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CHAPTER 1

INTRODUCTION

1.1 DEFINITION:

Computer graphics is concerned with all aspects of providing pictures or images using a computer. The field began humbly almost 50 years ago, with the display of a few lines on a cathode ray tube (CRT). The term "computer graphics" includes almost everything on computers that is not text or sound.

Pixel art is a form of digital art, created through the use of raster graphics software, where images are edited on the pixel level.

1.2 USES OF COMPUTER GRAPHICS:

Applications of computer graphics are many, however some of them are as explained below:

- **User Interfaces:**

  Word-processing, spreadsheet and desktop-publishing programs are typical applications of such user-interface techniques.

- **Interactive Plotting in Business, Science and Technology:**

  The common use of graphics is to create 2D and 3D graphs of mathematical, physical and economic functions, histograms, and bar and pie charts.

- **Computer Aided Drafting and Design (CAD):**

  In CAD, interactive graphics is used to design components and systems of mechanical, electrical and electronic devices including structures such as buildings, automobile bodies, aero planes, ship hulls etc.

- **Simulation & Animation for Scientific Visualization & Entertainment:**

  Computer-produced animated movies are becoming increasing popular for scientific and engineering visualization. Cartoon characters will increasingly be modelled in the computer as 3D shape descriptions. whose movements are controlled by computer commands.

- **2D Graphics:**

These editors are used to draw 2D pictures (line, rectangle, circle and ellipse) alter those with operations like cut, copy and paste. These may also support features like translation, rotation etc.

- **3D Graphics:**

These editors are used to draw 3D pictures (line, rectangle, circle and ellipse).

These may also support features like translation, rotation etc.

1.3 ADVANTAGES:

- **Scientific visualization**-it refer to the process of representing raw scientific data as images.
- **Information visualization** –it is the study of interactive visual.
- **Computer vision** –it is the field of study of artificial intelligence that trains computer to interpret and understand the visual world.
- **image processing**- it is analyses and manipulation of digitized image.
- **Computational geometry** –it is branch of computer science devoted to the study of algorithm which can be stated in terms of geometry.
- **Computational topology**- is is a subfield of topology with an overlap with areas of computer science.
- **Applied mathematics** –it is the application of mathematical methods by different fields such as physics, engineering, business etc.

1.4 OPENGL:

- Open Graphics Library is a standard specification defining a cross-language, crossplatform API for writing applications that produce 2D and 3D computer graphics.
- OpenGL is a low-level, procedural API, requiring the programmer to dictate the exact steps required to render a scene.
- OpenGL's basic operation is to accept primitives such as points, lines and polygons and convert them into pixels.

1.4.1 OPENGL ARCHITECTURE

The OpenGL architecture is structured as a state-based pipeline. Below is a simplified diagram of this pipeline. Commands enter the pipeline from the left.

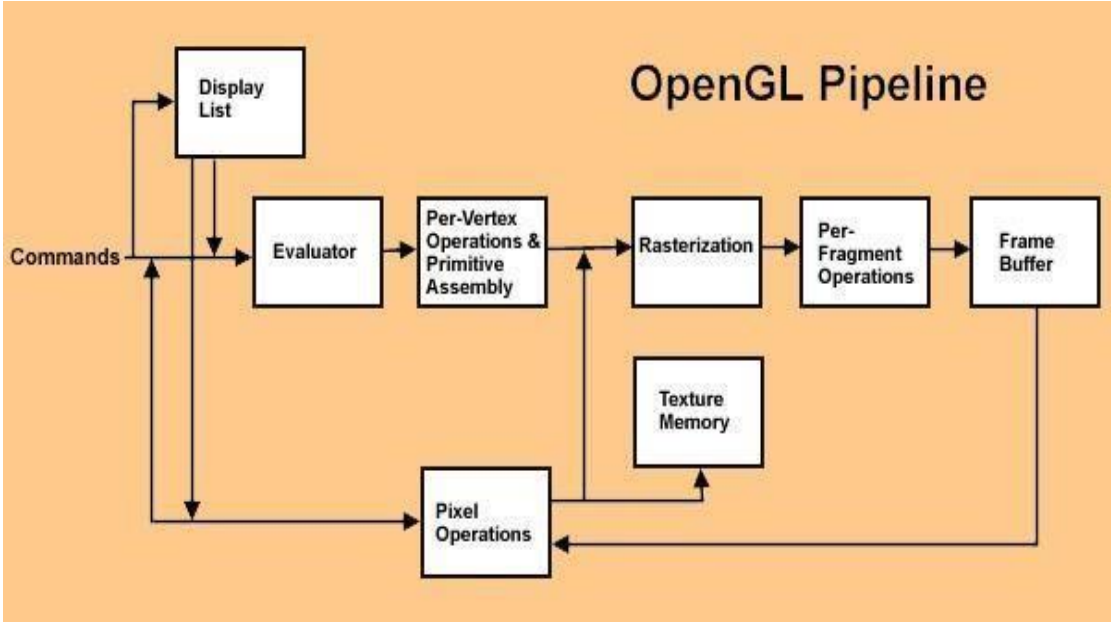

Figure 1.1: OpenGL Architecture

Commands may either be accumulated in display lists, or processed immediately through the pipeline. Display lists allow for greater optimization and command reuse, but not all commands can be put in display lists.

The first stage in the pipeline is the evaluator. This stage effectively takes any polynomial evaluator commands and evaluates them into their corresponding vertex and attribute commands.

The second stage is the per-vertex operations, including transformations, lighting, primitive assembly, clipping, projection, and viewport mapping.

The third stage is rasterization. This stage produces fragments, which are series of frame buffer addresses and values, from the viewport-mapped primitives as well as bitmaps and pixel rectangles.

The fourth stage is the per-fragment operations. Before fragments go to the frame buffer, they may be subjected to a series of conditional tests and modifications, such as blending or z-buffering.

Parts of the framebuffer may be fed back into the pipeline as pixel rectangles. Texture memory may be used in the rasterization process when texture mapping is enabled.

1.4.2 LIBRARY ORGANISATION IN OPENGL:

The following fig. shows the organization of the libraries for an X Window System environment. For this window system, GLUT will use GLX and the X libraries application program, however, can use only GLUT functions and thus can be recompiled with the GLUT library for other window systems.

