Computer Graphics & Image Processing Laboratory (21CSL66)

Exercise -1 : Bresenham's Line Drawing Algorithm:

```
#include <GL/glut.h>
void myinit()
{
   glClear( GL_COLOR_BUFFER_BIT );
   glClearColor( 0, 0, 0, 1 );
   gluOrtho2D(0,500,0,500);
}
void draw_pixel(int x,int y)
{
   glBegin(GL_POINTS);
      glVertex2d(x,y);
   glEnd();
}
void bresenhams(int x1,int y1,int x2,int y2)
{
   int dx,dy,x,y,p0,p,i,incx=1,incy=1;
   dx=abs(x2-x1);
   dy=abs(y2-y1);
   if(x2<x1)incx=-1;
   if(y2<y1)incy=-1;
   x=x1;
   y=y1;
   if(dx>dy)
   {
      draw_pixel(x,y);
      p=2*dy-dx;
      for(i=0;i<dx;i++)
      {
         x=x+incx;
         if(p>=0)
         {
            y=y+incy;
            p=p+(2*dy-2*dx);
         }
         else
         {
            y=y;
            p=p+2*dy;
         }
         draw_pixel(x,y);
      }
   }
   else
   {
    draw_pixel(x,y);
      p=2*dx-dy;
      for(i=0;i<dy;i++)
      {
         y=y+incy;
```

```
            if(p>=0)
            {
               x=x+incx;
               p=p+(2*dx-2*dy);
            }
            else
            {
               x=x;
               p=p+2*dx;
            }
            draw_pixel(x,y);
         }
      }
   }
   void display()
   {
      glColor3f( 1, 0, 0 );
      bresenhams(20,20,300,50); //Slope <1
      bresenhams(20,20,50,300); //slope >1
      bresenhams(20,20,300,300); //slope=1
      bresenhams(50,300,20,20);  //Negative slope >1
      bresenhams(300,50,20,20);  // Negative slope <1
      glFlush();
   }
   int main( int argc, char** argv )
   {
      glutInit(&argc, argv);
      glutInitDisplayMode(GLUT_SINGLE);
      glutInitWindowSize(500,500);
      glutInitWindowPosition(100,100);
      glutCreateWindow("Triangle");
      glutDisplayFunc(display);
      myinit();
      glutMainLoop();
      return 0;
   }
```

Exercise 2: Basic Geometric Operations – 2D Objects

```
#include<GL/glut.h>
#include<stdio.h>
#include <math.h>
float x[3][3]={{0,100,50},{0,0,50},{1,1,1}};
float r[3][3];
void myinit()
{
glClearColor(1,1,1,0);
gluOrtho2D(-100,500,-100,500);
}
void triangle(float x[3][3])
{
glColor4s(1,1,1,0);
glBegin(GL_TRIANGLES);
```

```
glVertex2f(x[0][0],x[1][0]);
glVertex2f(x[0][1],x[1][1]);
glVertex2f(x[0][2],x[1][2]);
glEnd();
}

void matrixmul(float mul[3][3]){
for (int i=0;i<3;i++)
for(int j=0;j<3;j++)
{
r[i][j]=0;
for (int k=0;k<3;k++)
r[i][j]=r[i][j]+mul[i][k]*x[k][j];
}
}

void translation(){
float t[3][3]={{1,0,100},{0,1,0},{0,0,1}};
printf("enter the values of tx and ty");
scanf("%f %f",&t[0][2],&t[1][2]);
matrixmul(t);
triangle(r);
}

void scaling(){
float s[3][3]={{1,0,0},{0,1,0},{0,0,1}};
printf("enter the values of sx and sy");
scanf("%f %f",&s[0][0],&s[1][1]);
matrixmul(s);
triangle(r);
}

void rotation()
{
float theta=0;
printf("enter the angle");
scanf("%f",&theta);
float angle=theta *3.14/180;
float cosx=cos(angle);
float sinx=sin(angle);
float rr[3][3]={{cosx,-sinx,0},{sinx,cosx,0},{0,0,1}};
matrixmul(rr);
triangle(r);
}
void displayMe()
{
glClear(GL_COLOR_BUFFER_BIT);
glColor3d(1,0,0);
int ch;
```

```
printf("enter the choice \n0 for normal triangle \n1 for translation\n2 for scaling\n3 for rotation\n");
scanf("%d",&ch);
glColor3d(1,1,1);
switch(ch)
{
case 0:
triangle(x);
break;
case 1:
translation();
break;
case 2:
scaling();
break;
case 3:
rotation();
break;
default:
printf("enter a valid choice");
}
glColor3d(1,0,0);
triangle(x);
glFlush();
}
int main(int argc,char ** argv)
{
glutInit(&argc,argv);
glutInitDisplayMode(GLUT_SINGLE);
glutInitWindowSize(500,500);
glutCreateWindow("Line Drawing Algorithm");
myinit();
glutDisplayFunc(displayMe);
glutMainLoop();
return 0;
}
```

