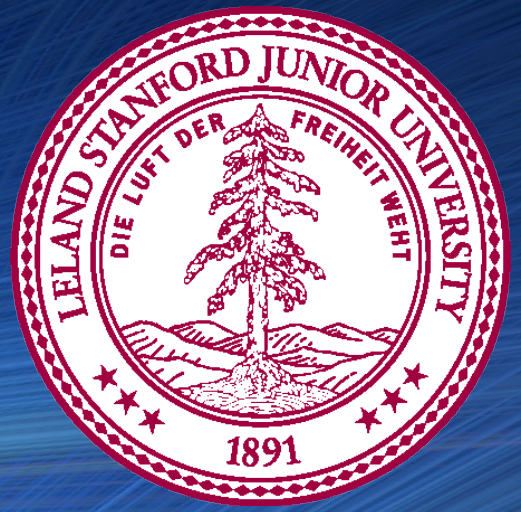

Images

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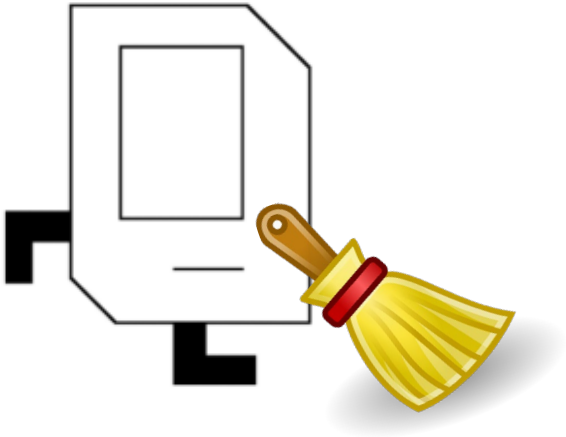
CS106A, Stanford University

Housekeeping



- Welcome Stanford Admits!

- Handout: Image Reference Guide
  - Posted under “Course” tab on class website
  - We'll be talking through a lot of that today

Review of Lists

Lists as Parameters

- When you pass a list as a parameter you are passing a reference to the actual list
  - It's like getting a URL to the list (*pass-by-reference*)
  - In function, changes to values in list persist after function ends

```
def add_five(num_list):
    for i in range(len(num_list)):
        num_list[i] += 5

def main():
    values = [5, 6, 7, 8]
    add_five(values)
    print(values)
```

Output

```
[10, 11, 12, 13]
```

When Passed as Parameters

Types that are "immutable"	Types that are "mutable"

`int`
`float`
`bool`
`string`
	`list`
	`Canvas`
	(we'll see more soon)

• When you assign new value to variable, you are assigning URL for variable (name of variable) to a new value. • For parameters, the original variable value you passed in is **not** changed when function is done.	• When you are changing the variable *in place*, the URL does not change, but the value pointed to by the URL does. • For parameters, it means original variable value you passed in **is** changed when function is done.

More on Lists as Parameters

- But, watch out if you create a new list in a function
  - Creating a new list means you're no longer dealing with list passed in as parameter.
  - It's like the URL you are using is pointing to a different page. (You have assigned the luggage tag to a new value in function.)
  - At that point you are no longer changing parameter passed in

```
def create_new_list(num_list):
    num_list.append(9)
    num_list = [1, 2, 3]

def main():
    values = [5, 6, 7, 8]
    create_new_list(values)
    print(values)
```

Output `[5, 6, 7, 8, 9]`

Note on Loops and Lists

```
list = [10, 20, 30]
```

- For loop using **`range`**:

```
for i in range(len(list)):
    list[i] += 1  # Modifying list in place
```

- For-each loop:

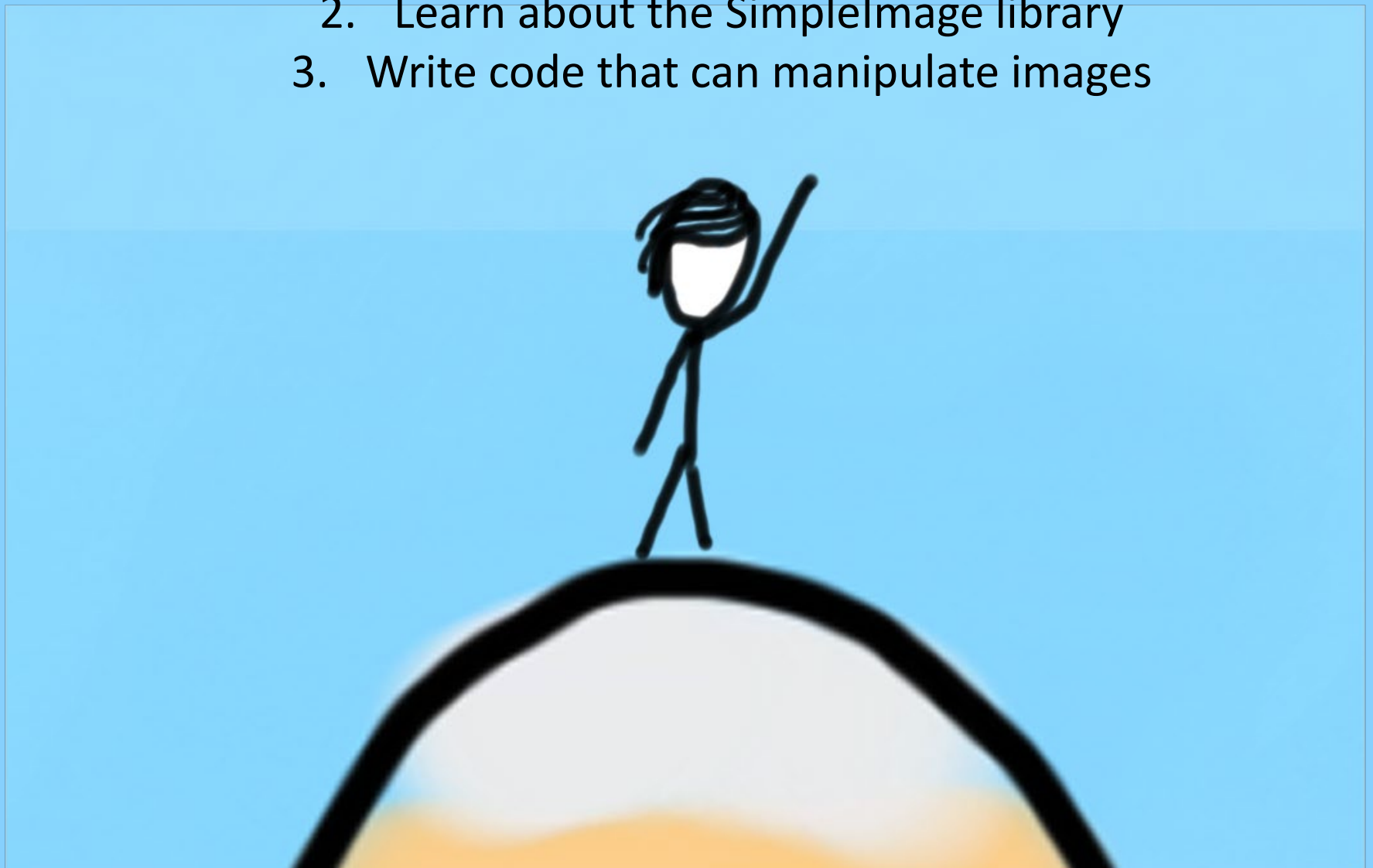
```
for elem in list: # Modifying local variable
    elem += 1     # elem. If elem is immutable
                  # type, not changing list!
```

- Often use for loop with range when *modifying* elements of list (when elements are *immutable types*)
- Often use for-each loop when ***not*** *modifying* elements of list or when elements are *mutable* types

