UCS1712 – GRAPHICS AND MULTIMEDIA LAB

Lab Exercise 6: 2D Composite Transformations and Windowing in C++ using OpenGL

Part A:

Code:

```
#include<gl/glut.h>
#include<bits/stdc++.h>
using namespace std;

constexpr auto PI = 3.14;
int n;
vector<pair<int, int>> coords;

int tx, ty;
int xr, yr;
int xf, yf;
double sx, sy;
double ang, angRad;
double shx, shy;
int opr1, opr2, rfl, sh, shd;

vector<vector<double>> T(3, vector<double>(3, 0));


void myInit(void) {
    glClearColor(1.0, 1.0, 1.0, 1.0);
    glColor3f(0.0f, 0.0f, 0.0f);
    glPointSize(4.0);
    glMatrixMode(GL_PROJECTION);
    glLoadIdentity();
    gluOrtho2D(-500, 500, -500, 500);
}

void DrawCartesianPlane() {
    glBegin(GL_LINES);
    glColor3f(0.0, 0.0, 0.0);
    glVertex2d(-500, 0);
    glVertex2d(500, 0);
    glVertex2d(0, -500);
    glVertex2d(0, 500);
```

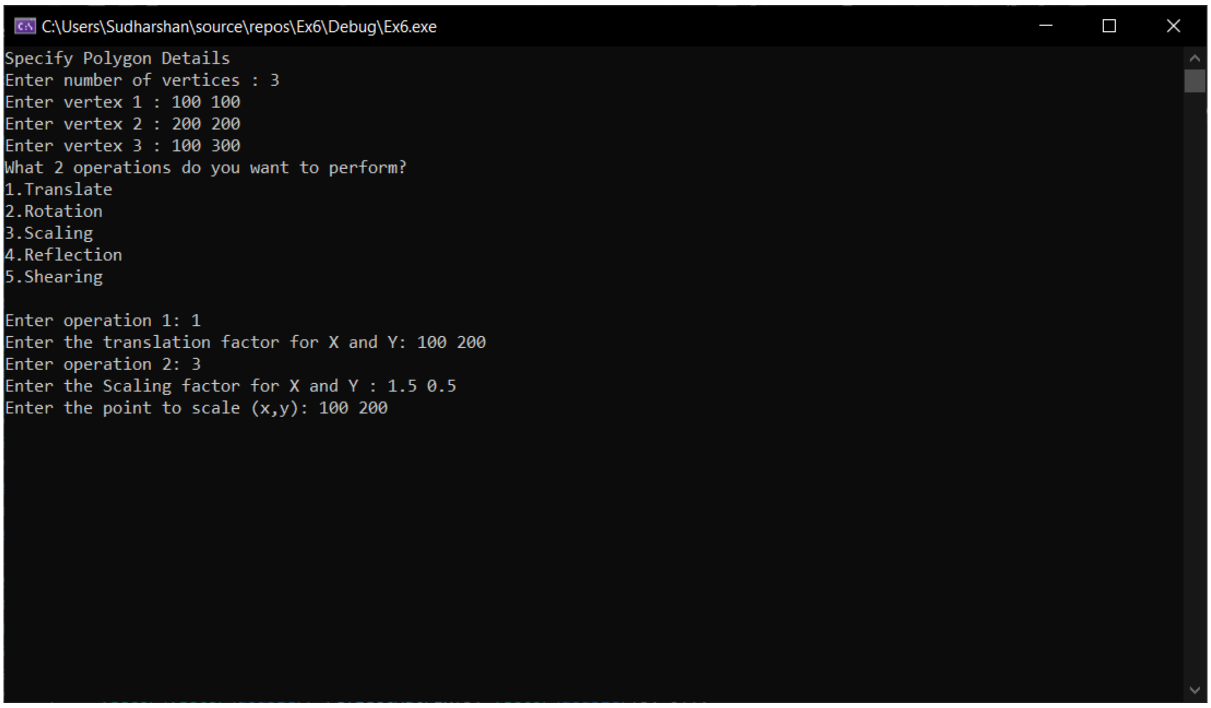
```cpp
    glEnd();
}

void drawPolygon()
{
    glBegin(GL_LINE_LOOP);
    glColor3f(0.0, 0.0, 0.0);
    for (int i = 0; i < n; i++)
    {
        glVertex2d(coords[i].first, coords[i].second);
    }
    glEnd();
}


vector<vector<double>> drawPolygonTrans()
{
    vector<vector<double>> transMatrix(3,vector<double>(3,0));
    transMatrix[0][0] = 1;
    transMatrix[1][1] = 1;
    transMatrix[2][2] = 1;
    transMatrix[0][2] = tx;
    transMatrix[1][2] = ty;
    return transMatrix;
}


vector<vector<double>> rotatePolygonFixed() {
    vector<vector<double>> rotatingMatrix(3, vector<double>(3, 0));
    rotatingMatrix[0][0] = cos(angRad);
    rotatingMatrix[1][1] = cos(angRad);
    rotatingMatrix[2][2] = 1;
    rotatingMatrix[1][0] = sin(angRad);
    rotatingMatrix[0][1] = -1 * sin(angRad);
    rotatingMatrix[0][2] = xr * (1 - cos(angRad)) + yr * sin(angRad);
    rotatingMatrix[1][2] = yr * (1 - cos(angRad)) - xr * sin(angRad);
    return rotatingMatrix;
}


vector<vector<double>> scalePolygonFixed() {
    vector<vector<double>> scalingMatrix(3, vector<double>(3, 0));
    scalingMatrix[0][0] = sx;
    scalingMatrix[1][1] = sy;
    scalingMatrix[2][2] = 1;
