Data Processing and Analysis in Python
Lecture 8
Colors and Images

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Colors and the RGB System

- Display area on a computer screen is made up of colored dots called picture elements or **pixels**

- Each pixel represents a color – the default is **black**
  - Change the color by running the **pencolor** method

- **RGB** is a common system for representing colors
  - RGB stands for **red**, **green**, and **blue**
  - Each color component can range from 0–255
  - A **true color** system

- Each color component requires **8 bits**
  - Total number of bits needed to represent a color value is 24
  - Total number of RGB colors is 2^{24} = 16,777,216

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Example RGB Colors

Color	RGB Values	Hexadecimal Value	Output
black	(0, 0, 0)	0x000000	
red	(255, 0, 0)	0xff0000	
green	(0, 255, 0)	0x00ff00	
blue	(0, 0, 255)	0x0000ff	
yellow	(255, 255, 0)	0xffff00	
cyan	(0, 255, 255)	0x00ffff	
magenta	(255, 0, 255)	0xff00ff	
gray	(127,127,127)	0x7f7f7f	
white	(255, 255, 255)	0xffffff	

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Turtle Graphics

- **Turtle graphics** toolkit provides a simple and enjoyable way to draw pictures in a window and gives you an opportunity to run several methods with an object

- Created by Seymour Papert and colleagues at MIT in late 1960s

- Imagine a turtle crawling on a piece of paper with a pen tied to its tail:
  - direct the turtle as it moves across the paper
  - tell it to lift or lower its tail
  - turn some number of degrees left or right
  - move a specified distance

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Turtle Graphics Example

```python
from turtle import Turtle
ttl = Turtle()
ttl.width(2) # For bolder lines
ttl.left(90) # Turn to face north
ttl.forward(30) # Draw a vertical line in black
ttl.left(90) # Turn to face west
ttl.up() # Prepare to move without drawing
ttl.forward(10) # Move to beginning of horizontal line
ttl.setheading(0) # Turn to face east
ttl.pencolor("red") # Change pen color to red
ttl.down() # Prepare to draw
ttl.forward(20) # Draw a horizontal line in red
ttl.hideturtle() # Make the turtle invisible
```