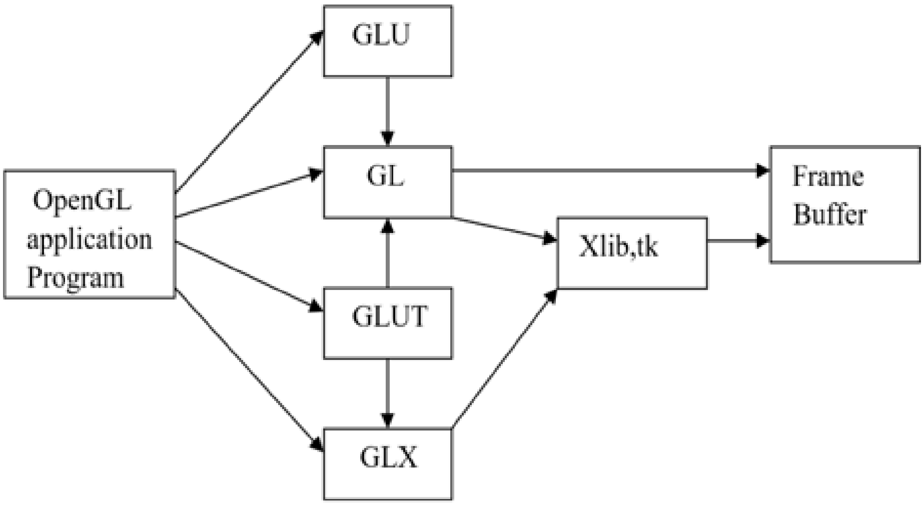

Figure 1.2: Library Organization

1.5 BASIC GRAPHICS SYSTEM:

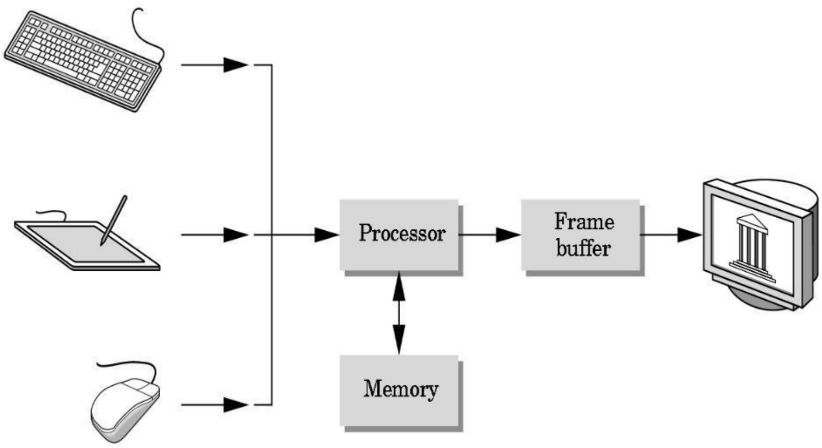

Figure 1.3: Basic Graphics System

Major elements in basic graphic system:

- **Input devices:**

Graphics workstations make use of various devices for data input. Most systems have keyboard and mouse, while some other systems have trackball, joystick, button boxes, touch panels, image scanners and voice systems.

- **Processor:**

Graphics processing unit, is used primarily for 3D applications. It is a singlechip processor that creates lighting effects and transforms objects every time a 3D scene is redrawn.

- **Memory:**

Memory refers to a design where the graphics chip does not have its own dedicated memory, and instead shares the main system RAM with the CPU and other components.

- **Frame buffer:**

A framebuffer is a portion of RAM containing a bitmap that drives a video display. It is a memory buffer containing a complete frame of data. The information in the buffer typically consists of colour values for values every pixel to be shown on the display.

- **Output devices:**

Graphics hardware output devices are that hardware that generates computer.

Graphics and allows them to be shown on a display. Some of the output devices are Monitors, Printers, Plotters, projectors, LCD Projection Panels, Speakers etc.

1.6 INTRODUCTION TO SOLAR SYSTEM

The Solar System consists of the Sun and the astronomical objects bound to it by gravity, all of which formed from the collapse of a giant molecular cloud approximately 4.6 billion years ago. Of the many objects that orbit the Sun, most of the mass is contained within eight relatively solitary planets[e] whose orbits are almost circular and lie within a nearly flat disc called the ecliptic plane. The four smaller inner planets, Mercury, Venus, Earth and Mars, also called the terrestrial planets, are primarily composed of rock and metal. The four outer planets, the gas giants, are substantially more massive than the terrestrials. The two largest, Jupiter and Saturn, are composed mainly of hydrogen and helium; the two outermost planets, Uranus and Neptune, are composed largely of ices, such as water, ammonia and methane, and are often referred to separately as "ice giants".

The Solar System is also home to two regions populated by smaller objects. The asteroid belt, which lies between Mars and Jupiter, is similar to the terrestrial planets as Six of the planets and three of the dwarf planets are orbited by natural satellites, usually termed "moons" after Earth's Moon. Each of the outer planets is encircled by planetary rings of dust and other particles.

The principal component of the Solar System is the Sun, a main sequence G2 star that contains 99.86 percent of the system's known mass and dominates it gravitationally. The Sun's four largest orbiting bodies, the gas giants, account for 99 percent of the remaining mass, with Jupiter and Saturn together comprising more than 90 percent.

Most large objects in orbit around the Sun lie near the plane of Earth's orbit, known as the ecliptic. All the planets and most other objects also orbit with the Sun's rotation (counterclockwise, as viewed from above the Sun's north pole).

The overall structure of the charted regions of the Solar System consists of the Sun, four relatively small inner planets surrounded by a belt of rocky asteroids, and four gas giants surrounded by the outer Kuiper belt of icy objects. Astronomers sometimes informally divide this structure into separate regions. The inner Solar System includes the four terrestrial planets and the main asteroid belt. The outer Solar System is beyond the asteroids, including the four gas giant planets. Since the discovery of the Kuiper belt, the outermost parts of the Solar System are considered a distinct region consisting of the objects beyond Neptune.

Kepler's laws of planetary motion describe the orbits of objects about the Sun. According to Kepler's laws, each object travels along an ellipse with the Sun at one focus. Objects closer to the Sun (with smaller semi-major axes) travel more quickly, as they are more affected by the Sun's gravity. On an elliptical orbit, a body's distance from the Sun varies over the course of its year. The orbits of the planets are nearly circular.

Due to the vast distances involved, many representations of the Solar System show orbit the same distance apart. In reality, with a few exceptions, the farther a planet or belt is from the Sun, the larger the distance between it and the previous orbit.

Most of the planets in the Solar System possess secondary systems of their own, being orbited by planetary objects called natural satellites, or moons (two of which are larger than the planet Mercury) or in the case of the four gas giants, by planetary rings; thin bands of tiny particles that orbit them in unison. Most of the largest natural satellites are in synchronous rotation, with one face permanently turned toward their parent.

The objects of the inner Solar System are composed mostly of rock, the collective name for compounds with high melting points, such as silicates, iron or nickel, that remained solid under almost all conditions in the protoplanetary nebula.

