Investigating the Effectiveness of Security-Enhancing Visual Protections for Immersive Collaboration

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Abstract

Immersive technologies such as augmented reality and virtual reality show great potential to enhance important workplace activities such as collaboration. It is important to carefully consider how these technologies will be incorporated into a professional setting to ensure tools based on these technologies will provide a high quality user experience while meeting the security needs of industry. We present a prototype tool that we have developed for collaborating over petroleum reservoir scenarios involving sensitive data using a visual data protection mechanism that allows for three levels of visual control over regions of data. We report on user feedback resulting from exploratory evaluation of the tool in one scenario with petroleum engineering subject matter experts.

Index Terms: Computing methodologies—Virtual reality; Security and privacy—Usability in security and privacy

1 Introduction

The oil and gas industry has long used visualization to help analyse the large, complex datasets that are commonly encountered in this field. Early attempts at immersive applications were regarded as promising, however factors such as the immaturity of the technology, the lack of effective 3D user interfaces and user readiness prevented immersion from fulfilling its promise [2].

More recently, the search for intuitive data modelling, visualization and analysis tools has lead to a variety of innovations using highly interactive visual computing technologies [7] and new immersive applications taking advantage of modern head mounted displays as well as CAVEs [1]. For instance, Cabral Mota et al. [5], utilized a virtual transparent lens that was attached to a controller or hand and removed occlusion to provide a clear view when probing into the reservoir data to understand hydraulic connectivity. Our application provides a variety of different immersive reservoir analysis techniques and is focused on understanding how professionals can collaborate over sensitive reservoir engineering data.

When considering a reservoir model, there are a variety of analysis tasks performed. One key task is to inspect embedded structures such as wells within the subsurface and visualize how they interface with the geology around them. The reservoir data must also be inspected to understand how areas of the reservoir interact when hydrocarbon extraction is occurring. Typical analysis involves searching for deficiencies in the geological model or regions of interest that may benefit or impede production. A commonality in these tasks is they require a user to understand the properties of specific cells within the model, while maintaining an understanding of the greater context of the reservoir structure such as layers, relative spatial location to wells or faults, and the form and location of specific geological features that effect production.

High-impact decisions are made as a result of the analysis of these datasets, often with time constraints and in collaboration with a variety of stakeholders across disciplines. Often in real-world scenarios, collaboration must occur between users with different levels of access to the data. Some users such as decision makers and key technical personnel within a government agency or oil company will have privileged access to the data. Others such as sub-contractors, trainees or partners in joint exploration ventures may have a lower level of access to the data. Currently, in order to collaborate over this data, all parties will be shown this sensitive data even if it is not required, relying only on legal agreements to prevent information leakage. Alternately manual effort will be expended to create carefully sanitized datasets that have important details removed. The sanitized models are then provided to parties with lower privilege and then conventional collaboration methods such as meetings are used to discuss these models with higher privilege users that have greater insight into the data.

There are significant flaws with both of these existing approaches. When sharing highly sensitive information with only legal protections, the fundamental security guideline of providing the minimum amount of information to parties that require it is not followed. Certainly, legal agreements can mitigate loss of information, however there is still no complete assurance that there will not be information leakage. All users have a complete understanding of the data, and it may be difficult to prove how that information is disseminated should information leakage occur. When sanitizing data and collaborating over the data using conventional techniques, much time and effort may be spent properly sanitizing the data, and errors may be made. Collaborating between users with different levels of access to the data that do not have a real time view of the specific information can be time consuming and frustrating.

Our system proposes to solve both of these issues. Users that have a lower level of access are provided a view that shows only what they need to see, and all parties can enjoy the efficiencies of real-time collaboration over the same dataset.

2 Related Work

Augmented reality (AR) security has been discussed broadly in a variety of works such as [6]. In this work security and privacy challenges for AR have been organized along two axes: system scope and functionality. Functionality is categorized into output, input and data access. The authors consider these functionality challenges as they arise in three different system scopes: single applications, multiple applications and multiple systems. Examples of these challenges chiefly relate to the sharing of input and output devices in real time and the complex access controls that are required on sensor data. The authors note however that this is a relatively unexplored medium that despite the challenges, presents many opportunities to address security and privacy in novel ways.

