భారతీయ సాంకేతిక విజ్ఞాన సంస్థ హైదరాబాద్
भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

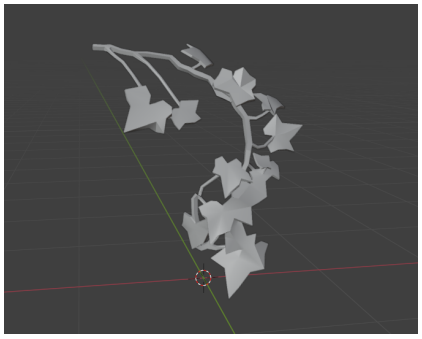
Mixar ML Assignment

Done by:
P Deepak Reddy - EE23BTECH11047

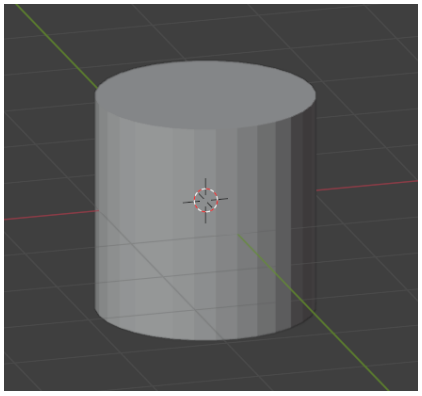
Task 1: Load and Inspect the Mesh

Initial Mesh Plots

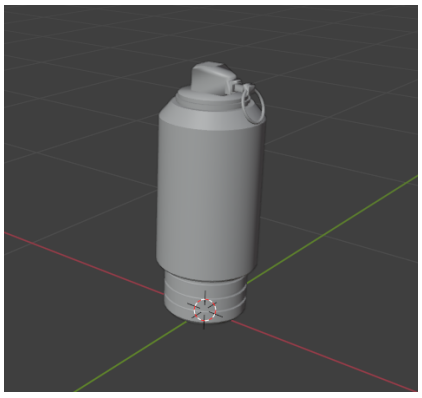
I have shown initial mesh plots in Blender



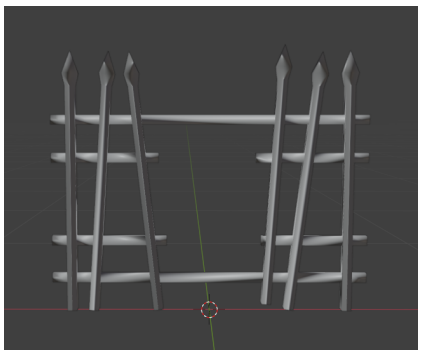
Branch Original Mesh



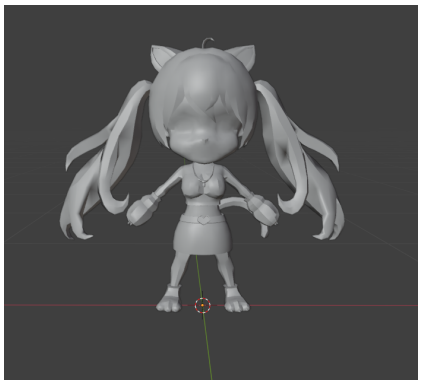
Cylinder Original Mesh



Explosive Original Mesh



Fence Original Mesh



Girl Original Mesh

Person Original Mesh

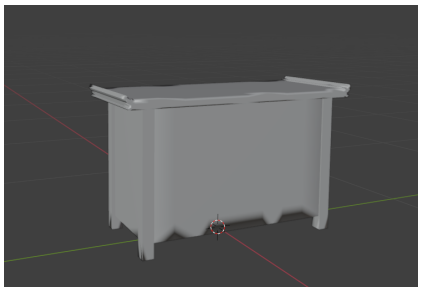
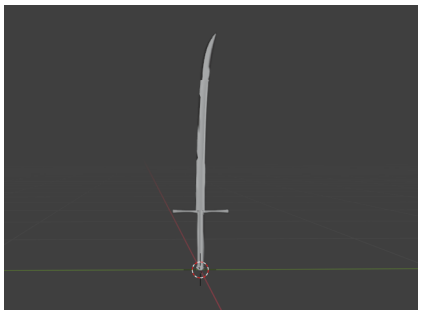


