Python: Short Overview and Recap

Benjamin Roth
Florian Fink

CIS LMU

Data Types

Object type	Example creation
Numbers (int, float)	`123, 3.14`
Strings	`'this class is cool'`
Lists	`[1, 2, [1, 2]]`
Dictionaries	`{'1': 'abc', '2': 'def'}`
Tuples	`(1, 'Test', 2)`
Files	`open('file.txt'), open('file.bin', 'wb')`
Sets	`set('a', 'b', 'c')`
Others	`boolean, None`
Program unit types	`functions, modules, classes`

Variables

- store data, e.g., numbers
- content can be changed (is variable)
- have a data type
- assignment: `var_name = value`, e.g., `num = 17`

Dynamic Typing

Python is a dynamically typed language (other than e.g. Java or C++, which are statically typed).

- types are determined automatically at runtime
- the type of a variable can change
- check the type of variables with type(var)

The Python REPL

The REPL (Read, Eval, Print Loop) is Python's interactive language shell. You can invoke it on the shell like this:

```
$ python
>>> x = 'world'
>>> print('hello', x)
hello world
>>> x = 3 - 3 * 6 + 2
>>> x
-13
>>> x = 'a' * 10
>>> x
'aaaaaaaaaa'
>>> quit()
```

Number data types

- integers, floating-point numbers, complex numbers, decimals, rationals
- Numbers support the basic mathematical operations, e.g.:
  - + addition
  - `*` , `/`, `//` multiplication, division

```
>>> 1/4 # Floating number devision
0.25
>>> 1//4 # Integer division
0
```

  - `**` exponentiation
  - `<` , `>` , `<=` , `>=` comparison
  - `!=` , `==` (in)equality

String data types

- Immutable sequence of single characters

```
s1="first line\nsecond line"
s2=r"first line\nstill first line"
s3="""first line
second line"""
s4='using different quotes'
```

- How to create the following two-line string?

```
what's up, "dude"?
-Bob
```

Unicode strings

Strings are Unicode by default in Python3.

```
>>> x = 'B\u00e4ume'
>>> print(x)
Bäume
>>> y = x.encode('utf-8')
>>> print(y)
b'B\xc3\xa4ume'
```

String operations I

```
s1 = 'the'
```

Operation	Description	Output
`len(s1)`	length of the string	`3`
`s1[0]`	indexing, 0-based	`'t'`
`s1[-1]`	backwards indexing	`'e'`
`s1[0:3]`	slicing, extracts a substring	`'the'`
`s1[:2]`	slicing, extracts a substring	`'th'`
`s1 + ' sun'`	concatenation	`'the sun'`
`s1 * 3`	repetition	`'thethethe'`
`!= , ==`	(in)equality	`True, False`

String operations II

```
s1 = 'these'
```

Operation	Description	Output
`'-'.join(s1)`	concatenate (delimiter: '-')	`'t-h-e-s-e'`
`s1.find('se')`	finds start of substring	`3`
`s1.replace('ese', 'at')`	replace substrings	`'that'`
`s1.split('s')`	splits at string	`['the','e']`
`s1.upper()`	upper case	`'THESE'`
`s1.lower()`	lower case	`'these'`

Lists

- collection of arbitrarily typed objects
- mutable
- positionally ordered
- no fixed size
- initialization: `L = [123, 'spam', 1.23]`
- empty list: `L = []`

List operations I

```
L = [123, 'spam', 1.23]
```

Operation	Description	Output
`len(L)`	length of the list	`3`
`L[1]`	indexing, 0-based	`'spam'`
`L[-1]`	backwards indexing	`1.23`
`L[0:2]`	slicing, extracts a sublist	`[123, 'spam']`
`L + [4, 5, 6]`	concatenation	`[123, 'spam', 1.23, 4, 5, 6]`
`L * 2`	repetition	`[123, 'spam', 1.23, 123, 'spam', 1.23]`

