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

Collaborative Environment for AR Creation

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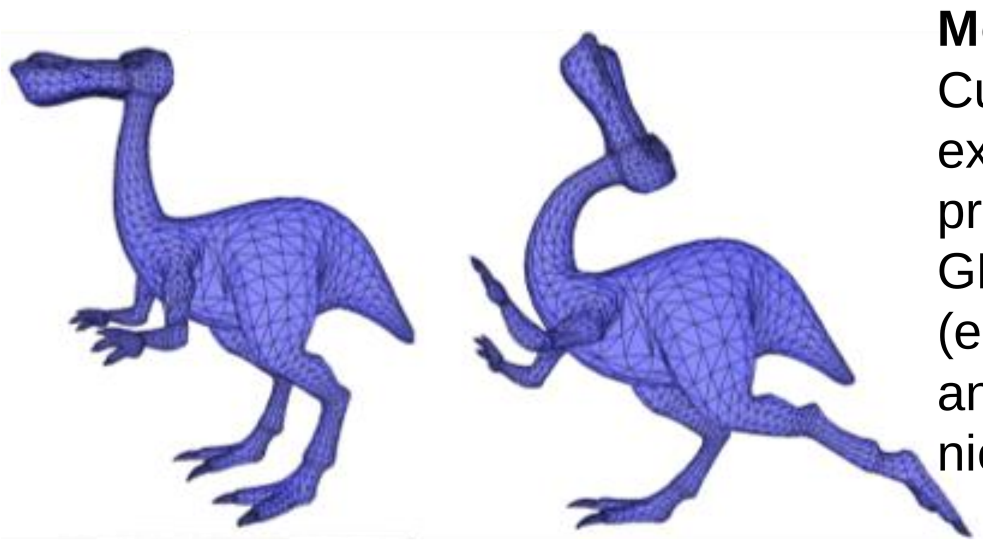
Introduction

Background

Collaboration between users while interacting with shared virtual content is essential to operating AR devices in everyday life. Collaborative AR for common, daily use cases requires two components: spatial sharing and real-time rendering. Spatially shared workspaces allow the rendering of virtual content in the same physical coordinates across users while real-time rendering gives users instant feedback about each other's actions. Together, these two components give users the ability to have virtual interactions that more naturally reflect their physical counterparts.



Motivation

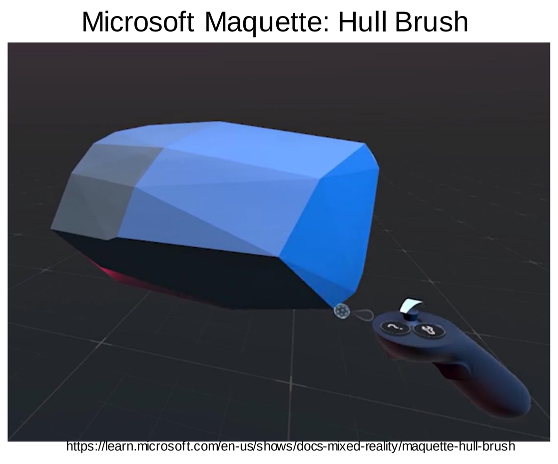
Currently, 3D-modelling requires extraordinary devices (e.g., 3D printers, CNC machines, high-end GPUs, etc.), expensive software (e.g., Inventor, Solidworks, etc.), and technical skills that tend to be niche to either the software or the machines used (e.g., Blender, MeshLab, etc.). Additionally, fabricated products can have varying tolerances. These constraints are in various industries like Machinery, Hardware Design, Fashion Designing etc.

Our solution eases the technology and knowledge constraints by leveraging an augmented reality environment, hand tracking, and network connectivity to create a more intuitive and collaborative workspace for 3D modeling.

