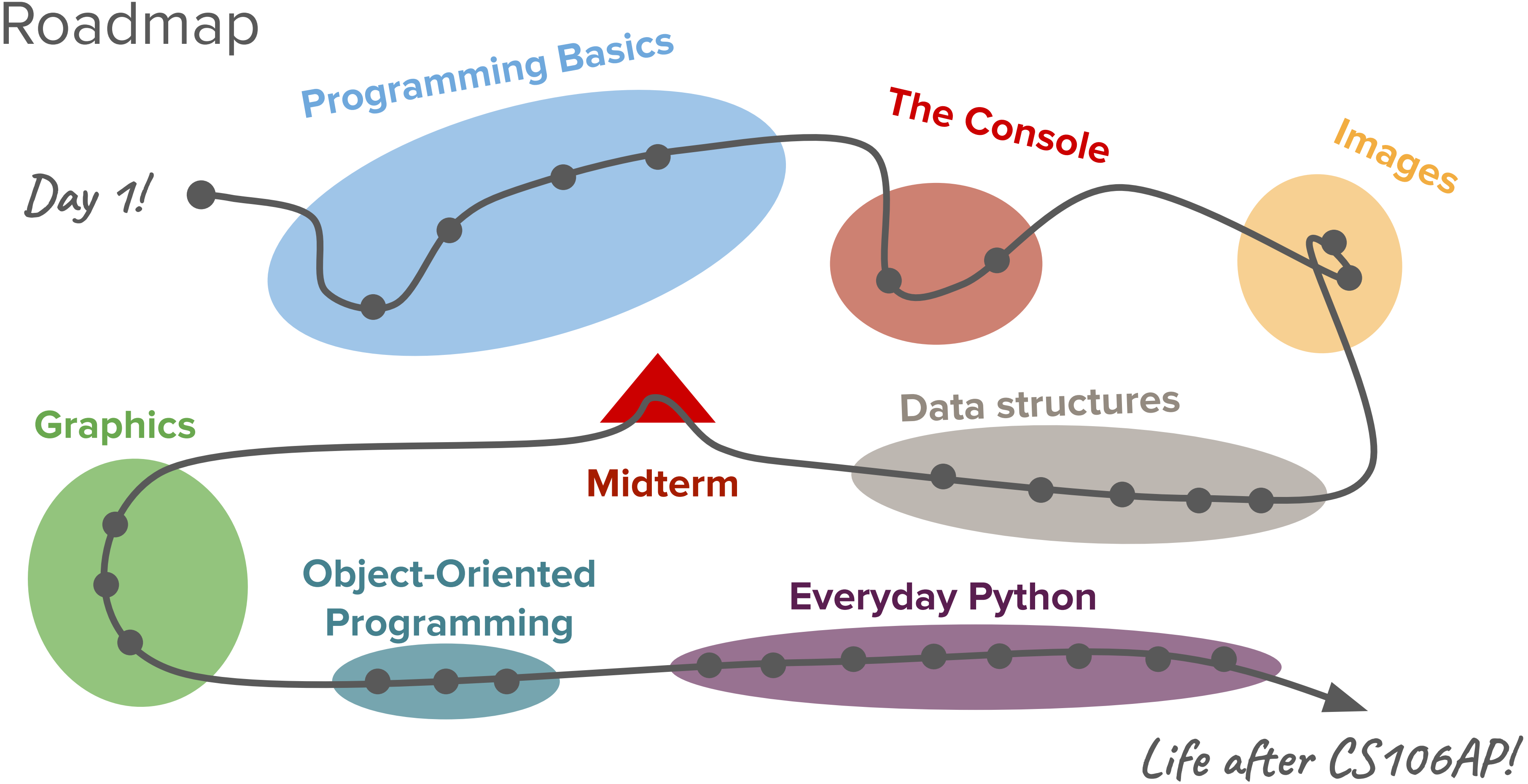
