CHAPTER 1

INTRODUCTION

1.1 Computer Graphics

Graphics provides one of the most natural means of communicating with a computer, since our highly developed 2D and 3D pattern recognition abilities allow us to perceive and process pictorial data rapidly and efficiently. Interactive computer graphics is the most important means of producing pictures since the invention of photography and television. It has the added advantage that, with the computer, we can make pictures not only of concrete real world objects but also of abstract, synthetic objects, such as mathematical surfaces and of data that have no inherent geometry, such as survey results.

1.2 OpenGL

OpenGL (Open Graphics Library) is a standard specification defining a cross language cross platform API for writing applications that produce 2D and 3D computer graphics. The interface consists of over 250 different function calls which can be used to draw complex 3D scenes from simple primitives. OpenGL was developed by Silicon Graphics Inc. (SGI) in 1992 and is widely used in CAD, virtual reality, scientific visualization, information visualization and flight simulation. It is also used in video games, where it competes with direct 3D on Microsoft Windows Platforms.OpenGL is managed by the non profit technology consortium, the Khronos group Inc.

OpenGL serves two main purposes :

- To hide the complexities of interfacing with different 3D accelerators, by presenting programmer with a single, uniform API
- To hide the differing capabilities of hardware platforms , by requiring that all implementations support the full OpenGL feature set.

OpenGL has historically been influential on the development of 3D accelerator, promoting a base level of functionality that is now common in consumer level hardware:

- Rasterized points, lines and polygons are basic primitives.
- A transform and lighting pipeline .
- Z buffering .
- Texture Mapping.
- Alpha Blending.

OpenGL Graphics Architecture :

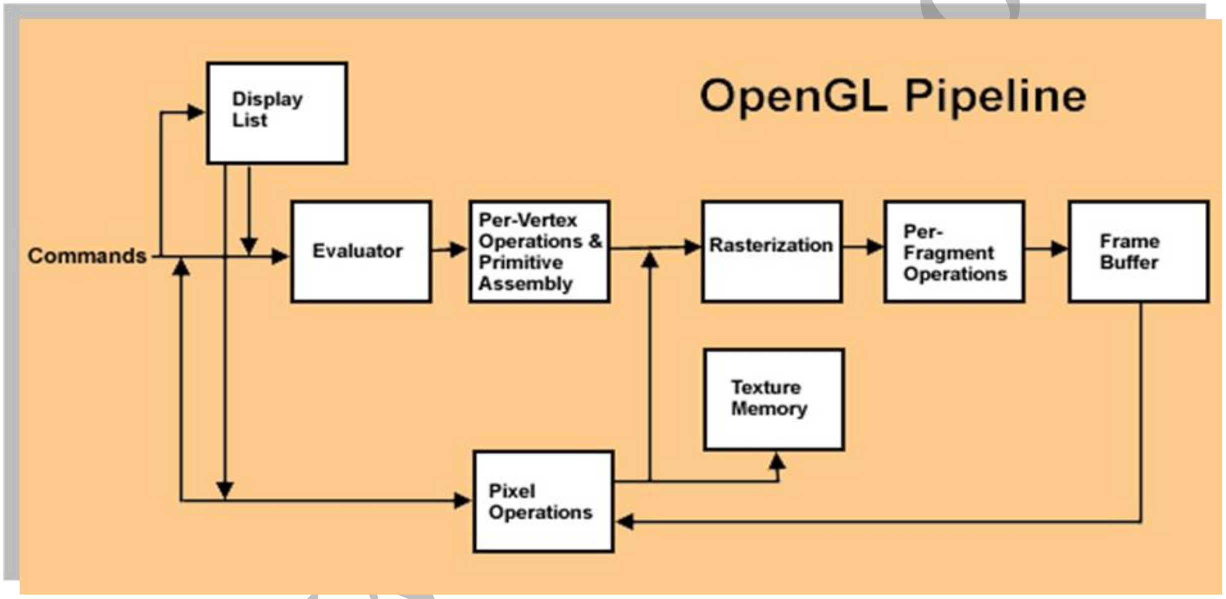


Fig 1.1 openGl Graphics Architecture

Display Lists :

All data, whether it describes geometry or pixels, can be saved in a display list for current or later use. When a display list is executed, the retained data is sent from the display list just as if it were sent by the application in immediate mode.

➢ Evaluators :

All geometric primitives are eventually described by vertices. Parametric curves and surfaces may be initially described by control points and polynomial functions called basis functions.

- **Per Vertex Operations :**

For vertex data, next is the "per-vertex operations" stage, which converts the vertices into primitives. Some vertex data are transformed by 4 x 4 floating-point matrices. Spatial coordinates are projected from a position in the 3D world to a position on your screen.

- **Primitive Assembly :**

Clipping, a major part of primitive assembly, is the elimination of portions of geometry which fall outside a half space, defined by a plane.

- **Pixel Operation:**

While geometric data takes one path through the OpenGL rendering pipeline, pixel data takes a different route. Pixels from an array in system memory are first unpacked from one of a variety of formats into the proper number of components. Next the data is scaled, biased, and processed by a pixel map. The results are clamped and then either written into texture memory or sent to the rasterization step.

- **Rasterization:**

Rasterization is the conversion of both geometric and pixel data into fragments. Each fragment square corresponds to a pixel in the framebuffer. Color and depth values are assigned for each fragment square.

- **Fragment Operations :**

Before values are actually stored into the framebuffer, a series of operations are performed that may alter or even throw out fragments. All these operations can be enabled or disabled.

1.3 Project Goal

The aim of this project is to develop a 3D Game which supports basic operations which include Movement, Artificial Intelligence, collision Detection and also transformation operations like translation, rotation, scaling etc on objects. The package must also have a user friendly interface .

1.4 Scope

It is developed in ECLIPSE. It has been implemented on UBUNTU platform. The 3-D graphics package designed here provides an interface for the users for handling the display and manipulation of Pac-Man Movements. The Keyboard is the main input device used.

Pac-Man :

The game was developed primarily by a young Namco employee Tōru Iwatani, over a year, beginning in April of 1979, employing a nine-man team. The original title was pronounced pakku-man and was inspired by the Japanese onomatopoeic phrase paku-paku taberu where paku-paku describes (the sound of) the mouth movement when widely opened and then closed in succession.

Although it is often cited that the character's shape was inspired by a pizza missing a slice, he admitted in a 1986 interview that it was a half-truth and the character design also came from simplifying and rounding out the Japanese character for mouth, kuchi as well as the basic concept of eating. Iwatani's efforts to appeal to a wider audience beyond the typical demographics of young boys and teenagers-eventually led him to add elements of a maze. The result was a game he named Puck Man.

CHAPTER 2

LITERATURE SURVEY

The Pac-Man game has its roots as a Japanese arcade game developed by Namco (now Namco Bandai) and licensed for distribution in the U.S. by Midway, first released in Japan on May 22, 1980. Pac-Man is universally considered as one of the classics of the medium, virtually synonymous with video games, and an icon of 1980s popular culture. When it was released, the game became a social phenomenon.