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Turtle Graphics Demo
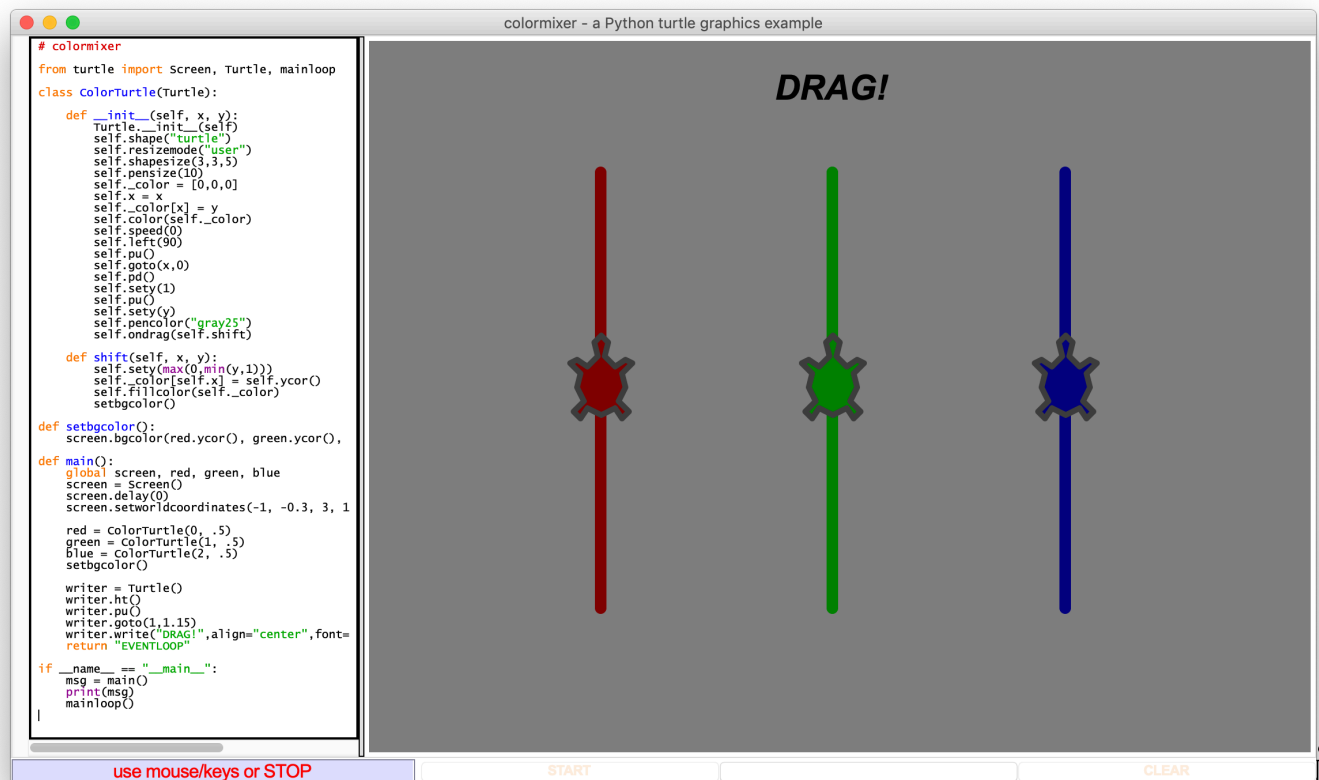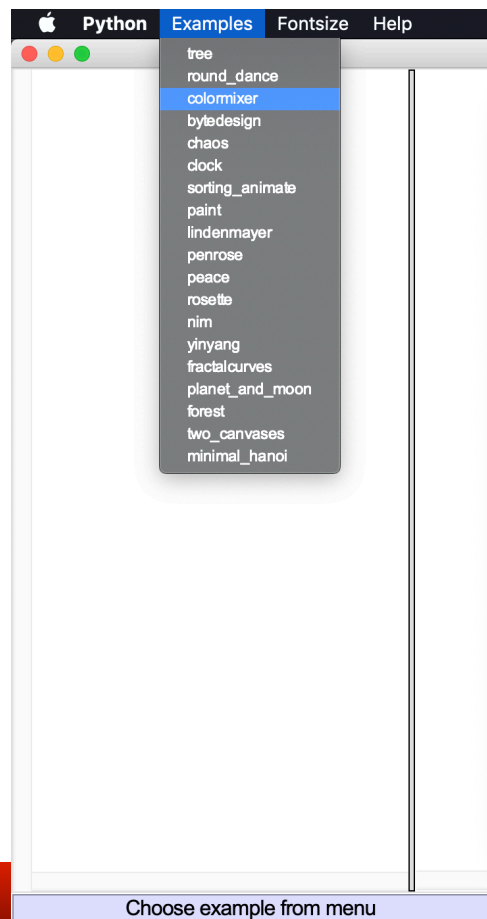
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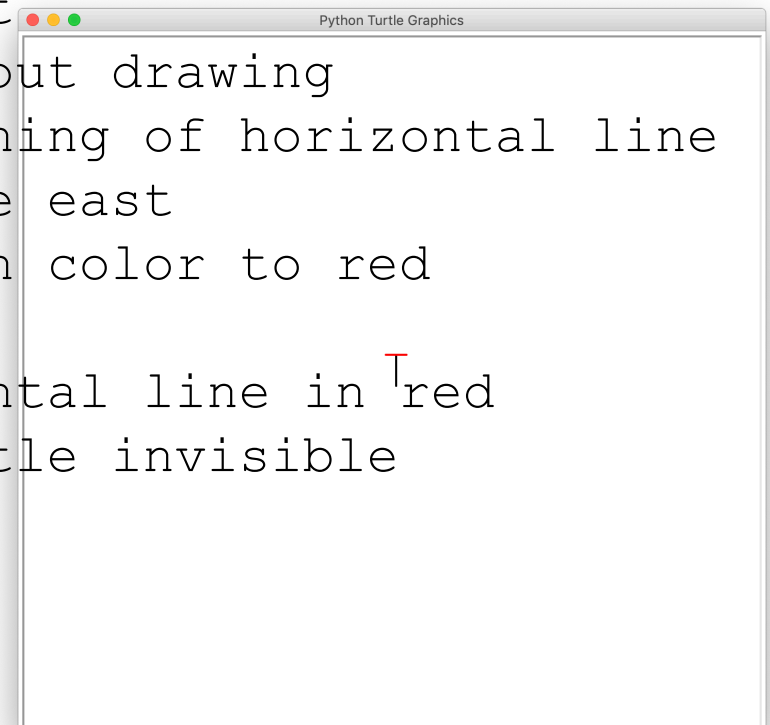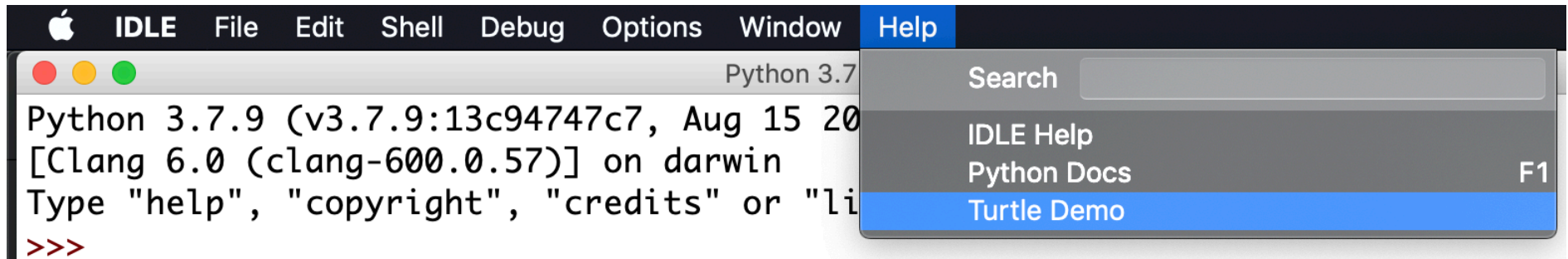
Image Processing