Table Original Mesh



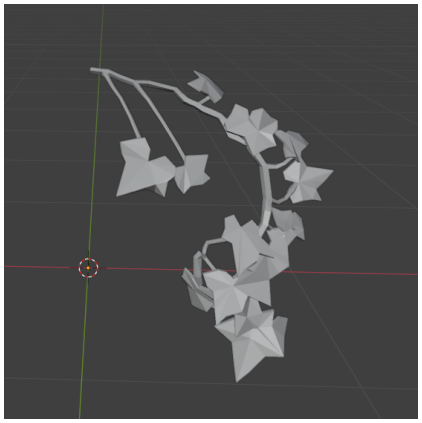
Talwar Original Mesh

Table 1: Vertex statistics for all 3D mesh samples

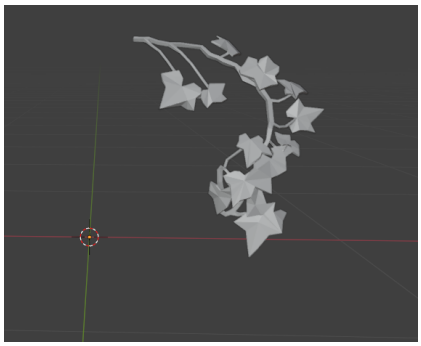
Mesh	Vertices	Min (x, y, z)	Max (x, y, z)	Mean (x, y, z)	Std (x, y, z)
branch	2767	[-0.8516, 0.0000, -0.4648]	[0.8496, 1.9004, 0.4629]	[0.0754, 1.0874, 0.1220]	[0.3434, 0.4570, 0.2001]
cylinder	192	[-1.0000, -1.0000, -1.0000]	[1.0000, 1.0000, 1.0000]	[0.0000, 0.0000, 0.0000]	[0.7071, 1.0000, 0.7071]
explosive	2812	[-0.1996, 0.0000, -0.1971]	[0.1996, 1.0000, 0.1971]	[0.0429, 0.5291, -0.0034]	[0.1151, 0.3899, 0.0947]
fence	1088	[-0.5000, 0.0000, -0.0225]	[0.5000, 0.8432, 0.0225]	[-0.0035, 0.4105, -0.0004]	[0.3458, 0.2540, 0.0110]
girl	8284	[-0.5000, 0.0000, -0.1814]	[0.5000, 0.9044, 0.1814]	[0.0021, 0.4034, 0.0140]	[0.1788, 0.2144, 0.0618]
person	3103	[-0.8438, 0.0000, -0.2129]	[0.8418, 1.9004, 0.2109]	[0.0049, 1.1595, -0.0036]	[0.3951, 0.5119, 0.0951]
table	3148	[-0.2089, 0.0000, -0.5000]	[0.2089, 0.6118, 0.5000]	[-0.0132, 0.3864, -0.0036]	[0.1531, 0.1919, 0.3461]
talwar	1668	[-0.0319, 0.0000, -0.1171]	[0.0319, 1.0000, 0.1171]	[0.0217, 0.3028, -0.0044]	[0.0112, 0.2369, 0.0468]

Task 2: Normalize and Quantize the Mesh

Normalization Meshes for branch.obj



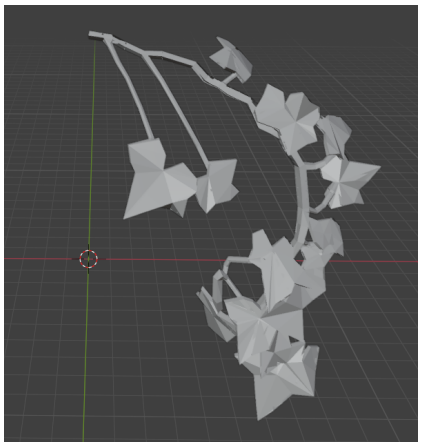
Branch Min Max Normalized Mesh



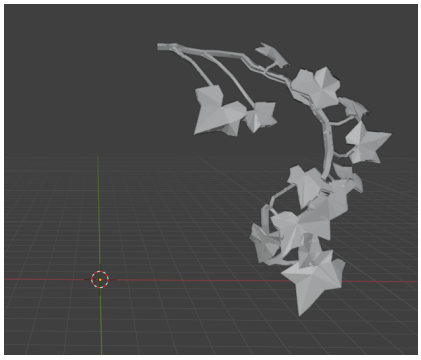
Branch Unit Sphere Normalized Mesh

Quantized Meshes for branch.obj

Quantized Mesh, which i obtained after performing quantization on Normalized Meshes. Quantized versions are much larger compared to the Normalized ones. if i compare quantized with normalized ones, they do not appear.



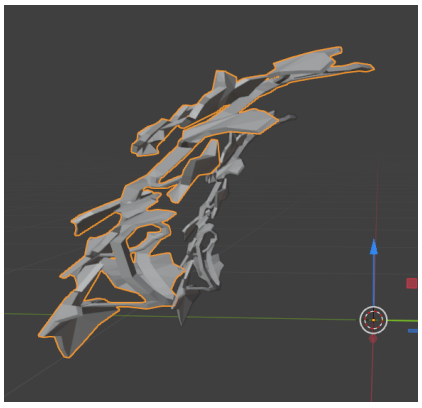
Branch Min Max Quantized Mesh



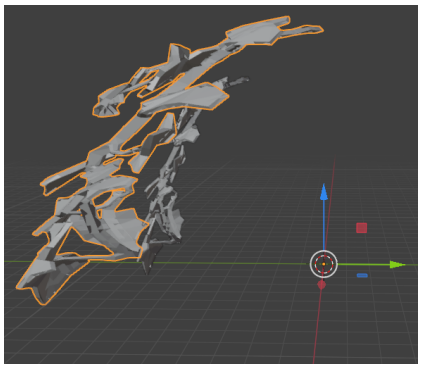
Branch Unit Sphere Quantized Mesh

Comparison of Normalized and Quantized Meshes for different Normalization Methods for branch.obj

Here, the yellow color mesh is min max normalized, and the other one is unit sphere normalized.

