Table of Contents

List of Figures

ABSTRACT

3D Animated Robot is a robot which is designed using OpenGL package in C++ programming language graphically. It's different part of the Robot looks realistic with a great precision design. It uses animation by pressing the LEFT/RIGHT button of your mouse. This mini project illustrates the basic functions of Robot. A robot simulator is a simulator used to create application for a physical robot without depending on the actual machine, thus saving cost and time. In some case, these applications can be transferred onto the physical robot (or rebuilt) without modifications. The term robot simulator can refer to several different robotics simulation applications. The application uses integrates the concepts of computer graphics, OpenGL API, C/C++ Programming to provide the simulation of maximum robotic movements.

ACKNOWLEDGEMENT

The success and final outcome of this project required a lot of guidance and assistance from many people and I am extremely privileged to have got this all along the completion of my project.

I would like to thank **Shri. Narayan Rao R Maanay**, Secretary, BNMEI, Bengaluru for providing the excellent environment and infrastructure in the college.

I would like to sincerely thank **Prof. T J Rama Murthy**, Director, BNMIT, Bengaluru for having extended his constant support and encouragement during the course of this project.

I would like to sincerely thank **Dr. S Y Kulkarni** ,Additional Director, BNMIT, Bengaluru for having extended his constant support and encouragement during the course of this project.

I would like to express my gratitude to **Prof. Eishwar N Maanay**, Dean, BNMIT, Bengaluru for his relentless support and encouragement.

I would like to thank **Dr. Krishnamurthy G N**, Principal, BNMIT, Bengaluru for his constant encouragement.

I would like to thank, **Dr. Chayadevi M L**, Professor & Head of the Department of Computer Science and Engineering for the encouragement and motivation she provides.

I would also like to thank **Mrs. Akshitha Katkeri,** Assistant Professor, Department of Computer Science and Engineering for providing me with her valuable insight and guidance wherever required throughout the course of the project and its successful completion.

PRAKSHI SINGH

1BG19CS072

Chapter 1

INTRODUCTION

1.1 Overview

Interactive computer graphics provides us with the most natural means of communicating information through a computer. Over the years advancements in computer graphics have enabled us to not only make pictures of real-world objects but also visualize abstract, synthetic objects such as mathematical surfaces and of data that have no inherent geometry, such as survey results. Some topics in computer graphics include user interface design, sprite graphics, vector graphics, 3D modeling, shaders, GPU design, implicit surface visualization with ray tracing, and computer vision, among others. The overall methodology depends heavily on the underlying sciences of geometry, optics, and physics. The computer on receiving signals from the input device can modify the displayed picture appropriately. To the user it appears that the picture is changing instantaneously in response to his commands. He can give a series of commands, each one generating a graphical response from the computer. In this way he maintains a conversation, or dialogue, with the computer.

1.2 Problem Statement

The aim of this application is to show a basic implementation of Flappy Bird game. The application will be implemented using the C programming language and the OpenGL API. The objective of the application is to demonstrate the game. The application will include user interaction through keyboard events; for the movement of the bird across the pillars.

1.3 Motivation

On a basic structural level, Flappy Bird is a case study in skill acquisition theory and a very interesting one at that. Specifically, it is well known from decades of research that acquiring almost any skill including learning to use devices like the seemingly simple interactive game Flappy Bird adheres generally to the Power Law of Practice.

1.4 Computer Graphics

Computer graphics and multimedia technologies are becoming widely used in educational applications because they facilitate non-linear, self-learning environments that particularly suited to abstract concepts and technical information.

Computer graphics are pictures and films created using computers. Usually, the term refers to computer-generated image data created with help from specialized graphical hardware and software. It is a vast and recent area in computer science. The phrase was coined in 1960, by computer graphics researchers Verne Hudson and William Fetter of Boeing. It is often abbreviated as CG, though sometimes erroneously referred to as CGI. Important topics in computer graphics include user interface design, sprite graphics, vector graphics, 3D modeling, shaders, GPU design, implicit surface visualization with ray tracing, and computer vision, among others.

The overall methodology depends heavily on the underlying sciences of geometry, optics, and physics. Computer graphics is responsible for displaying art and image data effectively and meaningfully to the user. It is also used for processing image data received from the physical world. Computer graphic development has had a significant impact on many types of media and has revolutionized animation, movies, advertising, video games, and graphic design generally.

1.5 OpenGL API

Open Graphics Library (OpenGL) is a cross-language, cross-platform application programming interface (API) for rendering 2D and 3D vector graphics. The API is typically used to interact with a graphics processing unit (GPU), to achieve hardware-accelerated rendering. Silicon Graphics Inc., (SGI) began developing OpenGL in 1991 and released it on June 30, 1992; applications use it extensively in the fields of computer-aided design (CAD), virtual reality, scientific visualization, information visualization, flight simulation, and video games. Since 2006 OpenGL has been managed by the non-profit technology consortium Khronos Group.

The OpenGL specification describes an abstract API for drawing 2D and 3D graphics. Although it is possible for the API to be implemented entirely in software, it is designed to be implemented mostly or entirely in hardware. The API is defined as a set of functions which may be called by the client program, alongside a set of named

integer constants. In addition to being language-independent, OpenGL is also cross-platform.

Given that creating an OpenGL context is quite a complex process, and given that it varies between operating systems, automatic OpenGL context creation has become a common feature of several game-development and user-interface libraries, including SDL, Allegro, SFML, FLTK, and Qt. A few libraries have been designed solely to produce an OpenGL-capable window. The first such library was OpenGL Utility Toolkit (GLUT), later superseded by freeglut. GLFW is a newer alternative.

1.5.1 OpenGL API 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 frame buffer. Colour 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.