- Digital image processing includes the principles and techniques for the following:
  - The capture of images with devices
    - such as flatbed scanners and digital cameras
  - The representation and storage of images in efficient file formats
  - Constructing the algorithms in image-manipulation programs
    - such as Adobe Photoshop
- Computers must use **digital** information which consists of **discrete** values
  - Sampling devices measure discrete color values at distinct points on a two-dimensional grid as **pixels**
  - As more pixels are sampled, the more realistic the resulting image will appear

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Image File Formats

- Once an image has been sampled, it can be stored in one of many file formats
  - A raw image file saves all of the sampled information

- Data can be compressed to minimize its file size
  - GIF (Graphic Interchange Format)
    - Uses a lossy compression and a color palette of up to 256 of the most prevalent colors in the image
  - JPEG (Joint Photographic Experts Group)
    - Uses lossless compression and a lossy scheme
  - PNG (Portable Network Graphics)
    - Lossless data compression replacement for GIF
    - With palettes of 24-bit RGB or 32-bit RGBA colors

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Image Manipulation Operations

- Examples:
  - Rotate an image
  - Convert an image from color to grayscale
  - Apply color filtering to an image
  - Highlight a particular area in an image
  - Blur all or part of an image
  - Sharpen all or part of an image
  - Control the brightness of an image
  - Perform edge detection on an image
  - Enlarge or reduce an image's size
  - Apply color inversion to an image
  - Morph an image into another image

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Properties of Images

- Coordinates of pixels in the two-dimensional grid range
  - (0, 0) at the upper-left corner to
  - (width−1, height−1) at lower-right corner
  - width/height are the image's dimensions in pixels
- Thus, the **screen coordinate system** for the display of an image is different from the standard Cartesian coordinate system

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Python Operating System (OS) Interfaces

- **os.getcwd**() returns a string representing the current working directory

- **os.listdir**(path='.') returns a list containing the names of the entries in the directory given by path

- **os.rename**(src, dst, *, src_dir_fd=None, dst_dir_fd=None) renames the file or directory src to dst

- **os.chdir**(path) changes the current working directory to path

- **os.mkdir**(path, mode=0o777, *, dir_fd=None) creates a directory named path with numeric mode

- **os.remove**(path, *, dir_fd=None) deletes the file path

- **os.rmdir**(path, *, dir_fd=None) deletes the directory path

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Python Imaging Library (PIL or Pillow)

- The **PIL** or **Pillow** module is an open-source tool

- Image class represents an image as a two-dimensional grid of RGB values

- Example:
  - Imports the Image class from the PIL module
  - Instantiates this class using the file name
  - Shows the image

```
>>> from PIL import Image
>>> image = Image.open("umd.png")
>>> image.show()
```

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Image Manipulation Operations

- **Examine its width and height:**
```
>>> width, height = image.size
225 225
```

- **Get a tuple of the RGB values:**
```
>>> image.getpixel((0, 0))
(0, 0, 0)
```

- **Rotate the image:**
```
>>> image.rotate(180)
```

- **Save this image under the given file name**
```
>>> image.save()
>>> image.save("new.png")
```

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