CSE4203: Computer Graphics

Lecture – 2

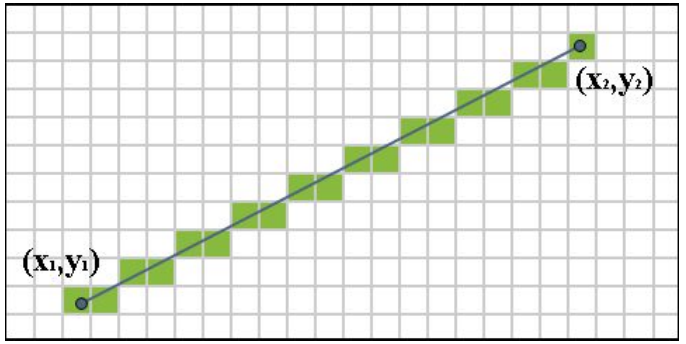
Raster Graphics

Outline

- Raster and Raster Images
- Image Compression
- Display Devices
- Pixel Values
- RGB Color
- Alpha Compositing

Raster (1/1)

- Most computer graphics images are presented on *raster display*.
  - i.e. television
  - has rectangular array of small light-emitting **pixels**
    - individually set to different colors to create desired image.

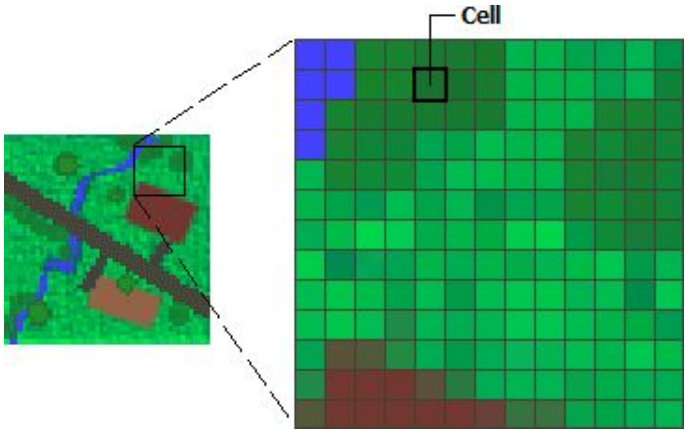


Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/
Image source: https://commons.wikimedia.org/wiki/File:Bresenham_line.png

Image Source: Internet

Storing Images (1/2)

- Raster Image:
  - used to store and process images, as rasters are common in devices
    - simply a **2D array**
    - stores the pixel value foreach pixel
    - usually a color stored as **three numbers (r, g, b)**



Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/
Image source: https://desktop.arcgis.com/en/arcmap/10.3/manage-data/raster-and-images/what-is-raster-data.htm

Image Source: Internet

Storing Images (2/2)

- Raster Image:
  - Considered as device-independent of the image to be displayed
  - Resolution Dependent i.e quality are measured using number of pixels per unit such as DPI
  - Resizing can result quality degradation
  - Common formats are JPEG, PNG, BMP

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Image source: https://desktop.arcgis.com/en/arcmap/10.3/manage-data/raster-and-images/what-is-raster-data.htm

Image Source: Internet

Image Compression (1/4)

- Image compression is a method used to reduce the size of images,
- Improves the rendering speed with reduced file size
- 2 methods of compression:
  - Lossless Compression
  - Lossy Compression

Credit: Lossy vs Lossless Compression: Differences & Advantages | Adobe

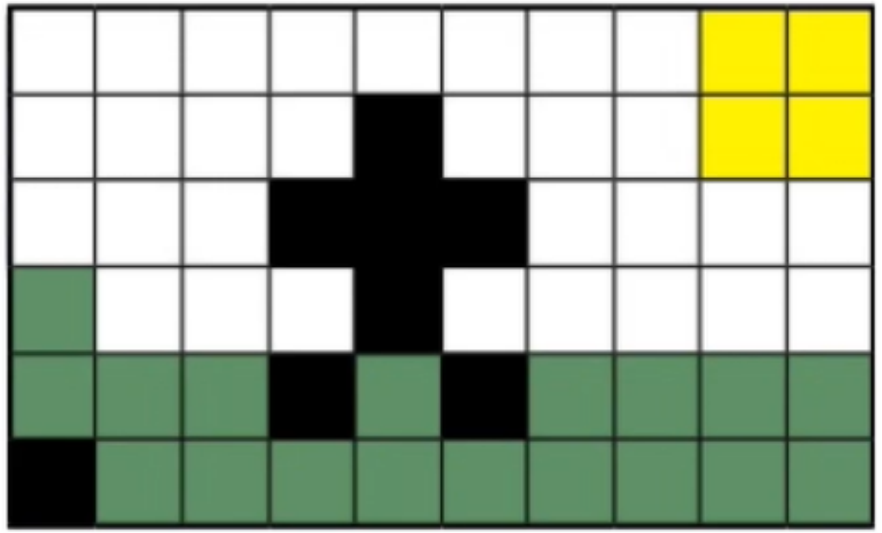
Image Compression (2/4)

