Introduction

The drilling of wells into complex reservoirs requires the close collaboration of experts from different domains. These experts tend to operate in different technical silos and communicate in terms that might be unfamiliar to other experts. Combine these issues with the time critical nature of drilling and the common situation where domain experts are remote to the drilling location and to each other, and it is clear that a difficult problem is made harder by the challenges of collaborating effectively. A collaboration environment must be established to ensure that critical decisions are made by (1) maximizing the expertise from each domain expert (2) ensuring that each domain expert is analysing an up to date and common set of data and (3) properly records the decisions that are made and why they were made. Historically the collaboration environment has been a mixture of paper maps on walls or large tables coupled with 3D reservoir models viewed through 2D computer monitors and a mix of email, video chats, phone and text communications. Paper maps are nearly always out of date relative to 3D models and 3D models often don’t reflect the latest data. Decisions are recorded in a haphazard way principally on email or personal journals. The authors believe that this uneven environment is not conducive to making the best decisions in a timely fashion nor to have a proper log of the decisions taken.

To explore an alternative, the authors have completed a pilot project to determine if an augmented reality system would greatly enhance the collaboration environment. The pilot allows the 3D drilling scenario to be rendered as a hologram in multiple locations to allow domain experts to collaborate on the drilling scenario. Unlike traditional approaches the domain experts are not constrained by 2D monitors or static wall-size paper maps. The hologram of the subsurface can be conveniently placed in an open area and the collaboration participants can literally walk through it, closely examining various features that draw their interest. Participants at a remote location are rendered as avatars. The model is updated as new data arrives. An immutable timeline records the observations of participants and the decisions taken. The net effect is as if the domain experts were transported to the subsurface area of interest. The authors believe that such an environment is conducive to productive and close collaboration of domain experts and will lead to well-informed decisions.

Background

Augmented Reality (AR) and its close cousins Virtual Reality (VR) and Mixed Reality (MR) are emerging technologies. In recent years AR/VR/MR has moved from the laboratory to the market in the form of a series of products that promise ever increasing performance and ever declining price points over time. At the same time few compelling applications have been developed which leverage these technologies and products. There have also been spectacular failures such as Google Glass. It might seem that AR/VR/MR will go the way of 3D TV and quadraphonic stereo. A more apt comparison however is to cellular phone technology which for decades was a market niche but now the smart phone is the must-have personal accessory for nearly everyone.

The terms AR, VR and MR are often used differently by different authors. This is reflective of the emerging nature of these technologies and the wide scope of application. The often cited virtuality continuum (Milgram 1994) helps put these terms in context.

The virtuality continuum describes a range of experience. One end of the spectrum is the real world while the other end of the spectrum is a completely generated world that we now call virtual reality. In between these two extremes is some form of mixing between the real world and elements of the virtual world. Augmented reality exists at point near the real-world end of the continuum where the user experience is very natural and enhanced with virtual elements.

In this paper we are concerned with AR. Specifically, we are concerned with AR as implemented in Microsoft’s HoloLens, a head mounted display that uses a see-through optical technology called waveguides to combine a view of the real world with images generated in the HoloLens.
Figure 1 The Virtual Reality Continuum. The left extent represents the real world while the right extent represents a completely generated world.

Figure 2 The Microsoft HoloLens. This is an untethered head mounted computer that generates holograms in the user’s view of the real world.

Industry Application of AR

AR has already acquired an impressive track record in various industries for commercial applications. Benefits have included lower costs, improved safety, improved outcomes and better real-time decision making. AR is used in the auto industry to simulate new vehicle interiors on low cost prototypes (Porter 2010). This approach is more cost effective than building high quality prototypes and more accurate than VR which cannot effectively assess human factors. AR has many applications in medicine, among them color coding veins and arteries during neurosurgery (Barfield 2015). AR has not yet been realized in the architecture, engineering and construction industries, but potential applications abound. Among many possible applications, prototype systems give users a type of x-ray vision to see buried utilities to avoid costly construction mistakes and to see through walls to inspect columns and rebar (Barfield 2015). AR will have applications in nearly all industries. For various historical reasons, the uptake for AR is much faster in some industries than others.