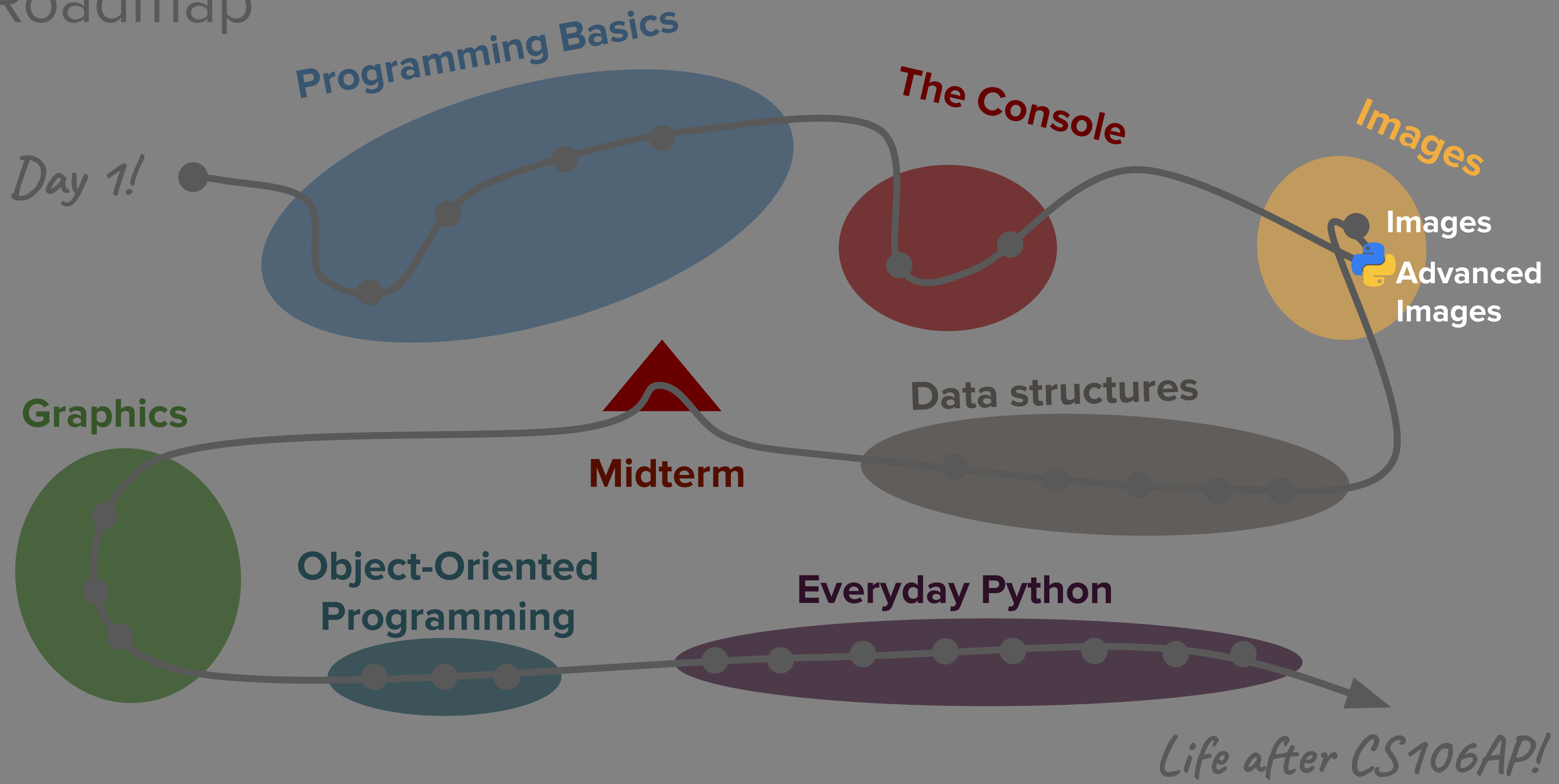
Images (Part 2)

