COMP120: Creative Computing: Tinkering

1: Tinkering Graphics I

Learning Outcomes

By the end of this workshop, you should be able to:

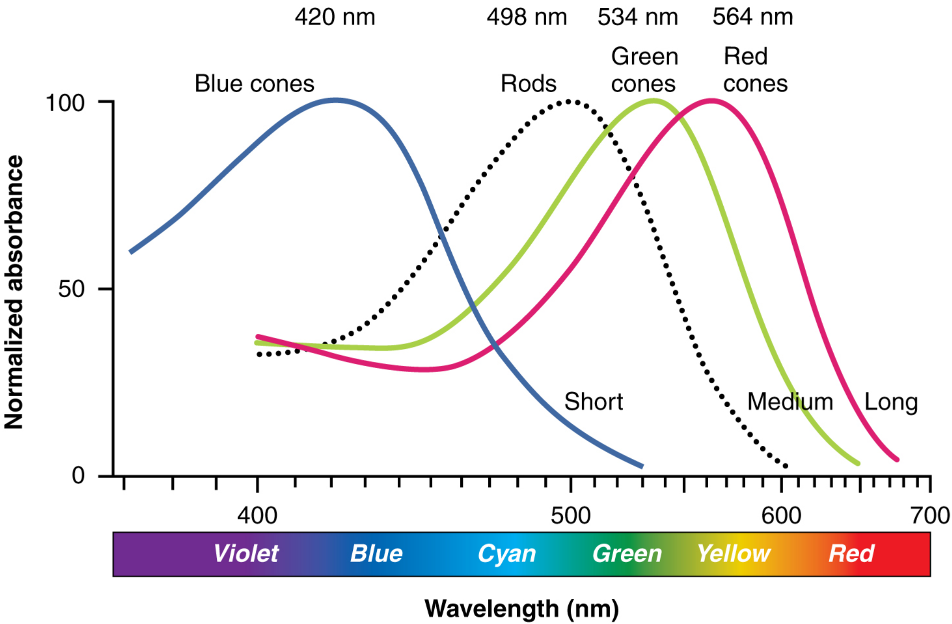
- **Explain how** pictures are digitised into raster images by a computer system
- **Apply** knowledge of colour models to **write** code that manipulates pixels in a surface
- **Use** functions, arguments, and basic data structures such as arrays

Light Perception

- Colour is continuous:
  - Visible light is in the wavelengths between 370nm and 730nm
  - i.e., 0.00000037 — 0.00000073 meters
- However, we *perceive* light around three particular peaks:
  - Blue peaks around 425nm
  - Green peaks around 550nm
  - Red peaks around 560nm

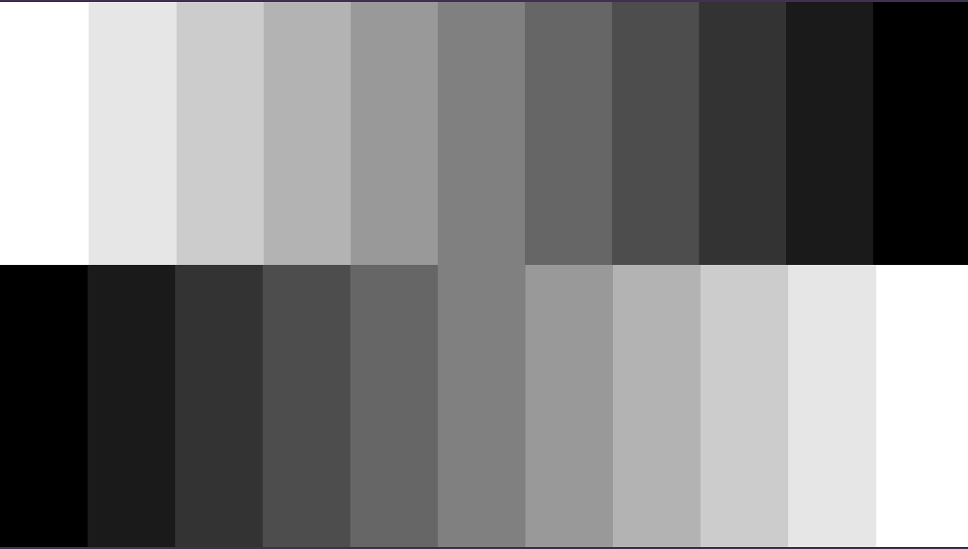
Light Perception

- Our eyes have three types of colour-sensitive photoreceptor cells called `cones' that respond to light wavelengths
- Our perception of colour is based on how much of each kind of sensor is responding
- An implication of this is perception overlap: we see two kinds of `orange' — one that's spectral and one that's combinatorial


420 nm
498 nm
534 nm
564 nm
Blue cones
Rods
Green cones
Red cones
100
50
0
Normalized absorbance
Short
Medium
Long
400
500
600
700
Violet
Blue
Cyan
Green
Yellow
Red
Wavelength (nm)

