Programming in Python[1]

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Lecture II: Control structures

Polls

To answer the questions I will rise please connect to:

`sli.do` Event#: 57146

(MS Teams: a tab in the channel is already set on that)

Summary

- Programming means to instruct an (automatic) interpret with a precise description of a computational process.
- (In fact, the only way to make a description precise is to specify exactly the interpreter)
- We use a software interpreter, itself a program interpreted by the operating system (the stack of interpreters can be much deeper).
- Our interpret (Python3) manipulates objects taken from types (that define which manipulations are possible), referred by variables, with special commands to ask the services provided by the operating system.

Basic types

`bool` `False`, `True` Logical operations

`int` `1`, `-33`, `1_000_000` ... Arithmetic operations, no upper or lower limit

`float` `1.0`, `.1`, `1.2e34` ... Arithmetic operations, limited but you have `float('infinity')` (and `float('nan')`)

```
sys.float_info(max=1.7976931348623157e+308
↪   , max_exp=1024, max_10_exp=308,
↪  min=2.2250738585072014e-308,
↪  min_exp=-1021, min_10_exp=-307,
↪  dig=15, mant_dig=53,
↪  epsilon=2.220446049250313e-16,
↪  radix=2, rounds=1)
```

`str` `'aaaa\nthis is on a new line'`, `"bbb'b\"b"` ... Concatenation, alphabetical ordering, replication, ...

Sequence of operations


```
1  x = 1 + 2 * 3
2  x = x + 1
```

The 2 lines of code translate to at least 5 “logical” instructions (maybe more, for example adding two big numbers require multiple instructions):

1. `2 * 3`
2. `1 + 6`
3. `x = 7`
4. `7 + 1`
5. `x = 8`

Flow of control

It is normally not very useful to write programs that do just one single computation. You wouldn't teach a kid how to multiply 32×43, but the general algorithm of multiplication (the level of generality can vary).

To write programs that address a family of problems we need to be able to select instructions to execute according to conditions.

```
if x < 0:
  x = -x

y = 2 * x
```

```
if x == -1:
  x = x + 1
else:
  x = 3 * x

y = 2 * x
```

In Python the indentation is part of the syntax and it is mandatory.

Repetitions

It is also useful to be able to repeat instructions: it is very convenient, but it also opens a deep Pandora's box...
There are two ways of looping in Python:

Repeat by iterating on the elements of a collection (similar to math notation $\sum_{i \in \{a,b,c\}} f(i)$)

```
for i in range(0, 5):
    # 0 1 2 3 4
    print(i)
```

Repeat while a (variable) condition is true

```
i = 0
while i < 5:
    print(i)
    i = i + 1
```

Loops can be difficult to understand

When you have loops, understanding the code can be a difficult task and the only general strategy is to track the execution.

```
# This is known as Collatz's procedure
n = ...
while n > 1:
  if n % 2 == 0:
    # if the remainder of division by 2 is 0, i.e. n
    ↪  is even
    n = n / 2
  else:
    n = 3*n + 1
```

We know (by empirical evidence) that it ends for all $n < 2^{68} \approx 10^{20}$, nobody is able to predict the number of iterations given any `n`.
With loops it is also hard to exploit parallel execution.

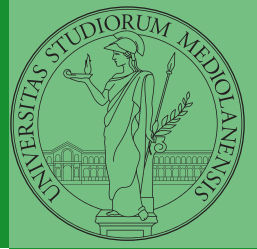
Learn to write loops can be hard

When you write a loop, you should have in mind two related goals:

1. the loop must terminate: this is normally easy with `for` loops (when the finite collection ends, the loop ends also), but it can be tricky with `while`s (remember to change something in the condition);
2. the loop repeats something: the programmer should be able to write the "repeating thing" in a way that makes it equal in its form (but probably different in what it does).

The second part (technically known as loop invariant) is the hardest to learn, since it requires experience, creativity, and ingenuity.

Homework



CS Circles chapters 6, 7C, and 9.