CS106AP Lecture 9

Roadmap


Day 1!
Programming Basics
The Console
Images
Data structures
Midterm
Graphics
Object-Oriented Programming
Everyday Python
Life after CS106AP!

Roadmap


Day 1!
Programming Basics
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Advanced Images
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Today’s questions

How can we manipulate images beyond changing color?

What does it mean for code to be “readable”?

Today's topics

1. Review
2. Advanced image manipulation
3. An exercise in style
4. Nested for loops
   (more image manipulation)
5. What's next?

A note about Karel…

In code, there are many ways to solve problems!

- Sometimes, certain solutions may be more “efficient” than others…
  - Developing this intuition will come with lots of practice.

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- But many times, there’s no difference.
  - Creativity in problem-solving is great!

In code, there are many ways to solve problems!

- Sometimes, certain solutions may be more “efficient” than others…
    - Developing this intuition will come with lots of practice.

- But many times, there’s no difference.
    - Creativity in problem-solving is great!

This is why we start the quarter with Karel!

CheckerboardKarel

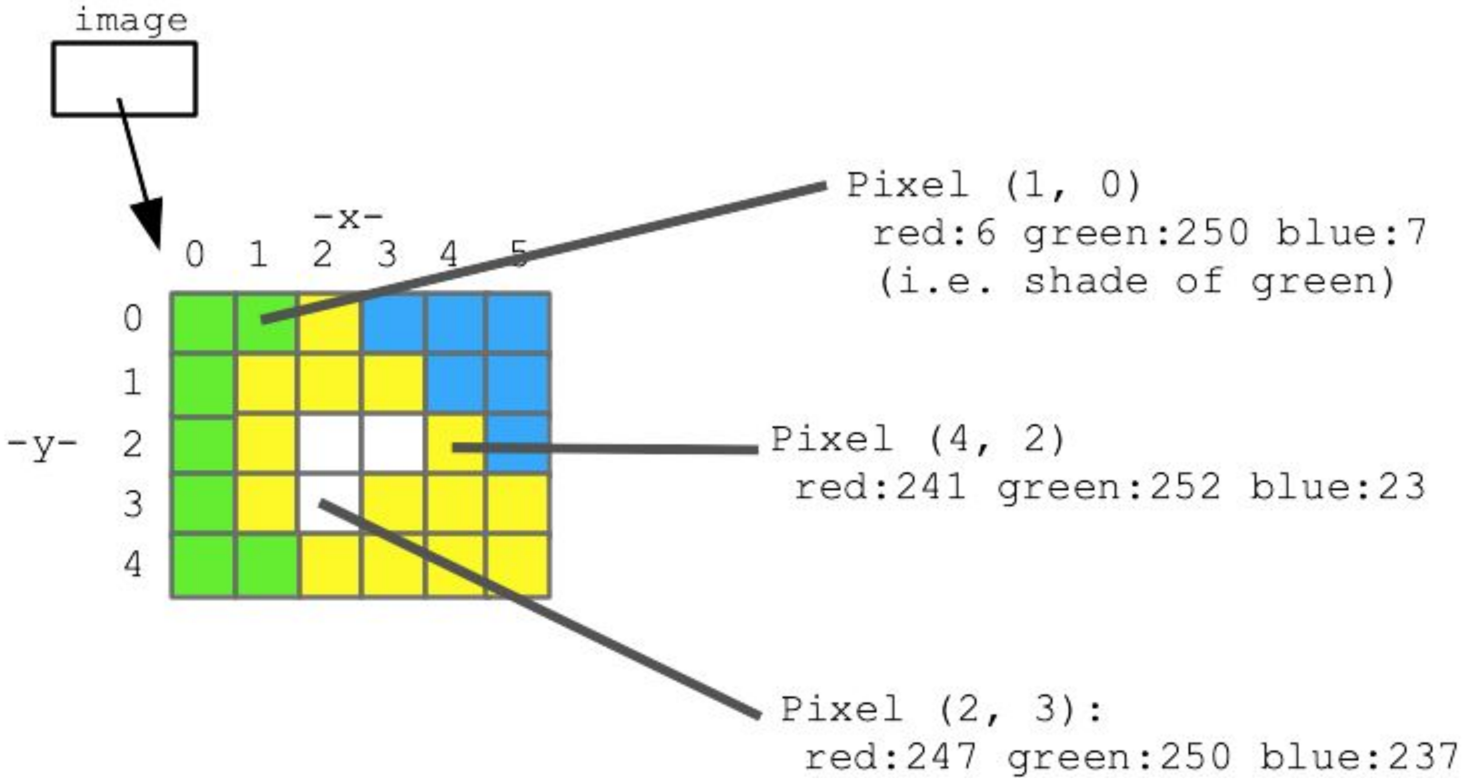
Ask your neighbors: How did you see the algorithm?

CheckerboardKarel

[demo]

Review

What is an image?



Pixel (1, 0)
red:6 green:250 blue:7
(i.e. shade of green)

Pixel (4, 2)
red:241 green:252 blue:23

Pixel (2, 3):
red:247 green:250 blue:237

Image courtesy of Nick Parlante

SimpleImage module

SimpleImage module

- Import the module

```
from simpleimage import SimpleImage
```

SimpleImage module

- Import the module

- Create a SimpleImage object and store it in a variable
    - Each SimpleImage object is made up of Pixel objects

```
image = SimpleImage(filename)
```

SimpleImage module

- Import the module
- Create a SimpleImage object and store it in a variable
- Show the image on your computer

```
image.show()
```

SimpleImage module

- Import the module
- Create a SimpleImage object and store it in a variable
- Show the image on your computer
- Idea: We manipulate images by editing their pixels!

