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BANGLADESH UNIVERSITY OF BUSINESS AND TECHNOLOGY

Lab Assignment-1

Course Code: CSE 342

Course Title: Computer Graphics Lab

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Topic: Assignment on 2D and 3D Graphics.

Answer: **Part-1**

2D Graphics

Introduction:

2D* computer graphics is the computer-based generation of digital images mostly from two-dimensional models (such as 2D geometric models, text, and digital images) and by techniques specific to them. 2D computer graphics started in the 1950s, based on vector graphics devices. These were largely supplanted by raster-based devices in the following decades. The PostScript language and the X Window System protocol were landmark developments in the field.

2D computer graphics is often used in applications that were first developed around traditional printing and drawing technologies. Typography, cartography, technical drawing, and advertising are examples of applications and technologies that originally used 2D computer graphics. In those applications, the two-dimensional image is not only a representation of a real-world object, but also an independent artifact with added semantic value. Two-dimensional models are often preferred because they give more direct control of the image than 3-D computer graphics. In many domains, such as desktop publishing, engineering, and business, a description of a document based on 2D computer graphics techniques can be much smaller than the corresponding digital image often by a factor of 1/1000 or more. This representation is also more flexible since it can be rendered at different resolutions to suit different output devices. For these reasons, documents and illustrations are often stored or transmitted as 2D graphic files.

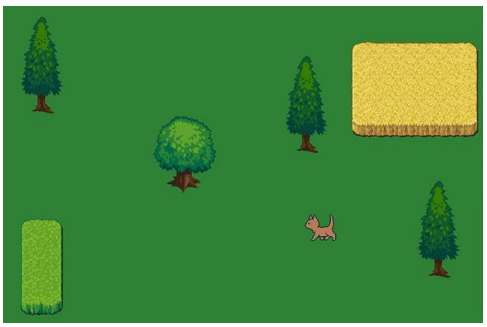

Figure 1: 2D graphics used in a Game

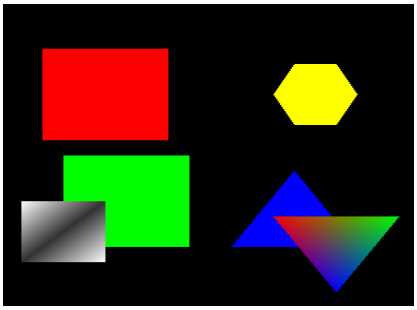

Figure 2: 2D graphics in OpenGL

*Short for two-dimensional or 2D is any virtual object with no appearance of depth. For example, if a graphic or image is 2D, it can only be viewed properly from a straight on viewpoint.

2D Shapes:

A Plane is two dimensional (2D). A polygon is a plane (2D) shape with straight sides. To be a **regular** polygon all the sides and angles must be the same:

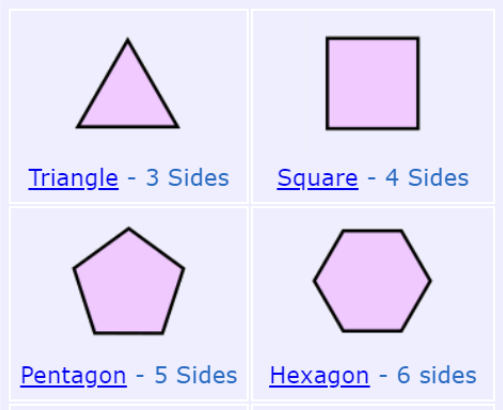

Figure 3: 2D shapes

2D Graphics Techniques:

2D graphics models may combine geometric models (also called vector graphics), digital images (also called raster graphics), text to be typeset (defined by content, font style and size, color, position, and orientation), mathematical functions and equations, and more. These components can be modified and manipulated by two-dimensional geometric transformations such as translation, rotation, scaling. HELLO in object oriented graphics, the image is described indirectly by an object endowed with a self-rendering method a procedure which assigns colors to the image pixels by an arbitrary algorithm. Complex models can be built by combining simpler objects, in the paradigms of object-oriented programming.

