Recursion

Silvio Peroni

✉ silvio.peroni@unibo.it   0000-0003-0530-4305   @essepuntato

Computational Thinking and Programming (A.Y. 2017/2018)

Second Cycle Degree in Digital Humanities and Digital Knowledge

Alma Mater Studiorum - Università di Bologna

Communication 1

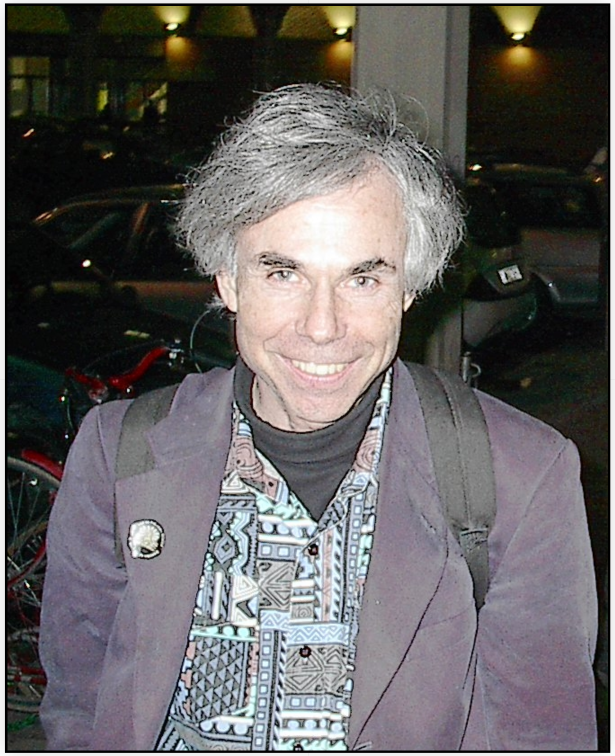
Informal news: the lecture of Friday the 8th of December (it is holiday...) will be anticipated the day before

Communication 2

It's about the time...

Any question about the previous lecture?

Historic hero: Douglas Hofstadter



He is a cognitive scientist

Research on self-reference: situations where something refers to itself

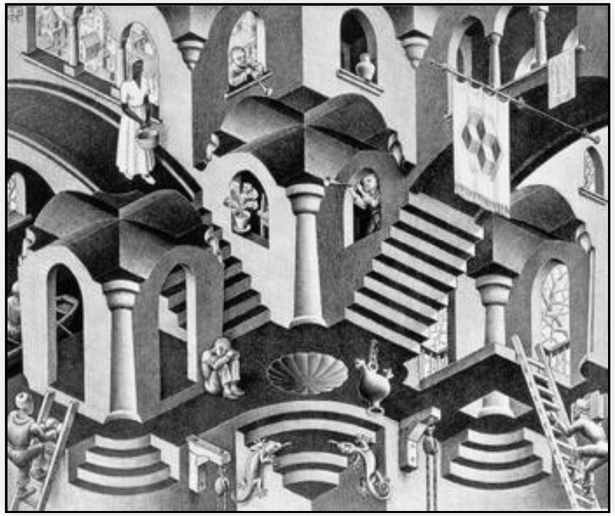
Author of *Gödel, Escher, Bach: An Eternal Golden Braid* where he investigated in depth the concept of self-reference

In 1980, he was awarded of the Pulitzer's for that book

One of the main book themes: concept of intelligence (including artificial intelligence)

Little Harmonic Labyrinth

Achilles and the Tortoise's adventures in entering in the inconsistent composite world depicted by Escher's *Convex and Concave*



Entering into and exiting from a world via the *pushing-potion* and *popping-tonic* respectively

Achilles and the Tortoise narrate (or are part of) a lot of stories, which include citations and references as well as self-citations and self-references

The genies and the lamps

Achilles uses of a magic lamp and evokes a genie

First wish: to have one hundred of wishes instead of the usual three

Genie: not possible for him, it's a meta-wish (i.e. a wish of a wish). It uses its meta-lamp to ekove the meta-genie asking for the same meta-wish

Meta-genie: not possible for him, it's a meta-meta-wish (i.e. a wish of a wish of a wish). It uses its meta-meta-lamp to ekove the meta-meta-genie

...