List operations II

```
L = [123, 'spam', 1.23]
```

Operation	Description	Output
`L.append('NI')`	append to the end	`[123, 'spam', 1.23, 'NI']`
`L.pop(2)`	remove item	`[123, 'spam']`
`L.insert(0, 'aa')`	insert item at index	`['aa', 123, 'spam', 1.23]`
`L.remove(123)`	remove given item	`['spam', 1.23]`
`L.reverse()`	reverse list (in place)	`[1.23, 'spam', 123]`
`L.sort()`	sort list (in place)	`[1.23, 123, 'spam']`

Nested lists

Let us consider the 3x3 matrix of numbers
`M = [[1, 2, 3], [4, 5, 6], [7, 8, 9]]` . `M` is a list of 3 objects, which are in turn lists as well and can be referred to as rows.

- `M[1]` – returns the second row in the main list: `[4, 5, 6]`
- `M[1][2]` – returns the third object situated in the in the second row of the main list: `6`

Dictionaries

- Dictionaries are **mappings**, not sequences
- They represent a collection of key:value pairs
- Example:
  ```
  d = {'food':'Spam', 'quantity':4, 'color':'pink'}
  ```
- Efficient access ($\sim$ constant time):
  what is the value associated with a key?
- They are mutable like lists:
  Key-value pairs can be added, changed, and removed
- Keys need to be immutable – why?

Dictionary operations I

```
>>> d = {'food':'Spam', 'quantity':4, 'color':'pink'}
>>> d['food']
#Fetch value of key 'food'
'Spam'
>>> d['quantity'] += 1 #Add 1 to the value of 'quantity'
>>> d
d = {'food':'Spam', 'quantity':5, 'color':'pink'}
```

Dictionary operations II

```
>>> d = {}
>>> d['name'] = 'Bob'
>>> #Create keys by assignment
>>> d['job'] = 'researcher'
>>> d['age'] = 40
>>> d
d = {'name':'Bob', 'job':'researcher', 'age':40}
>>> print(d['name'])
Bob
```

Dictionary operations III

```
>>> #Alternative construction techniques:
>>> d = dict(name='Bob', age=40)
>>> d = dict([('name', 'Bob'), ('age', 40)])
>>> d = dict(zip(['name', 'age'], ['Bob', 40]))
>>> d
{'age': 40, 'name': 'Bob'}
>>> #Check membership of a key
>>> 'age' in d
True
>>> d.keys()
#Get keys
['age', 'name']
>>> d.values() #Get values
[40, 'Bob']
>>> d.items() #Get all keys and values
[('age', 40), ('name', 'Bob')]
>>> len(d)
#Number of entries
2
```

Dictionary operations IV

```
>>> d = {'name': 'Bob'}
>>> d2 = {'age': 40, 'job': 'researcher'}
>>> d.update(d2)
>>> d
{'job': 'researcher', 'age': 40, 'name': 'Bob'}
>>> d.get('job')
'researcher'
>>> d.pop('age')
40
>>> d
{'job': 'researcher', 'name': 'Bob'}
```

Tuples

- Sequences like lists but immutable like strings
- Used to represent fixed collections of items

```
>>> t = (1, 2, 3, 4) #A 4-item tuple
>>> len(t) #Length
4
>>> t + (5, 6) #Concatenation
(1, 2, 3, 4, 5, 6)
>>> t[0] #Indexing, slicing and more
1
>>> len(t)
???
```

Sets

- Mutable
- Unordered collections of **unique** and **immutable** objects
- Efficient check ($\sim$ constant time), whether object is contained in set.

```
>>> set([1, 2, 3, 4, 3])
{1, 2, 3, 4}
>>> set('spaam')
{'a', 'p', 's', 'm'}
>>> {1, 2, 3, 4}
{1, 2, 3, 4}
>>> S = {'s', 'p', 'a', 'm'}
>>> S.add('element')
>>> S
{'a', 'p', 's', 'm', 'element'}
```

