COMPUTER GRAPHICS CAT 2

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GROUP 7

ICS 3B

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1. In 2021, Facebook Inc rebranded to Meta and in a statement made by Mark Zuckerberg, he said that the metaverse is the next evolution of social connection. Their company's vision is to help bring the metaverse to life, so they are changing their name to reflect their commitment to that future. Following the current trends, discuss how metaverse will deploy Computer Graphics to change Social Connections. [3 Marks]

The metaverse is a set of virtual spaces where you can create and explore with other people who aren't in the same physical space as you. It will interact more with the real world, incorporating things like augmented reality overlay. And you feel present with other people as if you were in other places, having different experiences that you couldn't necessarily do on a 2D app or webpage. It is going to be a really big part of the next chapter for the technology industry; we might start checking ourFacebook feed in Fortnite with a pair of augmented reality glasses.

a) Based on your response above, how will they use recent VR and AR technologies in achieving all the promises made? [2 Marks]

Virtual and Artificial reality can be used to render a 3D virtual world, a binaural audio system, positional and rotational real-time head tracking for six degrees of movement. These can be used to control user interaction with the created metaverse they will be in.

2. The major building blocks of the Phong lighting model consist of 3 components, giving examples discuss these three lighting components.

- Ambient lighting: light that may be distant for example, the moon, that lights up objects causing them to almost never be completely dark. To simulate this we use an ambient lighting constant that always gives the object some color.
- Diffuse lighting: simulates the directional impact a light object has on an object. The more a part of an object faces the light source, the brighter it becomes.
- Specular lighting: simulates the bright spot of a light that appears on shiny objects. Specular highlights are more inclined to the color of the light than the color of the object.

3. GLSL has, like any other programming language, data types for specifying what kind of variable we want to work with. List and discuss any four data types and how GLSL uses them in Computer Graphics.

The basic data types are as follows:

- int: used to describe integers for example ivecn which is a vector of n integers.
- uint: used to declare unsigned integers for example uvecn which is a vector of n unsigned integers.
- bool: used to declare values that are either true or false. For example, bvecn which is a boolean vector of n booleans.
- double: used to declare double-precision floating-point values. For example, dvecn which is a vector of n double components.

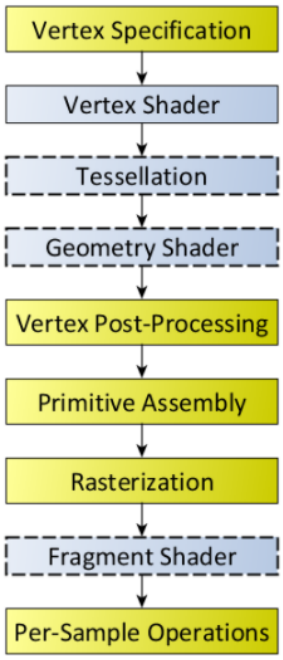
4. In OpenGL rendering pipeline, there exists nine stages of which four are reprogrammable
via shaders. Using a diagram, list and briefly discuss all these stages and what they are used for in OpenGL.

As seen in the diagram below, the stages of the OpenGL rendering pipeline are as follows:

- Vertex Specification: process where the application sets up an ordered list of vertices that define the boundaries of a primitive to send to the pipeline. This part of the pipeline deals with a number of objects like Vertex Array Objects (VAO) and Vertex Buffer Objects (VBO). Vertex Array Objects define what data each vertex has, while Vertex Buffer Objects store the actual vertex data itself.
    - Vertex Shader. perform basic processing of each individual vertex and receive the attribute inputs from the vertex rendering, converting each incoming vertex into a single outgoing vertex based on an arbitrary, user-defined program.
    - Tessellation: an optional process where primitives can be tessellated using two shader stages and a fixed-function tessellator between them. The Tessellation Control Shader (TCS) stage, which comes first, determines the amount of tessellation to apply to a primitive, as well as ensuring connectivity between adjacent tessellated primitives. The Tessellation Evaluation Shader (TES) stage comes last, and it applies the interpolation or other operations used to compute

user-defined data values for primitives generated by the fixed-function tessellation process.

- Geometry Shader: user-defined programs that process each incoming primitive, returning zero or more output primitives.
- Vertex Post Processing: stage in the OpenGL Rendering Pipeline where the vertex outputs of the Vertex Processing undergo a variety of operations.
- Primitive Assembly: process of collecting a run of vertex data output from the prior stages and composing it into a sequence of primitives. This process is determined by the type of primitive the user rendered. The output of this process is an ordered sequence of simple primitives such as lines, points, or triangles.
- Rasterization: primitives that reach this stage are then rasterized in the order in which they were given. The result of rasterizing a primitive is a sequence of fragments which are a set of states that are used to compute the final data for a pixel in the output framebuffer.
- Fragment Shader: it is the OpenGL pipeline stage after a primitive is rasterized. This stage processes a fragment generated by the rasterization into a set of colors and a single depth value.
- Per-Sample Operations: stage of the OpenGL rendering pipeline, where Fragments output from a Fragment Shader are processed, and their resulting data are written to various buffers.



