1. Euler Characteristics

   Euler characteristics is a topological invariant, a number that describes a topological space's shape or structure regardless of the way it is bent *(1)*. It is defined as follows:

   $$\lambda = V - E + F,$$

   Where V is vertices, E is edges and F is faces.

   The following result was obtained after applying the Euler characteristics to each of our model.

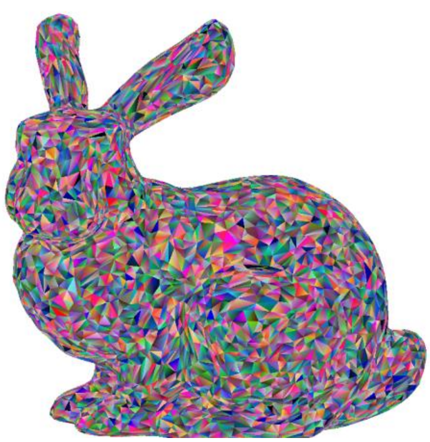
Model	Euler Characteristics	Number of handle observed in the model
Bunny	2	0
Dragon	0	1
Feline	-2	2
Happy	-10	6
Icosahedron	2	0
Octahedron	2	0
Sphere	2	0
Tetrahedron	2	0
Torus	0	1

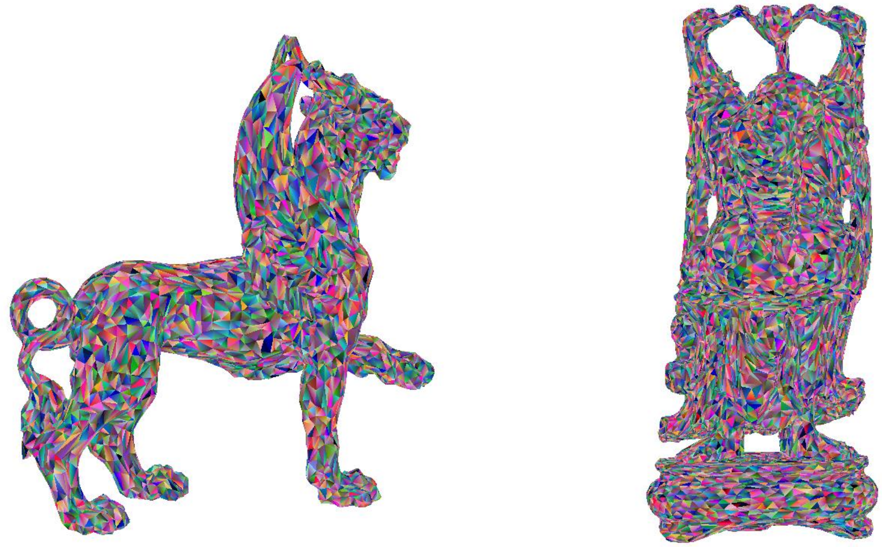
   From above it is found that the number of handle, **H** can be related to Euler Characteristics by the formula:

   $$H = 1 - \lambda/2$$

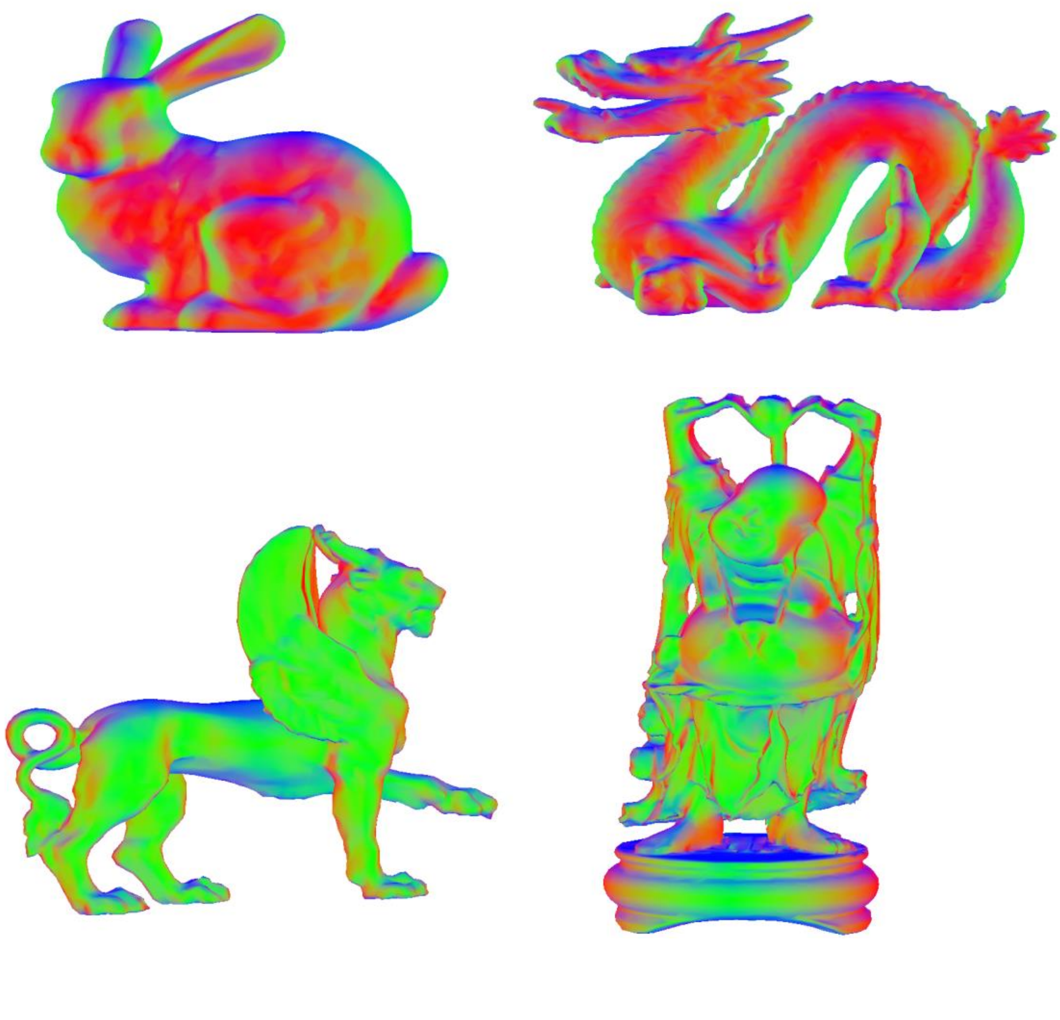
2. Mesh Coloring

   a. The results obtained after applying unique color to each of the polygon according to polygon ID is shown below:





b. The results obtained after applying color to each of the polygon according to normal are as follows:



c. The resultant image obtained after applying the given formula to each of 3D coordinates of the vertices are given below:

$$\boldsymbol{Red = f(floor\left(\frac{V_x}{L}\right)), Green = f(floor\left(\frac{V_y}{L}\right), Blue = f(floor\left(\frac{V_z}{L}\right)}$$

$$\boldsymbol{f(n) = \begin{cases} 0, & n\ is\ odd \\ 1, & n\ is\ even \end{cases}}$$

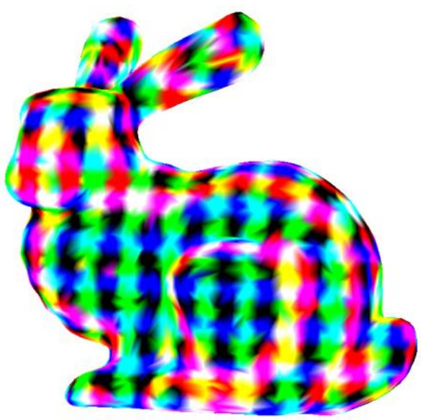
where $\boldsymbol{V_x}$, $\boldsymbol{V_y}$, $\boldsymbol{V_z}$ are the coordinates of the vertices in a mesh and L is user defined positive real number.

