SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

50.017 Graphics and Visualization

Quiz 2

Date: 2022-June-09

Time: 6:00pm – 6:30pm

Duration: 30 mins

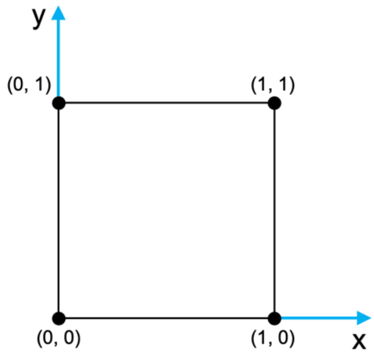
Student Name:

Student ID:

Instructions:

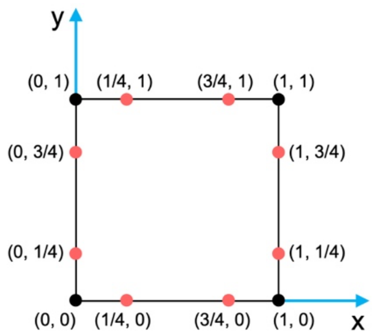
1. This quiz consists of 4 questions and 5 printed pages.
2. This is an Open Book quiz.
3. You may use calculators. Whether or not you choose to use a calculator, you should clearly and systematically write out all steps in your solutions.
4. Draft paper will be provided on request.

Q1. Consider the following unit square as a control polygon, our goal is to generate a 2D subdivision curve from this control polygon. Draw the resulting curve by subdividing this control polygon *once* using the *Corner Cutting* rule. Provide 2D coordinates of each vertex on this subdivision curve and the way that you derive these 2D coordinates. [2 Points]

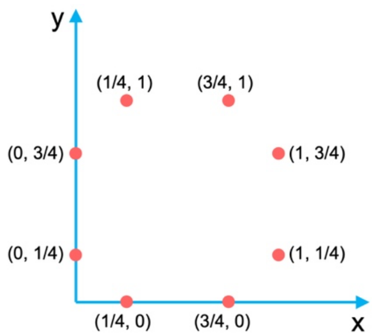


Solution:

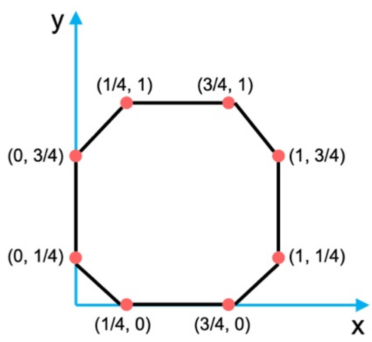
Insert two new vertices (in red) at 1/4 and 3/4 of each edge; see 2D coordinates of each new vertices in the below figure.



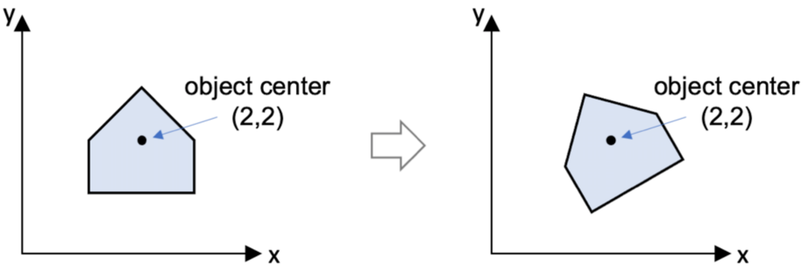
Remove the old vertices and the control polygon



Connect the new vertices to form the subdivision curve



Q2. Given a 2D object centered at $(2,2)$. Compute a transformation matrix that rotates the object around its center for 30 degrees counter-clockwise. [3 Points]



Before transformation   After transformation

Solution:

Matrix A_1 translates object center to origin:

$$\mathrm{A}_1 = \begin{bmatrix} 1 & 0 & -2 \\ 0 & 1 & -2 \\ 0 & 0 & 1 \end{bmatrix}$$

