NEPAL COLLEGE OF INFORMATION TECHNOLOGY

Balkumari, Lalitpur

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ASSIGNMENT FOR COMPUTER GRAPHICS

ASSIGNMENT 1

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Q1) What is Hardware Acceleration? Differentiate between a CPU and a GPU.

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Hardware acceleration refers to the use of specialized hardware to perform specific tasks more efficiently than is possible with general purpose CPUs. By offloading intensive computations to dedicated hardware, applications can achieve better performance, reduced power consumption, and improved responsiveness.

Aspect	CPU	GPU
Purpose	General purpose processing for various tasks.	Specialized for parallel processing tasks like graphics and AI.
Architecture	Few powerful cores for sequential tasks.	Thousands of smaller cores for simultaneous tasks.
Applications	Running OS, browsing and general computing.	Video editing, 3D rendering and AI processing
Strengths	Precision, Flexibility & versatility	speed & efficiency for parallel workloads
Examples	coding, browsing & office tasks	Gaming, video rendering & AI model training.

Q2) Explain the working mechanism of GPU.
→

A GPU processes data in parallel, making it ideal for tasks like rendering graphics or large-scale computations. The breakdown is as:

1. Parallel Processing
   Thousands of small cores work simultaneously on multiple tasks, processing data much faster than a CPU for parallelizable workloads.

2. ~~A~~ Data Handling
   - Receives Data (e.g. graphical commands or computation tasks) from CPU
   - Breaks data into smaller chunks for independent processing.

3. Fast Execution
   - The cores perform simple calculations quickly and in large numbers.
   - GPUs uses high-speed memory to store data and results during this process.

4. Output
   - For graphics: The GPU turns the processed data into images and displays them on the screen.
   - For other tasks: It sends the result back to CPU for more work.

Q3) List operating characteristics for following display technologies: raster refresh system, vector refresh systems.

→

Raster refresh systems:
- Build images line by line using a grid of pixels.
- Requires constant screen refresh (60-120Hz) to prevent flickering.
- Handles complex images well but can show pixelation.
- supports full colors and shading.
- Used in TVs, computer monitors, and modern display systems
- Needs a frame buffer to store pixel data.
- Higher energy consumption due to constant refreshing of the entire screen.

Vector refresh systems:
- Draws images using continuous lines between specified points.
- Refreshes only active areas, so it needs less frequent updating.
- Great for simple line based images but struggles with computer graphics.
- Limited in color options, usually monochrome or basic palettes.
- Commonly used in older systems like oscilloscopes, flight simulators.
- Requires digital-to-analog converters to draw line.
- Lower energy consumption, as only necessary parts are refreshed.

Q4) Differentiate betn Raster & Vector Display Technologies.

→

Aspect	Raster Display Technology	Vector Display Technology
Image Formation	Forms images using a grid of pixels.	Forms images by drawing lines bet^n points
Refresh Method	Refreshes the entire screen continuously.	Refreshes only the areas where lines need to be drawn.
Image Quality	Good for detailed images and complex scenes, but can look pixelated.	Excellent for sharp lines but not suited for complex images.
Complexity Handling	Handles complex and shaded images easily.	Best for simple, line based images & graphics.
Color & shading	Supports full color & shading.	Limited color options, often just monochrome or basic colors.
Hardware	Requires frame buffer to store pixel data.	Requires digital-to-analog converters to draw lines.
Energy consumption	Higher	Lower
Applications	Used in TVs, monitors & modern computer displays.	Used in early CAD systems, oscilloscope & simulators.

Q5) How much storage is required for each system if 24 bits per pixel are to be stored?

Sol^n

The storage required for an image or a system that uses 24 bits per pixel depends on the resolution of the system.

Here,

Storage (bits) = Width x Height x Bits per pixel

To convert into bytes,

$$\text{storage (bytes)} = \frac{\text{Storage (bits)}}{8}$$

Q6) Suppose an RGB raster system is to be designed using an 8-inch by 10-inch screen with a resolution of 100 pixels per inch in each direction. If we want to store 9 bits per pixel in the frame buffer, how much storage (in bytes) do we need for the frame buffer?

