Lecture 16: Object-Oriented Programming II

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Announcements

Survey Responses (Thanks!)

Highlights from the survey:

- Many students reevaluated their starting ability
- Lab checkoffs: most think they're worthwhile
  - Others think it's stressful or it's too easy
  - They should be *easy and not stressful*
  - It's not unreasonable to ask you to come to lab once a week
- Homework 3 and Quiz 4 were so hard!
  - Homework assignments are *graded on effort*
  - We will do coding quizzes a little differently

More Survey Responses

- Remove the auto-grader delay on projects!
  - *Nope, it's for your own good*
- Have two midterms instead of quizzes!
  - *Nope, it's for your own good*
- Brian and I will slow down the demos in lecture
  - When we can
- Brian's office hours are great
- Some administrative things are out of our control
- 1/6 students came to the potluck, 5/6 want another one

Roadmap

Introduction
Functions
Data
Mutability
Objects
Interpretation
Paradigms
Applications

- This week (Objects), the goals are:
  - To learn the paradigm of *object-oriented programming*
  - To study applications of, and problems that be solved using, OOP

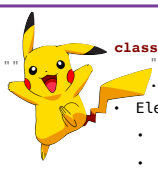
Inheritance

- Powerful idea in Object-Oriented Programming
- Way of *relating* similar classes together
- Common use: a *specialized* class inherits from a more *general* class

```
class <new class>(<base class>):
    ...
```

- The new class *shares* attributes with the base class, and *overrides* certain attributes
- Implementing the new class is now as simple as specifying how it's *different* from the base class

Inheritance Example (demo)



```
class Pokemon:
    """A Pokemon."""
    ...
```

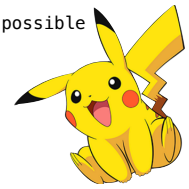
- Pokémon have:
  - a name
  - a trainer
  - a level
  - an amount of HP (life)
  - a basic attack: tackle
- Pokémon can:
  - say their name
  - attack other Pokémon

```
class ElectricType(Pokemon):
    """An electric-type Pokemon."""
    ...
```

- Electric-type Pokémon have:
  - a name
  - a trainer
  - a level
  - an amount of HP (life)
  - a basic attack: **thunder shock**
- Electric-type Pokémon can:
  - say their name
  - attack **and sometimes paralyze** other Pokémon

Designing for Inheritance

- ✓ Don't repeat yourself! Use *existing implementations*
- ✓ Reuse overridden attributes by accessing them through the *base class*
- ✓ Look up attributes on *instances* if possible



```
class ElectricType(Pokemon):
    basic_attack = 'thunder shock'
    prob = 0.1
    def attack(self, other):
        Pokemon.attack(self, other)
        if random() < self.prob and type(other) != ElectricType:
            other.paralyzed = True
            print(other.name, 'is paralyzed!')
```

Multiple Inheritance

- In Python, a class can inherit from multiple base classes
- This exists in many *but not all* object-oriented languages
- This is a tricky and often dangerous subject, so proceed carefully!

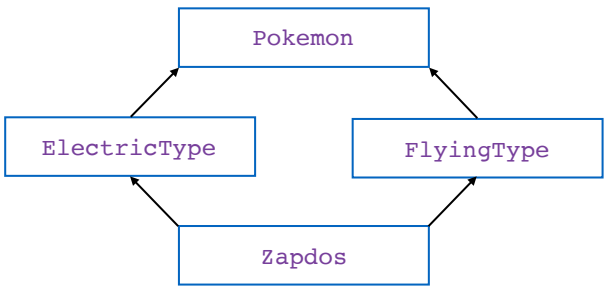
```
class FlyingType(Pokemon):
    basic_attack = 'peck'
    damage = 35
    def fly(self, location):
        print(self.trainer, 'flew to', location)
```

Multiple Inheritance Example

- Zapdos is a legendary bird Pokémon
  - Zapdos' attack, thunder, does a lot of damage
  - Zapdos can paralyze when attacking
  - Zapdos can fly
  - Zapdos can't say its own name

```
class Zapdos(ElectricType, FlyingType):
    basic_attack = 'thunder'
    damage = 120
    def speak(self):
        print('EEEEEEEE')
```