For each loops

For each loops

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

For each loops

```
image = SimpleImage(‘flower.jpg’)

for pixel in image:

    # Do something with pixel
```

Summary

- Use a **for each loop** to loop over all pixels in an image

- Edit a pixel by accessing and updating its **properties:**
  - **`pixel.x`**, **`pixel.y`** → coordinates (can’t be changed)
  - **`pixel.red`**, **`pixel.green`**, **`pixel.blue`** → RGB values
    - A higher R, G, or B value means a greater amount of that color

- Each SimpleImage also has properties:
  - **`image.width`** → maximum x value
  - **`image.height`** → maximum y value

Let’s make Photoshop!

What we’ve done so far

- Isolated an RGB channel (red)

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    - Modified only a particular half/quadrant in an image

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- Isolated an RGB channel (red)

- Darkened an image
  - Modified only a particular half/quadrant in an image

How would you write an if statement that only selects pixels in the upper right quadrant of an image?

```
if (pixel.x >= image.width // 2 and
          pixel.y < image.height // 2):
```

What we’ve done so far

- Isolated an RGB channel (red)

- Darkened an image
  - Modified only a particular half/quadrant in an image

- Grayscaled an image
  - Grayscaled only pixels of a particular color

What we’ve done so far

- Isolated an RGB channel (red)

- Darkened an image
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  - Grayscaled only pixels of a particular color

We’ve only manipulated color!

How can we manipulate images beyond changing color?

Greenscreen algorithm

[demo]

Redscreen ~~Greenscreen~~ algorithm

[demo]

Greenscreen algorithm

- This is how green-screening in movies works!

```
for pixel in image:
```

Loop over all pixels in the image

Greenscreen algorithm

- This is how green-screening in movies works!

```
for pixel in image:
    average = (pixel.red + pixel.green + pixel.blue) // 3
```

Average the RGB values for the pixel

Greenscreen algorithm

- This is how green-screening in movies works!

```
for pixel in image:
    average = (pixel.red + pixel.green + pixel.blue) // 3
    if pixel.red >= average * 1.6:
```

Filter for pixels whose red value is above the average times some “hurdle factor” (i.e. find “red-enough” pixels!)

Greenscreen algorithm

- This is how green-screening in movies works!

```
for pixel in image:
    average = (pixel.red + pixel.green + pixel.blue) // 3
    if pixel.red >= average * 1.6:
        # the key line:
        pixel_back = back.get_pixel(pixel.x, pixel.y)
```

Get the corresponding pixel from the “background” image

Greenscreen algorithm

- This is how green-screening in movies works!

```
for pixel in image:
    average = (pixel.red + pixel.green + pixel.blue) // 3
    if pixel.red >= average * 1.6:
        # the key line:
        pixel_back = back.get_pixel(pixel.x, pixel.y)
        pixel.red = pixel_back.red
        pixel.green = pixel_back.green
        pixel.blue = pixel_back.blue
```

Set the RGB values accordingly to "replace" the pixel!

An exercise in style

(a quick break from images)

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(a quick break from images)

Readability!

Takeaways

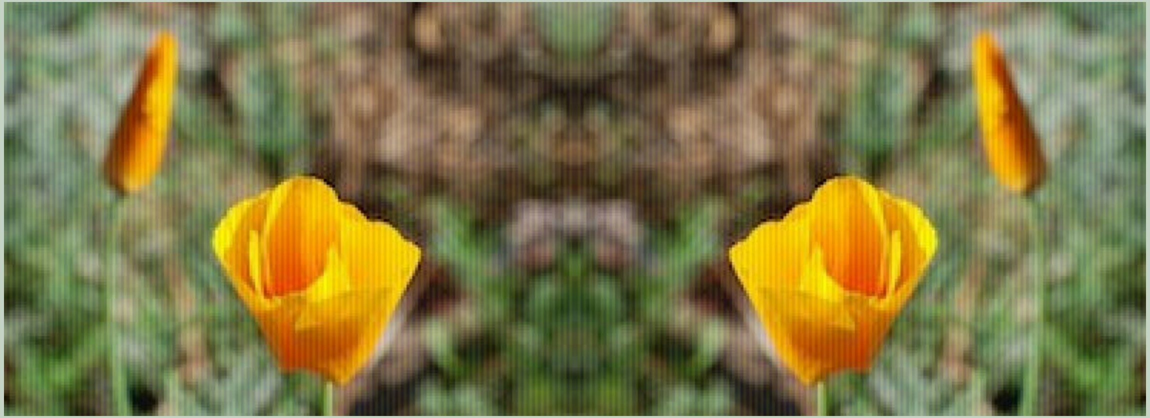
- "Readable" code can be more easily understood by anyone
    - Through good naming conventions and use of whitespace, it has a narrative/tells a story!

