Decomposition

Class outline:

- Modules
- Packages
- Modularity
- Modular design

Modules

Python modules

A Python module is a file typically containing function or class definitions.

link.py:

```
class Link:
    empty = ()

    def __init__(self, first, rest=empty):
        assert rest is Link.empty or isinstance(rest, Link)
        self.first = first
        self.rest = rest

    def __repr__(self):
        if self.rest:
            rest_repr = ', ' + repr(self.rest)
        else:
            rest_repr = ''
        return 'Link(' + repr(self.first) + rest_repr + ')'

    def __str__(self):
        string = '<'
        while self.rest is not Link.empty:
            string += str(self.first) + ' '
            self = self.rest
        return string + str(self.first) + '>'
```

Importing

Importing a whole module:

```
import link

ll = link.Link(3, link.Link(4, link.Link(5)))
```

Importing specific names:

```
from link import Link

ll = Link(3, Link(4, Link(5)))
```

Importing all names:

```
from link import *

ll = Link(3, Link(4, Link(5)))
```

Importing with alias

I don't recommend aliasing a class or function name:

```
from link import Link as LL

ll = LL(3, LL(4, LL(5)))
```

But aliasing a whole module is sometimes okay (and is common in data science):

```
import numpy as np

b = np.array([(1.5, 2, 3), (4, 5, 6)])
```

Running a module

This command runs a module:

```
python module.py
```

When run like that, Python sets a global variable `__name__` to "main". That means you often see code at the bottom of modules like this:

```
if __name__ == "__main__":
    # use the code in the module somehow
```

The code inside that condition will be executed as well, but only when the module is run directly.

Packages

Python packages

A Python package is a way of bundling multiple related modules together. Popular packages are NumPy and Pillow.

Example package structure:

```
sound/                          Top-level package
    __init__.py                 Initialize the sound package
    formats/                    Subpackage for file format conversions
            __init__.py
            wavread.py
            wavwrite.py
            aiffread.py
            aiffwrite.py
            auread.py
            auwrite.py
            ...
    effects/                    Subpackage for sound effects
            __init__.py
            echo.py
            surround.py
            reverse.py
            ...
    filters/                    Subpackage for filters
            __init__.py
            equalizer.py
            vocoder.py
            karaoke.py
            ...
```

Importing from a package

Importing a whole path:

```
import sound.effects.echo

sound.effects.echo.echofilter(input, output, delay=0.
```

Importing a module from the path:

```
from sound.effects import echo

echo.echofilter(input, output, delay=0.7, atten=4)
```

Installing packages

The Python Package Index is a repository of packages for the Python language.

Once you find a package you like, `pip` is the standard way to install:

```
pip install nltk
```

You may need to use `pip3` if your system defaults to Python 2.

Modularity

Modular design

A design principle: Isolate different parts of a program that address different concerns.

A modular component can be developed and tested independently.

Ways to isolate in Python:

Modular design

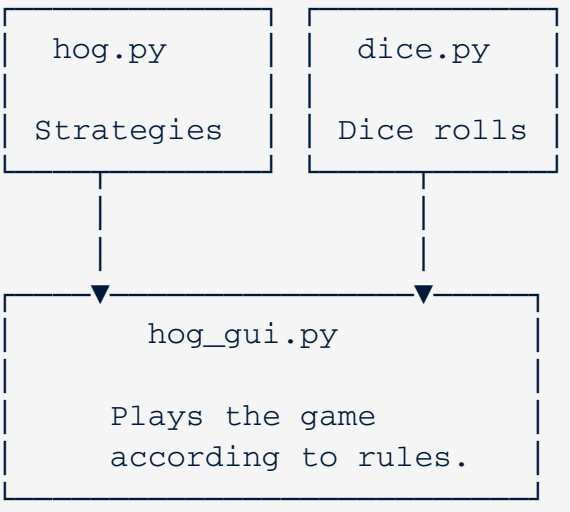
A design principle: Isolate different parts of a program that address different concerns.

A modular component can be developed and tested independently.