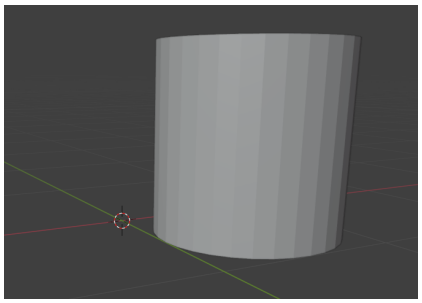


Branch Normalized Meshes

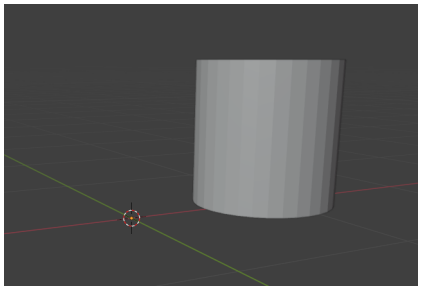


Branch Quantized Meshes

Normalization Meshes for cylinder.obj



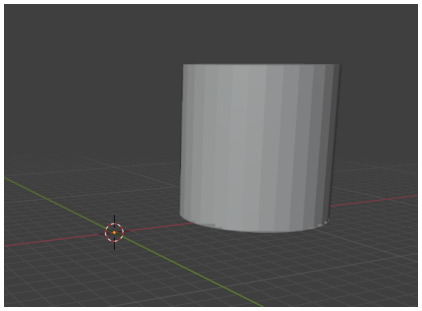
Cylinder Min Max Normalized Mesh



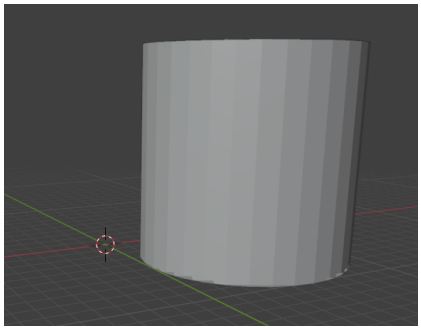
Cylinder Unit Sphere Normalized Mesh

Quantized Meshes for cylinder.obj

Quantized Mesh, which i obtained after performing quantization on Normalized Meshes. Quantized versions are much larger compared to the Normalized ones. if i compare quantized with normalized ones, they do not appear.



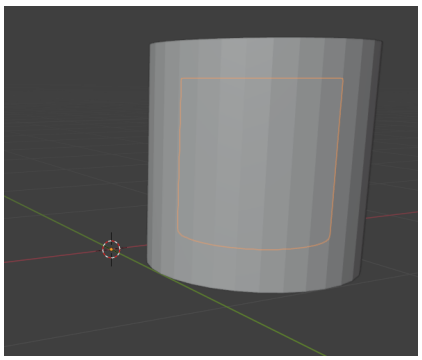
Cylinder Min Max Quantized Mesh



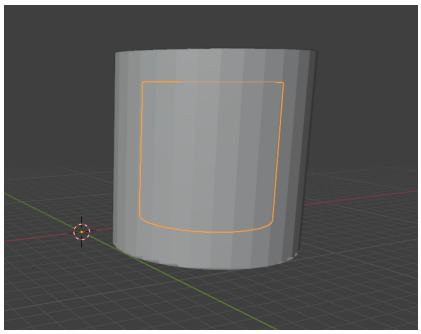
Cylinder Unit Sphere Quantized Mesh

Comparison of Normalized and Quantized Meshes for different Normalization Methods for cylinder.obj

Here, the yellow-colored meshes are the normalized unit sphere mesh and the quantized unit sphere mesh.

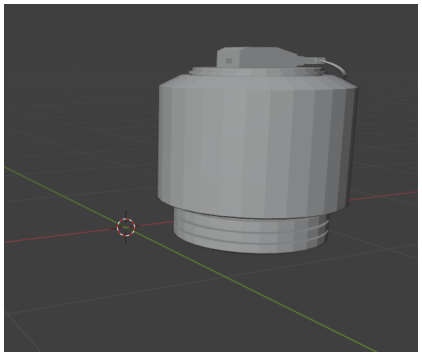


Cylinder Normalized Meshes

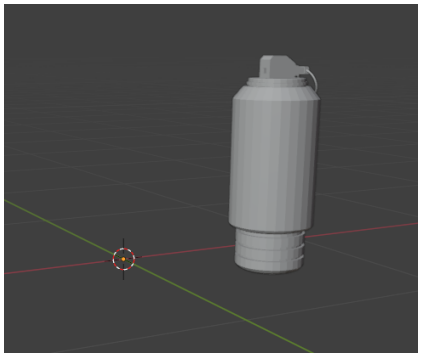


Cylinder Quantized Meshes

Normalization Meshes for explosive.obj



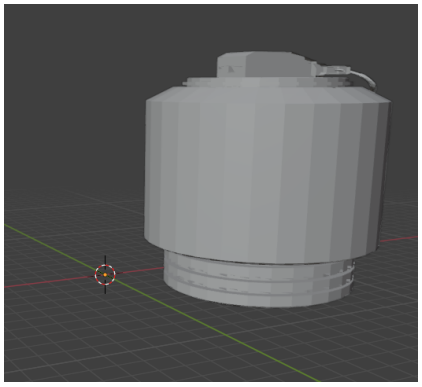
Explosive Min Max Normalized Mesh



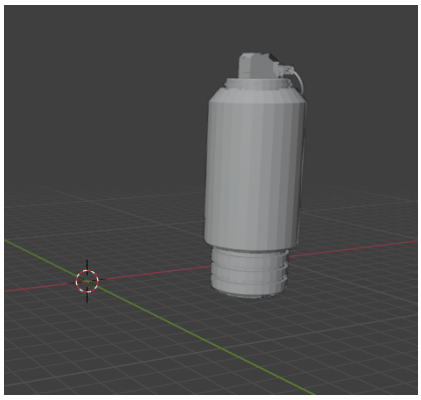
Explosive Unit Sphere Normalized Mesh

Quantized Meshes for explosive.obj

Quantized Mesh, which i obtained after performing quantization on Normalized Meshes. Quantized versions are much larger compared to the Normalized ones. if i compare quantized with normalized ones, they do not appear.