5. Using examples and stating clearly what they are used for in OpenGL, distinguish Vertex Buffer Objects (VBOs) from Vertex Array Objects (VAOs).

A Vertex Buffer Object (VBO) is a memory buffer in the high speed memory of your video card designed to hold information about vertices. For example, you can have a VBO to describe coordinates of a vertex and one to describe the color for that vertex. On the other hand, Vertex Array Object (VAO) is an object which contains one or more Vertex Buffer Objects and is designed to store the information for a complete rendered object. For example a cube constisting of 12 vertices with color for each vertex.

6. Game Engines are software responsible for processing the information used to generate electronic games.

a) In at most 100 words, discuss how game engines work

A game engine lays the software framework to build and create video games. They work by laying the framework that allows a user to create something like a video game more easily than if they had to make it from scratch. The framework provided varies from engine to engine, but

game engines typically include a 2D or 3D rendering engine. Game engines are responsible for rendering graphics, collision detection, memory management, and many more options.

b) Discuss any three game engines currently available for anyone interested in game development.

Unity- It is one of the easiest game engines due to its simple interface. One of the major features it packs is the fact that it enables developing games for multiple platforms. Using the Unity engine, games can be created for Android, iOS and other phone operating systems, including PC OS.

Unreal Engine is one of the most popular and best game engines for rendering detailed graphics. It can produce some of the best landscapes in gaming.

GameMaker is still widely deployed and used by multiple game developers. Instead of conventional programming, users can literally drag and drop items to create games a lot faster and with great ease.

c) If you were to build your game engine for the projects you are working on during the semester, discuss any five components of Game Engines you would mainly address

A game engine contains five components:

- The main game program which contains the game logic.
- A rendering engine which can be used to generate 3D animated graphics.
- An audio engine which consists of algorithms which are related to sounds.
- A physics engine to implement 'physical' laws within the system.
- Artificial intelligence which is a module designed to be used by software engineers with a specialist designation.

d) Explain how Machine Learning can be used in Graphics Accelerator Chipset to improve graphics rendering as well as in Game Engines [4 Marks]

Machine learning can be used to train models for graphics that are difficult to render. Graphics such as hair, its natural movement and its interaction with the environment is something that is very difficult to render. This is because hair in itself is composed of millions of hair strands together which can move in unison, in groups or alone. Training models to capture and display the movement of hair in a natural way could greatly assist in game rendering as this would make games appear more realistic and would allow them to model the real world even to a greater extent. This can also be translated to game engines where modules or subprograms could be created that specifically control hair movement and manipulation making it easier for game developers to come up with more realistic game characters.

7. [Submit a .cpp file for this question] Uniforms can be used to change a triangle's fill color from one color to another, for example say Red to Green to Blue (RGB), write a while render loop to show such a transition.

8. List and discuss any three types of surfaces that can be applied in Computer Graphics.

Quadric surfaces- this is an algebraic surface that is defined by second degree or quadratic equations in 2-D space.Examples of quadric surfaces are spheres,ellipsoids,paraboloids and hyperboloids.

Polygon surfaces- represents objects as a collection of surfaces which have a categorical wireframe display.Polygon surfaces are divided into two categories which are boundary representations (B-reps) and space-partitioning representations.B-reps describe 3D objects as a set of surfaces that separate the object interior from the environment while space partitioning representations are used to describe interior properties through partitioning the spatial regions to small contiguous solids such as cubes.

Super-quadric surfaces- these are surfaces formed through adding parameters to quadratic equations already used in quadratic surfaces.The incorporation of additional parameters in the

quadratic equation provides more flexibility for adjusting object shapes.Examples of super quadric surfaces include super-ellipse and the super-ellipsoid.

9.Discuss the uses of VBOs and VAOs as used in Computer Graphics.

VBO's - provides methods for uploading vertex data such as the position,color and vector to the device for non-immediate mode rendering.

VAO's - are designed to store the information needed for a complete rendered object such as the format of the vertex data as well as VBO's .

10.Discuss how hardware is important in Computer Graphics rendering

Rendering computer graphics requires reliable and efficient hardware such as a fast processor,large memory and display devices to make the render process possible.Computer graphics imaging and animations consume a considerable amount of hard drive space and the speed in which the hard drive can access files in the computer is important in computer graphics rendering. The memory devices are necessary in computer graphics as rendering is memory intensive .This is as a result of the Random Access Memory being used to store the running programs in a computer .These hardware play a crucial role in computer graphics as their properties such as size and speed for example greatly affect the process.

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