Positive answer: Achilles is granted with the permission

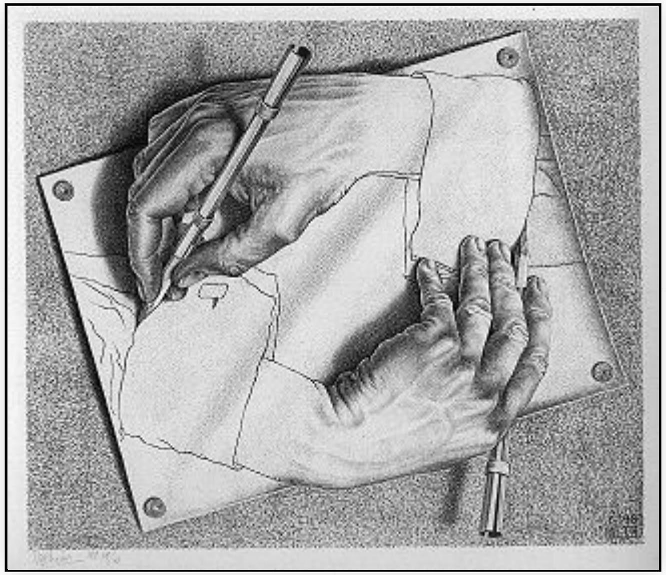
Achilles wishes that his wish would not be granted

Self-references for paradoxes

Achilles' wish concerns the denial of the wish it self, which results in a paradox by means of a self-reference

Other notable examples of self-references:

- Natural language:
  “this sentence is false”
- Graphical language:
  Escher's *Drawing hands*

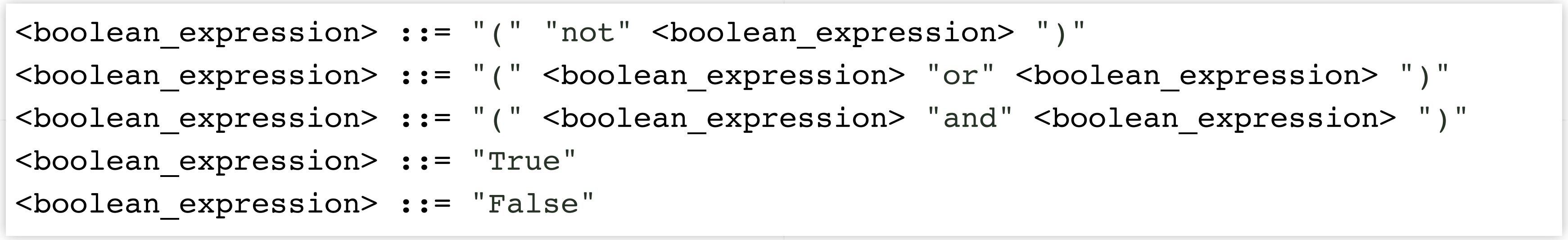


Recursion

We have a *recursion* when something is defined in terms of itself or of its type – i.e. when its definition contains a self-reference

Do we use it in our daily life?