- Variables help us "divide-and-conquer" within a function - breaking steps down into understandable pieces

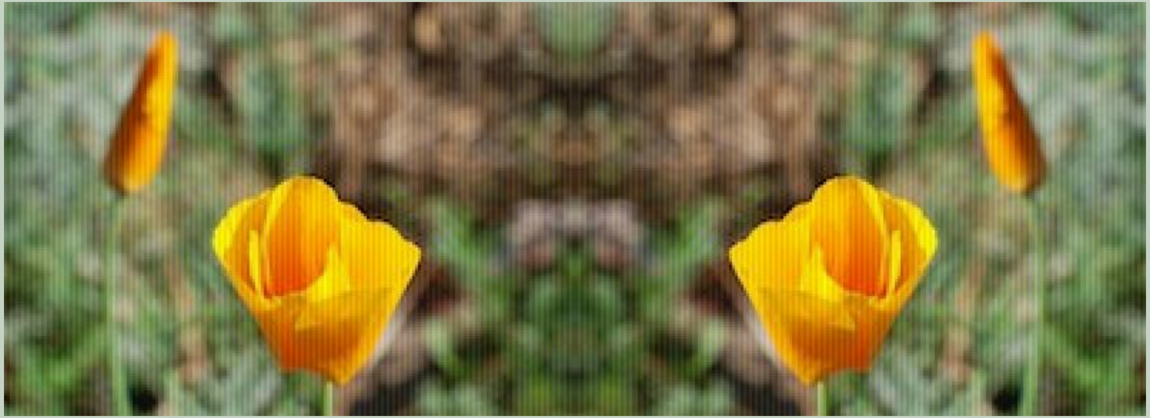
- Expressions can also be broken down into components to increase readability
    - More lines of code does not necessarily mean worse!

How can we manipulate images beyond just altering color?

```
mirror()
```



mirror()



What if we care about the pixels' x,y coordinates?

Nested for loops

```
for i in range(end_index_1):
    for j in range(end_index_2):
        # Do something
```

Nested for loops

```
for i in range(end_index_1):
    for j in range(end_index_2):
        # Do something
```

Repeats **`i * j`** *times!*

Nested for loops

```
image = SimpleImage(filename)
for y in range(image.height):
   for x in range(image.width):
      # Do something with pixel at x,y
```

Nested for loops

```
image = SimpleImage(filename)
for y in range(image.height):
   for x in range(image.width):
      # Do something with pixel at x,y
```

Iterates over all pixels and gives us access to **`x`** *and* **`y`**

Nested for loops

```
image = SimpleImage(filename)
for y in range(image.height):
    for x in range(image.width):
        # Do something with pixel at x,y
```

Iterate over the rows

Nested for loops

```
image = SimpleImage(filename)
for y in range(image.height):
   for x in range(image.width):
      # Do something with pixel at x,y
```

