LABORATORY FOR **Computational Sensing + Robotics** + JOHNS HOPKINS WHITING SCHOOL of ENGINEERING

Using Augmented Mirrors for Medical Application in Orthopedics

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Introduction

One of the most recurrent problems in egocentric Augmented Reality (AR) is the misestimation of depth. Providing alternative views from non-egocentric perspectives can help users' depth judgment by conveying additional useful information. In this project, we implemented *Augmented Mirrors,* which enable the user to simultaneously and dynamically visualize the real and virtual content of scenes from additional views, i.e., from real mirrors.

With the help of the contents that *Augmented Mirror* provides, users can judge the depth more confidently and perform more accurate alignment and insertion of a trocar during vertebroplasty, a procedure that requires high precision and accuracy for safe execution.

In this project, we built from scratch an *Augmented Mirror* unity package and deployed it directly onto the HoloLens HMD. Then, we designed a demo user scenario with Lego models as a simplified simulation of the trocar alignment and insertion. Finally, we investigated how we can develop this project into a more complicated Orthopedics surgery scene.

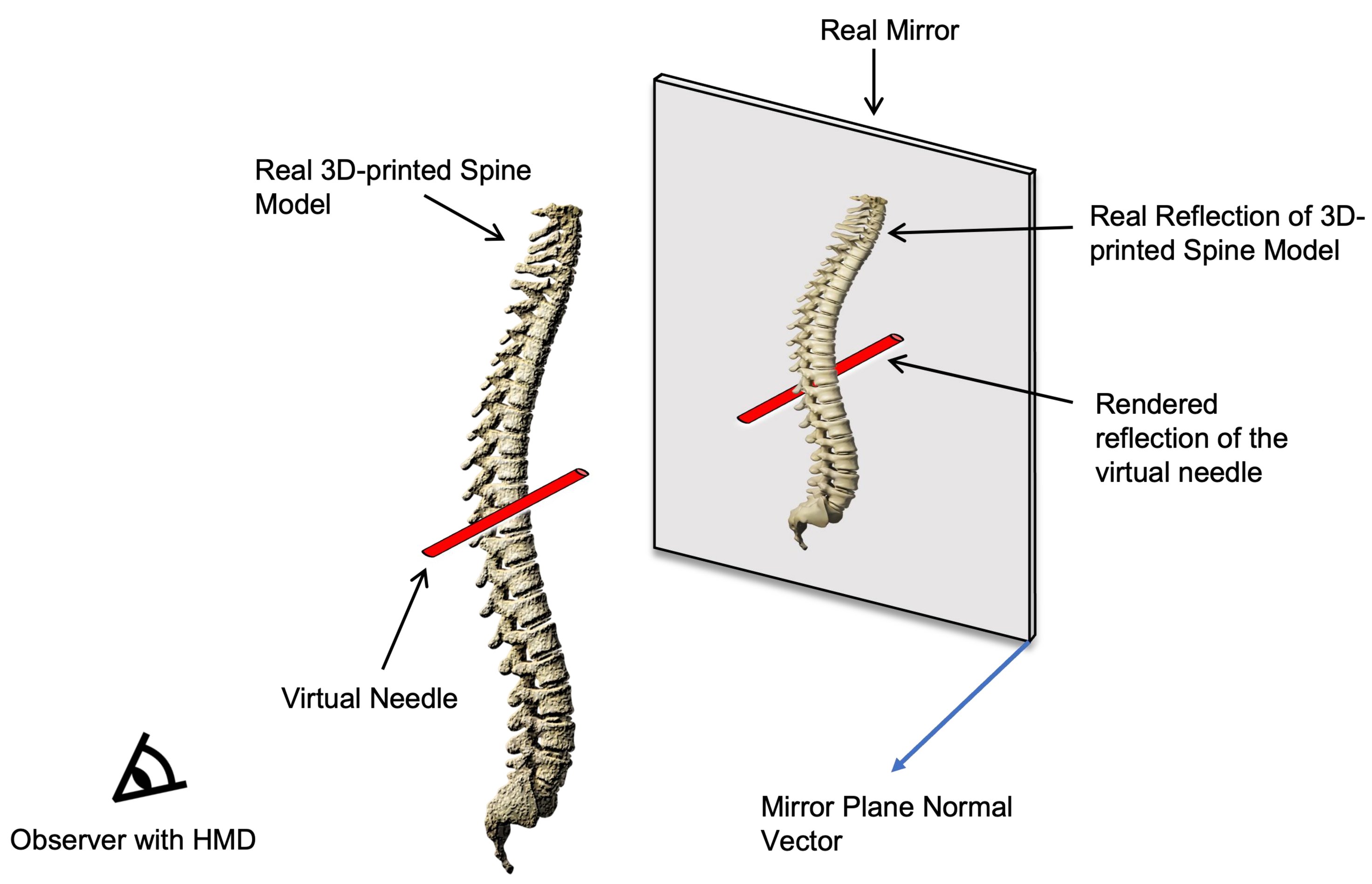

Figure 1: Augmented Mirror Illustration

Method

This project mainly contains two components, multi-objects tracking (mirror tracking and phantom tracking) and virtual content rendering. Multi-objects tracking provides us with the real-time poses of mirror and phantom w.r.t to the observer so that we can render the virtual content to overlay physical mirror.