The Pac-Man game is often credited with being a landmark in video game history, and is among the most famous arcade games of all time. The character also appears in more than 30 officially licensed games asequels, as well as in numerous unauthorized clones and bootlegs.

Basic Working Of Pac-Man :

The player controls Pac-Man through a maze, eating dots. When all dots are eaten, Pac-Man game is over. Four ghosts roam the maze, trying to catch Pac-Man. If a ghost touches Pac-Man, a life is lost. When all lives have been lost, the game ends. Near the corners of the maze are four larger, flashing dots known as "Energizers" or "Power Pills", which provide Pac-Man with the temporary ability to eat the ghosts.

The ghosts turn deep blue, reverse direction, and usually move more slowly till it returns to the normal state. When Pac-Man eats ghost during vulnerable state, ghost traverses back to the jail and re-initializes to start a new attack. Collision Detection for Pac-Man and Ghost, and Artificial Intelligence for Ghost has been implemented. A total of 260 points are assigned (1 point for normal pebble and 5 points for super pebble) and max lives of 3 is being setup with a 3-D Maze.

Related Data Structure :

Package uses data structures like Stack for storing the co-ordinates of primitives and also uses Arrays for storing the pixel values.

CHAPTER 3

HARDWARE AND SOFTWARE REQUIREMENTS

3.1 Hardware Requirements

- Pentium or higher processor.
- 512 MB or more RAM.

3.2 Software Requirements

This graphics package has been designed for UBUNTU Platform and uses ECLIPSE integrated environment.

Development Platform

UBUNTU 10.10

Development tool

ECLIPSE

Language Used In Coding

C++

CHAPTER 4

DESIGN

4.1 Proposed System

To achieve three dimensional effects, OpenGL software is proposed. It is software which provides a graphical interface. It is an interface between application program and graphics hardware. The advantages are:

- OpenGL is designed as a streamlined**.**
- It is a hardware independent interface, it can be implemented on many different hardware platforms.
- With OpenGL, we can draw a small set of geometric primitives such as points, lines and polygons etc.
- It provides double buffering which is vital in providing transformations.
- It is event driven software.
- It provides call back function.

Detailed Design

Transformation Functions

- **Translation:**

Translation is done by adding the required amount of translation quantities to each of the points of the objects in the selected area. If P(x,y) be the a point and (tx, ty) translation quantities then the translated point is given by

glTranslatef(dx,dy,dz) ;

- **Rotation:**

The rotation of an object by an angle 'a' is accomplished by rotating each of the points of the object. The rotated points can be obtained using the OpenGL functions

glRotatef(angle, vx,vy,vz);

- **Scaling:**

The scaling operation on an object can be carried out for an object by multiplying each of the points (x,y,z) by the scaling factors sx, sy and sz.

glScalef(sx,sy,sz);

CHAPTER 5

IMPLEMENTATION

5.1 User Defined Functions:

Function for pacman:

Pacman_Move ( )

{

Both the x and y updated coordinates are calculate

using the speed of the pacman and trigonometric functions.

}

Pacman_Draw()

{

Here , the pacman is drawn using the glutSolidSphere () function

And the eyes of the pacman is rendered using a combination of

Random coloring and glutSolidSphere () function.

}

Collision Detection For Pac-Man And Ghost:

Bool open()

{

Here, the condition to check if the board is open is given.

This is used for collision detection.

}

Function for Monsters:

```
Monster_init()
{
Here , all the variable values are initialized at the beginning of the
Game.
}

Monster_Move ()
{
Both the x and y updated coordinates are calculate
using  the  speed of the Monster and  trigonometric functions.
}

Monster_Updation()
{
Here, the state of the monster is updated.
The edibility condition is checked and the flag is set.
If the monster is eaten, then the jail timer starts &
The monster is sent to jail.
}

Monster_Vulnerable()
{
Checks the edible condition for the monsters.
}
Monster_Chase()
{
Here ,  depending on the edible condition for the
Monsters , they are set to chase pacman or escape from it.
This is done by using the x-y coordinates of the pacman.
The random movement of the monsters is also handled
}
```

Monster_draw()

{

Here, the pacman is drawn using the glutSolidSphere () function.

The color of the monsters is changed depending on the edible

Condition.

}

Function for Board:

Board_draw()

{

Here , the board is rendered.

Its done in 2 steps to avoid complication in depth.

Depending on the x-y coordinates , the board is rendered

Using different walls.

The pebbles are also rendered here .

Using the random f( ) , the color of the pebbles is changed

To give it a flicker effect.

}

Render_scene()

{

This is the default display function.

Here , the collision detection for pacman , the conditions for

Normal & super pills consumption, with monster movements

Are covered.

Options are provided for game control.

}

Create_list()

{

This function is used to create the basic primitive walls using
Display lists. Based on the position, the appropriate list are called.
}

In Built Functions Used

- **PushMatrix And PopMatrix**

Syntax: *glPushMatrix( );*

glPopMatrix( );

Description:

Pushes the current transformation matrix onto the matrix stack. The glPushMatrix() function saves the current coordinate system to the stack and glPopMatrix() restores the prior coordinate system.

- **Solid Sphere**

Syntax:

void glutSolidSphere (GLdouble radius , GLint slices, GLint stacks);

Parameters:

Radius:	The radius of the sphere.
Slices:	The number of subdivisions around the Z axis (similar to Lines of longitude).
Stacks:	The number of subdivisions along the Z axis (similar to Lines of latitude).

Description:

Renders a sphere centered at the modeling coordinates origin of the specified radius. The sphere is subdivided aroundthe Z axis into slices and along the Z axis into stacks.

get Async KeyState Function :

Syntax:

SHORT GetAsyncKeyState(int vKey);

Parameters:

`vKey [in] int;`

Specifies one of 256 possible key codes. You can use left- and right-distinguishing constants to specify certain keys.

Description:

The **GetAsyncKeyState** function determines whether a key is up or down at the time the function is called, and whether the key was pressed after a previous call to **GetAsyncKeyState.**

Return Value:

SHORT

- **Post Redisplay :**

Syntax:

void glutPostRedisplay( );

Description:

glutPostRedisplay marks the normal plane of current window as needing to be redisplayed. glutPostRedisplay may be called within a window's display or overlay display callback to re-mark that window for redisplay.

- **Timer Function** :

Syntax:

```
void  glutTimerFunc(unsigned int msecs, void(*func), int value);
```

Parameters:

`msecs` : Number of milliseconds to pass before calling the callback.

`func` : The timer callback function.

`value` : Integer value to pass to the timer callback.

Description:

glutTimerFunc registers the timer callback func to be triggered in at least msecs milliseconds. The value parameter to the timer callback will be the value of the value parameter to glutTimerFunc.

- **Bitmap Character :**

Syntax*:*

void glutBitmapCharacter(void *font , int character);

Parameters:

Font : Bitmap font to use.

Character : Character to render (not confined to 8 bits).

Description*:*

Without using any display lists, glutBitmapCharacter renders the character in the named bitmapfont. The available fonts are:

GLUT_BITMAP_TIMES_ROMAN_24 : A 24-point proportional spaced Times Roman font.

