LECTURE 6 MODELLING THE WORLD WITH OBJECTS

Fundamentals of Programming - COMP1005

Department of Computing
Curtin University

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Learning Outcomes

- Understand the main concepts in object-oriented programming and their value
- Read and explain object-oriented code
- Apply and create simple object-oriented Python code

CODE STRUCTURE
A REVIEW

Fundamentals of Programming

Lecture 6

Code Structure

- Across the semester we've learnt many elements of coding:
  - **Control structures**: if/else/elif, for loops, while loops
  - Creating and using **functions**
  - Creating and using **modules**
  - **Python style**: PEP-8, "readability counts"
  - **Data types**: int, float, string, list, array, set, dictionary
  - **Files**: text, csv
  - **Key packages**: numpy, scipy, matplotlib, pandas, random
  - **Environments**: python scripts, command lines, bash scripts, jupyter notebooks

Control structures: if, else, elif

- Truth values / boolean expressions can be used to control the flow of a program:

```
if (concession == "Y"):
    fare = 1.20
elif (multi == "Y"):
    fare = 5.00
else:
    fare = 3.00
```

- Note: the code within the if/elif/else block needs to be indented with <u>4 spaces</u>
- Multiple elif's can be used in sequence

Control structures: while loop

- While loops repeat a block of statements until the condition is false

```
finished = False

while not finished:
    if input("Finished? Y/N : ") == "Y":
        finished = True


n = 100
s = 0
counter = 1

while counter <= n:
    s = s + counter
    counter += 1

print("Sum of 1 until ",n ," : ", s)
```

Control structures: for loop

- For loops repeat for a set number of iterations

```
for num in range(10):
    print(num)                      # prints 0..9

for num in range(4,10):
    print(num)                      # prints 4..9

for num in range(20, -6, -2):
    print(num)                      # prints 20, 18, 16.. -4

n = 100
sum = 0
for counter in range(1,n+1):        # adds 1..100 = 5050
    sum = sum + counter
print("Sum of 1 until %d: %d" % (n,sum))
```

Why Functions?

- Makes your program easier to read and debug.
- Functions can make a program smaller by eliminating repetitive code. Later, if you make a change, you only have to make it in one place.
- Dividing a long program into functions allows you to debug the parts one at a time and then assemble them into a working whole.
- Well-designed functions are often useful for many programs. Once you write and debug one, you can reuse it

https://en.wikibooks.org/wiki/Think_Python/Functions

Functions

Function name

Argument

Function header

```
def print_lyrics2(count):
    for ii in range(count):
        print("I'm a lumberjack, ",\
              "and I'm okay.")
        print("I sleep all night ",\
              "and I work all day.")
    return("I'm okay")
```

Function body

Return value

Return statement

General Code Structure

```
import matplotlib.pyplot as plt
import numpy as np

def calcheat(row,col):
    subgrid = b[row-1:row+2,col-1:col+2]
    result = 0.1 * (subgrid.sum()+ b[row,col])
    return result

size = 10
b = np.zeros((size,size))
b2 = np.zeros((size,size))

for i in range(size):
    b[i,0] = 10

for timestep in range(5):
    for r in range(1, size-1):
        for c in range (1, size-1 ):
            b2[r,c] =calcheat(r,c)
    for i in range(size):
        b2[i,0] = 10
    b = b2.copy()

plt.title('Heat Diffusion Simulation')
plt.imshow(b2, cmap=plt.cm.hot)
plt.show()
```

import statements

function definitions

set up variables

input data

process data

output data

Procedural Programming

- So far we've been applying a **procedural** programming approach
- We've been focusing on the steps of the problem, breaking it down into a sequence of instructions
  - We have control structures to help with the flow through the sequence
- When we've found repetition, we've used functions (procedures) to factor out that code
- Although our code has been procedural, we have been using Objects…

  ... and, **in Python, everything's an object**

OBJECT ORIENTATION

Fundamentals of Programming

Lecture 6

Object-Orientation

- In object-oriented programming, we bundle the behaviour (methods) and data (attributes) together
- Benefits:
  - OO protects data from being used incorrectly
  - Increases code reuse (fewer errors)
  - Makes code easier to read and maintain
  - Objects "know" how to respond to requests
  - Relates to how objects function in the real world

Reference: Module 4 of Object-oriented Program Design, Curtin University, 2017

Classes – Specifying Objects

- Before we can use an object, we need to describe it as a **class** (of objects).
  - Similar to how we define a function once and use it multiple times
- The class specifies the state and behaviour an object can have:
  - State: what the object is
    - attributes or member fields
  - Behaviour: what the object does
    - methods or functions

