Windmill Simulation

CS352: Computer Graphics & Visualization Lab

Project Report

Course Instructor:

Dr. Somnath Dey

Submitted By:

Harsh Wardhan Dohaiya– 200001026

Mayank Tayal – 200001043

Rahul Raut – 200001064

Introduction

The simulation of various phenomena is a critical aspect of computer graphics, as it allows us to create visually compelling and immersive environments , also it facilitates the study of various parameters which allows in creating an optimal design of such structures . In this project, we focused on simulating Windmills and demonstrating the complete wind-energy system.

In this project, we have created a virtual windmill farm that showcases the simulation of a real-world windmill. Our goal was to create a realistic and interactive windmill simulation that mimics the behavior of a real-world windmill. To achieve this, we utilized various computer graphics techniques, including modeling, lighting, animation, and physics simulation.

In our windmill project, we have paid attention to even the smallest details to make it as realistic as possible. From the blades of the windmill to the surrounding landscape, we have created an immersive experience for the user. We have also included interactive elements such as user controls for the windmill's rotation, enabling users to experience the windmill in action.

Along with the windmill we tried to showcase the whole system involved in generation and transmission of wind energy . This includes the windmills , transformers, customers using the wind energy and the wires connecting them. We represented the flow of energy in real time in the sense that the house glows whenever the blades of the windmill rotates. Although not realistic, this demonstration gives the viewer an idea of how wind energy is generated and consumed.

We have also kept in mind the landscape where the windmills are actually found. They are generally found in plains near the foothills of mountains as the windflow near mountains help to generate electricity efficiently. We also tried to give an aesthetic view to make our simulation look beautiful.

Our project can find applications for high school students and teachers to understand the basic working of a windmill. Childrens can learn about windmills in an interactive and playful way using this model. After a bit of add-ons this may serve as a simulation app for physics scholars to determine the effect of various parameters and structures of windmills on the amount of electricity generated. This will help in optimizing the energy output of wind farms.

Specifications

Libraries used:

<GL/glut.h> , <GL/gl.h> : The GL Utility Toolkit (GLUT) is a library that provides a platform-independent API for creating graphical user interfaces (GUIs) in OpenGL. It provides a simple and easy-to-use interface for handling input, window management, and other tasks necessary for creating graphical applications.

"SOIL.h" : Simple OpenGL Image Library (SOIL) is a small and easy-to-use library that provides functions for loading, saving, and manipulating image files in OpenGL applications. SOIL supports a variety of image formats, including BMP, GIF, JPEG, PNG, and TGA, and provides functions for loading these formats into OpenGL textures.

Other basic C++ libraries were also used like #include <bits/stdc++.h>, #include <stdio.h>

How to run the Project:

1)Download the Zip file and extract it in a folder. This must include some cpp files and a settings icon image.

2)Install SOIL library using command :

```
$ sudo apt-get install libsoil-dev
```

3) After the installation is complete we are ready to run our program, use the following commands:

```
$ g++ Product.cpp -o product -lGL -lGLU -lglut -lSOIL
```

```
$ ./product
```

4) You will see a window where the project will be displayed. Use various keys to view the details.

Key Controls:

x : Anticlockwise rotation about X- axis

X: Clockwise rotation about X- axis

y : Anticlockwise rotation about Y- axis

Y: Clockwise rotation about Y- axis

z : Anticlockwise rotation about X- axis

Z: Clockwise rotation about X- axis

< : Zoom in

> : Zoom out

B: Turn on Manual Mode

r: Blades diverge

R: Blades converge

A: Increase the rotation speed of blades

a: Decrease the rotation speed of blades

C: Rotation of Head of Windmill from left to right

c: Rotation of Head of Windmill from right to left

l: To view from next viewing angle

j:To view from previous viewing angle

In Manual mode:

-> Move mouse from left to right to rotate windmill in anticlockwise direction

-> Move mouse from right to left to rotate windmill in clockwise direction

Note:

Your extracted project folder must include the following files:

- Background.cpp
- Figure.cpp
- House.cpp
- Product.cpp
- Settings.cpp
- Transformer.cpp
- Settings.jpeg
- SOIL.h

Functionalities Implemented :

Our project mainly dwells around the windmill, and we have tried to provide many functionalities on it. Apart from that we have made an effort to explain the transmission and consumption of wind energy superficially.

