CSE 493V VR SYSTEMS

IMMERSIVE ENVIRONMENT LIGHTING USING LIGHT PROBES

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ABSTRACT

Augmented and Mixed Reality struggle with realistic lighting, making virtual objects look out of place. To solve this, we use light probes—360° cameras that capture real-world lighting. Instead of complex HDR processing, we apply a simple blurring step to create real-time lighting estimates. This ensures virtual objects blend seamlessly into physical environments, enhancing realism in AR/MR applications.

IMPLEMENTATION

- 360 - camera captures environment lighting as equirectangular images.
- Images are retrieved through Open Spherical Camera API.
- Streaming HTTP Client decodes camera feed for the renderer.
- Blurring and ToneMapping is applied to approximate indirect lighting to approximate scattering.
- Images are fed into the graphics pipeline for lighting and rendering.

SCOPE FOR EXPANSION

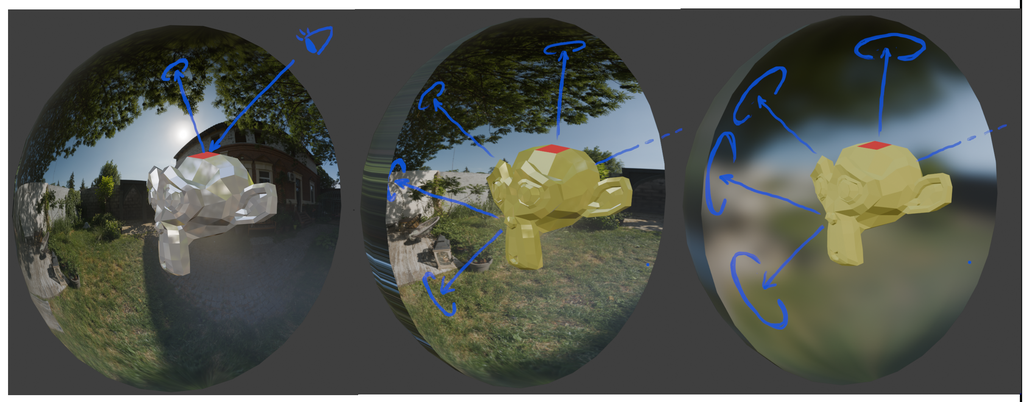
With further development time, and resources, we could develop the following features:

- Occlusion: We can use state-of-the-art depth estimation models to construct a depth map of the environment, which can be used as a stencil buffer in the graphics pipeline – allowing real-world objects to occlude and intersect with the virtual scene.
- Shadows: With the depth maps from the previous step, we can project shadows from prominent light sources in the environment texture onto an unprojected environment mesh, allowing virtual objects to cast shadows onto the real environment

METHODOLOGY

We can use the 360-Images of a scene to re-light a virtual scene. For diffuse lighting, sample the part of the environment map that is at the surface normal, for Specular reflections, we calculate a reflected ray and sample that part of the environment map.

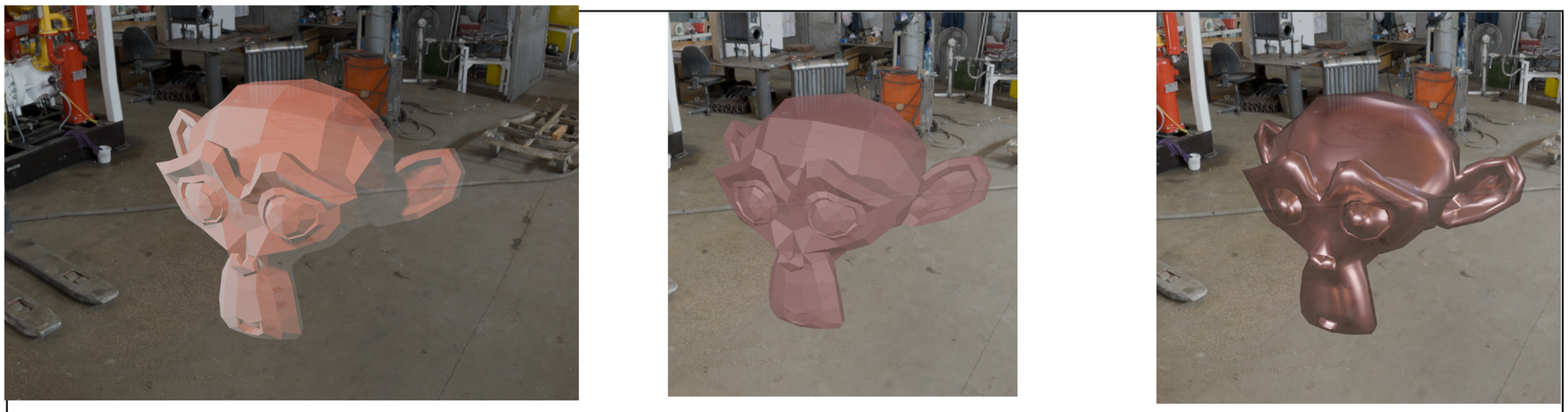
We can see that by blurring the environment texture, we can increase the roughness of our material. This is because blurring the environment approximates how an image is reflected off a surface, based on its roughness and specularity.



Sampling Specular Reflections | Sampling Diffuse Reflections | Sampling Diffuse Reflections (rough)

RESULTS

Streaming These textures in realtime, we can see better cohesion of the scene with the environment. Some limitations of this demo would be the lack of visual fidelity of AR, and would be better implemented in MR.



[1] Incorrect/Static Lighting | [2] Environment Lighting (Diffuse) Lighting (Specular) | [3] Environment

REFERENCES

[1] Open Spherical Camera API (https://developers.google.com/streetview/open-spherical-camera) [2] Vulkan (https://www.vulkan.org/) [3] Environment Lighting Methods (https://medium.com/@mrrsff/environment-mapping-hdr-lighting-in-c-using-opengl-c0530cb12579)