Putting it all together: averagescores.py

Learning Goals: Images

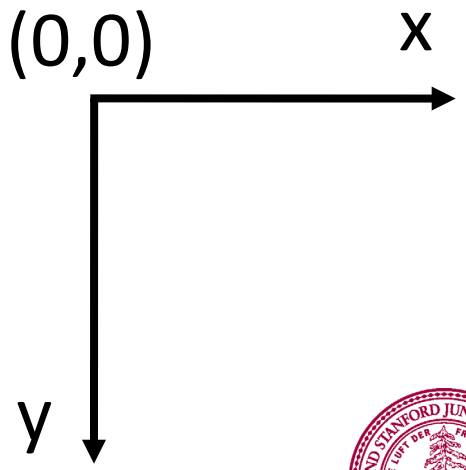
1. Understand how images are represented
2. Learn about the SimpleImage library
3. Write code that can manipulate images



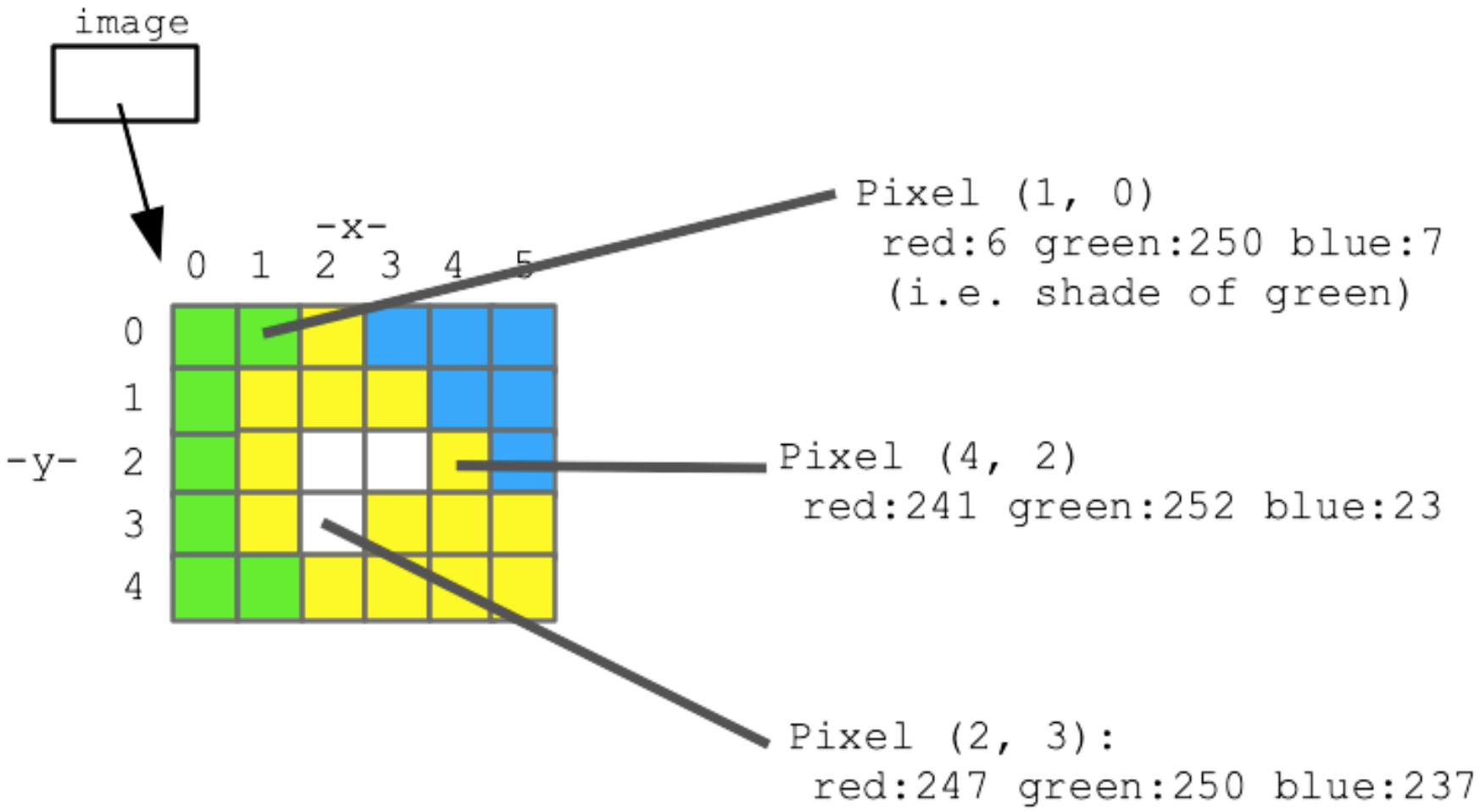
Images

What is an Image?

- Image made of square pixels
  - Example: flower.png
- Each pixel has x and y coordinates in the image
  - The origin (0, 0) is at the upper-left corner
  - y **increases** going down, x increases going right
- Each pixel has single color encoded as 3 **RGB** values
  - R = red; G = green; B = blue
  - Each value represents brightness for that color (red, green, or blue)
  - Can set RGB values to make any color!



Pixels in an Image Close-Up



Working with Images: Pillow and the SimpleImage library

Installing Pillow

- Pillow is a version of the Python Imaging Library (PIL)
  - Nick Parlante built SimpleImage library using Pillow
  - You'll be using SimpleImage in this class
  - So, you need to install Pillow first
- To install Pillow, open PyCharm Terminal tab and type (note the capital **`P`** in **`Pillow`**):
  - On a PC: **`py -m pip install Pillow`**
  - On a Mac: **`python3 -m pip install Pillow`**
  - Will see something like:

    ...bunch of stuff...

    `Successfully installed Pillow-10.3.0`
- Handout: Image Reference Guide contains more information

Using SimpleImage Library

- In folders for assignment or lecture on images, there is a file **`simpleimage.py`**
  - This is the SimpleImage library
- To use the SimpleImage library in your code, include at the top of your program file:

```
from simpleimage import SimpleImage
```

- This is importing the SimpleImage module, so that it is accessible in the code you write
  - Similar to when you used **`import random`** to use random number generator library