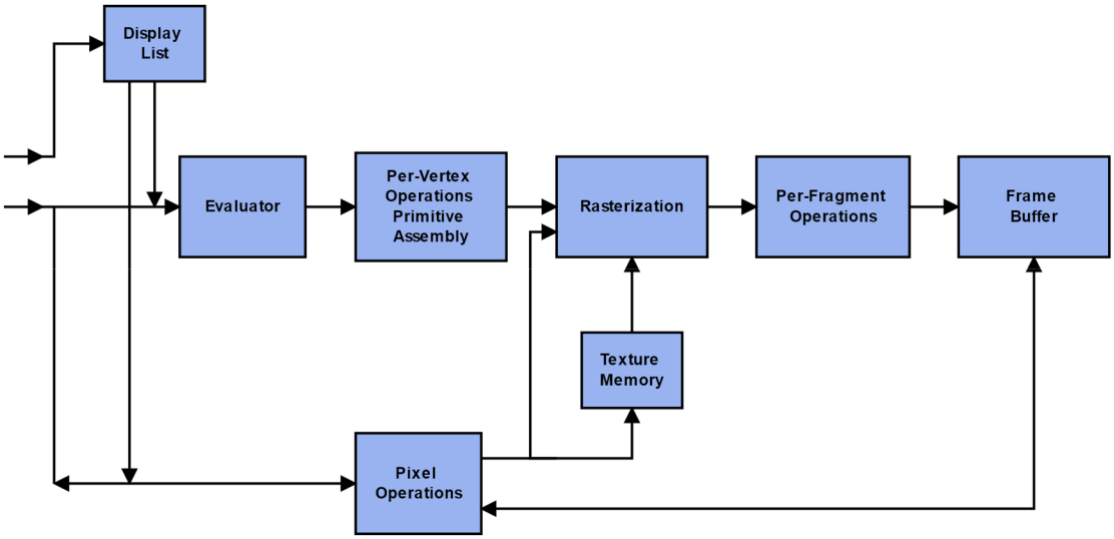

Fig 1.1 An illustration of the graphics pipeline process in OpenGL Architecture

1.6 Applications of Computer Graphics

Although many applications span two, three, or even all of these areas, the development of the field was based, for the most part, on separate work in each domain.

We can classify applications of computer graphics into four main areas:

1.6.1 Display of Information

Graphics has always been associated with the display of information. Examples of the use of orthographic projections to display floorplans of buildings can be found on 4000-year-old Babylonian stone tablets. Mechanical methods for creating perspective drawings were developed during the Renaissance. Countless engineering

students have become familiar with interpreting data plotted on log paper. More recently, software packages that allow interactive design of charts incorporating colour, multiple data sets, and alternate plotting methods have become the norm. In fields such as architecture and mechanical design, hand drafting is being replaced by computer-based drafting systems using plotters and workstations. Medical imaging uses computer graphics in a number of exciting ways.

1.6.2 Design

Professions such as engineering and architecture are concerned with design. Although their applications vary, most designers face similar difficulties and use similar methodologies. One of the principal characteristics of most design problems is the lack of a unique solution. Hence, the designer will examine a potential design and then will modify it, possibly many times, in an attempt to achieve a better solution. Computer graphics has become an indispensable element in this iterative process.

1.6.3 Simulation

Some of the most impressive and familiar uses of computer graphics can be classified as simulations. Video games demonstrate both the visual appeal of computer graphics and our ability to generate complex imagery in real time. Computer-generated images are also the heart of flight simulators, which have become the standard method for training pilots.

1.6.4 User Interfaces

The interface between the human and the computer has been radically altered by the use of computer graphics. Consider the electronic office. The figures in this book were produced through just such an interface. A secretary sits at a workstation, rather than at a desk equipped with a typewriter. This user has a pointing device, such as a mouse, that allows him to communicate with the workstation.

Chapter 2

LITERATURE SURVEY

2.1 History of Computer Graphics

The term "computer graphics" was coined in 1960 by William Fetter, a designer at Boeing, to describe his own job, the field can be said to have first arrived with the publication in 1963 of Ivan Sutherland's Sketchpad program, as part of his Ph.D. thesis at MIT. Sketchpad, as its name suggests, was a drawing program. Beyond the interactive drawing of primitives such as lines and circles and their manipulation – in particular, copying, moving and constraining – with use of the then recently invented light pen, Sketchpad had the first fully-functional graphical user interface (GUI) and the first algorithms for geometric operations such as clip and zoom. Interesting, as well, is that Sketchpad's innovation of an object-instance model to store data for geometric primitives foretold object-oriented programming. Coincidentally, on the hardware side, the year 1963 saw the invention by Douglas Engelbart at the Stanford Research Institute of the mouse, the humble device even today carrying so much of GUI on its thin shoulders.

Subsequent advances through the sixties came thick and fast: raster algorithms, the implementation of parametric surfaces, hidden-surface algorithms and the representation of points by homogeneous coordinates, the latter crucially presaging the foundational role of projective geometry in 3D graphics, to name a few. Flight simulators were the killer app of the day and companies such as General Electric and Evans & Sutherland, 6 co-founded by Douglas Evans and Ivan Sutherland, wrote simulators with real-time graphics.

The seventies, brought the Z-buffer for hidden surface removal, texture mapping, Phong's lighting model – all crucial components of the OpenGL API (Application Programming Interface) we'll be using soon – as well as keyframe-based animation. Photorealistic rendering of animated movie keyframes almost invariably deploys ray tracers, which were born in the seventies too.

Through the nineties, as well, the use of 3D effects in movies became pervasive. The Terminator and Star Wars series, and Jurassic Park, were among the early movies to set the standard for CGI. Toy Story from Pixar, 8 released in 1995, has special

importance in the history of 3D CGI as the first movie to be entirely computer-generated – no scene was ever pondered through a glass lens, nor any recorded on a photographic reel! It was cinema without film. Quake, released in 1996, the first of the hugely popular Quake series of games, was the first fully 3D game.

Another landmark from the nineties of particular relevance to us was the release in 1992 of OpenGL, the open-standard cross-platform and cross language 3D graphics API, by Silicon Graphics. OpenGL is actually a library of calls to perform 3D tasks, which can be accessed from programs written in various languages and running over various operating systems. That OpenGL was high-level (in that it frees the applications programmer from having to care about such low-level tasks as representing primitives like lines and triangles in the raster, or rendering them to the window) and easy to use (much more so than its predecessor 3D graphics API, PHIGS, standing for Programmer's Hierarchical Interactive Graphics System) first brought 3D graphics programming to the "masses". What till then had been the realm of a specialist was now open to a casual programmer following a fairly amicable learning curve.