Lossless Compression

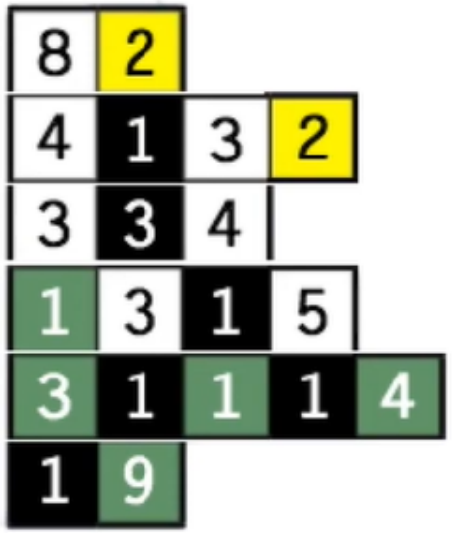
- Don’t impact the image quality
- Only removes additional, non-essential data automatically added by the device used to take the photo
- No significant reduction in file size
- Lossless Compression algorithms: Run-length encoding, Huffman coding
- Lossless formats are .RAW, .BMP, .GIF, and .PNG

Credit: Lossy vs Lossless Compression: Differences & Advantages | Adobe

How Run-Length Encoding (RLE) Works



This can be stored as data pairs for example



8W2Y
4W1B3W2Y
3W3B4W
1G3W1B5W
3G1B1G1B4G
1B9G

Credit: https://www.youtube.com/watch?v=cAAeSn8_aCU&ab_channel=MizComputing

Image Compression (3/4)

Lossy Compression

- Reduces the file size considerably by removing image data
- Quality might degrade
- This process is irreversible - can’t get back to the original file
- Common algorithms - discrete wavelet transform, fractal compression, transform encryption etc.
- Lossy format; JPEG, MPEG, AVC

Credit: Lossy vs Lossless Compression: Differences & Advantages | Adobe

Image Compression (4/4)

Image Source: Internet

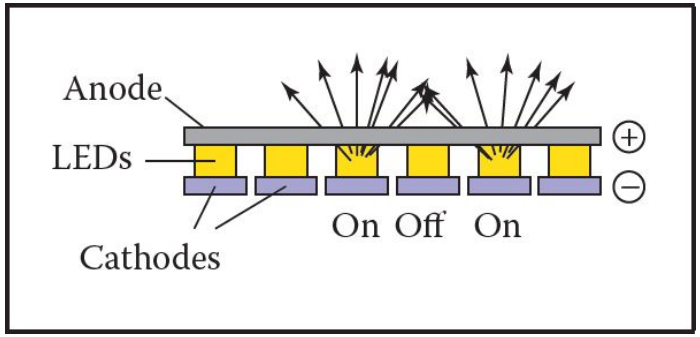
Display Devices (1/1)

- Transmissive Displays:
  - require a light source to illuminate them
  - backlight behind the array
    - i.e. in a projector, a lamp emits light projected onto the screen after passing through the array.
- Emissive Display:
  - it is its own light source.

Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

Emissive Displays (1/2)

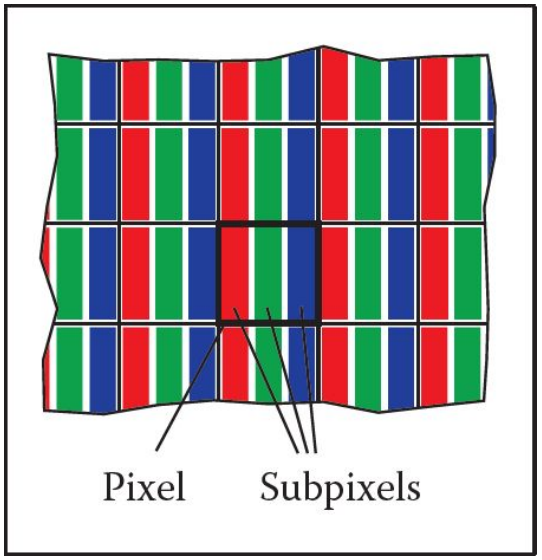
- Emissive Displays:
  - Example: light-emitting diode (LED)
  - Each pixel is composed of one or more LEDs (semiconductor devices)
    - emit light with intensity ↔ electrical current passing through them



Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

Emissive Displays (2/2)

- Sub-pixel:
  - Pixels divided into three independently controlled sub-pixels (R, G, B)
    - each with own LED (different materials)
    - emit light of different colors



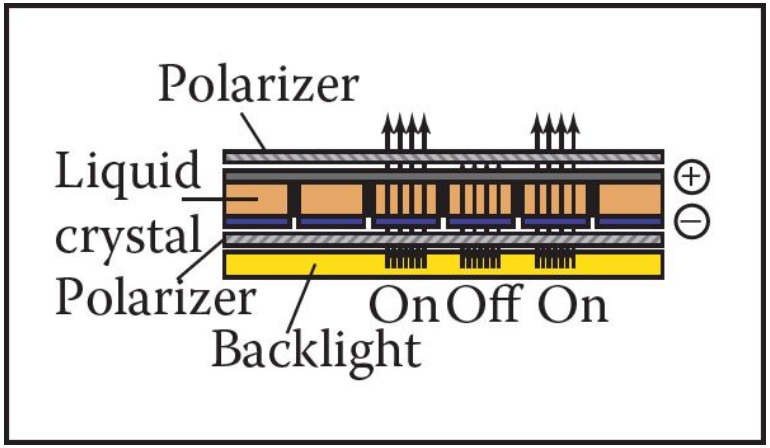
Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

Transmissive Displays (1/3)

- Transmissive Displays:
  - Example: light crystal display (LCD)

– Molecular structure of liquid crystal rotates the polarization of light that passes through it

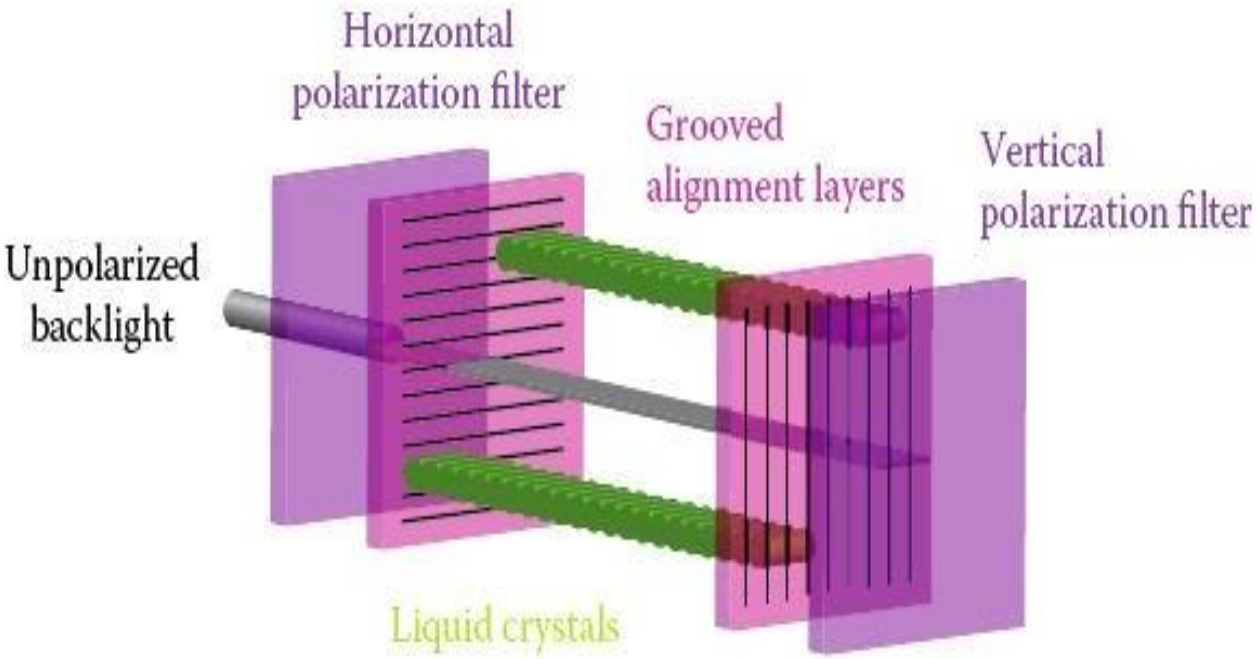
– LCDs also have sub-pixels.



Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

Transmissive Displays (2/3)

- Degree of rotation ↔ applied voltage

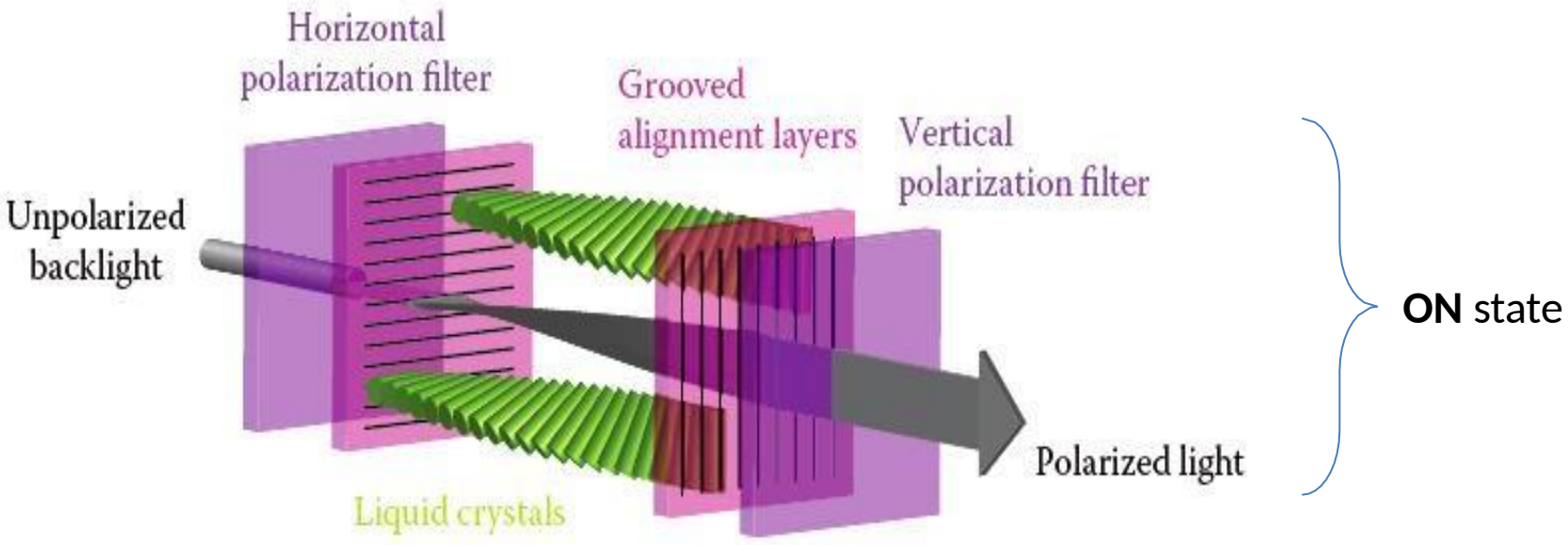


OFF state

Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

Transmissive Displays (2/3)

