Computational Structures in Data Science

Object-Oriented Programming: Part 2, Inheritance

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Announcements

- Midterm Feedback:
  - Sorry it was more difficult than intended.
  - We "dropped" the most difficult parts of Q4, G&H
  - Mean/Median were about 60%, just a bit lower than typical.
- Midterm Regrades:
  - Open tomorrow, for 1 week.
  - Please don't argue over the **weighting** of the rubric.
  - If your answer falls outside the rubric, but you think deserves credit, please demonstrate *why* your solution is correct or close to correct.
  - "Moar points plz" simply doesn't work. ☺

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Class Attributes: Keeping Track of Our Instances?

- **Problem:**
  - We can make many accounts… they all live in memory.
  - But how do we know what all of our accounts are?
  - How could we create an account number which is always increasing?
- Solution:
  - A *class* in Python can manage data shared across all instances
  - We call these *class attributes* which are distinguished from i*nstance attributes*

Classes Can Have Attributes Too!

- Class attributes (as opposed to *instance* attributes) belong to the class itself, instead of each object
  - This means there is one value which is shared for all of the class's objects
- Be Careful!
  - It's easy to overdo class attributes

- Methods that rely only on class attributes are called *class methods*
  - Python has some special features we won't use, but are useful:
    - https://docs.python.org/3/library/functions.html?highlight=classmethod#classmethod

Example: class attribute

```
class BaseAccount:
    account_number_seed = 1000

    def __init__(self, name, initial_deposit):
        self._name = name
        self._balance = initial_deposit
        self._acct_no = BaseAccount.account_number_seed
        BaseAccount.account_number_seed += 1

    def name(self):
        return self._name

    def balance(self):
        return self._balance

    def withdraw(self, amount):
        self._balance -= amount
        return self._balance
```

More class attributes

```
class BaseAccount:
    account_number_seed = 1000
    accounts = []
    def __init__(self, name, initial_deposit):
        self._name = name
        self._balance = initial_deposit
        self._acct_no = BaseAccount.account_number_seed
        BaseAccount.account_number_seed += 1
        BaseAccount.accounts.append(self)

    def name(self):
        ...

    def show_accounts():
        for account in BaseAccount.accounts:
            print(account.name(),
                  account.account_no(),account.balance())
```

Are There Better Approaches?

- **BEWARE! Class attributes are useful but can get confusing.**
- **Perhaps what want is a `Bank()` class**
  - The bank would have a create_account() method
  - Each Bank() would have its own accounts list, as a set of instance variables.

```
class Bank():
    def __init___(self):
        self.account_no_seed = 1000
        self.accounts = []
   def create_account(self, name, balance):
        acct = BaseAccount(name, balance,
self.account_no_seed)
        self.accounts.append(acct)
        self.account_no_seed += 1
```

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Object-Oriented Programming: "Magic" Methods

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Learning Objectives

- Python's Special Methods define built-in properties
  - `__init__ # Called when making a new instance`
  - `__sub__ # Maps to the - operator`
  - `__str__ # Called when we call print()`
  - `__repr__ # Called in the interpreter`

Special Initialization Method

`__init__` is called automatically when we write:

```
my_account = BaseAccount('me', 0)
```

```
class BaseAccount:

    def __init__(self, name, initial_deposit):
        self.name = name
        self.balance = initial_deposit

    def account_name(self):
        return self.name

    def account_balance(self):
        return self.balance

    def withdraw(self, amount):
        self.balance -= amount
        return self.balance
```

return None

More special methods

```
class BaseAccount:
        … (init, etc removed)
    def deposit(self, amount):
        self._balance += amount
        return self._balance

    def __repr__(self):
        return '< ' + str(self._acct_no) +
               '[' + str(self._name) + '] >'

    def __str__(self):
        return 'Account: ' + str(self._acct_no) +
               '[' + str(self._name) + ']'

    def show_accounts():
        for account in BaseAccount.accounts:
            print(account)
```

Goal: unambiguous

Goal: readable

More Magic Methods

- We will **not** go through an exhaustive list!
- Magic Methods start and end with "double underscores" `__`
- They map to built-in functionality in Python. Many are logical names:
  - `__init__` → Class Constructor
  - `__add__` → `+` operator
  - `__sub__` → `-` operator
  - `__getitem__` → `[]` operator
  - `__repr__` and `__str__` → control output
- A longer list for the curious:

Live Demo

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Object-Oriented Programming: Inheritance