Since its release OpenGL has been rapidly adopted throughout academia and industry. It's only among game developers that Microsoft's proprietary 3D API, Direct3D, which came soon after OpenGL bearing an odd similarity to it but optimized for Windows, is more popular.

The story of the past decade has been one of steady progress, rather than spectacular innovations in CG. Hardware continues to get faster, better, smaller and cheaper, continually pushing erstwhile high-end software down market, and raising the bar for new products. The almost complete displacement of CRT monitors by LCD and the emergence of high-definition television are familiar consequences of recent hardware evolution.

2.2 Related Work

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

Most of engineering and Architecture students are concerned with Design. CAD is used to design various structures such as Computers, Aircrafts, Building, in almost all kinds of Industries. Its use in designing electronic systems is known as electronic design automation (EDA). In mechanical design it is known as mechanical design

automation (MDA) or computer-aided drafting (CAD), which includes the process of creating a technical drawing with the use of computer software.

- **Computer Simulation**

Computer simulation is the reproduction of the behaviour of a system using a computer to simulate the outcomes of a mathematical model associated with said system. Since they allow to check the reliability of chosen mathematical models, computer simulations have become a useful tool for the mathematical modeling of many natural systems in physics (computational physics), astrophysics, climatology, chemistry, biology and manufacturing, human systems in economics, psychology, social science, health care and engineering. Simulation of a system is represented as the running of the system's model. It can be used to explore and gain new insights into new technology and to estimate the performance of systems too complex for analytical solutions.

- **Digital Art**

Digital art is an artistic work or practice that uses digital technology as part of the creative or presentation process. Since the 1970s, various names have been used to describe the process, including computer art and multimedia art. Digital art is itself placed under the larger umbrella term new media art. With the rise of social media and the internet, digital art application of computer graphics. After some initial resistance, the impact of digital technology has transformed activities such as painting, drawing, sculpture and music/sound art, while new forms, such as net art, digital installation art, and virtual reality, have become recognized artistic practices. More generally the term digital artist is used to describe an artist who makes use of digital technologies in the production of art. In an expanded sense, "digital art" is contemporary art that uses the methods of mass production or digital media.

- **Virtual Reality**

Virtual reality (VR) is an experience taking place within a computer-generated reality of immersive environments can be similar to or completely different from the real world. Applications of virtual reality can include entertainment (i.e., gaming) and educational purposes (i.e., medical or military training). Other, distinct types of VR style technology include augmented reality and mixed reality. Currently standard virtual

reality systems use either virtual reality headsets or multi-projected environments to generate realistic images, sounds and other sensations that simulate a user's physical presence in a virtual environment. A person using virtual reality equipment is able to look around the artificial world, move around in it, and interact with virtual features or items. The effect is commonly created by VR headsets consisting of a head-mounted display with a small screen in front of the eyes, but can also be created through specially designed rooms with multiple large screens. Virtual reality typically incorporates auditory and video feedback, but may also allow other types of sensory and force feedback through haptic technology.

- **Video Games**

A video game is an electronic game that involves interaction with a user interface to generate visual feedback on a two- or three-dimensional video display device such as a TV screen, virtual reality headset or computer monitor. Since the 1980s, video games have become an increasingly important part of the entertainment industry, and whether they are also a form of art is a matter of dispute. The electronic systems used to play video games are called platforms. Video games are developed and released for one or several platforms and may not be available on others. Specialized platforms such as arcade games, which present the game in a large, typically coin-operated chassis, were common in the 1980s in video arcades, but declined in popularity as other, more affordable platforms became available. These include dedicated devices such as video game consoles, as well as general-purpose computers like a laptop, desktop or handheld computing devices.

Chapter 3

SYSTEM REQUIREMENTS

3.1 Software Requirements

Software requirements deal with defining software resource requirements and prerequisites that need to be installed on a computer to provide optimal functioning of an application.

The following are the software requirements for the application :

- Operating System: Windows 10
- Compiler: GNU C/C++ Compiler
- Development Environment: Visual Studio 2019 Community Edition
- API: OpenGL API & Win32 API for User Interface and Interaction

3.2 Hardware Requirements

The most common set of requirements defined by any operating system or software application is the physical computer resources, also known as hardware.

- CPU: Intel or AMD processor
- Cores: Dual-Core (Quad-Core recommended)
- RAM: minimum 4GB (>4GB recommended)
- Graphics: Intel Integrated Graphics or AMD Equivalent
- Secondary Storage: 250GB
- Display Resolution: 1366x768 (1920x1080 recommended)

Chapter 4

SYSTEM DESIGN

4.1 Proposed System

The Basic proposed system is to show how to visualize dynamical processes in 3D environment on the example of nonlinear mathematical equation and mobile robot with differential chassis. Using openGL, by the solution of the model's differential equations, which describe its movement properties, it is possible to obtain data for visualization. The article presents the necessary steps to create an own C# Forms application that is based on OpenGL for visualization of dynamical system.

- We need to draw a robot which uses the polygons like square, rectangles, pentagons, triangle.
- Different Part of animated robot should look realistic with a great precision design.
- To animate robot, we need some function to be assigned via keyword actions or mouse clicks.
- Add rotation and translation effect for the motion in animated robot.

For setting the material:

SetMaterial(mat_specular2, mat_ambient2, mat_diffuse2, mat_shininess2)

Groups of GL commands that have been stored for subsequent execution the compilation mode, will be:

glNewList(SOLID_MECH_HIP, GL_COMPILE)

These two are the main GL functions which is the main functions responsible for the movement of robot and the 3D display of robot:

GL_COMPILE or GL_COMPILE_AND_EXECUTE.