2D Graphics Translation:

In Computer graphics, translation is a transformation* technique. 2D Translation is a process of moving an object from one position to another in a two dimensional plane. Consider a point object O has to be moved from one position to another in a 2D plane. Let-

- Initial coordinates of the object O = (X_{old}, Y_{old})
- New coordinates of the object O after translation = (X_{new}, Y_{new})
- Translation vector or Shift vector = (T_x, T_y)

*Transformations are helpful in changing the position, size, orientation, shape etc. of the object.

Given a Translation vector (T_x, T_y)-

- T_x defines the distance the X_{old} coordinate has to be moved.
- T_y defines the distance the Y_{old} coordinate has to be moved.

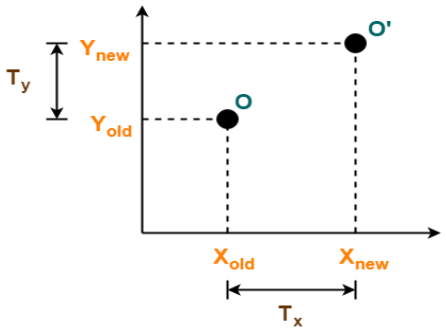

Figure 4: 2D Translation in Computer Graphics

This translation is achieved by adding the translation coordinates to the old coordinates of the object as-

- $X_{new} = X_{old} + T_x$ (This denotes translation towards X axis)
- $Y_{new} = Y_{old} + T_y$ (This denotes translation towards Y axis)

In Matrix form, the above translation equations may be represented as-

$$\begin{bmatrix} X_{new} \\ Y_{new} \end{bmatrix} = \begin{bmatrix} X_{old} \\ Y_{old} \end{bmatrix} + \begin{bmatrix} T_x \\ T_y \end{bmatrix}$$

Figure 5: Translation Matrix

- The homogeneous coordinates representation of (X, Y) is (X, Y, 1).
- Through this representation, all the transformations can be performed using matrix / vector multiplications.

The above translation matrix may be represented as a 3 x 3 matrix as-

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & T_x \\ 0 & 1 & T_y \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ 1 \end{bmatrix}$$

Figure 6: Translation Matrix (homogeneous coordinates representation)

2D Graphics Pros and Cons:

Pros

1. **Lower Costs:** Working with 2D Graphics can be a lot cheaper than 3D Graphics. This is mainly due to the advancements in software meaning not all animation needs to be drawn frame by frame, therefore reducing production time and in turn costs.
2. **Quicker to Produce:** With advancing software such as Toonboom and After effects, 2D Graphics is becoming faster and more accessible.
3. **Software:** The software used to create 2D animation is not as draining for our machines as 3D graphics software. We won't need a huge render farm with beefy graphics cards to run the software.
4. **Story Focused:** 2D graphics animations seem to be more story orientated. When working with 3D objects, it is easier to get the 'wow factor' with sweeping camera moves and powerful effects, but this can sometimes distract from the story or more intimate moments.

Cons

1. **Less Dynamic:** As briefly mentioned above, 2D can feel less dynamic compared to 3D. If for example we wanted to animate a car rolling, creating this in 2d would be really tricky as we should need to redraw the car from several angles and would become very time consuming. Alternatively, if we created the car in 3d space, we can simply rotate the car without having to redraw the car several times.
2. **Less in demand:** As 3D becomes more available there seems to have been a decrease in demand for 2D graphics. It is still popular and widely used, but 3D seems to be the 'flavor of the month'.
3. **Time consuming:** Cell based animation, which is the traditional way of drawing frame by frame, involves redrawing every single frame. If we keep in mind that in the UK, there are 25 frames per second that soon adds up to hundreds of drawings for a relatively short animation. That said, software like Toonboom has some great tools to speed up this process.

Part-2

3D Graphics

Introduction:

3D computer graphics, sometimes called **CGI**, **3DCG** or three-dimensional computer graphics are graphics that use a three dimensional representation of geometric data (often Cartesian) that is stored in the computer for the purposes of performing calculations and rendering 2D images. In the 2D system, we use only two coordinates X and Y but in 3D, an extra coordinate Z is added. 3D graphics techniques and their application are fundamental to the entertainment, games, and computer-aided design industries. It is a continuing area of research in scientific visualization. Furthermore, 3D graphics components are now a part of almost every personal computer and, although traditionally intended for graphics-intensive software such as games, they are increasingly being used by other applications.

