Python Programming

Speaker: Yun-Wei Lin

Materials: Prof. Chang-Chieh Cheng

National Yang Ming Chiao Tung University

Introduction to Python

- Why Python?
  - The learning of Python is more easy than other programming language for a beginner.
  - You can quickly design a useful application.
  - You can have increased motivation when you feel some sense of accomplishment
  - Cross-platform and portable code
  - Many free resources can be found on the internet
  - Development of AI applications
    - Scikit-learn
    - TensorFlow
    - Keras
    - PyTorch

The History of Python

- The concept of Python was started in the late 1980s
- The implementation of Python began in Dec.1989 by **Guido van Rossum** at Centrum Wiskunde & Informatica (CWI) in the Netherlands.
  - 16 Oct. 2000, Python 2.0 released.
  - 3 Dec. 2008, Python 3.0 released.
  - 28 Mar. 2018, Python 3.6.5 released.

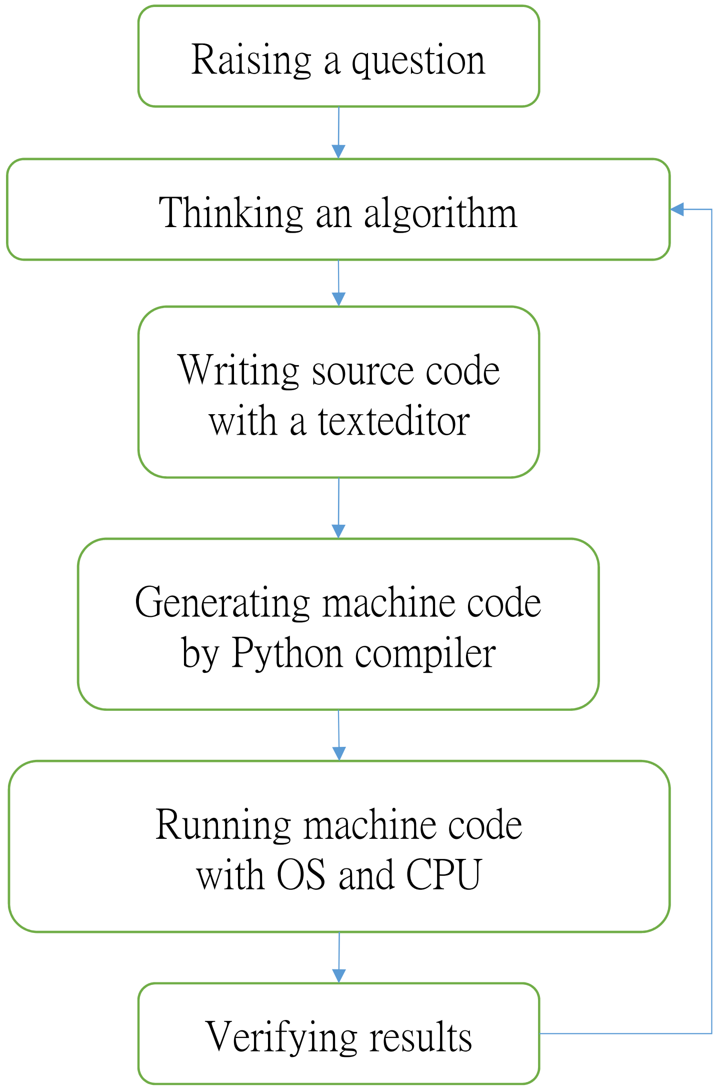
Guido van Rossum

Programming Environment

- Typical installation
  - Installing python 3.x
    - https://www.python.org/
  - Upgrading pip
    - python -m pip install --upgrade pip
  - Installing libraries
    - pip install numpy scipy matplotlib ipython jupyter pandas
  - About Jupyter Notebook
    - A web-based python IDE
    - https://jupyter.org/

In Windows, you need to append the paths of Python and Jupyter to PATH, which is a system environment variable for default paths.

Programming Flow


Raising a question
Thinking an algorithm
Writing source code with a texteditor
Generating machine code by Python compiler
Running machine code with OS and CPU
Verifying results

Simple Arithmetic

- What are the results of the following program?

```
print(1 + 2 + 3)
print(1 + 2 * 3 / 4)
```

Variables and Objects

- A variable or object can store a value for arithmetic.
  - A variable or object can provide a value in an arithmetical expression.
  - The value of a variable or object can be change.
- Run the following code:

```
x = 10
y = 2
print(x + y)
z = x / y
print(z)
x = x * z
y = y - z
print(x + y)
```

Variables and Objects

- Assignment operator "="
  - `a = b` means copying the value of `b` to `a`.
  - `a = b + c` means copying the value of `(b + c)` to `a`.
  - LHS, left-hand side
    - Creating variables
  - RHS, right-hand side
    - An expression can calculate values
  - Rule:
    1. RHS calculates **n** values
    2. LHS create **n** variables
    3. Assign the **n** values to the **n** variables, respectively.