    scalingMatrix[0][2] = xf * (1 - sx);
    scalingMatrix[1][2] = yf * (1 - sy);
    return scalingMatrix;
}
```

```
vector<vector<double>> reflection_Xaxis() {
    vector<vector<double>> reflectMatrix(3, vector<double>(3, 0));
    reflectMatrix[0][0] = 1;
    reflectMatrix[1][1] = -1;
    reflectMatrix[2][2] = 1;
    return reflectMatrix;
}
vector<vector<double>> reflection_Yaxis() {
    vector<vector<double>> reflectMatrix(3, vector<double>(3, 0));
    reflectMatrix[0][0] = -1;
    reflectMatrix[1][1] = 1;
    reflectMatrix[2][2] = 1;
    return reflectMatrix;
}
vector<vector<double>> reflection_origin() {
    vector<vector<double>> reflectMatrix(3, vector<double>(3, 0));
    reflectMatrix[0][0] = -1;
    reflectMatrix[1][1] = -1;
    reflectMatrix[2][2] = 1;
    return reflectMatrix;
}

vector<vector<double>> reflection_XeqYline() {
    vector<vector<double>> reflectMatrix(3, vector<double>(3, 0));
    reflectMatrix[0][1] = 1;
    reflectMatrix[1][0] = 1;
    reflectMatrix[2][2] = 1;
    return reflectMatrix;
}

vector<vector<double>> x_directionShear() {
    vector<vector<double>> shearMatrix(3, vector<double>(3, 0));
    shearMatrix[0][0] = 1;
    shearMatrix[1][1] = 1;
    shearMatrix[2][2] = 1;
    shearMatrix[0][1] = shx;
    return shearMatrix;
}

vector<vector<double>> y_directionShear() {
    vector<vector<double>> shearMatrix(3, vector<double>(3, 0));
    shearMatrix[0][0] = 1;
    shearMatrix[1][1] = 1;
    shearMatrix[2][2] = 1;
    shearMatrix[1][0] = shy;
    return shearMatrix;
}
```

```cpp
void executeTransformMatrix(int opr,int oprn) {
    vector<vector<double>> mat;
    if (opr == 1) {
        mat = drawPolygonTrans();
    }
    else if (opr == 2) {
        mat = rotatePolygonFixed();
    }
    else if (opr == 3) {
        mat = scalePolygonFixed();
    }
    else if (opr == 4) {
        if (rfl == 1) mat = reflection_Xaxis();
        else if (rfl == 2) mat = reflection_Yaxis();
        else if (rfl == 3) mat = reflection_origin();
        else if (rfl == 4) mat = reflection_XeqYline();
    }
    else {
