#4-2: Libraries and Documentation

CS SCHOLARS – PROGRAMMING

Learning Goals

Install **external modules** with the **pip** command

Read **documentation** to learn how to use a new module

Recap: Python Modules

The Python programming language comes with a large set of built-in functions that cover a range of different purposes. However, it would take too long to load all these functions every time we want to run a program.

Python organizes its different functions into **modules**. When you run Python, it loads only a small set of functions from the built-in module. To use any other functions, you must **import** them.

Pre-Installed Modules

We've already used a few core modules for homework assignments - mainly `math` and `tkinter`.

For a full list of python libraries, look here: https://docs.python.org/3/library/index.html

External Modules

There are many other libraries that have been built by developers outside of the core Python team to add additional functionality to the language. These modules don't come as part of the Python language, but can be added in. We call these **external modules**.

Popular external modules include matplotlib, scikit-learn, and pygame.

Finding Useful Modules

One of the main strengths of Python as a language is that there are thousands of external modules available, which means that you can start many projects based on work others have done instead of starting from scratch.

You can find a list of popular modules here: wiki.python.org/moin/UsefulModules

And a more complete list of pip-installable modules here: pypi.org

Install External Modules with `pip`

In order to use an external module, you must first **install** it on your machine. To install, you'll need to download the files from the internet to your computer, then integrate them with the main Python library so that the language knows where the module is located.

It is usually possible to install modules manually, but this process can be a major pain. Luckily, Python also gives us a streamlined approach for installing modules – the **`pip` module**! This feature can locate modules that are indexed in the Python Package Index (the list of commonly-used modules linked on the last slide), download them, and attempt to install them.

Running `pip`

Traditionally, programmers run `pip` from the **terminal**. This is a command interface that lets you make changes directly to your computer. You can access this in the application **Terminal** (Mac/Linux) or **Command Prompt** (Windows). To run `pip` in the terminal, use the command:

```
pip install module-name
```

This will identify the module and start the download and installation process. It may run into a **dependency error** if the module needs a second module to already be installed – in general, installing that module and then running `pip` again will fix the problem.

Note: you will not be able to run `pip` on CMU cluster machines, as these have restricted permissions. You may need to log into your main account on personal machines to run it.

Thonny Has its Own Installer

If you're using Thonny, you can install modules without using pip!

Go to **Tools > Manage Packages**. Search for the module you want to install and click on it in the results. Then click 'Install' and Thonny will handle the pip installation for you.

If you're using repl.it, the website will install packages for you! Just type `import packageName` at the top of the file and click Run, and repl.it will install the named package (in most cases).

Activity: Install an Image Library

As an example, let's install a library that lets us manipulate images.

Pillow is a lightweight and easy-to-install module that lets you manipulate images beyond .gif files. It lets you modify images or use different types of images in Tkinter.

You do: Try installing it now!

Using an Installed Module

Once you've successfully installed a module, you should be able to put

```
import module-name
```

at the top of a Python file, and it will load the module the same way it would load a built-in library. For the Pillow library, the import name is slightly different from the install name:

```
import PIL
```

Note: this may fail if you have multiple versions of Python installed on your machine. Make sure to use the `pip` associated with the version of Python you're using in your editor. You can check your editor's version in Thonny with Help > About Thonny, then call `pip` using

```
pythonversion-number -m pip install module-name
```

Learning how a Module Works

Once a new module is installed, you're still left with one major question: how do you use it?

This varies by module, but the best answer is to **read the documentation**. Most external modules have official documentation or APIs that describe which functions exist and how to use the module.

It can also be helpful to search online for other projects that have used the same module, to find examples of how to set it up. Many people have written helpful tutorials online for this exact purpose.

Two standard resources for finding help are **StackOverflow**, a site where people can ask questions about code and get answers from other developers, and **GitHub**, a site where people post open-source projects for others to use and contribute to.

Reminder: always cite others' work!

You'll sometimes find a useful bit of code in a StackOverflow post or a GitHub project that you'll want to use in your own project.

Whenever you copy code from online, make sure to **cite it** the same way you would cite a paragraph of text in an essay. You can do this by putting a comment above the copied code that includes a link to the URL you got the code from.

This serves two purposes. First- it gives credit to the individual who originally wrote the code. Second- if you run into a problem with the code later on, you'll be able to look back to the original source to find a solution.

Note: policies around copying code change when you're working on a commercial product. Read the fine print if you're planning to sell your code!

Learning the Pillow Library

To learn how to use the Pillow library, let's start from the documentation!

https://pillow.readthedocs.io/en/stable/index.html

It often helps to start with a tutorial or 'start here' page. Pillow's docs have one:

https://pillow.readthedocs.io/en/stable/handbook/tutorial.html

Pillow Images

Pillow makes it very easy to open image files, using the `Image.open` function. You can even display those images with `image.show`, or save them with `image.save`. All of this is explained directly in the tutorial!

```
from PIL import Image
img = Image.open("stella.jpg")
img.show()
img.save("new-stella.jpg")
```

Pillow Image Functions

You can provide Pillow images to the Tkinter `create_image` function, but you can also manipulate them directly!