Exercise 3: Develop a program to demonstrate basic geometric operations on the 3D object.

```
#include <GL/glut.h>
#include <stdlib.h>
#include<stdio.h>
typedef float point[3];
point v[]={{0.0,0.0,1.0},
{0.0,1.0,0.0},
{-1.0,-1.0,0.0},
{1.0,-1.0,0.0}};

int n;
void triangle(point a,point b,point c)
{
glBegin(GL_TRIANGLES);
```

```
glVertex3fv(a);
glVertex3fv(b);
glVertex3fv(c);
glEnd();
}
void divide_tri(point a,point b,point c,int m)
{
point v1,v2,v3; int j;
if (m>0)
{
 for(j=0;j<3;j++)
v1[j]=(a[j]+b[j])/2;
for(j=0;j<3;j++)
v2[j]=(a[j]+c[j])/2;
for(j=0;j<3;j++)
v3[j]=(b[j]+c[j])/2;
divide_tri(a,v1,v2,m-1);
divide_tri(c,v2,v3,m-1);
divide_tri(b,v3,v1,m-1);
}
else
        triangle(a,b,c);

}
void tetrahedron(int m)
{
glColor3f(1.0,0.0,0.0);
divide_tri(v[0],v[1],v[2],m);
glColor3f(0.0,0.0,0.0);
divide_tri(v[3],v[2],v[1],m);
glColor3f(0.0,1.0,.0);
divide_tri(v[0],v[3],v[1],m);
glColor3f(0.0,0.0,1.0);
divide_tri(v[0],v[2],v[3],m);
}
void display()
{
tetrahedron(n);
glFlush();
}
void myinit()
{
        glClearColor(1.0,1.0,1.0,1.0);
        glClear(GL_COLOR_BUFFER_BIT|GL_DEPTH_BUFFER_BIT);
        glOrtho(-2.0,2.0,-2.0,2.0,-2.0,2.0);

}
int main(int argc,char **argv)
{
```

```
printf("\nEnter the number of recursive steps you want");
scanf("%d", &n);
glutInit(&argc,argv);
glutInitDisplayMode(GLUT_SINGLE|GLUT_RGB|GLUT_DEPTH);
glutInitWindowSize(500,500);
glutCreateWindow("Ex 8: 3d Sierpinski's Gasket");
glutDisplayFunc(display);
myinit();
glEnable(GL_DEPTH_TEST);
glutMainLoop();
return 0;
}
```