Functions in SimpleImage Library

- Create a SimpleImage object by reading an image from file (jpg, png, gif, etc.) and store it in a variable.
  - Note: each SimpleImage object is made up of Pixel objects

```
my_image = SimpleImage(filename)
```

- Show the image on your computer.

```
my_image.show()
```

- We can manipulate an image by changing its pixels
- We can also create new images and set its pixels

Accessing Pixels in an Image

- We can use a "for-each" loop to access pixel in an image
- Recall basic `for` loop (using `range`):

```
for i in range(num):
    # i will go from 0 to num - 1
    do_something()
```

- For-each loop:

```
for item in collection:
    # Do something with item
```

- For-each loop with image:

```
image = SimpleImage("flower.jpg")
for pixel in image:
    # Do something with pixel
```

For-Each Loop Over Pixels

```
image = SimpleImage("flower.jpg")
for pixel in image:
    # Body of loop
    # Do something with pixel
```

This code gets repeated once for each pixel in image

- Like variable `i` in `for` loop using `range()`, `pixel` is a variable that gets updated with each loop iteration.
- `pixel` gets assigned to each pixel object in the image in turn.

Properties of Images and Pixels

- Each SimpleImage image has properties you can access:
  - Can get the width and height of image (values are in pixels)

    `image.width`, `image.height`

- Each pixel in an image also has properties:
  - Can get x, y coordinates of a pixel in an image

    `pixel.x` , `pixel.y`

  - Can get RGB values of a pixel

    `pixel.red`, `pixel.green`, `pixel.blue`

    - These are just integers between 0 and 255
    - Higher R, G, or B values means more of that color in pixel
  - Pixels are **mutable** objects!
  - Can **set** pixel RGB values in an image to change it!