Jupiter and Saturn are composed mainly of gases, the astronomical term for materials with extremely low melting points and high vapor pressure such as molecular hydrogen, helium, and neon, which were always in the gaseous phase in the nebula.

Out of nine planetsof the Solar System, Mercury, Venus, Mars, Jupiter and Saturn can be seen easily withthe naked eye. Two planets, Uranus, Neptune are very far off and have been discovered with telescope. Mercury is the smallest planet in the solar system and it is smallest in the solar system and it is nearestto the sun. Since the planet Mercury is closes to the sun, it is very hot during the day and life is not possible on it. Mercury is a fairly bright planet which can be seen in the east just before sunrise or in the westjust after sunset the planet 'Venus' isthebrightest object in the night sky. The third planet is ourown earth.

Sun

The Sun is the Solar System's star, and by far its chief component. Its large mass (332,900 Earth masses) produces temperatures and densities in its core great enough to sustain nuclear fusion, which releases enormous amounts of energy, mostly radiated into space as electromagnetic radiation, peaking in the 400–700 nm band we call visible light. The Sun is classified as a type G2 yellow dwarf, but this name is misleading as, compared to the majority of stars in our galaxy, the Sun is rather large and bright. Stars are classified by the Hertzsprung–Russell diagram, a graph that plots the brightness of stars with their surface temperatures. Generally, hotter stars are brighter. Stars following this pattern are said to be on the main sequence, and the Sun lies right in the middle of it. However, stars brighter and hotter than the Sun are rare, while substantially dimmer and cooler stars, known as red dwarfs, are common, making up 85 percent of the stars in the galaxy.

It is believed that the Sun's position on the main sequence puts it in the "prime of life" for a star, in that it has not yet exhausted its store of hydrogen for nuclear fusion. The Sun is growing brighter; early in its history it was 70 percent as bright as it is today.

The Sun is a population I star; it was born in the later stages of the universe's evolution, and thus contains more elements heavier than hydrogen and helium ("metals" in astronomical parlance) than older population II stars. Elements heavier than hydrogen and helium were formed in the cores of ancient and exploding stars, so the first generation of stars had to die before the universe could be enriched with these atoms. The oldest stars contain few metals, while stars born later have more. This high metallicity is thought to have been crucial to the Sun's developing a planetary system, because planets form from accretion of "metals".

Mercury

Mercury (0.4 AU from the Sun) is the closest planet to the Sun and the smallest planet in the

Solar System (0.055 Earth masses). Mercury has no natural satellites, and it's only known geological features besides impact craters are lobed ridges or rupes, probably produced by a period of contraction early in its history. Mercury's almost negligible atmosphere consists of atoms blasted off its surface by the solar wind. Its relatively large iron core and thin mantle have not yet been adequately explained. Hypotheses include that its outer layers were stripped off by a giant impact, and that it was prevented from fully accreting by the young Sun's energy.

Venus

Venus (0.7 AU from the Sun) is close in size to Earth, (0.815 Earth masses) and like Earth, has a thick silicate mantle around an iron core, a substantial atmosphere and evidence of internal geological activity. However, it is much drier than Earth and its atmosphere is ninety times as dense. Venus has no natural satellites. It is the hottest planet, with surface temperatures over 400 °C, most likely due to the amount of greenhouse gases in the atmosphere. No definitive evidence of current geological activity has been detected on Venus, but it has no magnetic field that would prevent depletion of its substantial atmosphere, which suggests that its atmosphere is regularly replenished by volcanic eruptions.

Earth

Earth (1 AU from the Sun) is the largest and densest of the inner planets, the only one known to have current geological activity, and is the only place in the universe where life is known to exist. Its liquid hydrosphere is unique among the terrestrial planets, and it is also the only planet where plate tectonics has been observed. Earth's atmosphere is radically different from those of the other planets, having been altered by the presence of life to contain 21% free oxygen. It has one natural satellite, the Moon, the only large satellite of a terrestrial planet in the Solar System.

Mars

Mars (1.5 AU from the Sun) is smaller than Earth and Venus (0.107 Earth masses). It possesses an atmosphere of mostly carbon dioxide with a surface pressure of 6.1 millibars (roughly 0.6 percent that of the Earth's). Its surface, peppered with vast volcanoes such as Olympus Mons and rift valleys such as Valles Marineris, shows geological activity that may have persisted until as recently as 2 million years ago. Its red colour comes from iron oxide (rust) in its soil. Mars has two tiny natural satellites (Deimos and Phobos) thought to be captured asteroids.

Jupiter

Jupiter (5.2 AU), at 318 Earth masses, is 2.5 times the mass of all the other planets put together. It is composed largely of hydrogen and helium. Jupiter's strong internal heat creates a number of semi-permanent features in its atmosphere, such as cloud bands and the Great Red Spot. Jupiter has 63 known satellites. The four largest, Ganymede, Callisto, Io, and Europa, show similarities to the terrestrial planets, such as volcanism and internal heating.Ganymede, the largest satellite in the Solar System, is larger than Mercury.

Saturn

Saturn (9.5 AU), distinguished by its extensive ring system, has several similarities to Jupiter, such as its atmospheric composition and magnetosphere. Although Saturn has 60% of Jupiter's volume, it is less than a third as massive, at 95 Earth masses, making it the least dense planet in the Solar System. The rings of Saturn are made up of small ice and rock particles.

Saturn has 62 confirmed satellites; two of which, Titan and Enceladus, show signs of geological activity, though they are largely made of ice.Titan, the second largest moon in the Solar System, is larger than Mercury and the only satellite in the Solar System with a substantial atmosphere.

Uranus

Uranus (19.6 AU), at 14 Earth masses, is the lightest of the outer planets. Uniquely among the planets, it orbits the Sun on its side; its axial tilt is over ninety degrees to the ecliptic. It has a much colder core than the other gas giants, and radiates very little heat into space. Uranus has 27 known satellites, the largest ones being Titania, Oberon, Umbriel, Ariel and Miranda.

Neptune

Neptune (30 AU), though slightly smaller than Uranus, is more massive (equivalent to 17 Earths) and therefore more dense. It radiates more internal heat, but not as much as Jupiter or Saturn. Neptune has 13 known satellites. The largest, Triton, is geologically active, with geysers of nitrogen. Triton is the only large satellite with a retrograde orbit. Neptune is accompanied in its orbit by a number of minor planets, termed Neptune Trojans, that are in 1:1 resonance with it.