These functions are there to move all the parts of the body these functions used 360 movement of body parts of robot:

```
heel2 = (heel2 - 3) % 360;
ankle1 = (ankle1 - 3) % 360;
elbow1 = (elbow1 + 2) % 360;
```

4.2 Data Flow Diagram

A data-flow diagram (DFD) is a way of representing a flow of a data of a process or a system (usually an information system). The DFD also provides information about the outputs and inputs of each entity and the process itself. A data-flow diagram has no control flow, there are no decision rules and no loops. For each data flow, at least one of the endpoints (source and / or destination) must exist in a process. The refined representation of a process can be done in another data-flow diagram, which subdivides this process into sub-processes. The data-flow diagram is part of the structured-analysis modelling tools. When using UML, the activity diagram typically takes over the role of the data-flow diagram. A special form of data-flow plan is a site-oriented data-flow plan.

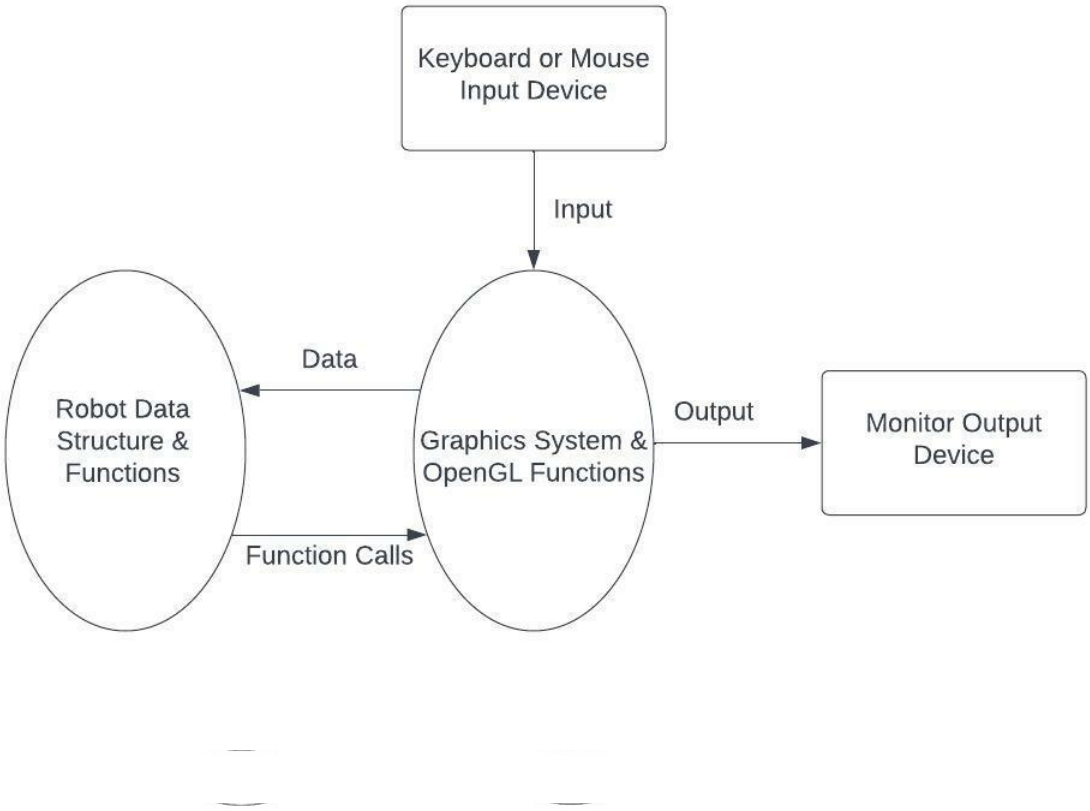

Figure 4.1 Level 0 Dataflow Diagram of the Proposed System

Figure 4.1 shows the Level 0 Dataflow diagram of the proposed application for a Robot. The keyboard and mouse devices are used for input to the application.
The graphics system processes these user keyboard/mouse interactions using built in OpenGL functions like glutKeyboardFunc(void *).

4.2 Flowchart

A flowchart is a visual representation of the sequence of steps and decisions needed to perform a process. Each step in the sequence is noted within a diagram shape. Steps are linked by connecting lines and directional arrows.

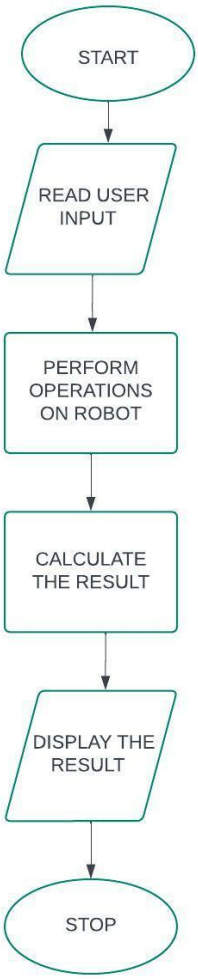

Figure 4.2 Flowchart of the Proposed System

Chapter 5

IMPLEMENTATION

5.1 Module Description

- **void init(void)**

This function is used to initializes color and shade models of the project using glClearColor and glShadeModel.

- **void display(void)**

This function is used to display the nest, bird, home target, obstacles using the translate, scale ,rotate ,push and pop matrix functions. We also use the glSolidCube() function.

- **void reshape(int w, int h)**

This function reshapes the screen using the gluPerspective function..

- **void Menu(int value)**

There are different menu available on the front page all these menus are there inside this menu function**.**

- **void Keyboard(unsigned char key, int x ,int y)**

This function defines the controls of the keyboard with various keys for the movement of arms legs tilt of head and the different views of this robot .

5.2 High Level Code

5.2.1 Built-In Functions

- **void glClear(glEnum mode);**

Clears the buffers namely color buffer and depth buffer. mode refers to GL_COLOR_BUFFER_BIT or DEPTH_BUFFER_BIT.

- **void glTranslate[fd](TYPE x, TYPE y, TYPE z);**

Alters the current matrix by displacement of (x, y, z), TYPE is either GLfloat or GLdouble.

- **void glutSwapBuffers();**

  Swaps the front and back buffers.