GLUT_BITMAP_HELVETICA_18 : A 18-point proportional spaced Helvetica font.

- **Raster Position**

Syntax:

void glRasterPos3f(GLfloat x, GLfloat y, GLfloat z);

Parameters:

x*:* Specifies the x-coordinate for the current raster position.
y*:* Specifies the y-coordinate for the current raster position.
z*:* Specifies the z-coordinate for the current raster position.

Description:

OpenGL maintains a 3-D position in window coordinates. This position, called the raster position, is maintained with subpixel accuracy. It is used to position pixel and bitmap write operations.

- **Color Function**

Syntax :

void glColor3ub(GLubyte red, GLubyte green, GLubyte blue);

Parameters :

red *:* The new red value for the current color.
green *:* The new green value for the current color.
blue*:* The new blue value for the current color.

Description:

This function randomly generates different color based on the rand() function.

- **Keyboard Function**

Syntax:

void glutKeyboardFunc(void (*func)(unsigned char key, int x, int y));

`func`: The new keyboard callback function.

Description:

glutKeyboardFunc sets the keyboard callback for the *current window*. When a user types into the window, each key press generating an ASCII character will generate a keyboard callback.

- **ShadeModel**

Syntax*:*

void glShadeModel(GLenum mode);

Parameters*:*

Mode: Specifies a symbolic value representing a shading technique. Accepted values are GL_FLAT and GL_SMOOTH. The initial value is GL_SMOOTH.

Description:

GL primitives can have either flat or smooth shading. Smooth shading, the default, causes the computed colors of vertices to be interpolated as the primitive is rasterized typically assigning different colors to each resulting pixel fragment. Flat shading selects the computed color of just one vertex and assigns it to all the pixel fragments generated by rasterizing a single primitive

5.2 ALGORITHM

Step1: Initialize the graphics window and its size using GLUT functions.

Step 2: Register the keyboard and display call backs in main function.

Step3: When arrow keys are pressed ghosts are released from jail

Step 4: If left arrow is pressed the Pac-man move towards left in the maze eating the pebbles simultaneously points are incremented, when points becomes 260 the game is restored.

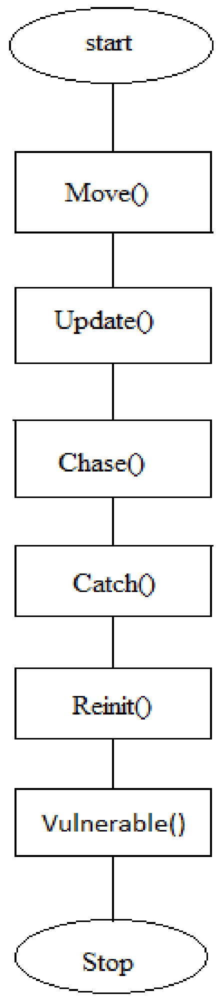
Step 5: If right, up, down arrows is pressed Pac-man moves in respective direction eating pebbles.

Step 6: If Pac-man eats super pebbles ghosts become edible and vulnerable function is called

Step 7: If Pac-man collides the ghosts in vulnerable state ghosts go to jail. If the ghosts are uneaten in vulnerable state update function is called.

Step 8: If Pac-man collides with ghosts provided ghosts are not in vulnerable state Pac-man becomes edible and lives are decremented by one. If lives becomes zero the game is over.