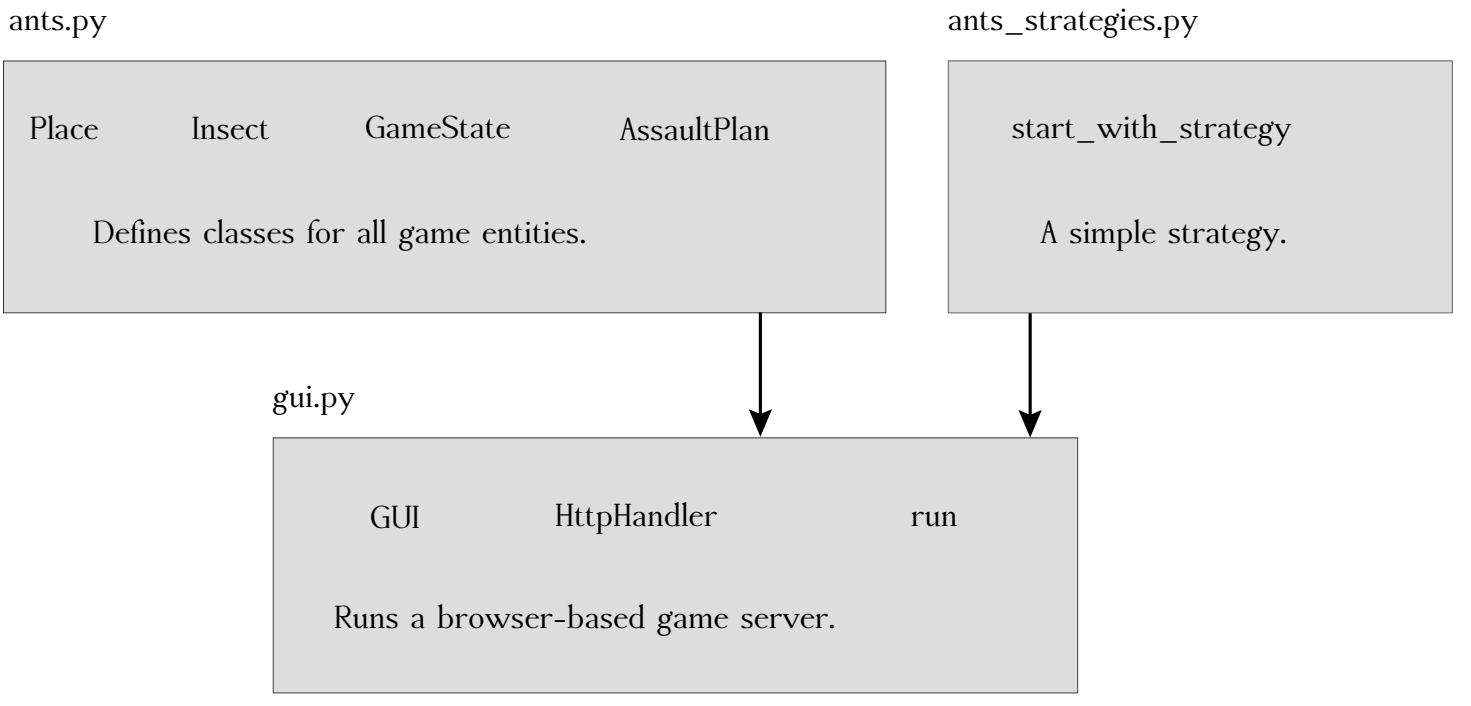
Ways to isolate in Python:

- Functions
- Classes
- Modules
- Packages

Hog design

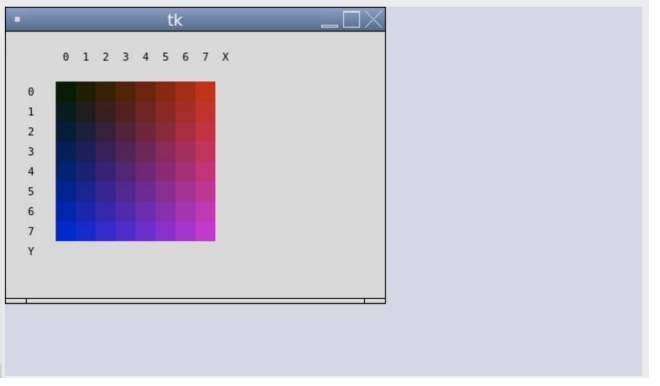

hog.py
Strategies
dice.py
Dice rolls
hog_gui.py
Plays the game
according to rules.

