Python

ECE 650
Methods & Tools for Software Engineering (MTSE)
Fall 2019

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Python

Created by Guido van Rossum in early 90s

- simple and elegant syntax emphasizing readability
- dynamic type system (”duck” typing)
- automatic memory management
- dynamically interpreted

Python 2.0 released in 2000

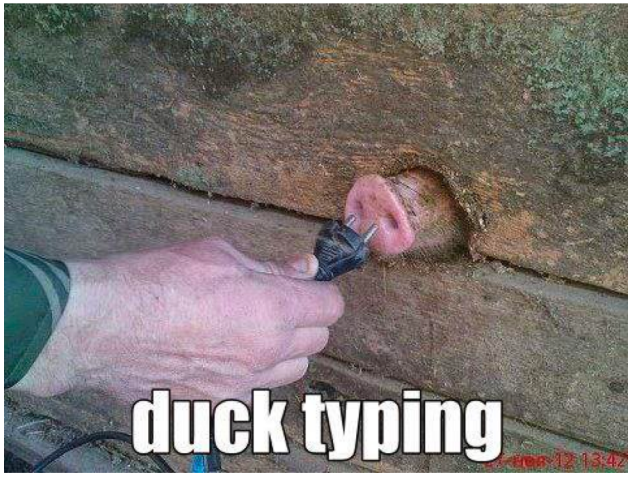
Python 3.0 released in 2008

- many new features
- NOT backward compatible to Python 2.0
- both version 2 and 3 are still actively used

We use Python v2.7 in the course

- January 2020 is EOL of Python2

Duck Typing



http://stereobooster.github.io/duck-typing

"if it walks like a duck and quacks like a duck, then it must be a duck"

A type of any object / expression is determined dynamically based on what operations (methods / functions) the objects involved support

- if the code works then it is typed correctly

This means that there are very few checks that can be done before the code is executed

- thus, a poorly tested program might contain hidden code paths that do not are not even executable (i.e., do not produce any answer)

Many Flavors of Python

CPython (a.k.a. Python)

- the official implementation of Python in C
- a defacto standard of the language

PyPy

- an alternative implementation
- based on RPython framework for developing interpretes for dynamic languages

Jython

- a Java-based implementation
- compiles Python into Java bytecode

Cython

- a C-based implementation
- compiles Python into C for more efficient execution

Don’t forget that there is version 2 and version 3 of everything!

IPython

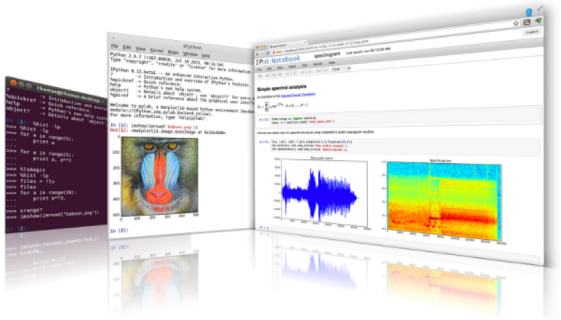
IP[y]: IPython
Interactive Computing

An interactive shell for Python

- written in Python

Much more user friendly than the standard Python interpreter

- many helpful features to discover available modules, methods
- easy access to documentation
- good way to learn the language by trying



Part of a bigger echo system

- Jupyter, Python Notebooks, graphs, and many more
- https://ipython.org/

We will only use the interactive shell

https://docs.python.org/2/tutorial/index.html

PYTHON TUTORIAL

https://notebooks.azure.com/arie-gurfinkel/projects/ece650-py

CALCULATOR EXAMPLE

Virtualenv

It is hard to maintain consistent development environment

- your code might require 3rd party libraries and specific versions of these
- different environments might provide different libraries and these might change as system administrator updates the system
- you might want to develop on one machine but make sure that it works on another (i.e., develop on personal machine, run on `ecelinux[1-3]`)

`virtualenv` simplifies the management of virtual python environment

- not a virtual machine! no overhead! (except for extra space)
- maintains local copies of desired libraries
- multiple virtual environments can co-exist together

- see course web site for setup details
  - https://ece.uwaterloo.ca/~agurfink/ece650/tutorial/2019/08/25/virtualenv-intro