Multiple Inheritance Example (demo)

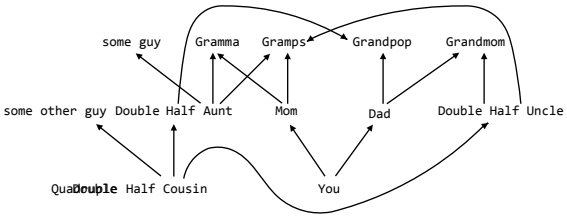


More on Design

- This example has been shortened for lecture purposes, and could have better design if done properly
- We should create a class for every species of Pokémon
  - Consequently, we should *not* create instances of the `Pokemon`, `ElectricType`, or `FlyingType` classes
- We should create classes for different types of attacks, with damage and special effect attributes
  - The relationship between classes that reference each other (e.g., `Pokemon` and `Tackle`) is called *composition*
- Good design is a bigger topic in future classes

Complicated Inheritance

To show how complicated inheritance can be, let's look at an analogy through biological inheritance.



Moral of the story:
Inheritance, especially multiple inheritance, is complicated and weird. Use it carefully!

Exceptions

Raising and handling exceptions

Exceptions (demo)

- In Python, *exceptions* alter the control flow of programs for exceptional circumstances, e.g., errors
- Exceptions cause the program to halt immediately and print a stack trace if not handled
- There are many different types of exceptions

```
>>> square
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'square' is not defined
```

stack trace

exception type

line number

message

Raising Exceptions (demo)

- We can cause an exception in our program by using the **raise** statement:

```
raise <expression>
```

- <expression> must evaluate to either an exception class or instance
  - Otherwise, an error occurs…
- An exception class is any class that inherits from the built-in **BaseException** class
  - Almost all built-in exceptions inherit from the **Exception** class, which inherits from **BaseException**

User-defined Exceptions

- It's possible to create our own exception types by defining a new class that inherits from **Exception** or a subclass of **Exception**
- These user-defined exceptions can then be used in **raise** statements, just like any other exception
- There aren't many reasons to create new exceptions, since Python already has so many

```
class MySpecialException(Exception):
    def __init__(self, msg):
        # special magic

raise MySpecialException('so special')
```

Handling Exceptions (demo)

- The **try** statement allows us to handle exceptions and continue running our program

```
try:
    <try suite>
except <exception type> as <name>:
    <except suite>
```

Execution Rule for try Statements:

1. Execute the <try suite>.
2. If an exception of <exception type> is raised, switch to executing the <except suite> with <name> bound to the exception that was raised.

Interfaces

Python protocols and magic methods

Interfaces

- Computer science often involves *communication* between different components
  - Communication between the program and the user, between two different programs, between two objects in the same program, etc.
  - This can get very complicated, since these components often have different behaviors and specifications
- Interfaces specify *rules for communication* between these components, and this is a form of abstraction!
  - E.g., to use an object, we don't need to know how it is implemented if we know the interface for the object
  - There are several common interfaces that are widely used in Python, called *protocols*

Python Object Interfaces (demo)

- In Python, object interfaces are usually implemented through *magic methods*
  - Special methods surrounded by double underscores (e.g., `__init__`) that add "magic" to your classes
- We will look at two examples of these interfaces:
  - The arithmetic interface
  - The (mutable) container protocol
- For more information, see: http://www.rafekettler.com/magicmethods.html

Custom Containers (demo)

- Python has many built-in container types: lists, tuples, ranges, dictionaries, etc.
- Python also has a protocol for defining custom container classes
- Defining custom containers is as easy as implementing the `__len__`, `__getitem__`, and `__contains__` magic methods
- `__len__` is called by `len`, `__getitem__` is used in indexing, and `__contains__` is used in membership
- To create a mutable container, we can also implement the `__setitem__` and `__delitem__` methods

Summary

- Inheritance allows us to *implement relationships* between classes and simplify our programs
- Interfaces allow for *standardized interaction* between different components by defining rules for communication
  - Implementing interfaces in Python can allow our custom classes to behave like built-in classes
- Both are tools for abstraction, and learning them well is one of the keys to becoming a great object-oriented programmer