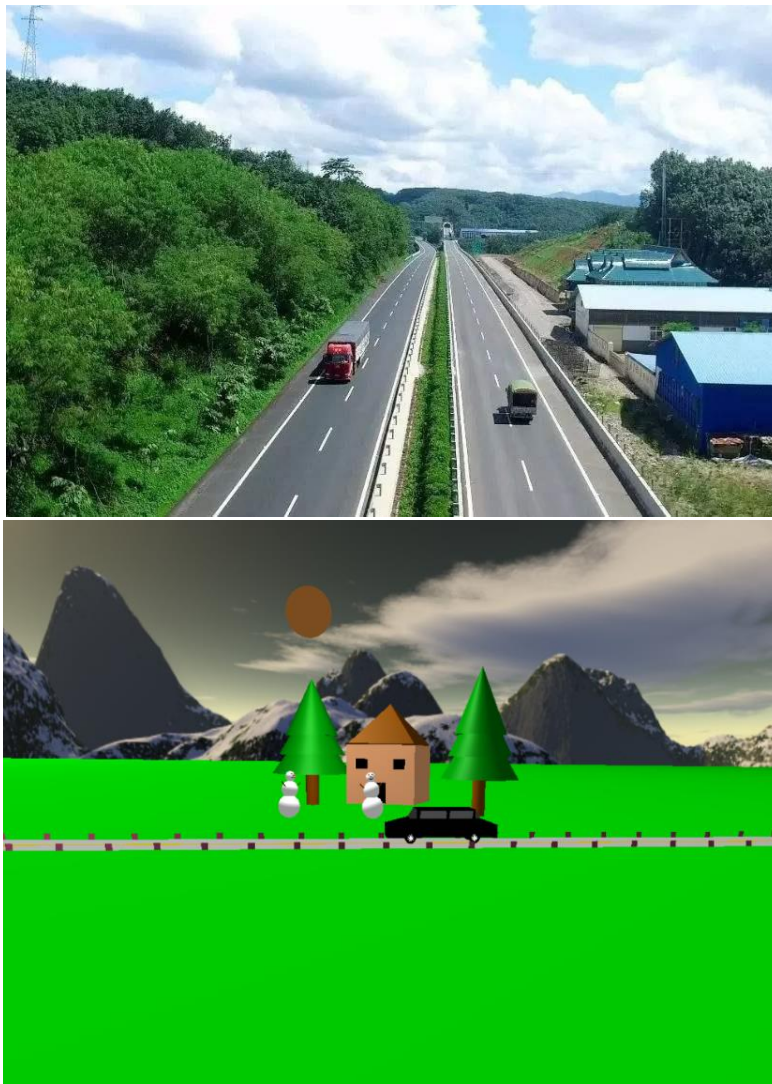


Computer Graphics Project

Full Program Report

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Since the beginning of the project, some creative ideas have been contributed called ‘A highway knifes through the jungle’. Based on the inspiration of the following picture, there is a scenario about a road and a car, which are simulated as the idea of this project. Roadside trees and houses are also be added to the scene. Moreover, enlightened by some given example 3D scene screenshots, snow scenes are added, snowflakes floating in the air and snow on the ground included. At the end of the project, all these ideas are basically completed as shown below.

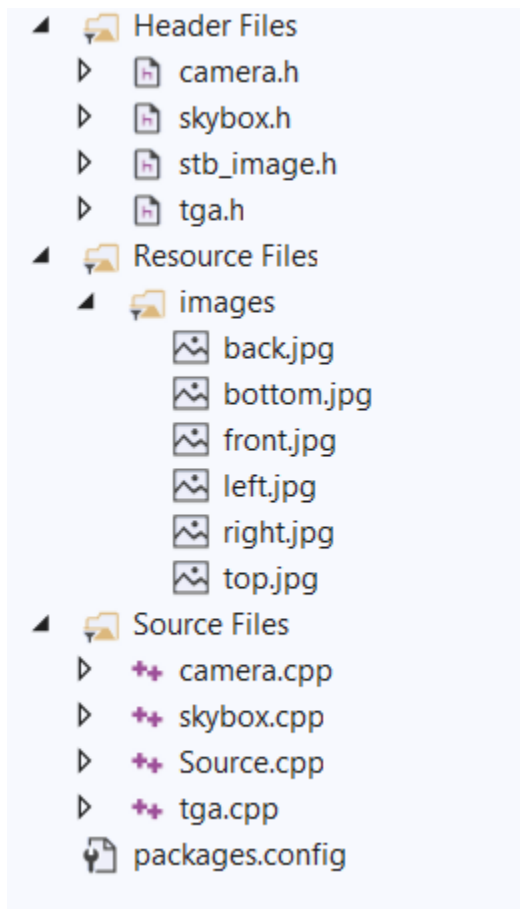


How to use the program:

The program should be run with a package named “nupengl”.

 nupengl.core.0.1.0.1	2020/11/17 22:02	File folder
 nupengl.core.redist.0.1.0.1	2020/11/17 22:02	File folder

After installing this package, let me introduce the role of following files.



Main function is in the file “source.cpp” and most of other architectures are in the same file, for example, 3D object creation, animation and keyboard functions. “camera.h” and “camera.cpp” are from projects of labs and are used for controlling the change of different perspectives. “stb_image.h”, “skybox.h” and “skybox.cpp” are utilized for design of skybox of the full scene. Moreover, “tga.h” and “tga.cpp” are designed for textures of sun and moon.

All the images which need to be imported, such as the front side image of skybox, will be put in a folder named “images”.

Requirements:

The following is a detailed explanation of requirements with the code and screenshots.

3D objects creation

First of all, the 3D objects of car, road, house, tree, moon and snowman and so on are created.

3D Objects

- Highway
- Wheel flag on the road
- Jungle
- Car
- Snowmen
- Trees
- House
- Moon and Sun

```
//method to create a house
void house(void){ ... }

//method to create a tree
void tree(void){ ... }

//method to create moon/ sun
void moonOrSun(void){ ... }

//method to create snowman
void snowman(void){ ... }

//method to create car
GLvoid DrawCar(){ ... }

//method to create road
GLvoid DrawRoad(){ ... }

//method to create overall scene
GLvoid DrawGLScene(){ ... }
```

a. Car creation:

The main work of the car creation is to drawing cube.

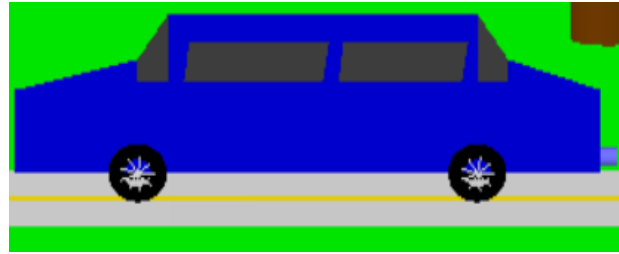
```
231 GLvoid DrawCar() {
232     glPushMatrix();
233
234     glTranslatef(0, -2.0, 0);
235     glBegin(GL_QUADS);
236
237     /* top of cube*/
238     /******FRONT BODY*****/
239     glColor3f(r, g, b);
240     glVertex3f(0.2, 0.4, 0.6);
241     glVertex3f(0.6, 0.5, 0.6);
242     glVertex3f(0.6, 0.5, 0.2);
243     glVertex3f(0.2, 0.4, 0.2);
244
245     /* bottom of cube*/
246     glVertex3f(0.2, 0.4, 0.6);
247     glVertex3f(0.6, 0.2, 0.6);
248     glVertex3f(0.6, 0.2, 0.2);
249     glVertex3f(0.2, 0.2, 0.2);
250
251     /* front of cube*/
252     glVertex3f(0.2, 0.2, 0.6);
253     glVertex3f(0.2, 0.4, 0.6);
254     glVertex3f(0.2, 0.4, 0.2);
255     glVertex3f(0.2, 0.2, 0.2);
256
257     /******back of cube*****/
258     glColor3f(r, g, b);
259     glVertex3f(1.8, 0.5, 0.6);
260     glVertex3f(1.8, 0.5, 0.2);
261     glVertex3f(2.1, 0.4, 0.2);
262     glVertex3f(2.1, 0.4, 0.6);
263
264     /* bottom of cube*/
265     glVertex3f(2.1, 0.2, 0.6);
266     glVertex3f(2.1, 0.2, 0.2);
267     glVertex3f(1.8, 0.2, 0.6);
268     glVertex3f(1.8, 0.2, 0.2);
269
270     /* back of cube*/
271     glVertex3f(2.1, 0.4, 0.6);
272     glVertex3f(2.1, 0.4, 0.2);
273     glVertex3f(2.1, 0.2, 0.2);
274     glVertex3f(2.1, 0.2, 0.6);
275
276     /* left of cube*/
277     glVertex3f(1.8, 0.2, 0.2);
278     glVertex3f(1.8, 0.5, 0.2);
279     glVertex3f(2.1, 0.4, 0.2);
280     glVertex3f(2.1, 0.2, 0.2);
281
282     glEnd();
283
284     //
285     glBegin(GL_TRIANGLES);
286
287     /* top of cube*/
288     glColor3f(0.3, 0.3, 0.3);
289     glVertex3f(0.6, 0.5, 0.6);
290     glVertex3f(0.6, 0.5, 0.2);
291     glVertex3f(0.7, 0.65, 0.2);
292     glVertex3f(0.7, 0.65, 0.6);
293
294     glEnd();
295
296     //
297     glBegin(GL_TRIANGLES);
298
299     /* top of cube*/
300     glColor3f(0.3, 0.3, 0.3);
301     glVertex3f(0.6, 0.5, 0.6);
302     glVertex3f(0.7, 0.65, 0.6);
303     glVertex3f(0.7, 0.65, 0.2);
304     glVertex3f(0.6, 0.5, 0.2);
305
306     glEnd();
307
308     glPopMatrix();
309 }
```

