Computational Structures in Data Science

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Lecture #09: Object-Oriented Programming

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

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**

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

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!

Mind Refresher 3

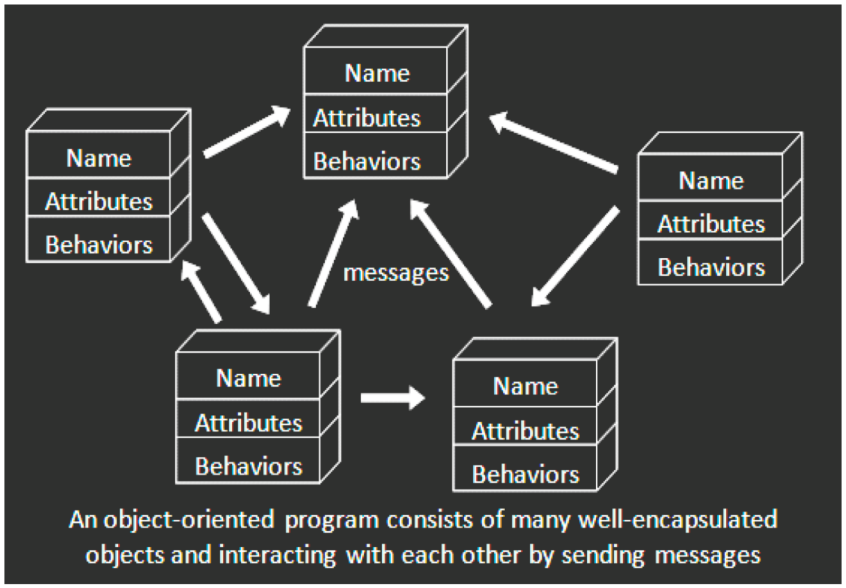
- **Where do we hide states?**