Print Multiple Objects

- **`print`** is a function, which can display a message or data of a variable on screen.
  - **argument**: an input value of a function call.
  - Any two arguments are delimited by a comma.

```
x = 10
y = 2
z = x / y
print(x, y, z)
```

  - **print** can output the values of arguments in the order from left to right.
  - Any two output results are delimited by a space

Print Objects and Texts

- Run the following code:

```
x = 10
y = 2
z = x / y
print("X divided by Y is ", z)
print(x, "divided by", y, "is", z)
```

- How many arguments in each print?
- Let's try it:
  - Change the values of `x` and `y` by any number.
  - The symbol of multiplication is `*`.
  - Please modify this example so that the result is

```
X times by Y is 20
10 times 2 is 20
```

Strings

- In programming, we call a text is a **string.**
- Character
  - A unit of a text.
  - A letter, a numerical digit, or a symbol.
- String
  - A series of **characters**.
  - For example, `"Hello"` consists of five characters that are `'H', 'e', 'l', 'l',` and `'o'`.
- String representation
  - Single quotes
    - `'ABC'`
    - `'123456890'`
  - Double quotes
    - `"ABC"`
    - `"1234567890"`
  - No different between single quotes and double quotes

Strings

- Let's try it
  - Run the following program and see what results will be output.
  - Can you explain the reason of each output?

```
x = "XYZ"
y = 'ABC'
print(x, y)

x = "123"
y = '456'
z = x + y
print(z)

x = 123
y = 456
z = x + y
print(z)
```

```
x = "123"
y = 456
z = x + y
print(z)
```

Special Character

- Single quote

```
x = "\'"
print(x)
```

- Double quote

```
x = '\"'
print(x)
```

- tab

```
x = 'ABC\tXYZ'
print(x)
```

- newline

```
x = 'ABC\nXYZ'
print(x)
```

Data Input

- **`input(prompt_string)`**
  - Read a string from standard input.
  - You can type data in IPython console window.
  - The trailing newline is stripped. (not including the newline character).

```
x = input("Input the first string: ")
print(x)
y = input("Input the second string: ")
print(x, y)
```

Comment in Python

- Comment
  - An explanation or annotation in the source code.
  - All comments will be ignored by Python interpreter.
- Single line comment #

```
# test
print(1 + 2 + 3)         # the result is 6
print(1 + 2 * 3 / 4)     # 2.5
```

- Multiple-line comment """ … """

```
"""
This is my first Python program.
I love Python
very much!
"""
print(1 + 2 + 3)         # the result is 6
print(1 + 2 * 3 / 4)     # 2.5
```

Operators

lowest precedence

highest precedence

Operator	Description
:=	Assignment expression
lambda	Lambda expression
if – else	Conditional expression
or	Boolean OR
and	Boolean AND
not x	Boolean NOT
in, not in, is, is not, <, <=, >, >=, !=, ==	Comparisons, including membership tests and identity tests
|	Bitwise OR
^	Bitwise XOR
&	Bitwise AND
<<, >>	Shifts
+, -	Addition and subtraction
*, @, /, //, %	Multiplication, matrix multiplication (numpy), division, floor division, remainder 5
+x, -x, ~x	Positive, negative, bitwise NOT
**	Exponentiation 6
await x	Await expression
x[index], x[index:index], x(arguments...), x.attribute	Subscription, slicing, call, attribute reference
(expressions...), [expressions...], {key: value...}, {expressions...}	Binding or parenthesized expression, list display, dictionary display, set display

Arithmetic Operators

`+`	addition	`x + y`
`-`	subtraction	`x - y`
`*`	Multiplication	`x * y`
`/`	Division	`x / y`
`%`	modulus	
`**`	exponent	
`//`	Floor division (integer division)	

```
x = 11
y = 7
z = x % y
print(z)        # 4
z = y ** 2
print(z)        # 49
z = 2 ** 0.5
print(z)        # 1.4142135623730951
z = x / y
print(z)        # 1.5714285714285714
z = x // y
print(z)        # 1
```

Arithmetic Operators

- `//` Floor division
  - dividing and rounding down to the nearest integer.
  - `z = x // y`
    - `z` will be the nearest integer of `x / y` and smaller than `x / y`

```
x = 5
y = 2
z = x // y
print(z)          # 2

x = -5
y = 2
z = x // y
print(z)          # -3
```

```
x = 5
y = 2

a = x // y
b = -x // y
print(a, b)     # 2, -3

a = x // y
b = -a
print(a, b)     # ?, ?
```

