

Lab06 for CPT205 Computer Graphics

Part 1. Bezier Curves

A Bezier curve is defined by a set of control points P_0 through P_n , where n is called its order ($n = 1$ for linear, 2 for quadratic and so on). The first and last control points are the end points of the curve; however, the intermediate control points (if any) may not lie on the curve.

Type in the following code, compile and run it. Get a good understanding of what the program does.

```
// Bezier_Curves.cpp

#define FREEGLUT_STATIC
#include <GL/freeglut.h>

GLfloat step = 2;

GLfloat ctrlpoints[4][3] = { // 4 points to define a cubic Bezier curve
    { -2.0, -2.0, 0.0 },      // Point 0
    { -2.0,  2.0, 0.0 },      // Point 1
    {  2.0, -2.0, 0.0 },      // Point 2
    {  2.0,  2.0, 0.0 } };    // Point 3

void when_in_mainloop() { // idle callback function
    glutPostRedisplay(); // force OpenGL to redraw the current window
}

void keyboard_input(unsigned char key, int x, int y) {
    if (key == 'q' || key == 'Q')
        exit(0);
    else if (key == 'i' || key == 'I') {
        step++;
        if (step > 4)
            step = 4;
    }
    else if (key == 'd' || key == 'D') {
        step--;
        if (step < 2)
            step = 2;
    }
}

void myinit(void) {
    glClearColor(0.0, 0.0, 0.0, 1.0);

    /* glMap1f(GLenum target, GLfloat u1, GLfloat u2, GLint stride, GLint order, const GLfloat *points)
    glMap1f defines a one-dimensional evaluator.
    target specifies what the control points represent. It also specifies the type of points, e.g.
    GL_MAP1_VERTEX_3: Each control point has three floating-point values representing x, y, and z.
    GL_MAP1_VERTEX_4: Each control point has four floating-point values representing x, y, z and w.
    GL_MAP1_TEXTURE_COORD_3: Each control point has three floating-point values representing the s, t, and
    r texture coordinates.
    GL_MAP1_TEXTURE_COORD_4: Each control point is four floating-point values representing the s, t, r and
    q texture coordinates.
    u1 and u2 specify a linear mapping of u.
    stride specifies the number of floats or doubles between the beginning of a control point and the
    beginning of the next in the data structure referenced in points.
    order specifies the number of control points. It must be positive.
    points specifies a pointer to the array of control points */
    glMap1f(GL_MAP1_VERTEX_3, 0.0, 1.0, 3, step, &ctrlpoints[0][0]);

    glEnable(GL_MAP1_VERTEX_3); // Enable the evaluator.
}

void myDisplay(void) {
    myinit();

    glClear(GL_COLOR_BUFFER_BIT);

    //Plot Bezier Curve between Point 1 and Point 4
    glColor3f(1.0, 1.0, 1.0);
    int number = 50;
    glBegin(GL_LINE_STRIP);
```

```

for (int i = 0; i <= number; i++) {
    /* glEvalCoord1f evaluates the one-dimensional maps that are enabled.
    void glEvalCoord1f(GLfloat u);
    u specifies a value that is the domain coordinate u to the basis function defined in a previous
    glMap1 function. */
    glEvalCoord1f((GLfloat)i / number);
}
glEnd();

//Plot 4 Points
glPointSize(5.0);
glColor3f(1.0, 1.0, 0.0);
glBegin(GL_POINTS);
for (int i = 0; i < 4; i++) {
    glVertex3fv(&ctrlpoints[i][0]); // Draw each control point
}
glEnd();

glFlush();
}

void myReshape(GLsizei w, GLsizei h) {
    glViewport(0, 0, w, h); // define the viewport

    glMatrixMode(GL_PROJECTION); // the projection transformation
    glLoadIdentity(); // clear the matrix
    glFrustum(-1.0, 1.0, -1.0, 1.0, 1.5, 20.0);

    glMatrixMode(GL_MODELVIEW); // back to modelview matrix
    glLoadIdentity(); // clear the matrix
    gluLookAt(0, 0, 5, 0, 0, 0, 0, 1, 0);
}

int main(int argc, char** argv) {
    glutInit(&argc, argv);
    glutInitDisplayMode(GLUT_SINGLE | GLUT_RGBA);
    glutInitWindowSize(600, 600);
    glutCreateWindow("Bezier");

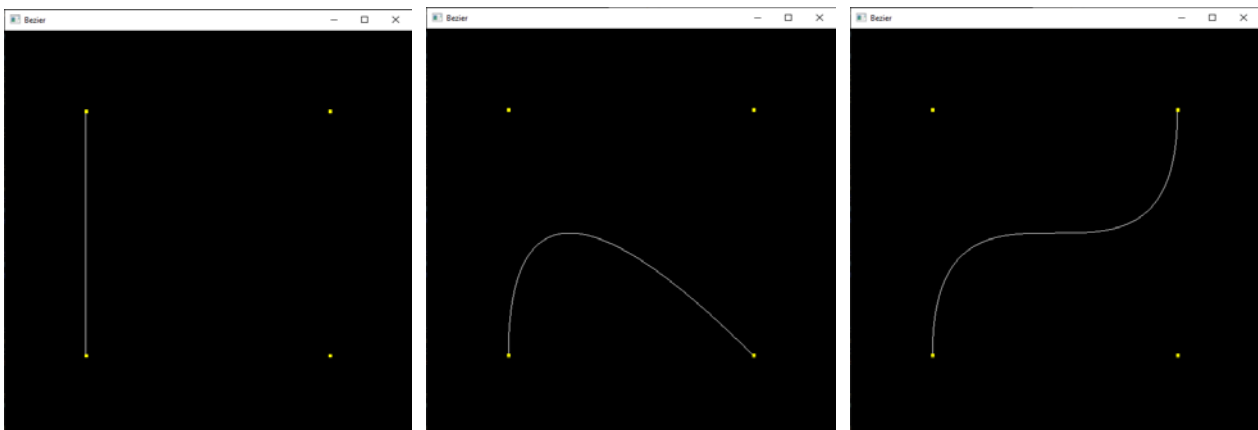
    glutReshapeFunc(myReshape);
    glutDisplayFunc(myDisplay);

    glutIdleFunc(when_in_mainloop);

    glutKeyboardFunc(keyboard_input);

    glutMainLoop();
}