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Learning Objectives

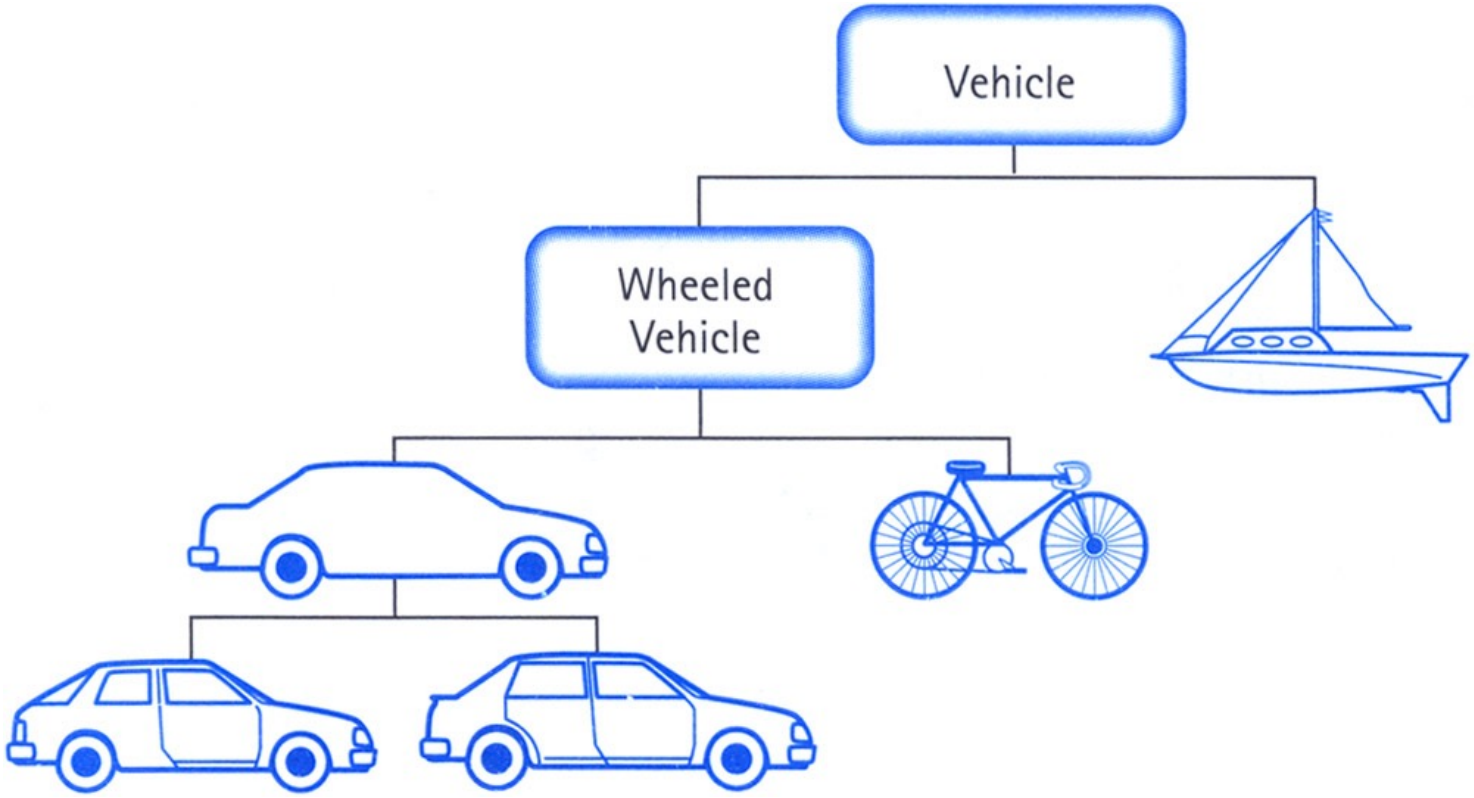
- Inheritance allows classes to reuse methods and attributes from a parent class.
- super() is a new method in Python
- Subclasses or child classes are distinct from on another, but share properties of the parent.

Inheritance

- Define a class as a specialization of an existing class
- Inherent its attributes, methods (behaviors)
- Add additional ones
- Redefine (specialize) existing ones
  - Ones in superclass still accessible in its namespace

Class Inheritance

- Classes can inherit methods and attributes from parent classes but extend into their own class.



Python class statement

```
class ClassName:
    <statement-1>
    .
    .
    .
    <statement-N>
```

```
class ClassName ( inherits / parent-class ):
    <statement-1>
    .
    .
    .
    <statement-N>
```

Example

```
class BaseAccount:
    def __init__(self, name, initial_deposit):
        # Initialize the instance attributes
        self._name = name
        self._acct_no = Account._account_number_seed
        Account._account_number_seed += 1
        self._balance = initial_deposit

class CheckingAccount(BaseAccount):
    def __init__(self, name, initial_deposit):
        # Use superclass initializer
        BaseAccount.__init__(self, name, initial_deposit)
        # Alternatively:
        # super().__init__(name, initial_deposit)
        # Additional initialization
        self._type = "Checking"
```

Accessing the Parent Class

- `super()` *binds* methods in the parent or "superclass" to the current instance
  - Can be called anywhere in our class
  - Handles passing `self` to the method
  - Handles looking up an attribute on a parent class, too.
- We can directly call `ParentClass.method(self, …)`
  - This is not quite as flexible if our class structure changes.
- In general, prefer using **super()**!
- Outside of C88C, things can get complex…
  - https://docs.python.org/3/library/functions.html#super

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Object-Oriented Programming: Evolving The Bank Model

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Composing Classes Together

- Currently, our `BaseAccount` stores a lot of data in class attributes...
- This suggests we are trying to accomplish an entirely new kind of class, or object
  - A Bank!
- We should extract that these functions into their own class
- A bank can now manage:
  - making accounts
  - keeping track of account numbers
  - showing and listing accounts

Live Demo