5.3 DATA FLOW DIAGRAM



CHAPTER 6

SNAPSHOTS

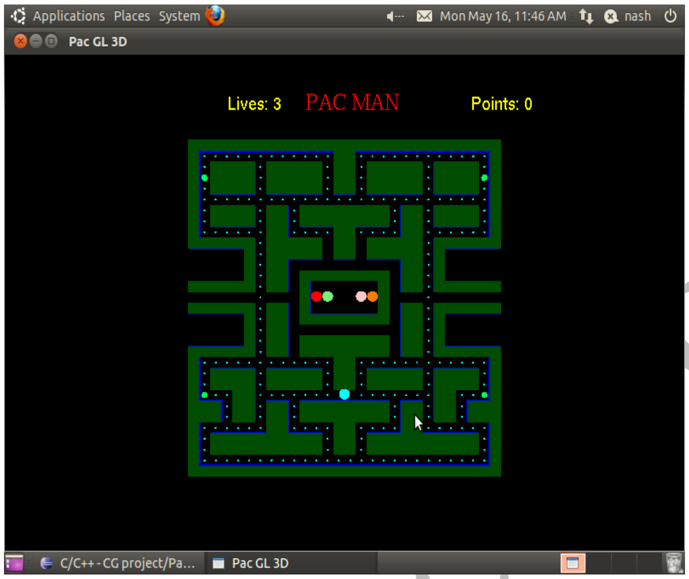


Fig 6.1 Initial View Of Pac-Man

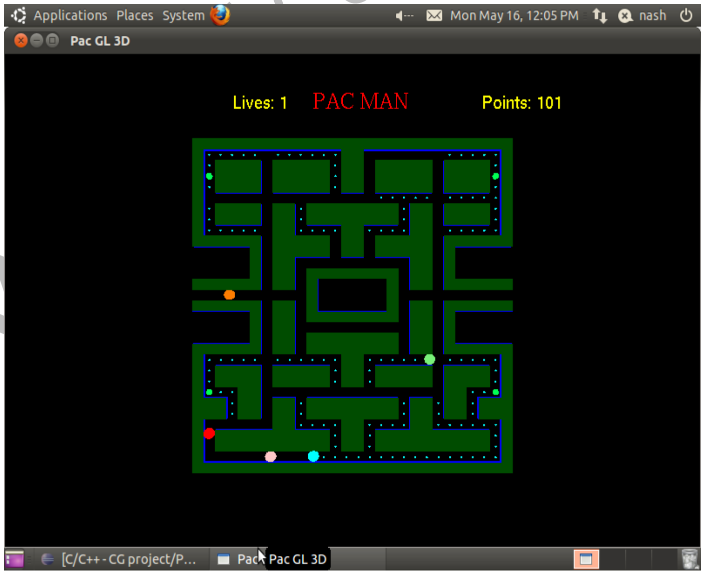


Fig 6.2 Ghosts Chasing The Pac-Man

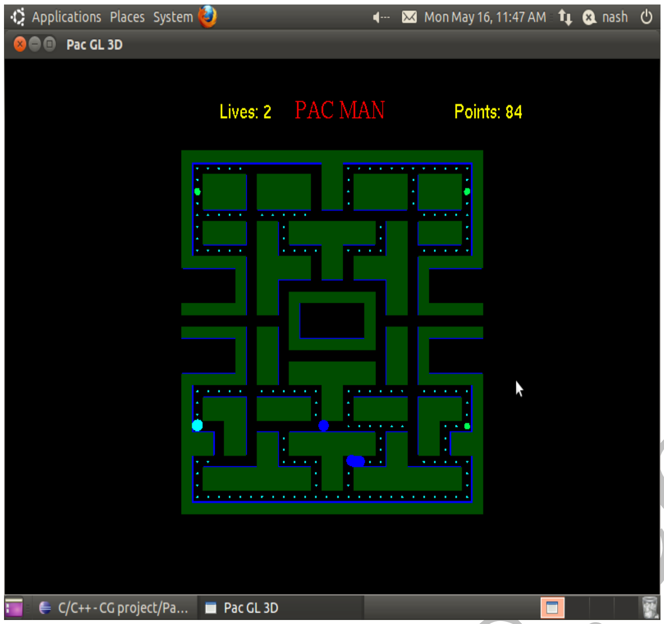


Fig 6.3 Ghosts In The Vulnerable State

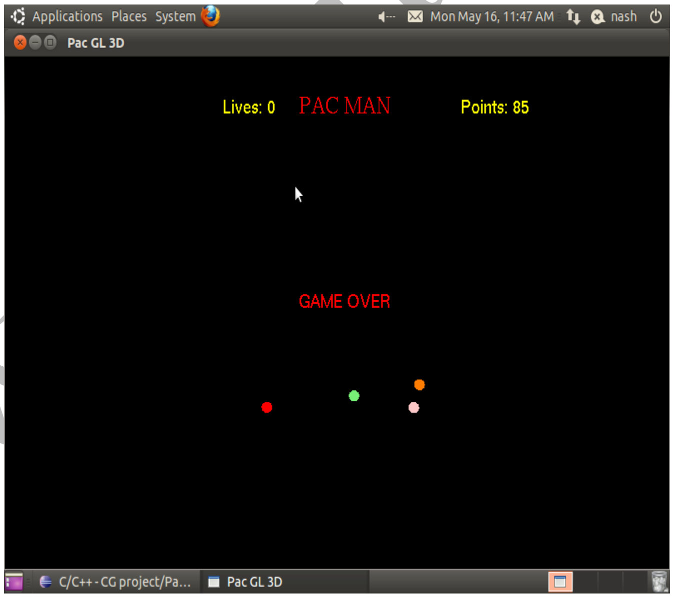


Fig 6.4 Game Over

CHAPTER 7
CONCLUSION AND FUTURE ENHANCEMENTS

We have tried our level best to build the project efficiently and correctly and have succeeded in building a better project, but may not be a best project. We have implemented the required functions which we had stated earlier. After all testing process, the game is now ready to be played.

In future the following enhancements could be done:

- Providing Camera Movement.
- Providing More Number of Levels.
- Providing High Quality Graphics.
- Implementing Shortest Path Algorithm for Ghosts.

