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Introduction to Immersive Reality

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Abstract

Computer visualization continues to improve and to more realistically represent nature. It is now possible to take geological, geophysical, drilling, engineering, and economic data, and to correctly position this data in time and space. Immersive Reality uses new developments in computer projection hardware and software, and allows this data to be displayed at human scale, allowing scientists and management to walk around the middle of the data, as if they were walking around in a forest of wells and canopies. This paper introduces how Immersive Reality technologies are being used in aerospace, automotive, education, entertainment, manufacturing, medical, military, as well as oil & gas exploration and production.[1] In addition, it will introduce the theme of this special OTC session in Immersive Reality.

Data

Spatial relationships provide a common theme across the disciplines mentioned above. Aerospace engineers work with the effect of various shapes on air flow. Automotive engineers are more and more influenced by air flow, and they have a lot of equipment and wiring to package in a small space. Educational and entertainment uses of the technology are exploding, allowing students to be a particle influenced by gravity, magnetics, or electrical forces, or to walk around in the land of dinosaurs. In the world of manufacturing, it is important to understand the assembly line, as well as the components and how they are to be connected together. Doctors know the approximate shape and location of organs in the human body, and it varies a little bit with each individual. Generals want to know the terrain, flight paths, and a holistic view of the battlefield. And of course in hydrocarbon exploration we want the drill bit to hit the targets which the seismic data has imaged and geoscientists have interpreted as a prospective subsurface earth model.

Spatial relationships are recorded using individual x,y,z points, spread-sheets or tables, vectors, images, or movies. Experiencing how a series of point are related in an Immersive Environment opens new understanding, as shown in Figure 1. Most of the author's direct experience with Immersive Environments is using them to find hydrocarbons. Amazing describes how much more information is transferred from the data to the interpreters mind and from one interpreter to another interpreter or to management, when all of the data is evaluated simultaneously, in 3-D, using Immersive Reality. Numerous case histories have been presented in geotechnical conferences and at vendor facilities showing the value of simultaneously displaying satellite data, air photos, air magnetics, gravity, topography, lease ownership, source, migration, timing, play fairways, play types, outcrop analogs, prospect specifics (location, extent, depth, volumetrics, trapping, etc.), analog fields and reservoirs, spec and proprietary seismic data location, well locations, deviation surveys, production histories, etc. Figure 2 illustrates this by showing the interaction of an Urban Planner with the author when they are reviewing legacy seismic data describing an exploration trend in Oklahoma.

One of the keys to this new technology being useful is the ability to directly read in data from its native format. In oil & gas exploration and production this means tops from geologic interpretation files, well locations from well files, perforations and production histories from spread-sheet tables, synthetic seismic traces from modeling programs, horizons and faults from one of a dozen different interpretation programs, seismic attribute sections and volumes from processing and interpretation systems, etc.

This process, with parallel data structures is undertaken in each of the different disciplines mentioned above, whether in collecting, processing, or interpreting spatial data, information, and knowledge. Professional language barriers keep developers from sharing and learning from each other, across disciplinary boundaries. Another key is to have the data indexed spatially, temporally, and by the activity or process in which the data is used.

Bowen Loftin has defined Virtual Reality as "the application of integrated technologies to create an immersive, multi-sensory computer-generated environment that supports direct interaction by two or more participants."[2]

Tools

Immersive Reality environments are complex. There are many parts to each set-up, and each part needs to be working together in order for the entire system to be functional. Components include hardware, software, displays (visual, auditory, haptic, vestibular), tracking, interaction devices, networking, etc. Early development has been tied to supercomputers of various types. These early prototypes are giving way to PC driven networks of theaters, which provide an environment for multi-person collaboration, even though participants are located at different sites.

When first walking into an Immersive Reality Environment, the most obvious component is the large screen. These can be large monitors, front or rear projected screens, flat or curved in one dimension (cylindrical) or in two dimensions (spherical). The display is more immersive if it is large enough for participants to walk around in the middle of the display space, involving their entire body in the experience. Human scale visualization allows participants to interact with data and presentations as if the data and presentations were another person, and, given the images are stereo, participants truly become immersed in the data. Head-mounted displays are not as effective as theaters, specifically because more of the participant's body is immersed in a theater configuration.