1. Multi-Objects Tracking:

- We created image markers in Vuforia database and imported them into our project.
- After attaching these images in the real objects, we can track them in Unity.

2. Virtual Content Rendering:

Once the poses of the Augmented Mirror are known, we can compute the pose of a virtual camera that generates the virtual reflection. As shown in figure 2, the virtual content an observer should see on the real mirror is the same as the view from the virtual camera. According to the reflection law, we can find the pose of the virtual camera:

$$V = {}^{O}_{W}T \cdot M_{reflection} \cdot {}^{M}_{W}T \cdot O \quad (1)$$

Using the unity standard rendering pipeline, the overlaid virtual content can be generated as follow:

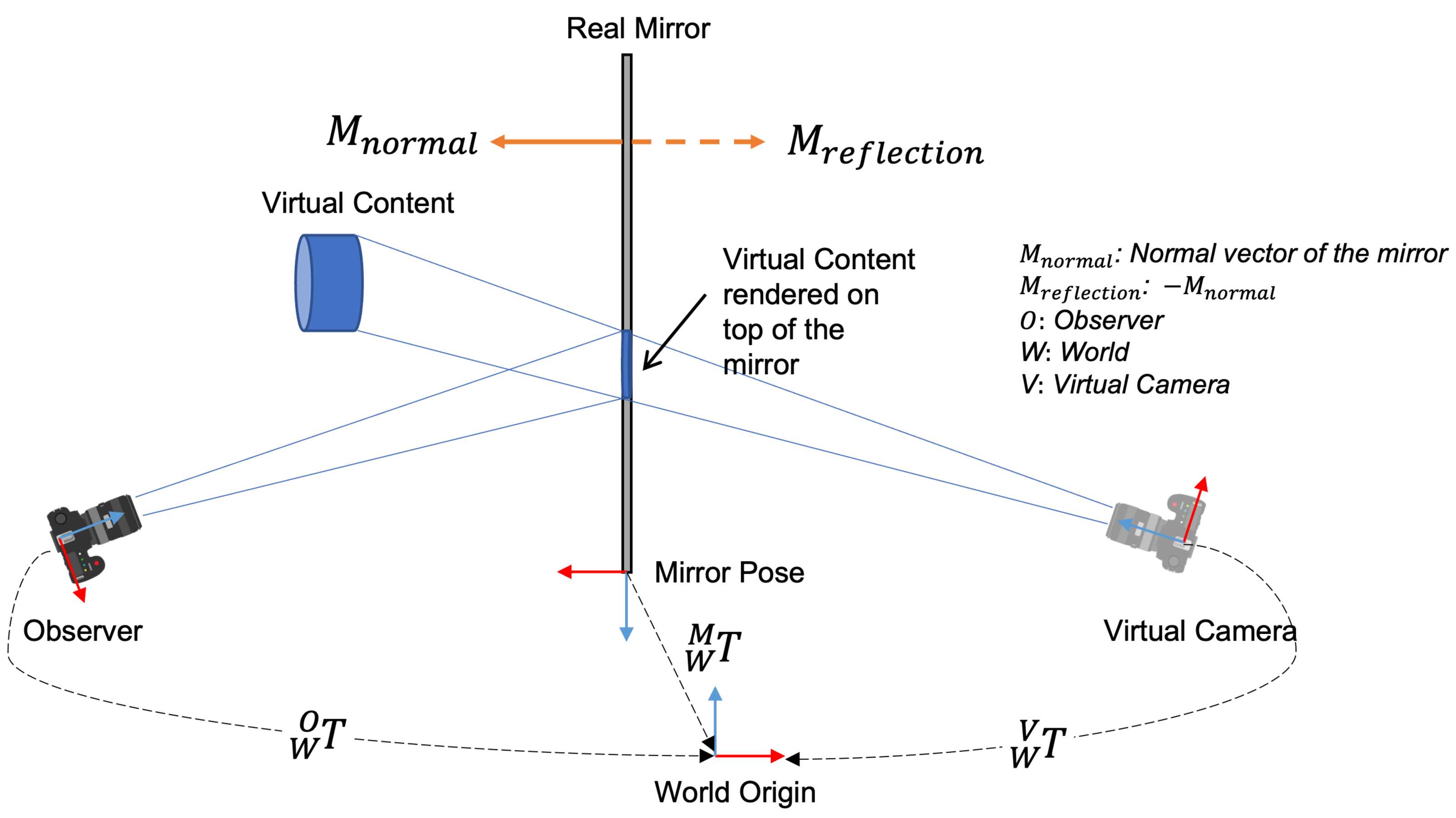

Figure 2: Frame transformations for generating a virtual camera

1. Duplicate the observer camera into the position and orientation of the virtual camera V as in (1).
2. Create a shader to render the scene from the virtual camera viewpoint.
3. Create a material from the shader in step 3 and apply it to the mirror plane.

