Display Devices Numerical

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Terminologies

- **Resolution**: widhth*height
- **Aspect ratio**: width/height
- **Frame Buffer**: buffer memory required to store one frame data
- **Refresh Rate**: no of times display completes its retrace procedure in one second.
- **Access Time**: time required to fetch data from frame buffer and display on monitor pixels
- **Color depth**: per pixel frame buffer
- **PPI** : pixels per inch
- **Retrace procedure**:
- **Horizontal and vertical retrace time**:

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If the image dimension is 2500 x 3192 then what is the size of the image in terms of Mega Pixels?

Given,

Resolution = 2500*3192

Size of image = 2500*3192 pixels =7980000 pixels

= 7980000 pixels /10^6

= 7.98 Megapixels

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Assuming that a certain full-color (24-bit per pixel) RGB raster system has a 512-by-512 frame buffer, how many distinct color choices (intensity levels) would we have available?

Given,

Color depth = 24-bits per pixel

Total number of distinct color available is = 2^{24} = 16777216.

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For a raster system with a resolution of 1280 by 1024 what is the size of frame buffer (in byte) required to store 10 bits per pixel?

Given,

Resolution = 1280*1024

Frame buffer needed for a pixel = 10bits

Size of frame buffer = resolution of screen*frame buffer for a pixel

= 1280*1024*10 bits

= 13107200 bits

Size of frame buffer(in bytes) = 13107200 bits /8

=1638400 byes

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How long would it take to load a 640 by 480 frame buffer with 12 bits per pixel, if 10^5 bits can be transferred per second.

Given,

Resolution = 640*480

Frame buffer needed for a pixel = 12bits

Transfer rate = 10^5 bits per sec

Time to load a frame = ?

Size of frame buffer = resolution of screen*frame buffer for a pixel

= 640*480*12 bits

= 3686400 bits

Time to load a frame = $\frac{size\ of\ frame\ buffer}{transfer\ rate}$

$= \frac{3686400}{10^5}$

= 36.864 sec

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How long would it take to load a 12 bit per pixel frame buffer with a resolution of 1280 by 1024, if 10^5 bits can be transferred per second. How long would it take to load 24 bits per pixel frame buffer with a resolution of 1280*1024 with using the same transfer rate.[2018 Fall]

Part-I

Given,

Color depth(per pixel frame buffer) = 12 bit

Transfer rate = 10^5 bits per sec

Resolution = 1280*1024

Time to load a frame = ?

Frame size = color depth * resolution

= 12*1280*1024 bits

= 15728640 bits

Time to load frame = $\frac{frame\ size}{transfer\ rate}$

$= \frac{15728640\ bits}{100000\ bits\ per\ \text{sec}}$

= 157.28 sec

Part-II

Given,

Color depth(per pixel frame buffer) = 24 bit

Transfer rate = 10^5 bits per sec

Resolution = 1280*1024

Time to load a frame = ?

Frame size = color depth * resolution

= 24*1280*1024 bits

= 31457280 bits

Time to load frame = $\frac{frame\ size}{transfer\ rate}$

$= \frac{31457280\ bits}{100000\ bits\ per\ \text{sec}}$

= 314.57 sec

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If pixels are accessed from the frame buffer with an average speed 50 nanoseconds and the total resolution of the screen is 1024*1024 will there be a flicering effect produced on the screen.

Given,

Average access time for a pixel = 50ns

Resolution = 1024*1024

Refresh rate = ?

Time taken to load a frame = Resolution * Average access time for a pixel

= 1024*1024*50*10^{-9} = 0.0524 sec

Refresh rate = $\frac{1}{time\ taken\ to\ load\ a\ frame}$

$= \frac{1}{0.0524} Hz$

= 19.08 Hz

The human eye can generally detect flicker below 60 Hz. Since the calculated frame rate (19.08 fps) is significantly lower than 60 Hz, there will likely be a flickering effect on the screen.

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On an average it takes 20ns for a raster graphics system to access the pixel value from the frame buffer and glow the phusphore dot on the screen. If the total resolution of the screen is 640*480 will this access rate produce a flickering effect?

Given,

Average access time for a pixel = 20ns

Resolution = 640*480

Refresh rate = ?

