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CSE - B

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
UCS1712 – GRAPHICS AND MULTIMEDIA LAB

Lab Exercise 5: : 2D Transformations in C++ using OpenGL

To apply the following 2D transformations on objects and to render the final output along with the original object.
1) Translation
2) Rotation
 a) about origin
 b) with respect to a fixed point (xr,yr)
3) Scaling with respect to
 a) origin - Uniform Vs Differential Scaling
 b) fixed point (xf,yf)
4) Reflection with respect to
 a) x-axis
 b) y-axis
 c) origin
 d) the line x=y
5) Shearing
 a) x-direction shear
 b) y-direction shear
Note: Use Homogeneous coordinate representations and matrix multiplication to perform transformations. Divide the output window into four quadrants. (Use LINES primitive to draw x and y axis.

Aim:
To implement 2D transformations on objects using C++ using OpenGL

Algorithm:

Application of a sequence of transformations to a point:

P' = M2.M1.P
 = M.P

Composite transformations is formed by calculating the matrix product of the individual transformations and forming products of transformation matrix.

Code:

5a.cpp:

```
#include <stdio.h>
#include <GL/glut.h>
#include <math.h>
```

```
#include <string.h>
#define pi 3.142857
void mm(double m[3][3], double v[3])
{
    for (int i = 0; i < 3; ++i)
    {
        double temp = 0;
        for (int k = 0; k < 3; ++k)
            temp += m[i][k] * v[k];
        v[i] = temp;
    }
}
int X = 100, Y = -50;
void draw_pixel(int x, int y)
{
    glBegin(GL_POINTS);
    glVertex2i(x, y);
    glEnd();
}
void output(int x, int y, const char *string)
{

    glRasterPos2f(x, y);
    int len, i;
    len = (int)strlen(string);
    for (i = 0; i < len; i++)
    {
        glutBitmapCharacter(GLUT_BITMAP_HELVETICA_12, string[i]);
    }
}
void obj(int a, int b, int c, int d, int w, int x, int y, int z)
{
    glBegin(GL_QUADS);
    glVertex2d(a, b);
    glVertex2d(c, d);
    glVertex2d(w, x);
    glVertex2d(y, z);

    glEnd();
}
void myInit(void)
{
    glClearColor(0.0, 0.0, 0.0, 1.0);
    glColor3f(0.0, 1.0, 0.0);
    glPointSize(1.0);
    glMatrixMode(GL_PROJECTION);
    glLoadIdentity();
    gluOrtho2D(-780, 780, -420, 420);
}
void display(void)
{
    glClear(GL_COLOR_BUFFER_BIT);
    glColor3f(1.0, 1.0, 1.0);
    glBegin(GL_LINES);
    glVertex2d(0, 420);
```

```
    glVertex2d(0, -420);
    glEnd();
    glBegin(GL_LINES);
    glVertex2d(780, 0);
    glVertex2d(-780, 0);
    glEnd();

    glColor3f(0.0, 1.0, 0.0);

    // TRANSLATION
    double x1[3];
    double x2[3];
    double x3[3];
    double x4[3];