First Case: L =0.5

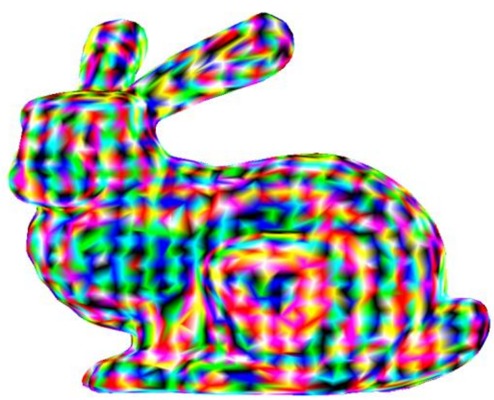
d. After applying 3D checkerboard color schemes, it is found that with increase in the value of L the grids become larger and stops after changing after certain point. Similarly when the value of L is decreased, the grids starts getting small and finally show minimum changes on further decrease of L values.

L= 10000

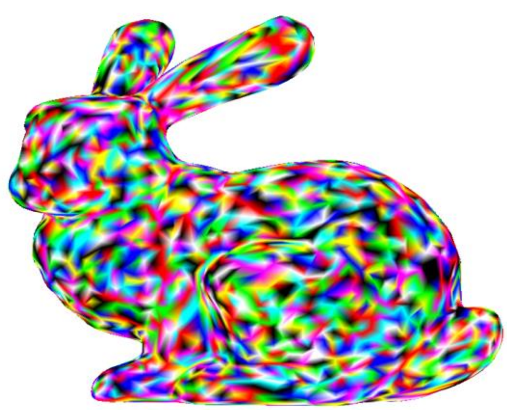
L=1.5



L=0.1



L=0.05

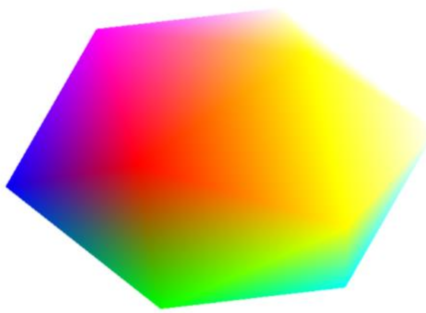


L=0.00005

e. In case of Icosahedron, the 3D checkerboard color mapping does not gives visible 3D grids. In case of other models, the grid were perfectly visible and only disappears when the value of L tends to become smaller and smaller.

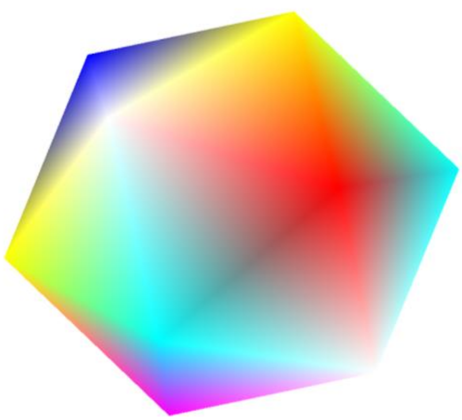
The main cause of the problem which I think in Icosahedron is that it consists of very few triangles. Since the number of triangles are less, the color of the vertices are interpolated and is clearly visible while in case of the other models, the vertices are so dense that the interpolation between colors is too small to observe.

The 3D checker color mapping can be improved if we can subdivide triangle at such a point that the color interpolation between two vertices become negligible.

