COS 344: L2 Chapter 3

Cobus Redelinghuys

University of Pretoria

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Class Representative

1. Who would like to be class representative for COS344 in 2024?
   - Only nominee: Hamza Mokiwa

Introduction

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  - Rectangular array of pixels.
    - Pixel - picture element

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- Example:
  - Displays (output)
  - Printer (output)
  - Image sensor (input)

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- Device independent description of the image.
  - The display approximates the image.

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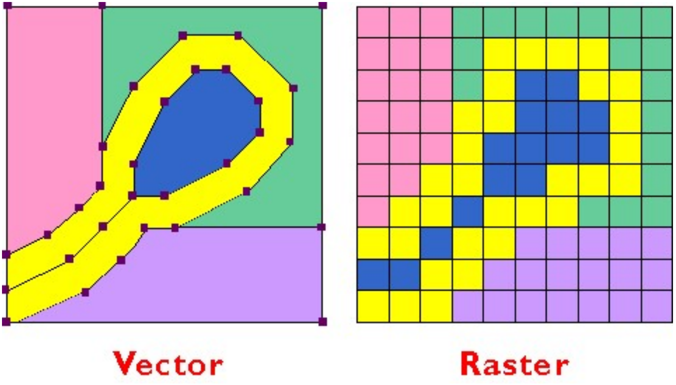
- Advantages and disadvantages?
  - Adv: Perfect for high resolution displays
  - DAdv: First be rasterized before displayed.
- Use cases?

Example



https://cdn.safe.com/wp-content/uploads/2021/05/03094728/vector-vs-raster.jpg

Section 3.2: Images, Pixels, and Geometry

- Section 3.1 is left to curious students.
- Graphical computations rely on abstraction of the display device.
- Images in the real world are functions defined over two-dimensional areas:
  - The light of the display is a function of the position on the display.
  - The light on a camera sensor is a function of the position on a camera sensor.
  - etc.
- An image can be abstracted to have the formula:

$$I(x, y) : R \to V$$

  where $R \subset \mathbb{R}^2$ and V is the set of possible pixel values.
- What is the dimensions of V?

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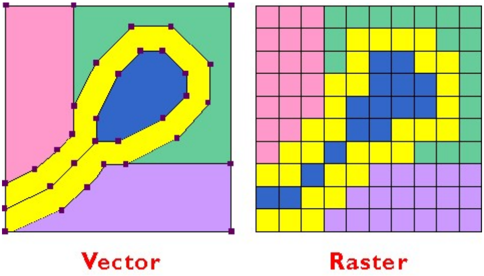
- What is the dimensions of V?
  - It depends on the pixel information.

Point sample

Local average of the color at a specific point.



Assume the colors in the raster image are the average of all the colors in a single "cell" when overlaid on the vector image.

2D coordinate convention

- The textbook's convention:
  - The position of a pixel in a raster image is given by: (i, j)
    - i is the x-Cartesian coordinate or column.
    - j is the y-Cartesian coordinate or row.
  - The origin $(0, 0)$ is in the bottom left corner.
  - If there are n_x columns and m_y rows, the top right coordinates are: $(n_x - 1, m_y - 1)$

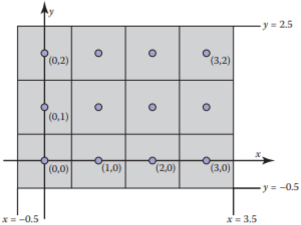


Figure 3.10. Coordinates of a four pixel × three pixel screen. Note that in some APIs the y-axis will point downward.

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- *Low Dynamic Range* (LDR) images.
  - Images using integer numbers to represent pixel values.
- *High Dynamic Range*(HDR) images.
  - Images using floating-point numbers to represent pixel values.
- Examples of V's dimension:
  - Grey scale: $V = \mathbb{R}^+$
  - RGB: $V = (\mathbb{R}^+)^3$

- What are the effects of using less bits to store an image compared to the amount of bits used to create/capture it?

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  - Clipping
  - Quantization or banding

Clipping

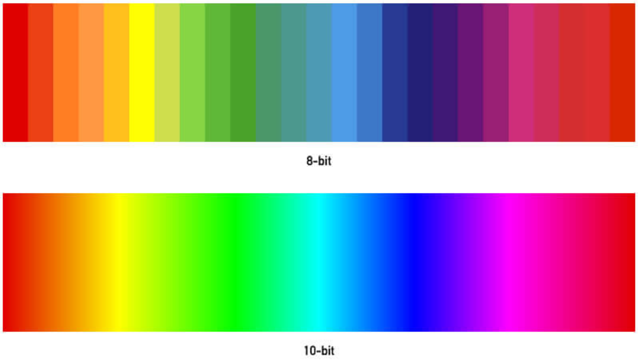
When the value of a pixel exceeds the fixed-range, the value is bounded to the minimum or maximum value of the range.

Quantization or banding

The color jumping effect caused by the rounding of values to less precise values.

- What are examples of each?
- Section 3.2.2 skipped.

Example



https://fujifilm-x.com/en-us/wp-content/uploads/sites/11/2020/06/EXPOSURE_CENTER_8-bit-10-bit_Video-Colour.jpg

Section 3.3: RGB Color

- Colors are formed by blending three primary lights.
- Why is it not RYB?