However, the creation of wheel is remarkable. In the code, the variation 'angle' is related to the interaction to move the car. As a result, when moving the car, it is obvious that the wheels are moving and rotating.

```

439 //*****WHEEL
440
441 glColor3f(0.7, 0.7, 0.7);
442 glPushMatrix();
443 glBegin(GL_QUADS);
444 for (theta = 0; theta < 360; theta = theta + 40)
445 {
446     glVertex3f(0.6, 0.2, 0.62);
447     glVertex3f(0.6 + (0.08 * (cos(((theta + angle) * 3.14) / 180))), 0.2 + (0.08 * (sin(((theta + angle) * 3.14) / 180))), 0.62);
448 }
449 glEnd();
450
451 glBegin(GL_QUADS);
452 for (theta = 0; theta < 360; theta = theta + 40)
453 {
454     glVertex3f(0.6, 0.2, 0.18);
455     glVertex3f(0.6 + (0.08 * (cos(((theta + angle) * 3.14) / 180))), 0.2 + (0.08 * (sin(((theta + angle) * 3.14) / 180))), 0.18);
456 }
457 glEnd();
458
459 glBegin(GL_QUADS);
460 for (theta = 0; theta < 360; theta = theta + 40)
461 {
462     glVertex3f(1.7, 0.2, 0.18);
463     glVertex3f(1.7 + (0.08 * (cos(((theta + angle) * 3.14) / 180))), 0.2 + (0.08 * (sin(((theta + angle) * 3.14) / 180))), 0.18);
464 }
465 glEnd();

```



b. Road and background creation:

The idea of the creation of the ground and the road is to create a small cuboid with small height. Along the road, wheel flags are set up at fixed distances.

```

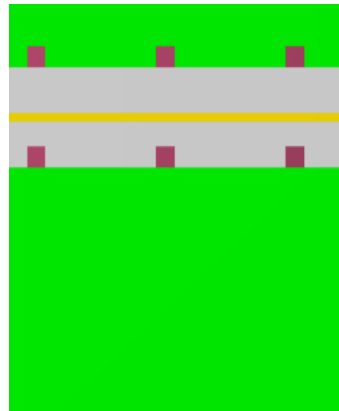
490 GLvoid DrawRoad() {
491     //*****road
492     glPushMatrix();
493     glTranslatef(0, -2.0, 0);
494
495     glBegin(GL_QUADS);
496
497     glPushMatrix();
498     glTranslatef(xw, 0, 0);
499     glColor3f(0, 1, 0);
500     glVertex3f(-100, 0.1, -100);
501     glVertex3f(-100, 0.1, 0);
502     glVertex3f(100, 0.1, 0);
503     glVertex3f(100, 0.1, -100);
504
505     glColor3f(0.7, 0.7, 0.7);
506     glVertex3f(-100, 0.1, 0);
507     glVertex3f(-100, 0.1, 0.45);
508     glVertex3f(100, 0.1, 0.45);
509     glVertex3f(100, 0.1, 0);
510
511     glColor3f(1.0, 0.75, 0.0);
512     glVertex3f(-100, 0.1, 0.45);
513     glVertex3f(-100, 0.1, 0.55);
514     glVertex3f(100, 0.1, 0.55);
515     glVertex3f(100, 0.1, 0.45);
516
517     glColor3f(0.7, 0.7, 0.7);
518     glVertex3f(-100, 0.1, 0.55);
519     glVertex3f(-100, 0.1, 1);
520 }