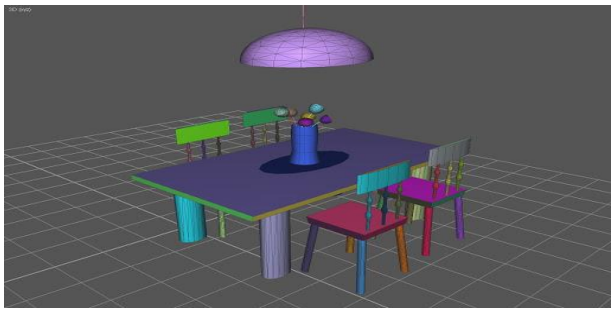

Figure 7: 3D Graphics

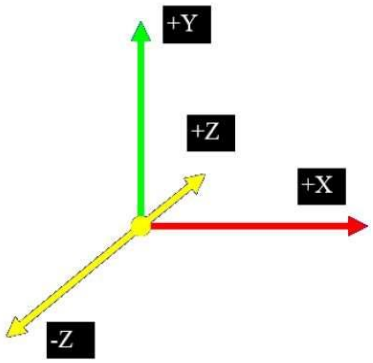

Figure 8: 3D coordinates

3D Shapes:

A Solid is three-dimensional (3D). 3D shapes are nothing but solids that consist of 3 dimensions, namely - length, breadth, and height. The "D" in "3D shapes" stands for "**Dimensional**." Three-dimensional objects having three dimensions namely length, breadth, and height.

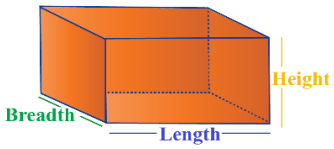

Figure 9: 3D shape with 3 dimensions

These 3D shapes occupy space and are found in our day-to-day life. We touch, feel, and use them.

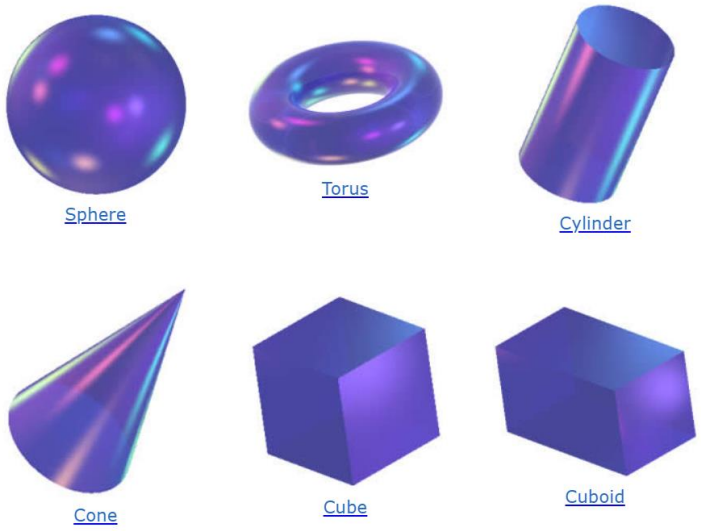

Figure 10: 3D shapes

3D Graphics Translation:

In 3D translation, we transfer the Z coordinate along with the X and Y coordinates. The process for translation in 3D is similar to 2D translation. A translation moves an object into a different position on the screen.

The following figure shows the effect of translation −

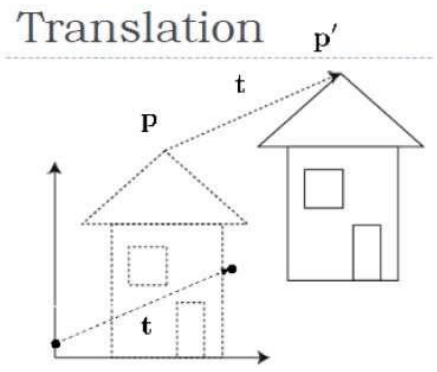

Figure 11: 3D Graphics Translation

A point can be translated in 3D by adding translation coordinate (tx, ty, tz) to the original coordinate X, Y, Z to get the new coordinate X′, Y′, Z′.