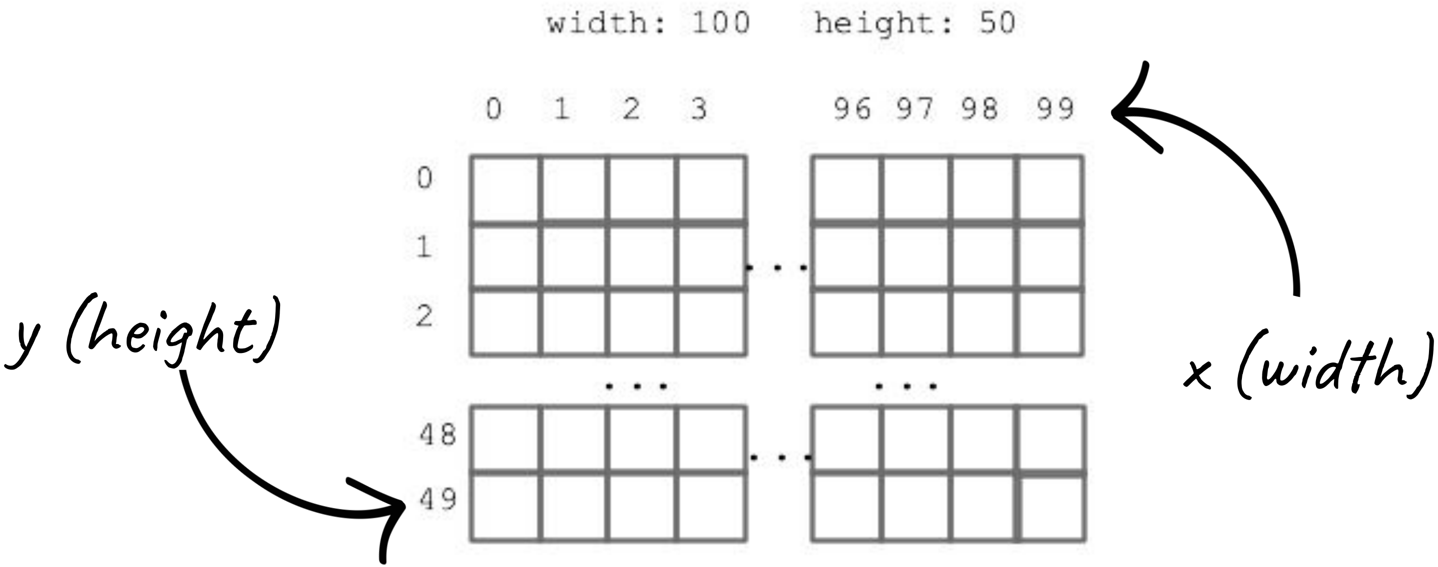
Iterate over the columns

Nested for loops

```
image = SimpleImage(filename)
for y in range(image.height):
    for x in range(image.width):
        pixel = image.get_pixel(x, y)
        # Do something with pixel
```

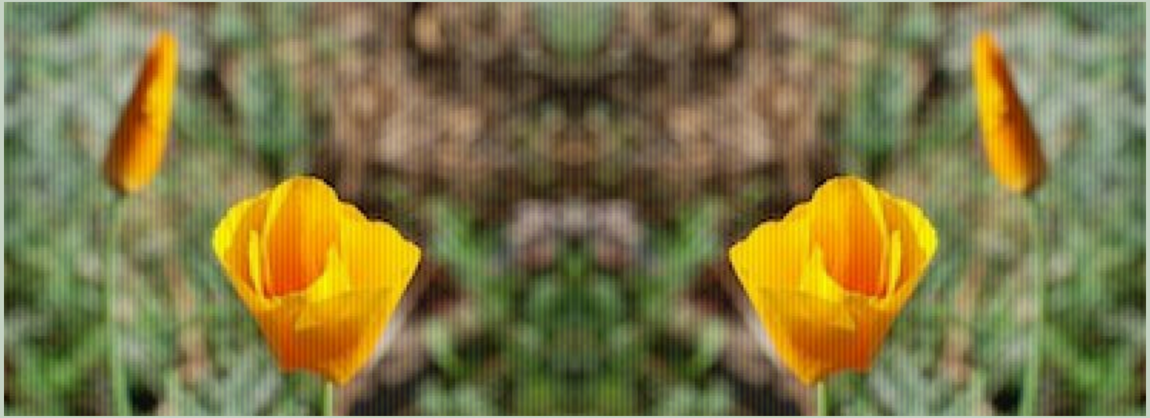
Gets the pixel at x,y

Image coordinate system



`mirror()`

[demo]



What’s the difference?

```
def darker(filename):
    img = SimpleImage(filename)
    for px in img:
        px.red = px.red // 2
        px.green = px.green // 2
        px.blue = px.blue // 2
    return img
```

```
def darker(filename):
    img = SimpleImage(filename)
    for y in range(img.height):
        for x in range(img.width):
            px = img.get_pixel(x, y)
            px.red = px.red // 2
            px.green = px.green // 2
            px.blue = px.blue //  2
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```
def darker(filename):
    img = SimpleImage(filename)
    for y in range(img.height):
        for x in range(img.width):
            px = img.get_pixel(x, y)
            px.red = px.red // 2
            px.green = px.green // 2
            px.blue = px.blue //  2
    return img
```

Nothing!