Matrix A_2 rotates object around its center for 30 degrees:

$$\mathrm{A}_2 = \begin{bmatrix} \sqrt{3}/2 & -1/2 & 0 \\ 1/2 & \sqrt{3}/2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

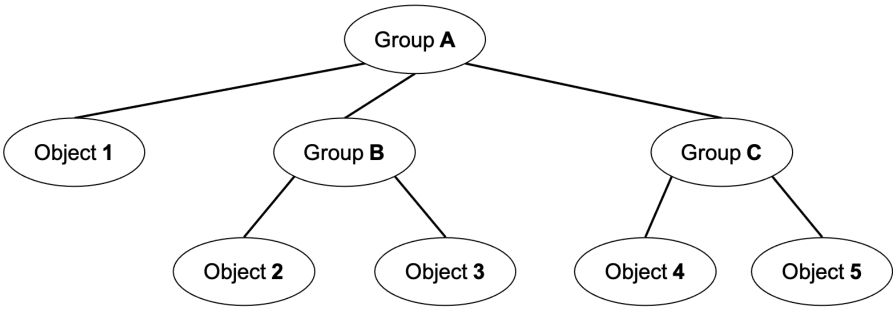
Matrix A_3 translates object back to its center:

$$\mathrm{A}_3 = \begin{bmatrix} 1 & 0 & 2 \\ 0 & 1 & 2 \\ 0 & 0 & 1 \end{bmatrix}$$

Concatenate above transformations:

$$\mathrm{A} = \mathrm{A}_3\mathrm{A}_2\mathrm{A}_1 = \begin{bmatrix} \sqrt{3}/2 & -1/2 & 3-\sqrt{3} \\ 1/2 & \sqrt{3}/2 & 1-\sqrt{3} \\ 0 & 0 & 1 \end{bmatrix}$$

Q3. In the following scene graph, we translate Group A with vector $(2, 0,0)^{\mathrm{T}}$(with respect to the world), then translate Group B with vector $(0, 4,0)^{\mathrm{T}}$ (with respect to Group A), and finally rotate Object 3 around y-axis for 45 degrees (with respect to Group B). Compute the transformation matrix applied on Object 3 in the world coordinate frame. [3 Points]



Solution:

The three transformation matrices are:

Translating Group A: $M_1 = \begin{bmatrix} 1 & 0 & 0 & 2 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

Translating Group B: $M_2 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 4 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

Rotating Object 3: $M_3 = \begin{bmatrix} \cos 45 & 0 & \sin 45 & 0 \\ 0 & 1 & 0 & 0 \\ -\sin 45 & 0 & \cos 45 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$ = $\begin{bmatrix} \sqrt{2}/2 & 0 & \sqrt{2}/2 & 0 \\ 0 & 1 & 0 & 0 \\ -\sqrt{2}/2 & 0 & \sqrt{2}/2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

In hierarchical models, matrices for the lower hierarchy nodes go to the right in the matrix multiplication. Hence, the resulting transformation is:

$$M = M_1 M_2 M_3 = \begin{bmatrix} \sqrt{2}/2 & 0 & \sqrt{2}/2 & 2 \\ 0 & 1 & 0 & 4 \\ -\sqrt{2}/2 & 0 & \sqrt{2}/2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

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Q4. A color has a RGB value (0.2, 0.2, 0.9). Represent the color using CMY and CMYK color models, respectively. [2 Points]

Solution:

The CMY value of the color is:

(1.0, 1.0, 1.0) – (0.2, 0.2, 0.9) = (0.8, 0.8, 0.1)

The CMYK value of the color is:

K = min{C, M, Y} = min{0.8, 0.8, 0.1} = 0.1

C = (1- R) – K = 1 – 0.2 – 0.1 = 0.7

M = (1- G) – K = 1 – 0.2 – 0.1 = 0.7

Y = (1- B) – K = 1 – 0.9 – 0.1 = 0.0