```



Part 2. Bezier Surfaces

Type in the following code, compile and run it. You will get a Bezier Surface.

```
// Bezier Surfaces

#define FREEGLUT_STATIC
#include <GL/freeglut.h>

GLfloat r = 0; // incremental step for angle of rotation

//Control points
GLfloat ctrlpoints[3][3][3] = {
    {{0.0, 2.0, 2.0}, {2.0, 2.0, 2.0}, {2.0, 0.0, 2.0}},
    {{0.0, 2.0, 0.0}, {2.0, 2.0, 0.0}, {2.0, 0.0, 0.0}},
    {{0.0, 2.0, -2.0}, {2.0, 2.0, -2.0}, {2.0, 0.0, -2.0}},
};

void keyboard_input(unsigned char key, int x, int y) {
    if (key == 'q' || key == 'Q')
        exit(0);
    else if (key == 'i' || key == 'I') {
        r += 1;
        if (r >= 360)
            r = 0;
    }
    else if (key == 'd' || key == 'D') {
        r -= 1;
        if (r <= 0)
            r = 360;
    }
}

void when_in_mainloop() { // idle callback function
    glutPostRedisplay(); // force OpenGL to redraw the current window
}

void myinit(void) {
    glClearColor(0.0, 0.0, 0.0, 1.0);

    /* glMap2f defines a two-dimensional evaluator.
    void glMap2f(GLenum target, GLfloat u1, GLfloat u2, GLint ustride, GLint uorder, GLfloat v1, GLfloat v2,
    GLint vstride, GLint vorder, const GLfloat * points);
    Compared with glMap1f, glMap2f adds v1 and v2 to specify a linear mapping of v. The definitions of
    vstride and vorder are the same as ustride and uorder. */
    glMap2f(GL_MAP2_VERTEX_3, 0, 1, 3, 3, 0, 1, 9, 3, &ctrlpoints[0][0][0]);
    glEnable(GL_MAP2_VERTEX_3);

    /* glMapGrid2f defines a two-dimensional mesh.
    void glMapGrid2d(GLint un, GLdouble u1, GLdouble u2, GLint vn, GLdouble v1, GLdouble v2);
    un specifies the number of partitions in the grid range interval [u1, u2]. Must be positive.
    u1 and u2 specify the mappings for integer grid domain values i = 0 and i = un.
    vn specifies the number of partitions in the grid range interval [v1, v2].
    v1 and v2 specify the mappings for integer grid domain values j = 0 and j = vn. */
    glMapGrid2f(20, 0.0f, 1.0f, 20, 0.0f, 1.0f);

    //Do depth comparisons and update the depth buffer.
    glEnable(GL_DEPTH_TEST);
}

void myDisplay(void) {
