp on their skills, saving significant amount of money.

The participants of Gurchillaet al. [2]research were able to accomplish the tasks of editing a well trajectory faster in an immersive virtual environment than in a desktop environment. In this experiment, sixteen participants planned four oil wells. Each participant planned two tracks for wells on a desktop workstation with a stereoscopic display and two tracks for wells in immersive virtual environment. The solution time required for an individual participant to perform two tasks in a virtual immersive environment was faster than the solution time required for the same participant to perform two tasks in a desktop environment. Fifteen participants completed the task in IVE faster than on the desktop, while only one participant completed the task faster on the desktop.

The participants in this research had a broader understanding and accurate views in immersive environment, which show the number of correct decisions. Nine participants were the best solutions in IVE, one participant performed better in a desktop environment, and six participants had the same number of correct solutions in both environments. There was not only an increase in the speed of solving problems, but also an increase in the accuracy of solutions, which is very important for the oil and gas industry, where saving time and money comes first

V. A COLLABORATIVE WORKFLOW

With improved technology, people need to analyze more and more data. Therefore, the methods that help process this data should also keep up with the times. The described project from Ismail et al [6] is a service-oriented architecture designed to create a collaborative environment called Collaborative Engineering Environment (CEE). It integrates Virtual Reality methods into a system in which the execution of various engineering modeling sequences is modeled as scientific workflow. Attention will be paid to offshore oil and gas engineering. Cooperation is most important in this area, because solutions are interdependent. Each decision or team activity can affect others. For example, when designing an oil platform, changing the position of large and heavy equipment on a process plant can jeopardize the stability of the production unit. There is also an internal connection between the decisions of various subprojects, which requires intensive interaction and discussion between the working departments. Another reason to establish a connection is that, experts are dealing with the same information, for example, on risers, geolocation systems, platforms, etc. As a rule, they have different ideas about this data, based on their specialization.

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Another difficulty, when working with offshore engineering projects, is visualization of large engineering models. At the conceptual design stage of an industrial enterprise, several simulations are needed to assess the reliability and implementation of the project. Some of these simulations require tremendous computing power, such as using computer clusters. To provide the user with a full understanding of the results, visualization should be as accurate as possible.

The CEE architecture provides a variety of computer-supported collaboration technologies. The system consists of three components: Collaborative Visualization Environment (CVE) based on a Videoconference system (VCS) and a Virtual Reality Visualization (VRV); Project Management Environment (PME) is responsible for overall project management and tracking of all information and various artifacts; and a Scientific Workflow Environment (ScWfE) is associated with Grid Computing Infrastructure (GCI) to perform huge engineering simulations. Thanks to the flexibility of CEE, it can be used to jointly solve problems or collect new data. Each workflow includes a sequence of simulations and is processed by joint visualization.

VI. CONCLUSION

Virtual reality technology is already deeply rooted in our daily lives; from the entertainment tool they have gradually become used for professional needs. Virtual reality technologies are used by both architects and designers, as well as doctors and engineers. Especially these technologies are useful in the oil and gas production, which is one of the most expensive industries.

Visualization and further processing of geological data is very important for successful exploration of oil-bearing formations. Virtual reality technology greatly simplifies the processing of large amounts of data. In addition, the use of technology reduces the likelihood of errors, it is important in this industry, where mistakes can lead to millions of dollars' losses.

The main problem is the transfer of CAD models to virtual reality applications. Because these models were not naturally created for transmission to the virtual environment. Many specialists work on this problem and find compromise solutions, which in turn bring some aspects to the sacrifice of others. One such solution is ENVIRON, most of whose research is focused on rendering massive models in real time.

Another usage area of virtual reality technology is the creation of collaborative workspaces. Due to the presence of many departments that are responsible for their projects, cooperation plays an important role in the successful implementation of all the work. This article contains information about the Collaborative Engineering Environment technology, using the example of production onan oil platform. Since cooperation is most important there because of the limited space and remoteness of land.

While virtual reality technologies have almost reached the limit on entertainment, they have significant growth potential in the oil and gas industry. Industrial companies have sufficient resources and good reasons to invest in the development of virtual reality technologies for use in the enterprise.

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