Exercise 4 Develop a program to demonstrate 2D transformation on basic objects

```
#include<GL/glut.h>
#include<stdio.h>
void myinit()
{
   gluOrtho2D(-500,500,-500,500);
}
void drawtriangle()
{
glBegin(GL_POLYGON);
glVertex2f(100,100);
glVertex2f(200,100);
glVertex2f(150,150);
glEnd();
}
void translate()
{

   glPushMatrix();
      glTranslated(100,0,0);
      drawtriangle();
   glPopMatrix();

}



void rotate_triangle()
{

   glPushMatrix();
      glRotated(45,0,0,1);
      drawtriangle();
   glPopMatrix();

}
```

```
void pivot_point_rotate()
{   glColor3f(1,1,0); // yellow
   glPushMatrix();
      glTranslated(100,100,0); //translate back to the original position
      glRotated(45,0,0,1); // Rotate degree 45
      glTranslated(-100,-100,0); //translate to Origin
      drawtriangle();
   glPopMatrix();
}
void scale_triangle()
{
   glPushMatrix();
      glScaled(2,2,1);
      drawtriangle();
   glPopMatrix();

}
void pivot_point_scale()
{   glColor3f(1,1,0); // yellow
   glPushMatrix();
   glTranslated(100,100,0);
   glScaled(2,2,1);
   glTranslated(-100,-100,0);
   drawtriangle();
   glPopMatrix();
}
void display()
{
glClear(GL_COLOR_BUFFER_BIT);
glClearColor(0,0,0,0);
glColor3f(1,0,0); //Red
drawtriangle();
//glutPostRedisplay();
glFlush();
}
void menu_rotate(int id)
{
   glClear(GL_COLOR_BUFFER_BIT);
   drawtriangle();
   switch(id)
      {
       case 1:
          translate();
          break;
       case 2:
          rotate_triangle();
          break;
        case 3:
          pivot_point_rotate();
```

```
            break;
        case 4:
            scale_triangle();
            break;
           case 5:
            pivot_point_scale();
            break;
         default:
           exit(0);
        }
        //glutPostRedisplay();
}


int main(int argc,char **argv)
{
glutInit(&argc,argv);
glutInitDisplayMode(GLUT_SINGLE|GLUT_RGB);
glutInitWindowSize(500,500);
glutCreateWindow("Transformation");
myinit();
glutCreateMenu(menu_rotate);

glutAddMenuEntry("Translate",1);
          glutAddMenuEntry("Rotation About origin",2);
          glutAddMenuEntry("Rotation About Fixed Point",3);
          glutAddMenuEntry("Scale About Origin",4);
          glutAddMenuEntry("Scale About Fixed Point",5);
          glutAddMenuEntry("EXIT",6);


   glutAttachMenu(GLUT_RIGHT_BUTTON);
glutDisplayFunc(display);


glutMainLoop();
return 0;
}
```

Exercise 5: Basic 3D Transformation

```
#include<GL/glut.h>
float ambient[]={1,1,1,1};
float light_pos[]={2,2,2,1};
void align()
{
glRotated(50,0,1,0);
glRotated(10,-1,0,0);
glRotated(11,0,0,-1);
}
void obj(double tx,double ty,double tz,double sx,double sy,double sz)
```

```
{
align();
glTranslated(tx,ty,tz);
glScaled(sx,sy,sz);
glutSolidCube(1);
glLoadIdentity();
}
void display()
{
glClear(GL_COLOR_BUFFER_BIT|GL_DEPTH_BUFFER_BIT);
obj(0,0,0.5,1,1,0.04); // three walls
obj(0,-0.5,0,1,0.04,1);
obj(-0.5,0,0,0.04,1,1);
obj(0,-0.3,0,0.02,0.2,0.02); // four table legs
obj(0,-0.3,-0.4,0.02,0.2,0.02);
obj(0.4,-0.3,0,0.02,0.2,0.02);
obj(0.4,-0.3,-0.4,0.02,0.2,0.02);
obj(0.2,-0.18,-0.2,0.6,0.02,0.6); // table top
align();
glTranslated(0.3,-0.1,-0.3);

glutSolidTeapot(0.09);// tea pot
glFlush();
glLoadIdentity();
}
int main(int argc, char **argv)
{
glutInit(&argc, argv);
glutInitDisplayMode(GLUT_SINGLE|GLUT_RGB|GLUT_DEPTH);
glutInitWindowSize(700,700);
glutCreateWindow("Teapot");
glutDisplayFunc(display);
glEnable(GL_LIGHTING);
glEnable(GL_LIGHT0);
glMaterialfv(GL_FRONT,GL_AMBIENT,ambient);
glLightfv(GL_LIGHT0,GL_POSITION,light_pos);
glEnable(GL_DEPTH_TEST);
glutMainLoop();
}
```