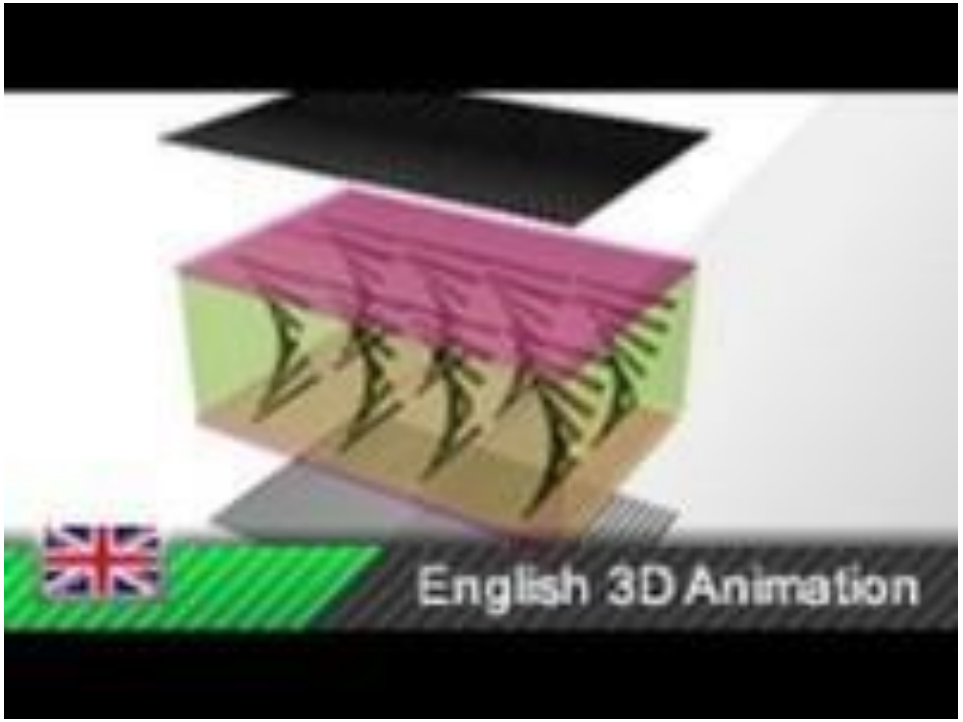
- Degree of rotation ↔ applied voltage



Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

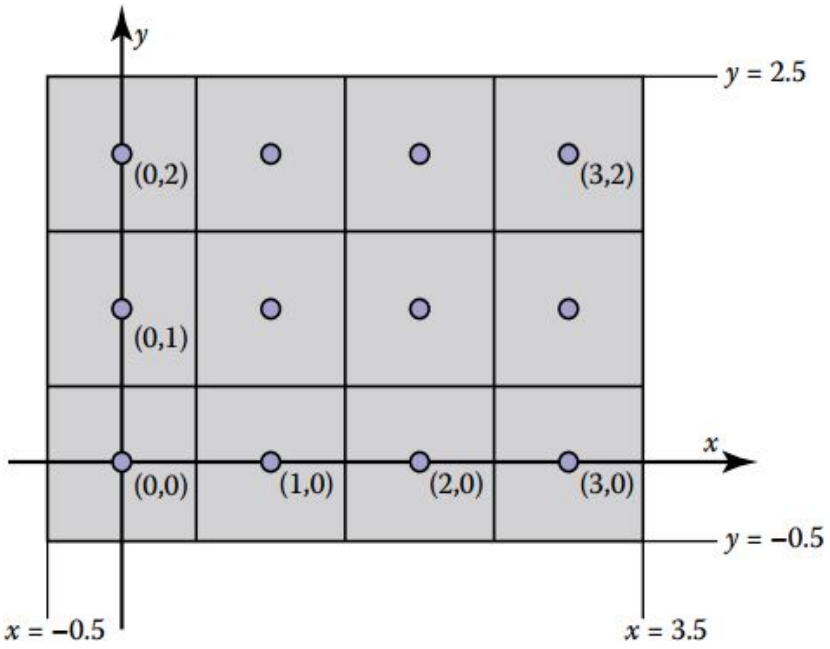
Transmissive Displays (3/3)

youtu.be/k7xGQKpQAWw?t=77



Pixel Values (1/1)

- Coordinate system for raster screen:
  - Convention:



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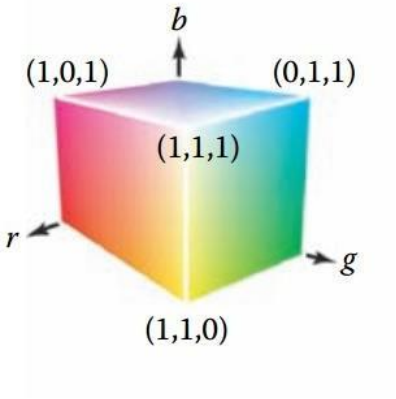
RGB Color (1/1)

black = (0, 0, 0), red = (1, 0, 0), green = (0, 1, 0),
blue = (0, 0, 1), yellow = (1, 1, 0), magenta = (1, 0, 1),
cyan = (0, 1, 1), white = (1, 1, 1)