    x1[2] = x2[2] = x3[2] = x4[2] = 1;
    x1[0] = 100;
    x1[1] = 100;
    x2[0] = 200;
    x2[1] = 100;
    x3[0] = 200;
    x3[1] = 200;
    x4[0] = 100;
    x4[1] = 200;
    obj(x1[0], x1[1], x2[0], x2[1], x3[0], x3[1], x4[0], x4[1]);
    output(110, 210, "originalA:");
    double T[3][3] = {{1, 0, 150}, {0, 1, 150}, {0, 0, 1}};
    mm(T, x1);
    mm(T, x2);
    mm(T, x3);
    mm(T, x4);

    obj(x1[0], x1[1], x2[0], x2[1], x3[0], x3[1], x4[0], x4[1]);
    output(260, 360, "translatedA:");

    // ROTATION
    double R[3][3] = {{cos(pi / 4), -sin(pi / 4), 0}, {sin(pi / 4), cos(pi / 4),
0}, {0, 0, 1}};
    x1[0] = 100;
    x1[1] = 100;
    x2[0] = 200;
    x2[1] = 100;
    x3[0] = 200;
    x3[1] = 200;
    x4[0] = 100;
    x4[1] = 200;
    mm(R, x1);
    mm(R, x2);
    mm(R, x3);
    mm(R, x4);
    //  printf("%lf%lf%lf%lf%lf%lf%lf%lf", x1[0], x1[1], x2[0], x2[1], x3[0],
x3[1], x4[0], x4[1]);
    printf("%f%f%f%f%f%f%f%f", x1[0], x1[1], x2[0], x2[1], x3[0], x3[1], x4[0],
x4[1]);
    obj(x1[0], x1[1], x4[0], x4[1], x3[0], x3[1], x2[0], x2[1]);
    output(10, 300, "rotatedA:");
```

```
    printf("%lf", cos(pi / 4));

    // PIVOTROTATION
    double PR[3][3] = {{cos(-pi / 4), -sin(-pi / 4), -X * cos(-pi / 4) + Y * sin(-
pi / 4) + X}, {sin(-pi / 4), cos(-pi / 4), -X * sin(-pi / 4) - Y * cos(-pi / 4) +
Y}, {0, 0, 1}};
    x1[0] = 100;
    x1[1] = 100;
    x2[0] = 200;
    x2[1] = 100;
    x3[0] = 200;
    x3[1] = 200;
    x4[0] = 100;
    x4[1] = 200;
    glColor3f(1.0, 1.0, 1.0);
    output(X - 15, Y - 20, "(rotPivot)");
    glPointSize(5);
    glBegin(GL_POINTS);
    glVertex2d(X, Y);
    glEnd();
    glColor3f(0.0, 1.0, 0.0);
    mm(PR, x1);
    mm(PR, x2);
    mm(PR, x3);
    mm(PR, x4);
    //  printf("%lf%lf%lf%lf%lf%lf%lf%lf", x1[0], x1[1], x2[0], x2[1], x3[0],
x3[1], x4[0], x4[1]);
    printf("%f%f%f%f%f%f%f%f", x1[0], x1[1], x2[0], x2[1], x3[0], x3[1], x4[0],
x4[1]);

    obj(x1[0], x1[1], x4[0], x4[1], x3[0], x3[1], x2[0], x2[1]);
    // obj(x1[0],x1[1],x2[0],x2[1],x3[0],x3[1],x4[0],x4[1]);
    // SCALING
    x1[0] = -50;
    x1[1] = -50;
    x2[0] = -100;
    x2[1] = -50;
    x3[0] = -100;
    x3[1] = -100;
    x4[0] = -50;
    x4[1] = -100;
    glColor3f(1.0, 0.0, 1.0);
    obj(x1[0], x1[1], x2[0], x2[1], x3[0], x3[1], x4[0], x4[1]);
    output(-100, -40, "originalB:");
    double S[3][3] = {{2, 0, 0}, {0, 2, 0}, {0, 0, 1}};
    mm(S, x1);
    mm(S, x2);
    mm(S, x3);
    mm(S, x4);
    obj(x1[0], x1[1], x2[0], x2[1], x3[0], x3[1], x4[0], x4[1]);
    output(-200, -90, "scaledB:");

    // PIVOTSCALING
    int px = -200, py = -200;
    glColor3f(1.0, 1.0, 1.0);
```