```

```

531 ...
532 if (wheelflag)
533 {
534     glPushMatrix();
535     glTranslatef(xw, 0, 0);
536     glColor3f(0.5, .2, 0.3);
537     glBegin(GL_QUADS);
538     for (i = 0; i < 200; i += 0.2)
539     {
540         glVertex3f(-100 + i, 0, 1);
541         glVertex3f(-99.9 + i, 0, 1);
542         glVertex3f(-99.9 + i, 0.2, 1);
543         glVertex3f(-100 + i, 0.2, 1);
544         i += 0.5;
545     }
546     for (i = 0; i < 200; i += 0.2)
547     {
548         glVertex3f(-100 + i, 0, 0);
549         glVertex3f(-99.9 + i, 0, 0);
550         glVertex3f(-99.9 + i, 0.2, 0);
551         glVertex3f(-100 + i, 0.2, 0);
552         i += 0.5;
553     }
554     glEnd();
555     glPopMatrix();
556 }
557 glPopMatrix();

```



c. House creation:

```

117 //method to create a house
118 void house(void) {
119     glRotated(-20, 0, 1, 0);
120     //roof
121     glPushMatrix();
122     glColor3f(.388, .2, .0039);
123     glScaled(.5, .5, .5);
124     glRotated(45, 0, 1, 0);
125     glutSolidOctahedron();
126     glPopMatrix();
127     //house
128     glColor3f(.871, .612, .416);
129     glTranslated(0, -.38, 0);
130     glutSolidCube(.73);
131     //windows
132     glColor3f(0, 0, 0);
133     glTranslated(-.2, .13, .32);
134     glutSolidCube(.12);
135     glTranslated(.4, 0, 0);
136     glutSolidCube(.12);
137     //door
138     glTranslated(-.2, -.355, .046);
139     glScaled(.5, 1.1, 0);
140     glutSolidCube(.23);
141 }

```



d. Tree creation:

```

143 //method to create a tree
144 void tree(void) {
145     //trunk
146     glPushMatrix();
147     glColor3f(.388, .2, .0039);
148     GLUQuadric* qobj = gluNewQuadric(); //cyl:
149     glRotated(90, 1, 0, 0);
150     gluCylinder(qobj, .05, .05, .4, 30, 30);
151     glPopMatrix();
152     //tree leaves
153     glColor3f(0, .415, .0156);
154     glTranslated(0, -.23, 0);
155     glRotated(-90, 1, 0, 0);
156     glutSolidCone(.3, .3, 40, 40);
157     glTranslated(0, 0, .1);
158     glutSolidCone(.25, .3, 40, 40);
159     glTranslated(0, 0, .1);
160     glutSolidCone(.2, .3, 40, 40);
161 }
162

```



e. Snowman (same as the result of the first coursework):

```

181 void snowman(void) {
182     //body
183     glPushMatrix();
184     glColor3f(1, 1, 1);
185     glTranslated(0, 1, 0);
186     glutSolidSphere(.9, 100, 100);
187     glTranslated(0, 0, -2.25, 0);
188     glutSolidSphere(1.5, 100, 100);
189     glTranslated(0, 0, -3, 0);
190     glutSolidSphere(2, 100, 100);
191     glPopMatrix();
192     //face
193     glPushMatrix();
194     //eyes
195     glTranslated(-.35, 1.5, .75);
196     glColor3f(0, 0, 0);
197     glutSolidSphere(.1, 100, 100);
198     glTranslated(.65, 0, 0);
199     glutSolidSphere(.1, 100, 100);
200     glColor3f(.8, .3, 0);
201     //nose
202     glTranslated(-.325, -.3, .14);
203     glutSolidCone(.15, 1, 100, 100);
204     //mouth
205     glColor3f(0, 0, 0);
206     glTranslated(-.3, -.4, 0);
207     glutSolidSphere(.07, 100, 100);
208     glTranslated(.15, -.075, 0);
209     glutSolidSphere(.07, 100, 100);
210     glTranslated(.15, -.005, 0);