Unit Testing

A *unit test* exercises a unit of functionality to test its behavior

A *unit test framework* provides a standard mechanism for

- specifying a test (setup, execution, expected result, teardown)
- executing a test
- generating test reports

Python includes a Unit Test framework called unittest

- https://docs.python.org/2/library/unittest.html

It is important to design your code with testing in mind

- e.g., a code that simply reads and writes to standard input and output is harder to test than code that provides a more structured interaction

Anatomy of a Unit Test

include module

A test case is a collection of tests

A method is a test

Calls to `assertXXX()` methods indicate test results

Entry point for the test when ran from command line

```
import unittest

class TestStringMethods(unittest.TestCase):

    def test_upper(self):
        self.assertEqual('foo'.upper(), 'FOO')

    def test_isupper(self):
        self.assertTrue('FOO'.isupper())
        self.assertFalse('Foo'.isupper())

    def test_split(self):
        s = 'hello world'
        self.assertEqual(s.split(), ['hello', 'world'])
        # check that s.split fails when the separator is not a string
        with self.assertRaises(TypeError):
            s.split(2)

if __name__ == '__main__':
    unittest.main()
```

Designing for Testing

Factor the program into meaningful units / components

- e.g., parser, command processor, components, data structures, etc.

Each unit should have a well defined specification

- what are legal inputs
- what are legal outputs
- how inputs and outputs are passed around

Avoid monolithic design that reads standard input and writes standard output

Good design requires more work

- additional functionality specifically for testing / debugging purposes
- but ultimately will save time of the overall development

coverage.py

A *test coverage* is a metric identifying how much of a program has been executed by a given test (or a set of inpiuts)

- e.g., #statements executed / # total statements

Statement coverage measures the number of statements executed

Branch coverage, in addition, measures the number of branches taken

- a branch is covered if both true- and false-branches are taken in some execution

In Python (or any interpreted language) statement/branch coverage are especially important

- a code that is not covered is never executed; it might be (almost) complete nonesense

Coverage.py is a widely used coverage tool for Python

- https://coverage.readthedocs.io/en/coverage-4.4.1/

coverage.py usage

`coverage run PYTHON_PROGRAM`

- executes the program and monitors which statements are executed

`coverage run –branch PYTHON_PROGRAM`

- executes the program and monitors which statements are executed and which branches are followed

`coverage html`

- generates an HTML report showing coverage of the last run
- can only be executed after coverage-run as shown above
- the result is placed in `htmlconv/index.html`

Regular Expressions

RegEx – a language to specify and discover patterns in strings

(Basic) Syntax

```
regex ::=   letter                  (exact match)
            ( regex )               (grouping)
            regex?                  (zero or one)
            regex+                  (one or more)
            regex*                  (zero or more)
            regex regex             (sequence)
            regex | regex           (choice)

letter ::= (see next slide)
```

Regular Expressions (Cont'd)

```
letter ::=    char              (exact match)
              .                 (matches any character)
              [ char+ ]         (any char in the group)
              [^ letter+ ]      (any char not in a group)

char ::= (a single character)
```

Python RE library

- https://docs.python.org/2/library/re.html
- provides many additional "characters" and extra operators to refine and simplify the matching
- provides API to find matches in strings

Regular Expressions by Example

Single Digit: `[0-9]`

Non-Digit: `[^0-9]`

Non-Space: `[^ ]`

Natural number: `[0-9]+`

Integer: `[-]?[0-9]+`

Decimal: `[0-9]+(\.[0-9]+)?`

In Python

```
import re
r = re.compile(r'[0-9]+')
v = r.findall('555-4567 ext. 3483')
print v
```

Design for A1

Command Parser

- input: line of text
- output: command or error

Street Database

- a list of streets and their line segments
- interface: add/delete/change/check street

Graph

- a store for edges and vertices

Graph Generator

- input: Street Database
- output: Graph

Graph Printer

- input: a graph
- output: a graph in the output format of A1

Python

Course Website

https://ece.uwaterloo.ca/~agurfink/ece650/tutorial/2019/09/13/python

The Python Tutorial

http://docs.python.org/tutorial/

Think Python, 2nd edition

http://www.greenteapress.com/thinkpython/

Data Programming course notes

http://courses.cs.washington.edu/courses/cse140/13wi/calendar/lecturelist.html

Python Tutor

http://www.pythontutor.com/