CHAPTER 2

REQUIREMENT SPECIFICATION

2.1 SOFTWARE SPECIFICATION

- **Operating System:** Windows 10
- **Cross Platform API:** Open GL
- **Programming Language:** C Language
- **Compiler:** Visual Studio

2.2 HARDWARE SPECIFICATION

- **Processor**: intel i5
- **RAM:** 8GB
- **System type:** 64-bit processor
- **Monitor:** VGA compatible (CRT OR LCD-TFT)

CHAPTER 3

PROJECT DESIGN

3.1 DESCRIPTION

The project “SOLAR SYSTEM” is meant as a source of recreation where one can sit in front of the computer and have the vision of a plant in space. This package is developed to provide opportunities to climb aboard the earth for the adventure of the lifetime. It is aimed to create starts and planets and give constant motion to these objects.

The sun and its family of eight planets are imagined to be placed in a background of bright twinkling starts along with a comet in constant motion.

The lighting effect in the background appears as though the planet is rotating and revolving around the sun in the galaxy. The most important aspect of this project is that ,one can sit back ,relax and watch constantly occurring motion of the planet and the stars just depicting the fact that “as passengers of the earth our voyage never ends!”

This chapter documents a detailed description of the implementation of our project. We have incorporated several inbuilt OpenGL functions in this project. The following code snippet enables the easy rendering of solid sphere with different colors and makes them to rotate and translate. {

```
. . . . .
glRotatef    (s..    .);
glTranslatef(.   .   .);
glRotatef(.     .     .);
glColor3f(.     .     .);
glutSolidSphere(.   .
.);
. . . . .
}
```

3.2 FLOWCHART

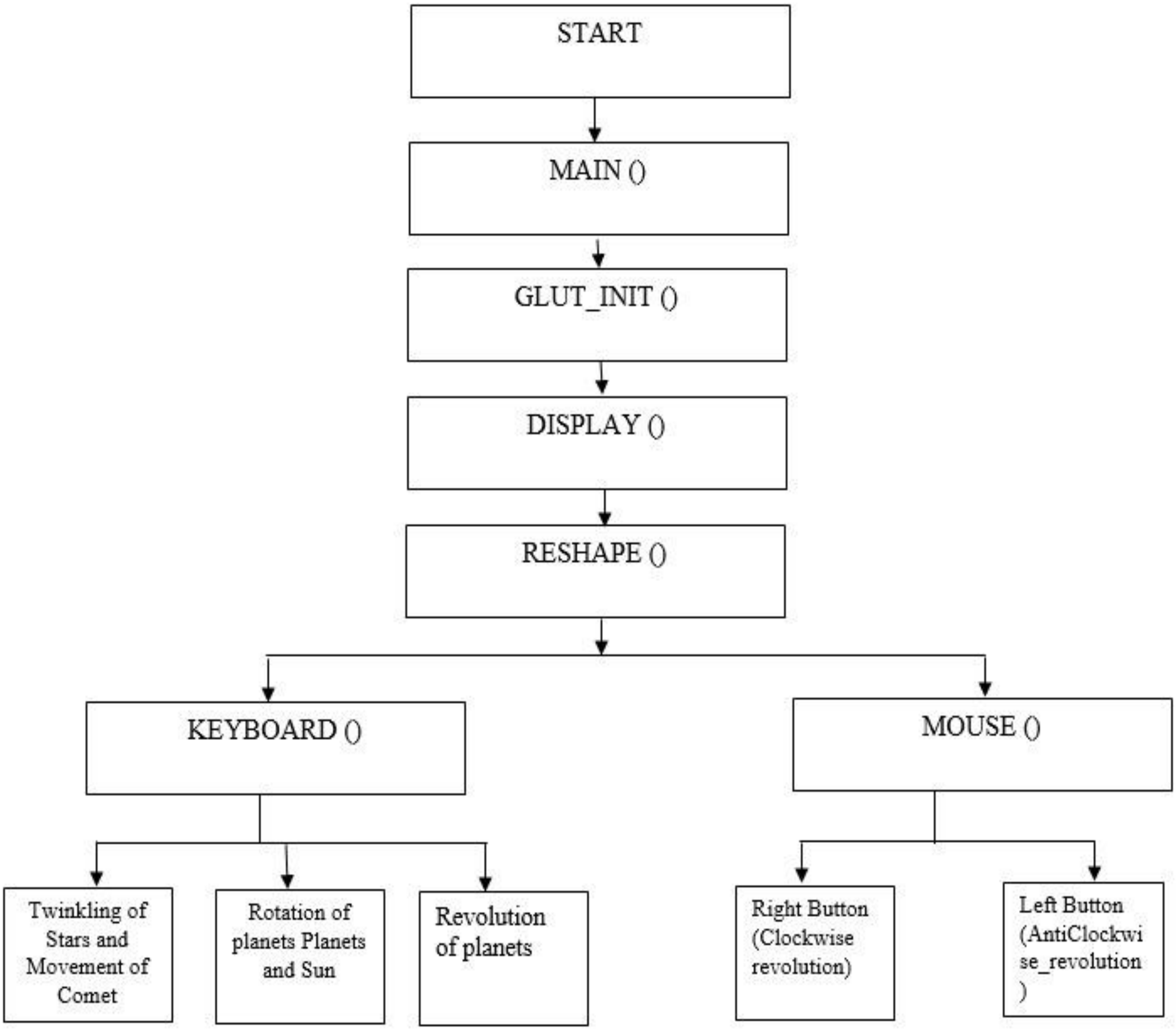

Figure 3.1 FlowChart

CHAPTER 4

FUNCTION DEFINITIONS AND THEIR SYNTAX

4.1 DEFINITION:

OpenGL (Open Graphics Library) is a cross-platform, hardware accelerated, language independent, industrial standard API for producing 3D (including 2D graphics). The OpenGl graphics rendering commands issued by the applications could be directed to the graphics hardware and accelerated.

4.2 WORKING WITH THE WINDOWS SYSTEM:

In OpenGL, an object is made up of geometric primitives such as triangle, quad, line segment and a point. A primitive is made up of two or more vertices. OpenGL supports the following primitives: A geometric primitive is defined by specifying its vertices using the glVertex () function, enclosed within a pair glBegin () and glEnd ().

4.2.1 WINDOWS MANAGER SETUP USING GLUT:

- **glutInit (&argc, argv):**

  Initializes GLUT, processes any command-line arguments for X functions.

- **glutInitDisplayMode (unsigned int mode):**

  Sets the basic display modes. Usual mode constants are GLUT_SINGLE, GLUT_DOUBLE, GLUT_RGB, GLUT_INDEX and GLUT_DEPTH.

- **glutInitWindowSize (int width, int height):**

  Sets the size of screen in pixels.

- **glutInitWindowPosition (int x, int y):**

  Sets the initial window position on the screen for upper left corner.

- **glutCreateWindow (char *title):**

  Creates a top-level window labelled with title.