Perhaps you want to crop an image? Try searching for the term 'crop' in the page and see what you can find!

```
newImg = img.crop([200, 200,
                   3500, 2500])
newImg.save("new-stella.jpg")
```

Example: Create Mosaic

Let's say we want to create a mosaic of Stella pictures using Pillow. We can **alternate between coding and reading the documentation** to put together the code that we need.

First, we want to figure out how to change the image's size. Browsing the tutorial shows...

- We can get the height and width from `img.size`
- We can call `img.resize([newHeight, newWidth])` to create a new image of that size

Example: Combining Images

Next, we want to determine how to combine multiple images together.

More browsing shows that:

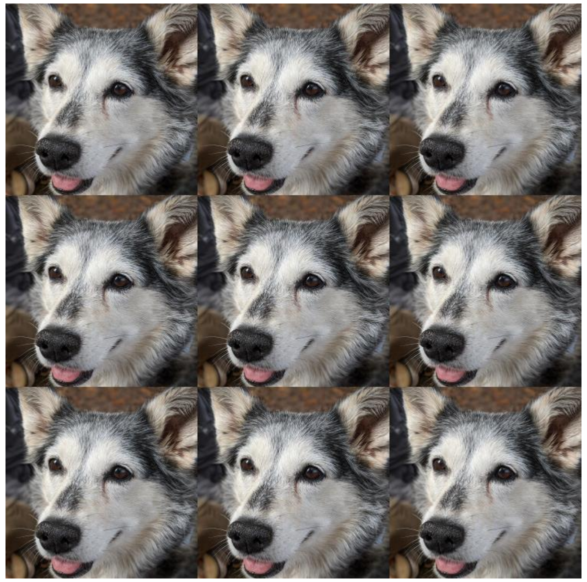
- We can create an empty image with `Image.new("RGB", [width, height])`
- We can paste images into the empty image, along with coordinates, using `img.paste`

Now we can start creating something real!

Example: 3x3 Grid

We can combine regular Python code (in this case, loops) with the library functions to make a cool result!

```
from PIL import Image

img = Image.open("stella.jpg")
print(img.size) # initially 3024 x 4032
img = img.crop([24, 24, 3024, 3024]) # make it square
smallStella = img.resize([1000, 1000]) # make a small version

result = Image.new("RGB", [3000, 3000])
for row in range(3):
    for col in range(3):
        result.paste(smallStella, [col*1000, row*1000])
result.save("stella-grid.jpg")
```

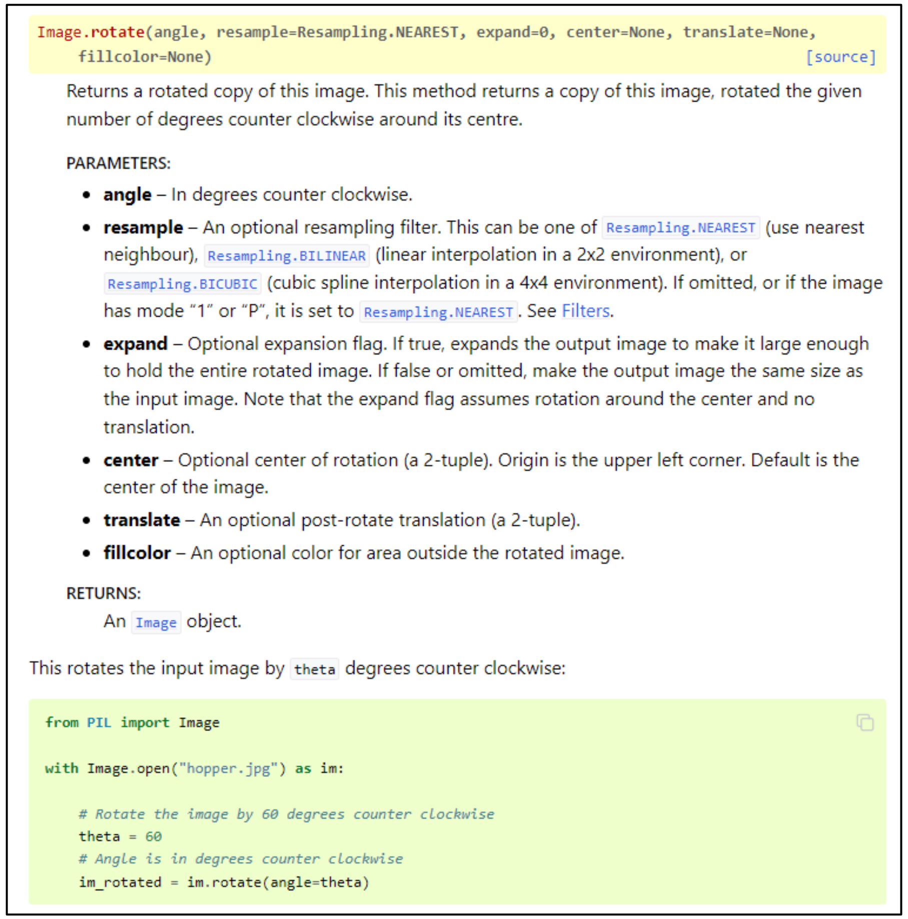


Consult Module References for Methods

We can find even more cool things that the library can do by checking the **module references**.