Sound (speech and hearing) and haptics (force, pressure, tactile, thermal, vestibular, vibration, etc.) add to the reality of presentations. Sight gives us length, width, height, color, motion, and objects. It is useful to know if someone you are giving an immersive environment presentation to is color blind, does not see in stereo, or has hearing loss. Obtaining this personal information can become an issue in giving effective presentations. Sound gives us loudness, pitch, voice, location, and is particularly useful in hydrocarbon exploration, because we can hear behind us. We can use sound as a navigation aid. In addition, humans have much more audio dynamic range than visual dynamic range. We can hear the equivalent of angstroms to kilometers, whereas we need telescopes and microscopes to see across this same range. Olfactory (presence, memory stimulus, diagnostics) and vestibular (posture and acceleration) displays are being experimented with, and they have problems with sampling, capture, diffusion, human variability, and relation to vision.

Immersive Reality can be personal (helmet, visor, or boom or push devices), for small groups (CAVES™ and desks or workbenches), or for large group presentations (centers, walls, or theaters). Each configuration has unique characteristics of portability, affordability, information density, collaborativeness, and immersiveness. Displays can consist of points (attached or not), lines (tethered or not), surfaces (tethered or not and above or beneath), volumes (tethered or not and inside or outside), time (velocity or acceleration), translation (forward or backwards, up or down, left or right), rotation (left or right, up or down), warping (in each axis), and users want to be able to grab, group, or move these objects along, across, or through the workspace.

Interaction in three-dimensions works at the macro level (electromagnetic, acoustic, inertial, optical), the micro level (hand or finger tracking with gloves, image based, or measuring muscular impulses), by gaze detection, speech recognition, with devices (3-D mouse, SpaceBall, 3-D force delivery, joysticks), and eventually by thought (training and human variability are key issues here).

Problem Space

Immersive Reality technology has issues, including hardware costs, software usability, domain-specific applications, cyber-sickness, human inertia, culture, and demonstrated effectiveness.[2] Computers had similar issues when they first became available. Just as the computer issues of size, cost, climate control, processor speed, input, and output were overcome, the issues facing Immersive Reality will be solved. A key difference is that Immersive Reality is closer aligned to basic human spatial, temporal, and activity experience than computers alone have ever been. This fact alone will drive development of the technology to where it allows the data, information, and knowledge our computer systems and networks store for us to become some of our new companions.

For example, humans can understand seven variables at one time. Hydrocarbon exploration involves at least 30 variables.[2] Interactive integration of these 30 variables requires access to a new set of variables before users forget what the question they were asking was. Computers can provide the data, and it needs to be provided in an intuitively understandable way. Immersive Reality provides this forum. However, there are still basic issues to overcome. For instance, the higher in management, the less desire there is to put on stereo glasses and feel like someone is making fun of them behind their back. As the Nintendo generation moves into the corporate office, these inhibitions will dissolve. Also, as the technology is used for entertainment, AEC (architecture, engineering, and construction), medical, genealogical, historical simulations, and other presentations, it will become better accepted and the user interfaces will improve. A key factor is decreasing latency, which is directly effected by Moores Law and the improvements in computer processor speed and increased memory availability.

Immersive Reality provides a new way to learn, to measure, to monitor, to interpret, and to design. As such, this technology touches most aspects of human life and modern culture. This means that the problem space being addressed is about as broad as the general problem space being addressed by humanity itself.

Solution Space

Exploring for hydrocarbons starts by defining a new exploration concept, based on known successes in an area-of-interest (AOI), use of data mining to define leads, and applying pattern finding technologies to define prospects within specific areas-of-mutual-interest (AMIs). The systems productivity of any computer system involved with understanding or decision making is ultimately limited by the speed of information transfer between the computer system and the human mind.[4] Working across scales, which can range from a geologic basin (multiple states), to a play fairway (a few counties), to a specific well path location (a few acres), is the ideal solution space for Immersive Reality. Computer derived models allow the development of robust earth models as well as collaboration between team members across different disciplines and located at different sites. It is easy to make the case that Immersive Reality is opening the door to forming a virtual oil company. Of course, technology alone is not the only component of a virtual company. There must also be experience, track record, and ethereal business concepts such as trust, humility, tolerance, and the ability to work as a member of a team, located in many places.