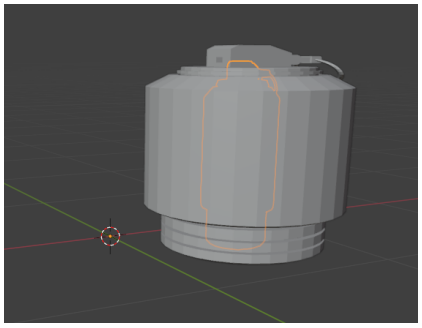
Explosive Min Max Quantized Mesh



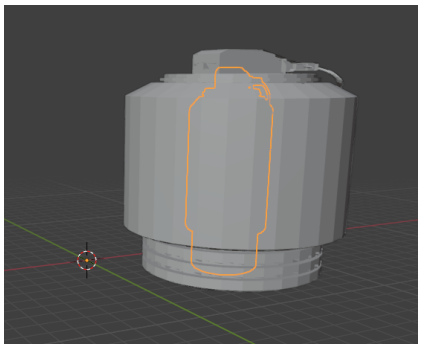
Explosive Unit Sphere Quantized Mesh

Comparison of Normalized and Quantized Meshes for different Normalization Methods for cylinder.obj

Here, the yellow-colored meshes are the normalized unit sphere mesh and the quantized unit sphere mesh.

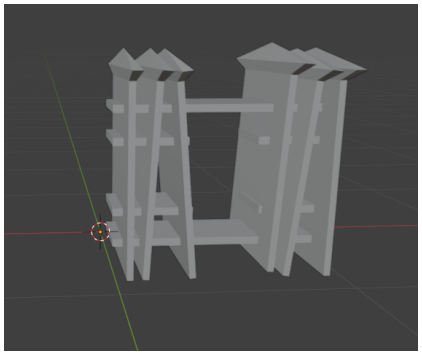


Explosive Normalized Meshes

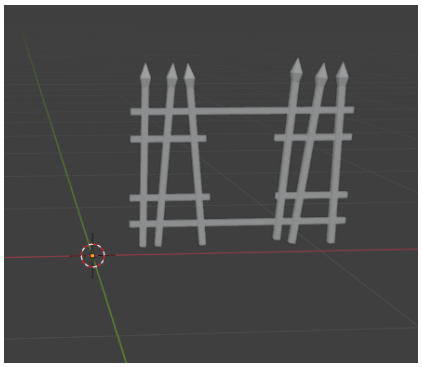


Explosive Quantized Meshes

Normalization Meshes for fence.obj



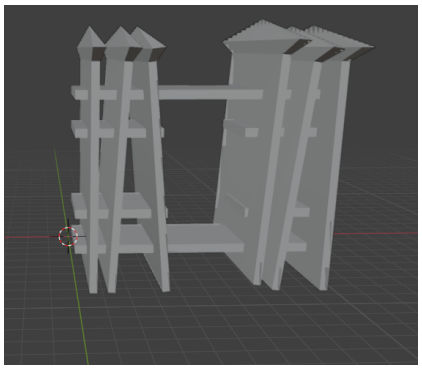
Fence Min Max Normalized Mesh



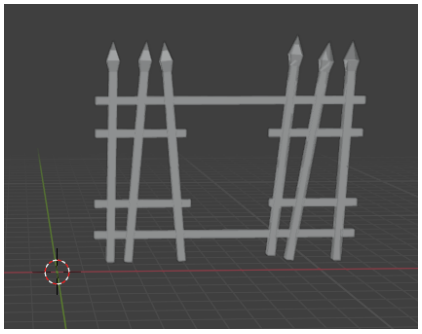
Fence Unit Sphere Normalized Mesh

Quantized Meshes for fence.obj

Quantized Mesh, which i obtained after performing quantization on Normalized Meshes. Quantized versions are much larger compared to the Normalized ones. if i compare quantized with normalized ones, they do not appear.



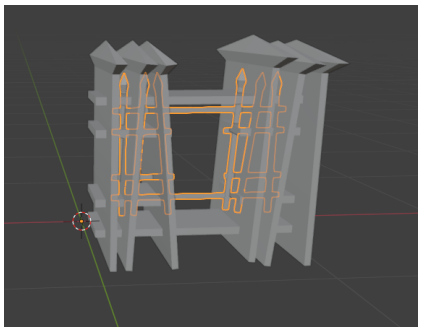
Fence Min Max Quantized Mesh



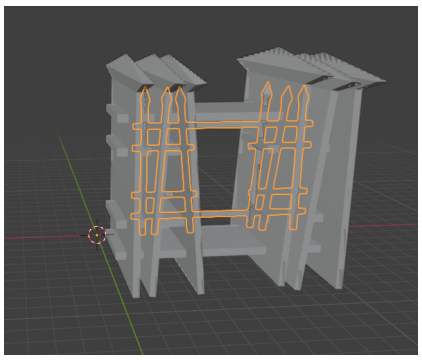
Fence Unit Sphere Quantized Mesh

Comparison of Normalized and Quantized Meshes for different Normalization Methods for fence.obj

Here, the yellow-colored meshes are the normalized unit sphere mesh and quantized unit sphere mesh.