        if (shd == 1) mat = x_directionShear();
        else mat = y_directionShear();
    }
    if (oprn == 1) T = mat;
    else {
        vector<vector<double>> res(3,vector<double>(3,0));
        for (int i = 0; i < 3; i++) {
            for (int j = 0; j < 3; j++) {
                for (int k = 0; k < 3; k++) {
                    res[i][j] += T[i][k] * mat[k][j];
                }
            }
        }
        T = res;
    }
}

void drawTransformedPolygon() {
    glBegin(GL_LINE_LOOP);
    glColor3f(1.0, 0.0, 0.5);
    vector<pair<int, int>> newCoords;
    vector<double> curpoint(3, 0), matProduct(3, 0);
    for (int i = 0; i < n; i++) {
        curpoint[0] = coords[i].first;
        curpoint[1] = coords[i].second;
        curpoint[2] = 1;
        matProduct[0] = 0;
        matProduct[1] = 0;
        matProduct[2] = 0;
        for (int j = 0; j < 3; j++) {
            for (int k = 0; k < 3; k++) {
                matProduct[j] += T[j][k] * curpoint[k];
            }
        }
        newCoords.push_back(make_pair(round(matProduct[0]), round(matProduct[1
])));
    }

    for (int i = 0; i < n; i++)
    {
        glVertex2d(newCoords[i].first, newCoords[i].second);
    }
    glEnd();
}

void myDisplay() {
    glClear(GL_COLOR_BUFFER_BIT);
    glColor3f(0.0, 0.0, 0.0);
    DrawCartesianPlane();
    drawPolygon();
    executeTransformMatrix(opr1, 1);
    executeTransformMatrix(opr2, 2);
    drawTransformedPolygon();
    glFlush();
}

void getDetails(int opr) {
    if (opr == 1) {
        cout << "Enter the translation factor for X and Y: ";
        cin >> tx >> ty;
    }
    else if (opr == 2) {
        cout << "Enter the angle of rotation: ";
        cin >> ang;
        angRad = ang * PI / 180;
        cout << "Enter the point to rotate about: ";
        cin >> xr >> yr;
    }
    else if (opr == 3) {
        cout << "Enter the Scaling factor for X and Y : ";
        cin >> sx >> sy;

        cout << "Enter the point to scale (x,y): ";
        cin >> xf >> yf;
    }
    else if (opr == 4) {
        cout << "Enter axis about reflection"<<endl;
```