Immersive Reality bridges the manufacturing gap between CAD and physical prototypes.[5] Companies like Ford Motor Company have learned that virtual prototyping is highly interactive, and, since it is digital, it is easily distributed. From a human factor perspective the system should be non-invasive, easily to use, and have a fast learning curve.[5] Of course the quality of the simulation must match the required fidelity of the final product.

The new economy is based around time instead of capital, market cap instead of profit and loss, services instead of products, collaborative teams instead of command and control, virtual integration instead of vertical integration, and information instead of assets.[7] Immersive Reality touches each of these issues, specifically because it is the ideal methodology to rapidly transfer data from a computer to the human mind. The information about assets is becoming more valuable than the assets, and this information can best be interactively evaluated in an Immersive Environment.

Results, Observations, and Conclusions

The power of human scale visualization and direct interaction with data in an immersive environment, as if scientists, engineers, and management were interacting with another individual, is highlighted by the number of immersive environments which are being set up in oil and gas companies around the world. This technology is creating a fundamental change in the way the individuals in the oil and gas industry interact with data, information, knowledge, and the way in which decision making occurs. Immersive Reality has the potential to become a disruptive technology, particularly as it migrates from science-based research projects to home-based entertainment commodities.

Maps and blueprints have been the planning basis on which offshore technology has been developed, operated, and maintained for decades. Immersive Reality is making maps and blueprints obsolete, particularly as projects become larger, include more components, are in harsher environments, deeper water, and are more automated. This OTC Special Session is a tutorial, an introduction to, and a status report on the state of the new computer generated world of Immersive Reality.

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Figures

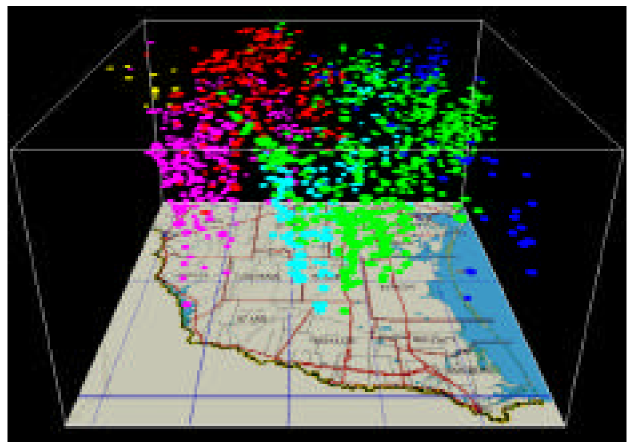

Figure 1. Production history data derived courtesy of NRG Associates from Texas Railroad Commission from District 4 in South Texas. Deposition starts on the left with bands of Eocene, then Wilcox, Vicksburg, Frio, and Miocene near and offshore.

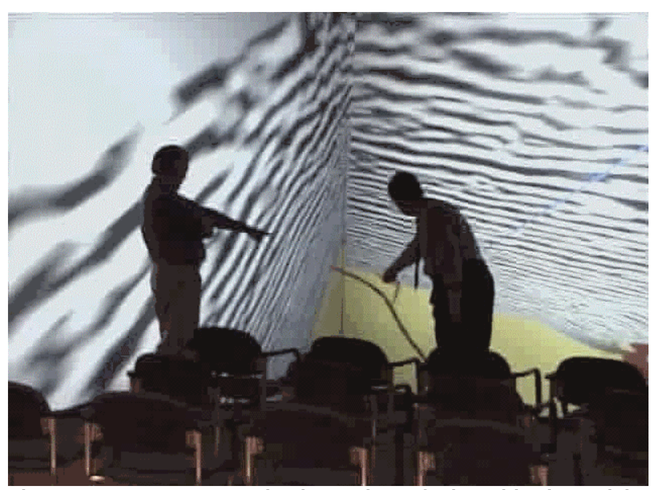

Figure 2. Legacy paper seismic sections, fault and horizon picks, wells and lease holding, etc. all come alive when users are directly interacting with the all of the data in three-dimensions in an Immersive Environment.