Programming Lab 08

I will provide you with the header file Projection.h, which contains the following three function prototypes

```
Affine CameraToWorld(const Camera& cam);
Affine WorldToCamera(const Camera& cam);
Matrix CameraToNDC(const Camera& cam);
```

(the header files Camera.h and Affine.h have been included). You are to implement these functions, which are described below.

CameraToWorld(cam) – returns the affine transformation that maps camera space coordinates to world space coordinates. Note that the dimensions of the viewport are the same in both coordinate systems.

WorldToCamera(cam) – returns the affine transformation that maps world space coordinates to camera space coordinates. Note that the dimensions of the viewport are the same in both coordinate systems. This transformation moves cam (via rotation and translation) to the canonical camera, whose center of projection is at the origin and with right, up, and back vectors aligned along the x, y, and z axes (respectively). In particular, the lookat vector of the canonical camera points along the negative z-axis.

CameraToNDC(cam) – returns the matrix that represents the transformation from camera coordinates to normalized device coordinates. Here the normalized device coordinate system is such that the view frustum is mapped to the standard cube:

$$\left(-1 \leq x \leq 1, -1 \leq y \leq 1, -1 \leq z \leq 1\right)$$

and such that the near face maps to the standard cube face at z = 1, and the far face maps to the standard cube face at z = 1. Recall that this matrix can be taken to be

$$\Pi = \begin{bmatrix} 2D/W & 0 & 0 & 0 \\ 0 & 2D/H & 0 & 0 \\ 0 & 0 & \frac{n+f}{n-f} & \frac{2nf}{n-f} \\ 0 & 0 & -1 & 0 \end{bmatrix}$$

where W, H give the width and height of the camera viewport, D is the distance from the center of projection (the origin in camera coordinates) to the viewport, and n,f give the distance to the near and far planes. A perspective divide is needed after applying this matrix to a point.

Your submission for this task should consist of a single file named Projection.cpp. You may only include the header file Projection.h (which automatically includes Affine.h and Camera.h).