Encapsulation

- A (an object of a) class makes use of the "information hiding" principle
  - Communication with the rest of the software system is clearly defined
    - methods are the means for communication
  - Its obligations to the software system are clearly defined
    - what services the class offers (via data and methods)
  - Implementation details should be hidden from the user
    - don't need to know how it does things to use it

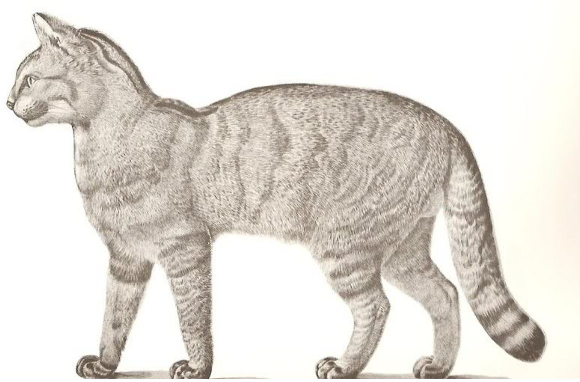
Class Specification

- Must include:
  - Details of the communication with the rest of the software system (method names)
  - The exact data representation required
  - Exactly how the required functionality is to be achieved (method implementation)

Classes and Objects

- An object is an **instance of** a class
- The class definition provides a template for an object
- An object gives details for a particular instance

Generic cat = class "cat"



Specific cat = instance
"Oogie" of class "cat"

http://s460.photobucket.com/user/stefer24/media/scan0024.jpg.html

Class roles

- Every class is designed with a specific **role** in mind.
- The total set of functional requirements for a software system is broken down into a set of tasks
- Collections of tasks are grouped together and mapped to roles
- Roles are mapped to specific classes

Class Responsibility

- Take the requirements for a software application:
  - Identify the classes required
  - Assign specific Responsibilities to each class
  - Determine relationships between classes (see later)
  - Repeat the above steps until the design is correct
  - Each responsibility should be handled by that class and no other
    - Example: If a responsibility for keeping track of a person's name is assigned to a class called PersonClass then:
    - No other class should have this information
    - Other classes which need this information should refer to this class when the information is required

Comparison to non-OO design

- In a top-down procedural approach, we design an algorithm by starting with a main module and using step-wise refinement to determine the processing steps
- Some of these steps get refined into sub modules and the process repeats until the design is refined enough to code

- Under Object Orientation this all changes…

OO design

- Before the algorithm is designed:
  - The classes are identified
  - Each class is assigned role(s) or responsibilities
  - The required sub modules are designed (i.e. Constructors, accessors, etc)
  - Each Class is thoroughly tested via a test harness

- Finally, the main algorithm and any required sub modules is designed (making use of the developed classes in the process)

Nouns and Verbs

- Like algorithm design, the determination of classes is still a bit of an art form
- One simple technique is the nouns and verb approach:
  - Nouns are mapped to classes
  - Verbs are mapped to sub modules within classes
  - The definition of noun and verb gets stretched to cover collections of words
  - Result is that:
    - Sub module names should always describe an action (i.e. getName)
    - Class names should always describe a thing (e.g. PersonClass)
- It is important to note that the set of classes proposed will change over the design phase

Object Communication

- Sometimes referred to as **message passing**:
  - When an object of one class calls an object of another class it is passing a message (i.e. A request to the object to perform some task)
- The [public] methods must provide the functionality required for the class to fulfill its role.
- There are five categories of methods in a class:
  - The Constructors
  - The Accessor Methods (aka Interrogative Methods)
  - The Mutator Methods (aka Informative Methods)
  - Doing Methods (aka Imperative Methods)
  - [Private] methods

Classes in Python

- Order your code consistently for FOP
- Declare the components of each class in the following order:
  - Declarations for class constants
  - Declarations for **class variables**/fields
    - variables which are global to the class
  - Declarations of **instance variables** (local to each instance)
  - Declarations for the Constructors (__init__)
  - *Accessor methods* *Python instance and class variables are*
  - *Mutator methods* *public, so basic set/gets are not req'd*
  - Doing methods ("public")
  - Internal methods ("private")
- Note that everything in Python is "public" (unlike Java, C++) so we can only **treat** methods and data as private

Example: song

```
class Song():

    def __init__(self, lyrics):
        self.lyrics = lyrics

    def sing_me_a_song(self):
        for line in self.lyrics:
            print(line)

lumberjack = Song(["I'm a lumberjack and I'm OK",
                   "I sleep all night",
                   "And I work all day"])

spam = Song(["SPAM, SPAM, SPAM, SPAM",
             "spam, spam, spam, spam"])

lumberjack.sing_me_a_song()
spam.sing_me_a_song()
```