Related Work

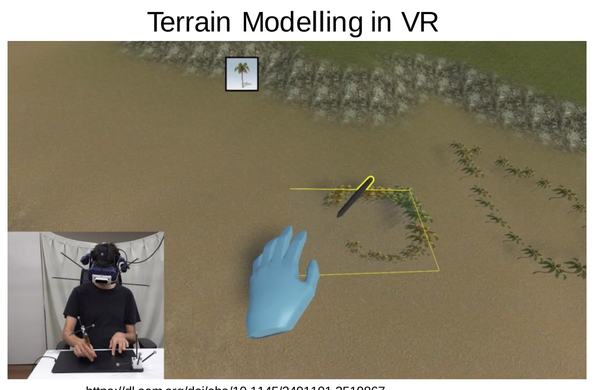
Past research and commercial products show that free-form object placement, 3D-modelling (e.g., Microsoft Mesh, Microsoft Maquette and Grid3D) and designing are possible with various devices. But they also experience shortcomings like limited workspace, physical surface need or specialized tracked controllers.

Microsoft Maquette: Hull Brush



https://learn.microsoft.com/en-us/windows/mixed-reality/maquette-hull-brush

Terrain Modelling in VR

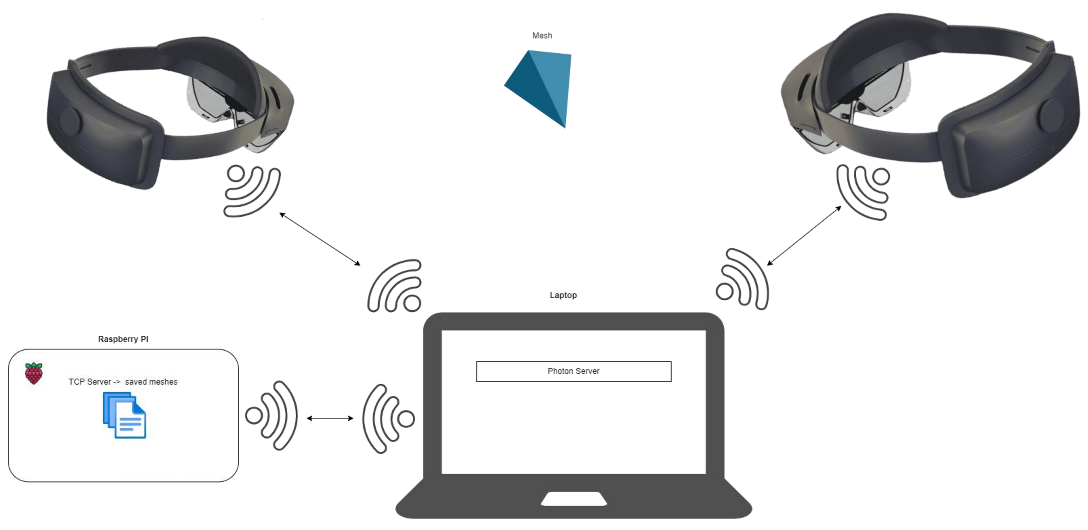


https://dl.acm.org/doi/abs/10.1145/3491101.3519667

Method

In the proposed collaborative AR solution, it is necessary to reflect the users' presences and their interactions with the virtual content to the other users sharing the workspace. Therefore, changes to the space are relayed through a PUN2 network to all the users in the space. The virtual content share a common coordinate system with the help of World Locking Tools developed for unity which localizes not just the users but also any virtual content created in the space for all users.

The major features of the solution relies on the frame transformation between the object's local reference frame to the world reference frame setup by the World Locking tool to manipulate the object shape.