Sol^n

Here,

Total no. of pixels $= 8 \times 100 \times 10 \times 100$

$= 800 \times 1000$

Storage (bits) $= 800 \times 1000 \times 9$

$= 7200000$

$$\text{storage (bytes)} = \frac{7200000}{8}$$

$= 900,000$ bytes Ans

Q7) How long would it take to load a 800 by 600 frame buffer with 24 bits per pixel, if 10^5 bits can be transferred per second? How long would it take to load a 32-bit per pixel frame buffer with a resolution of 1280 by 1024 using this same transfer rate?

Sol^n

Total no. of bits for frame $= 800 \times 600 \times 24$

$= 11520000$

The time needed to load frame buffer $= \dfrac{11520000}{10^5}$ sec

$= 115.2$ sec Ans

Total no. of bits for frame $= 1280 \times 1024 \times 32$

$= 41943040$

Time needed to load frame buffer $= \dfrac{41943040}{10^5}$

$= 419.43$ sec Ans

Q8) Consider two raster systems with resolutions of 640 by 480 and 1280 by 1024. How many pixels could be accessed per second in each of these systems by a display controller that refreshes the screen at a rate of 75 frames per second? What is the access time per pixel in each system?

Sol^n

For system 1,

Total pixels $= 640 \times 480 = 307{,}200$ pixels

Pixels per second = Total pixels x Refresh rate

$= 307200 \times 75$

$= 23,040,000$

Access time per pixel $= \frac{1}{23040000}$ sec

$= 4.3 \times 10^{-8}$ sec Ans

For system 2,

Total pixels $= 1280 \times 1024$

Pixels per second $= 1280 \times 1024 \times 75$

Access time per pixel $= \frac{1}{1280 \times 1024 \times 75}$

$= 1.02 \times 10^{-8}$ sec Ans

Q9) A Raster system can produce a total number of 512 different levels of intensities from a single pixel composed of red, green and blue phosphor dots. If the total resolution of the screen is 1280 x 1024, what will be the required size of frame buffer for the display purpose?

Soln

We know,

Levels of intensities $= 2^{\text{Bit per pixel}}$

Or, $\log_2(512)$ = Bits per pixel

∴ Bits per pixel = 9 bits

Hence, Storage for frame buffer $= 1280 \times 1024 \times 9$

$= 11,796,480$ bits

$= \frac{11796480}{8}$ bytes

$= 1474560$ bytes

$= \frac{1474560}{1024}$ KB

$= 1440$ KB Ans

Q10) Write short notes on Refresh rate, Aspect Ratio, Resolution, Persistence.

→

Refresh rate:

The refresh rate of a display refers to how many times per second the image on the screen is refreshed. A higher refresh rate, like 75 Hz or 120 Hz, provides smoother motion, making it ideal for fast-moving content like games or videos. Lower refresh rates can cause flickering and a less pleasant viewing experience.

Aspect Ratio:

The aspect ratio is the ratio between the width and height of the screen or image, commonly written as width : height. For example, a 16 : 9 aspect ratio is standard for most modern displays and gives a widescreen view, while 4 : 3 is an older standard.

Resolution:

Resolution describes the number of pixels that make up the image on the screen. Higher resolutions offer sharper and clearer images. For instance, Full HD (1920 x 1080) and 4K (3840 x 2160) are common resolutions for better image detail.

Persistence:

Persistence refers to how long a pixel stays on the screen after its no longer being refreshed. High persistence can cause ghosting or motion blur, while lower persistence can provide clearer images but might cause flickering, especially during fast movements.

Q11) If on average, pixels are accessed from the frame buffer with an access time of 20 ns and the total resolution of the screen is 1024 x 1024, will there be a flickering effect seen on the screen?

