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BLG634E 3D Vision – HW1

Guideline for submitting your homework: In submitting your homework:

i. Comment your codes clearly.
ii. All your code should be written in Python language.
iii. Do not send your HWs via e-mail. No exception!

Assignment 1: In this assignment you will work with 3D rotations.

Task 1- Plotting a 3D Object [5 pts]

Using numpy-stl, mpl_toolkits and matplotlib libraries read the “cow.stl” and plot the 3D cow as in the Figure 1, using the skeleton code given below.

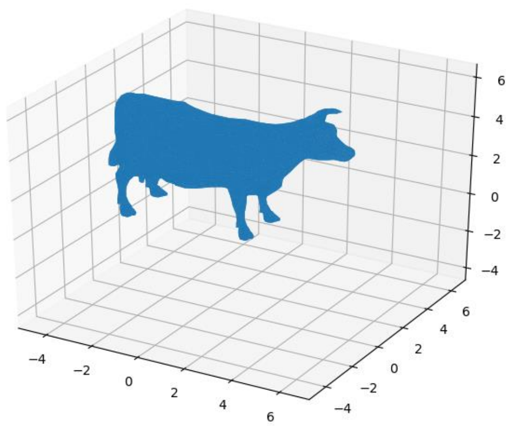

Figure 1: The cow in 3D grid

```
from stl import mesh
from mpl_toolkits import mplot3d
from matplotlib import pyplot
import numpy as np

figure = pyplot.figure()
axes = mplot3d.Axes3D(figure)
mesh_cow = mesh.Mesh.from_file('cow.stl')


print(mesh_cow.points.shape) #(5804, 9) Each triangular face of the
cow in column view
print(mesh_cow.vectors.shape) #(5804, 3, 3) Each triangular face of
the cow in 3x3 view. Each row represents a vertex.


axes.add_collection3d(mplot3d.art3d.Poly3DCollection(mesh_cow.vectors
))
#Add the 3D faces to the created matplotlib axes


min = np.min(mesh_cow.vectors.reshape(-1))
```

```
max = np.max(mesh_cow.vectors.reshape(-1))#Find minimum and maximum
units to place the cow in a cubular grid.

axes.auto_scale_xyz([min, max], [min, max], [min, max])
pyplot.show()
```

Then, use a **homogenous transform matrix** on each vertex to squeeze the model a bit to add a **"calf"** nearby the cow as given in Figure 2.

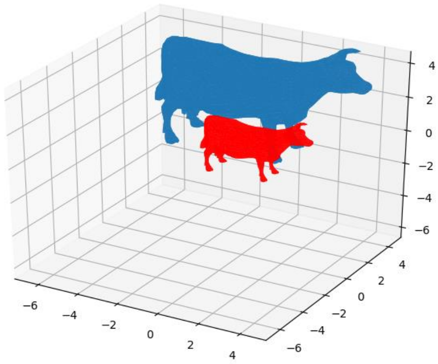

Figure 2: The cow and the calf

Task 2 - Exponential Coordinate Representation of 3D Rotations [20 pts]

(i) Start with a rotation angle of 45 degrees around z-axes. Calculate your 3x3 rotation matrix Ro, using the corresponding w_o vector in R^3 and using Rodrigues formula.

Rotate the cow object by the 3D rotation matrix Ro and display your original object and the rotated object superimposed on each other.

Visualization: Use the rendering given in the previous part with transparency and different colors for each cow as given in Figure 3.

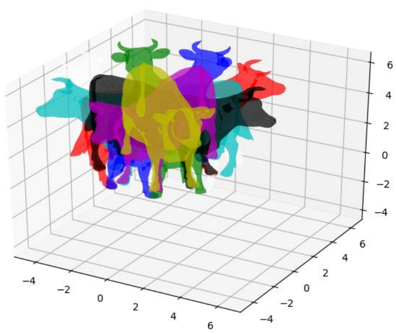

Figure 3: Rotated Cows

(ii) Repeat (i) with a rotation around the axis: w2 = [0.3, 0.7, -1]. Use norm of the axis vector as the amount of rotation. **Use default camera view.**

Typically, you have to choose the center of rotation appropriately. If the object is already centered, you will not have to worry about that.

Task 3: Tańcząca Polska Krowa [15 pts]

i. Rotate your object around w1 = [1, 0.5, 0], then rotate the result around w2 = [0.3, 0.7, -1] vector. Use the norm of each w vector as the amount of radians for rotation. Show your result.

ii. Now rotate your object first around w2 then around w1 vector given in (i).

Do you obtain the object in the same position after (i) and (ii) ? Can you say that 3D rotations are commutative or not?

Task 4: Perturbed Rotations [20 pts]

Now, choose an axis vector w, and perturb w vector in each of its 3 components by 2 times (e.g. +- 5). Using Rodrigues formula, calculate your 3x3 rotation matrix Ri for i=1,...,6.

Rotate your 3D object by each of the 3D rotation matrices Ri and display all the rotated objects superimposed with different colors and transparency.

Task 5: Quaternion Representation of 3D Rotations [20 pts]

Carry out the Task 3 by quaternions. Convert those rotations given by their axis vectors to quaternion representations q1 and q2. Carry out the consecutive quaternion multiplications to obtain the resulting quaternions and their corresponding rotation matrices. Comment on the result.

Task 6: Explain by a few sentences [10 pts]

I) Is there a singularity in the Exponential Coordinates? If yes, can it be overcome?
II) Is there a singularity in Quaternions?
III) Why is the quaternion representation preferred over Euler angle representation for 3D rotations?

Task 7: Computing Angles [10 pts]

Read Dr. Gregory G. Slabaugh's report titled "Computing Euler angles from a rotation matrix"[i]. Find which Euler angles are used in the transformation matrix given below. Apply the rotation to the object

I. Directly
II. Using rotation matrices R_x, R_y, R_z.

and show that your findings are true.

$$\begin{bmatrix} 0.8365 & -0.5245 & -0.1585 \\ 0.2241 & 0.5915 & -0.7745 \\ 0.5000 & 0.6124 & 0.6124 \end{bmatrix}$$

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[i] Slabaugh, G. G. (1999). Computing Euler angles from a rotation matrix. Retrieved on August, 6(2000), 39-63.