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Poster

Interactive X-Ray Vision Mediated Reality

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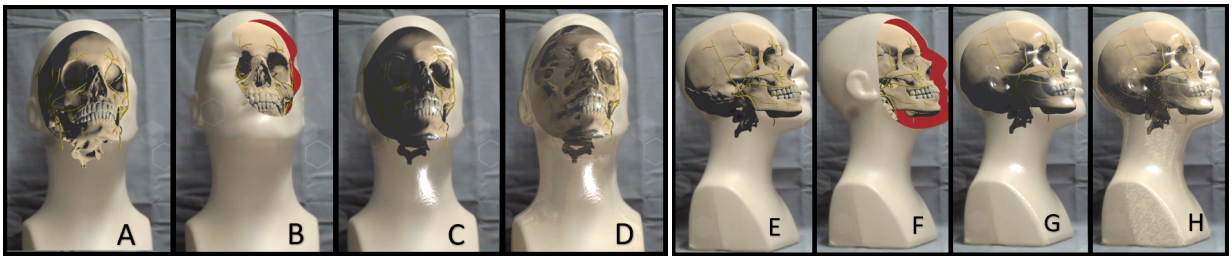

Figure 1: *Interactive Mediated Reality scene for a mannequin head with anatomical skull visualisation: A-D represents front view, E-H represents side view. A and E are the naive overlay baseline; B and F are cut-away visualization of the scene. C, D, G, and H are the scenes from proposed glass phantom overlay with different intensities of specular reflections from environment map*

Abstract

In this poster, we explore a novel approach to improve the spatial perception of embedded virtual objects in a mixed reality environment by manipulating the material appearance of real objects. Addressing the challenge of establishing a perceptually robust connection to the real world in situated visualizations, our approach provides a means for seamlessly integrating virtual objects with their real-world counterparts. This approach, which we refer to as glass phantom rendering, aims, in particular, to improve the perception of containment, emulating the characteristics of real-world glass-encased exhibits in museums. Visual results from our proof-of-concept implementation demonstrate an enhanced perception of virtual objects being embedded inside real-world objects, setting the stage for further exploration to optimize and more deeply explore this and other similar effects in future work.

CCS Concepts

• ***Human-centered computing*** → ***Visualization;*** • ***Computing methodologies*** → ***Mixed / augmented reality; Perception;***

1. Introduction

We propose implementing interactive mediated reality [GGS03], by altering the real object's material appearance to enhance spatial perception of embedded virtual objects in a situated visualization mixed reality scene with x-ray vision. We try to address the issue of lack of a tangible connection to the real world anchor in a situated visualization scene. When virtual objects are superimposed onto the real world, they might appear to "float", breaking coherence and immersion in the mixed reality experience. To avoid this unintended interpretation, researchers focus on techniques to enhance the visual integration of virtual objects with the real environment. This can involve improving shadowing, surface interaction, and the overall alignment of virtual objects with their real-world counterparts.

This work presents an instance of phantom rendering [BWRT96], to augment spatial perception in situated scientific visualization [BKT*22]. Our approach involves transforming the appearance of a captured 3D real-world object to resemble that of glass to achieve this phantom effect. Emulating the characteristics of real world glass exhibits in a museum display, the proposed approach aims to enhance the perception of containment (i.e., objects within other objects) [AST09] in mixed reality scenes. To the best of our knowledge. such an approach has yet to be investigated. Specular reflections generated using image-based lighting [Deb06] are incorporated to enhance the realism of the glass surface, and seamlessly embed virtual objects within real objects in the mixed reality scene. We present a proof of concept implementation of our theoretical framework, showcasing preliminary results that indicate an improvement in containment cues of embedded virtual objects.

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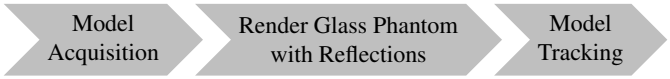

Figure 2: *Proposed Interactive Mediated Reality Pipeline*

Our proposed pipeline, as shown in Figure 2, involves overlaying a simulated specular glass reflection on a solid real object in the scene. The reflection is rendered by image-based lighting using a captured environment map of the real scene. We present a prototype implementation where the visibility of a virtual skull, representing an internal object, is demonstrated through the outer shell of a real head. We use a photogrammetry scan of a mannequin head [†] that closely matches the real object we physically possessed. We use Vuforia tools for the creation of 3D model target, which enables tracking of three-dimensional objects in real-world environments, in the Unity game engine on an Intel Core i7-9750H laptop on a RTX 2060 GPU using a webcam. For the purposes of our proof-of-concept study, we enhance tracking by isolating the desired object within the scene and providing a uniform background, such as a gray cloth in our case.

(a) **(b)** **(c)** **(d)** **(e)**

Figure 3: *Virtual (a) & real (b) mannequin heads with captured environment map (c) used to generate glass phantom (d), (e)*

2. Results & Discussion

We implemented a spherical cutaway approach [FS92] for our generated scene to compare against as a baseline approach in providing spatial relationship. On examination of the various visualizations in Figure 1 we can see depth ambiguities in the naive approach where the virtual object is simply overlaid on the scene, creating a sense of disconnection between the virtual and real elements. The cutaway approach provides a sense of containment but takes away valuable contextual information from the real scene. Our proposed approach appears to offer a potentially effective solution for improving the relative depth perception between the real and virtual objects, while preserving most of the information.

However, we also observe excessive specular reflections, which occur when we increase the reflectivity of the surface, leading to visual clutter. We believe that more subtle containment cues for embedded objects could be achieved by fine-tuning the intensity of specular reflections. Further on, we aim to explore the optimal tradeoff between clutter and spatial perception through user studies with different types of visualization scenarios discussed in the literature, such as mechanical parts inside a car, structures such as pipes or wiring inside buildings areas etc.

Extensions of our approach in a head mounted display form factor could be further explored, wherein one could combine eye-tracked spherical cuts with the specular reflections. With eye tracking, one could achieve gaze contingent blending between the cutaway and our approach, overlaying the reflections only on the parts where the user is not looking. This would help reduce clutter and maintain a clear spatial relationship in the MR scene. This has further implications on optical see through head mounted displays, where white specular reflections would be opaque and may not allow the user to visualize the underlying information properly.

We believe that our work provides a proof of concept for the potential of introducing a seamless and subtle spatial cue by changing the appearance of physical objects to enhance the spatial perception of embedded objects. The proposed research could benefit various domains, including education, scientific visualization, construction, and museums, by improving the spatial perception of virtual objects embedded within real-world scenes. For example, it could be used to visualize the internal structures of objects, such as mechanical parts inside a car or wiring inside buildings. This can aid in the design and analysis of various systems and structures. The approach needs to be further validated and investigated by performing rigorous user studies, to gain a deeper understanding of the impact and potential benefits of such modifications for spatial perception and to optimize the resulting visualization for improved user experience. For instance, users could be asked to rate the degree to which the modifications occlude details in the scene or how they impact realism and clutter.

Acknowledgments

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† https://skfb.ly/6xP6J