- **void glMatrixMode(GLenum mode);**

  Specifies which matrix will be affected by subsequent transformations, Mode can be GL_MODELVIEW or GL_PROJECTION.

- **void glLoadIdentity( );**

  Sets the current transformation matrix to identity matrix.

- **void glutInit(int *argc, char **argv);**

  Initializes GLUT; the arguments from main are passed in and can be used by the application.

- **void glutInitDisplayMode(unsigned int mode);**

  Requests a display with the properties in the mode; the value of mode is determined by the logical OR of options including the color model (GLUT_RGB, GLUT_INDEX) and buffering (GLUT_SINGLE, GLUT_DOUBLE).

- **void glutMainLoop();**

  Causes the program to enter an event-processing loop.

- **void glutCreateWindow(char *title);**

  Creates a window on display; the string title can be used to label the window. The return value provides a reference to the window that can be used when there are multiple windows.

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

  Registers the display function func that is executed when the window needs to be redrawn.

- **void glutKeyboardFunc(void *f(char key, int width, int height))**

  Registers the keyboard callback function . The callback function returns the ASCII code of the key pressed and the position of the mouse.

- **void glClearColor(GLclampf r, GLclampf g, GLclamp b, Glclamp a)**

  Sets the present RGBA clear color used when clearing the color buffer. Variables of type GLclampf are floating point numbers between 0.0 and 1.0.

- **void glViewport(int x ,int y, GLsizei width, GLsizei height)**

Specifies the width*height viewport in pixels whose lower left corner is at (x,y) measured from the origin of the window.

- **void glColor3[b I f d ub us ui](TYPE r, TYPE g, TYPE b)**

Sets the present RGB colors. Valid types are bytes(b), int(i), float(f), double(d), unsigned byte(ub), unsigned short(us), and unsigned int(ui). The maximum and minimum value for floating point types are 1.0 and 0.0 respectively, whereas the maximum and minimum values of the discrete types are those of the type, for eg, 255 and 0 for unsigned bytes.

- **void glutInitWindowSize(int width, int height);**

Specifies the initial height and width of the window in pixels.

- **void glutInitWindowPosition(int width,int height);**

Specifies the position of the window.

- **void glutReshapeFunc(void *f(int width, int height));**

Registers the reshape callback function f. the callback function returns the height and width of the new window. The reshape callback invokes the display callback.

5.2.2 User Implementation

- **Reshape Function**

```
void myReshape(int w, int h)
{
   glViewport(0, 0, w, h);
   glMatrixMode(GL_PROJECTION);
   glLoadIdentity();
   gluPerspective(65.0, (GLfloat)w / (GLfloat)h, 1.0, 20.0);
   glMatrixMode(GL_MODELVIEW);
   glLoadIdentity();
   glTranslatef(0.0, 1.2, -5.5);  /* viewing transform  */
}
```

glutReshapeFunc sets the reshape callback for the current window. The reshape callback is triggered when a window is reshaped.

- **Display Function**

```
        void display(void)
{
   glClearColor(0.0, 0.0, 0.0, 0.0);
   //glClearColor(1.0, 1.0, 1.0, 1.0);
   glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
   glEnable(GL_DEPTH_TEST);
   glPushMatrix();
   glRotatef((GLfloat)turn, 0.0, 1.0, 0.0);
   glRotatef((GLfloat)turn1, 1.0, 0.0, 0.0);
#ifdef LIGHT
   if (solid_part) {
      glPushMatrix();
      lighting();
      glPopMatrix();
   }
   else
      disable();
#endif
#ifdef DRAW_MECH
   glPushMatrix();
   glTranslatef(0.0, elevation, 0.0);
   DrawMech();
   glPopMatrix();
#endif
#ifdef DRAW_ENVIRO
   glPushMatrix();
   if (distance >= 20.136)
              distance = 0.0;
            glTranslatef(0.0, -5.0, -distance);
            glCallList(SOLID_ENVIRO);
            glTranslatef(0.0, 0.0, 10.0);
```

```
        glCallList(SOLID_ENVIRO);
          glPopMatrix();
        #endif
          glPopMatrix();

          glLoadName(TEXTID);
          glColor3f(1, 1, 0);
          DrawTextXY(-2.5, 0.2, 2.0, 0.0015, "1BG19CS072");
          DrawTextXY(-2.5, 0.5, 2.0, 0.0015, "PRAKSHI SINGH");
          DrawTextXY(2.5, 2.2, -2.0, 0.0015, "1BG19CS072");
          DrawTextXY(2.5, 2.7, -2.0, 0.0015, "PRAKSHI SINGH");
          glFlush();
          glutSwapBuffers();

        }
```

This function is also called display call back function, it defines how to window will be visible. As well as what type of light should be there and structure of the background scene.

- **Keyboard Input**

```
void keyboard(unsigned char key, int x, int y)
{

  int i = 0;
  if (key == 27) exit(0);
  switch (key) {
    /* start arm control functions */
  case 'q': {
    shoulder2Subtract();
    i++;
    i++;
  }
      break;
  case 'a': {
    shoulder2Add();
    i++;
  }
      break;
  case 'w': {
    shoulder1Subtract();
    i++;
  }break;
case 's': {
      shoulder1Add();
      i++;
  }
      break;
  case '2': {
    shoulder3Add();
```

```
        case 'j': {
              RaiseLeg1Forward();
              i++;
           }
                 break;
           case 'u': {
              LowerLeg1Backwards();
              i++;
           }
                 break;
           case 'U': {
              RaiseLeg1Outwards();
              i++;
           }
                 break;
           case 'J': {
              LowerLeg1Inwards();
              i++;
           }
                 break;
           case 'N': {
              Heel2Add();
              i++;
           }
                 break;
           case 'n': {
              Heel2Subtract();
              i++;
           }
                 break;
           case 'M': {
              Heel1Add();
              i++;
           }
                 break;
           case 'm': {
              Heel1Subtract();
              i++;
           }
                 break;
        case 'k': {
              Ankle2Add();
              i++;
           }
                 break;
           case 'K': {
              Ankle2Subtract();
              i++;
           }
                 break;
```

```
case 'l': {
        Ankle1Add();
        i++;
    }
        break;
    case 'L': {
        Ankle1Subtract();
        i++;
    }
        break;
        /* end of leg control functions */

        /* start of light source position functions */
    case 'p': {
        LightTurnRight();
        i++;
    }
        break;
    case 'i': {
        LightTurnLeft();
        i++;
    }
        break;
    case 'o': {
        LightForwards();
        i++;
    }
        break;
    case '9': {
        LightBackwards();
        i++;
    }
        break;

        /* end of light source position functions */
    }
    if (i)
        glutPostRedisplay();
}
```

This function provides various operations that can be done with the scene as well as the robot. Some of the example include, moving it's arms, legs and also changing the environment lighting.