    myinit();

    glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);

    //Plot Bezier surface
    int num1 = 10;
    int num2 = 30;

    glPushMatrix();

    glRotatef(r, 1, 0, 0);

    glPushMatrix();

    for (int m = 0; m <= 3; m++) {
```

```

glRotatef(90, 0.0f, 0.0f, 1.0f);
glColor3f(1.0, 0.0, 0.0);
for (int j = 0; j <= num1; j++) {
    glBegin(GL_LINE_STRIP);
    for (int i = 0; i <= num2; i++) {
        /* glEvalCoord2f evaluates the one-dimensional maps that are enabled.
        void glEvalCoord2f(GLfloat u, GLfloat v);
        u specifies a value that is the domain coordinate u to the basis function defined in a
        previous glMap2 function.
        v specifies a value that is the domain coordinate v to the basis function defined in a
        previous glMap2 function. */
        glEvalCoord2f((GLfloat)i / num2, (GLfloat)j / num1);
    }
    glEnd();

    glBegin(GL_LINE_STRIP);
    for (int i = 0; i <= num2; i++) {
        glEvalCoord2f((GLfloat)j / num1, (GLfloat)i / num2);
    }
    glEnd();
}
}

//Plot 9 points
int m = 0;
glPointSize(5.0);
glColor3f(1.0, 1.0, 0.0);
glBegin(GL_POINTS);
for (int j = 0; j < 3; j++) {
    for (int i = 0; i < 3; i++) {
        glVertex3fv(&ctrlpoints[j][i][m]);
    }
}
glEnd();

glPopMatrix();
glPopMatrix();

glFlush();
}

void myReshape(GLsizei w, GLsizei h) {
    glViewport(0, 0, w, h); // define the viewport

    glMatrixMode(GL_PROJECTION); // projection transformation
    glLoadIdentity(); // clear the matrix
    glFrustum(-1.0, 1.0, -1.0, 1.0, 1.5, 20.0);
    gluLookAt(0, 0, 6, 0, 0, 0, 0, 0, 1, 0);

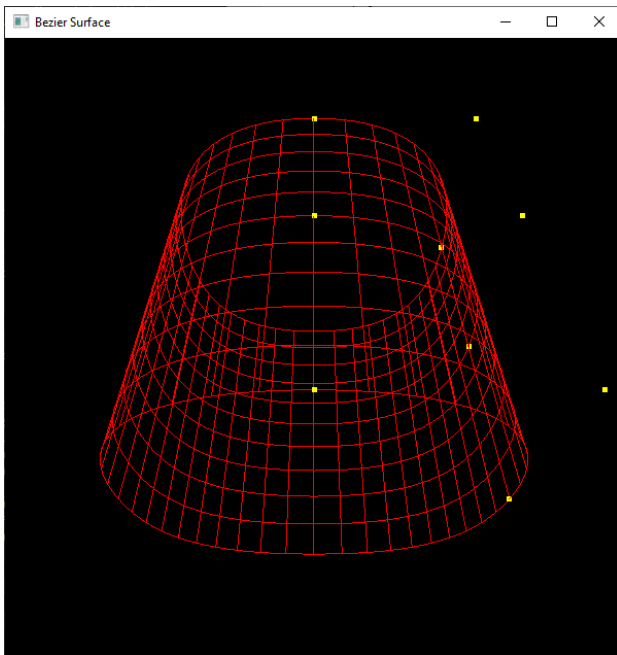
    glMatrixMode(GL_MODELVIEW); // back to modelview matrix
    glLoadIdentity(); // clear the matrix
}

int main(int argc, char** argv) {
    glutInit(&argc, argv);
    glutInitDisplayMode(GLUT_SINGLE | GLUT_RGBA);
    glutInitWindowSize(600, 600);
    glutCreateWindow("Bezier Surface");

    glutDisplayFunc(myDisplay);
    glutKeyboardFunc(keyboard_input);
    glutReshapeFunc(myReshape);
    glutIdleFunc(when_in_mainloop);

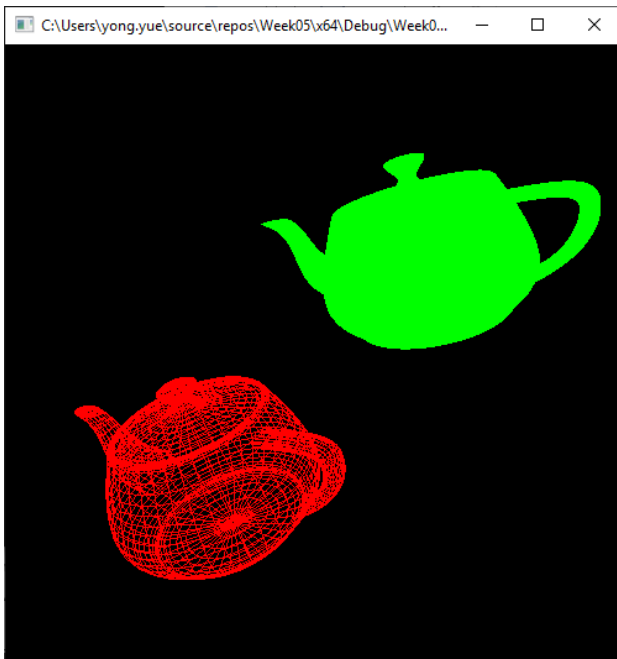
    glutMainLoop();
}