- **glutDisplayFunc(void(*func) (void)):**

  Sets the callback function, provided by the program, that GLUT will call when a window must be redisplayed.

- **glutMainLoop ():**

  Starts the event loop: never return.

4.2.2 WINDOW MANAGER INPUT HANDLING FUNCTIONS:

- **glutReshapeFunc(void(*func) (int width, int height)):**

  Registers the callback function that GLUT calls on window reshape events.

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

  Registers the callback function that GLUT calls on a keyboard event. The parameter is the ASCII value of the key pressed.

- **glutMouseFunc(void(#func) (int button, int state, int x, int y)):**

  Registers the callback function that GLUT calls on a mouse event. The parameter button may be GLUT_LEFT_BUTTON, GLUT_RIGHT_BUTTON or GLUT_MIDDLE_BUTTON.

- **glutPostRedisplay(void):**

  Nudges the main loop to call display (); sometimes useful after keyboard or mouse input changes some display parameters.

- **glFlush ():**

  Flush the graphics output buffer.

4.2.3 VIEWING AND MODELLING TRANSFORMATIONS:

- **glMatrixMode (GLenum mode):**

  Sets the matrix to be works on. The values for mode are GL_MODELVIEW, GL_PROJECTION, GL_TEXTURE which make use of the modelview, projection, texture matrices respectively.

- **glLoadIdentity(void):**

  Set the current matrix to identity...

4.2.4 COLOR AND CLEARING THE SCREEN:

- **glClearColor (float red, float green, float blue, float alpha):**

  Sets the clear color to red, blue or green with value alpha.

- **glClear (GLbitfield mask):**

  Used to clear the buffer indicated by mask using clear color. The Values for mask are GL_COLOR_BUFFER_BIT and GL_DEPTH_BUFFER_BIT.
- **glColor3f (float red, float green, float blue):**

  Sets the current drawing color to red, blue or green.

4.3 INTERACTIONS:

GLUT supports interaction with the computer mouse that is triggered when one of the three typical buttons is pressed. A mouse callback function can be initiated when a given mouse button is pressed or released. The command glutMouseFunc () is used to specify the callback function to use when a specified button is in a given state at a certain location.

GLUT interaction using keyboard inputs is handled very similarly to those with the mouse. The command glutKeyboardFunc () is used to run a callback function and pass as parameters, the ASCII code of the pressed key.

4.4 TRANSFORMATIONS:

Vertex transformations (such as rotations, translations and scaling) and projections (such as perspective and orthographic) can all be represented by applying an appropriate 4 ×4 matrix to the coordinates representing the vertex. If v represents a homogeneous vertex and M is a 4 × 4transformation matrix, then M v is the image of v under the transformation by M. After transformation, all transformed vertices are clipped so that x, y, and z are within the screen co-ordinates.

Although any non-singular matrix M represents a valid projective transformation, a few special matrices are particularly useful.

4.4.1 THREE-DIMENSIONAL TRANSLATION:

A position P = (x, y, z) in three-dimensional space is translated to a location P'= (x', y', z') by adding translation distances tx, ty, and tz to the Cartesian coordinates of P:We can express these three-dimensional translation operations in matrix form

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & t_x \\ 0 & 1 & 0 & t_y \\ 0 & 0 & 1 & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

P`=T.P glTranslate (x, y, z) function is used.

Moving a coordinate position with translation vector T = (tx, ty , tz) .

4.4.2 THREE-DIMENSIONAL SCALING:

The matrix expression for the three-dimensional scaling transformation of a position

P = (x, y, z) is given by

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} s_x & 0 & 0 & 0 \\ 0 & s_y & 0 & 0 \\ 0 & 0 & s_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

The three-dimensional scaling transformation for a point position can be represented as P`=S.P where scaling parameters $s_x$, $s_y$, and $s_z$ are assigned any positive values. Explicit expressions for the scaling transformation relative to the origin are x`= x. s_x y`= y. $s_y$ z`=z. s_z glScale (x, y, z) function is used.

4.4.3 THREE-DIMENSIONAL ROTATION:

Rotation is moving of an object about an angle. Movement can be anticlockwise or clockwise.3D rotation is complex as compared to the 2D rotation. For 2D we describe the angle of rotation, but for a 3D angle of rotation and axis of rotation are required. This axis can be either x or y or z.

Matrix for representing three-dimensional rotations about the Z axis

$$x' = x\cos\theta - y\sin\theta$$
$$y' = x\sin\theta + y\cos\theta$$
$$z' = z$$

$$\begin{pmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Matrix for representing three-dimensional rotations about the X axis

$$y' = y\cos\theta - z\sin\theta$$
$$z' = y\sin\theta + z\cos\theta$$
$$x' = x$$

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Matrix for representing three-dimensional rotations about the Y axis

$$z' = z\cos\theta - x\sin\theta$$
$$x' = z\sin\theta + x\cos\theta$$
$$y' = y$$

$$\begin{pmatrix} \cos\theta & 0 & \sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

4.5 VIEWING:

Viewing in 3D involves the following considerations:

- We can view the object in any spatial positions.
- 3D description of objects must be projected onto the flat viewing surface of the output device.

- The clipping boundaries enclose a volume of space.

4.5.1 VIEWING TRANSFORMATION:

Conversion of objection descriptions from world to viewing coordinates is equivalent to a transformation that superimposes the viewing reference frame onto the world frame using the basic geometric translate-rotate operations:

- Translate the view reference point to the origin of the world-coordinate system.
- Apply rotations to align the x_v, y_v, and z_v axes (viewing coordinate system) with the world x_w, y_w, z_w axes, respectively.