Firstly in regard to the rotation of the windmill the user is offered with two choices. If they just want to see the simulation of rotation, we give the option of Auto Mode. In this mode wind speed is randomly selected and the blades rotate at speed determined by the winds. There is no input from the user and user interaction is nil. Still here a user can increase and decrease the wind speed using key A and a respectively.

The other mode is a manual mode. This is interactive mode where the user can check the effect of wind speed and direction on the rotation of the windmill using the movement of the mouse cursor. This can be viewed as the user is simulating the wind speed and direction using the mouse cursor.

Below is an object-wise description of functionalities followed by description of overall project functionality.

Windmill Functionalities:

- **Auto Mode**: While in this mode, the blades of the Windmill move due to wind, the user doesn't have to give any signal or control.
- **Change in Speed**: Vary the speed of windmill blades Rotation in Auto Mode, thus varying the amount of electricity generated, which is reflected in the brightness of the bulb glowing in the house (only for pictorial purposes).
- **Manual Mode**: When you switch to the manual mode, you can simulate the flow of wind through moving the mouse cursor on the screen. When you move the cursor from left to right, the blades of the windmill rotate clockwise, while when you move the cursor from right to left the blades rotate anti clockwise. The speed of blades depends on speed and displacement of your cursor.
- **Rotate the head of Windmills**: You can also rotate the head of the windmill. In the real world this functionality is provided so that you can align your blades with the direction of wind and generate maximum possible electricity.
- **Change Blade Structure**: You can change the structure of your blades in respect to one another thus generating various windmill configurations.

Menu Functionalities:

- **Switch Views** : You can change views either using keys or through the menu located at the top leftmost corner. There are multiple views such as Front View, Closeup, Back View, side views, Hill top View, etc.
- **Switch Modes** : Using the menu you can transit between manual and auto mode.These modes are explained above.

- **Get Help** : Instructions about various keyboard controls and shortcuts to control the simulation and views.

House Functionality:

- In the house we have set a light bulb which is visible through the window of the house. This represents the generation of electricity in real time (for pictorial understanding, this doesn't happen in the real world and there is a battery to store electricity in between). The intensity of the light bulb depends on the speed of the windmill, it intensifies with increase in the speed of wind (rotation speed of blades of the windmill).

Transformations:

- The user can get a 360-degree view of the field by rotation about the Y-axis. He can watch the simulation through whichever horizontal view to understand working of various parts of the windmill.
- The user can zoom in and zoom out at any point in the simulation to get a detailed view of the blades and windmill structure.

Info Box:

- There is an information box at the right top of the window. This displays the current wind speed in real time, along with the total electricity generated by the windmill farm. This feature works in both auto and manual mode.

We have used various primitives to model various structures used in our simulation. We enabled depth buffer and depth testing to get proper 3-D effect and this facilitated the hidden face removal.

Our structure includes a set Windmills, a transformer, electricity lines transporting electricity from generation point to house via the transformer, a house with a light bulb inside, a mountain range in the background, sun and clouds in the sky, and terrain on which all of this stands.

The structure of the windmill includes various components. We have the windmill blades which rotate about the axle at the tip of the motor cylinder. The motor cylinder is attached to the energy tower and houses a motor inside which converts the rotational kinetic energy of blades into electrical energy. This sits on the top of an energy tower which is a frustum shape which stores and propagates the energy produced. There is a circular base on which the energy tower stands.

For modeling the terrain we stored the terrain as a 2-D matrix, where the indexes of the matrix gives the X and Z coordinate and the x,z th entry of the matrix stores the height of the terrain at that point. This is generated randomly so as to try to mimic real terrain as much as possible. The height of terrain at a point in turn decides its color.

We have added the lighting effect and considered our light source as the sun itself. For this our light source is considered at infinity and direction is set such that it leads to proper Global illumination. The normals at the polygon surfaces are used to show shading effects. Along with this we used the material function to provide material properties to the surfaces like shining, ambient light etc.