```



Part 3. Teapots

This part consists of a header file (**Teapot.h**) and a source code file (**Teapot.cpp**) for creating a wireframe teapot and a solid teapot. Read and load the two files into a new project, compile and run it. You will see the two teapots which you can rotate around the three axes.



Part 4. Zoom and Pan (Further Sample Code for Lab 05)

```
// Zoom and Pan

#define FREEGLUT_STATIC
#include <GL/freeglut.h>

//Hide the terminal windows
#pragma comment (linker, "/subsystem:\"windows\" /entry:\"mainCRTStartup\"")

// XYZ position of the camera
float x = 0.0f, y = 1.0f, z = 5.0f;

void changeSize(int w, int h) {
    // Prevent a divide by zero, when window is too short
    if (h == 0)
        h = 1;
    float ratio = w * 1.0 / h;

    // Use the Projection Matrix
    glMatrixMode(GL_PROJECTION);

    // Reset Matrix
    glLoadIdentity();

    // Set the viewport to be the entire window
    glViewport(0, 0, w, h);

    // Set the correct perspective.
    gluPerspective(45.0f, ratio, 0.1f, 100.0f);

    // Get Back to the Modelview
    glMatrixMode(GL_MODELVIEW);
}

// Draw a simple man body
void drawMan() {
    glColor3f(1.0f, 1.0f, 1.0f);
    // Draw Body
    glTranslatef(0.0f, 0.75f, 0.0f);
    glutSolidSphere(0.75f, 20, 20);

    // Draw Head
    glTranslatef(0.0f, 1.0f, 0.0f);
    glutSolidSphere(0.25f, 20, 20);
}

void renderScene(void) {
    // Clear Color and Depth Buffers
    glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
    // Reset transformations
    glLoadIdentity();
    // Set the camera
    gluLookAt(x, y, z, x, y, z - 1.0, 0.0f, 1.0f, 0.0f);

    glPushMatrix();
    glTranslatef(0.0, 0.0, 0.0);
    drawMan();
    glPopMatrix();

    glutSwapBuffers();
}

void processNormalKeys(unsigned char key, int x, int y) {
    //Press ESC quit
    if (key == 27)
        exit(0);
}

void processSpecialKeys(int key, int xx, int yy) {
    float fraction = 0.2f;

    switch (key) {
        //Camera move left
        case GLUT_KEY_LEFT:
            x -= fraction;
            break;
    }
}
```

```

        //Camera move right
    case GLUT_KEY_RIGHT:
        x += fraction;
        break;
        // Camera move up
    case GLUT_KEY_UP:
        y += fraction;
        break;
        // Camera move down
    case GLUT_KEY_DOWN:
        y -= fraction;
        break;
        // Zoom out
    case GLUT_KEY_PAGE_UP:
        z += fraction;
        break;
        // Zoom in
    case GLUT_KEY_PAGE_DOWN:
        z -= fraction;
        break;
    }
}

int main(int argc, char** argv) {
    // init GLUT and create window
    glutInit(&argc, argv);
    glutInitDisplayMode(GLUT_DEPTH | GLUT_DOUBLE | GLUT_RGBA);
    glutInitWindowPosition(100, 100);
    glutInitWindowSize(320, 320);
    glutCreateWindow("Movement");

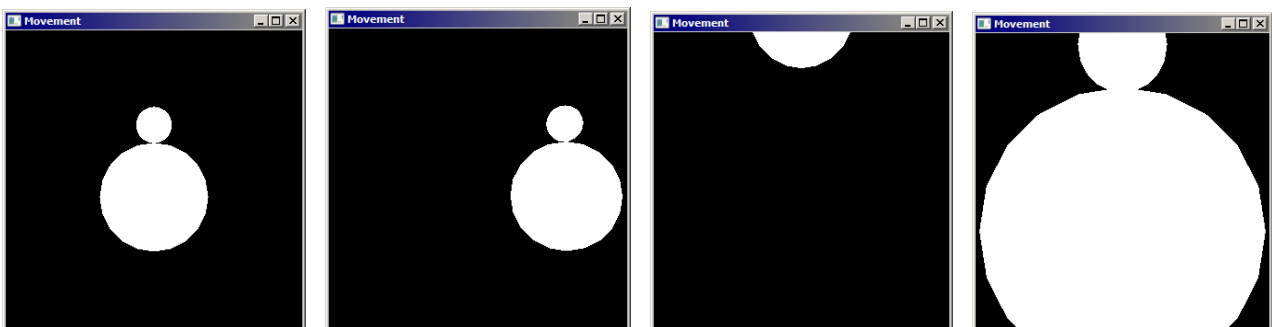
    // register callbacks
    glutDisplayFunc(renderScene);
    glutReshapeFunc(changeSize);
    glutIdleFunc(renderScene);
    glutKeyboardFunc(processNormalKeys);
    glutSpecialFunc(processSpecialKeys);

    // OpenGL init
    glEnable(GL_DEPTH_TEST);

    // enter GLUT event processing cycle
    glutMainLoop();

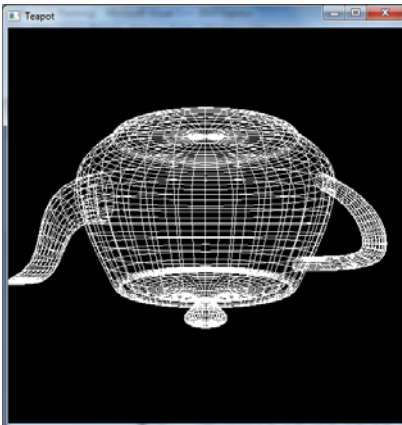
    return 1;
}