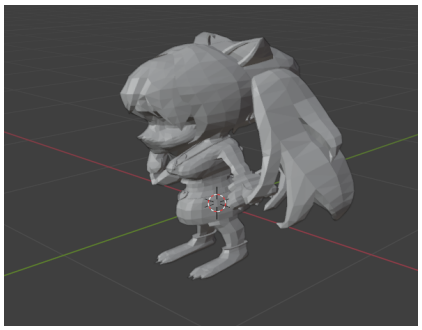


Fence Normalized Meshes

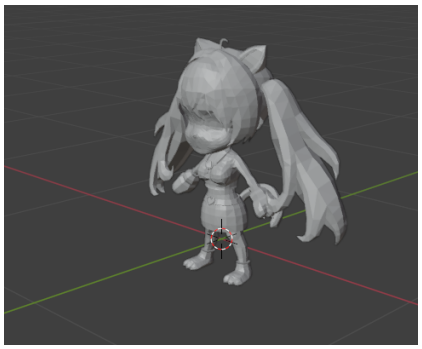


Fence Quantized Meshes

Normalization Mesh for girl.obj



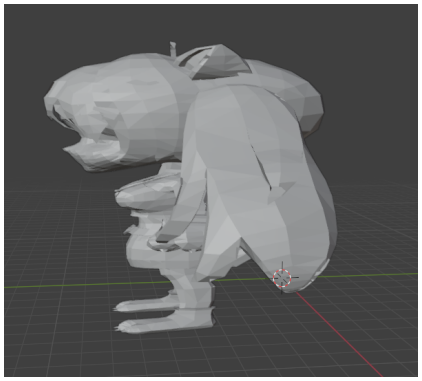
Girl Min Max Normalized Mesh



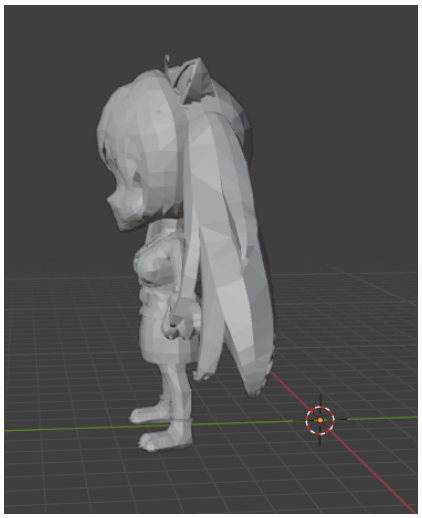
Girl Unit Sphere Normalized Mesh

Quantized Meshes for girl.obj

Quantized Mesh, which i obtained after performing quantization on Normalized Meshes. Quantized versions are much larger compared to the Normalized ones. if i compare quantized with normalized ones, they do not appear.



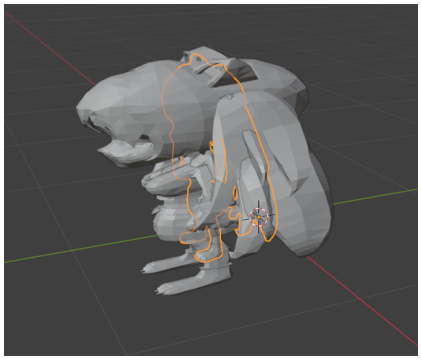
Girl Min Max Quantized Mesh



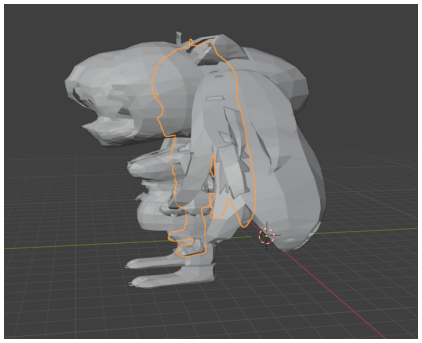
Girl Unit Sphere Quantized Mesh

Comparison of Normalized and Quantized Meshes for different Normalization Methods for girl.obj

Here, the yellow-colored meshes are normalized unit sphere mesh and quantized unit sphere mesh.



Girl Normalized Meshes

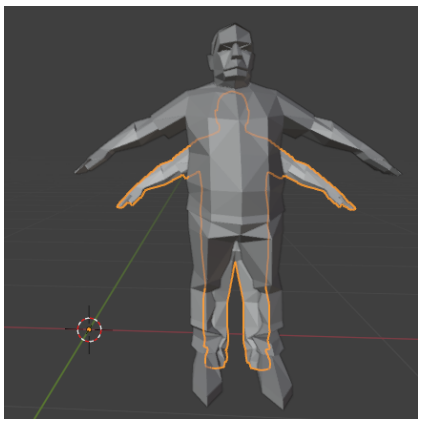


Girl Quantized Meshes

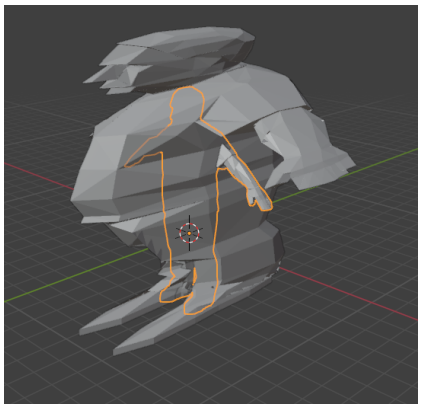
For the remaining meshes person, table and talwar. I directly compared the normalized in the same blender file. and also i compared the quantized ones in the same blender file.

Comparison of Normalized and Quantized Meshes for different Normalization Methods for person.obj

Here, the yellow-colored meshes are normalized unit sphere mesh and quantized unit sphere mesh.



Person Normalized Meshes



Person Quantized Meshes

Comparison of Normalized and Quantized Meshes for different Normalization Methods for table.obj

Here, the yellow-colored meshes are normalized unit sphere mesh and quantized unit sphere mesh.