```



f. Sun and moon creation:

```

165 void moonOrSun(void) {
166     GLfloat pos1[] = { 0, 0, 0, 1 }, //light position
167     emission1[] = { 0, 0, 0, 1 },
168     emission_default[] = { 0, 0, 0, 1 },
169     amb1[] = { .4, .4, .4, 1.0 }; //ambient intensity
170
171     glTranslated(.05, 0, 0);
172     glLightfv(GL_LIGHT1, GL_POSITION, pos1);
173     glMaterialfv(GL_FRONT, GL_EMISSION, emission1);
174     glutSolidSphere(.4, 40, 40);
175     glMaterialfv(GL_FRONT, GL_EMISSION, emission_default);
176     glLightfv(GL_LIGHT1, GL_AMBIENT, amb1);
177     glEnable(GL_LIGHTING);
178     glEnable(GL_LIGHT1);
179 }
180

```



Keyboard functions

Then, some keyboard functions are considered. For example, moving the car, different viewpoint of the scene environment, change the car color and so on.

```
void idle(void) { ... }
```

```
void NormalKey(GLubyte key, GLint x, GLint y) { ... }
```

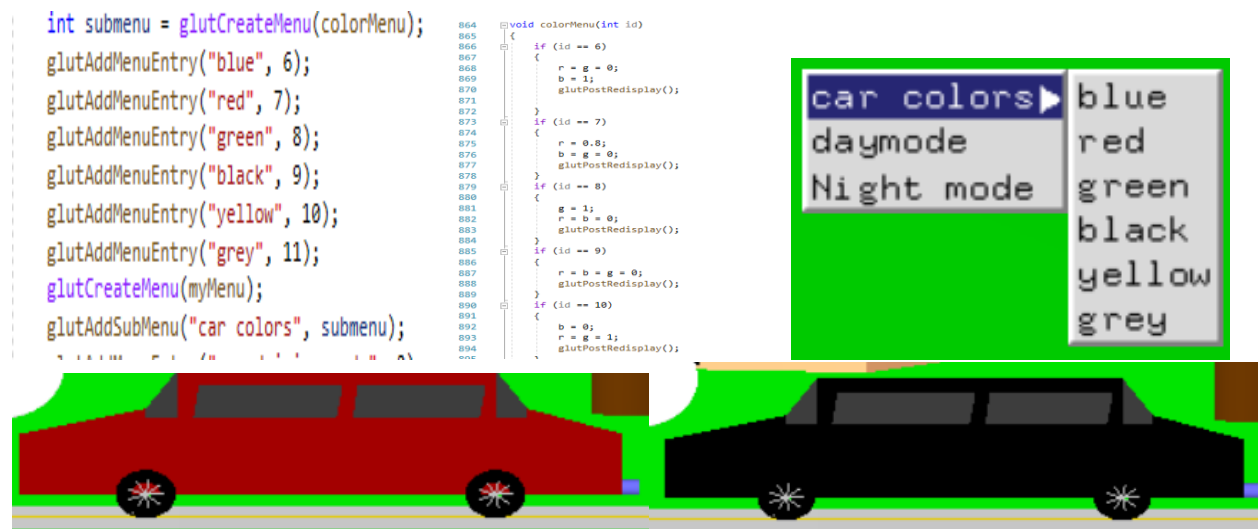
```
static void SpecialKeyFunc(int Key, int x, int y) { ... }
```

```
void myMenu(int id) { ... }
```

```
void colorMenu(int id) { ... }
```

a. Change the color of the car:

Car color change is a submenu implemented in the function “colorMenu”



b. Move the car:

Car move is implemented in the function “SpecialKeyFunc”.

Use Left arrow (<-) and right arrow (->) on the keyboard to control the move of the car.

```

static void SpecialKeyFunc(int Key, int x, int y)
{
    switch (Key) {
    case GLUT_KEY_RIGHT:
        xt += 0.02;
        angle += 5;

        glutPostRedisplay();
        break;

    case GLUT_KEY_LEFT:
        xt -= 0.02;
        angle += 5;

        glutPostRedisplay();
        break;
    }
}

```

c. Change the mode of day and night:

Altering day and night is implemented in the function “myMenu”.

```

835 if (id == 3)
836 {
837     dayNight = 1;
838     moon = false;
839     glClearColor(1, 1, 1, 1);
840     glDisable(GL_FOG);
841     glutPostRedisplay();
842 }
843
844 if (id == 4)
845 {
846     dayNight = 0;
847     moon = true;
848     fog = 1;
849     glClearColor(0.1, 0.1, 0.1, 0);
850     GLfloat fogcolour[4] = { 0.0,0.0,0.0,1.0 };
851
852     glFogfv(GL_FOG_COLOR, fogcolour);
853     glFogf(GL_FOG_DENSITY, 0.5);
854     glFogi(GL_FOG_MODE, GL_EXP);
855     glHint(GL_FOG_HINT, GL_FASTEST);
856     glEnable(GL_FOG);
857
858     glutPostRedisplay();
859 }
860

```

d. Change the viewpoint and perspective (e.g. X, Y and Z keys on the keyboard):

X (x): Rotate all 3D objects around x-axis

Y (y): Rotate all 3D objects around y-axis

Z (z): Rotate perspective around z-axis

U (u): Translate all 3D objects up

1(2): Alter between FILL and LINE

d(a): Scale up and scale down of perspective

s(w): Translate to left and translate to right

i(k): Pitch

q(e): Yaw

j(l): Roll

```
727 void NormalKey(GLubyte key, GLint x, GLint y)
728 {
729     switch (key) {
730         case 'x': xangle += 5.0;
731             glutPostRedisplay();
732             break;
733         case 'X': xangle -= 5.0;
734             glutPostRedisplay();
735             break;
736         case 'y':
737             yangle += 5.0;
738             glutPostRedisplay();
739             break;
740         case 'Y':
741             yangle -= 5.0;
742             glutPostRedisplay();
743             break;
744         case 'z':
745             zangle += 5.0;
746             glutPostRedisplay();
747             break;
748         case 'Z':
749             zangle -= 5.0;
750             glutPostRedisplay();
751             break;
752         case 'u': /* Move up */
753             yt += 0.2;
754             break;
755         case '1':
756             glPolygonMode(GL_FRONT, GL_LINE);
757             glutPostRedisplay();
758             break;
759         case '2':
760             glPolygonMode(GL_FRONT, GL_FILL);
761             glutPostRedisplay();
762             break;
763         case 'd':
764             cam.slide(0.1, 0, 0);
765             glutPostRedisplay();
766             break;
767         case 'a':
768             cam.slide(-0.1, 0, 0);
769             glutPostRedisplay();
770             break;
771         case 's':
772             cam.slide(0, 0, 0.5);
773             glutPostRedisplay();
774             break;
775         case 'w':
776             cam.slide(0, 0, -0.5);
777             glutPostRedisplay();
778             break;
779         case 'i':
780             cam.pitch(-0.1);
781             glutPostRedisplay();
782             break;
783         case 'k':
784             cam.pitch(0.1);
785             glutPostRedisplay();
786             break;
787         case 'q':
788             cam.yaw(-0.1);
789             glutPostRedisplay();
790             break;
791         case 'e':
792             cam.yaw(0.1);
793             glutPostRedisplay();
794             break;
795         case 'j':
796             cam.roll(-0.1);
797             glutPostRedisplay();
798             break;
799         case 'l':
800             cam.roll(0.1);
801             glutPostRedisplay();
802             break;
803     }
```

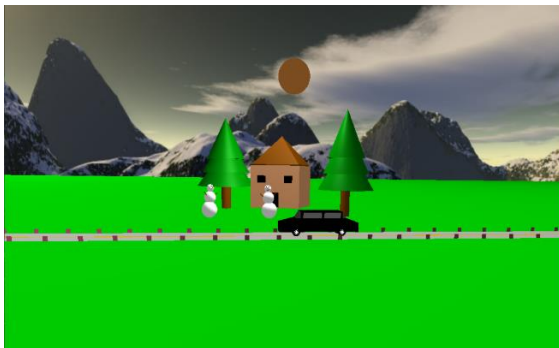
Animation

According to the animation, the sun and moon move from left to right alternately and the snowman will keep spinning.

```
695 void idle(void) {
696     //movement of moon/sun
697     moonHorizontal = moonHorizontal + .002;
698     if (goDown == false) moonVertical = moonVertical + .0004;
699     if (moonHorizontal > 5.5) {
700         moonHorizontal = 0;
701         moonVertical = 0;
702         goDown = false;
703     }
704     if (moonVertical > .45 || goDown == true) {
705         goDown = true;
706         moonVertical = moonVertical - .0004;
707     }
708     //movement for snowmen
709     if (sLeft) {
710         snowmanMove = snowmanMove + 1.5;
711         if (snowmanMove >= 20) {
712             sLeft = false;
713             sRight = true;
714         }
715     }
716     if (sRight) {
717         snowmanMove = snowmanMove - 1.5;
718         if (snowmanMove <= -20) {
719             sLeft = true;
720             sRight = false;
721         }
722     }
723     glutPostRedisplay();
724 }
725
726
727 void NormalKey(GLubyte key, GLint x, GLint y)
```