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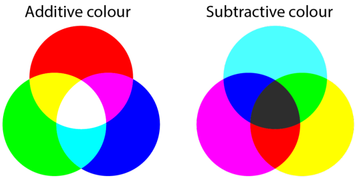
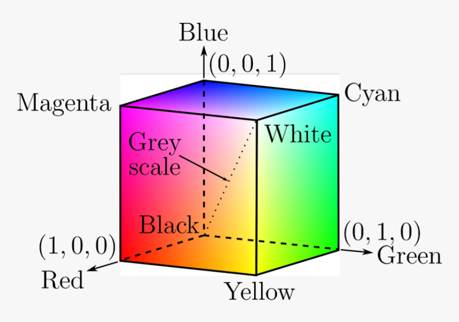
- Colors are formed by blending three primary lights.
- Why is it not RYB?
  - RYB are primary colors under subtractive color mixing.
  - RBG are primary colors under additive color mixing.



https://rmit.pressbooks.pub/app/uploads/sites/42/2022/10/additivesubtractivecolour-1024x524.png

Color cube

- What if RBG is thought of as a 3D Cartesian coordinate system:



https://www.pngitem.com/pimgs/m/592-5920896_rgb-color-model-cube-hd-png-download.png

- How to determine the number of possible levels each primary color has in RGB color system?

$$possibleLevels(n) = 2^{\frac{n}{3}}$$

  where n is the number of color bits of the system.
- Example:
  How many possible color levels does each primary color have in a 24-bit RGB color system?

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- Example:
How many possible color levels does each primary color have in a 24-bit RGB color system?

$$possibleLevels(24) = 2^{\frac{24}{3}}$$

$$= 2^8$$

$$= 256$$

Section 3.4: Alpha Compositing

Compositing

Effect caused by having two images overlapping each other.

- The possible use cases for compositing and their effect on the background pixel:

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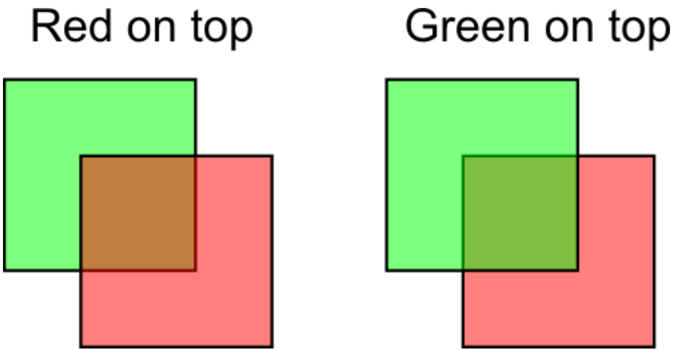
Compositing

Effect caused by having two images overlapping each other.

- The possible use cases for compositing and their effect on the background pixel:
  1. Opaque foreground pixels
     - Replaces background pixel.
  2. Entirely transparent foreground pixels
     - Do not change the background pixel.
  3. Partially transparent foreground pixels
     - Blending of foreground and background pixel colors.

Example



https://i.stack.imgur.com/8rWZ5.png

Pixel blending

- In order to blend pixel colors the following equation is used:

$$c = \alpha c_f + (1 - \alpha) c_b$$

  where:
  - c is the resultant color
  - c_f is the color of the foreground pixel
  - c_b is the color of the background pixel
  - α is the fraction of the image covered by the foreground layer.
    - Think of this as the translucency of the foreground pixel.
- Fun examples:
  `https://ciechanow.ski/alpha-compositing/`

Alpha channel

- The possible ways to store the alpha value of each pixel:
  1. As a separate grey-scale image.
  2. A fourth channel on the RGB system which is known as RGBA.
- Modifying the *possibleLevels* function to account for alpha values gives:

$$possibleLevelsAlpha(n) = 2^{\frac{n}{4}}$$

Visual Example

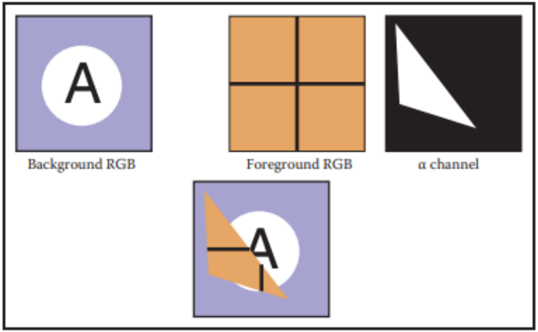


Figure 3.14. An example of compositing using Equation (3.2). The foreground image is in effect cropped by the α channel before being put on top of the background image. The resulting composite is shown on the bottom.

Calculation Example

Assume the foreground pixel has the color cyan $\begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix}$ and the background pixel has the color yellow $\begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix}$. Assume the pixel coverage is 0.3 what would the resultant color be?

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$$= \begin{bmatrix}0.7\\1\\0\end{bmatrix}$$

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Lossless

No information is lost during the compression of lossless formats.

Lossy

Information is unrecoverably lost during compression of lossy formats.

- Examples of file formats:

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- Examples of file formats:
  1. JPEG
  2. TIFF
  3. PPM
  4. PNG

- Note for the homework assignment you will need to be able to take a screenshot of the current image displayed to screen.
- This involves using a function like `glReadPixels` to retrieve all the rendered pixels.
- You will also need to investigate a file format other than ppm in which you will save the images.
- This involves reading the standard for the file format typical in the same fashion as one would find the RFC for networking protocols.

Any questions?

Joke of the day - By ChatGPT

Why did the RGB values go to therapy?

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Why did the RGB values go to therapy?

Because they couldn't agree on which color space to be in—they were feeling blue, green, and red all at once!