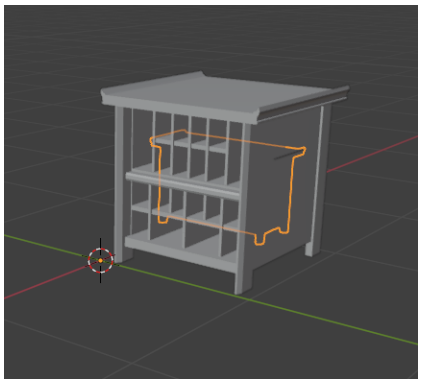


Table Normalized Meshes

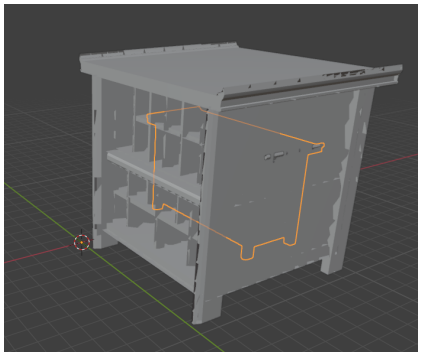
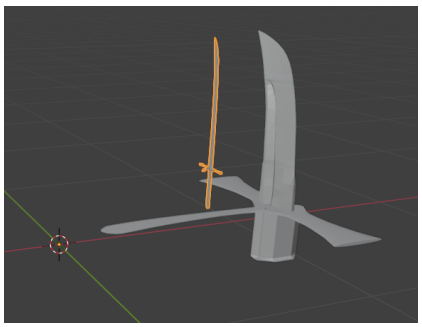


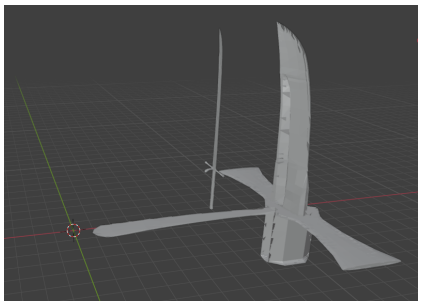
Table Quantized Meshes

Comparison of Normalized and Quantized Meshes for different Normalization Methods for talwar.obj

Here, the yellow-colored meshes are normalized unit sphere mesh and quantized unit sphere mesh.



Talwar Normalized Meshes



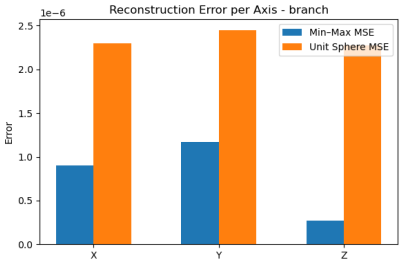
Talwar Quantized Meshes

which normalization method preserves the mesh structure better?

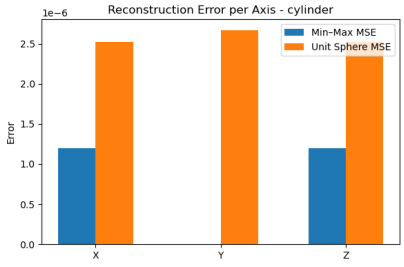
Between the two methods , Unit sphere normalization preserves the mesh structure better. It scales all vertices uniformly based on the largest distance from the center, maintaining the relative proportions and avoiding the axis wise distortions that can occur in Min-Max Normalization.

Task 3: Dequantize, Denormalize, and Measure Error

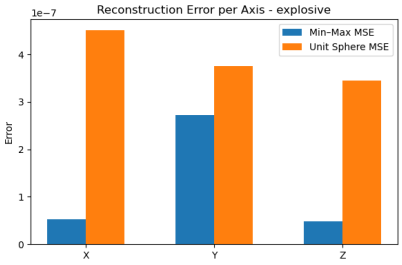
Plots of error metrics



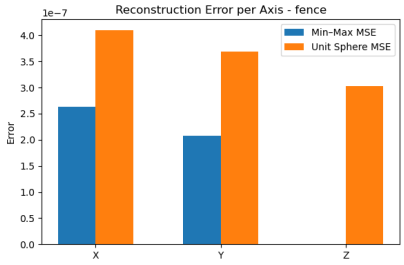
Branch Axis Error Plot



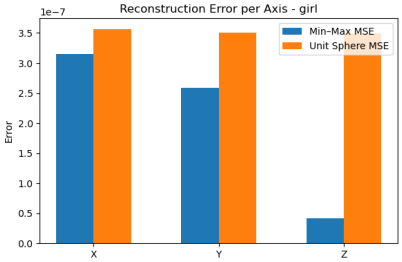
Cylinder Axis Error Plot



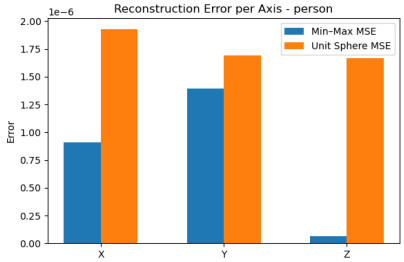
Explosive Axis Error Plot



Fence Axis Error Plot



Girl Axis Error Plot



Person Axis Error Plot

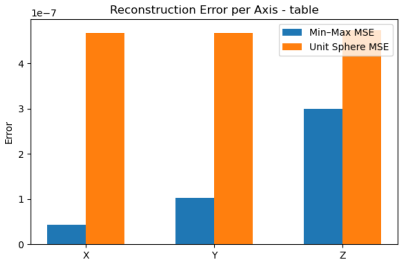
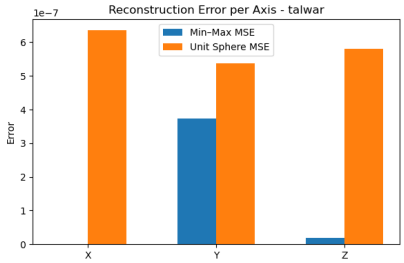
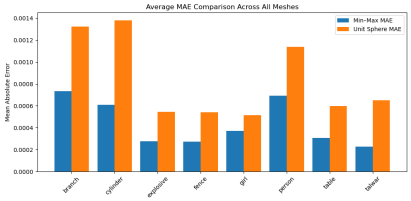