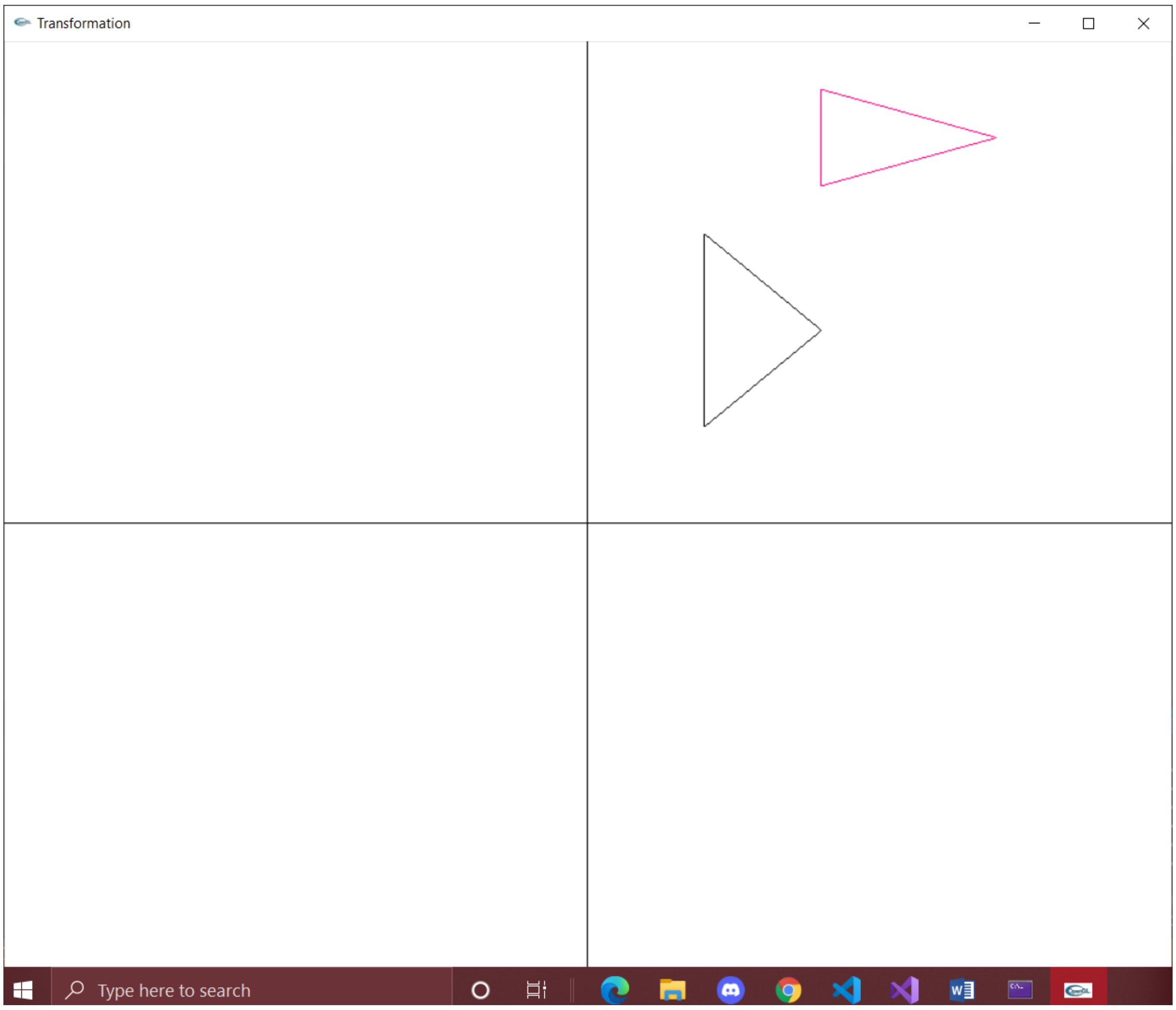
```cpp
        cout << "1. X-axis" << endl;
        cout << "2. Y-axis" << endl;
        cout << "3. origin" << endl;
        cout << "4. X=Y line" << endl;
        cin >> rfl;
    }
    else {
        cout << "Which direction do you want to shear about?" << endl;
        cout << "1.X-direction" << endl;
        cout << "2.Y-direction" << endl;
        cin >> shd;
        cout << "Enter shear parameter: ";
        cin >> sh;
        if (shd == 1) sh = shx;
        else sh = shy;
    }
}
int main(int argc, char** argv) {
    cout << "Specify Polygon Details" << endl;
    cout << "Enter number of vertices : ";
    cin >> n;
    int x, y;
    for (int i = 0; i < n; i++) {
        cout << "Enter vertex " << i + 1 << " : ";
        cin >> x >> y;
        coords.push_back(make_pair(x, y));
    }
    cout << "What 2 operations do you want to perform?" << endl;
    cout << "1.Translate" << endl;
    cout << "2.Rotation" << endl;
    cout << "3.Scaling" << endl;
    cout << "4.Reflection" << endl;
    cout << "5.Shearing" << endl;

    cout << endl << "Enter operation 1: ";
    cin >> opr1;
    getDetails(opr1);
    cout << "Enter operation 2: ";
    cin >> opr2;
    getDetails(opr2);

    glutInit(&argc, argv);
    glutInitDisplayMode(GLUT_SINGLE | GLUT_RGB);
    glutInitWindowSize(1000, 1000);
    glutCreateWindow("Transformation");
    glutDisplayFunc(myDisplay);
    myInit();
    glutMainLoop();
    return 0;
}
```