- **Menu Function**

```
void glutMenu(void)
{

   int glut_menu[13];

   glut_menu[5] = glutCreateMenu(null_select);
   glutAddMenuEntry("forward       : q,w", 0);
   glutAddMenuEntry("backwards     : a,s", 0);
   glutAddMenuEntry("outwards      : z,x", 0);
   glutAddMenuEntry("inwards       : Z,X", 0);

   glut_menu[6] = glutCreateMenu(null_select);
   glutAddMenuEntry("upwards       : Q,W", 0);
   glutAddMenuEntry("downwards     : A,S", 0);
   glutAddMenuEntry("outwards      : 1,2", 0);
   glutAddMenuEntry("inwards       : 3,4", 0);

   glut_menu[1] = glutCreateMenu(null_select);
   glutAddMenuEntry(" : Insert", 0);

   glut_menu[8] = glutCreateMenu(null_select);
   glutAddMenuEntry("forward       : y,u", 0);
   glutAddMenuEntry("backwards     : h.j", 0);
   glutAddMenuEntry("outwards      : Y,U", 0);
   glutAddMenuEntry("inwards       : H,J", 0);

   glut_menu[9] = glutCreateMenu(null_select);
   glutAddMenuEntry("forward       : n,m", 0);
   glutAddMenuEntry("backwards     : N,M", 0);


   glut_menu[10] = glutCreateMenu(null_select);
   glutAddMenuEntry("toes up       : K,L", 0);
   glutAddMenuEntry("toes down     : k,l", 0);

   glut_menu[11] = glutCreateMenu(null_select);
   glutAddMenuEntry("right         : right arrow", 0);
   glutAddMenuEntry("left          : left arrow", 0);
   glutAddMenuEntry("down          : up arrow", 0);
   glutAddMenuEntry("up            : down arrow", 0);

   glut_menu[12] = glutCreateMenu(null_select);
   glutAddMenuEntry("right         : p", 0);
   glutAddMenuEntry("left          : i", 0);
   glutAddMenuEntry("up            : 9", 0);
   glutAddMenuEntry("down          : o", 0);
```

```
    glut_menu[4] = glutCreateMenu(NULL);
    glutAddSubMenu("at the shoulders? ", glut_menu[5]);
    glutAddSubMenu("at the elbows?", glut_menu[6]);

    glut_menu[7] = glutCreateMenu(NULL);
    glutAddSubMenu("at the bottompart? ", glut_menu[8]);
    glutAddSubMenu("at the knees?", glut_menu[9]);
    glutAddSubMenu("at the ankles? ", glut_menu[10]);

    glut_menu[2] = glutCreateMenu(null_select);
    glutAddMenuEntry("turn left    : d", 0);
    glutAddMenuEntry("turn right    : g", 0);
    glutAddMenuEntry("Rocketpod    : v", 0);

    glut_menu[3] = glutCreateMenu(null_select);
    glutAddMenuEntry("tilt backwards : f", 0);
    glutAddMenuEntry("tilt forwards  : r", 0);

    glut_menu[0] = glutCreateMenu(NULL);
    glutAddSubMenu("move the arms.. ", glut_menu[4]);
    glutAddSubMenu("fire the vulcan guns?", glut_menu[1]);
    glutAddSubMenu("move the legs.. ", glut_menu[7]);
    glutAddSubMenu("move the torso?", glut_menu[2]);
    glutAddSubMenu("move the upper portion?", glut_menu[3]);
    glutAddSubMenu("rotate the scene..", glut_menu[11]);
#ifdef MOVE_LIGHT
    glutAddSubMenu("rotate the light source..", glut_menu[12]);
#endif

    glutCreateMenu(menu_select);
#ifdef ANIMATION
    glutAddMenuEntry("Start Walk", 1);
    glutAddMenuEntry("Stop Walk", 2);
#endif
    glutAddSubMenu("How do I ..", glut_menu[0]);
    glutAddMenuEntry("Quit", 3);
    glutAttachMenu(GLUT_LEFT_BUTTON);
    glutAttachMenu(GLUT_RIGHT_BUTTON);
}
```

This function is to define various menus, here many menus are created and linked to each other. This is used to define various operations like which part of the robot we want to simulate.

- **Main function**

```
int main(int argc, char** argv)
{
#ifdef GLUT
   /* start of glut windowing and control functions */
   glutInit(&argc, argv);
   glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGBA | GLUT_DEPTH);
   glutInitWindowSize(1000, 1000);
   glutCreateWindow("glutmech: Vulcan Gunner");
   myinit();
   glutDisplayFunc(display);
   glutReshapeFunc(myReshape);
#ifdef GLUT_KEY
   glutKeyboardFunc(keyboard);
#endif
#ifdef GLUT_SPEC
   glutSpecialFunc(special);
#endif
   glutMenu();
   glPointSize(2.0);
   glutMainLoop();
   /* end of glut windowing and control functions */
#endif
   return 0;          /* ANSI C requires main to return int. */
}
```

This function is the main function, which is responsible for initialising glut with the operating system. And all call back functions are saved or registered here with the main function.

Chapter 6

RESULTS

- **Start Page**

The starting page of the application on clicking mouse button , menu will be open then we can choose to start walk as well as stop the walk, and there are different other options which we can choose according to our needs to simulate different movements of the robot.