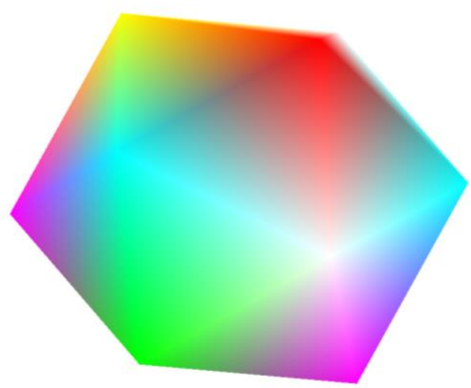


L =10000

L=10



L =0.01

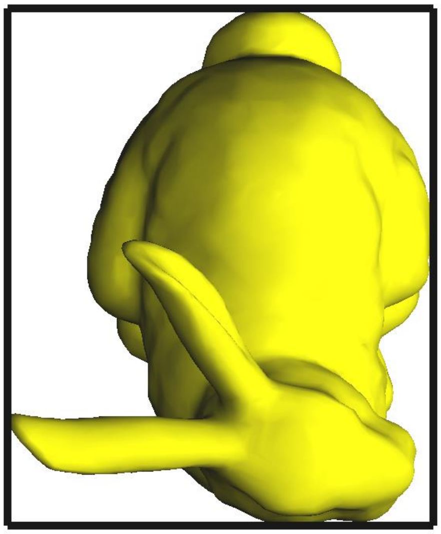


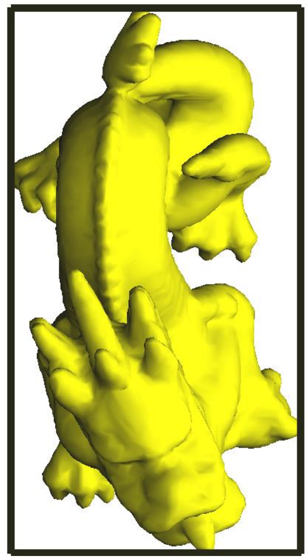
L=0.001

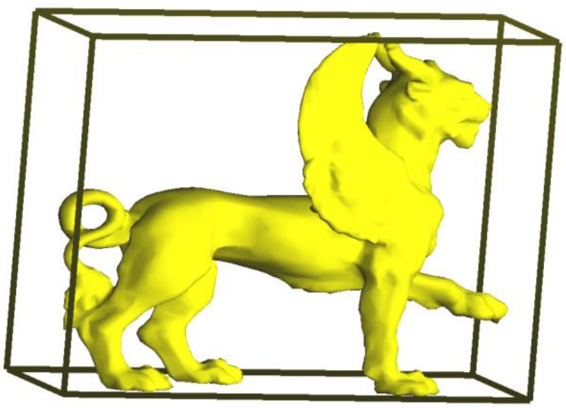
3. Bounding Boxes

To compute the bounding box, I have implemented the three different ways. Some of the results are shown below:

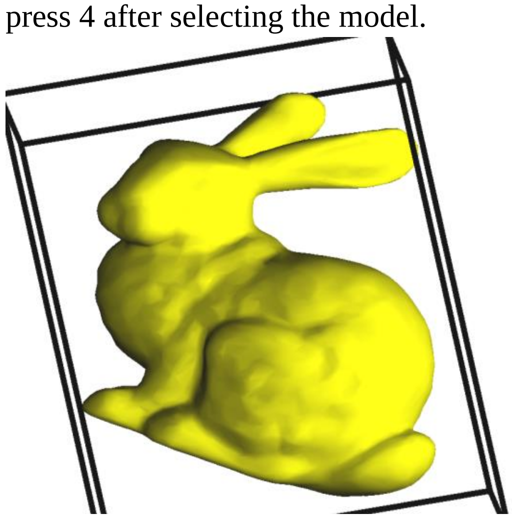
1. Bounding box according first moment (Center of Gravity): To see the result in the code press 5 after selecting the model.

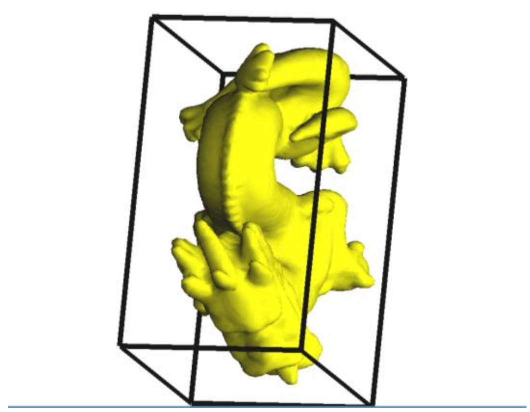






2. Bounding box according to second moment (Orientation): To see the result in the code press 4 after selecting the model.





3. Bounding box according to second moment based on normal: To see the result in the code press 6 after selecting the model.