Output:



C:\Users\Sudharshan\source\repos\Ex6\Debug\Ex6.exe

```
Specify Polygon Details
Enter number of vertices : 3
Enter vertex 1 : 100 100
Enter vertex 2 : 200 200
Enter vertex 3 : 100 300
What 2 operations do you want to perform?
1.Translate
2.Rotation
3.Scaling
4.Reflection
5.Shearing

Enter operation 1: 1
Enter the translation factor for X and Y: 100 200
Enter operation 2: 3
Enter the Scaling factor for X and Y : 1.5 0.5
Enter the point to scale (x,y): 100 200
```



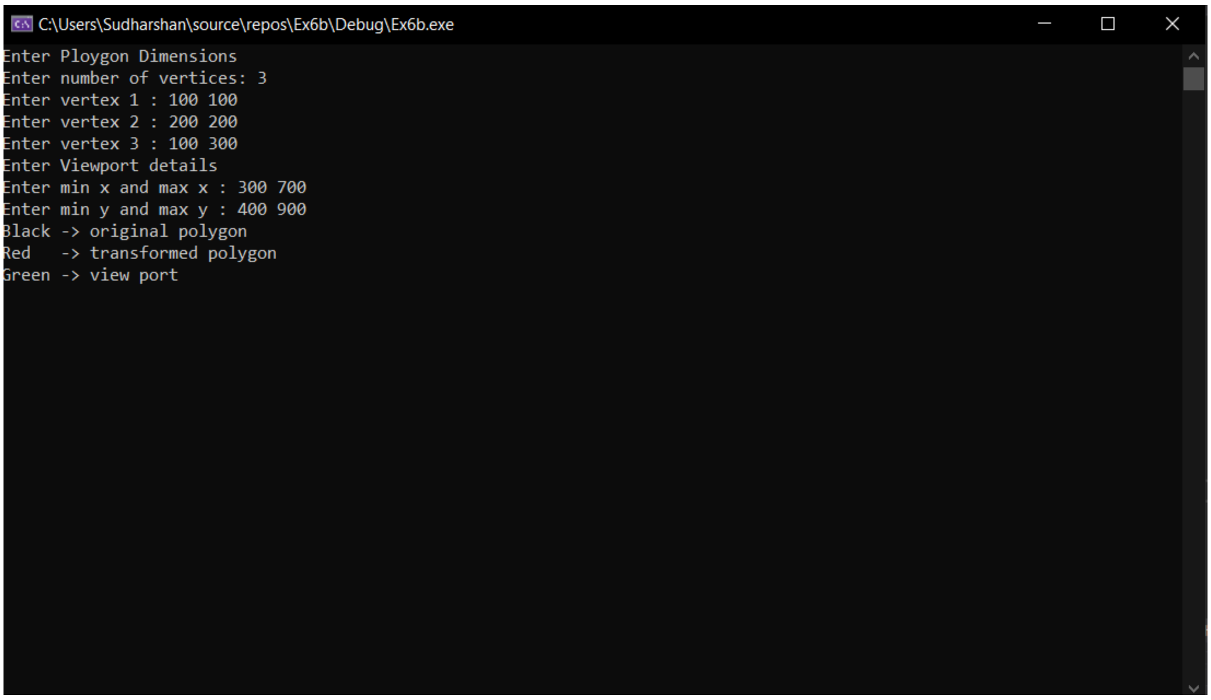
PartB:

Code:

```
#include<gl/glut.h>
#include<vector>
#include<utility>
#include<iostream>
#include<math.h>
using namespace std;


int n;
vector<pair<int, int>> coords;
int xv_min, xv_max, yv_min, yv_max;
int xw_min = 0, yw_min = 0, xw_max = 1000, yw_max = 1000;
```

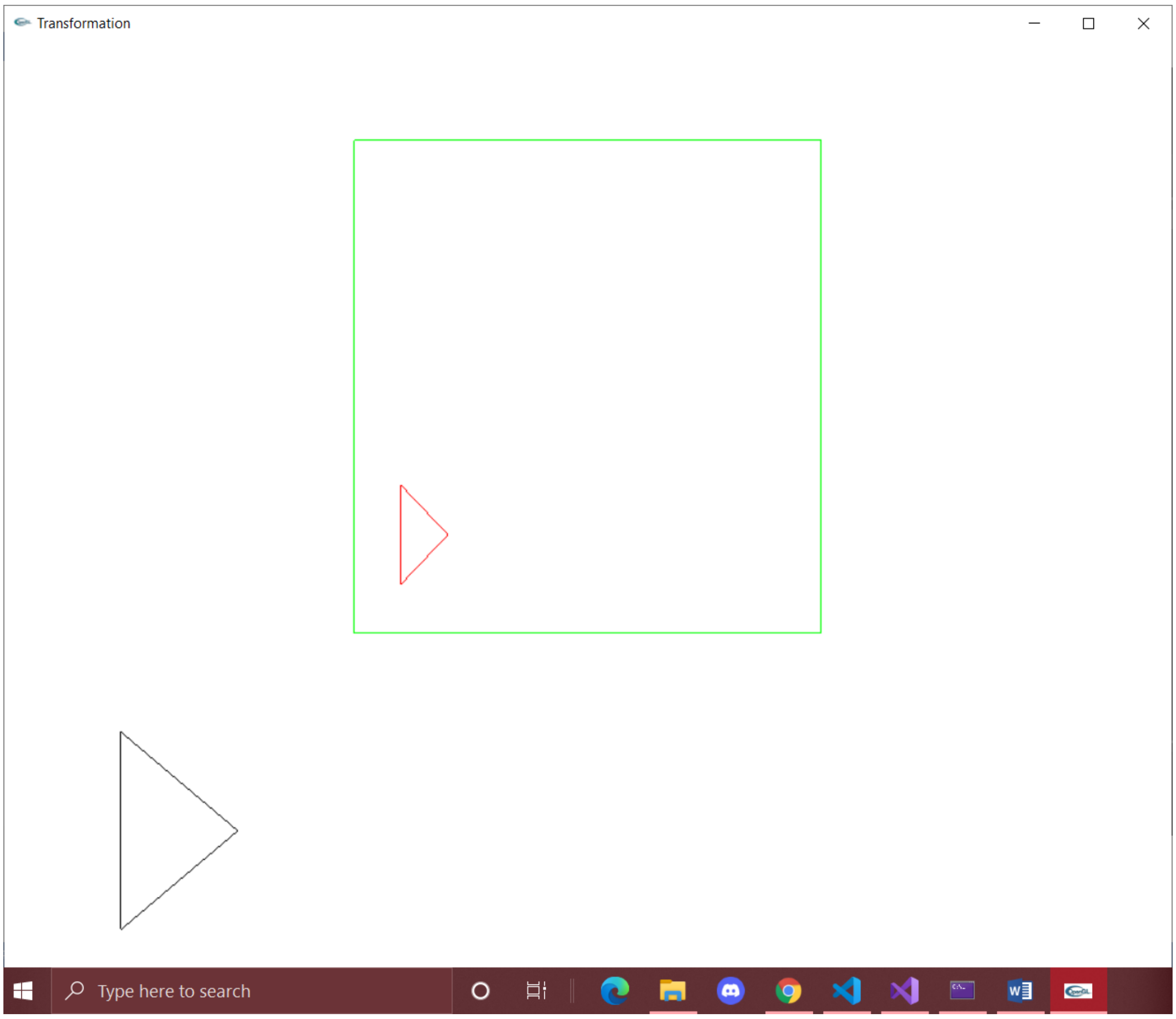
```
double sx, sy;

void myInit(void) {
      glClearColor(1.0, 1.0, 1.0, 1.0);
      glColor3f(0.0f, 0.0f, 0.0f);
      glPointSize(4.0);
      glMatrixMode(GL_PROJECTION);
      glLoadIdentity();
      gluOrtho2D(0, 1000, 0, 1000);
}

void drawVWPort() {
      glBegin(GL_LINE_LOOP);
      glColor3f(0.0f, 1.0f, 0.0f);
      glVertex2d(xv_min, yv_min);
      glVertex2d(xv_min, yv_max);
      glVertex2d(xv_max, yv_max);
      glVertex2d(xv_max, yv_min);
      glEnd();
}

void drawWPolygon() {
      glBegin(GL_LINE_LOOP);
      for (int i = 0; i < n; i++) {
            glVertex2d(coords[i].first, coords[i].second);
      }
      glEnd();
}
void drawVPolygon() {
      glBegin(GL_LINE_LOOP);
      glColor3f(1.0f, 0.0f, 0.0f);
      for (int i = 0; i < n; i++) {
            glVertex2d(xv_min + (coords[i].first - xw_min) * sx, yv_min + 
(coords[i].second - yw_min) * sy);
      }
      glEnd();
}

void myDisplay() {
      glClear(GL_COLOR_BUFFER_BIT);
      glColor3f(0.0, 0.0, 0.0);
      drawWPolygon();
      drawVPolygon();