Exercise 6: Animation Effect on Simple Objects

```
#include <GL/glut.h>
float ambient[]={1,0,0,1};
float light_pos[]={2,2,2,1};
static float theta[3] = {0,0,0};
int axis = 0;
int ch=1;
void mouse(int button, int state, int x, int y)
{
   if(button == GLUT_LEFT_BUTTON && state == GLUT_DOWN)
```

```
        axis = 0;
    if(button == GLUT_MIDDLE_BUTTON && state == GLUT_DOWN)
        axis = 1;
    if(button == GLUT_RIGHT_BUTTON && state == GLUT_UP)
        axis = 2;
}
void idle(){
    theta[axis] += 2;
    if(theta[axis] > 360)
        theta[axis] = 0;
    glutPostRedisplay();
    }
void display()
{
    glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
    glClearColor(1,1,1,1);
    glLoadIdentity();
    glRotatef(theta[0],1,0,0);  // rotation about x
    glRotatef(theta[1],0,1,0); // rotate about y
    glRotatef(theta[2],0,0,1); // rotate about z
    if(ch==1)
    glutSolidCube(1);
    if(ch==2)
    glutSolidTeapot(0.5);
    if(ch==3)
    glutSolidCone(0.5,0.5,20,20);
    glFlush();
    glutSwapBuffers();  // use whenever you use double buffer
}
void menu(int id)
{
switch(id)
{
case 1:
            ch=1;
            break;
case 2:
            ch=2;
            break;
case 3:
            ch=3;
            break;
}
}
int main(int argc, char ** argv)
{
    glutInit(&argc,argv);
    glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGB | GLUT_DEPTH);
    glutInitWindowSize(500,500);
```

```
    glutCreateWindow("Color Cube");
    glutCreateMenu(menu);
glutAddMenuEntry("Cube",1);
glutAddMenuEntry("Teapot",2);
glutAddMenuEntry("Cone",3);
glutAttachMenu(GLUT_RIGHT_BUTTON);
    glutDisplayFunc(display);
    glEnable(GL_LIGHTING);
glEnable(GL_LIGHT0);
glMaterialfv(GL_FRONT,GL_AMBIENT,ambient);
glLightfv(GL_LIGHT0,GL_POSITION,light_pos);
    glutMouseFunc(mouse); //change axis of rotation
    glutIdleFunc(idle);
    glEnable(GL_DEPTH_TEST);
    glutMainLoop();
    return 0;
}
```

Image Processing

Exercise 6: Splitting of Images into Four

```
import cv2
import matplotlib.pyplot as plt
image = cv2.imread('index.jpeg')
image_mat= cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
ht,wd,c=image.shape

midy=ht//2
midx=wd//2

tl=image_mat[:midy,:midx]
tr=image_mat[:midy,midx:]
bl=image_mat[midy:,:midx]
br=image_mat[midy:,midx:]

fig,axs=plt.subplots(2,2)
l_title=["Top Left","Top Right","Bottom Left","Bottom Right"]
l_var=[tl,tr,bl,br]

k=0
for i in range(2):
    for j in range(2):
        axs[i,j].imshow(l_var[k])
        axs[i,j].set_title(l_title[k])
        axs[i,j].axis("off")
        k=k+1


plt.axis("off")
plt.show()
```