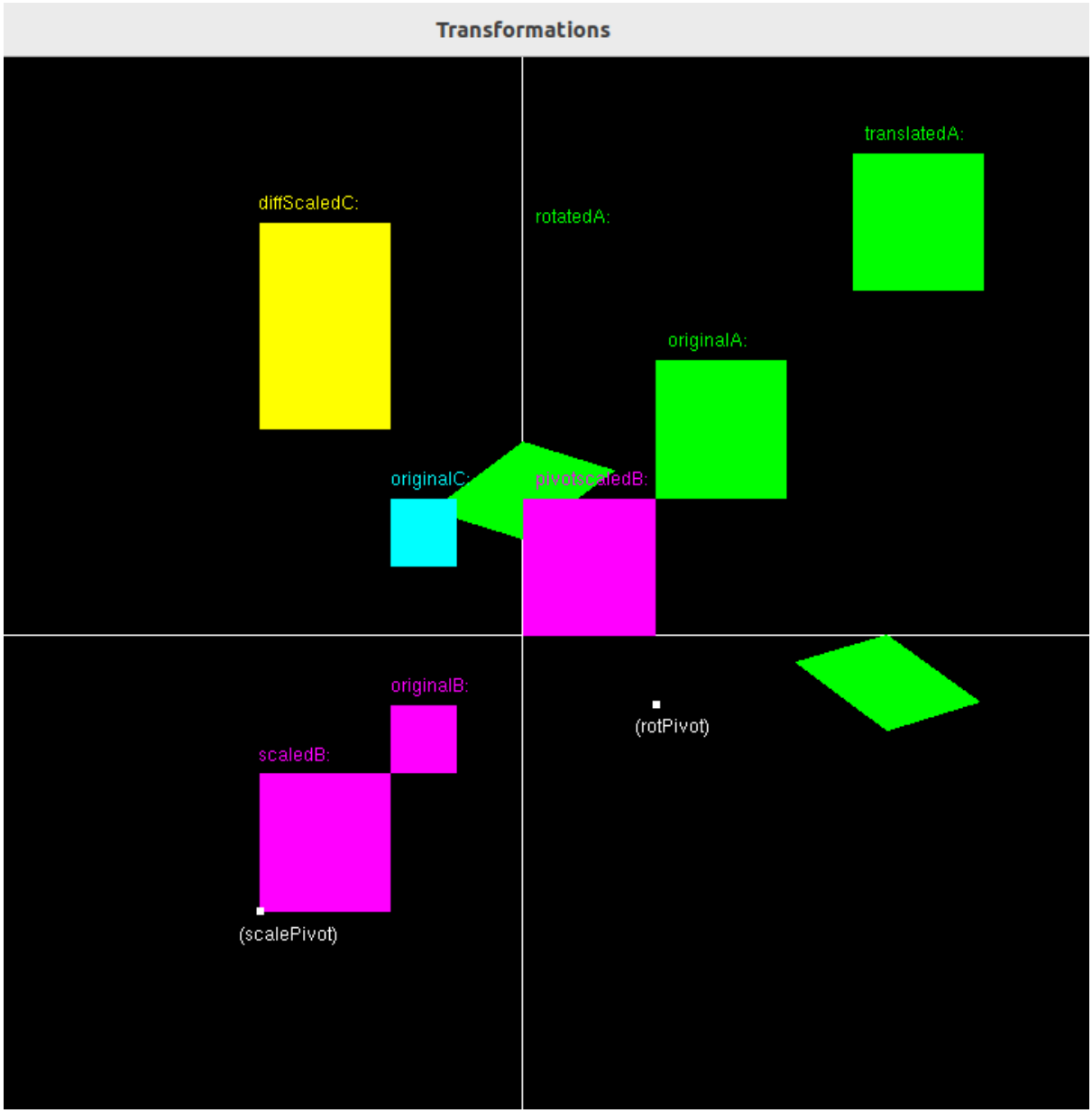
```
    output(px - 15, py - 20, "(scalePivot)");
    glPointSize(5);
    glBegin(GL_POINTS);
    glVertex2d(px, py);
    glEnd();
    glColor3f(1.0, 0.0, 1.0);
    x1[0] = -50;
    x1[1] = -50;
    x2[0] = -100;
    x2[1] = -50;
    x3[0] = -100;
    x3[1] = -100;
    x4[0] = -50;
    x4[1] = -100;
    double PS[3][3] = {{2, 0, 200}, {0, 2, 200}, {0, 0, 1}};
    mm(PS, x1);
    mm(PS, x2);
    mm(PS, x3);
    mm(PS, x4);
    obj(x1[0], x1[1], x2[0], x2[1], x3[0], x3[1], x4[0], x4[1]);
    output(10, 110, "pivotscaledB:");

    // DIISCALING
    glColor3f(0.0, 1.0, 1.0);
    obj(-50, 50, -100, 50, -100, 100, -50, 100);
    output(-100, 110, "originalC:");
    int dsx = 2, dsy = 3.5;
    glColor3f(1.0, 1.0, 0.0);
    obj(-50 * dsx, 50 * dsy, -100 * dsx, 50 * dsy, -100 * dsx, 100 * dsy, -50 *
dsx, 100 * dsy);
    output(-200, 310, "diffScaledC:");

    glFlush();
}
int main(int argc, char **argv)
{
    glutInit(&argc, argv);
    glutInitDisplayMode(GLUT_SINGLE | GLUT_RGB);
    glutInitWindowSize(1366, 768);
    glutInitWindowPosition(0, 0);
    glutCreateWindow("Transformations");
    myInit();
    glutDisplayFunc(display);
    glutMainLoop();
}
```