→

Here,

Access Time per pixel $= 20ns = 20 \times 10^{-9}$ sec

so,

Total access time = Total pixel x Access time per pixel

$= 1024 \times 1024 \times 20 \times 10^{-9} = 0.02097$ sec

For ideal condn,

Refresh time per pixel $= \frac{1}{60}$ sec $= 0.01667$ sec

Since, total access time for all pixels is greater than refresh time per cycle, the screen will not be able to refresh all pixels before next refresh cycle starts. This mismatch can lead to flickering.

Yes, there will be flickering.

Q12) How does the video controller work along the frame buffer to produce different intensities out of single pixel on the screen?

→

The frame buffer is a portion of memory that stores the pixel data for the entire screen. Each pixel has values representing the intensity of the three primary colours : red, green and blue (RGB). These intensity values determine how bright or dark each colour will appear on screen. The frame buffer stores these values for every pixel, allowing the screen to display image.

The video controller is responsible for reading the pixel data from frame buffer & sending to display. It converts intensity values stored in frame buffers into signals that controls the brightness of corresponding pixel on screen. The VC adjust the amount of light emitted by each dot (R, G, B) base on intensity values it reads from frame buffer.

As VC continuously refreshes the screen, it reads & updates the pixel data at a fast rate (60/sec or more). This allows the screen to display smooth transitions in brightness & color, creating detailed images with wide range of intensities. In this way, the frame buffer & VC work together to display images on screen by controlling intensity of pixel colour.

Q13) A raster scan system has 14 inch by 10 inch screen with a resolution of 200 pixels per inch in each direction. If the VC refreshes the screen at a rate of 60 frames per second, how many pixels could be accessed per second & what is the access time per pixel of screen?

Sol^n

Total no. of pixels = $14 \times 200 \times 10 \times 200$

We have, Refresh rate = 60

Total pixels per second = $14 \times 200 \times 10 \times 200 \times 60$

= 336,000,000 pixels per second Ans

Again,

Access time per pixel = $\frac{1}{\text{Pixels per second}}$

$= 2.98 \times 10^{-9}$ sec

= 2.98 ns Ans

Q14) Differentiate between Emissive and Non emissive display. Explain the working principle of plasma panels, LED and LCDs.

→

Working principles:

1. Plasma panels

Plasma panels use tiny cells filled with a gas mixture (e.g. neon and xenon) that gets ionized to produce plasma when electricity passes through it. The plasma emits UV light, which excites phosphor coatings in cells to produce visible light.

Features:

- Produces high brightness & vibrant colors
- Offers excellent viewing angles
- Energy-intensive and can have screen burn-in issues.

2. LED displays
LED displays consist of small diodes that emit light when an electric current passes through them. Modern LED screens are often arrays of these diodes that are used as backlights for LCDs or as direct emissive displays (e.g. OLEDs).
Features :
- Bright, energy-efficient & long-lasting
- capable of high contrast & dynamic range
- Used in TVs, monitors & outdoor displays.

3. Liquid crystal Displays (LCDs)
LCDs use liquid crystal molecules sandwiched between two polarising filters. When an electric current is applied, the crystals align to control the amount of light passing through. A backlight or external light source provides illumination.
Features :
- Lightweight & energy efficient
- Requires backlighting as it is non-emissive
- widely used in monitors, smartphones & TVs

P.T.O.

Aspect	Emissive display	Non-Emissive display
Definition	Produces light directly from the screen	Relies on external light sources for visibility
Examples	Plasma panels, LED displays, OLEDs	LCDs, e-paper
Working Principle	Emits light by energizing pixels or materials.	Modulates external light using filters or polarizers
Power Consumption	Typically higher due to direct light emission	Lower as it depends on ambient light or backlighting.
Image Quality	Better contrast and vibrant colors.	Dependent on quality of external light

Q15) Explain different Hardware and softwarecomponents used for Graphical display purpose.

→

Graphical display systems rely on a combination of hardware and software components to render and manage visual content.

Hardware components:

1. Display Devices
   - Monitors : Commonly used devices, including LCD, LED, OLED and CRT displays.

- Projectors : Display images or videos on large surfaces
- Touchscreens : Interactive displays combining i/p & o/p functionality.