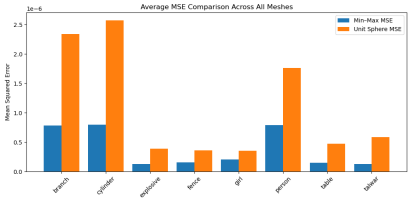
Table Axis Error Plot



Talwar Axis Error Plot

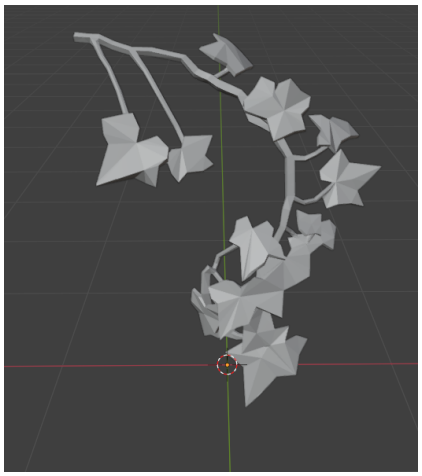


Comparison MAE for All Meshes

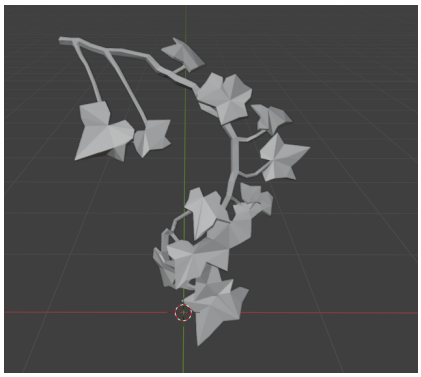


Comparison MSE for All Meshes

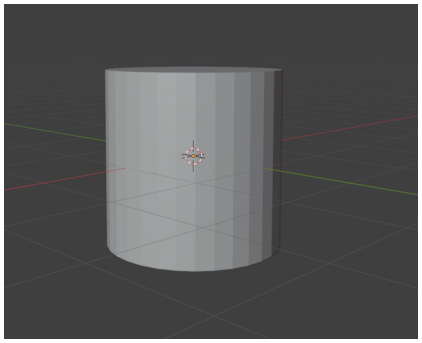
Reconstruction Meshes



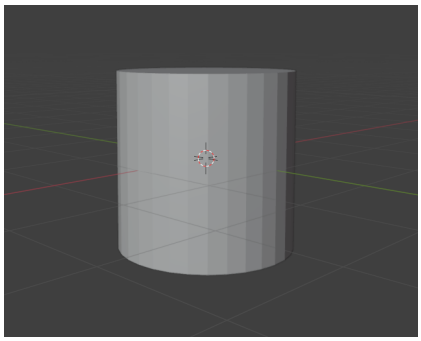
Reconstructed Branch Min Max Mesh



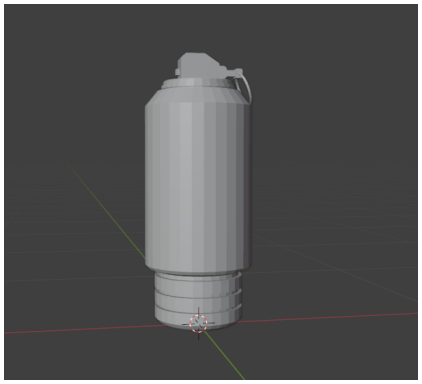
Reconstructed Branch Unit Sphere Mesh



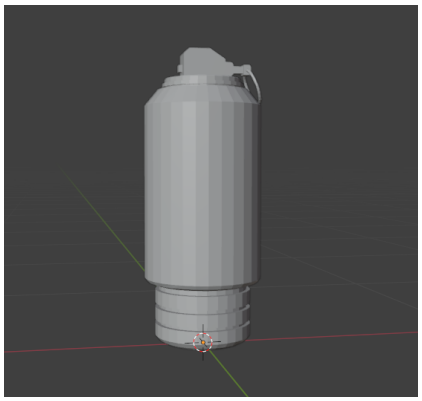
Reconstructed Cylinder Min Max Mesh



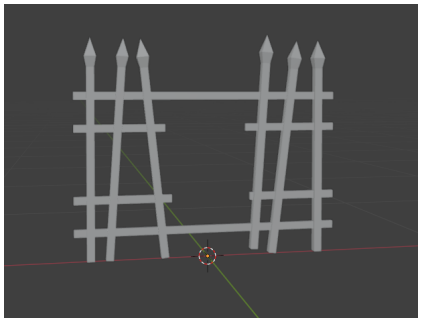
Reconstructed Cylinder Unit Sphere Mesh



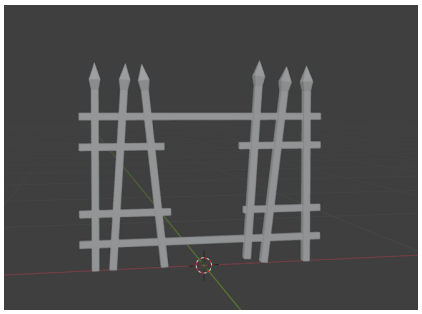
Reconstructed Explosive Min Max Mesh



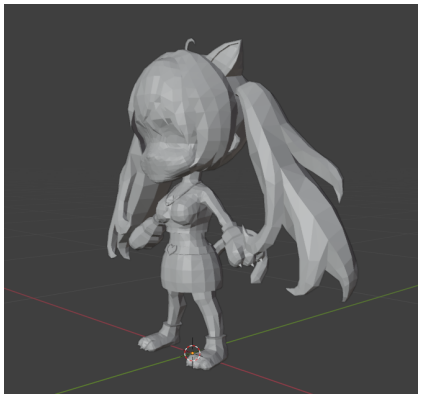
Reconstructed Explosive Unit Sphere Mesh