Arithmetic Operators

- `%` Modulus
  - `x % y`
    - `x - x // y * y`

```
x = 11
y = 3
z = x % y        # 11 - (3 * 3)
print(z)         # 2

x = -11
y = 3
z = x % y        # -11 - (-4 * 3)
print(z)         # 1

x = 11
y = -3
z = x % y        # 11 - (-4 * -3)
print(z)         # -1
```

```
x = 11.4
y = 3
z = x // y       # 11.4 - (3 * 3)
print(z)         # 2.4

x = -11.4
y = 3
z = x // y       # -11.4 - (-4 * 3)
print(z)         # 0.6

x = 11.4
y = -3
z = x % y        # 11.4 - (-4 * -3)
print(z)         # -0.6
```

Arithmetic Assignment Operators

- `+=` `x += y` ➔ `x = (x + y)`
- `-=` `x -= y` ➔ `x = (x - y)`
- `*=` `x *= y` ➔ `x = (x * y)`
- `/=` `x /= y` ➔ `x = (x / y)`
- `%=` `x %= y` ➔ `x = (x % y)`
- `**=` `x **= y` ➔ `x = (x ** y)`
- `//=` `x //= y` ➔ `x = (x // y)`

```
x = 1
x += 1
print(x)        # 2
x *= x
print(x)        # 4
x %= 5
print(x)        # 4
x //= x - 1
print(x)        # 1
```

```
x = 1
x += x += 1     # Invalid syntax
x *= (x /= 1)   # Invalid syntax
```

Augmented Assignments

- **Augmented assignment operators**
  - `+=, -=, *=, ...`
  - `a += b` means copying the value of `b` to `a`.
  - `a = b + c` means copying the value of `(b + c)` to `a`.
  - LHS, left-hand side
    - An expression can create variables
    - LHS contains an undefined name will cause a `NameError`
  - RHS, right-hand side
    - An expression can calculate values
  - Rule:

    1. LHS create n variables

    2. RHS calculates **n** values

    3. Calculating the values of LHS and RHS with the augmented operator.

    4. Assign the **n** values to the **n** variables, respectively.

String Operators

- + String concatenation
- += String appending

```
x = 'james' + 'cheng' + 'cs'  # Concatenate three strings
print(x)                      # jameschengcs

y = x + '@''nctu.edu.tw'
       # + can be omitted for concatenating literal strings
print(y)                  # jameschengcs@nctu.edu.tw

z = "email: "
z += y                    # Appending y to z
print(z)                  # email: jameschengcs@nctu.edu.tw
```

Number to String

- `str(number)`

```
x = 123
y = 456
z = x + y
print(z)                    # 579
z = str(x) + str(y)
print(z)                    # 123456
```

- Let’s try it:
  - Modify the fifth line, **`z = str(x) + str(y)`**, such that the result of the 6th line is

`123 + 456 = 579`

Lists

- Creating a list which can contain many objects
  - `listname = [object1, object2, …, objectN]`
- Accessing an item of a list
  - `listname[index]`
    - `index` is an integer.
  - The index of the first object in the list is **zero.**
    - zero-based indexing

```
L = [10, 20, 30, 4, 5, 6]
print(L[0])                    # 10
print(L[3])                    # 4
L[2] += L[4] + L[5]
print(L[2])                    # 41
print(L)                        #[10, 20, 41, 4, 5, 6]
```

Lists

- An index can be negative.

```
L = [10, 20, 30, 4, 5, 6]     # N = 6
print(L[-1])    # ➔ L[N - 1] ➔ L[5] ➔ 6
print(L[-2])    # ➔ L[N - 2] ➔ L[4] ➔ 5
print(L[-6])    # ➔ L[N – 6] ➔ L[0]
```

- -N ≤ index < N

```
L = [10, 20, 30, 4, 5, 6]     # N = 6
print(L[6])     # Out of range!
print(L[-7])    # ➔ L[N - 7] ➔ Out of range!
```

Lists

- The types of objects in a list can be different.

```
L = [10, 20, 30, 'ABC', '123', '456']
print(L[0])                 # 10
print(L[3])                 # ABC

L[0] += L[1] + L[2]
print(L[0])                 # 60

L[3] += L[4] + L[5]
print(L[3])                 # ABC123456

L[1] = L[4] + L[5]
print(L[1])                 # 123456
                            # L[1] is changed to a string
```

Lists

- Be careful with the type error.

```
L = [10, 20, 30, 'ABC', '123', '456']

L[2] += L[4] + L[5]    # Type error!
                       # L[2] is an integer
                       # but L[4] + L[5] is a string
```

  - We will learn how to check the type of an object later.