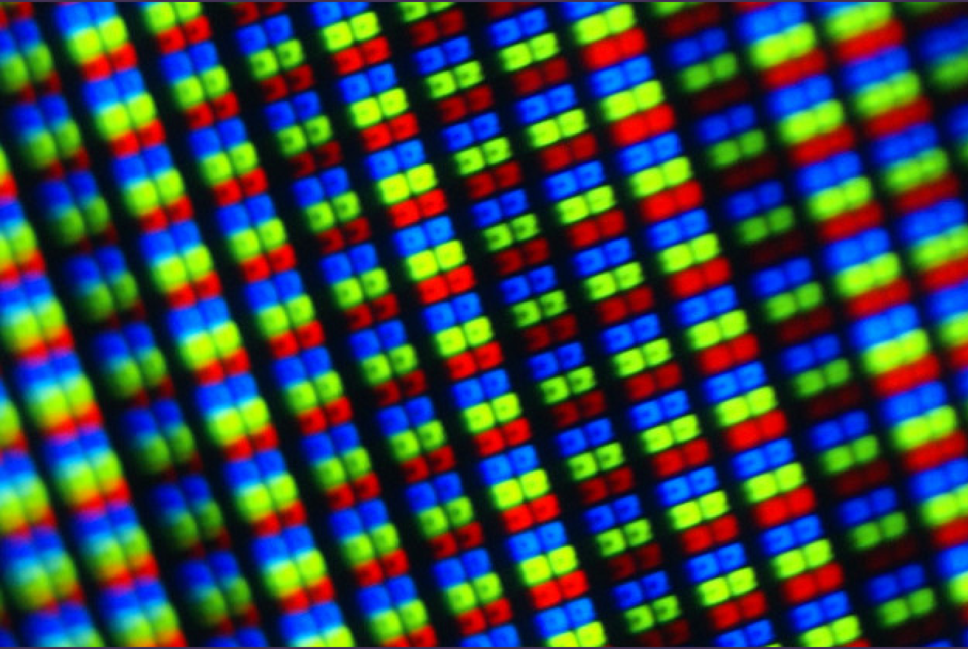
Luminance vs Colour

- Our eyes have another type of photoreceptor cells called 'rods' that respond to light intensity
- Our perception, however, is actually luminance: a relativistic contrast of *borders* of things (i.e., motion)
  - Luminance is *not* the amount of light, but our perception of the amount of light
  - Much of our luminance perception is based on comparison to background, not raw values
- An implication of this is perception overlap: we see blue as 'darker' than red when the intensity is actually the same



Resolution

- We have a limited number of rods and cones in our eyes
- This means humans perceive vision in a limited resolution — yet, we perceive vision as continuous
- We take advantage of this human characteristic in computer monitors



Pixels

- We digitize pictures into many little dots
- Enough dots and it looks like a continuous whole to our eye
- Each element is referred to as a *pixel*

Pixels

Pixels must have:

- a color
- a position

Pictures and Surfaces

A picture is a *matrix* of pixels

- It is not a continuous line of elements, that is, a one-dimensional *array*
- A picture has two dimensions: width and height
- It's a two-dimensional *array*

0	1	2	3
15	12	13	10

	0	1	2	3
0	15	12	13	10
1	9	7	2	1
2	6	3	9	10

Pictures and Surfaces

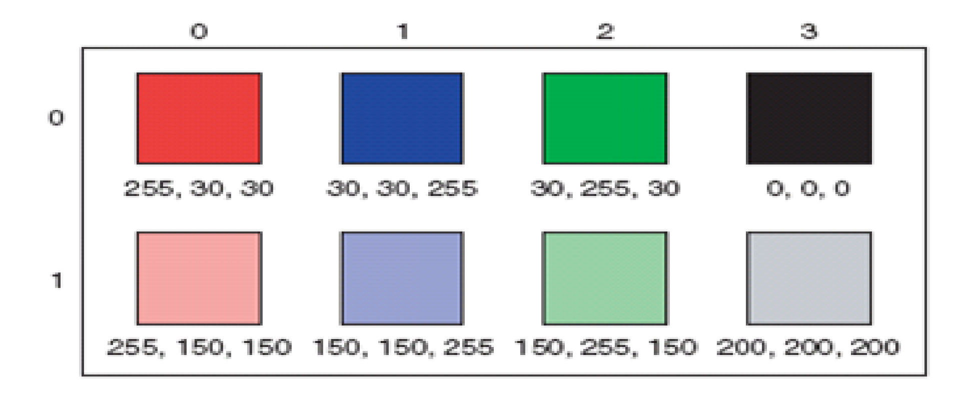
- (x, y) —or— (horizontal, vertical)
- (1,0) = 12
- (0, 2) = 6

Encoding Colour

- Each element in the matrix is a pixel, with the matrix defining its position and the value defining its colour
- Computer memory stores numbers, so colour must be encoded into a number:
  - CMYK = cyan, magenta, yellow, black
  - HSB = hue, saturation, brightness
  - RGBA = red, green, blue, alpha (transparency)
- By default, PyGame uses RGBA

Encoding RGB

- Each component color (red, green, and blue) is encoded as a single byte
- Colors go from `(0,0,0)` to `(255,255,255)`:
  - If all three components are the same, the colour is in grey-scale
  - `(0,0,0)` is black
  - `(255, 255, 255)` is white
- Why `255`?