Total access time to load a frame = Resolution * Average access time for a pixel

$= 640*480*20*10^{-9} = 0.006114$ sec

Refresh rate $= \frac{1}{time\ taken\ to\ load\ a\ frame}$

$= \frac{1}{0.006114} Hz$

= 162.76 Hz

For human eye flickering threshold if 60 Hz, and calculated frame rate is 162.76 there will not be flickering effect on the screen.

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In case of raster system with resolution of 640 by 480, How many pixels could be accessed per second in this system by a display controller that refreshes the screen at a rate of 60 frames per second? What is the access time per pixel in each system.

Given,

Resolution = 640*480

Refresh rate = 60 fps

Total pixel on a frame = 640* 480 = 307200 pixels

Total pixels accessed per sec = resolution * refresh rate

= 640*480*60

= 18432000 pixels

18432000 pixels are accessed at time = 1 sec

1 pixel will be accessed at time $= \frac{1}{18432000} = 5.425*10^{-8}$ sec

Therefore, access time per pixel = 54.25 nanosec

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A raster scan system has 12 inch by 10 inch screen with a resolution of 120 pixels per inch in each direction. If the video controller refreshes the screen at the rate of 60 frames per second. How many pixels could be accessed per second and what is the access time per pixel of the screen.

Given,

Resolution = 12*10

Refresh rate = 60 fps

Total pixel on a frame = 12*120*10*120= 1728000 pixels

Total pixels accessed per sec = resolution * refresh rate

= 1728000*60

= 103680000 pixels

103680000 pixels are accessed at time = 1 sec

1 pixel will be accessed at time = $\frac{1}{103680000}$ = 0.000138 sec

Therefore, access time per pixel = 9.6 ns

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If your mobile phone have a total resolution of 1080 by 1920 pixels with 375ppi, then what would be the LED screen size of your mobile phone(Screen size measured diagonally.)

Given,

Resolution = 1080*1920

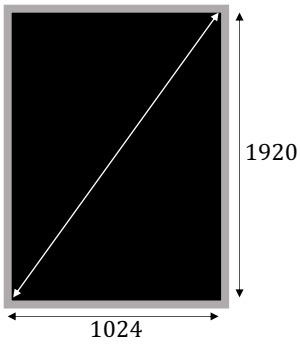
Screen pixel ratio = 375ppi

Size of screen =?

Using Pythagorean theorem,

Diagonal pixels = $\sqrt{\text{width}^2+\text{height}^2}$

= $\sqrt{1024^2+1920^2}$ = 2202.9 ≈ 2203



We have,

375 pixels per 1 inch in screen.

1 pixel = $\frac{1}{375}$ inch

2203 pixels = $\frac{1}{375}$ * 2203 = 5.87 inch

Therefore, the screen size of mobile phone would be approximately 5.87inch.

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A raster system with a color depth of 32 bits per pixel has a resolution of 1280 by 720. How many pixels could be accessed per second in this system by a display controller that refreshes the screen at a rate of 60 frames per second.

Given,

Color depth = 32 bits

Resolution = 1280*720

Refresh rate = 60fps

Pixels accessed per second = Resolution * refresh rate

= 1280*720*60 pixels

= 55,296,000 pixels

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If the total resolution of the system is 1280 by 1024 and can produce a total number of 16777216 distinct intensities out of single pixel on the screen, then what might be the size of frame byffer used in this system?

Given,

Resolution = 1280*1024

Intensity levels = 16777216

Size of frame buffer =?

Color depth required to express 16777216 destinct intensities is,

$\log_2(16777216) = 2^{24} = 24$ bits per pixel

Size of frame buffer = Resolution * color depth

= 1280*1024*24

= 31,457,280 bits

Therefore, size of frame buffer is, (31,457,280 bits/8) = 3,932,160 bytes.

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A raster sytem with a color depth of 32 bits per pixel has a resolution of 1280 by 720, what is the required size of frame buffer? Also calculate it, if the total number of intensities that can be produced out of a single pixel is 65536.

Part-I

Given,

Resolution = 1280*720

Color depth = 32 bits

Size of frame buffer =?

Size of frame buffer = Resolution * color depth

= 1280*720*32

= 29,491,200 bits

Therefore, size of frame buffer is,

(29,491,200 bits/8) = 3686400 bytes.

Part-II

For 65536 intensity levels,

Color depth required to express 65536 destinct intensities is,

$\log_2(65536) = 2^{16} = 16$ bits per pixel

Size of frame buffer = Resolution * color depth

= 1280*720*16

= 14745600 bits

Therefore, size of frame buffer is,

(14745600 bits/8) = 1843200 bytes.