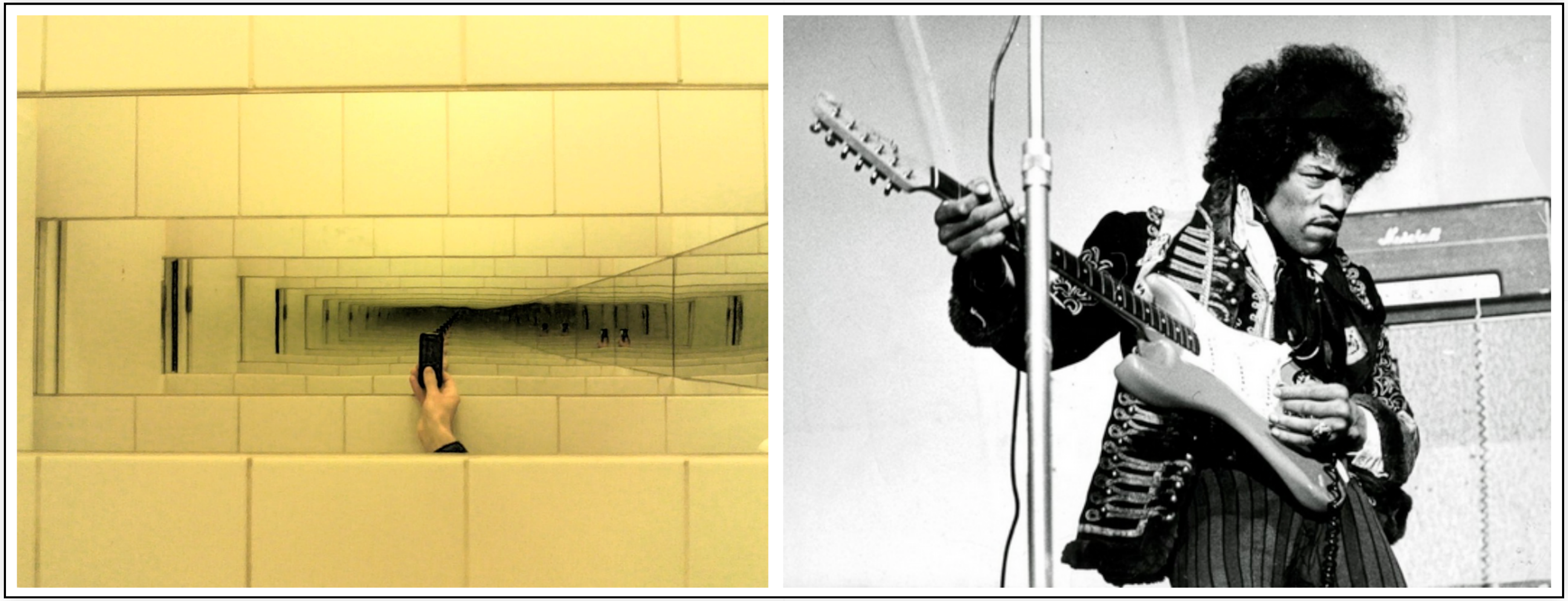
Linguistics: recursive rules in formal grammars



```
<boolean_expression> ::= "(" "not" <boolean_expression> ")"
<boolean_expression> ::= "(" <boolean_expression> "or" <boolean_expression> ")"
<boolean_expression> ::= "(" <boolean_expression> "and" <boolean_expression> ")"
<boolean_expression> ::= "True"
<boolean_expression> ::= "False"
```

Chomsky argued that recusion is essential in human language: Alice thinks Bob said Christine read books

Mirrors and sounds



Recursion in Computer Science

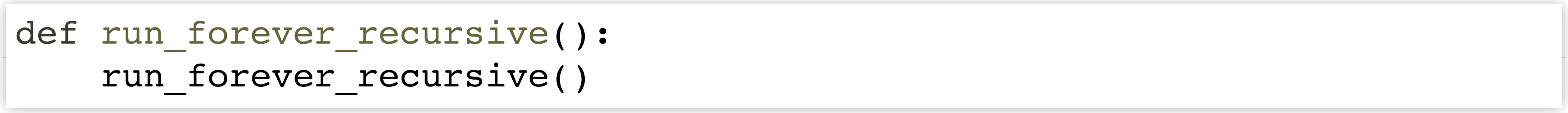
It is an alternative to the iteration (i.e. foreach and while loops)

It is often used when a solution to a particular computational problem depends on the partial solutions of smaller instances of the same problem

Computer Scientists tame recursion to avoid infinite loops:

1. one or more base cases, which describe the terminating scenarios
2. one or more recursion steps, where the algorithm is run gain with a reduced input

What could possibly go wrong?



```
def run_forever_recursive():
    run_forever_recursive()
```