- Let’s try it:
  - `L = [10, 20, 30, 'ABC', '123', '456']`
  - Design a program to swap the first and last objects of `L`, such that the result of `print(L)` is

    `['456', 20, 30, 'ABC', '123', 10]`

Lists

- The length of a list
  - The number of items in a list
  - `len(list_object)`

```
L = [10, 20, 30, 'ABC', '123', '456']

print(len(L))   # 6
```

Lists

- Range accessing
  - `list[ S:T:D ]`
    - From `S` to `T`, `T` is not included, with an interval `D`.
    - The defaults values of `S`, `T`, and `D` are `0`, `N`, and `1` respectively.
    - `S < T` and the `S` and `T` must have the same sign; otherwise, the result is an empty list.

```
L = [10, 20, 30, 'ABC', '123', '456']
print( L[1:5:1] )      # [20, 30, 'ABC', '123']
print( L[1:5:2] )      # [20, 'ABC']
print( L[2:4] )        # Item 2 ~ Item 3
print( L[:3] )         # Item 0 ~ Item 2
print( L[3:] )         # Item 3 ~ Item N - 1
print( L[0:len(L)] )
print( L[-6:-1] )
print( L[:] )
print( L[::3])
```

Lists

- Range accessing

```
L = [10, 20, 30, 'ABC', '123', '456']
print(L[1:1])          # []
print(L[2:1])          # []
print(L[-1:-2])        # []
print(L[-2:3]) # []
```

Lists

- List operators
  - + list concatenation
  - += list appending

```
L1 = [10, 20, 30]
L2 = [40, 50, 60]
L3 = L1 + L2
print(L3)                    # [10, 20, 30, 40, 50, 60]
L1 += L1
print(L1)                    # [10, 20, 30, 10, 20 ,30]
```

Lists

- String can be regarded as a read-only list of characters.

```
s = 'ABCDEF'
print(s[0])     # A
print(s[3])     # D
```

- That means you **cannot** modify any character of a string.

```
s = 'ABCDEF'
s[2] = 'X'     # Error! each character is read-only!
```

- Range access in string:

```
s = 'ABCDEF'
print(s[1:3])   # BC
print(s[:3])    # ABC
print(s[2:])    # CDEF
```

Lists

- Converting a string to a character list.
  - `list(string_object)`
- Converting a character list to a string.
  - `str().join(list_object)`
    or
    `''.join(list_object)`

```
s = 'ABCDEF'
L = list(s)
print(L[0])     # A
print(L[3])     # D
L[2] = 'X'
print(L)        # ['A', 'B', 'X', 'D', 'E', 'F']
print(s)        # ABCDEF
s = ''.join(L)
print(s)        # ABXDEF
```

Assignment and List

- For integers and floats, the assignment is similar to data replication.

```
x = 1
y = x
y += 1
print(x)        # 1
print(y)        # 2

x = 0.5
y = x
y += 1
print(x)        # 0.5
print(y)        # 1.5
```

Assignment and List

- For other object, the assignment is similar to reference change (change the linking)

```
L1 = [1, 2, 3]
L2 = L1
L2[0] += 10
print(L1)      # [11, 2, 3]
print(L2)      # [11, 2, 3]
```

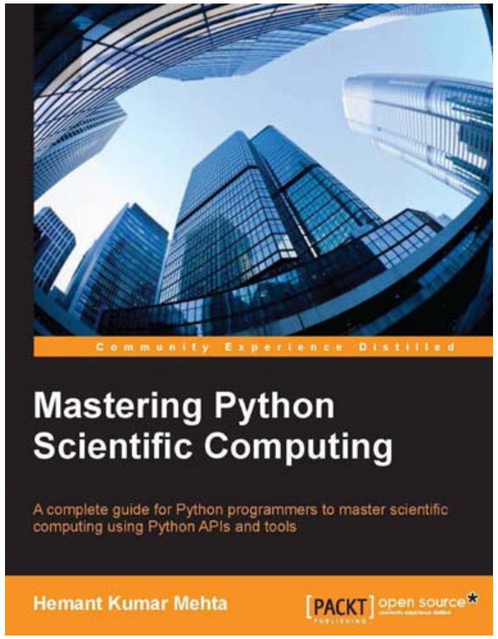
Assignment and List

- For string, the assignment is similar to reference change (change the linking).
  - However, string data is read-only, which means you cannot modify every character of a string

```
s1 = "hello"
s2 = s1
s2 = "abc"
print(s1)       # hello
print(s2)       # abc
```

Textbook

- Hemant Kumar Mehta, ***Mastering Python Scientific Computing***, Packt Publishing, Sep. 2015.


Community Experience Distilled
Mastering Python Scientific Computing
A complete guide for Python programmers to master scientific computing using Python APIs and tools
Hemant Kumar Mehta
[PACKT] open source