Output

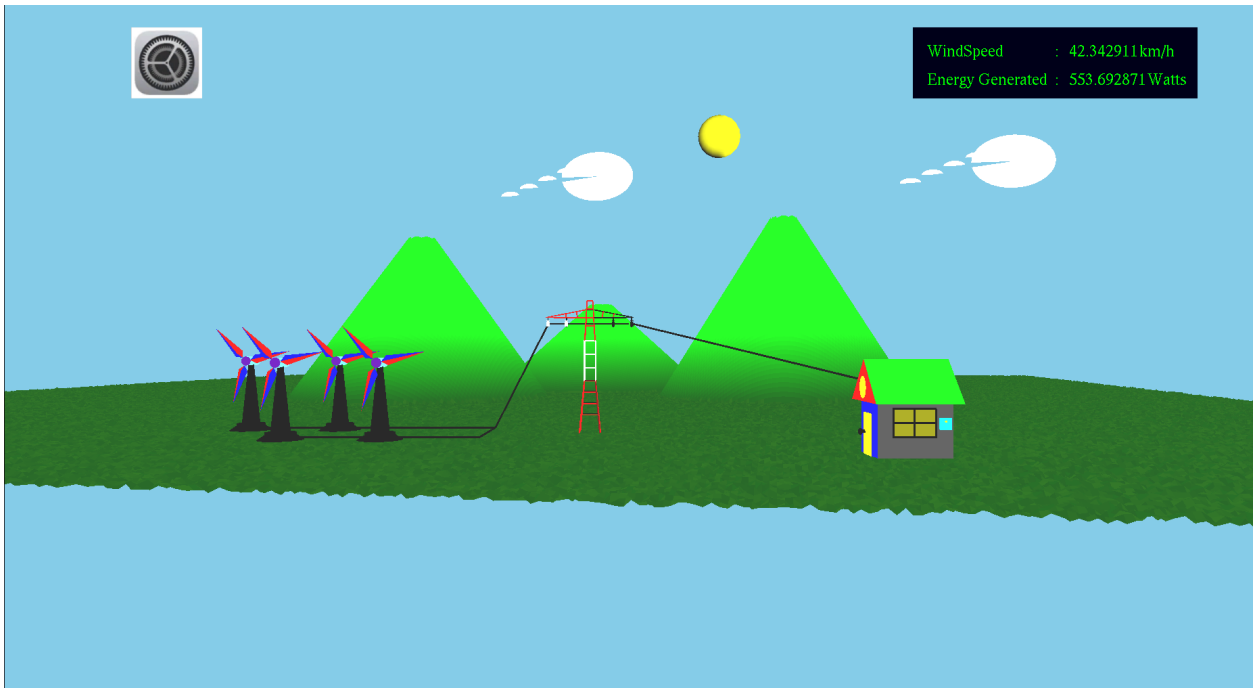

Fig. Front view of the windmill system

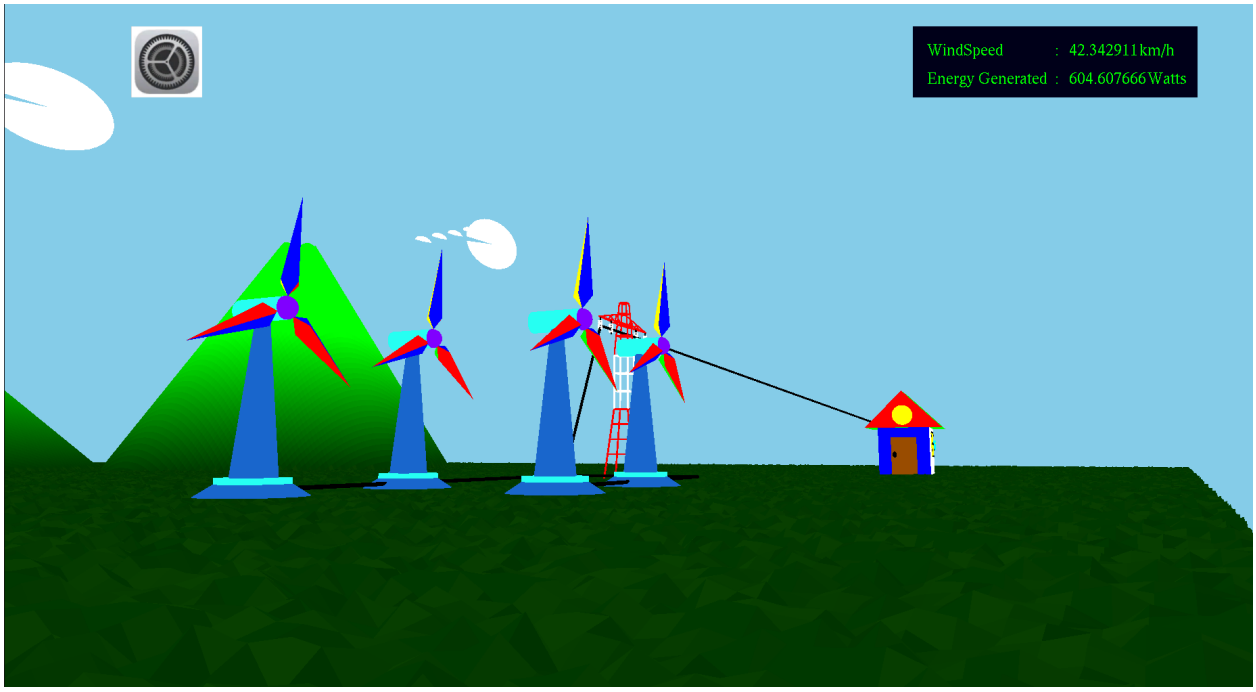

Fig. Closeup view of the windmill