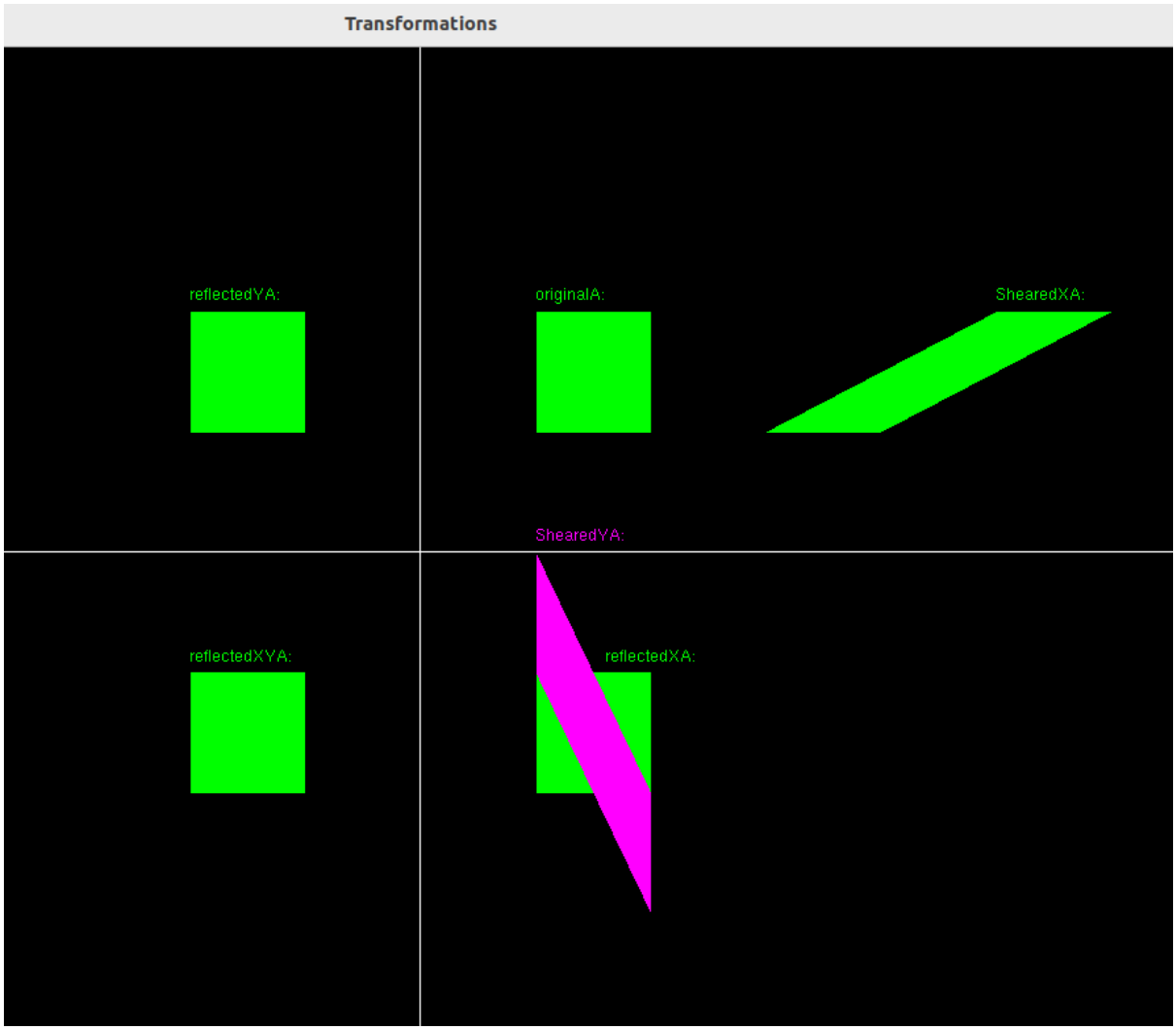
5b.cpp:

run.sh:

```
g++ 5.cpp -lGL -lglut -lGLU
./a.out
```

Sample I/O:





Learning Outcomes:

Learnt to do composite transformations. Learnt to do translation, reflection, shearing, rotation and scaling.