What’s the difference?

```
def darker(filename):
    img = SimpleImage(filename)
    for px in img:
        px.red = px.red // 2
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        px.blue = px.blue // 2
    return img
```

```
def darker(filename):
    img = SimpleImage(filename)
    for y in range(img.height):
        for x in range(img.width):
            px = img.get_pixel(x, y)
            px.red = px.red // 2
            px.green = px.green // 2
            px.blue = px.blue //  2
    return img
```

For **`darker()`***, we prefer this code.*

What’s the difference?

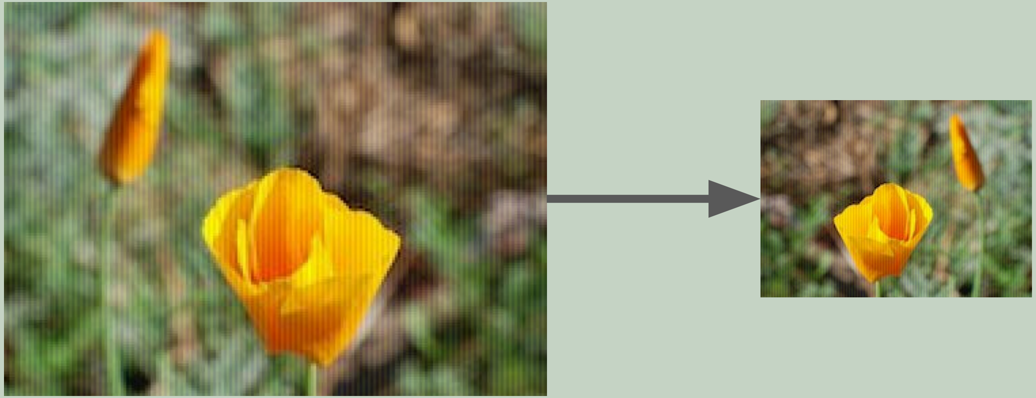
```
def darker(filename):
    img = SimpleImage(filename)
    for px in img:
        px.red = px.red // 2
        px.green = px.green // 2
        px.blue = px.blue // 2
    return img
```

```
def darker(filename):
    img = SimpleImage(filename)
    for y in range(img.height):
        for x in range(img.width):
            px = img.get_pixel(x, y)
            px.red = px.red // 2
            px.green = px.green // 2
            px.blue = px.blue //  2
    return img
```

We only want to use nested for loops if we care about **`x`** *and* **`y`**

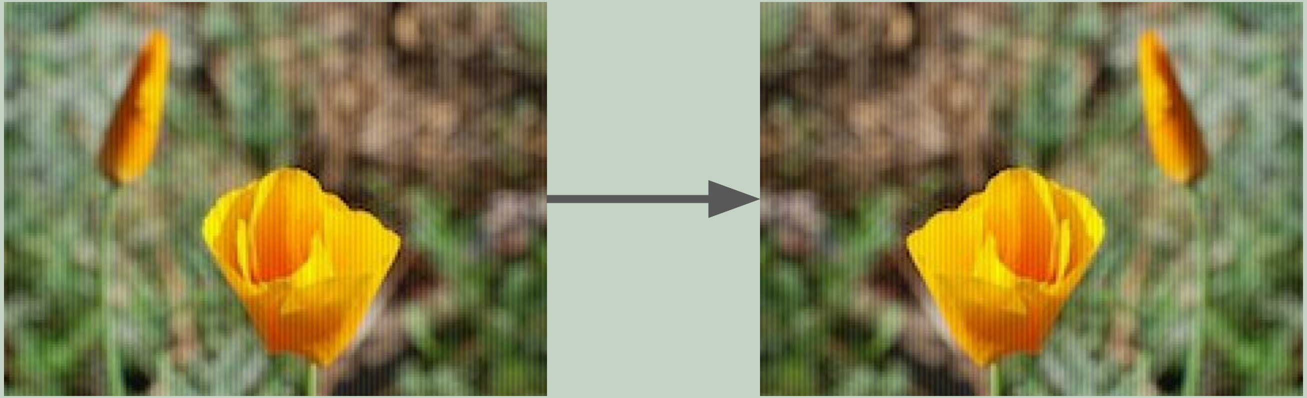
Now you try it!