A variety of visual protection mechanisms have been applied to maintaining the privacy of individuals that are recorded in video [4]. There have been some attempts to introduce visual obfustication to help users focus on important information while de-emphasising information that is less important in a given context [3]. However

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there seems to be little work that applies visual protection methods to facilitate collaboration over data by users with different levels of access to the data.

3 Collaboration Tool

The current implementation supports collaboration between the HTC Vive, Oculus Rift, Microsoft Hololens and a public display. There is a simple representation of an avatar for each collaborator, and users can work together on separate devices. Collaboration may also be achieved in our CAVE. We will often take work from HMD devices and display it in the CAVE for larger presentations or collaboration sessions.

Our prototype does not only allow binary access to the data. Users may be denied access and provided full access. Users may also have a third level of access which we call conceptual access. This provides a conceptual overview of the information while reducing the detail available. This is very helpful for collaboration since a user with a higher level of access can collaborate with users with lower levels of access, when a conceptual view of the information will suffice. In our application specifically, users with conceptual access are able to view the structure and spatial location of features, but are not able to see the detail such as the property values of the cells or the colour of the cells that represents their property values. This allows a user with a higher level of access to see all the information, while providing only structural and spatial information to users with only a conceptual view. Areas of key information may also have a protected region placed around them that prevents viewing of any detail so neither properties or structure is visible.

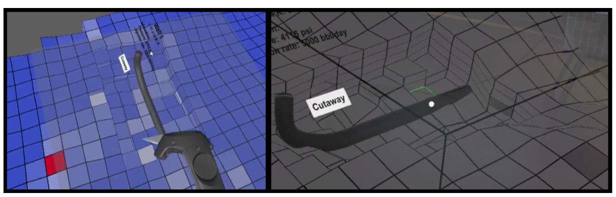

Figure 1: Detail and context views. Reservoir scenario view around the well with cells removed for inspection of interior details. On the left is the view from the HTC Vive with full access to the protected area. On the right is the view on the Microsoft Hololens with the property values obscured so the user can only see the structure.

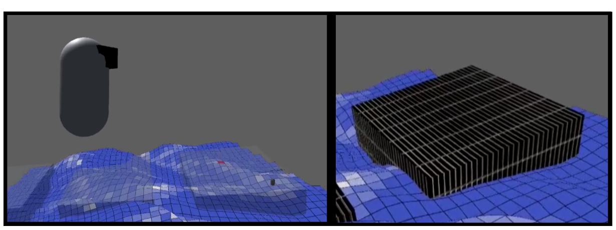

Figure 2: Detail view with avatar and protected area. On the left, view of the reservoir on the HTC Vive with full access. On the right is a the view of a protected area using the Oculus Rift where the user has no access.

In an initial evaluation with three reservoir engineering subject matter experts, we received very positive feedback, validating that providing an asymmetry of information in a real-time collaboration tool was useful and would help them work with varied parties more effectively. When performing a simplified but representative reservoir engineering well placement task they were able to achieve this task by working together, despite some participants only having a conceptual view of some areas no access to other regions. Although these results are preliminary, this provides important guidance and validation by subject mater experts with an academic and professional background in this field.

Figure 3: Left: Collaboration with the head mounted devices (Oculus Rift, HTC Vive, Microsoft Hololens). Right: Collaboration in the CAVE.

4 Future Work

We hope to run further studies to identify user preferences and needs related to protecting information in these collaboration scenarios. As we gather more insight into user needs and preferences, we hope this will provide us with additional methods of visual obfustication that will protect against information leakage while enabling collaboration. We hope that we can find additional ways to apply these protection mechanisms that go beyond demarcating a spatial region. Finally we would like to perform more studies to validate the techniques that we have currently implemented.

5 Conclusion

A workplace environment can have complex privacy requirements and diverse user groups with different backgrounds and expertise. Data must be protected in scenarios that may require collaboration with social or time pressures encouraging bad privacy behaviour on the user's part. We have analysed the needs of industry experts when collaborating over sensitive reservoir engineering data. Based on this analysis, we have developed a tool that directly addresses this need. Based on a feedback session with subject matter experts, we have received some preliminary but overwhelmingly positive feedback regarding our visual obfustication approach to controlling information leakage in a collaborative immersive reservoir engineering scenario.

Acknowledgments

This work was supported by the Energi Simulation / Frank and Sarah Meyer Collaboration Centre.

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