APPENDIX A

```
#include<ctype.h>
#include<GL/glut.h>
#include<math.h>
#include<stdio.h>
#define M_PI 3.14159265358979323846264338327950288419716939937510
#define false 0
#define true 1

const int BOARD_X = 31;
const int BOARD_Y = 28;

int board_array[BOARD_X][BOARD_Y] =
                {{8,5,5,5,5,5,5,5,5,5,5,5,5,1,1,5,5,5,5,5,5,5,5,5,5,5,5,7},
                {6,0,0,0,0,0,0,0,0,0,0,0,0,2,4,0,0,0,0,0,0,0,0,0,0,0,0,6},
                {6,0,8,1,1,7,0,8,1,1,1,7,0,2,4,0,8,1,1,1,7,0,8,1,1,7,0,6},
                {6,0,2,11,11,4,0,2,11,11,11,4,0,2,4,0,2,11,11,11,4,0,2,11,11,4,0,6},
                {6,0,9,3,3,10, 0,9,3,3,3,10,0,9,10,0,9,3,3,3,10,0,9,3,3,10,0,6},
                {6,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,6},
                {6,0,8,1,1,7,0,8,7,0,8,1,1,1,1,1,1,7,0,8,7,0,8,1,1,7,0,6},
                {6,0,9,3,3,10,0,2,4,0,9,3,3,11,11,3,3,10,0,2,4,0,9,3,3,10,0,6},
                {6,0,0,0,0,0,0,2,4,0,0,0,0,2,4,0,0,0,0,2,4,0,0,0,0,0,0,6},
                {9,5,5,5,5,7,0,2,11,1,1,7,0,2,4,0,8,1,1,11,4,0,8,5,5,5,5,10},
                {0,0,0,0,0,6,0,2,11,3,3,10,0,9,10,0,9,3,3,11,4,0,6,0,0,0,0,0},
                {0,0,0,0,0,6,0,2,4,0,0,0,0,0,0,0,0,0,0,2,4,0,6,0,0,0,0,0},
                {0,0,0,0,0,6,0,2,4,0,8,5,5,1,1,5,5,7,0,2,4,0,6,0,0,0,0,0},
                {5,5,5,5,5,10,0,9,10,0,6,0,0,0,0,0,0,6,0,9,10,0,9,5,5,5,5,5},
                {0,0,0,0,0,0,0,0,0,0,6,0,0,0,0,0,0,6,0,0,0,0,0,0,0,0,0,0},
                {5,5,5,5,5,7,0,8,7,0,6,0,0,0,0,0,0,6,0,8,7,0,8,5,5,5,5,5},
                {0,0,0,0,0,6,0,2,4,0,9,5,5,5,5,5,5,10,0,2,4,0,6,0,0,0,0,0},
                {0,0,0,0,0,6,0,2,4,0,0,0,0,0,0,0,0,0,0,2,4,0,6,0,0,0,0,0},
                {0,0,0,0,0,6,0,2,4,0,8,1,1,1,1,1,1,7,0,2,4,0,6,0,0,0,0,0},
                {8,5,5,5,5,10,0,9,10,0,9,3,3,11,11,3,3,10,0,9,10,0,9,5,5,5,5,7},
                {6,0,0,0,0,0,0,0,0,0,0,0,0,2,4,0,0,0,0,0,0,0,0,0,0,0,0,6},
                {6,0,8,1,1,7,0,8,1,1,1,7,0,2,4,0,8,1,1,1,7,0,8,1,1,7,0,6},
                {6,0,9,3,11,4,0,9,3,3,3,10,0,9,10,0,9,3,3,3,10,0,2,11,3,10,0,6},
                {6,0,0,0,2,4,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,2,4,0,0,0,6},
                {2,1,7,0,2,4,0,8,7,0,8,1,1,1,1,1,1,7,0,8,7,0,2,4,0,8,1,4},
                {2,3,10,0,9,10,0,2,4,0,9,3,3,11,11,3,3,10,0,2,4,0,9,10,0,9,3,4},
                {6,0,0,0,0,0,0,2,4,0,0,0,0,2,4,0,0,0,0,2,4,0,0,0,0,0,0,6},
                {6,0,8,1,1,1,1,11,11,1,1,7,0,2,4,0,8,1,1,11,11,1,1,1,1,7,0,6},
                {6,0,9,3,3,3,3,3,3,3,3,10,0,9,10,0,9,3,3,3,3,3,3,3,3,10,0,6},
                {6,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,6},
                {9,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,10}};


int pebble_array[BOARD_X][BOARD_Y] =
           {{0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0},
            {0,1,1,1,1,1,1,1,1,1,1,1,1,0,0,1,1,1,1,1,1,1,1,1,1,1,1,0},
            {0,1,0,0,0,0,1,0,0,0,0,0,1,0,0,1,0,0,0,0,0,1,0,0,0,0,1,0},
            {0,3,0,0,0,0,1,0,0,0,0,0,1,0,0,1,0,0,0,0,0,1,0,0,0,0,3,0},
            {0,1,0,0,0,0,1,0,0,0,0,0,1,0,0,1,0,0,0,0,0,1,0,0,0,0,1,0},
            {0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,0},
           {0,1,0,0,0,0,1,0,0,1,0,0,0,0,0,0,0,0,1,0,0,1,0,0,0,0,1,0},
            {0,1,0,0,0,0,1,0,0,1,0,0,0,0,0,0,0,0,1,0,0,1,0,0,0,0,1,0},
            {0,1,1,1,1,1,1,0,0,1,1,1,1,0,0,1,1,1,1,0,0,1,1,1,1,1,1,0},
            {0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0},
            {0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0},
            {0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0},
            {0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0},
            {0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0},
            {0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0},
            {0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0},
            {0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0},
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            {0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0},
            {0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0},
            {0,1,1,1,1,1,1,1,1,1,1,1,1,0,0,1,1,1,1,1,1,1,1,1,1,1,1,0},
            {0,1,0,0,0,0,1,0,0,0,0,0,1,0,0,1,0,0,0,0,0,1,0,0,0,0,1,0},
            {0,1,0,0,0,0,1,0,0,0,0,0,1,0,0,1,0,0,0,0,0,1,0,0,0,0,1,0},
            {0,3,1,1,0,0,1,1,1,1,1,1,1,0,0,1,1,1,1,1,1,1,0,0,1,1,3,0},
            {0,0,0,1,0,0,1,0,0,1,0,0,0,0,0,0,0,0,1,0,0,1,0,0,1,0,0,0},
            {0,0,0,1,0,0,1,0,0,1,0,0,0,0,0,0,0,0,1,0,0,1,0,0,1,0,0,0},
            {0,1,1,1,1,1,1,0,0,1,1,1,1,0,0,1,1,1,1,0,0,1,1,1,1,1,1,0},
            {0,1,0,0,0,0,0,0,0,0,0,0,1,0,0,1,0,0,0,0,0,0,0,0,0,0,1,0},
            {0,1,0,0,0,0,0,0,0,0,0,0,1,0,0,1,0,0,0,0,0,0,0,0,0,0,1,0},
            {0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,0},
            {0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0}};


GLubyte list[5];

int tp_array[31][28];

int pebbles_left;

double speed1 = 0.1;

double angle1 = 90;

double a=13.5, b=23;

bool animate = false;

int lives=3;

int points=0;


void keys();
unsigned char ckey='w';
void mykey(unsigned char key,int x,int y);
bool Open(int a,int b);
void Move()
{
        a +=  speed1*cos(M_PI/180*angle1);
        b +=  speed1*sin(M_PI/180*angle1);
        if(animate&&ckey==GLUT_KEY_UP&& (int) a - a > -0.1 && angle1 != 270)      //w
                {
                        if (Open(a,b-1))
                        {
                                animate = true;
                                angle1 = 270;
                        }
                }

                else if(animate&&ckey==GLUT_KEY_DOWN&& (int) a - a > -0.1 && angle1 != 90)// s
                {
                        if (Open(a,b+1))
                        {
                                animate = true;
                                angle1= 90;
                        }
                }

                else if(animate&&ckey==GLUT_KEY_LEFT&& (int) b - b > -0.1 && angle1 != 180)//a
                {
                        if (Open(a-1,b))
                        {
                                animate = true;
                                angle1 = 180;
                        }
                }

                else if(animate&&ckey==GLUT_KEY_RIGHT&& (int) b - b > -0.1 && angle1 != 0)//d
                {
                        if (Open(a+1,b))
                        {
                                animate = true;
                                angle1 = 0;
                        }
                }
}


void Pac(void)
{
        //Draw Pacman
        glColor3f(0,1,1);
        glPushMatrix();

        glTranslatef(a,-b,0);
        glTranslatef(0.5,0.6,0);
        glTranslatef((float)BOARD_X/-2.0f,(float)BOARD_Y/2.0f,0.5);
        glutSolidSphere(0.5,15,10);
        glPopMatrix();
}


//Monster Drawing And Moving Begins

bool open_move[4];

bool gameover = false;

int num_ghosts = 4;

int start_timer=3;
```

```
class Ghost
{
  private:

 public:
        bool edible;
                 int edible_max_time;
                 int edible_timer;
        bool eaten;
                 bool transporting;
        float color[3];
                 double speed;
                 double max_speed;
                 bool in_jail;
                 int jail_timer;
                 double angle;
                 double x, y;

                 Ghost(double, double);


              ~Ghost(void);

                 void Move(); //Move the Monster

                 void Update(void);  //Update Monster State

                 void Chase(double, double, bool*);  //Chase Pacman

                 bool Catch(double, double);        //collision detection

                 void Reinit(void);

                 void Vulnerable(void);

                 void Draw(void);   //Draw the Monster