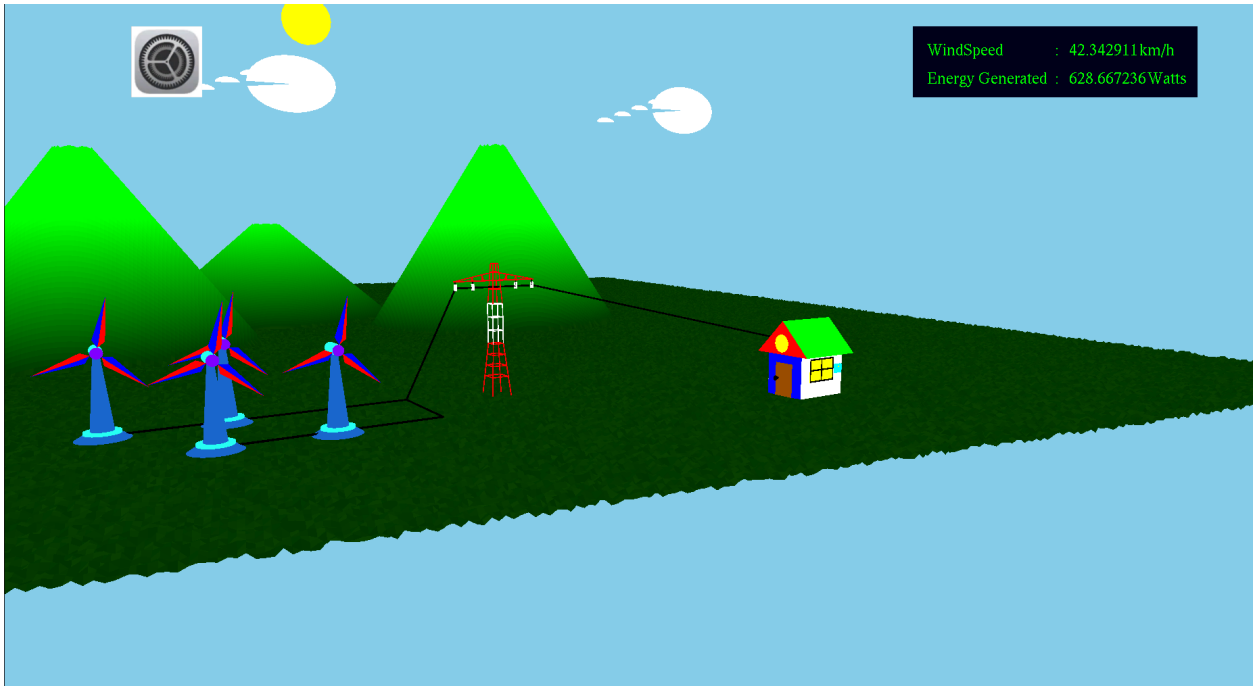

Fig. Side Left view of the windmill system

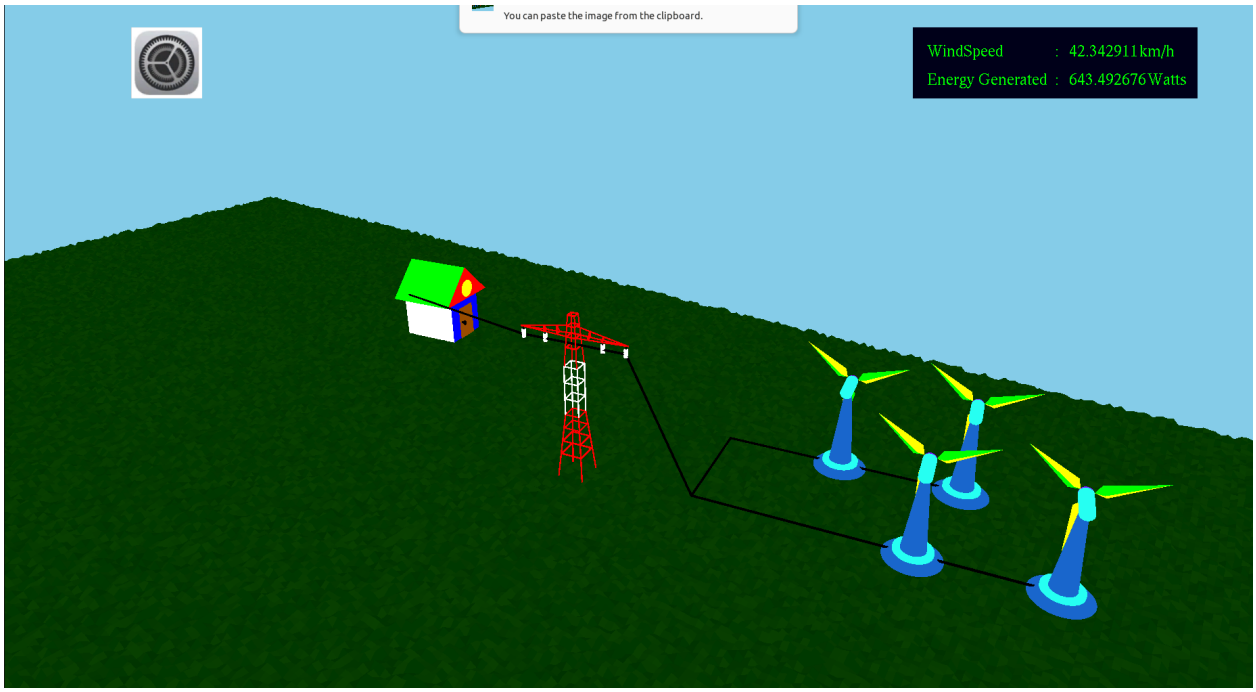

Fig. Back view of the windmill system