Ants design

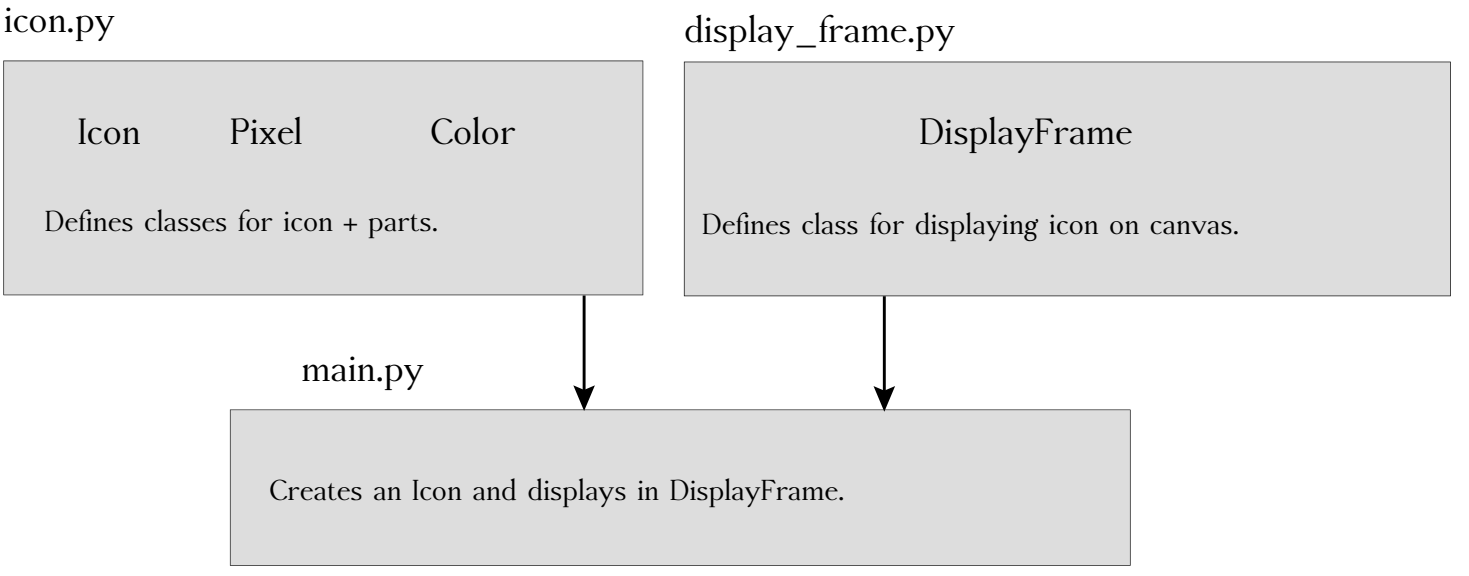


See also: Ants class diagram

Icon project

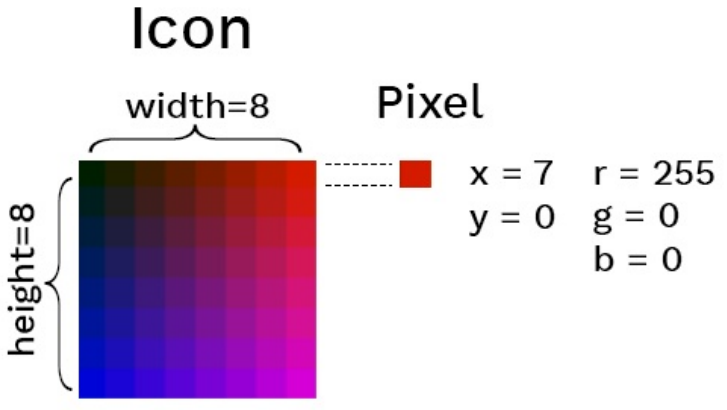


Icon design


icon.py
Icon
Pixel
Color
Defines classes for icon + parts.
display_frame.py
DisplayFrame
Defines class for displaying icon on canvas.
main.py
Creates an Icon and displays in DisplayFrame.