$$T = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ t_x & t_y & t_z & 1 \end{bmatrix}$$

P' = P·T

$$[X'\ Y'\ Z'\ 1] = [X\ Y\ Z\ 1] \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ t_x & t_y & t_z & 1 \end{bmatrix}$$

$$= [X + t_x\ \ Y + t_y\ \ Z + t_z\ \ 1]$$

3D Modeling:

In 3D computer graphics, **3D modeling** is the process of developing a mathematical coordinate-based representation of any surface of an object (inanimate or living) in three dimensions via specialized software. Three-dimensional (3D) models represent a physical body using a collection of points in 3D space, connected by various geometric entities such as triangles, lines, curved surfaces, etc. Being a collection of data (points and other information), 3D models can be created manually, algorithmically (procedural modeling), or by scanning. Their surfaces may be further defined with texture mapping.

3D models are used for a variety of mediums including video games, movies, architecture, illustration, engineering, and commercial advertising. Engineers and architects use it to plan and design their work. Animators and game designers rely on 3D modeling to bring their ideas to life. And just about every Hollywood blockbuster uses 3D modeling for special effects, to cut costs, and to speed up production. For example, the HBO series ***Game of Thrones*** uses 3D modelling + animation to mock up every episode before filming.

Almost all 3D models can be divided into two categories:

- **Solid**: These models define the volume of the object they represent (like a rock). Solid models are mostly used for engineering and medical simulations, and are usually built with constructive solid geometry.
- **Shell** or **boundary**: These models represent the surface, i.e. the boundary of the object, not its volume (like an infinitesimally thin eggshell). Almost all visual models used in games and film are shell models.

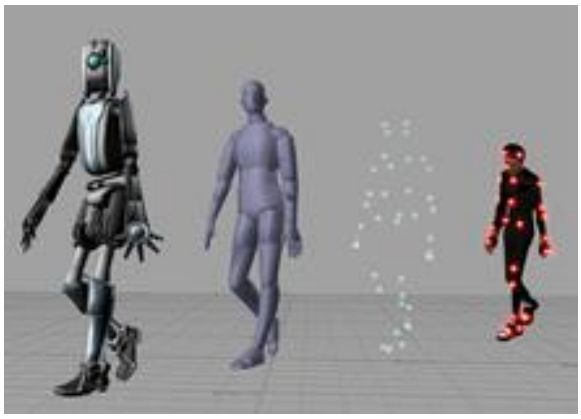

Figure 12: 3D Modeling

3D Graphics Pros and Cons:

Pros

1. **Superior movement:** All characters and objects are built in a 3D meaning we simply move the camera around in a similar way to how we could move a camera in the real world. This gives us more flexibility with moving through the world. It also allows us to rotate in 3D space without having to redraw each frame.
2. **More realistic:** Technology has advanced so much that we can now create photorealistic renders of our animation.
3. **Possibilities:** 3D animation allows us to do things that might not be possible in 2D or the real world. Going back to our example of a car rolling, this is obviously a dangerous stunt to perform in the real world and a tricky thing to create a 2D world. 3D offers the safest and more accurate interpretation.

4. **Reuse models:** Once we have modelled our character, we can reuse them in an infinite amount of new projects, which will save our both time and resources.
5. **Rise in popularity:** Production houses like Disney, dream works and Pixar has helped drive the popularity of 3D animation across all platforms.

Cons

1. **Limited imagination:** 3D is tricky to stylize compared to the vast array of styles that can be created in 2D. There is a reason that most 3D animated characters have a similar style. we are somewhat limited by the rig when creating a character.
2. **More complicated:** There are several elements involved in making a 3D graphics that complicate the process compared to 2D graphics. When making a 2D graphics, we design the characters and animate them. When working in 3D we need to model the character, animate the character, add lightning and create textures before we are able to see a glimpse of what the final work will look like. It is a time consuming process and requires a lot of computer power to produce.
3. **Long lead times:** Before we even get to see our character there is a lot of work involved which results in longer lead times.

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