                 void game_over(void);

};

Ghost *ghost[4];

Ghost::~Ghost(void){}

Ghost::Ghost(double tx, double ty)
{
             tx = x;
             ty = y;
             angle = 90;
             speed = max_speed=1;
             color[0] = 1;
             color[1] = 0;
             color[2] = 0;
             eaten = false;
             edible_max_time =300;
             edible = false;
             in_jail = true;
        jail_timer = 30;
}

void Ghost::Reinit(void)
{
        edible = false;
        in_jail = true;
        angle = 90;
}

//Move Monster
void Ghost::Move()
{
        x +=  speed*cos(M_PI/180*angle);
        y +=  speed*sin(M_PI/180*angle);
}
void Ghost::game_over()
{

}

void Ghost::Update(void)
{

        if ((int)x == 0 && (int) y == 14 && (!(transporting)))
        {
                angle=180;
        }

        if (x < 0.1 && (int) y == 14)
        {
                x = 26.9;
                transporting = true;
        }

        if ((int)x == 27 && (int) y == 14 && (!(transporting)))
        {
                angle=0;
        }

        if (x > 26.9 && (int) y == 14)

        {
                x = 0.1;
                transporting = true;
        }

        if ((int)x == 2 || (int)x == 25)
                transporting = false;

        if (((int) x < 5 || (int) x > 21) && (int) y == 14 && !edible && !eaten)
                speed = max_speed/2;
                speed = max_speed;

        //edibility
        if (edible_timer == 0 && edible && !eaten)
        {
                edible = false;
                speed = max_speed;
        }
         if (edible)
                edible_timer--;

        //JAIL
        if (in_jail && (int) (y+0.9) == 11)
        {
                in_jail = false;
                angle = 180;
        }

        if (in_jail && ((int)x == 13 || (int)x == 14))
        {
                angle = 270;
        }

        //if time in jail is up, position for exit
        if (jail_timer == 0  && in_jail)

        {
                //move right to exit
                if (x < 13)
                        angle = 0;
                if (x > 14)
                        angle = 180;
        }

        //decrement time in jail counter
        if (jail_timer > 0)
                jail_timer--;

        //EATEN GHOST SEND TO JAIL
        if (eaten && ((int) x == 13 || (int) (x+0.9) == 14) && ((int)y > 10 && (int) y < 15))
        {
                in_jail = true;
                angle = 90;
                if((int) y == 14)
                {
                        eaten = false;
                        speed = max_speed;
                        jail_timer = 66;
                        x = 11;
                }
        }
}


bool Ghost::Catch(double px, double py)
{
        // Collision Detection
        if (px - x < 0.2 && px - x > -0.2 && py - y < 0.2 && py - y > -0.2)
        {
                return true;
        }
        return false;
```

```
}

//called when pacman eats a super pebble

void Ghost::Vulnerable(void)
{
        if (!(edible))
        {
                angle = ((int)angle + 180)%360;
                speed = max_speed;
        }
        edible = true;
        edible_timer = edible_max_time;
        //speed1=0.15;
}



void Ghost::Chase(double px, double py, bool *open_move)
{
        int c;
        if (edible)
                c = -1;
        else
                c = 1;

        bool moved = false;

        if ((int) angle == 0 || (int) angle == 180)
        {
                if ((int)c*py > (int)c*y && open_move[1])
                        angle = 90;

                else if ((int)c*py < (int)c*y && open_move[3])
                        angle = 270;
        }

        else if ((int) angle == 90 || (int) angle == 270)
        {

                if ((int)c*px > (int)c*x && open_move[0])
                        angle = 0;
                else if ((int)c*px < (int)c*x && open_move[2])
                        angle = 180;
        }

        //Random Moves Of Monsters

        if ((int) angle == 0 && !open_move[0])
                angle = 90;

        if ((int) angle == 90 && !open_move[1])
                angle = 180;

        if ((int) angle == 180 && !open_move[2])
                angle = 270;
```

```
         if ((int) angle == 270 && !open_move[3])
                angle = 0;

        if ((int) angle == 0 && !open_move[0])
                angle = 90;


}

void Ghost::Draw(void)
{

        if (!edible)
                glColor3f(color[0],color[1],color[2]);

        else
        {
                if (edible_timer < 150)
                        glColor3f((edible_timer/10)%2,(edible_timer/10)%2,1);
                if (edible_timer >= 150)
                        glColor3f(0,0,1);

        }

        if (eaten)
                glColor3f(1,1,0); //When Eaten By PacMan Change Color To Yellow

        glPushMatrix();
        glTranslatef(x,-y,0);
        glTranslatef(0.5,0.6,0);
        glTranslatef((float)BOARD_X/-2.0f, (float)BOARD_Y/2.0f,0.5);
        glutSolidSphere(.5,10,10);
        glPopMatrix();

}


void tp_restore(void)
{
        for (int ISO = 0; ISO < BOARD_X; ISO++)
        {
                for (int j = 0; j < BOARD_Y; j++)
                {
                        tp_array[ISO][j] = pebble_array[ISO][j];
                }
        }
        pebbles_left = 244;
}


void Draw(void)
{

        glColor3f(1,0,1);

        //split board drawing in half to avoid issues with depth
        for (int ISO = 0; ISO < BOARD_X; ISO++)
```

```
	{
		for (int j = 0; j < BOARD_Y/2; j++)
		{

			glColor3f(0,0,1);
			int call_this = 0;

			glPushMatrix();
			glTranslatef(-(float) BOARD_X / 2.0f,-(float) BOARD_Y / 2.0f, 0);


			glTranslatef(j, BOARD_Y - ISO,0);

			glPushMatrix();
			glTranslatef(0.5,0.5,0);

			switch (board_array[ISO][j])
			{
			case 4:
				glRotatef(90.0,0,0,1);
			case 3:
				glRotatef(90.0,0,0,1);
			case 2:
				glRotatef(90.0,0,0,1);
			case 1:
				call_this = 1;
				break;
			case 6:
				glRotatef(90.0,0,0,1);
			case 5:
				call_this = 2;
				break;
			case 10:
				glRotatef(90.0,0,0,1);
			case 9:
				glRotatef(90.0,0,0,1);
			case 8:
				glRotatef(90.0,0,0,1);
			case 7:
				call_this = 3;
				break;
			}

			glScalef(1,1,0.5);
			glTranslatef(-0.5,-0.5,0);
			glCallList(list[call_this]);
			glPopMatrix();
			//now put on the top of the cell
			if (call_this != 0 || board_array[ISO][j] == 11)
			{
				glTranslatef(0,0,-0.5);
				glCallList(list[4]);
			}
			glPopMatrix();

			if (tp_array[ISO][j] > 0)
			{
```

```
                                        glColor3f(0,300,1/(float)tp_array[ISO][j]);
                                        glPushMatrix();
                                        glTranslatef(-(float) BOARD_X / 2.0f,-(float) BOARD_Y / 2.0f, 0);
                                        glTranslatef(j, BOARD_Y - ISO,0);
                                        glTranslatef(0.5,0.5,0.5);
                                        glutSolidSphere(0.1f*((float)tp_array[ISO][j]),6,6);
                                        glPopMatrix();
                              }
                    }
          }


          int ISO;

          for (ISO= 0; ISO< BOARD_X; ISO++)
          {
                    for (int j = BOARD_Y-1; j >= BOARD_Y/2; j--)
                    {
                              glColor3f(0,0,1);
                              int call_this = 0;

                              glPushMatrix();

                              glTranslatef(-(float) BOARD_X / 2.0f,-(float) BOARD_Y / 2.0f, 0);
                              glTranslatef(j, BOARD_Y - ISO,0);

                              glPushMatrix();
                              glTranslatef(0.5,0.5,0);
                              switch (board_array[ISO][j])
                              {