0
1
2
3
0
255, 30, 30
30, 30, 255
30, 255, 30
0, 0, 0
1
255, 150, 150
150, 150, 255
150, 255, 150
200, 200, 200

Encoding Bits

- If we have one bit, we can represent two patterns:
  - 0
  - 1
- If we have two bits, we can represent two patterns:
  - 00
  - 01
  - 10
  - 11
- As a general rule: In n bits, we can have 2^n patterns
- One of these patterns will be 0, so the highest value we can represent is: $2^8 - 1$, or 255

Encoding Bits

- RGB uses 24-bit color (i.e., $3 * 8 = 24$)
  - That's 16,777,216 (224) possible colours
  - Our eyes cannot discern many colours beyond this
  - The big issue is the monitor: they can`t reliably reproduce 16 million colours
- RGBA uses 32-bit colour
  - No additional colour, but offers support for transparency

Encoding Bits

- Use this information to estimate the size of a bitmap:
  - 320x240x24 = 230,400 bytes
  - 640x480x32 = 1,228,800 bytes
  - 1024x768x32 = 3,145,728 bytes
- Why do we have smaller numbers here?

Activity #1

In pairs:

- Setup a basic project in PyGame
- Refer to the following documentation
  - `www.pygame.org/docs/ref/surface.html`
  - `www.pygame.org/docs/ref/pixelarray.html`
- Manipulate the pixels in a surface using PixelArray

Make a Picture Less Red

```
def decreaseRed(pict):
  pixelMatrix = getPixels(pict)
  for pixel in pixelMatrix:
    value = getRed(pixel)
    setRedPixel(pixel, value * 0.5)
```

Note: This source code excerpt will not work in PyGame.

Activity #2

In pairs:

- Define a function that turns all of the red values of pixels into blue values...
- ...and all of the blue values into red values

Swap Channels

```
def swapRedBlueChannels(pict):
  pixelMatrix = getPixels(pict)
  for pixel in pixelMatrix:
    red_value = getRed(pixel)
    blue_value = getBlue(pixel)
    setRedPixel(pixel, blue_value)
    setBluePixel(pixel, red_value)
```

Note: This source code excerpt will not work in PyGame.

Activity #3

In pairs:

- Refer to the following documentation:
  - `//www.pygame.org/docs/ref/image.html`
- Define a function that loads an image and turns it to greyscale

Make a Picture Grey-scale

```
def loadGrayscale(file):
  pixelMatrix = getPixels(makePicture(file))
  for pixel in pixelMatrix:
    red = getRed(p)
    green = getGreen(p)
    blue = getBlue(p)

    pixelValue = (red+green+blue)/3

    setRedPixel(pixel,pixelValue)
    setGreenPixel(pixel, pixelValue)
    setBluePixel(pixel, pixelValue)
```

Note: This source code excerpt will not work in PyGame.

Activity #4

In pairs:

- Refer to the following documentation:
  - `//www.pygame.org/docs/ref/image.html`
- Define a function that loads an image and turns it to its negative

Make a Picture Negative

```
def neg(picture):
  pixelMatrix = getPixels(makePicture(file))
  for pixel in pixelMatrix:
    red = getRed(p)
    green = getGreen(p)
    blue = getBlue(p)

    setRedPixel(pixel,255-red)
    setGreenPixel(pixel, 255-green)
    setBluePixel(pixel, 255-blue)
```

Note: This source code excerpt will not work in PyGame.

Activity #5

In pairs:

- Refer to the following documentation:
  - `//www.pygame.org/docs/ref/time.html`
- Define a function that loads an image and animates a sunset

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Decrease Luminance Over Time

```
def decreaseRed(picture, amount):
  for p in getPixels(picture):
    value=getRed(p)
    setRed(p,value*amount)

amount = 0.1 #tinker with this value
wait_time = 50 #tinker with this value

for i in range(10):
  decreaseRed(picture, amount)
  decreaseGreen(picture, amount)
  decreaseBlue(picture, amount)
  wait(50)
```

Note: This source code excerpt will not work in PyGame.

Activity #6

In pairs:

- Refer to the following documentation:
  - `https://docs.python.org/2/tutorial/introduction.html#lists`
- Define a function that animates copying the top half of a picture to its bottom half

Copying Part of a Picture

```
def copyHalf(picture):
 pixels = getPixels(picture)
 for index in range(0,len(pixels)/2):
   sourcePixel = pixels[index]
   sourceRGBValue = getColor(sourcePixel)
   destinationPixel = pixels[index + len(pixels)/2]
   setColor(destinationPixel,sourceRGBValue)
 repaint(picture)
```

Note: This source code excerpt will not work in PyGame.