2. GPU (Graphics Processing Unit)
Specialized for rendering images and 3D graphics

3. VRAM (Video Memory)
Stores textures and frame data for fast GPU access

4. Graphic Cards
Integrate GPUs and VRAM for enhanced performance

5. Frame Buffer
Holds pixel data for display o/p.

6. Input Devices
Mice, keyboards, and graphic tablets for user interaction

7. Display Adapters
HDMI, DisplayPort, VGA interfaces.

Software Components :

1. Graphics Drivers
Enable OS-GPU communication

2. Graphics APIs
Tools like DirectX, OpenGL, Vulkan for rendering.

3. Rendering Software
Tools like Blender, Maya for 2D/3D visualization.

4. OS and GUIs
Systems (windows, macOS) & frameworks (GNOME, KDE) for user interaction.

5. Game Engines
Unity, Unreal for interactive and real time graphics.

6. Editing software
Photoshop, GIMP for content creation

Q16) A laser printer is capable of printing two pages (size 9x11 inches) per second at the resolution of 600 pixels per inch. How many bits per second does such device require? (Assume 1 pixel = n bits)

sol^n

Page width = 9 inches x 600 pixels/inch
= 5400 pixels

Page height = 11 x 600 = 6600 pixels
Pixels per page = 5400 x 6600 = 35,640,000 pixels

Printer per second:
Printer speed = 2 pages per sec
Pixel per second = 35640000x2 = 71,280 pixels/sec

Let n = no. of bits per pixel
∴ Bits per sec = 71280000xn bits/sec

Solution depends on the value of n (bits per pixel):
Monochrome (1-bit per pixel): 71280000 bits/sec
Grayscale (8-bit per pixel): 570,240,000 bits/sec
Color (24-bit per pixel) = 1,710,720 bits/sec Ans

Q17) Your mobile phone has a total resolution of 1920 x 1080 with 423 PPI. What is the display size of your mobile?

Sol:

Total resolution = 1920 x 1080 pixels

Pixel Density = $\frac{1920}{423}$

= 4.54 inches

Also, Pixels in height = 1080

Height in inches = $\frac{1080}{423}$

= 2.25 inches

Diagonal = $\sqrt{(4.54)^2 + (2.55)^2}$

= $\sqrt{27.11}$

= 5.21 inches Ans

Q18) What is the fraction of the total refresh time per frame spent in retrace of the electron beam for a non-interlaced raster system with a resolution of 1024 by 800, a refresh rate of 75Hz, a horizontal retrace time of 3 microseconds & a ~~ver~~ vertical retrace time of 450 microseconds.

Sol^n Total pixels $= 1024 \times 800 = 819{,}200$ pixels

Refresh rate $= 75$ Hz

Total frame time $= \dfrac{1}{75} = 0.01333$ seconds

Horizontal:

Retrace time $= 3\mu s = 3 \times 10^{-6}$ sec

Total horizontal lines $= 800$

Horizontal line time $= \dfrac{0.01333}{800} = 16.67 \times 10^{-6}$ sec/line

Horizontal retrace time $= 3\mu s = 3 \times 10^{-6}$ sec

Vertical retrace time $= 450\mu s = 450 \times 10^{-6}$ sec

Total horizontal lines $= 800$.

Total horizontal retrace time $= 3 \times 10^{-6} \times 800$

$= 2.4 \times 10^{-3}$ sec.

so, Total refresh time $= 2.4 \times 10^{-3} + 450 \times 10^{-6}$

$= 2.85 \times 10^{-3}$ sec.