An OOP Icon

Goal: Use OOP to represent an Icon with pixels at a particular location with a particular color.



The Color class

```
class Color:

    def __init__(self, r, g, b):
        self.r = r
        self.g = g
        self.b = b

    def __repr__(self):
        return f"Color({self.r},{self.g},{self.b})"

    def to_hex(self):
        return f"#{self.r:02x}{self.g:02x}{self.b:02x}"
```

```
red = Color(255, 0, 0)
print(red.to_hex())
```

The Pixel class

```
class Pixel:
    def __init__(self, x, y, r, g, b):
        self.x = x
        self.y = y
        self.color = Color(r, g, b)

    def __repr__(self):
        return f"Pixel({self.x},{self.y},{self.color})"
```

```
pixel = Pixel(0, 7, 255, 0, 0)
print(pixel.color.to_hex())
```

The Icon class

```
class Icon:

    def __init__(self, width, height, pixels=None):
        self.width = width
        self.height = height
        self.pixels = pixels
        if not self.pixels:
            self.pixels = [ Pixel(x, y, 0, 0, 0)
                for x in range(width) for y in range(height)]

    def __repr__(self):
        pixels = ",".join([repr(pixel) for pixel in self.pixels])
        return f"Icon({self.width}, {self.height}, {self.pixels})"
```

```
icon = Icon(2, 2, [Pixel(0, 0, 255, 0, 0),
    Pixel(0, 1, 255, 50, 0),
    Pixel(1, 0, 255, 100, 0),
    Pixel(1, 1, 255, 150, 0)])

for pixel in icon.pixels:
    pixel.color.g += 50
```

The DisplayFrame class

```
from tkinter import Canvas, Frame, BOTH, font

class DisplayFrame(Frame):

    def __init__(self):
        super().__init__()
        self.pack(fill=BOTH, expand=1)
        self.canvas = Canvas(self)
        self.canvas.pack(fill=BOTH, expand=1)

    def draw_icon(self, icon):
        x_offset = 50
        y_offset = 50
        pixel_size = 20

        for pixel in icon.pixels:
            top_left_x = x_offset + pixel.x * pixel_size
            top_left_y = y_offset + pixel.y * pixel_size
            self.canvas.create_rectangle(
                top_left_x,
                top_left_y,
                top_left_x + pixel_size,
                top_left_y + pixel_size,
                outline="",
                fill=pixel.color.to_hex())
```

All together

```
from tkinter import Tk

from icon import Icon, Pixel, Color
from display_frame import DisplayFrame

# Initialize the Tkinter frame and canvas
root = Tk()

display = DisplayFrame()
display.draw_icon(icon)

# Run Tkinter loop
root.mainloop()
```

Visit the Repl.it demo to see all the classes used with the Python tkinter package for graphics rendering.

Iterator-producing functions

What happens if we...

map the pixels?

```
changer = lambda p: Pixel(p.x, p.y,
    p.x * 30,
    p.color.g + 30,
    p.y * 30)
icon.pixels = list(map(changer, icon.pixels))
```

filter the pixels?

```
is_odd = lambda p: p.x % 2 == 0
icon.pixels = list(filter(is_odd, icon.pixels))
```

Iterable-processing functions

What happens if we ask for the min and max of the pixels?

```
max_pix = max(icon.pixels)
min_pix = min(icon.pixels)
```

Iterable-processing functions

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```

Python doesn't know how to compare `Pixel` instances! Two options:

- Implement dunder methods (`__eq__`, `__lt__`, etc)
- Pass in a key function that returns a numerical value:

```
rgb_adder = lambda p: p.color.r + p.color.g + p.color.b
max_pix = max(icon.pixels, key=rgb_adder)
min_pix = min(icon.pixels, key=rgb_adder)
```

Python Project of The Day!

Panda3D

Panda3D: an open-source, completely free-to-use engine for realtime 3D games, visualizations, simulations, experiments. Written in C++ with Python bindings.

Github organization, Open Collective