AR Potential in the Oil & Gas Subsurface

The compelling reason for using AR in drilling scenarios is to improve real-time decision making. Drilling into oil & gas reservoirs involves monitoring and making changes to the drilling plan while drilling is in progress. Wells are planned based on subsurface models which inherently lack the precision needed to steer the well to the planned geological targets. As the well is being drilled, measurement-while-drilling (MWD) and logging-while-drilling (LWD) technologies provide a steady stream of raw data to the surface which can be integrated into the existing subsurface model to incrementally improve the model accuracy and the well plan and therefore greatly increase the chance of success for the entire operation. The integration of data from the wellbore into the model is not automatic and must be supervised by a team of domain experts who are under time pressure to continually assess the drilling plan and take appropriate action. The time pressure exists because it is cost prohibitive to stop or delay the drilling operation to wait for analysis. Finally, this real-time collaboration is further complicated by
the need for round-the-clock analysis and the common situation where the team of domain experts is remote from the drill site and often separated by great distances from each other.

There are many models of real-time decision making (Azuma 2005). Perhaps the simplest and the most often cited is the OODA loop (Boyd 1996), an acronym made from Observe, Orient, Decide and Act. OODA has a military origin and defines the essence of winning on the battlefield as being able to run your OODA loop faster than the enemy thereby making better decisions leading to victory. In the context of a drilling scenario, the adversary is Nature which is revealing sometimes unexpected problems as drilling progresses. The challenge of applying the OODA loop to a drilling scenario is to be able run the OODA loop faster than new problems are revealed in the subsurface.

Current practice in subsurface collaboration is for the domain experts to collaborate by clustering around large display monitors if they are co-located or using separate displays in conjunction with video chat and screen sharing tools if they are not. This is less than ideal for several reasons. The first reason is that the use of 2D screens to gain a shared understanding of a 3D problem is limiting. Another reason is that human-to-human interaction is impaired by the ineffectiveness of eye contact or visual cues in such an environment. Billinghurst (1999) exhaustively elaborates all the barriers to collaboration through fixed screens and describes how AR can address each of them. Consider a team of architects collaborating around a table covered with blueprints of a new building. Such a shared work environment would be greatly preferred over screen-based approaches. The goal of augmented reality drilling scenario is to have domain experts collaborating around a shared 3D visualization of the drilling operation.

**Example Drilling Scenario**

Several drilling scenarios were considered in the pilot, one of which is described here. For the scenarios we used real proprietary and public datasets. In this scenario, named “sidetrack”, a well that is being drilled runs into severe problems which halts drilling activity. The domain experts must evaluate a plan to add a sidetrack to the existing well bore in order to save the well.

![Figure 3 The “sidetrack” drilling scenario being analysis in AR by a geologist, a well engineer and a management team member. The remote well engineer points with her laser to the problematic well section. The displayed dataset was modified from free surveys of the Dutch F3 block which are released by dGB via the Open Seismic Repository (OSR).](image-url)
The problematic well path up to the sidetrack depth along with RT GR log and the updated formation tops added along the wellbore have been to the current geological model. The domain experts in this scenario include a geologist and a well engineer. The geologist and well engineer are not collocated. Each wears a HoloLens and examines the most up to date 3D model of the subsurface showing the current extent of the wellbore. Observations and decisions taken are recorded in a timeline that is immutable and will represent the historical log of the collaboration. A management team member co-located with the geologist also joins the collaboration session using an iPad. Whether co-located or remote the collaboration participants can speak to each other and see gestures made by others. The well engineer plans various sidetracks on the wellbore which are immediately commented on and evaluated by the other participants.

Conclusions

The real trial proved that AR technology has advanced to the point where complex subsurface geology and equipment such as well bores can be realistically modeled as holograms in detail that rivals the best 2D displays. Given that AR has shown increasing penetration and utilization in various industries, there can be little doubt that AR will have an impact on subsurface analysis. The challenge is to determine the use cases where AR is best applied using current technology. The authors believe that one such application is subsurface collaboration for real time decision making. The pilot project described here is being further developed into a production system and will be applied for more field trials in near future.

References


dgB Earth Science: https://www.dgbes.com/

