Poster: Reactive Mesh Simplification for Augmented Reality Head Mounted Displays

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CCS CONCEPTS

• **Human-centered computing** → *Ubiquitous and mobile computing*;

1 INTRODUCTION

While untethered Augment Reality (AR) Head mounted displays (HMDs) [2] hold the potential to open new application scopes, as mobile computing platforms, their lifetime is severely limited. Lengthening the lifetime of these devices suggest the need for display content management techniques. Given that the *complexity* of the objects that are displayed on the scene can have a high impact on the overall lifetime performance of the untethered AR HMDs, there are needs to find ways to simplify the complex objects displayed on the screen.

We propose Octree-based Mesh Simplification (OSM) to simplify the presentation of 3D objects. Specifically, OSM simplifies the geometry data of a model to simplified boxes, called "voxels" by dividing the object and its surroundings into a tree structure of cubes. When user view direction data is given, and the objects that are on the current scene but out-of-focus are identified, OSM can help reduce the energy used for rendering such objects.

2 OCTREE-BASED MESH SIMPLIFICATION

The number of triangles that consist an object (i.e., object complexity) can have high impact on the energy usage of an untethered AR HMDs, given that complex objects take more effort to process through the graphics pipeline. Therefore, while providing high quality objects for focused objects, it is also important that we "simplify meshes" for objects that the user is *not* currently focused on.

Mesh simplification, a well-studied topic in the graphics research community, is used in various applications. Among various methods, we use the voxelization-based mesh simplification (VMS) [1] approach. A "voxel" is a 3D equivalent of a pixel, the minimum cube unit of representation for a 3D object. VMS uses a low-pass filter to suppress the vertices that represent the mesh's high-frequency component, and creates voxels from the remaining low-frequency points. Through this process, the original 3D object is simplified to a less-complex object. However, despite its effectiveness, there exists an overhead of having to transform all mesh components to the frequency domain and reconstructing the object after the filtering. For this reason, using a typical VMS method is not suitable for our resource constraint environment. Instead, we propose mesh simplification using octrees, trees with eight children nodes.

In the initialization phase, we compute the object's bounding box using the vertex information of an object as provided by the application, and then divide the object into eight cubes in the 3D space. Once this is done, we iterate through the vertices and check if a vertex is included in one of the the divided boxes. We continue this process for a predefined depth d_O number of iterations. As a result, we will have 8^{d_O} number of boxes where some will have vertices included and some not. Now, by constructing a tree of this structure (where the parent node is the cube prior to dividing in 8 sub-pieces and the sub-cubes are the children), we check from bottom-up, if the sub-tree of each node is a "full tree" or not. If full, the parent node merges the vertices contained in its child nodes. If not, the tree stays the way it is. The outcome of this process will have a list of leaf nodes (that can no longer be merged), which contain information on spatially correlated vertices. For each leaf node, a voxel is created, which results in a simplified version of the original 3D object, and this can be used to represent objects that the user may be less-focused on within the current scene. Determining if the user is currently focused to an object can be determined using gaze tracking or head orientation data.

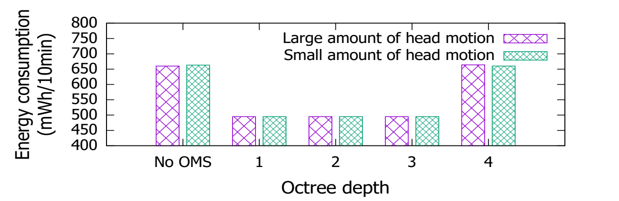

Figure 1: Impact of octree depth d_O on the Hololens energy

To measure the impact of the OSM scheme, we collect natural head motion data from an IRB-approved study using the Microsoft Hololens HMD and measure the energy usage for head motion samples that make different quantities of motions (e.g., small amount of motion and large amount of motion) while varying the octree depth d_O. As 1 shows, as octree depth d_O increases to more than 4, the energy usage increases. This means at this stage, the computation cost of the octree construction override the benefits of OMS. Nevertheless, compared to the case where is not used, applying mesh simplification can benefit the system's energy usage performance in shallow d_O by up to ~25%. Furthermore, while we omit graphs due to the lack of space, we note that the latency for performing OSM, with $d_O < 4$ was less than $\sim$ 70 msec.

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