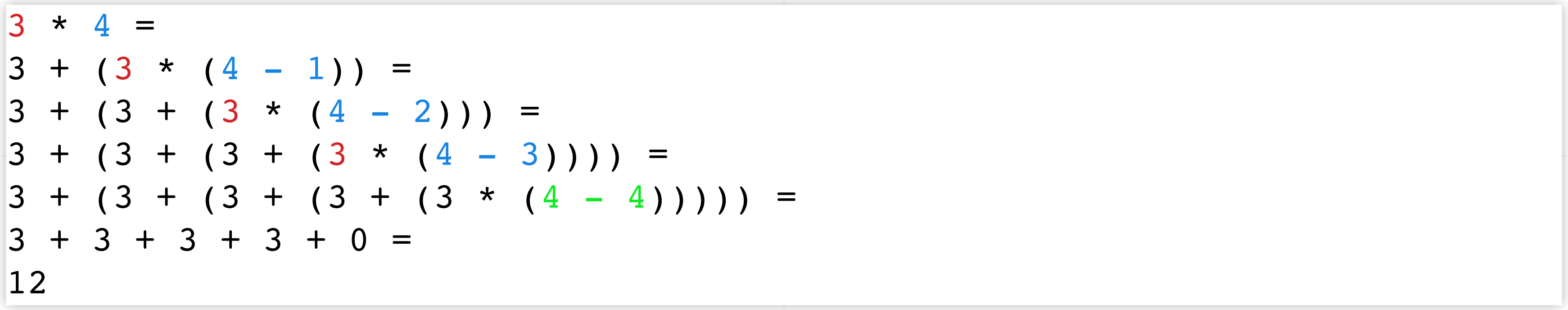
The `run_forever` algorithm implemented by means of a recursion step – with no base cases

Recursive algorithm: an example

Computational problem: multiply two non-negative integers

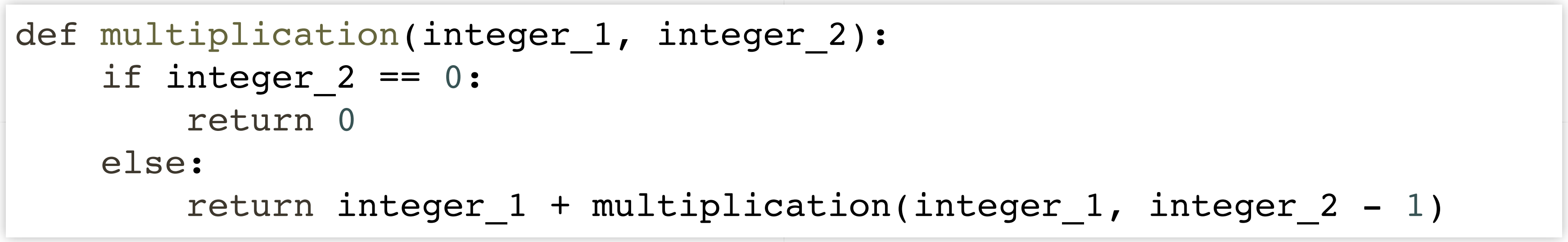
E.g.: 3 * 4 = 3 + 3 + 3 + 3

n1 * n2 = n1 + (n1 * (n2 - 1))



```
3 * 4 =
3 + (3 * (4 - 1)) =
3 + (3 + (3 * (4 - 2))) =
3 + (3 + (3 + (3 * (4 - 3)))) =
3 + (3 + (3 + (3 + (3 * (4 - 4))))) =
3 + 3 + 3 + 3 + 0 =
12
```

Multiplication: the algorithm



```
def multiplication(integer_1, integer_2):
    if integer_2 == 0:
        return 0
    else:
        return integer_1 + multiplication(integer_1, integer_2 - 1)
```

END

Recursion

Silvio Peroni

✉ silvio.peroni@unibo.it iD 0000-0003-0530-4305 @essepuntato

Computational Thinking and Programming (A.Y. 2017/2018)

Second Cycle Degree in Digital Humanities and Digital Knowledge

Alma Mater Studiorum - Università di Bologna