Results

Our HoloLens deployed *Augmented Mirror* application demonstrated relatively good mirror tracking accuracy and a clear rendering of the virtual content onto the mirror. Future improvements include using NDI makers and STTAR tracking to have a more robust mirror pose estimation.

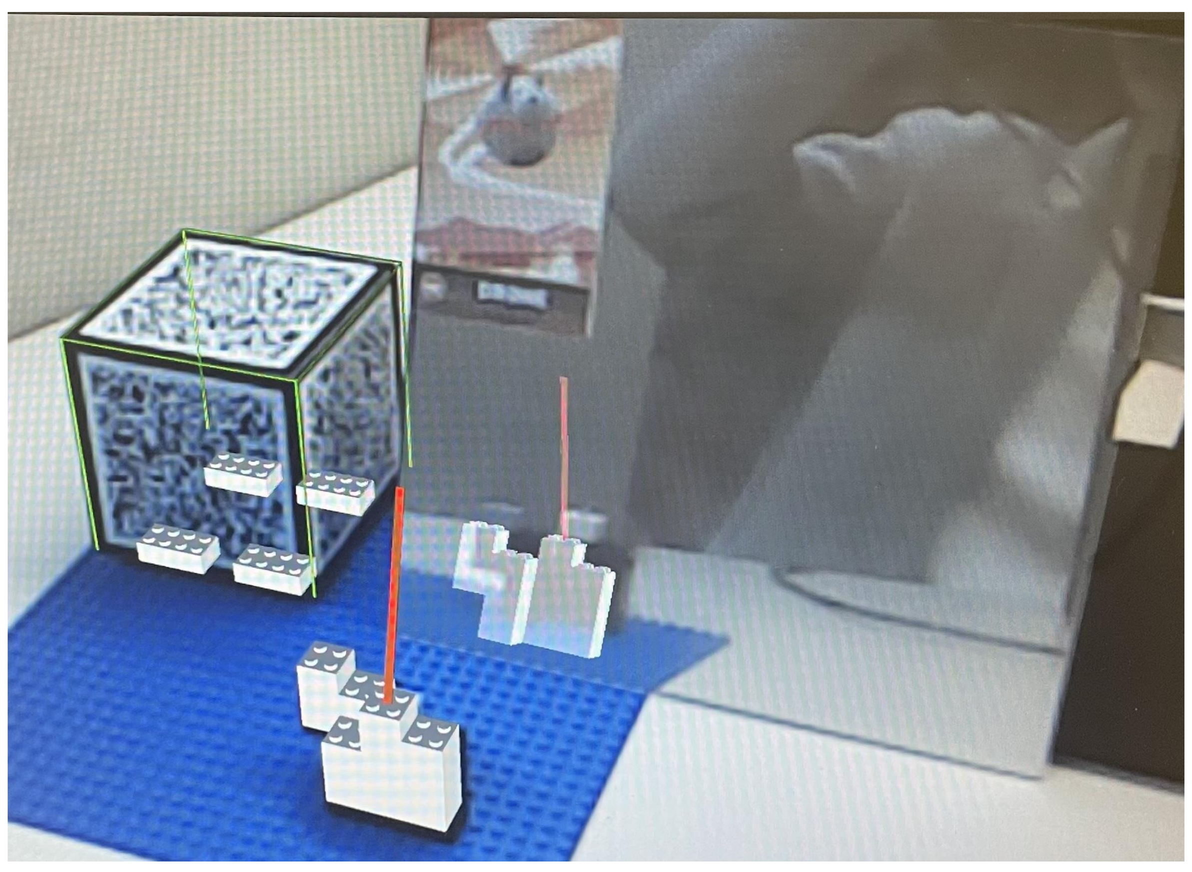

Figure 3: Augmented Mirror Lego Demo

Conclusions

In our project, we developed an Augmented Mirror platform and a simplified simulation of trocar placement in vertebroplasty to show the feasibility and potential usefulness of a such platform. We were able to demonstrate that users can more accurately place the needle into the target dimples with the help of the Augmented Mirror (i.e., having 2 views) than with a single view.

Future work involves designing and implementing novel alignment guidance methods and a surgical simulation that more closely represents the trocar placement procedure in vertebroplasty.