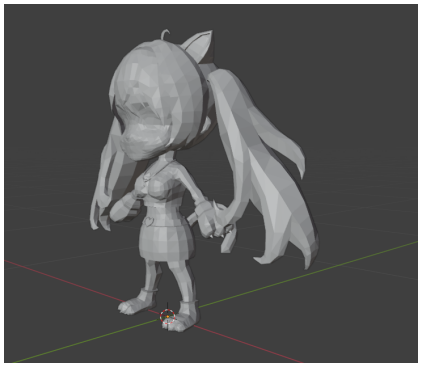
Reconstructed Fence Min Max Mesh



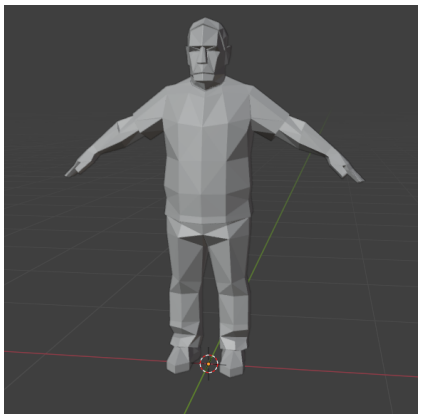
Reconstructed Fence Unit Sphere Mesh



Reconstructed Girl Min Max Mesh

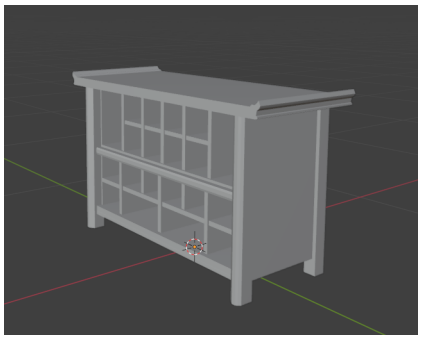


Reconstructed Girl Unit Sphere Mesh

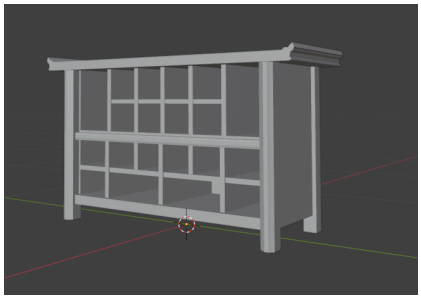


Reconstructed Person Min Max Mesh

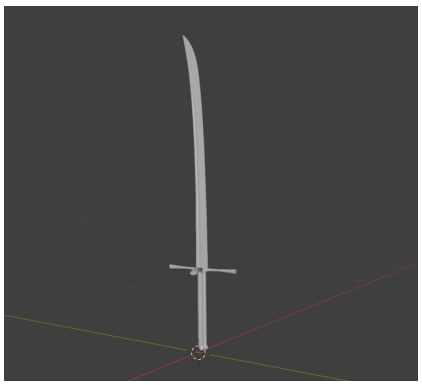
Reconstructed Person Unit Sphere Mesh



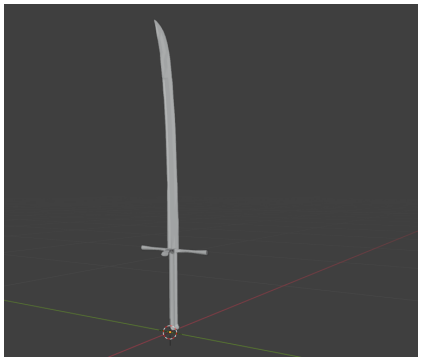
Reconstructed Table Min Max Mesh



Reconstructed Table Unit Sphere Mesh



Reconstructed Talwar Min Max Mesh



Reconstructed Talwar Unit Sphere Mesh

Which normalization and quantization combination gives the least error?

Among all meshes, the Min–Max normalization with uniform quantization consistently produced the lowest reconstruction error across all axes. The Unit Sphere normalization introduced slightly higher MSE and MAE values, likely due to the scaling and shifting involved in centering the mesh within a sphere. This shows that Min–Max normalization preserves the original geometric proportions more effectively during quantization and dequantization. Across all models (branch, cylinder, fence, etc.), the error pattern remains similar — smallest for Min–Max, slightly larger but stable for Unit Sphere. Hence, for consistent mesh preprocessing with minimal distortion, Min–Max normalization is the preferred choice.

For example, The original girl.obj mesh appears smooth and well-defined, while the Min–Max reconstructed version retains most details with slight roughness. The Unit Sphere reconstructed mesh looks comparatively uneven, confirming that Min–Max normalization preserves mesh structure more accurately than Unit Sphere normalization.

What pattern do you observe?

Across all meshes, the Min–Max normalization consistently produced lower reconstruction errors (MSE and MAE) than the Unit Sphere method. This pattern shows that scaling each axis independently (Min–Max) preserves the original geometry better, while Unit Sphere normalization slightly distorts proportions due to uniform global scaling.