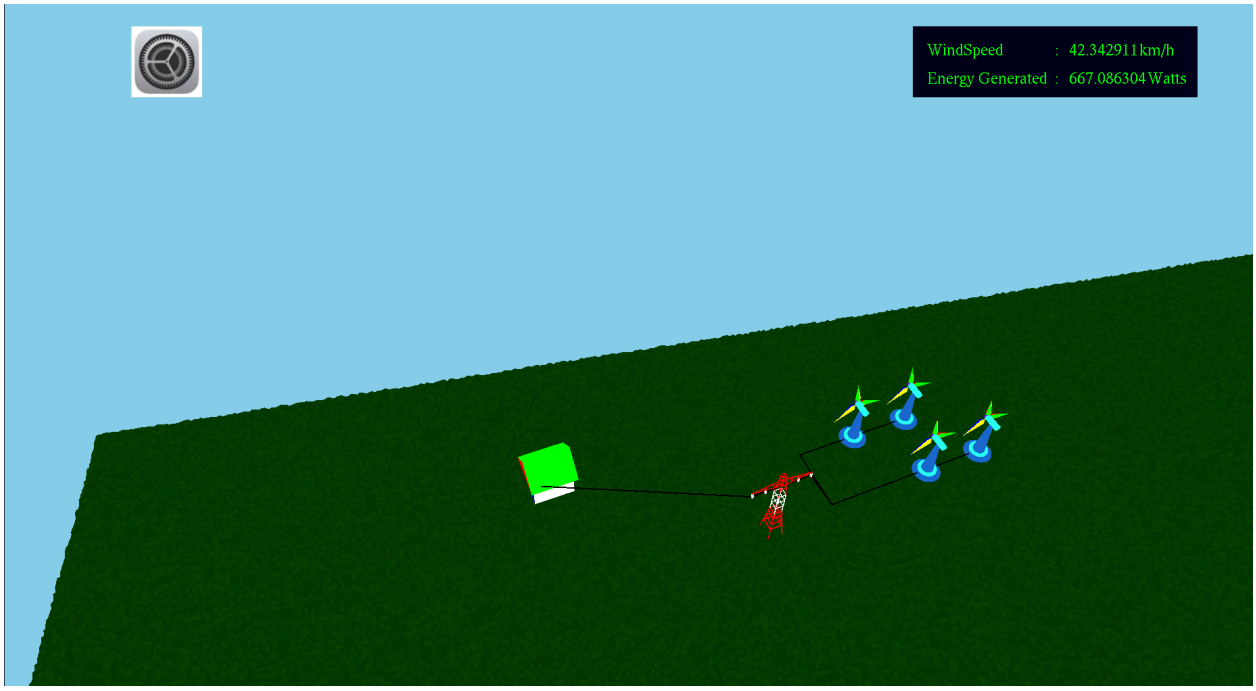

Fig. Top view of the windmill system

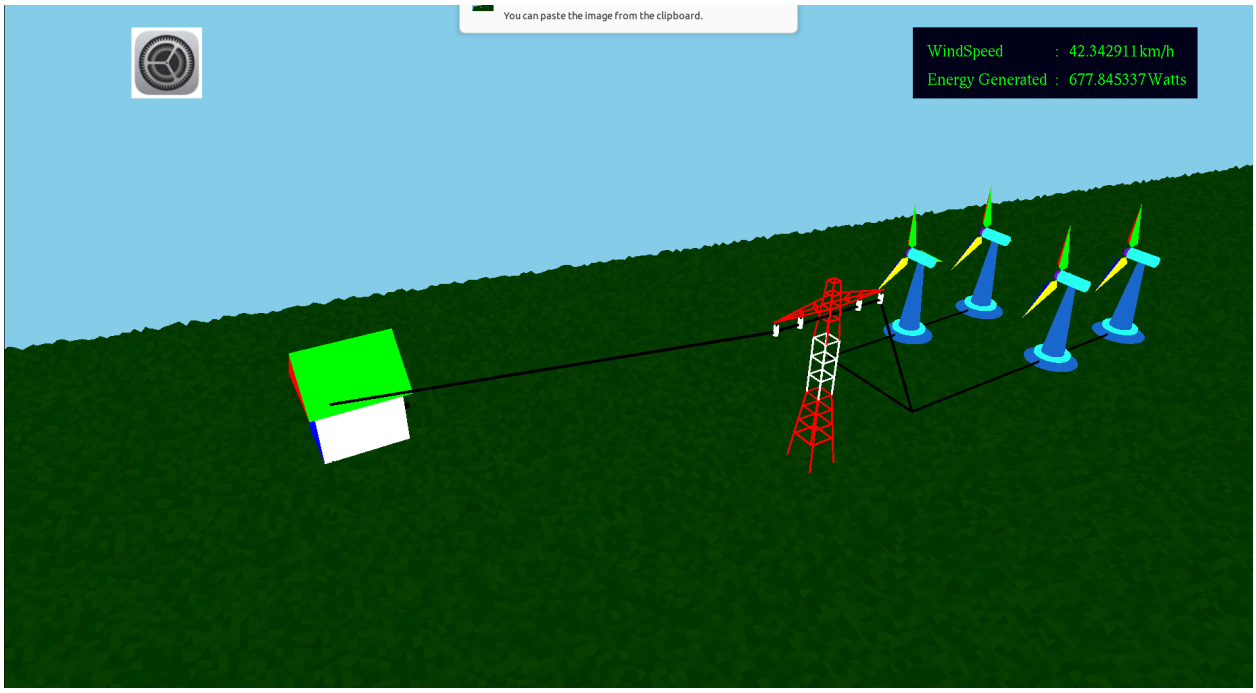

Fig. Hill Top view of the windmill system