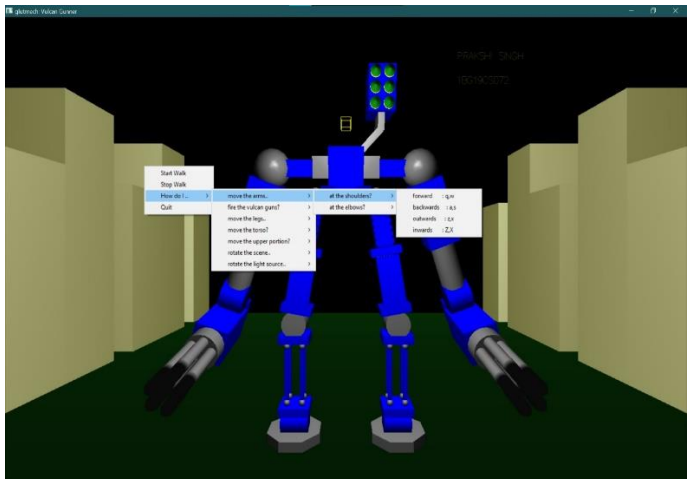

Figure 6.1 Start Page of the Application

- **Gun Fire**

It is one of the option that is available in the menu, on selecting this option, the robot reloads the guns in front of it and that depicts it's shooting or firing of guns.

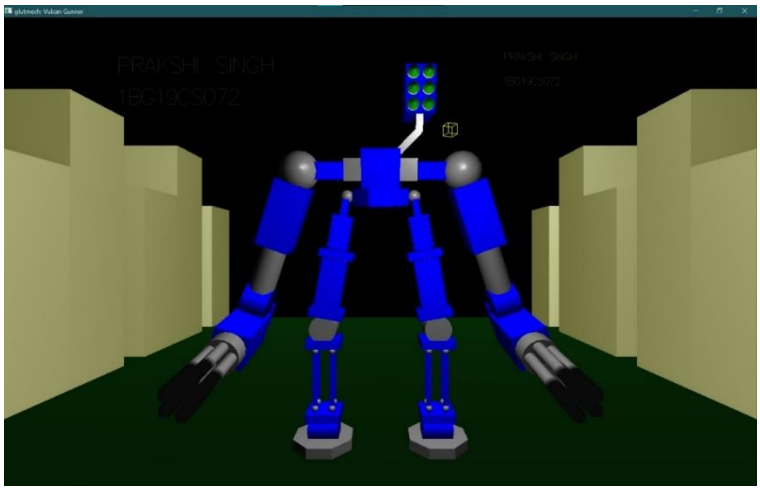

Figure 6.2 GUN Fire

- **Move Hand Forward**

  We can move the arm of the robot via two ways, either via its elbow or via shoulder, by referring the drop down menu available. In below picture, robot's arm from elbow is moved.

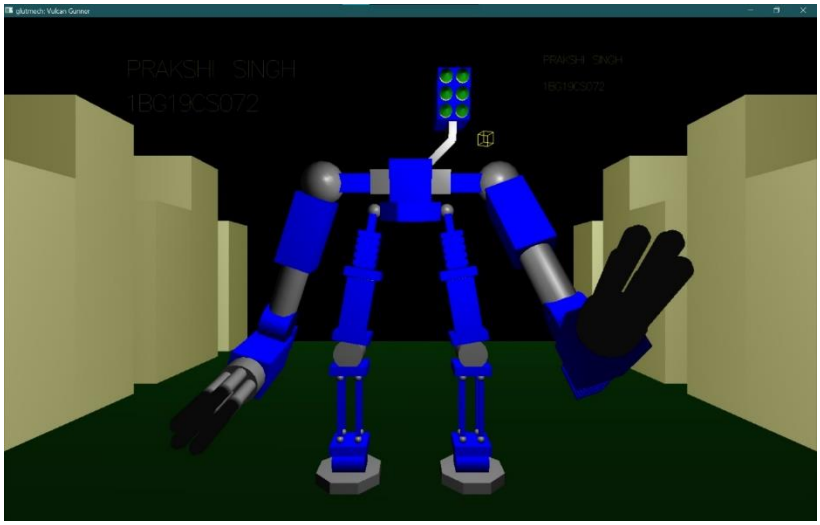

Figure 6.3 Move Arm from elbow forward

- **Move leg Forward**

  We can move the leg of the robot via three ways, either via its bottompart or via knees or via ankles, by referring the drop down menu available. In below picture, robot's leg is moved via its knees.

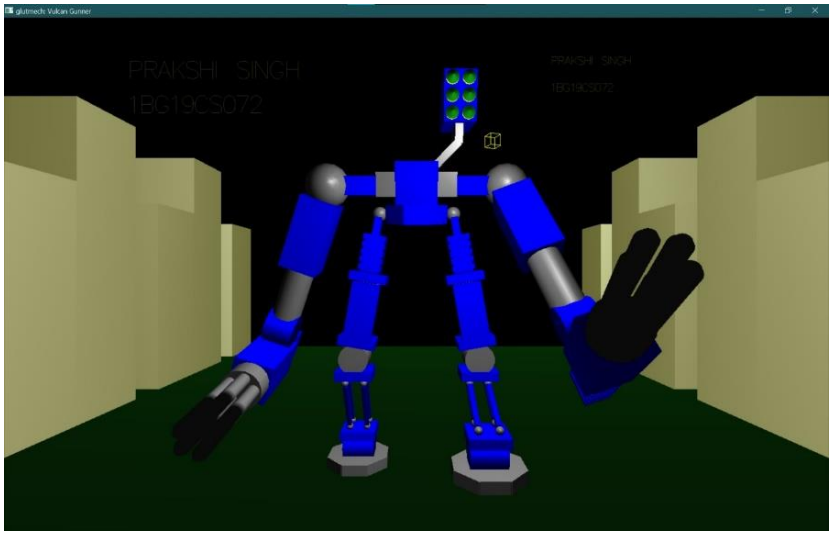

Figure 6.4 Move leg forward

- **Rotating the scene**

When the robot is simulated for the first time, it is visible from one view, we can change the viewing of the scene by using arrow keys i.e., left, right, top and bottom.