Example: A Darker Image

```
def darker(image):
    """
    Makes image passed in darker by halving red, green, blue
    values. Note: changes in image persist after function ends.
    Demonstrate looping over all the pixels of an image,
    changing each pixel to be half its original intensity.
    """
    for pixel in image:
        pixel.red = pixel.red // 2
        pixel.green = pixel.green // 2
        pixel.blue = pixel.blue // 2


def main():
    flower = SimpleImage('images/flower.png')
    darker(flower)
    flower.show()
```

Image objects are mutable (like lists). If you change one in a function, the changes persist after function ends.

Example: Get Red Channel

```
def red_channel(filename):
    """
    Reads image from file specified by filename.
    Changes the image as follows:
    For every pixel, set green and blue values to 0
    yielding the red channel.
    Return the changed image.
    """
    image = SimpleImage(filename)
    for pixel in image:
        pixel.green = 0
        pixel.blue = 0
    return image
```

Example: Grayscale

```
def compute_luminosity(red, green, blue):
    """
    Calculates luminosity of a pixel using NTSC formula.
    """
    return (0.299 * red) + (0.587 * green) + (0.114 * blue)


def grayscale(filename):
    """
    Read image from file specified by filename. Change image to
    grayscale using the NTSC luminosity formula and return it.
    """
    image = SimpleImage(filename)
    for pixel in image:
        lum = compute_luminosity(pixel.red, pixel.green, pixel.blue)
        pixel.red = lum
        pixel.green = lum
        pixel.blue = lum
    return image
```

Let's take it out for a spin!

imageexamples.py

Greenscreening

What is Greenscreening?

- Like the movies (and Zoom backgrounds)
  - Have original image with areas that are "sufficiently green."
  - Replace "green" pixels with pixels from corresponding x, y locations in another image

What is Greenscreening?

- Like the movies (and Zoom backgrounds)
  - Have original image with areas that are "sufficiently green."
  - Replace "green" pixels with pixels from corresponding x, y locations in another image

```
INTENSITY_THRESHOLD = 1.6

def greenscreen(main_filename, back_filename):
    image = SimpleImage(main_filename)
    back = SimpleImage(back_filename)
```

What is Greenscreening?

- Like the movies (and Zoom backgrounds)
  - Have original image with areas that are "sufficiently green."
  - Replace "green" pixels with pixels from corresponding x, y locations in another image

```
INTENSITY_THRESHOLD = 1.6

def greenscreen(main_filename, back_filename):
    image = SimpleImage(main_filename)
    back = SimpleImage(back_filename)
    for pixel in image:
```

What is Greenscreening?

- Like the movies (and Zoom backgrounds)
  - Have original image with areas that are "sufficiently green."
  - Replace "green" pixels with pixels from corresponding x, y locations in another image

```
INTENSITY_THRESHOLD = 1.6

def greenscreen(main_filename, back_filename):
    image = SimpleImage(main_filename)
    back = SimpleImage(back_filename)
    for pixel in image:
        average = (pixel.red + pixel.green + pixel.blue) // 3
        # See if this pixel is "sufficiently" green
        if pixel.green >= average * INTENSITY_THRESHOLD:
```

What is Greenscreening?

- Like the movies (and Zoom backgrounds)
  - Have original image with areas that are "sufficiently green."
  - Replace "green" pixels with pixels from corresponding x, y locations in another image

```
INTENSITY_THRESHOLD = 1.6

def greenscreen(main_filename, back_filename):
    image = SimpleImage(main_filename)
    back = SimpleImage(back_filename)
    for pixel in image:
        average = (pixel.red + pixel.green + pixel.blue) // 3
        # See if this pixel is "sufficiently" green
        if pixel.green >= average * INTENSITY_THRESHOLD:
            # If so, overwrite pixel in original image with
            # corresponding pixel from the back image.
            x = pixel.x
            y = pixel.y
            image.set_pixel(x, y, back.get_pixel(x, y))
    return image
```

Let's try it!
(But using red instead of green)

Learning Goals

1. Understand how images are represented
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