Song: lumberjack
lyrics: ["I'm a lumberjack and I'm OK", "I sleep all night", "And I work all day"]

https://learnpythonthehardway.org/book/ex40.html

Example: dog tricks

```
class Dog():

    def __init__(self, name):
        self.name = name
        self.tricks = []

    def add_trick(self, trick):
        self.tricks.append(trick)

d1 = Dog('Brutus')
d2 = Dog('Dude')

d1.add_trick('roll over')
d1.add_trick('sit')
d2.add_trick('stay')
d2.add_trick('roll over')
print("Dog's name: ", d1.name, "\nDog's tricks: ", d1.tricks)
print("Dog's name: ", d2.name, "\nDog's tricks: ", d2.tricks)
```

Dog: d1
name: Brutus tricks: ["roll over", "sit"]

Example: bank account

BankAccount: bank

interest_rate: 0.3
name: 'Everyday'
number: '007'
balance: 2000

```
class BankAccount ():
    interest_rate = 0.03
    def __init__(self, name, number, balance):
        self.name = name
        self.number = number
        self.balance = balance


bank = BankAccount('Everyday', '007', 2000)

print("Name: ", bank.name, "\tNumber: ",
      bank.number, "\tBalance: ", bank.balance)
```

Output:

```
Name:  Everyday     Number:  007  Balance:  2000
```

Example: bank account

```
class BankAccount ():
    interest_rate = 0.03
    def __init__(self, name, number, balance):
        self.name = name
        self.number = number
        self.balance = balance
```

BankAccount: bank

interest_rate: 0.03
name: 'Everyday'
number: '007'
balance: 2000

Class variable

Instance variables

Example: bank account (v2)

```
class BankAccount ():
    interest_rate = 0.03
    def __init__(self, name, number, balance):
        self.name = name
        self.number = number
        self.balance = balance


accounts = []
bank = BankAccount('Everyday', '007', 2000)
accounts.append(bank)
bank = BankAccount('Cheque A/C', '008', 3000)
accounts.append(bank)
bank = BankAccount('Term Deposit', '009', 20000)
accounts.append(bank)

total = 0
for i in range(len(accounts)):
    print("Name: ", accounts[i].name, "\tNumber: ", accounts[i].number,
          "\tBalance: ", accounts[i].balance)
    total = total + accounts[i].balance
print("\t\t\t\t\tTotal: ", total)
```

Example: bank account (v2)

```
class BankAccount ():
    inte
    def
```

```
OUTPUT:
Name:  Everyday         Number:  007  Balance:  2000
Name:  Cheque A/C       Number:  008  Balance:  3000
Name:  Term Deposit     Number:  009  Balance:  20000
                                      Total:  25000
```

```
accounts = []
bank = BankAccount('Everyday', '007', 2000)
accounts.append(bank)
bank = BankAccount('Cheque A/C', '008', 3000)
accounts.append(bank)
bank = BankAccount('Term Deposit', '009', 20000)
accounts.append(bank)

total = 0
for i in range(len(accounts)):
    print("Name: ", accounts[i].name, "\tNumber: ", accounts[i].number,
          "\tBalance: ", accounts[i].balance)
    total = total + accounts[i].balance
print("\t\t\t\t\tTotal: ", total)
```

Example: bank account (v3)

```
class BankAccount ():
    interest_rate = 0.03
    def __init__(self, name, number, balance):
        self.name = name
        self.number = number
        self.balance = balance

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

    def  deposit(self, amount):
        self.balance = self.balance + amount

    def add_interest(self):
        self.balance += self.balance * self.interest_rate

def balances():
    total = 0
    for i in range(len(accounts)):
        print("Name:", accounts[i].name, "\tNumber: ", accounts[i].number,
              "\tBalance: ", accounts[i].balance)
        total = total + accounts[i].balance
    print("\t\t\t\t\tTotal: ", total)
```

Example: bank account (v3)

```
accounts = []
bank = BankAccount('Everyday', '007', 2000)
accounts.append(bank)
bank = BankAccount('Cheque A/C', '008', 3000)
accounts.append(bank)
bank = BankAccount('Term Deposit', '009', 20000)
accounts.append(bank)
balances()

print("\nDoing some transactions...\n")
accounts[0].deposit(100)
accounts[1].withdraw(500)
accounts[2].add_interest()
balances()
```

Output:

```
Name:  Everyday          Number:  007     Balance:  2000
Name:  Cheque A/C        Number:  008     Balance:  3000
Name:  Term Deposit      Number:  009     Balance:  20000
                                          Total:  25000

Doing some transactions...

Name:  Everyday          Number:  007     Balance:  2100
Name:  Cheque A/C        Number:  008     Balance:  2500
Name:  Term Deposit      Number:  009     Balance:  20600.0
                                          Total:  25200.0
```

Self

- Why do I need self when I make __init__ or other functions for classes?
- If you don't have self, then code like cheese = 'Gorgonzola' is ambiguous.
- That code isn't clear about whether you mean the *instance's* cheese attribute/variable, *or* a local variable named cheese.
- With self.cheese = 'Gorgonzola' it's very clear you mean the instance attribute self.cheese.
- You can use any variable name, but self is the convention.

https://learnpythonthehardway.org/book/ex40.html

OO Design…Where to begin?