Sets

```
>>> s1 = set(['s', 'p', 'a', 'm', 'element'])
>>> 'element' in s1
True
>>> 'spam' in s1
False
>>> s2 = set('ham')
>>> s1.intersection(s2)
{'m', 'a'}
>>> s1.union(s2)
{'s', 'm', 'h', 'element', 'p', 'a'}
```

$\Rightarrow$ intersection and union return a new set, the original sets stay unchanged

Immutable vs. Mutable

- Immutable:
  - numbers
  - strings
  - tuples
- Mutable:
  - lists
  - dictionaries
  - sets
  - newly coded objects

Control flow: if-statements

```
>>> x = 'killer rabbit'
... if x == 'roger':
...     print('shave and a haircut')
... elif x == 'bugs':
...     print('whats up?')
... else:
...     print('run away!')
run away!
```

Note!

The `elif` statement is the equivalent of `else if` in Java or `elsif` in Perl.

Control flow: While loops

```
>>> while True:
...     print('Type Ctrl-C to stop me!')
...
>>> x = 'spam'
... while x: #while x is not empty
...     print(x)
...     x = x[1:]
...
spam
pam
am
m
```

$\Rightarrow$ `x[len(x):len(x)]` returns the empty string.

Control flow: For loops

The for loop is a generic iterator in Python: it can step through the items in any ordered sequence or other iterable objects (strings, lists, tuples, and other built-in iterables, as well as new user-defined iterables).

```
L = [1, 2, 3, 4]
for i in L:
    print(i)
for i in range(0, 5):
    print(i)
for i in range(0, 5)[1:-1]:
    print(i)
```

Files: Read file line by line

```
file_name = '/path/to/file.txt'
with open(file_name, mode='r') as f:
    for line in f.readlines():
            # Lines still contain line-breaks.
            # Print without newline:
        print(line, end='')
```

How to remove trailing new line?

Files: Write file line by line

```
file_name = '/path/to/file.txt'
lines = ['line1', 'second line', 'another line', 'last one']

with open(file_name, mode='w') as f:
    for line in lines:
            f.write(line + '\n')
```

Reading and writing Unicode

The default input/output encodings are depedend on the system's locale settings. You should set it explicitly in the call to open(...).

```
>>> x = 'Bäume'
>>> with open('x.txt', 'w', encoding='utf-8') as f:
...     f.write(x)
5
>>> with open('x.txt', 'w', encoding='ascii') as f:
...     f.write(x)
Traceback (most recent call last):
File "<stdin>", line 1, in <module>
UnicodeEncodeError: 'ascii' codec can't encode ...
>>> with open('x.txt', 'w') as f:
...     f.write(x)
???
```

Functions

- A function is a device that groups a set of statements so they can be run more than once in a program
- Why use functions?
  - Maximizing code reuse and minimizing redundancy
  - Procedural decomposition

Defining functions

Functions are defined using the `def` keyword. They can have zero or more arguments and may return a result.

```
def function_name(arg1, arg2, ..., argN):
    statements...
    return result
```

To call a function use `function_name(arg1, arg2, ...)`.

```
>>> def fib(x):
...     if x <= 1:
...         return x
...     return fib(x-1) + fib(x-2)
>>> fib(7)
13
```

Function objects

Functions are normal python objects – they can be bound to other variables, be put into lists or dictionaries and even be used as parameter for other functions.

```
>>> def add(x, y):
...         return x + y
>>> def mul(x, y):
...         return x * y
>>> def do(x, y, f):
...         return f(x, y)
>>> f = mul # Bind the variable f to the function mul.
>>> f(3, 5)
15
>>> f = add # Bind the variable f to the function add.
>>> do(8, 4, f)
12
```