`shrink()`



`flip_horizontal()`

[demo]



Summary

- Use nested for range() loops to manipulate pixels when we care about x,y
    - Use **`image.get_pixel(x, y)`** to get the pixel at the specific coordinates

Summary

- Use nested for range() loops to manipulate pixels when we care about x,y

- Common pattern: Swapping two variables
  - Use a temporary ("temp") variable to store the old value

```
x1 = 3
x2 = 4
temp = x1
x1 = x2
x2 = temp
```

Summary

- Use nested for range() loops to manipulate pixels when we care about x,y

- Common pattern: Swapping two variables

- **`SimpleImage.blank(new_width, new_height)`** allows us to create a new, empty image of a specific size
    - Then we can loop over its pixels to set their RGB

Summary

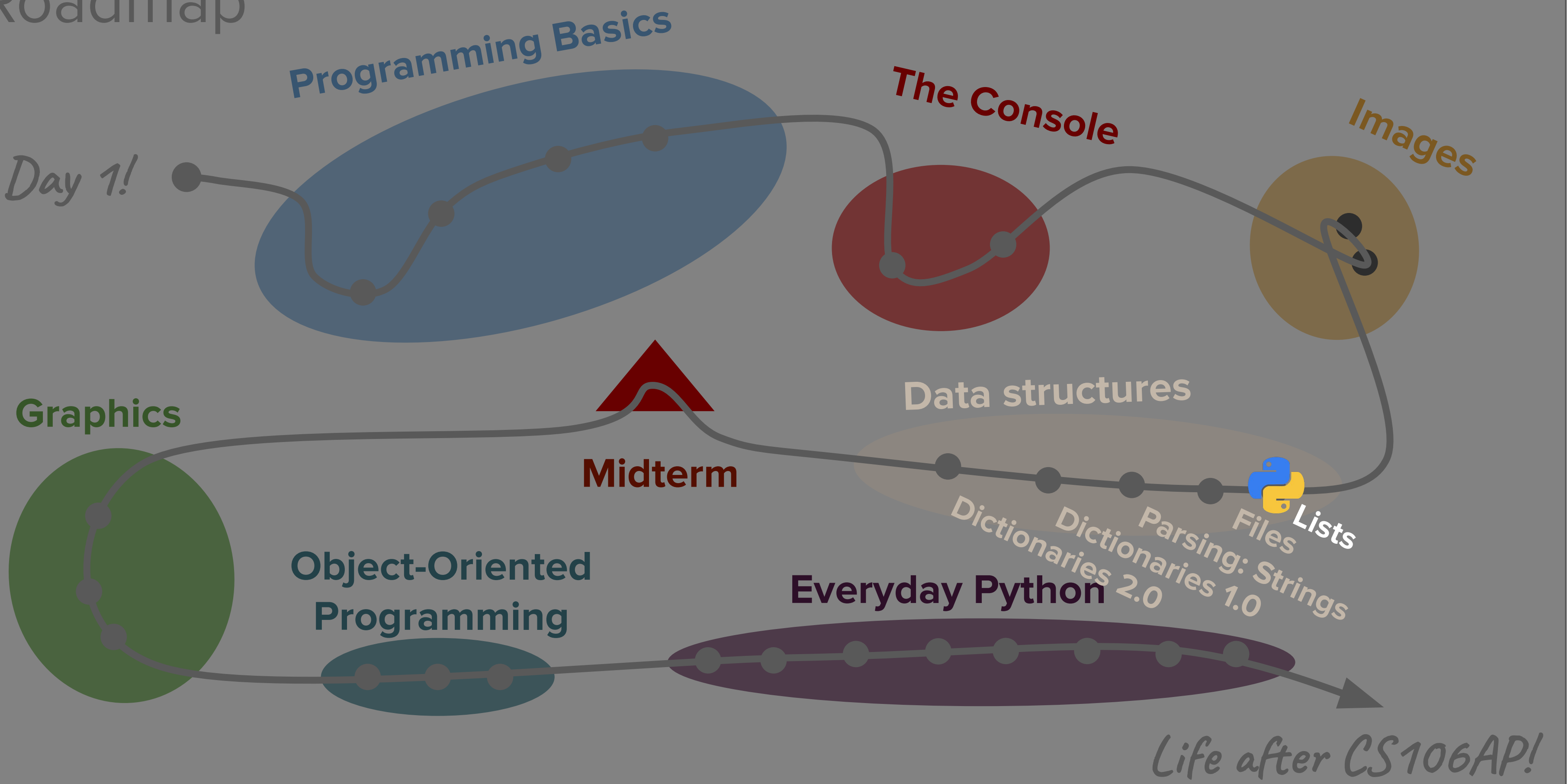
- Use nested for range() loops to manipulate pixels when we care about x,y

- Common pattern: Swapping two variables

- **`SimpleImage.blank(new_width, new_height)`** allows us to create a new, empty image of a specific size

What’s next?

Roadmap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