These are pages that describe in depth all the methods you can use when you import a certain part of a module. For example, let's look at the `im.rotate` documentation in the `Image` module.

The page describes required and optional arguments, says what the function does, and gives an example of how to use the method!



```
Image.rotate(angle, resample=Resampling.NEAREST, expand=0, center=None, translate=None,
    fillcolor=None)                                                               [source]
```

Returns a rotated copy of this image. This method returns a copy of this image, rotated the given number of degrees counter clockwise around its centre.

PARAMETERS:

- **angle** – In degrees counter clockwise.
- **resample** – An optional resampling filter. This can be one of `Resampling.NEAREST` (use nearest neighbour), `Resampling.BILINEAR` (linear interpolation in a 2x2 environment), or `Resampling.BICUBIC` (cubic spline interpolation in a 4x4 environment). If omitted, or if the image has mode "1" or "P", it is set to `Resampling.NEAREST`. See Filters.
- **expand** – Optional expansion flag. If true, expands the output image to make it large enough to hold the entire rotated image. If false or omitted, make the output image the same size as the input image. Note that the expand flag assumes rotation around the center and no translation.
- **center** – Optional center of rotation (a 2-tuple). Origin is the upper left corner. Default is the center of the image.
- **translate** – An optional post-rotate translation (a 2-tuple).
- **fillcolor** – An optional color for area outside the rotated image.

RETURNS:

An `Image` object.

This rotates the input image by `theta` degrees counter clockwise:

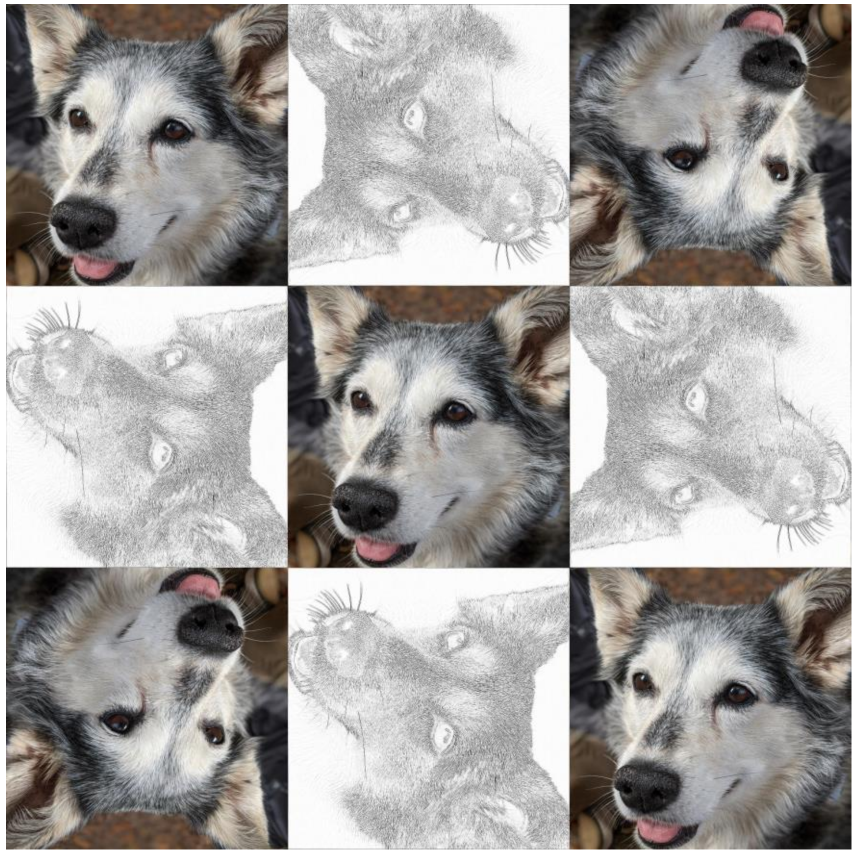
```
from PIL import Image

with Image.open("hopper.jpg") as im:

    # Rotate the image by 60 degrees counter clockwise
    theta = 60
    # Angle is in degrees counter clockwise
    im_rotated = im.rotate(angle=theta)
```

Example: Add Some Flair

We can keep exploring what's possible in the library to add even more customization!

- `img.rotate` lets us rotate the image by a given number of degrees
- `img.filter` lets us apply special filters, like contour or embossing

This is the real power of libraries – we can use these special features directly without having to implement them ourselves.



Activity: Learn a New Library

You do: work with a small group of students to install and learn about a new library. Try to create a small example using the library to practice how it works!

After you've had some time to research and work, we'll go around the room and share what we've found.

Here are some recommended libraries to try out:

- NumPy/SciPy (math and science functions)
- Matplotlib (graphs and charts)
- Beautiful Soup (webscraping)
- Pydub (audio)
- Pygame (game development)

Learning Goals

Install **external modules** with the **pip** command

Read **documentation** to learn how to use a new module