                              case 4:
                                        glRotatef(90.0,0,0,1);
                              case 3:
                                        glRotatef(90.0,0,0,1);
                              case 2:
                                        glRotatef(90.0,0,0,1);
                              case 1:
                                        call_this = 1;
                                        break;
                              case 6:
                                        glRotatef(90.0,0,0,1);
                              case 5:
                                        call_this = 2;
                                        break;
                              case 10:
                                        glRotatef(90.0,0,0,1);
                              case 9:
                                        glRotatef(90.0,0,0,1);
                              case 8:
                                        glRotatef(90.0,0,0,1);
                              case 7:
                                        call_this = 3;
                                        break;
                              }
                              glScalef(1,1,0.5);
                              glTranslatef(-0.5,-0.5,0);
                              glCallList(list[call_this]);
```

```
                                glPopMatrix();
                                //now put on top
                                if (call_this != 0 || board_array[ISO][j] == 11)
                                {
                                        glTranslatef(0,0,-0.5);
                                        glCallList(list[4]);
                                }
                                glPopMatrix();

                                if (tp_array[ISO][j] > 0)
                                {
                                        glColor3f(0,300,1/(float)tp_array[ISO][j]);
                                        glPushMatrix();

                                        glTranslatef(-(float) BOARD_X / 2.0f,-(float) BOARD_Y / 2.0f, 0);
                                        glTranslatef(j, BOARD_Y - ISO,0);
                                        glTranslatef(0.5,0.5,0.5);
                                        glutSolidSphere(0.1f*((float)tp_array[ISO][j]),6,6);
                                        glPopMatrix();
                                }
                        }
                }
                Pac();
}


bool Open(int a, int b)
{
        if (board_array[b][a] > 0)
        {
                return false;
        }
        return true;
}


void RenderScene();


void mykey(unsigned char key,int x,int y)
{

        if (start_timer > 0)
        {
                start_timer--;

        }
}
void specialDown(int key,int x,int y)
{
        if (start_timer > 0)
                        start_timer--;
        ckey=key;
                if(key==GLUT_KEY_UP&& (int) a - a > -0.1 && angle1 != 270)      //w
                {
                        if (Open(a, b - 1))
                        {
                                animate = true;
                                angle1 = 270;

                         }
                  }

                else if(key==GLUT_KEY_DOWN&& (int) a - a > -0.1 && angle1 != 90)// s
                {
                        if (Open(a,b + 1))
                        {
                                animate = true;
                                angle1= 90;
                        }
                }



               else if(key==GLUT_KEY_LEFT&& (int) b - b > -0.1 && angle1 != 180)//a
                {
                        if (Open(a-1,b))
                        {
                                animate = true;
                                angle1 = 180;

                        }
                }

                else if(key==GLUT_KEY_RIGHT&& (int) b - b > -0.1 && angle1 != 0)//d
                {
                        if (Open(a+1, b))
                        {
                                animate = true;
                                angle1 = 0;
                        }
                }
}

void specialUp(int key,int x,int y)
{

}

void P_Reinit()
{
        a = 13.5;
        b = 23;
        angle1 = 90;
        animate = false;
        Pac();
}


void G_Reinit(void)
{

        start_timer = 3;
        //ghost initial starting positions
        int start_x[4] = {11,12,15,16};
        float ghost_colors[4][3] = {{255,0,0},{120,240,120},{255,200,200},{255,125,0}};

        for (int i = 0; i < num_ghosts; i++)
        {

                ghost[i]->Reinit();
                ghost[i]->x = start_x[i];
                ghost[i]->y = 14;
                ghost[i]->eaten = false;
                ghost[i]->jail_timer = i*33 + 66;
                ghost[i]->max_speed = 0.1 - 0.01*(float)i;
                ghost[i]->speed = ghost[i]->max_speed;

                //colorize ghosts
                for (int j = 0; j < 3; j++)
                        ghost[i]->color[j] = ghost_colors[i][j]/255.0f;
        }
}



void renderBitmapString(float x, float y, void *font, char *string)
{
         char *c;
         glRasterPos2f(x,y);

         for (c=string; *c != '\0'; c++)
         {
                  glutBitmapCharacter(font, *c);
         }
}


void Write(char *string)
{
        while(*string)
        glutBitmapCharacter(GLUT_BITMAP_HELVETICA_18, *string++);
}

void print(char *string)
{
        while(*string)
        glutBitmapCharacter(GLUT_BITMAP_TIMES_ROMAN_24, *string++);
}


//Display Function->This Function Is Registered in glutDisplayFunc

void RenderScene()
{
        glClear(GL_COLOR_BUFFER_BIT|GL_DEPTH_BUFFER_BIT);
        //Through Movement->From One End To The Other

        if ((int)a == 27 && (int) b == 14 && angle1 == 0)
        {
                a = 0;
                animate = true;
        }

        else
        if ((int)(a + 0.9) == 0 && (int) b == 14 && angle1 == 180)
        {
                a = 27;
                animate = true;
        }

        //Collision Detection For PacMan
        if (animate)
                Move();

        if(!(Open((int)(a + cos(M_PI/180*angle1)),
                (int)(b + sin(M_PI/180*angle1)))) &&
                a - (int)a < 0.1 && b - (int)b < 0.1)

                        animate = false;


        if (tp_array[(int)(b+0.5)][(int)(a+0.5)]== 1)
        {
                tp_array[(int)(b+0.5)][(int)(a+0.5)]= 0;
                pebbles_left--;
                points+=1;
        }


        //Super Pebble Eating
        else if(tp_array[(int)(b+0.5)][(int)(a+0.5)] == 3)
        {
                tp_array[(int)(b+0.5)][(int)(a+0.5)]= 0;
                pebbles_left--;
                points+=5;

                for (int i = 0; i < 4; i++)
                {
                        if (!ghost[i]->eaten)
                                ghost[i]->Vulnerable(); //Calls A Function To Make Monster Weak
                }
        }

        //All The Pebbles Have Been Eaten
        if (pebbles_left == 0)
        {
                G_Reinit();
                P_Reinit();
                tp_restore();
                points=0;
                lives=3;
        }


        if (!gameover)
                Draw();
```

```
        for (int d = 0; d < num_ghosts; d++)
        {

                if (!gameover && start_timer == 0)
                        ghost[d]->Update();

                if (!ghost[d]->in_jail &&
                        ghost[d]->x - (int)ghost[d]->x < 0.1 && ghost[d]->y - (int)ghost[d]->y < 0.1)
                {

                        bool open_move[4];

                        //Finding Moves
                        for (int ang = 0; ang < 4; ang++)
                        {
                                open_move[ang] = Open((int)(ghost[d]->x + cos(M_PI/180*ang*90)),