```

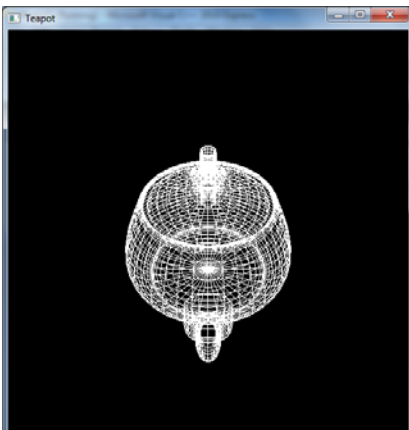


Part 5. Sample Solutions to Tasks 2-6 for 1.4 Viewing/Projection Functions of Part I for Lab05

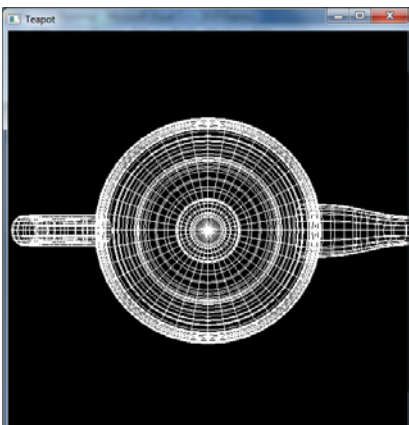
Task2: Specify different values for the **gluLookAt** function to see the following image
`gluLookAt(0,0,5,0,0,0,0,-1,0);`



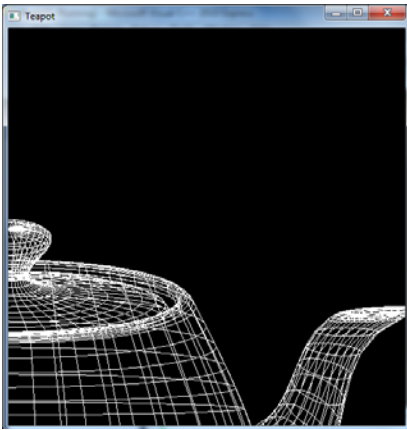
Task3: Specify different values for the **gluLookAt** function to see the following image
`gluLookAt(5,5,0,0,0,0,0,1,0);`



Task4: Specify different values for the **gluLookAt** function to see the following image
`gluLookAt(0,5,0,0,0,0,0,0,-1);`



Task5: Specify different values for the **glFrustum** function to see the following image
`glFrustum(0.0, 1.0, 0.0, 1.0, 1.5, 20.0);`
`gluLookAt(0, 0, 5, 0, 0, 0, 0, 1, 0);`



Task6: Add the **glRotatef** function to see the following image
`glRotatef(90, 1, 0, 0);`