Ex: 9 - Edge Detection

```
import cv2
import numpy as np
from matplotlib import pyplot as plt

image = cv2.imread('index.jpeg')
image_mat= cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
gray_image = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
sobel_x = np.array([[-1, 0, 1],
                    [-2, 0, 2],
                    [-1, 0, 1]])

sobel_y = np.array([[-1, -2, -1],
                    [ 0,  0,  0],
                    [ 1,  2,  1]])

edges_x = cv2.filter2D(gray_image, -1, sobel_x)
edges_y = cv2.filter2D(gray_image, -1, sobel_y)
```

```
edges = cv2.addWeighted(edges_x, 0.5, edges_y, 0.5, 0)
edges_rgb = cv2.cvtColor(edges, cv2.COLOR_BGR2RGB)


sobelx = cv2.Sobel(gray_image, cv2.CV_64F, 1, 0, ksize=5)
sobely = cv2.Sobel(gray_image, cv2.CV_64F, 0, 1, ksize=5)
texture=sobelx+sobely

l_title=["Original","Edge Detection","Texture Extraction"]
l_var=[image_mat,edges_rgb,texture]

fig,axs=plt.subplots(1,3)
for i in range(3):
   axs[i].imshow(l_var[i])
   axs[i].set_title(l_title[i])

plt.show()
```

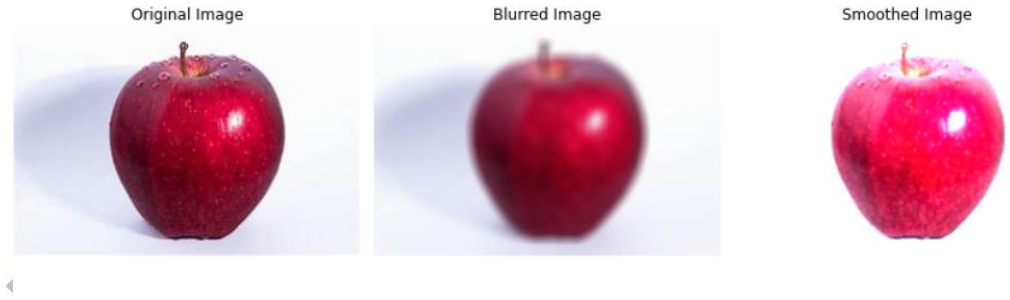
Exercise – 10 : Write a program to blur and smoothing an image

```
import cv2
import numpy as np
import matplotlib.pyplot as plt
from skimage.metrics import structural_similarity as ssim

image = cv2.imread('fruit.jpg')
image_rgb = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
kernel_size = 9

blur_kernel = np.ones((kernel_size, kernel_size), dtype=np.float32) / (kernel_size *
kernel_size)

blurred = cv2.filter2D(image_rgb, -1, blur_kernel)

smooth_kernel =
        np.array([[2, 2, 2],
                  [2, 10, 2],
                  [2, 2, 2]], dtype=np.float32) / 13

smoothed = cv2.filter2D(image_rgb, -1, smooth_kernel)

gray_original = cv2.cvtColor(image_rgb, cv2.COLOR_RGB2GRAY)
gray_blurred = cv2.cvtColor(blurred, cv2.COLOR_RGB2GRAY)
gray_smoothed = cv2.cvtColor(smoothed, cv2.COLOR_RGB2GRAY)

ssim_original_blurred, _ = ssim(gray_original, gray_blurred, full=True)
ssim_original_smoothed, _ = ssim(gray_original, gray_smoothed, full=True)


print(f'SSIM between original and blurred images: {ssim_original_blurred:.4f}')
print(f'SSIM between original and smoothed images: {ssim_original_smoothed:.4f}')
```

```
fig, axs = plt.subplots(1,3, figsize=(12, 10))

axs[0].imshow(image_rgb)
axs[0].set_title('Original Image')
axs[0].axis('off')

axs[1].imshow(blurred)
axs[1].set_title('Blurred Image')
axs[1].axis('off')

axs[2].imshow(smoothed)
axs[2].set_title('Smoothed Image')
axs[2].axis('off')
plt.tight_layout()
plt.show()
```

Output:

```
SSIM between original and blurred images: 0.8390
SSIM between original and smoothed images: 0.8560
```

