Computational Structures in Data Science

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Lecture #09: Object-Oriented Programming

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http://inst.eecs.berkeley.edu/~cs88

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Computational Concepts Toolbox

- Data type: values, literals, operations,
- Expressions, Call expression
- Variables
- Assignment Statement
- Sequences: tuple, list
- Dictionaries
- Data structures
- Tuple assignment
- Function Definition Statement
- Conditional Statement
- Iteration: list comp, for, while
- Lambda function expr.
- Higher Order Functions
  - Functions as Values
  - Functions with functions as argument
  - Assignment of function values
- Higher order function patterns
  - Map, Filter, Reduce
- Function factories – create and return functions
- Recursion
  - Linear, Tail, Tree
- Abstract Data Types
- Generators
- Mutation
- Object Orientation

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Mind Refresher 1

- A mutation is…

A) A monster from a movie
B) A change of state
C) Undesirable
D) All of the above

Solution:
B) A change of state

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Mind Refresher 2

- We try to hide states because…

A) We don't like them
B) Math doesn't have them
C) It's easier to program not having to think about them
D) All of the above

Solution:
C) It's easier not to have to think about them. Remember: *n* Boolean variables: 2^n states!

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Mind Refresher 3

- Where do we hide states?

A) Local variables in functions
B) Private variables in objects
C) Function arguments in recursion
D) All of the above

Solution:
D) All of the above

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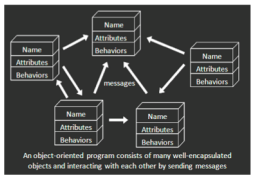
Object-Oriented Programming (OOP)

- Objects as data structures
  - With methods you ask of them
    - » These are the behaviors
  - With local state, to remember
    - » These are the attributes
- Classes & Instances
  - Instance an example of class
  - E.g., Fluffy is instance of Dog
- Inheritance saves code
  - Hierarchical classes
  - E.g., pianist special case of musician, a special case of performer
- Examples (though not pure)
  - Java, C++



www3.ntu.edu.sg/home/ehchua/programming/java/images/OOP-Objects.gif

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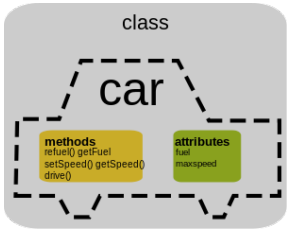
Classes

- Consist of data and behavior, bundled together to create abstractions
  - Abstract Data Types
- A class has
  - attributes (variables)
  - methods (functions)

  that define its behavior.



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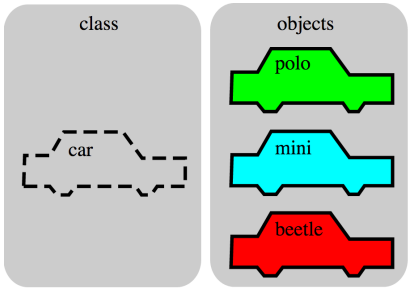
Objects

- An object is the instance of a class.



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Objects

- Objects are concrete instances of classes in memory.
- They can have state
  - mutable vs immutable
- Functions do one thing (well)
  - Objects do a collection of related things
- In Python, everything is an object
  - All objects have attributes
  - Manipulation happens through methods

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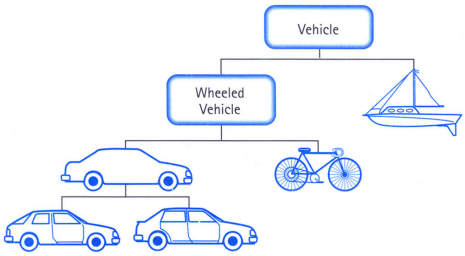
Class Inheritance

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



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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

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Python class statement

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


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


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Example: Account

```
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
```

new namespace

attributes

The object

da dot

methods

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Creating an object, invoking a method

```
my_acct = BaseAccount()
my_acct.init("John Doe", 93)
my_acct.withdraw(42)
```

The Class Constructor

da dot

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Special Initialization Method

```
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

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More on Attributes

- Attributes of an object accessible with 'dot' notation
  `obj.attr`
- You can distinguish between "public" and "private" data.
  - Used to clarify to programmers how you class should be used.
  - In Python an _ prefix means "this thing is private"
  - `_foo` and `__foo` do different things inside a class.
  - More for the curious.
- Class variables vs Instance variables:
  - Class variable set for all instances at once
  - Instance variables per instance value

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Example

```
class BaseAccount:

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

    def name(self):
        return self.name

    def balance(self):
        return self.balance

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


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Example: "private" attributes

```
class BaseAccount:

    def __init__(self, name, initial_deposit):
        self._name = name
        self._balance = initial_deposit

    def name(self):
        return self._name

    def balance(self):
        return self._balance

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


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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
```


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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())
```


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Example

```
class Account(BaseAccount):
    def deposit(self, amount):
        self._balance += amount
        return self._balance
```


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More special methods

```
class Account(BaseAccount):
    def deposit(self, amount):
        self._balance += amount
        return self._balance

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

Goal: unambiguous

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

Goal: readable

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


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Classes using classes

```
class Bank:
    accounts = []

    def add_account(self, name, account_type,
                    initial_deposit):
        assert (account_type == 'savings') or
               (account_type == 'checking'), "Bad Account type"
        assert initial_deposit > 0, "Bad deposit"
        new_account = Account(name, account_type,
                              initial_deposit)
        Bank.accounts.append(new_account)

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


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