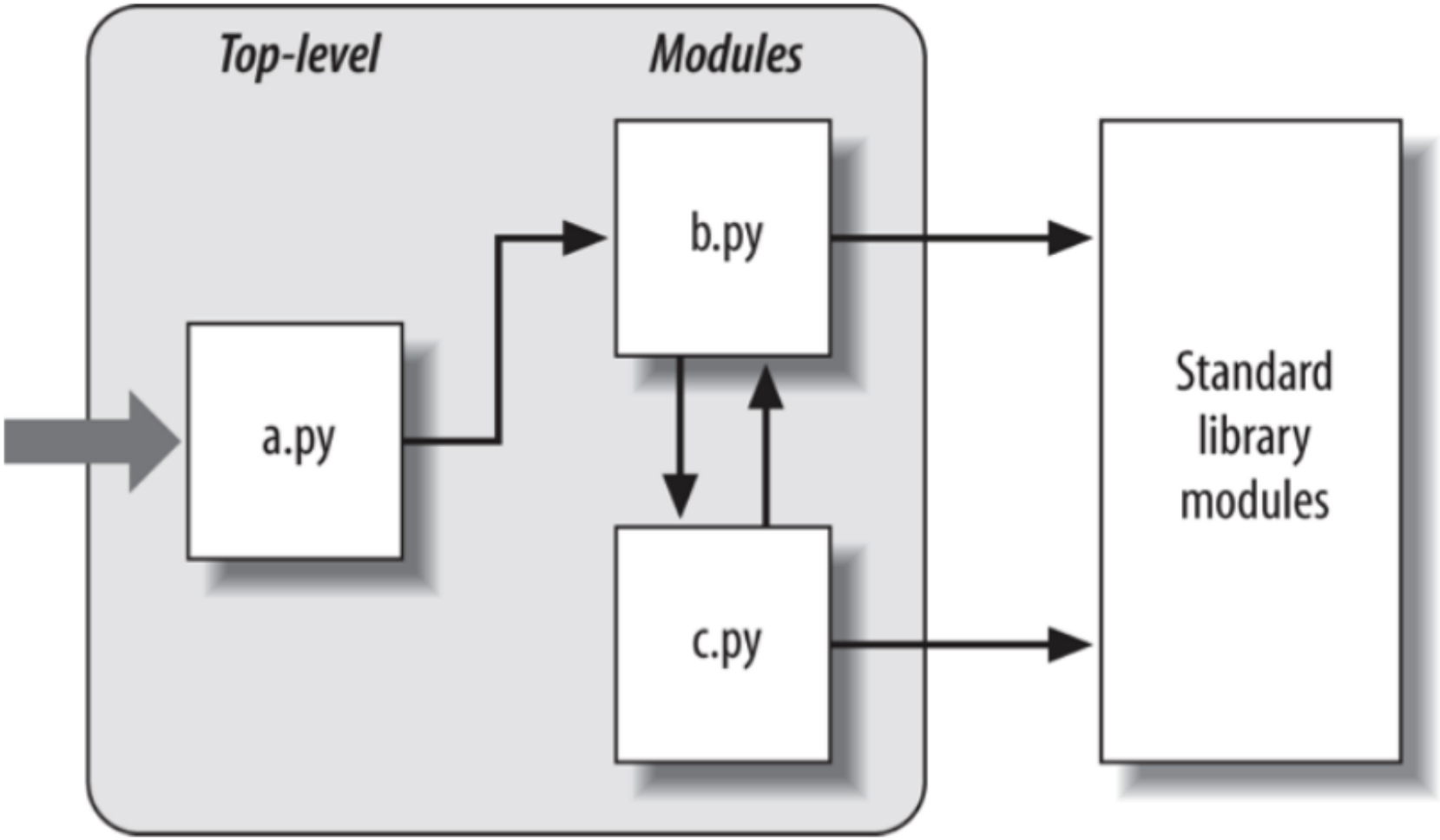
Function objects II

```
>>> # Put the functions into a dictionary.
>>> d = {}
>>> d['addiere'] = add
>>> d['multipliziere'] = mul
>>> print(d)
{'addiere': <function add at 0x7f21432cd8b0>,
  'multipliziere': <function mul at 0x7f214472f670>}
>>> # Call a function using its names in the dictionary.
>>> d['multipliziere'](3, 14)
42
```