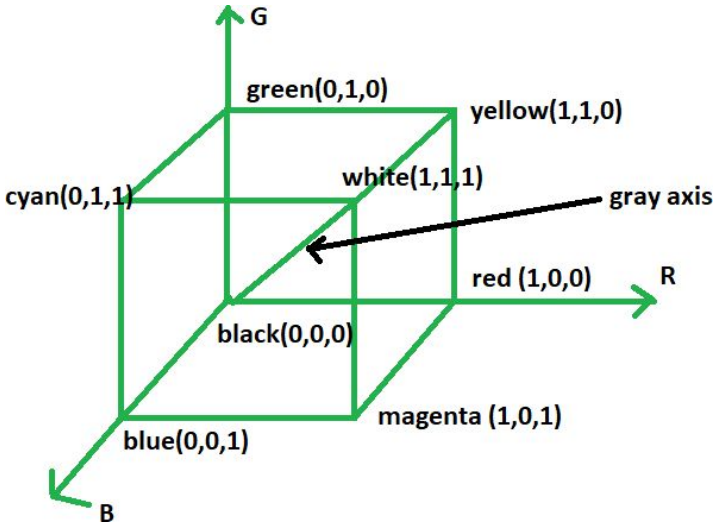
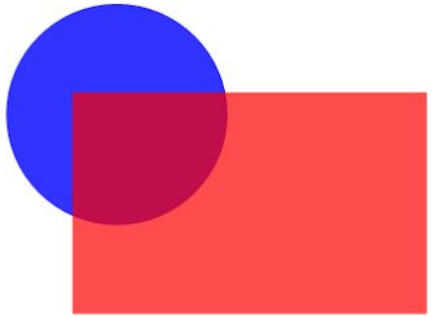


Image Source: https://www.geeksforgeeks.org/computer-graphics-the-rgb-color-model/

Alpha Compositing (1/3)

- Partially overwriting the contents of a pixel.
  - Where we have a background and want to insert a foreground image over it.
    - Transparent
    - Opaque (not transparent)
    - Partially Transparent



Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/
Image source: http://www.graphicalweb.org/2005/papers/abstractsvgopen/index.html

Image Source: Internet

Alpha Compositing (2/3)

- foreground and background must be blended.

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

- α = Fraction of the pixel covered by the foreground layer

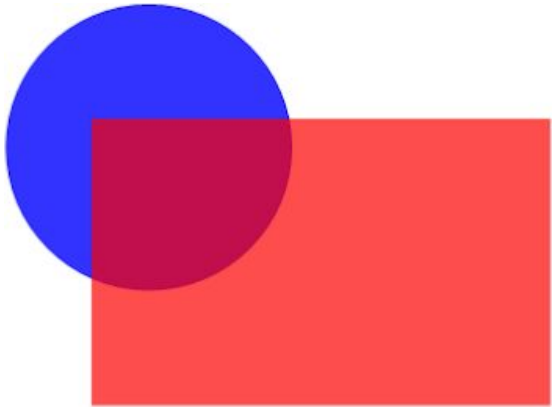


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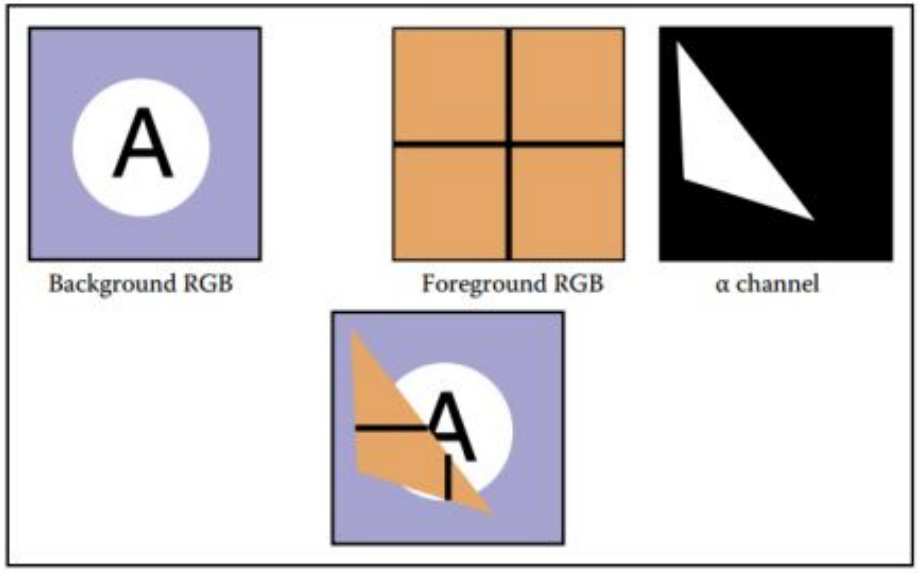
Image source: http://www.graphicalweb.org/2005/papers/abstractsvgopen/index.html