Horizontal line time $= \dfrac{0.01333}{800} = 16.67 \times 10^{-6}$

Fraction of total refresh time spent in retrace,

Fraction $= \dfrac{\text{Total retrace time}}{\text{Total frame time}}$

$= \dfrac{2.85 \times 10^{-3}}{0.01333} \times 100\% = 21.4\%$

Q19) How much time is spent scanning across each row of pixels on a raster system with a resolution of 1280 x 1024 & a refresh rate of 50 frame per second.

sol

Total pixels per frame = 1280×1024

Total frame time = $\frac{1}{50} = 0.02$ sec

Total vertical lines = 1024

Time per line = Total frame time / Total vertical lines

$= \frac{0.02}{1024}$

$= 1.953 \times 10^{-5}$ sec

Now,

No. of pixel per line = 1280

Time to scan across each row = Time per line

$= 1.953 \times 10^{-5}$ sec Ans

Q20) Suppose we have a video monitor with a display area that measures 12 inches across and 9.6 inches high. If the resolution is 1280 by 1024 and the aspect ratio is 1, what is the diameter of each screen point?

sol

screen width = 12 inches

Horizontal pixels = 1280

Horizontal pixel density = $\frac{1280}{12}$ = 106.67 pixels/inch

Horizontal : vertical = 1280 : 1024

= 5 : 4

Screen dimensions match with 1:1 aspect ratio.

∴ Pixel diameter = 106.67 pixels/inch

$= \frac{1}{106.67}$

= 0.00937 inch

= 0.238 mm Ans

Q21) What is frame buffer? What is its role in producing color display?

→

A frame buffer is a section of memory that holds pixel data for a display. Each pixel is represented by color information, typically in formats like RGB, where the intensity of red, green and blue components defines the pixel's color. Higher color depths may also include an alpha channel for transparency.

During rendering, the CPU or GPU calculates the colors for all pixels and writes this data to the frame buffer. The display hardware continuously reads the frame buffer to generate the visible image on the screen.

To avoid visual artifacts like flickering or tearing, ~~the~~ modern systems use double buffering. While one buffer (the front buffer) is being displayed, the next frame is prepared in another buffer (the back buffer). Once the new frame is ready, the buffer swap roles. This setup ensures smooth & seamless visual o/p.

In summary, the frame buffer is essential for translating rendered pixel data into the vibrant and stable images we see on color displays.

Q22) Explain the use of Computer Graphics in Industry, Data visualization and simulation.

→

Computer graphics play a crucial role across various domains, including industry, data visualization and simulation.

(i) Industry

- CAD : Used for designing products, machinery, and buildings with precision.
- Prototyping : Enables virtual testing & refinement of products
- Marketing : Creates realistic 3D visuals for ads & promotions
- AR/VR : Used for training, troubleshooting & layout planning

(ii) Data Visualization

- Charts and Graphs : Simplify numerical data for easy interpretation
- 3D visualizations : Represent complex data like weather patterns & stock trends.
- Interactive Dashboards : Allow real-time data exploration and analysis.

(iii) Simulation

- Training : Simulates real world scenarios for pilots, drivers and healthcare.

- Testing : Analyzes systems under virtual conditions (e.g. crash testing)
- Research : Models phenomena like climate change or chemical processes.

Q23) Write an essay on the recent trends in the field of computer Graphics.

→

Recent Trends in field of computer Graphics

The field ~~in~~ of computer graphics has been rapid advancements, driven by improvements in hardware, algorithms, and innovative applications. From lifelike visual effects in entertainment to real time data visualization, recent trends have revolutionized the way we interact with and perceive digital media.

1. Real Time Rendering
Technologies like ray tracing and global illumination enable lifelike visuals in games, virtual production, and simulations, powered by engines like unreal and unity.

2. Virtual and Augumented Reality (VR/AR)
VR creates immersive experiences for gaming and training, while AR enhances real-world tasks in design, education, and healthcare. Devices like Meta Quest and HoloLens drive adoption.

3. AI in Graphics

AI accelerates texture creation, animation, and rendering. Tools like NVIDIA DLSS improve performance and quality, while AI-generated content simplifies workflows.

4. Photorealism

Advanced rendering algorithms produce lifelike imagery, impacting films, games & virtual prototyping.

These trends showcase the increasing role of graphics in entertainment, industry and beyond.