Assignment 3: Simple Computer Graphics

2018 Fall EECS205002 Linear Algebra

Due: 2018/12/12

One of the major task of computer graphics (CG) is to project 3D objects onto a 2D screen. In this assignment, you will see how important linear algebra is for CG. Let's first work on a simple object. Figure 1 shows the coordinates of a cube, which has eight points and six faces. The coordinates of points and the points of each face are recorded in Table **??**. Note the coordinate follows the right-hand rule, which means $\vec{x} \times \vec{y} = \vec{z}$, and the points of each face are in the counter-clock wise order. Such rule and ordering is important when we want to compute the normal vectors of the faces correctly.

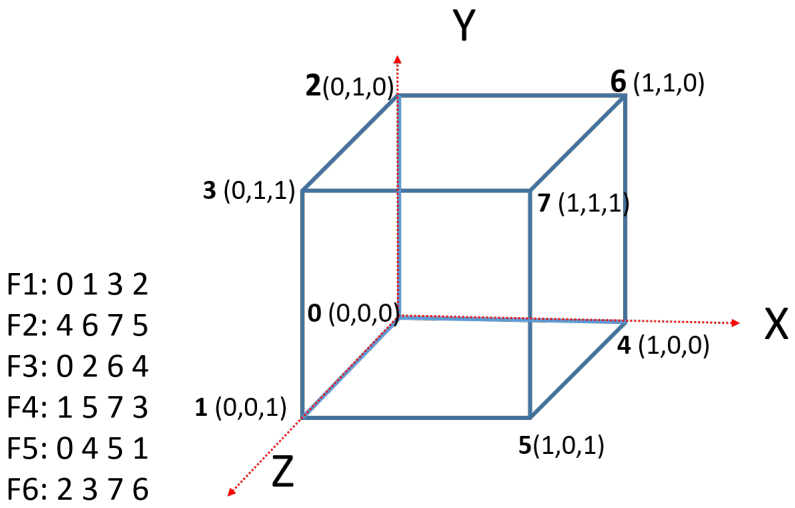
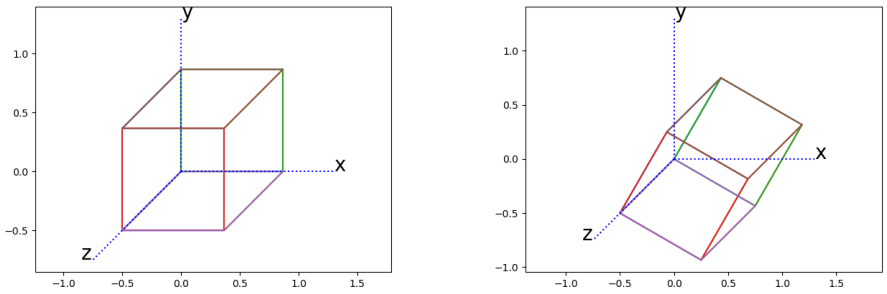


Figure 1: The coordinate of a cube.

Now we can use the knowledge of linear algebra to transform the cube into different shapes. For example, we can rotate the cube on the x-y plane by multiplying the coordinates with

$$R = \begin{bmatrix} \cos(\theta) & \sin(\theta) & 0 \\ -\sin(\theta) & \cos(\theta) & 0 \\ 0 & 0 & 1 \end{bmatrix},$$



(a) Original cube

(b) Rotation

(c) Skew

(d) Hidden surface removal

Figure 2: Different linear transformation of the cube and the hidden surface removal.

(as shown in Figure 2(b)) or shew the cube in the z direction by

$$S = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 2 & 0 & 1 \end{bmatrix}.$$

as shown in Figure 2(c). You can also enlarge or shrink the cube in each direction by

$$M = \begin{bmatrix} m_1 & 0 & 0 \\ 0 & m_2 & 0 \\ 0 & 0 & m_3 \end{bmatrix}.$$

The best thing is that you can combine different linear operations by the products of different transformation matrices. We call such transformation *compounded transformation*.

1 Assignment in Python

1. Design a convex object with at least 7 faces, and show it.
2. Design 8 different transformations, at least half of them should be compounded transformations. Show the results and the transformation matrices.
3. How to remove the hidden surfaces? Show the plots without hidden surfaces, and explain how do you do that. (Hint: you can assume the viewing direction is fixed.)

2 Submission

1. Write a report in PDF file that include your object, the figures after transformation, and transformation matrices. Give proper explanation for each one.
2. Python codes of all figures.
3. Zip them and submit to iLMS system