                                        (int)(ghost[d]->y + sin(M_PI/180*ang*90)));


                        }

      //Chase Pac Man
                        if (!ghost[d]->eaten)
                        {
                        if(ghost[d]->x - (int)ghost[d]->x < 0.1 && ghost[d]->y - (int)ghost[d]->y < 0.1)
                                        ghost[d]->Chase(a, b, open_move);
                        }

                        else
                        {
                                if(ghost[d]->x - (int)ghost[d]->x < 0.1 && ghost[d]->y - (int)ghost[d]->y <
0.1)
                                        ghost[d]->Chase(13, 11, open_move);
                        }
                }


                if (ghost[d]->in_jail && !(Open((int)(ghost[d]->x + cos(M_PI/180*ghost[d]->angle)),
                        (int)(ghost[d]->y + sin(M_PI/180*ghost[d]->angle)))) && ghost[d]->jail_timer > 0
&&ghost[d]->x - (int)ghost[d]->x < 0.1 && ghost[d]->y - (int)ghost[d]->y < 0.1)
                        {
                           ghost[d]->angle = (double)(((int)ghost[d]->angle + 180)%360);
                        }


                if (!gameover && start_timer == 0)
                        ghost[d]->Move();
                   ghost[d]->Draw();

                if(!(ghost[d]->eaten))
                {
                        bool collide = ghost[d]->Catch(a,b);

                        //Monster Eats PacMan
                        if (collide && !(ghost[d]->edible))
                        {
                                lives--;
```

```
                    if (lives == 0)
                    {
                        gameover = true;
                        lives=0;
                        ghost[d]->game_over();
                    }

                    P_Reinit();
                    d = 4;
                }

                //PacMan Eats Monster And Sends It To Jail
                else if (collide && ((ghost[d]->edible)))
                {

                    ghost[d]->edible = false;


                    ghost[d]->eaten = true;
                    ghost[d]->speed = 1;
                }
            }
        }

        if(gameover==true)
        {
            glColor3f(1,0,0);
            renderBitmapString(-5, 0.5,GLUT_BITMAP_HELVETICA_18 ,"GAME OVER");
        }

  char tmp_str[40];

  glColor3f(1, 1, 0);
  glRasterPos2f(10, 18);
        sprintf(tmp_str, "Points: %d", points);
  Write(tmp_str);

        glColor3f(1, 0, 0);
  glRasterPos2f(-5, 18);
        sprintf(tmp_str, "PAC MAN");
  print(tmp_str);

        glColor3f(1, 1, 0);
  glRasterPos2f(-12, 18);
        sprintf(tmp_str, "Lives: %d", lives);
  Write(tmp_str);

  glutPostRedisplay();
  glutSwapBuffers();
}



void create_list_lib()
{
        //Set Up Maze Using Lists
        list[1] = glGenLists(1);
```

```
         glNewList(list[1], GL_COMPILE);

          //North Wall
          glBegin(GL_QUADS);
          glColor3f(0,0,1);
          glNormal3f(0.0, 1.0, 0.0);
                    glVertex3f(1.0, 1.0, 1.0);
                    glVertex3f(1.0, 1.0, 0.0);
                    glVertex3f(0.0, 1.0, 0.0);
                    glVertex3f(0.0, 1.0, 1.0);
          glEnd();

          glEndList();

   list[2] = glGenLists(1);
   glNewList(list[2], GL_COMPILE);



     glBegin(GL_QUADS);
          //North Wall
          glColor3f(0,0,1);
          glNormal3f(0.0, 1.0, 0.0);
                    glVertex3f(1.0, 1.0, 1.0);
                    glVertex3f(1.0, 1.0, 0.0);
                    glVertex3f(0.0, 1.0, 0.0);
                    glVertex3f(0.0, 1.0, 1.0);
             //South Wall
             glColor3f(0,0,1);
             glNormal3f(0.0, -1.0, 0.0);
                    glVertex3f(1.0, 0.0, 0.0);
                    glVertex3f(1.0, 0.0, 1.0);
                    glVertex3f(0.0, 0.0, 1.0);
                    glVertex3f(0.0, 0.0, 0.0);
          glEnd();
          glEndList();

   list[3] = glGenLists(1);

   glNewList(list[3], GL_COMPILE);
          glBegin(GL_QUADS);
   //North Wall
          glColor3f(0,0,1);
          glNormal3f(0.0f, 1.0f, 0.0f);
                    glVertex3f(1.0, 1.0, 1.0);
                    glVertex3f(1.0, 1.0, 0.0);
                    glVertex3f(0.0, 1.0, 0.0);
                    glVertex3f(0.0, 1.0, 1.0);
             //East Wall
                    glColor3f(0,0,1);
                    glNormal3f(1.0, 0.0, 0.0);
                    glVertex3f(1.0, 1.0, 0.0);
                    glVertex3f(1.0, 1.0, 1.0);
                    glVertex3f(1.0, 0.0, 1.0);
                    glVertex3f(1.0, 0.0, 0.0);
          glEnd();
          glEndList();
   list[4] = glGenLists(1);

   glNewList(list[4], GL_COMPILE);
           glBegin(GL_QUADS);
           //Top Wall
           glColor3f(-1,0.3,0);
           glNormal3f(1.0, 0.0, 1.0);
              glVertex3f(1, 1, 1.0);
              glVertex3f(0, 1, 1.0);
              glVertex3f(0, 0, 1.0);
              glVertex3f(1, 0, 1.0);
           glEnd();
           glEndList();
}


void init()
{



          /*   float   color[4];
           Enable Lighting.
           glEnable(GL_LIGHT0);
           glEnable(GL_LIGHTING);

           Ambient And Diffuse Lighting
           glColorMaterial(GL_FRONT, GL_AMBIENT_AND_DIFFUSE);
           glEnable(GL_COLOR_MATERIAL);

   color[0] = 1.0f; color[1] = 1.0f; color[2] = 0.0f; color[3] = 0.0f;
           glLightfv(GL_LIGHT0, GL_DIFFUSE, color);

           color[0] = 1.0f; color[1] = 0.0f; color[2] = 1.0f; color[3] = 1.0f;
           glLightfv(GL_LIGHT0, GL_AMBIENT, color);*/


           glEnable(GL_NORMALIZE);

           glMatrixMode(GL_PROJECTION);
           glLoadIdentity();

           gluPerspective(60,1.33,0.005,100);

           glMatrixMode(GL_MODELVIEW);
           glLoadIdentity();
   gluLookAt(-1.5, 0, 40, -1.5, 0, 0, 0.0f,1.0f,0.0f);
}

void erase()
{
           glColor3f(0.1,0.0,0.0);
           glBegin(GL_POLYGON);
           glVertex2f(0,0);
           glVertex2f(0.5,0);
           glVertex2f(0.25,0.5);
           glEnd();
}
```

```
int main(int argc,char **argv)
{
   glutInit(&argc,argv);
           glutInitDisplayMode(GLUT_RGBA | GLUT_DOUBLE | GLUT_DEPTH );
           glutInitWindowSize(1200, 780);
           glutInitWindowPosition(0,0);
           glutCreateWindow("Pac GL 3D");

   init();

   glutDisplayFunc(RenderScene);

           create_list_lib();

           glutKeyboardFunc(mykey);

           glutSpecialFunc(specialDown);
           glutSpecialUpFunc(specialUp);



           glEnable(GL_DEPTH_TEST);

           int start_x[4] = {11,12,15,16};

           for (int ISO = 0; ISO < num_ghosts; ISO++)
           {
                      ghost[ISO] = new Ghost(start_x[ISO],14);
           }

           float ghost_colors[4][3] = {{255,0,0},{120,240,120},{255,200,200},{255,125,0}};
           int ISO;

           for (ISO = 0; ISO < num_ghosts; ISO++)
           {
                      ghost[ISO]->x = start_x[ISO];
                      ghost[ISO]->y = 14;
                      ghost[ISO]->eaten = false;
                      ghost[ISO]->max_speed = 0.1 - 0.01*(float)ISO;
                      ghost[ISO]->speed = ghost[ISO]->max_speed;

                      //colorize ghosts
                      for (int j = 0; j < 3; j++)
                                 ghost[ISO]->color[j] = ghost_colors[ISO][j]/255.0f;


           }

           for ( ISO = 0; ISO < BOARD_X; ISO++)
           {
                         for (int j = 0; j < BOARD_Y; j++)
                         {
                                 tp_array[ISO][j] = pebble_array[ISO][j];

                          }
           }
```

```
            pebbles_left = 244;
            glShadeModel(GL_SMOOTH);
            glutMainLoop();
            return 0;
}
```

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