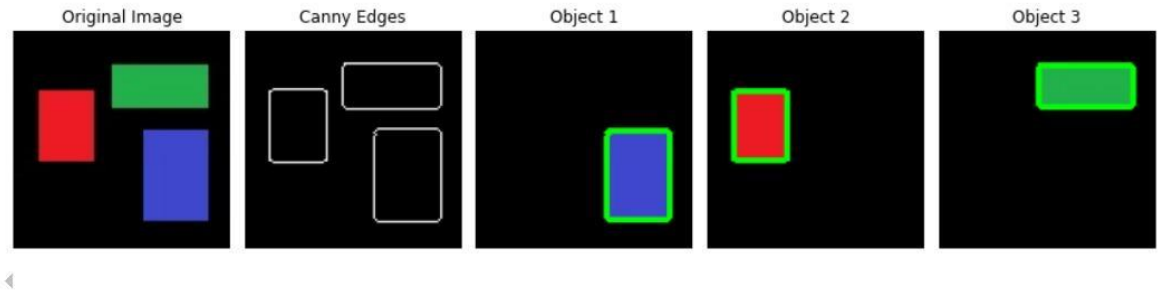


Exercise 11: Write a program to Contour an Image

```
import cv2
import numpy as np
import matplotlib.pyplot as plt

image = cv2.imread('shape.jpg')

gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)

# Perform Canny edge detectio
edged = cv2.Canny(gray, 30, 200)

# Finding Contours
contours, hierarchy = cv2.findContours(edged.copy(), cv2.RETR_EXTERNAL,
cv2.CHAIN_APPROX_SIMPLE)
print("Number of Contours found = " + str(len(contours)))

# Draw all contours on the original image
cv2.drawContours(image, contours, -1, (0, 255, 0), 3)
```

```
# Create a list to store cropped images of each object
cropped_images = []

# Iterate through contours
for i, contour in enumerate(contours):
    # Create a mask image for each contour
    mask = np.zeros_like(gray)
    cv2.drawContours(mask, [contour], 0, 255, -1)
    # Extract the object using the mask

    object_extracted = np.zeros_like(image)
    object_extracted[mask == 255] = image[mask == 255]
    # Convert BGR to RGB for displaying with Matplotlib
    object_extracted_rgb = cv2.cvtColor(object_extracted, cv2.COLOR_BGR2RGB)
    # Append the extracted object to the list
    cropped_images.append(object_extracted_rgb)
fig, axs = plt.subplots(1, len(cropped_images)+2, figsize=(12, 4))

# Plot the original image
axs[0].imshow(cv2.cvtColor(image, cv2.COLOR_BGR2RGB))
axs[0].set_title('Original Image')
axs[0].axis('off')

axs[1].imshow(edged, cmap='gray')
axs[1].set_title('Canny Edges')
axs[1].axis('off')

for i in range(len(cropped_images)):
    axs[i+2].imshow(cropped_images[i])
    axs[i+2].set_title(f'Object {i+1}')
    axs[i+2].axis('off')

plt.tight_layout()
plt.show()
```

Output



Exercise – 12: Write a program to detect a face/s in an Image

```
import cv2
import matplotlib.pyplot as plt
```

```
# Load the image
image_path = 'cricket.jpg'
image = cv2.imread(image_path)

face_cascade = cv2.CascadeClassifier(cv2.data.haarcascades +
'haarcascade_frontalface_default.xml')

gray_image = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)

# Detect faces in the image
faces = face_cascade.detectMultiScale(gray_image, scaleFactor=1.1, minNeighbors=5,
minSize=(30, 30))

# Initialize a list to store cropped faces
cropped_faces = []

# Draw rectangles around the detected faces and crop them
for (x, y, w, h) in faces:
    cv2.rectangle(image, (x, y), (x+w, y+h), (255, 0, 0), 2)
    cropped_faces.append(image[y:y+h, x:x+w])

# Display each cropped face separately
plt.figure(figsize=(12, 6))
for i, face in enumerate(cropped_faces):
    plt.subplot(1, len(cropped_faces), i + 1)
    plt.imshow(cv2.cvtColor(face, cv2.COLOR_BGR2RGB))
    plt.axis('off')
    plt.title(f'Face {i + 1}')
plt.tight_layout()
plt.show()
```

Original Image

Face 1 Face 2 Face 3 Face 4 Face 5 Face 6 Face 7 Face 8