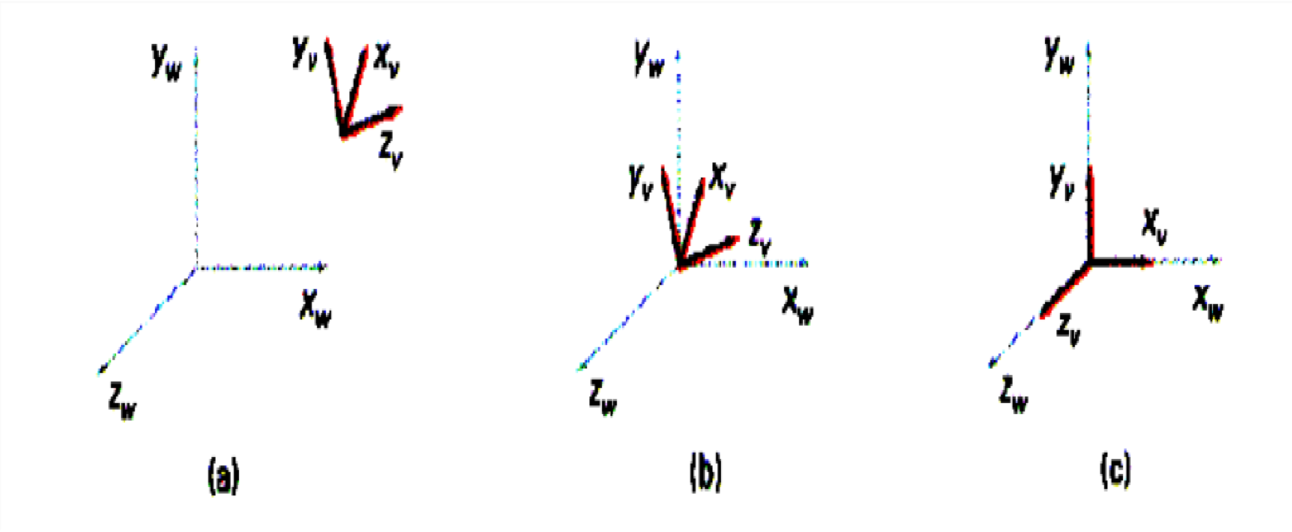

Fig 4.1: Viewing Transformation

4.5.2 User Interface:

Keyboard Based Interface

Using the keyboard user can make the planets to rotate on their own axis and revolve round the Sun. The stars are made to twinkle and the Comet is made to revolve round the Sun.

1. The keys **m, v, e, r, j, s, u, n** are used to rotate the planets.

2. The keys **M, V, E, R, J, S, U, N** are used to revolve the planets around the Sun.

3. The key **z** rotates the sun, **B** gives both the rotation and revolution of the planets around the rotating Sun with a Comet revolution and Star's twinkle.

4. Pressing the key **A** revolves all the planets and comet and the key **a** rotates all the planets around the rotating Sun with Stars twinkling in the background.
5. The key **b** is used to make the stars twinkle and **c** for the revolution of the Comet.

Mouse Interface

Using the mouse user can make the planets to rotate and revolve round the Sun and Comet to revolve round the Sun.

Left Button: Rotates and revolves the planets and Comet in anticlockwise direction.

Middle Button: Rotates and revolves the planets and Comet in clockwise direction.

Right Button: Rotates and revolves the planets and Comet in clockwise direction.

CHAPTER 5

IMPLEMENTATION

The implementation of the different objects in this project is divided into different module.

MODULE 1:

SUN:

The sun is drawn by using the following lines of code.

```
{glPushMatrix ();
 glRotatef (…);
 glLightfv (GL_LIGHT0
,GL_POSITION,position); glDisable
(GL_LIGHTING); glutSolidSphere(…);
glPopMatrix();
}
```

MODULE 2:

PLANETS WITH RINGS:

The planets Saturn and Uranus are the 2 planets in our solar system with rings. They are implemented using the following codes.

```
{glPushMatrix ();
glRotatef (…);
 glTranslatef (…);
gluLookAt
(0.0,10.0,2.0,1.0,0.0,0.0,0.0,0.0,1.0);
glutSolidSphere (…); int i=0;
glBegin   (GL_QUAD_STRIP);   for   (i=0;
i<=360; i++)
{
glVertex3f(sin(i*3.1416/180)*0.5,cos(i*3.1416/180)*0.5,0);
glVertex3f(sin(i*3.1416/180)*0.7,cos(i*3.1416/180)*0.7,0); }
 glEnd ();
glPopMatrix (); }
```

MODULE 3:

EARTH:

The earth is drawn along with its natural satellite, moon which revolve round the earth. The following lines of codes are used to implement the earth and the moon.

```
{glPushMatrix ();
glRotatef (…);
 glTranslatef (…);
 glRotatef (…);
glColor3f (…);
glutSolidSphere (…); /*draw planet
earth*/ glRotatef (…);
 glTranslatef (…);
glColor3f (…);
glutSolidSphere     (…);      /*draw
moon*/
 glPopMatrix ();
}
```

MODULE 4:

OTHER PLANETS:

The remaining planets are Mercury, Venus, Mars, Jupiter and Neptune. All these planets are implemented using the same set of codes by changing the values and colors.

```
{glPushMatrix ();
 glRotatef (...);
glTranslatef (...);
 glRotatef (...);
glColor3f (...);
glutSolidSphere(...);/*draw smaller planetmercury*/
 glPopMatrix();
}
```

MODULE 5:

STARS:

The stars are implemented in the background using the following lines of codes.

```
{glPushMatrix ();
 glTranslatef (…);
gluLookAt
(0.0,10.0,0.0,1.0,0.0,0.0,0.0,0.0,3.0);
glRotatef (…);
glScalef (…);
glColor3f (…);
glutSolidSphere (…);
glPopMatrix ();
}
```

MODULE 6:

COMET:

The comet is made to revolve round the sun. The following codes are used to implement the comet.

```
{glPushMatrix ();
glRotatef((GLfloat)c,6.0, -14.0, -6.0);
glTranslatef (5.0, 3.0, -1.0);
glScalef (0.60, 0.0, 2.5);
glColor3f (7.5, 9.5, 2.0);
glutSolidSphere (0.2, 12,6); /*draw comet*/
glPopMatrix ();
}
```