      drawVWPort();
      glFlush();
}

int main(int argc, char** argv) {
	cout << "Enter Ploygon Dimensions" << endl;
	cout << "Enter number of vertices: ";
	cin >> n;
	int x, y;
	for (int i = 0; i < n; i++) {
		cout << "Enter vertex " << i + 1 << " : ";
		cin >> x >> y;
		coords.push_back(make_pair(x, y));
	}
	cout << "Enter Viewport details" << endl;
	cout << "Enter min x and max x : ";
	cin >> xv_min >> xv_max;
	cout << "Enter min y and max y : ";
	cin >> yv_min >> yv_max;

	sx = (xv_max - xv_min) * 1.0 / (xw_max - xw_min);
	sy = (yv_max - yv_min) * 1.0 / (yw_max - yw_min);

	cout << "Black -> original polygon " << endl;
	cout << "Red   -> transformed polygon" << endl;
	cout << "Green -> view port" << endl;

	glutInit(&argc, argv);
	glutInitDisplayMode(GLUT_SINGLE | GLUT_RGB);
	glutInitWindowSize(1000, 1000);
	glutCreateWindow("Transformation");
	glutDisplayFunc(myDisplay);
	myInit();
	glutMainLoop();
	return 0;
}
```

Output:



C:\Users\Sudharshan\source\repos\Ex6b\Debug\Ex6b.exe

```
Enter Ploygon Dimensions
Enter number of vertices: 3
Enter vertex 1 : 100 100
Enter vertex 2 : 200 200
Enter vertex 3 : 100 300
Enter Viewport details
Enter min x and max x : 300 700
Enter min y and max y : 400 900
Black -> original polygon
Red   -> transformed polygon
Green -> view port
```


Transformation
Type here to search