- Find your objects
- If we wanted to keep track of our household animals: cats, dogs and birds
- We could make classes for cats, dogs and birds
- For each animal, we might track:
  - name
  - date of birth
  - colour
  - breed

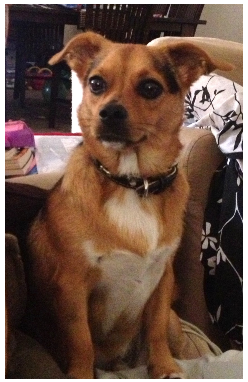
Test our objects out…

CAT

Name: Oogie
DOB: 1/1/2006
Colour: Grey
Breed: Fluffy

DOG

Name: Dude
DOB: 1/1/2011
Colour: Brown
Breed: Jack Russell



BIRD

Name: Big Bird
DOB: 10/11/1969
Colour: Yellow
Breed: Canary

animals.py - Dog Class (v2)

```
class Dog():

    myclass = "Dog"

    def __init__(self, name, dob, colour, breed):
        self.name = name
        self.dob = dob
        self.colour = colour
        self.breed = breed

    def printit(self):
        print('Name: ', self.name)
        print('DOB: ', self.dob)
        print('Colour: ', self.colour)
        print('Breed: ', self.breed)
        print('Class: ', self.myclass)
```

animals.py - Cat Class

```
class Cat():

    myclass = "Cat"

    def __init__(self, name, dob, colour, breed):
        self.name = name
        self.dob = dob
        self.colour = colour
        self.breed = breed

    def printit(self):
        print('Name: ', self.name)
        print('DOB: ', self.dob)
        print('Colour: ', self.colour)
        print('Breed: ', self.breed)
        print('Class: ', self.myclass)
```

animals.py - Bird Class

```
class Bird():

    myclass = "Bird"

    def __init__(self, name, dob, colour, breed):
        self.name = name
        self.dob = dob
        self.colour = colour
        self.breed = breed

    def printit(self):
        print('Name: ', self.name)
        print('DOB: ', self.dob)
        print('Colour: ', self.colour)
        print('Breed: ', self.breed)
        print('Class: ', self.myclass)
```

Pets.py

```
from animals import Dog
from animals import Cat
from animals import Bird

dude = Dog('Dude', '1/1/2011', 'Brown', 'Jack Russell')
oogs = Cat('Oogie', '1/1/2006', 'Grey', 'Fluffy')
bbird = Bird('Big Bird', '10/11/1969', 'Yellow', 'Canary')

dude.printit()
oogs.printit()
bbird.printit()
```

Or…

from animals import *

Pets.py

```
from animals import Dog
from animals import Cat
from animals import Bird

dude = Dog('Dude', '1/1/2011', 'Brown', 'Jack Russell')
oogs = Cat('Oogie', '1/1/2006', 'Grey', 'Fluffy')
bbird = Bird('Big Bird', '10/11/1969', 'Yellow', 'Canary')

dude.printit()
oogs.printit()
bbird.printit()
```

```
Name:  Dude
DOB:  1/1/2011
Colour:  Brown
Breed:  Jack Russell
Class:  Dog

Name:  Oogie
DOB:  1/1/2006
Colour:  Grey
Breed:  Fluffy
Class:  Cat

Name:  Big Bird
DOB:  10/11/1969
Colour:  Yellow
Breed:  Canary
Class:  Bird
```

If you try to print dude directly:

animals.Dog object at 0x10108d978

Summary

- Understand the main concepts in object-oriented programming and their value
- Read and explain object-oriented code
- Apply and create simple object-oriented Python code

Practical Sessions

- We'll be coding objects and using them

Assessments

- We've sat Prac Test 2 in the week preceding this lecture

- We have an in-class written test next week during the lecture
- The assignment will be released after the test

Mid-semester Test

- 60 minutes + 5 minutes reading time
- Covers weeks 1-6 of lectures, weeks 1-5 of practicals
  - i.e. just simple questions from OO
  - Questions based on lectures, practicals, practical tests, revision questions and review questions
- Examples are available on Blackboard
- Hopefully will have a ComSSA revision TBA

Next week…

- Test during lecture – 22/9/19
  - If you have a Curtin Access Plan, and haven't informed me, do so ASAP.

- Lecture 7:
  - Relationships in Object-orientation
  - Exception handling