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

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++

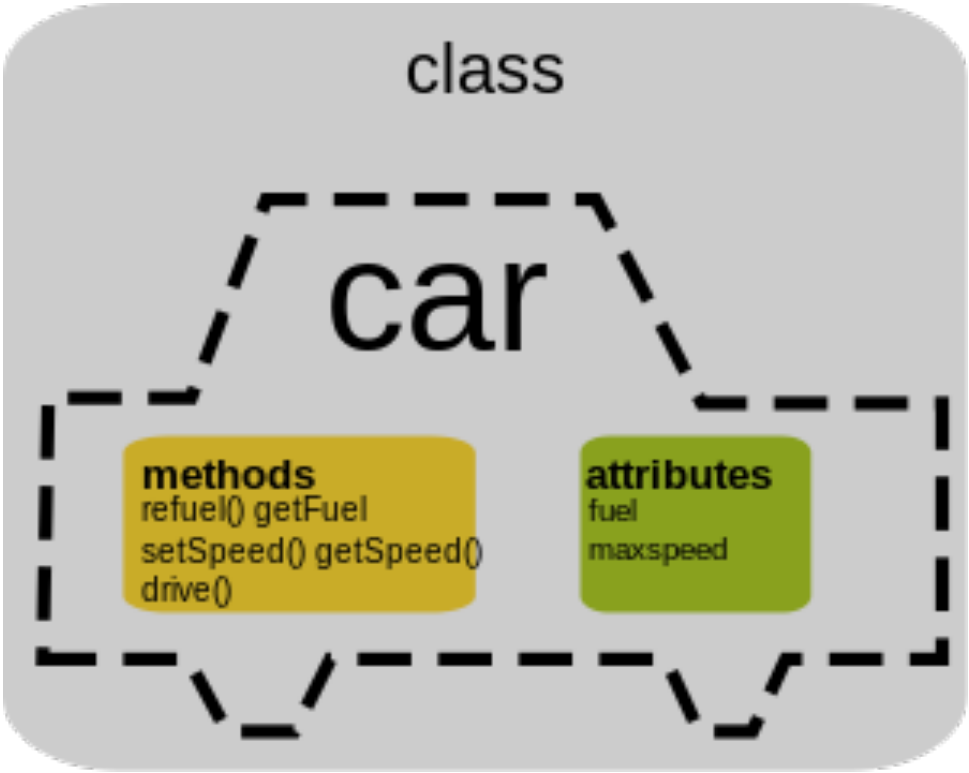


www3.ntu.edu.sg/home/ehchua/programming/java/images/OOP-Objects.gif

Classes

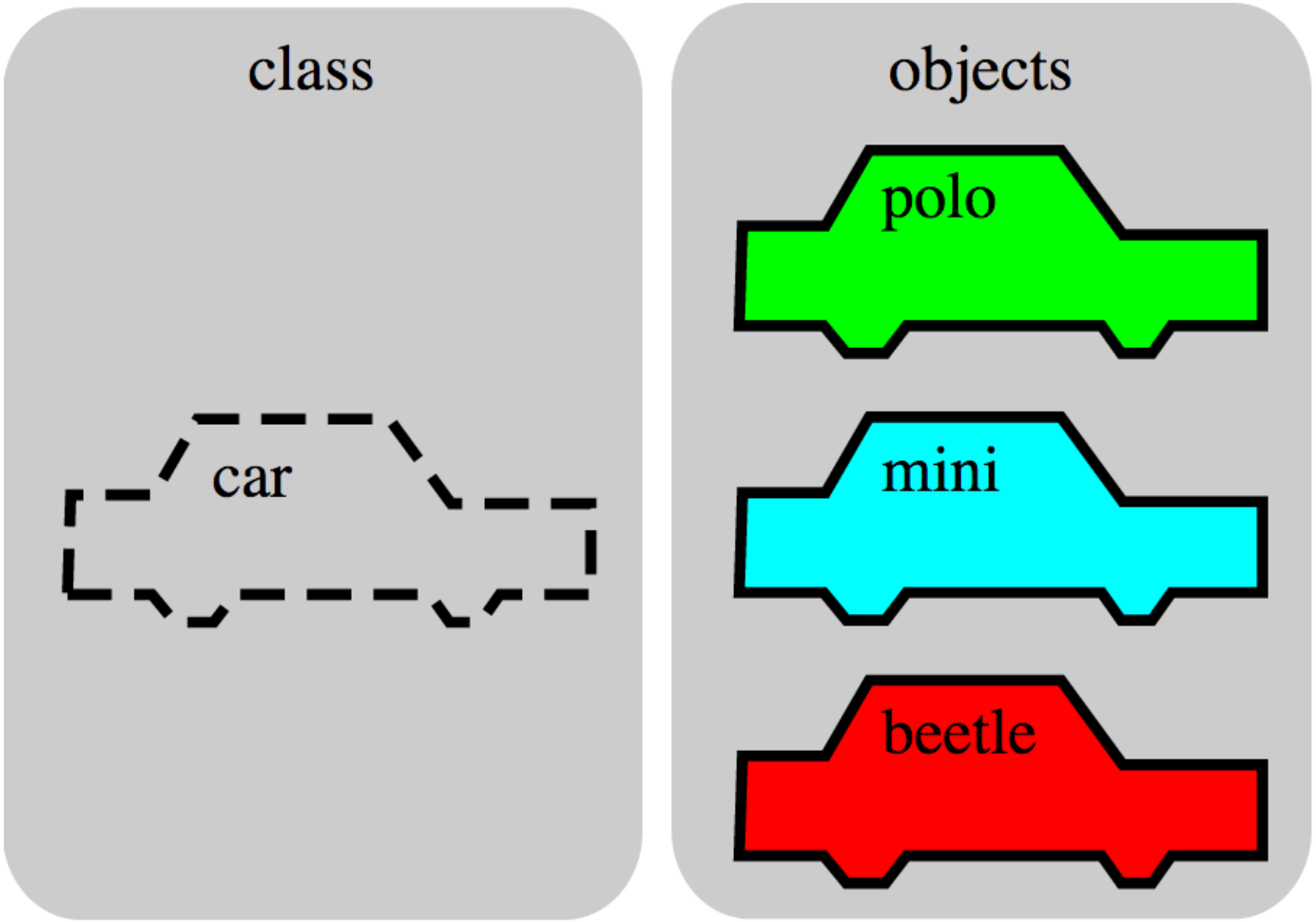
- **Consist of data and behavior, bundled together to create abstractions**
  - **Abstract Data Types**
- **A class has**
  - **attributes (variables)**
  - **methods (functions)**

  that define its behavior.



