



Hand Occlusion

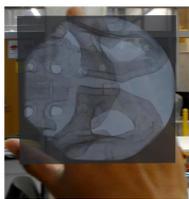
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Introduction

Current HMDs, such as HoloLens, barely provide hand occlusion when putting a hand between HMDs and the AR content. This causes the virtual objects should have been occluded appear above the hand when putting a hand on the top of the virtual object, which will interference hand motion and cause unrealistic perception.

Our work aims at fixing this problem and improving the perception in Microsoft HoloLens.



No Hand Occlusion



HMD: Microsoft HoloLens

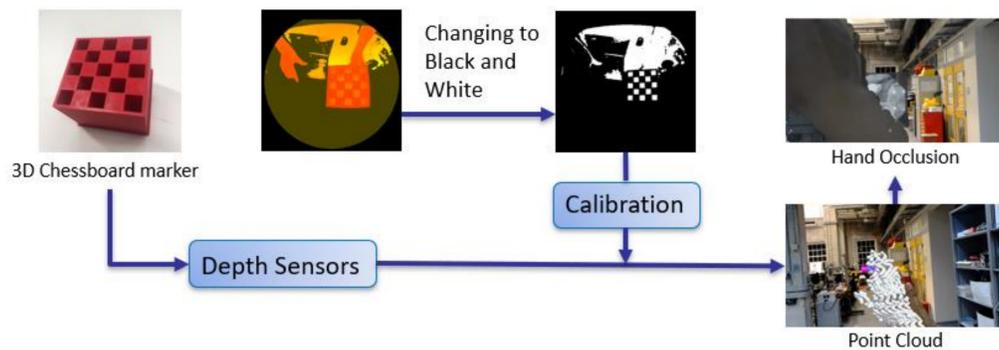
Expected Result and Process



- The HoloLens detects the surface with sensors and renders a virtual object .
- A hand shows out and stays on the top of the virtual object.
- The HoloLens' sensors detect the hand and renders the been covered part of the virtual objects in transparent.

Method

HoloLens Research mode



Ideal image pixel (u, v)
Distortion Parameter: k_1, k_2, p_1, p_2
Principal Point: c_x, c_y

$$\begin{cases} x' = (u - c_x) / f_x \\ y' = (v - c_y) / f_y \end{cases} \rightarrow \begin{cases} x'' = x' \cdot (1 + k_1 \cdot r^2 + k_2 r^4) + 2p_1 x' y' + p_2 (r^2 + 2x'^2) \\ y'' = y' \cdot (1 + k_1 \cdot r^2 + k_2 r^4) + 2p_2 x' y' + p_1 (r^2 + 2y'^2) \end{cases}$$

In camera coordinate,

$$\begin{cases} x_c = (u - c_x) * depth / f_x \\ y_c = (v - c_y) * depth / f_y \\ z_c = depth \end{cases}$$

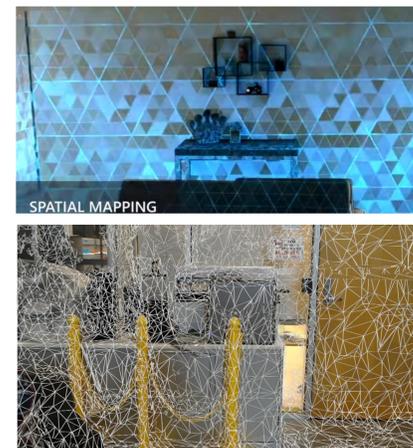
Real Depth Value for (u, v) ← Two-dimensional linear interpolation ← $\begin{cases} u_d = f_x \cdot x'' + c_x \\ v_d = f_y \cdot y'' + c_y \end{cases}$

HoloLens Spatial Mapping

Spatial Mapping:

- Provides a detailed representation of real-world surfaces in the environment
- Able to do classification, occlusion, and rendering (as transparent)

Spatial Mapping has high latency, so we change the mesh updating time and the number of triangles to calculate per cubic meter to get the fastest refreshment and best result.



HoloLens Spatial Mapping ideal

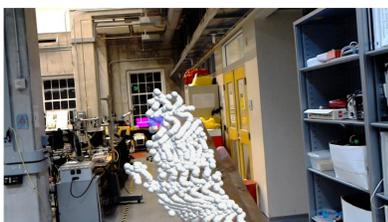
Spatial Mapping in Real World

Results

HoloLens Research mode



Original Scene



Point Cloud



Hand Occlusion

HoloLens Spatial Mapping



Virtual Object



Move and Place



Occlusion with Grid



Occlusion without Grid

Conclusions

We achieved the Hand Occlusion with HoloLens with both methods

HoloLens Research mode:

- We implement a way to calibrate depth camera without RGB information.
- Achieve hand occlusion with HoloLens I without extra sensors. (Other related work implement hand occlusion in HoloLens using Leap Motion or Kinect).
- Future work will be based on more accurate calibration and reduce the time lag using vertex shader.

HoloLens Spatial Mapping:

- Because of the Hand gestures system, HoloLens can not identification user's hand as a real object in the spatial mapping.



User's hand close to sensors



Others' hand



User's hand close to sensors