Fig. Demonstration of view options in Menu

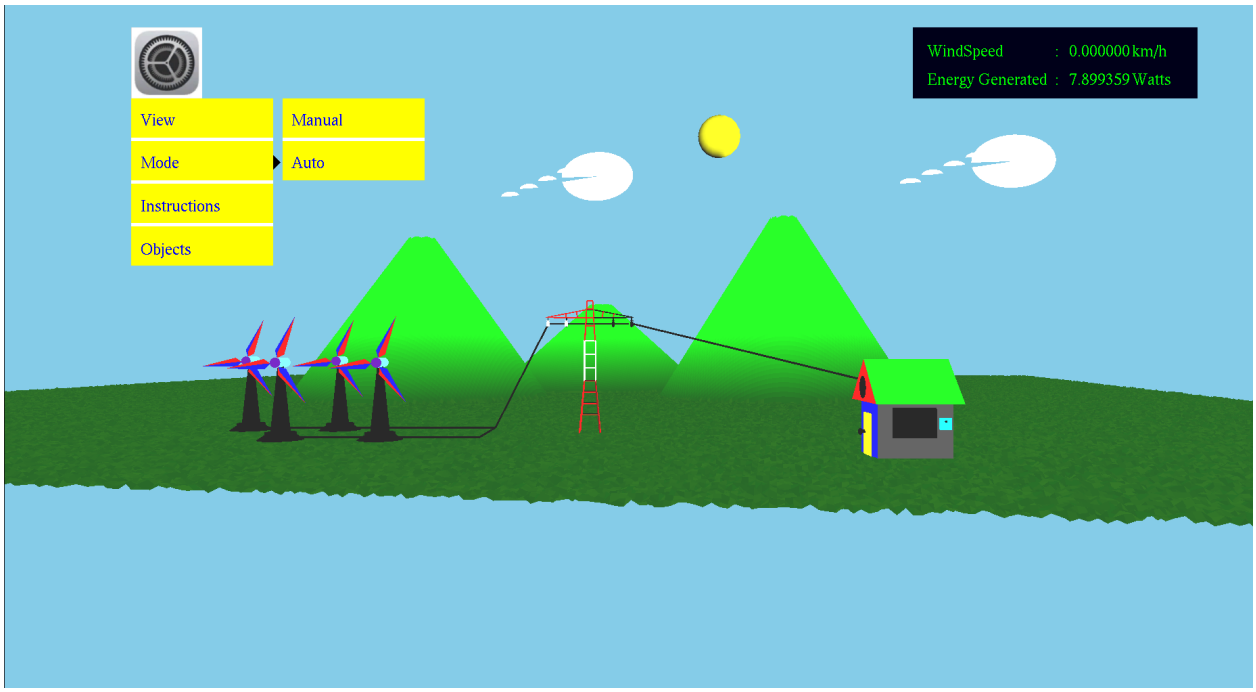

Fig. Demonstration of different modes in Menu

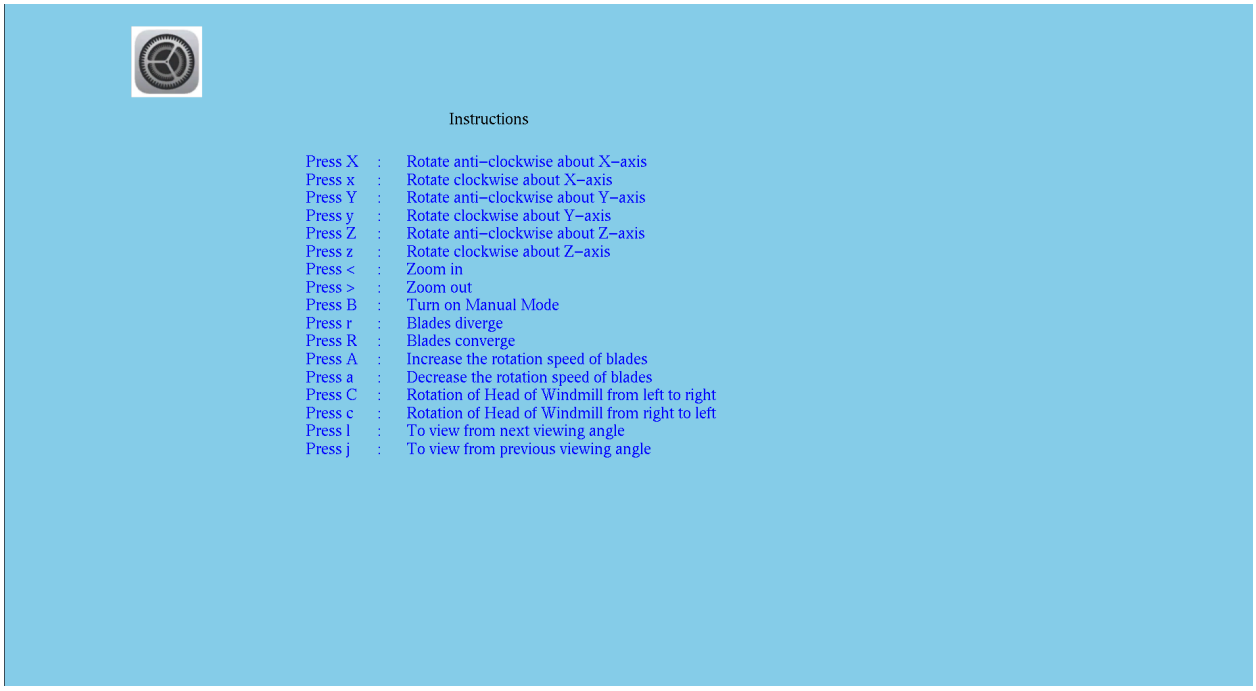