Objects

- **An object is the instance of a class.**

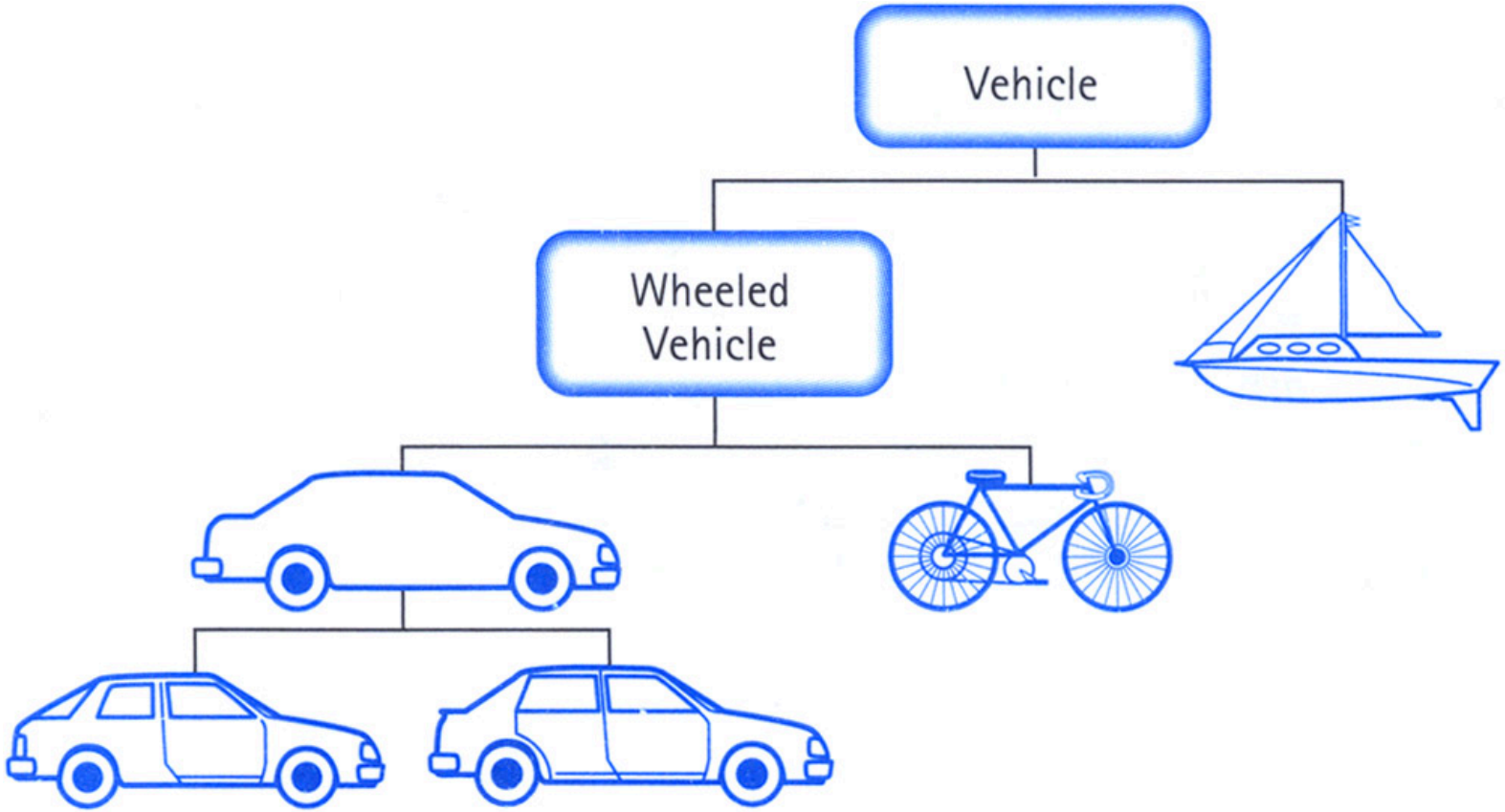


Objects

- 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

Class Inheritance

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



Inheritance

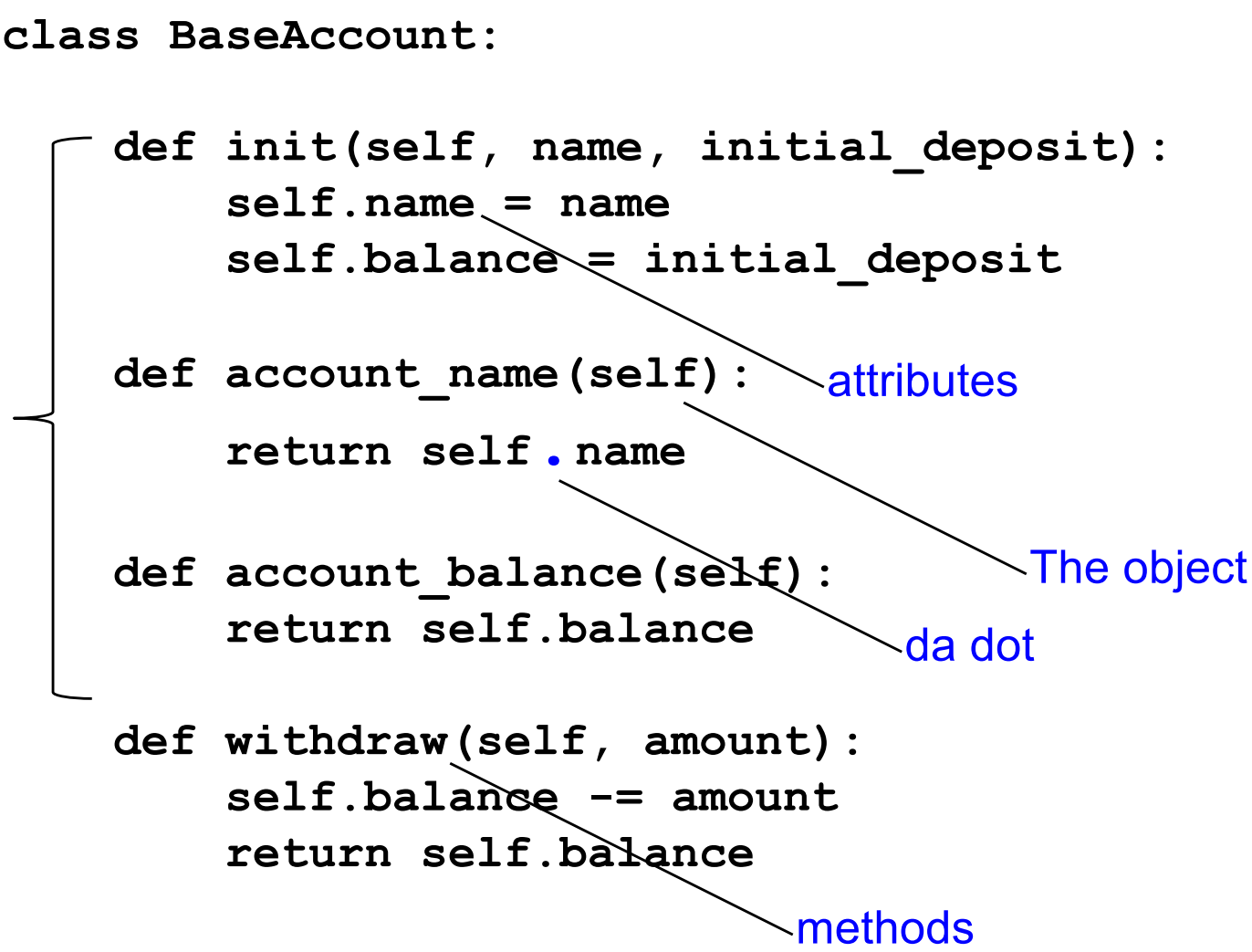
- Define a class as a specialization of an existing class
- Inherent its attributes, methods (behaviors)
- Add additional ones
- Redefine (specialize) existing ones
  - Ones in superclass still accessible in its namespace

Python class statement

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


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

Example: Account



Creating an object, invoking a method

The Class Constructor

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

da dot

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

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**

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
```

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
```

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())
```

Example

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

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) + '] >'

    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

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)
```