CS-411 – Assignment 2 (5%)

2D Modeling and Viewing

Due by: October 5, 2017

1. The purpose of this assignment is to practice modeling and viewing transformations in 2D.
2. Answer the following questions by both writing and multiplying the relevant matrices and vectors by hand and by writing a small JavaScript program to solve them (excluding the last 4 questions):
   (a) Given the 2D point $(1, 1)$ find its coordinates after translating it by $(2, 3)$.
   (b) Given the 2D point $(1, 1)$ find its coordinates after scaling it by $(2, 2)$.
   (c) Given the 2D point $(1, 1)$ find its coordinates after rotating it by 45 degrees.
   (d) Given the 2D point $(1, 1)$ find its coordinates in homogeneous coordinates.
   (e) Given the 2DH point $(1, 1, 2)$ in homogeneous coordinates, find the 2D point corresponding to it.
   (f) Given the 2DH point $(1, 2, 3)$ in homogeneous coordinates, find another homogeneous point representing the same 2D point.
   (g) Given the 2D point $(1, 2, 3)$ in homogeneous coordinates find the (x, y) coordinates of the 2D point corresponding to it.
   (h) Explain the meaning of the 2DH point $(1, 1, 0)$. What does it represent?
   (i) Given the 2D point $(2, 5)$ find its coordinate after rotating it by 30^0 about the origin.
   (j) Given the 2D point $(2, 5)$ find its coordinate after rotating it by 30^0 about the point $(1, 2)$.
   (k) Given the 2D point $(2, 5)$ find its coordinate after translating it by $(3, 4)$ and then rotating it by 45^0 about the origin.
   (l) Given the 2D point $(2, 5)$ find its coordinate after rotating it by 45^0 about the origin and then translating it by $(3, 4)$.
   (m) Given the point $(5, 6)$ in a world coordinate system, find its coordinates in a camera coordinate system. Assume that the camera coordinate system is translated by $(1, 2)$ with respect to the world coordinate system and rotated by 45^0 with respect to the world coordinate system.
   (n) Given that I want first to rotate an object using a matrix R and then translate it using a matrix T, what should be the combined matrix (expressed in terms of R and T) that needs to be applied to the object.
   (o) Find the window to viewport transformation that transforms from a window defined by $(1, 1)(2, 2)$ to a viewport defined by $(3, 3)(4, 5)$.
   (p) Given the line segment $(1, 1)(2, 2)$ what would be the binary code the point $(1, 1)$ receives using the Cohen-Sutherland line clipping algorithm assuming that the clipping window is defined by $(0, 0)(1, 1)$.
   (q) Explain how to test that a line segment is completely inside or outside the clipping window.

3. Write a WebGL program that implements the following:

   (a) Generate a random path made of connected line segments and move a 2D object (a polygon) along this path by shifting its center to points along the path. Start by moving the object along a straight line, then when reaching the boundary of the window bounce the object into a new straight line path.

   (b) In addition to moving the object, rotate it about its center so that it moves and rotates at the same time.

   (c) Add buttons to increase/decrease the animation rate, stop the animation, and zoom in/out. Zooming in/out could be done by changing the camera window.

   (d) Add a button for toggling a mode in which past positions of the object are drawn as line segments.

   (e) Add a button for toggling a mode in which the object is moved along the path without continuously rotating it. Instead the object moves along the path so that a vector attached to it remains perpendicular to the path. A possible way to achieve this is to use the following steps:

   - Find a vector in the direction of the path (e.g. current position - previous position).
   - Normalize this vector by dividing it by its magnitude.
   - Rotate this vector by 90 degrees to find a perpendicular vector.
   - Prepare a 2D rotation matrix with first row as the normalized path vector and second row as the perpendicular vector. Note that you need a 2D rotation in homogeneous coordinates.
   - Apply this rotation to rotate the triangle (note that you need to combine transformations so that the rotation is about the center of the triangle).

   (f) A skeleton program will be provided. You are not required to use the provided skeleton program and may modify it as needed.

   (g) Note that it is easier to write the program using $4x4$ transformation matrices and $4x1$ vectors with a zero Z coordinate. E.g.:

```
var V  = new Vector4([1,2,0,1]);
var SM = new Matrix4();
SM.setScale(1/3,1/3,0);
var V1 = SM.multiplyVector4(V);
```

4. Follow the submission instructions of assignment 1.