Fog effect

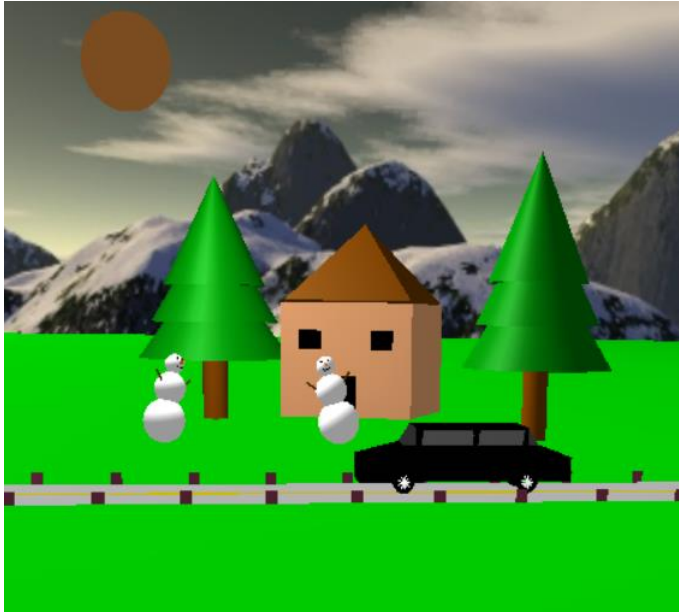
Fog effect are used for day and night alternation.



Light effect

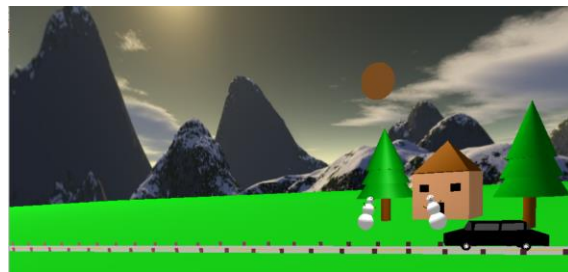
The sun or moon is set as the light source. So with the animation of sun or moon, the light effect can be overserved obviously.





Texture and skybox

Texture are mainly set on the sun or moon and skybox. However, the effect of sun texture is not very appropriate, so that add the texture of sun or moon as comment.



Initialization and main function

```
//
40 void InitGL(GLfloat Width, GLfloat Height)
41 {
42     // Add line width, ditto */
43     glClearColor(1, 1, 1, 1);
44     glViewport(0, 0, Width, Height);
45     gluPerspective(45.0, Width / Height, 0.1, 100.0);
46     glMatrixMode(GL_PROJECTION);
47     glLoadIdentity();
48     glOrtho(-3, 3.0, -4, 2.0, -50.0, 50.0);
49
50     t = gluNewQuadric();
51     gluQuadricDrawStyle(t, GLU_FILL);
52
53     glEnable(GL_LIGHTING);
54
55     glEnable(GL_LIGHT0);
56
57     GLfloat amb0[] = { 0.2f, 0.2f, 0.2f, 1.0f };
58     GLfloat diffuse0[] = { 0.8f, 0.8f, 0.8f, 1.0f };
59     GLfloat specular0[] = { 0.5f, 0.5f, 0.5f, 1.0f };
60     GLfloat pos0[] = { 1.5f, 1.0f, 4.0f, 1.0f };
61
62     glLightfv(GL_LIGHT0, GL_AMBIENT, amb0);
63     glLightfv(GL_LIGHT0, GL_DIFFUSE, diffuse0);
64     glLightfv(GL_LIGHT0, GL_SPECULAR, specular0);
65     glLightfv(GL_LIGHT0, GL_POSITION, pos0);
66
67     glMatrixMode(GL_MODELVIEW);
68     glLoadIdentity();
69 }
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