CHAPTER 6

SNAPSHOTS

6.1 SOLAR SYSTEM WITH REVOLUTION

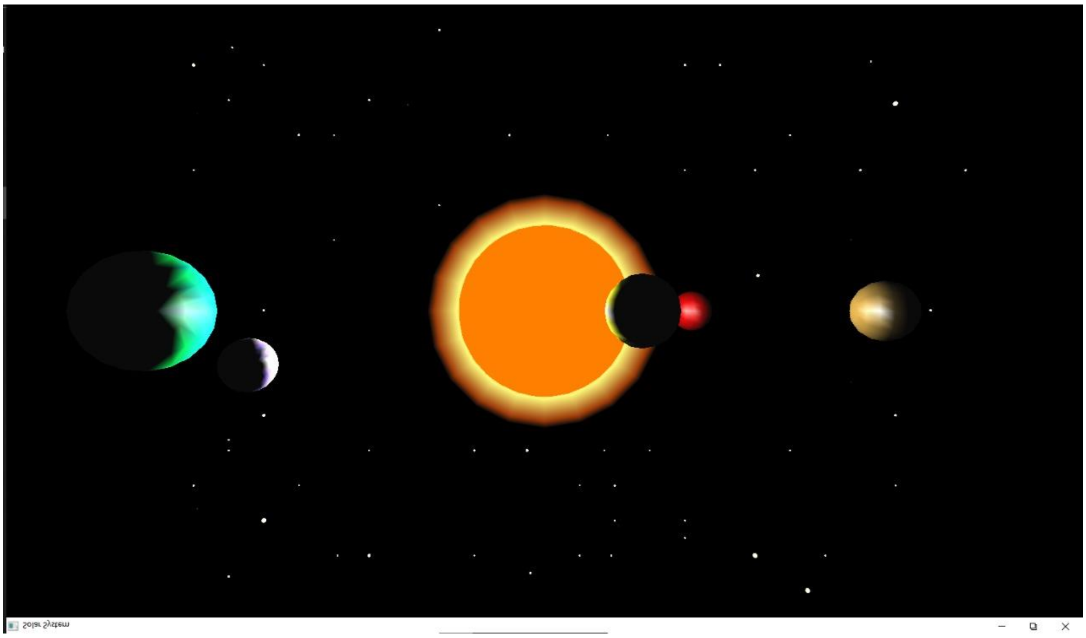

Fig 6.1: Solar System with revolution of planets

6.2 ROTATION OF SUN

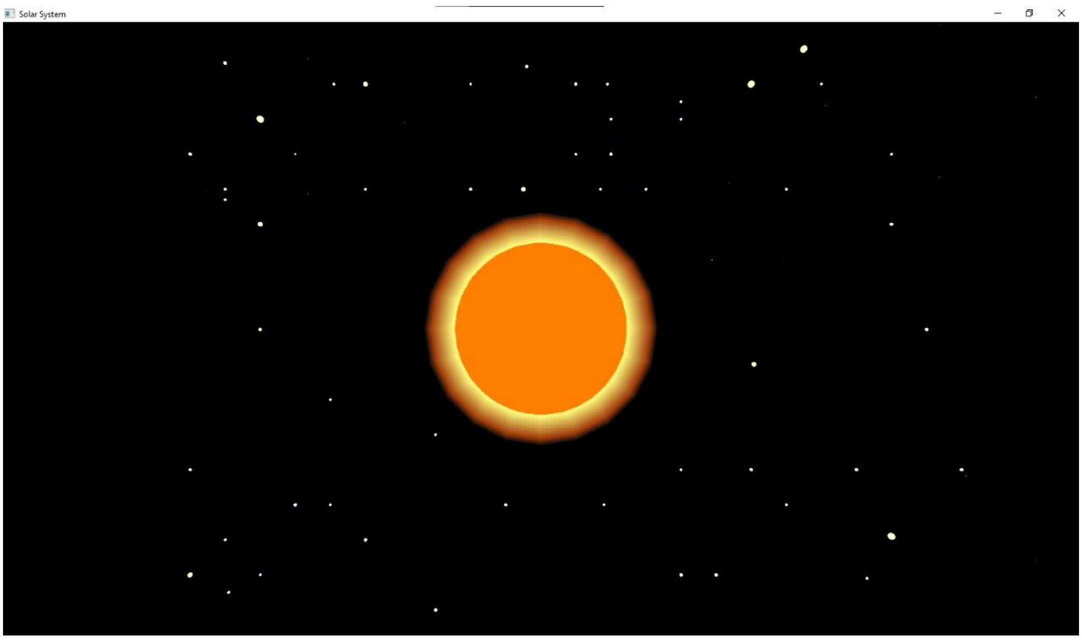

Fig 6.2: Rotation of Sun

6.3 SOLAR SYSTEM WITH REVOLUTION OF MERCURY

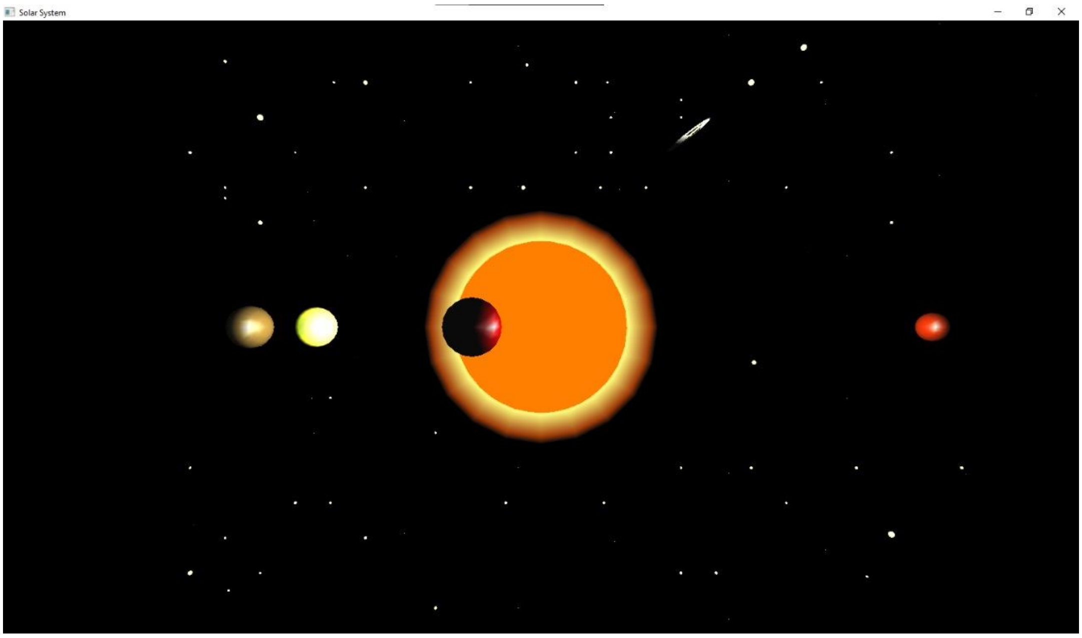

Fig 6.3 Solar System with revolution of mercury

6.4 SUN, TWINKLING STARS AND COMET

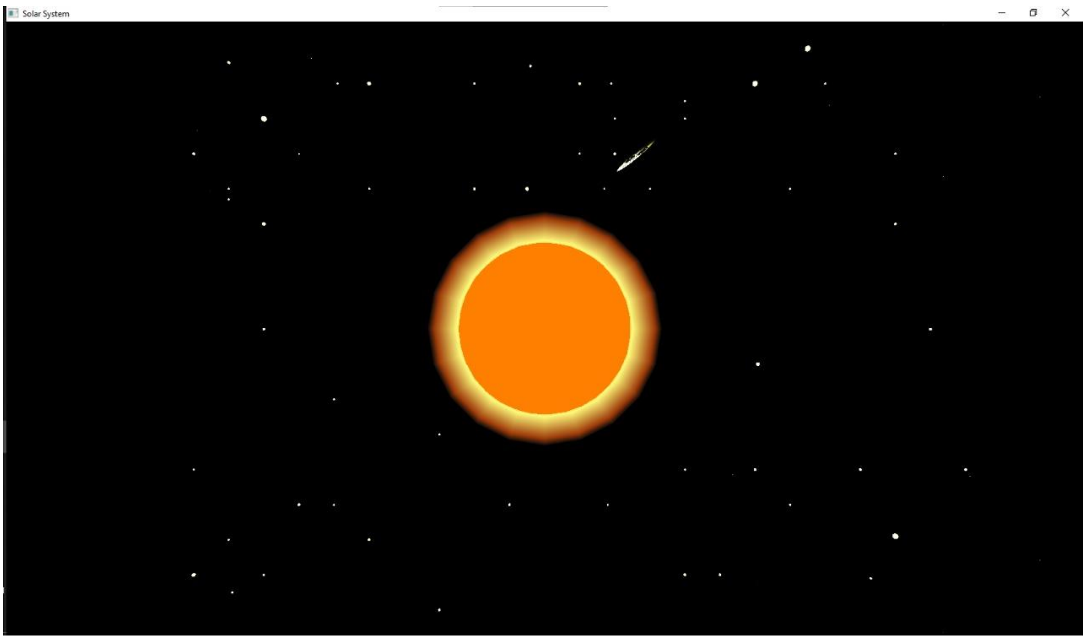

Fig 6.4 Sun, twinkling stars and comet

6.5 ROTATION OF EARTH AND MOON

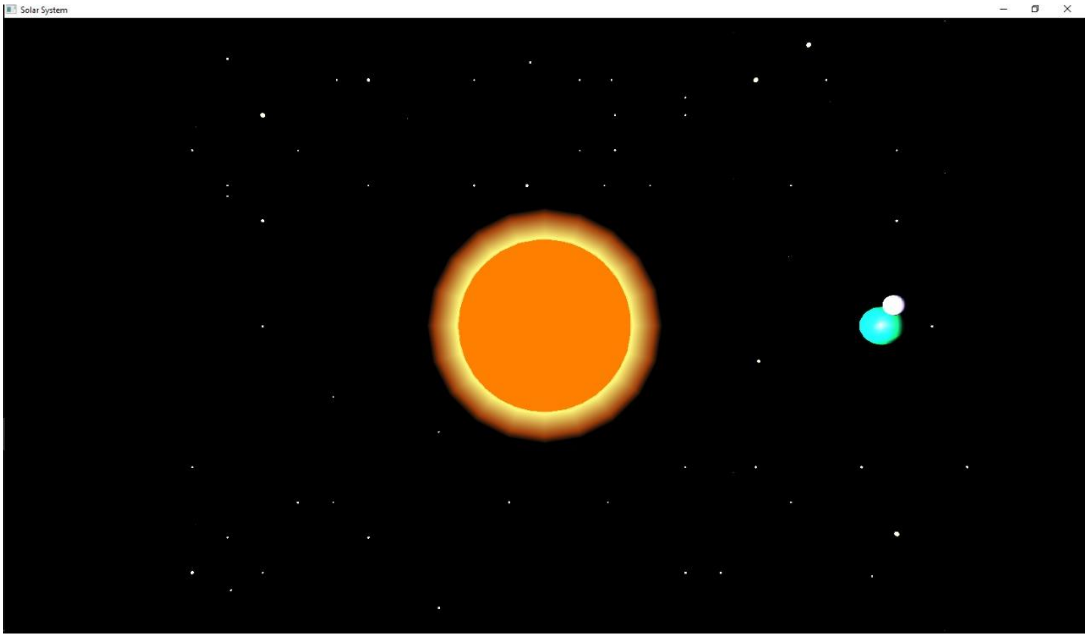

Fig 6.5 Rotation of earth and moon

6.6 FINAL VIEW

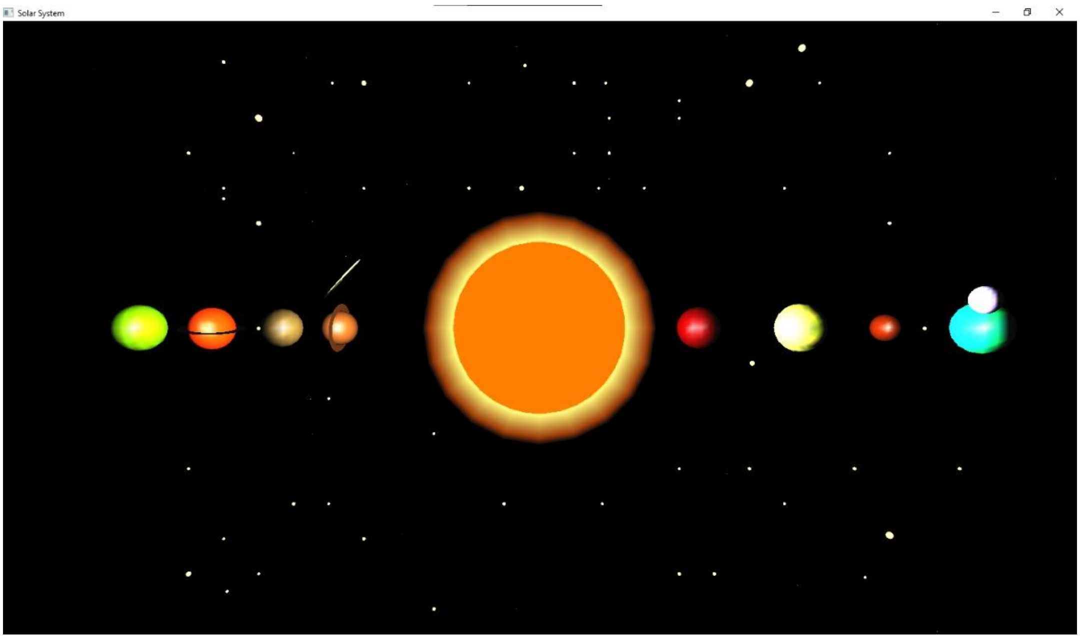

Fig 6.6 Final view of Solar System

CHAPTER 7

CONCLUSION

The development of this project would improve the user's knowledge about computer graphics and OpenGL. In this project the planets, sun, comet and starts act as per the users's command. This project will serve as a delight to the eyes of the night sky watchers. This project provides good understanding of OpenGL prominent function like Translation, Rotation, Scaling keeping the factors of usability in mind we have develop the project to provide ease of use. This project will allow user to interact with it through the use of devices like keyboard or mouse.

CHAPTER 8

FUTURE ENHANCEMENT

A more sophisticated interface for editing the universe could be provided. It might allow the user to edit the position of planets by dragging them around the widow. Other scene-related values could be written out when the simulation state is saved. The visual aids could benefit from text labels beside the planets. A feature to calculate the necessary velocity of the planet can be added.

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