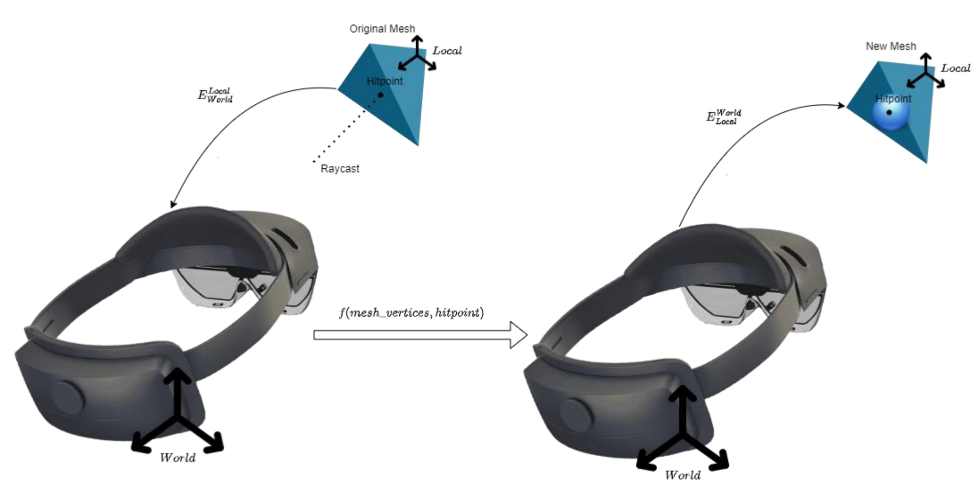


Electronics Diagram

The software offers a suite of functionalities: saving, loading, relocating, scaling, measuring, non-verbal collaborative communication channels and object shape manipulation. Additional flexibility allows the user to draw a custom 2D-shape, conversion to a 3D object and finer alterations to the shape of the 3D object.

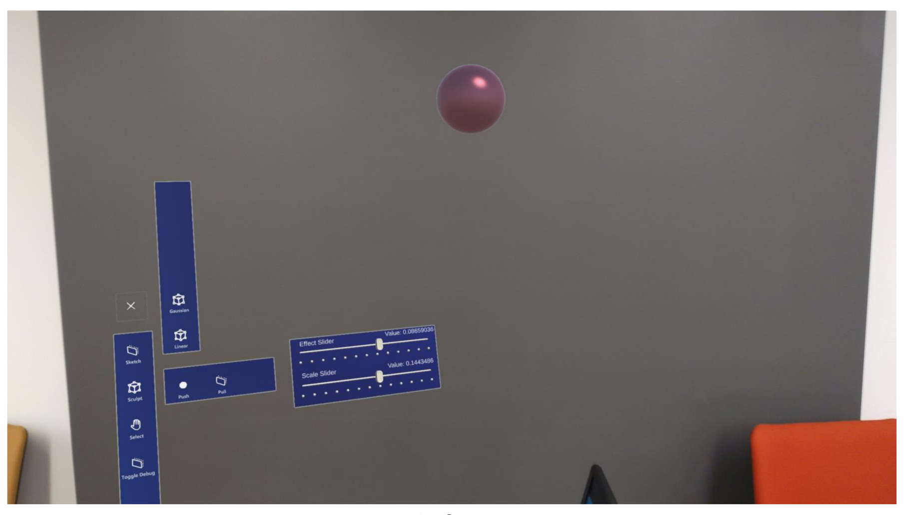
$$q'_L = T^L_W * (T^W_L * q_L + \Delta d_W)$$

q'_L = New Coordinate
T^L_W = World to Local Coordinate Transformation
T^W_L = Local to World Coordinate Transformation
q_L = Current Coordinates
Δd_W = Change in coordinates in World Frame



Mesh Deformation: Before and After

Results



Before

After

We have not conducted quantitative studies to evaluate the effectiveness of the system at this time. However, feedback from early user testing has indicated that the platform offers a convincing and user-friendly system by which to manipulate 3D models in a collaborative setting. Notably, counter to previous works, our platform does not need physical/tracked tools and has a virtually unlimited workspace.

Conclusion

The proposed solution allows users to collaborate on 3D models in real-time. This is accomplished by using a variety of tools and techniques to ensure that multiple users have a synchronized experience in the same virtual space. Some of the activities that users can currently do with the proposed solution include:

- Viewing 3D models from different angles and perspectives
- Manipulating 3D models by moving, rotating, and scaling them
- Collaborating on 3D models with other users in real-time
- Saving and loading 3D models

By providing an accessible and collaborative environment for 3D modeling, the proposed solution aims to make it easier for users to create and share their work with others.

Future Work

Some possible next steps for the project could include:

- Ability to export meshes to common 3D modelling formats
- Integrating generative networks such as DALLE-2 for 3D object generation seeded by either text and/or voice cues
- Cross-platform support: any handheld device with a front facing camera with ability to run Microsoft's WLT and/or Microsoft's Azure Spatial Anchors can run the platform in theory.
- Multi-perspective tools such as adjustable mirrors showing each other's viewpoints
- Testing and refining the solution with a wider group of users (e.g. graphic designers) to gather feedback and improve the overall design

Acknowledgements

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