In below picture the scene is moved towards the left.

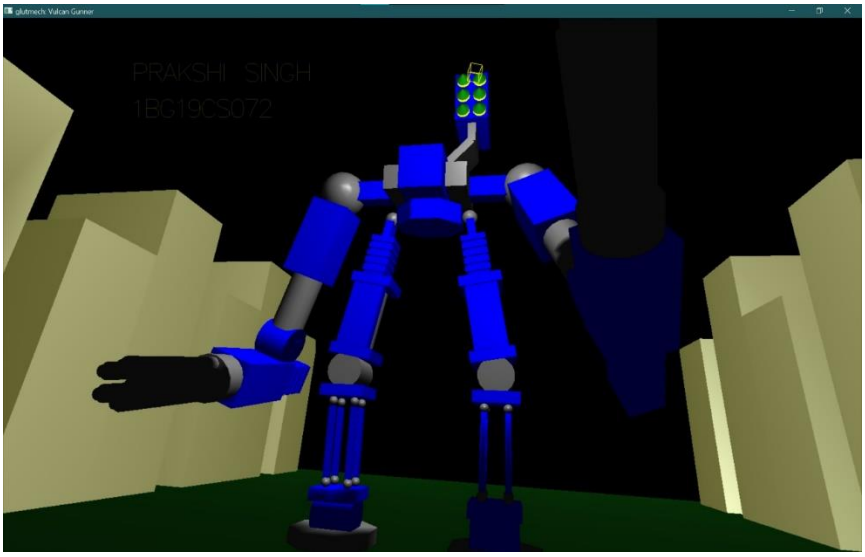

Figure 6.5 Rotate Scene

- **Changing the light position**

We can change the way in which light is visible, by changing the position of the light source. The option that can be used for this is available in the drop-down menu for convenience.

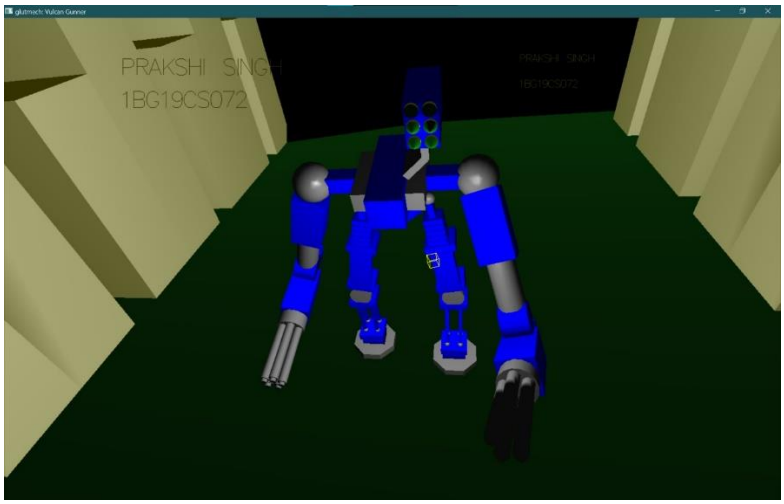

Figure 6.6 Top view by changing light position

- **Starting the walk**

The simulated robot can be made to walk, the walk of the robot can be started by selecting one of the options from the drop-down menu. Each part of the robot changes when the robot starts walking. The walk of the robot can be made to stop, by selecting the option from the drop-down menu.

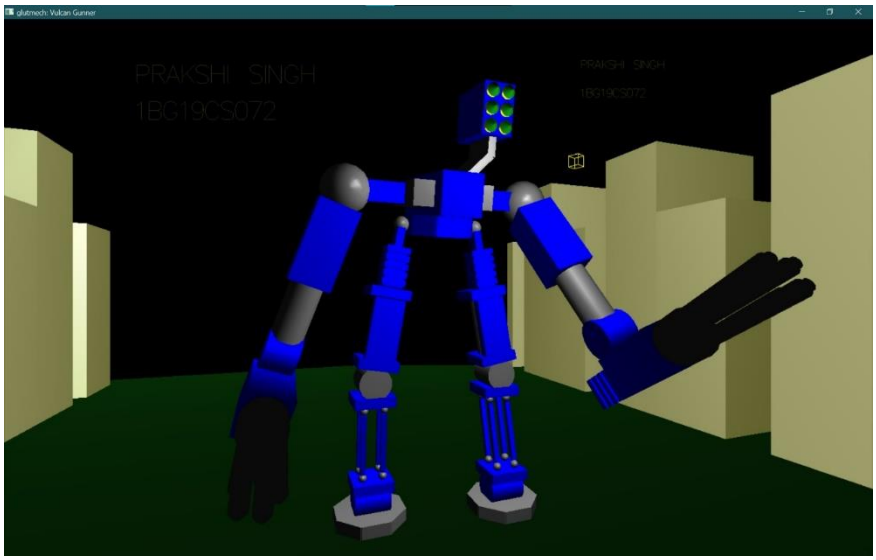

Figure 6.7 Start walking

Chapter 7

CONCLUSION AND FUTURE ENHANCEMENTS

The project Robot Simulation was planned, developed and demonstrated as expected. Robot Simulation was designed using OpenGl and C functions. It is a user friendly interface and a single User mode where we keep the track of robot when it will walk when stop when to fire gun when to move and hoe to move hand and legs.

As a future enhancement we can create a robot gun rotation effect robot can jump run according to user want there can be various robot where there can be fight between the robots as it is tilting it can tilt more fly in air and action sequence can be portraited in the scene .

BIBLIOGRAPHY

[1] Edward Angel: Interactive Computer Graphics: A Top-Down Approach 5th Edition, Addison – Wesley, 2008

[2] Donald Hearn and Pauline Baker: OpenGL, 3rd Edition, Pearson Education, 2004

[3] Wikipedia: Flappy Bird - https://en.wikipedia.org/wiki/Flappy bird

[4] Wikipedia: Computer Graphics – https://en.wikipedia.org/wiki/ComputerGraphics