Week 02

Flat Vs Free Form Model Classification

To identify if the model is flat or free form we went with three approaches.

1. **Principal Component Analysis (PCA):**
    - PCA finds how the model spreads in 3 directions (length, width, thickness).
    - Eigenvalues tell us how much the data spreads in each direction.
    - Bigger eigenvalue, model is stretched more in that direction.
    - Smaller eigenvalue, model is almost flat in that direction.
    - In flat models, the eigenvalue for thickness is much smaller than the other two.
    - We check this by dividing the smallest eigenvalue by the largest.
    - If the ratio < 0.1, the model is classified as flat.
    - This method works even if the model is rotated.

2. **Bounding Box Dimensions:**
    - First, we calculate the mesh's bounding box, which is the smallest box that completely contains the model.
    - We then identify the thickness (the smallest side of the box) and the largest dimension.
    - Next, we compute the ratio: thickness ÷ largest dimension.
    - If the ratio < 0.1, the model is classified as flat.

3. **Overhang Angles:**
    - Check the angle of each face of the mesh compared to the vertical (Z-axis).
    - Flat models have most faces aligned close to vertical, meaning they have few large overhangs.
    - We counted faces with angles > 30° (large overhangs).
    - If the number of faces with large overhang angles is low, the model is considered flat.

For the final classification, each method votes on whether the model is flat, and if two or more methods classify it as flat, the model is labeled flat; otherwise, it is labeled free form.

Model Size Classification

- o Each STL model is loaded using the numpy-stl library, which gives access to all the vertices of the mesh.
- o For each model, we calculate the bounding box by finding the minimum and maximum coordinates along the X, Y, and Z axes.
- o The difference between the maximum and minimum coordinates gives the model's size along each axis (length, width, height).
- o The largest of these three values represents the model's maximum physical dimension.
- o Models are classified based on this largest dimension:
  - ➢ ≤ 50 mm → small
  - ➢ 150 mm → big
  - ➢ Anything in between we considered as medium

filename	max_dimension_	category
104559.stl	150	BIG
105220.stl	181.8	BIG
37653.stl	406.91	BIG
38290.stl	268	BIG
38554.stl	187.69	BIG
38558.stl	223.14	BIG
38631.stl	299.6	BIG
38646.stl	193.79	BIG
38753.stl	216.75	BIG
38781.stl	200	BIG
40661.stl	187.46	BIG
40662.stl	187.46	BIG
40741.stl	243.04	BIG
40888.stl	151.24	BIG
41089.stl	20000	BIG

Figure 1:Results

104401.stl	32	SMALL
104403.stl	37.6	SMALL
104431.stl	2	SMALL
104445.stl	1.2	SMALL
104582.stl	48.81	SMALL
104969.stl	35.75	SMALL
105174.stl	42.45	SMALL
105230.stl	43.27	SMALL
105326.stl	46.55	SMALL
105330.stl	20	SMALL
105335.stl	43.99	SMALL
34783.stl	40.89	SMALL
34784.stl	40.89	SMALL
34785.stl	29.52	SMALL
37012.stl	31.98	SMALL
37179.stl	40.71	SMALL
37215.stl	50	SMALL
37221.stl	45	SMALL
37225.stl	44	SMALL

Figure 2:Results

103742.stl	135.2	MEDIUM
103815.stl	140	MEDIUM
103817.stl	140	MEDIUM
103821.stl	76	MEDIUM
103824.stl	79	MEDIUM
103825.stl	79	MEDIUM
103826.stl	79	MEDIUM
104187.stl	133.08	MEDIUM
104188.stl	133.08	MEDIUM
104290.stl	99.32	MEDIUM
104294.stl	99.32	MEDIUM
104301.stl	105.06	MEDIUM
104400.stl	60.79	MEDIUM
104402.stl	55.6	MEDIUM
104404.stl	59.6	MEDIUM
104421.stl	99.32	MEDIUM
104432.stl	99.32	MEDIUM
104442.stl	132.78	MEDIUM
104509.stl	121.5	MEDIUM
104510.stl	121.5	MEDIUM
104511.stl	115.83	MEDIUM
104512.stl	61.85	MEDIUM
104513.stl	115.83	MEDIUM
104563.stl	82.61	MEDIUM
104606.stl	62.44	MEDIUM

Figure 3:Results