Modules

- Packaging of program code and data for reuse
- Provides self contained namespaces that avoid variable name clashes across programs
- The names that live in a module are called its attributes
- one Python file $\sim$ one module
- Some modules provide access to functionality written in external languages such C++ or Java. (wrappers)

Module imports



Modules

- import – Lets a client (importer) fetch a module as a whole
- from – Allows clients to fetch particular names from a module
- as – lets you rename imported names

```
>>> import nltk
>>> from nltk.corpus import download
>>> download('stopwords')
>>> from nltk.corpus import stopwords as sw
>>> sw.words('english')
```

Installing modules locally

```
# Create the virtual environment in the `env` folder.
$ python3 -m venv env
$ source env/bin/activate
$ pip install nltk
$ python3
>>> import nltk
>>> from nltk.corpus import stopwords
>>> nltk.corpus.download('stopwords')
>>> stopwords.words('english')
['i', 'me', 'my', ...]
>>> quit()
# Deactivate the virtual environment.
$ deactivate
```

Regular expressions

- A regular expression is an expression that defines a formal language.
- Regular expressions are mostly used to match specific strings and extract sub-patterns from strings.

Regex	**Language**
`a`	$L = \{a\}$
`ab`	$L = \{ab\}$
`a|bc*`	$L = \{a, b, ac, bc, acc, bcc, ...\}$
`a*b*`	$L = \{\varepsilon, a, b, aa, ab, bb, ..., aaaaaab, ...\}$

Regular Expressions

What can you match with the following regular expressions?

1. `'^[Tt]he\b .*'`
2. `'[:;]-?[\|opPD\)\(]'`
3. `'<.*?>'`
4. `'\d +-year-old'`

- Documentation: `https://docs.python.org/3/library/re.html`
- Test your regex online: `https://pythex.org/`

Regular Expressions

- To use Regular Expressions in Python, import the module re
- Then, there are two basic ways that you can use to match patterns:
  - `re.match()`:
    Finds match of pattern at the beginning of a string
  - `re.search()`:
    Finds match of pattern anywhere in a string `re.match()`
- Both return a *match* object, that stores more information about the match, and `None` when there is no match.

Regular Expressions

```
import re
wordlist = ['farmhouse', 'greenhouse', 'guesthouse']
for w in wordlist:
    if re.match('(g.*?)(?=house)', w):
        print(w)
```

```
match = re.search(pattern, string)
if match:
    match_str = match.group(0)
```

Compiling regular expressions

If the same regular expression is used repeatedly (in a loop), it is more efficient to compile it outside of the loop.

```
import re
wordlist = ['farmhouse', 'greenhouse', 'guesthouse']
regex = re.compile('(g.*?)(?=house)')
for w in wordlist:
    if regex.match(w):
        print(w)
```

Python classes

```
class Classifier:
    def __init__(self, lambda1, lambda2):
        self.l1 = lambda1
        self.l2 = lambda2

    def train(self, data):
        ....

    def test(self, data):
        ....

if __name__ = '__main__':
    data = 'This is training data'
    testdata = 'This is test data'
    lambda1 = 0.002
    lambda2 = 0.0005
    model = Classifier(lambda1, lambda2)
    model.train(data)
    model.test(testdata)
```

Python classes overloading of operators

```
class X:
    def __init__(self, a, b):
        self.a = a
        self.b = b

    def __getitem__(self, k):
        if k == 'a':
            return self.a
        if k == 'b':
            return self.b
        raise KeyError

if __name__ = '__main__':
    x = X('a value', 'b value')
    v = x['a']
    print(v)
```

Summary

- Data types: numbers, strings, tuples, lists, dictionaries
- Mutable / Immutable
- If-statement, while-loop, for-loop
- Reading / writing from files
- Functions
- Importing modules
- Regular expressions
- Classes and objects (next week)
- **Any questions?**