Alpha Compositing (3/3)

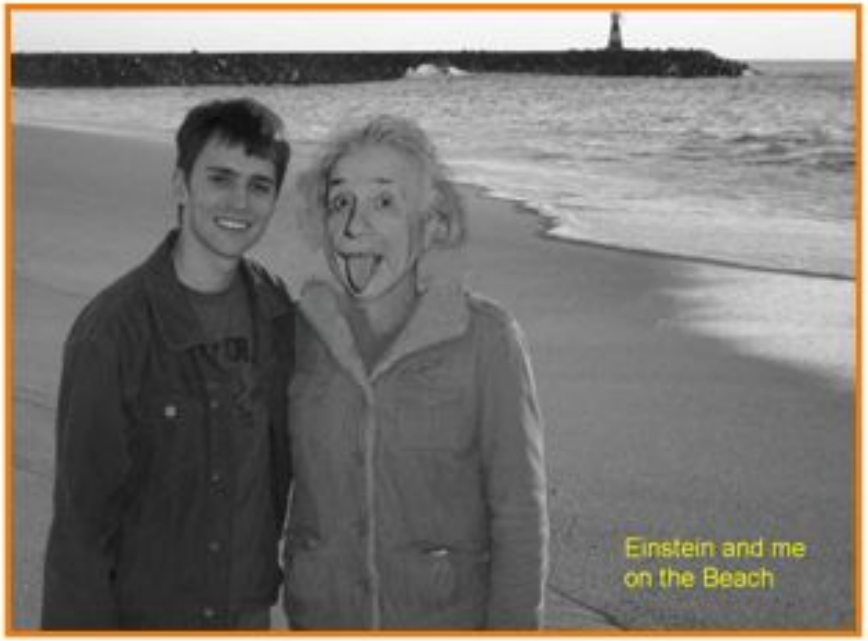
- Alpha Mask:

  - The α values for all the pixels is stored in a separate gray scale image.



Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

What can you do with it? Get a photo with Einstein



Source: http://graphics.cs.cmu.edu/courses/15-463/2007_fall/Lectures/blending.pdf

What can you do with it? Horror Photo!!

Source: http://graphics.cs.cmu.edu/courses/15-463/2007_fall/Lectures/blending.pdf

Practice Question 1

- Given that, C_f = 1.0, C_b = 0.5 and C = 0.8, where, C_f, C_b and C are the foreground, background and composite intensities respectively. Determine the alpha(α) value to perform alpha compositing.

Practice Question 2

Consider an image with resolution of 1500 x 1500. Each pixel in the image can hold up to 8 bit of data.

a) What is the file size of the image in MB?

b) If the image is compressed with a compression ration of 1.5. What is the file size of the compressed image?

Practice Question 2

Consider an image with resolution of 1500 x 1500. Each pixel in the image can hold up to 8 bit of data.

a) What is the file size of the image in MB?

Solution:

Total number of pixels in the image = 1500 x 1500 = 2250000

Each pixel can hold 8 bit data.

So, the size of the original image = 2250000 x 8 = 1800,0000 bits

= 18000,000 / 8 = bytes = 2250000 bytes = ?? MB

Practice Question 2

Consider an image with resolution of 1500 x 1500. Each pixel in the image can hold up to 8 bit of data.

b) If the image is compressed with a compression ration of 1.5. What is the file size of the compressed image?

Solution:

Compression ratio = original image size / compressed image size

Compressed image size = original image size / compression ratio

= 2.25 MB / 1.5 = 1.5 MB

Further Reading

- Fundamentals of Computer Graphics, 4th Edition - Chapter 3
- https://www.adobe.com/uk/creativecloud/photography/discover/lossy-vs-lossless.html

Thank You