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A lazer printer is capable of printing two pages (size 9*11 inch) per second at resolution of 600 pixels per inch. How many bits per second does such device required? (Assume 1 pixel = n bits)?

Given,

Page size = 9*11

Resolution = 600 PPI

Total pixels per page = 9*600*11*600 = 35640000 pixels

As printer is able to print 2 pages per second.

Total pixels per second = 35640000*2 = 71280000

Total bits per second = Total pixels per second * Bits per pixel

=71280000 * n bits

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Consider a non-interlaced raster monitor with a resolution of 1280*1024. If horizontal and vertical retrace times are 20 microsecond each, then calculate the fraction of the total refresh time per frame spent in retrace of electron beam? Assume refresh rate of 60 frames per second.

Given,

Resolution = 1280*1024

Retrace times,

R_{hz}=20ms

R_{vt}=20ms

Refresh rate = 60fps

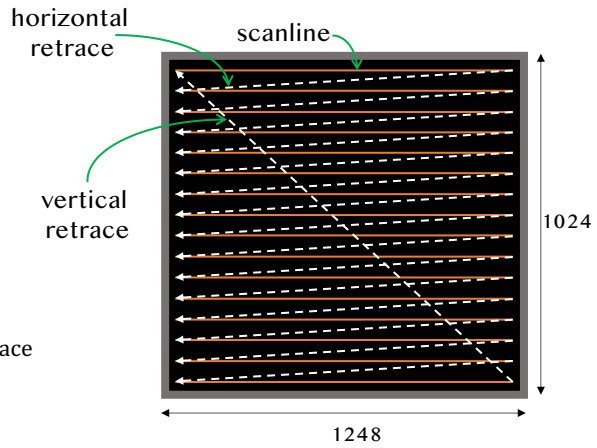
Retrace time per frame = 20*1024 + 20 = 20500ms

=0.0205sec

Refresh time per frame = $\frac{1}{refresh\ rate} = \frac{1}{60} = 0.0167$sec

Fraction of the total refresh time per frame spent in retrace

$= \frac{\text{Total retrace time per frame}}{\text{Total refresh time per frame}} = \frac{0.0205}{0.0167} = 1.23$



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Assignment Solutions.

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Consider three different raster systems with resolutions of 640 by 480, 1280 by 1024, and 2560 by 2048. What size frame buffer (in bytes) is needed for each of these systems to store 12 bits per pixel? How much storage is required for each system if 24 bits per pixel are to be stored?

Part-I

Given,

Resolution = 640 by 480

Color Depth = 12 bits per pixel

Size of frame buffer = Resolution * Color depth

= 640*480*12 =

If color depth = 24 bits per pixel,

Size of frame buffer = Resolution * Color depth

= 640*480*24 =

Part-II

Resolution = 1280 by 1024

Color Depth = 12 bits per pixel

Size of frame buffer = Resolution * Color depth

= 1280*1024*12 =

If color depth = 24 bits per pixel,

Size of frame buffer = Resolution * Color depth

= 1280*1024*24 =

Part-III

Resolution = 2560 by 2048

Color Depth = 12 bits per pixel

Size of frame buffer = Resolution * Color depth

= 2560*2048*12 =

If color depth = 24 bits per pixel,

Size of frame buffer = Resolution * Color depth

= 2560*2048*24 =

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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 6 bits per pixel in the frame buffer, how much storage (in bytes) do we need for the frame buffer?

Given,

Size of screen = 8*10 inch

Resolution = 100 PPI

Total pixels on the screen =Width (in inch) * Resolution × Height (in inch) * Resolution

Total pixels = 8*100*10*100 = 800000 pixels

Color Depth = 6 bits per pixel

Size of frame buffer = Total pixels on the screen * Color Depth

= 800000*6

= 4800000 bits

= 4800000 bits /8 = 600000 bytes

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How long would it take to load a 640 by 480 frame buffer with 12 bits per pixel, if 10^5 bits can be transferred per second? How long would it take to load a 24-bit per pixel frame buffer with a resolution of 1280 by 1024 using this frame transfer rate?

Solution on lecture sides.

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Suppose we have a computer with 32 bits per word and a transfer rate of 1 mip (one million instructions per second). How long would it take to fill the frame buffer of a 300-dpi (dot per inch) laser printer with a page size of 8.5 Inches by 11 inches?