Fig. Demonstration of the instructions guide

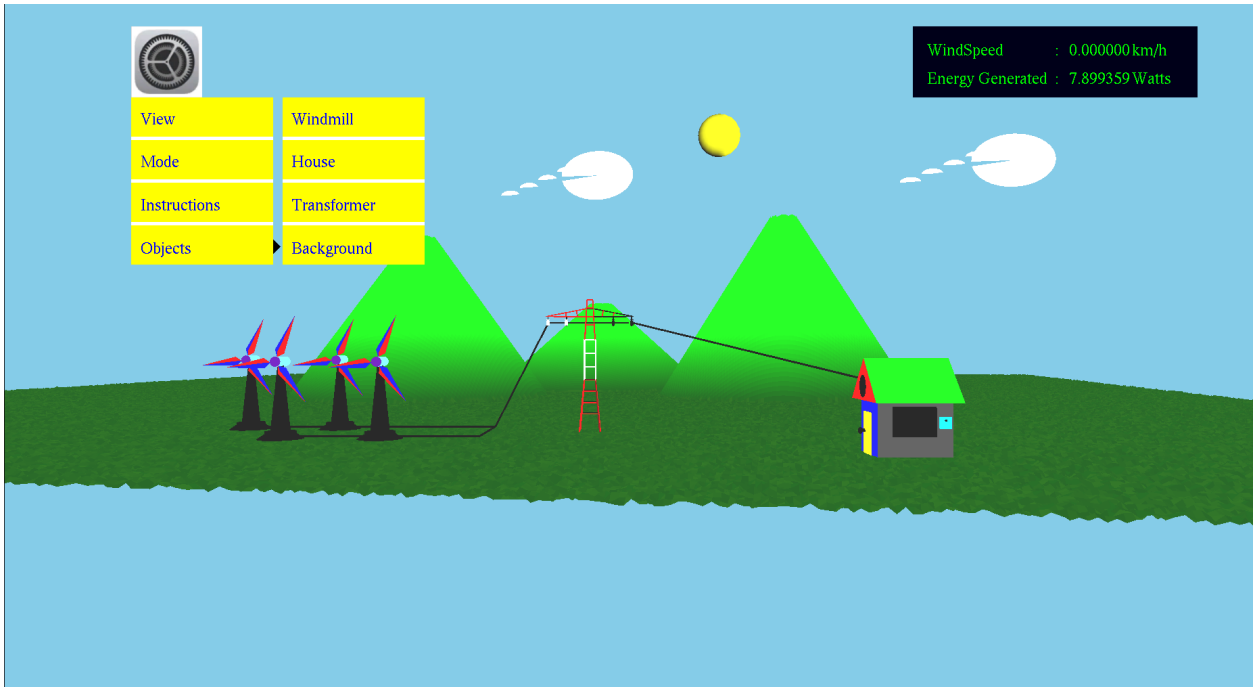

Fig. Click on respective option to see individual view of each object

References

- https://www3.ntu.edu.sg/home/ehchua/programming/opengl/CG_Examples.html
- https://www.codemiles.com/c-opengl-examples/drawing-cone-using-opengl-t9013.html