Total number of dots (pixels) on the page:

Dots per horizontal inch: 8.5 inches * 300 dpi = 2550 dots

Dots per vertical inch: 11 inches * 300 dpi = 3300 dots

Total dots: 2550 dots * 3300 dots = 8,415,000 dots

Calculate the size of the frame buffer

Assuming one bit per pixel (for black and white printer): 8,415,000 dots * 1 bit/dot = 8,415,000 bits

Size in bytes: 8,415,000 bits / 32 bits = 262,968.75 words

Calculate the time to fill the frame buffer = Number of words / Transfer rate

262,968.75 words / 1,000,000 instructions/second

≈ 0.26 seconds

Therefore, it would take approximately 0.26 seconds to fill the frame buffer of the printer.

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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 60 frames per second? What is the access time per pixel in each system?

Part-I

Solution on lecture slide.

Part-II

Given,

Resolution = 1280*1024

Refresh rate = 60 fps

Total pixel on a frame = 1280*1024= 1310720 pixels

Total pixels accessed per sec = resolution * refresh rate

= 1280*1024 *60

= 78643200 pixels

18432000 pixels are accessed at time = 1 sec

1 pixel will be accessed at time = $\frac{1}{78643200}$ = $1.27*10^{-8}$ sec

Therefore, access time per pixel = 12.7 nanosec

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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?

Given,

Display size = 12 inches by 9.6 inches

Resolution = 1280 by 1024

Aspect ratio = 1

Diameter of each screen point = ?

Pixels per inch (horizontal) = Resolution width / Display width = 1280 pixels / 12 inches

≈ 106.67 pixels/inch

Pixels per inch (vertical) = Resolution height / Display height = 1024 pixels / 9.6 inches

≈ 106.67 pixels/inch

Since the aspect ratio is 1, the pixel pitch will be the same horizontally and vertically.

Diameter of each screen point (Pixel pitch) = 1 / (Pixels per inch)

=1 / 106.67 pixels/inch ≈ 0.0094 inches

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How much time is spent scanning across each row of pixels during screen refresh on a raster system with a resolution of 1280 by 1024 and a refresh rate of 60 frames per second?

Given,

Resolution = 1280*1024

Refresh rate = 60fps

Total number of pixels on the display device = 1280*1024 = 1310720

Total number of pixels accessed per sec = Resolution * Referesh Rate

=1280*1024*60 = 78643200 pixels

Here, 78643200 pixels are accessed per second. Then,

Access time for each pixel = $\frac{1}{78643200}$ sec

Access time for each row = $\frac{1}{78643200}$*1280 = 0.00001627604 sec = 16.27 μs

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Consider a non-interlaced raster monitor with a resolution of n by m (m scan lines and n pixels per scan line), a refresh rate of r frames per second, a horizontal retrace time of t_{hz} and a vertical retrace time of t_{vert} . What is the fraction of the total refresh time per frame spent in retrace of the electron beam?

Given,

Resolution = n*m

Refresh rate = r fps

Horizontal retrace time = t_{hz}

Vertical retrace time = t_{vert}

Total retrace time per frame= $m*t_{hz}+t_{vert}$

Refresh time per frame = $\frac{1}{r}$

fraction of the total refresh time per frame spent in retrace of the electron beam is,

$$= \frac{m*thz+tvert}{1/r}$$

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What is the fraction of the total refresh time per frames spent in retrace of the electron beam for a noninterlaced raster system with a resolution of 1280 by 1024, a refresh rate of 60 Hz, a horizontal retrace time of 5 microseconds, and a vertical retrace time of 500 microseconds?

Given,

Resolution = 1280*1024

Retrace times,

R_{hz}=5μs

R_{vt}=500μs

Refresh rate = 60fps

Retrace time per frame = 5*1024 + 500 = 5620 μs

=0.00562sec

Refresh time per frame = $\frac{1}{refresh\,rate} = \frac{1}{60}$ = 0.0167sec

Fraction of the total refresh time per frame spent in retrace

$= \frac{\text{Total retrace time per frame}}{\text{Total refresh time per frame}} = \frac{0.00562}{0.0167} = 0.3365$

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Assuming that a certain full-color (24-bit per pixel) RGB raster system has a 512-by-512 frame buffer, how many distinct color choices (intensity levels) would we have available? How many different colors could we display at any one time?

Solution on lecture slide.

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