ETH zürich

Departement Informatik

Programming and Problem-Solving

Introduction to the Course

Dennis Komm

Spring 2021 – February 25, 2021

Welcome to the Course

Material

Lecture website

https://lec.inf.ethz.ch/ppl

Moodle Course

https://moodle-app2.let.ethz.ch/course/view.php?id=14883

The Team

Lecturer	Dennis Komm
Assistants	Manuela Fischer
	Jonas Hein
	David Sommer
	Cathirn Elich
	Lea Fritschi
	Sarah Kamp
	Safira Piasko
	Sara Steiner

Appointments

Lecture	Thursday, 16:15 – 18:00
Exercises	Monday, 13:15 – 15:00 Thursday, 10:15 – 12:00
Exam	End of the semester

Goal of Today's Lecture

- General information about the lecture
- The projects, using **[code]expert**
- Introduction to Algorithms
- The first Python program

Introduction to the Course

Computers and Algorithms

Computer – Concept

- What does a computer have to be able to do to compute?
- Does it have to be able to multiply?
- Isn’t it sufficient to be able to add?

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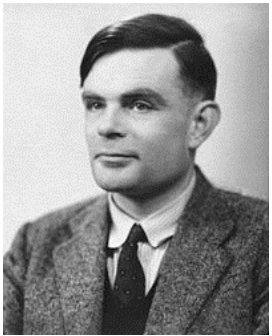


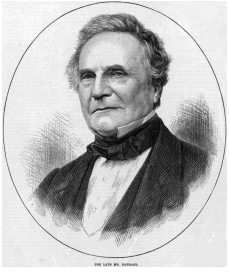
Alan Turing [Wikimedia]

Turing Machine [Alan Turing, 1936]

- Finite number of states
- Memory consisting of arbitrarily many cells
- Pointer to current cell
- Pointer can change cell's content and move left or right

Computer – Implementation

- **Analytical Engine** – Charles Babbage (1837)
- **Z1** – Konrad Zuse (1938)
- **ENIAC** – John von Neumann (1945)



Charles Babbage [Wikimedia]

Konrad Zuse [Wikimedia]

John von Neumann [Wikimedia]

Algorithm: Central Notion of Computer Science

Algorithm

- Method for step-by-step solution of a problem

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- Execution does not require intellect, only accuracy

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- Execution does not require intellect, only accuracy
- after **Muhammad al-Chwarizmi**;
  author of a arabic
  math book (around 825)

"'Dixit algorizmi. . . '" Latin translation [Wikimedia]

“The Oldest (Known) Non-Trivial Algorithm”

Euclid’s Algorithm

from Euclid’s *Elements*, 300 BC

- Input: integers $a > 0$, $b > 0$
- Output: gcd of a and b

Input: a and b
while $b \neq 0$
    if $a > b$ then
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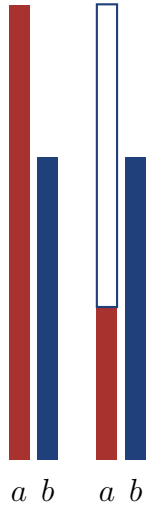

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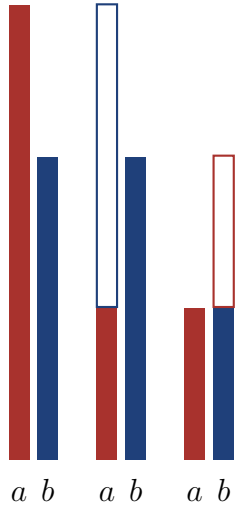

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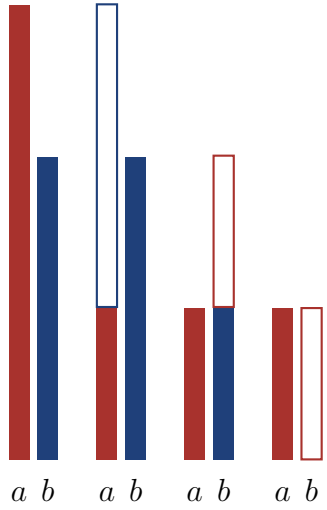

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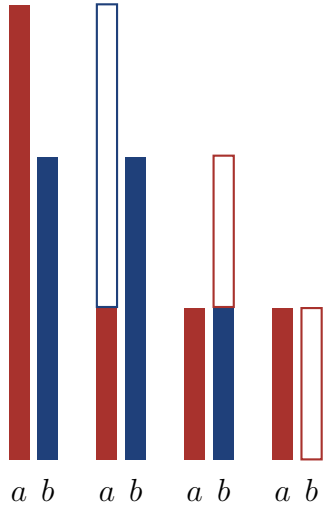
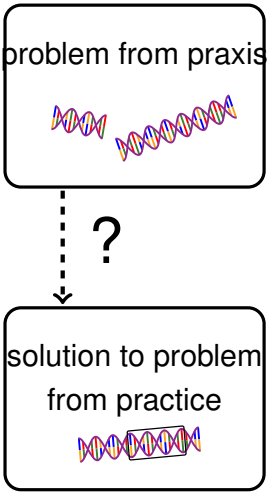


Introduction to the Course

Goals

1. Computer Science in the Natural Sciences



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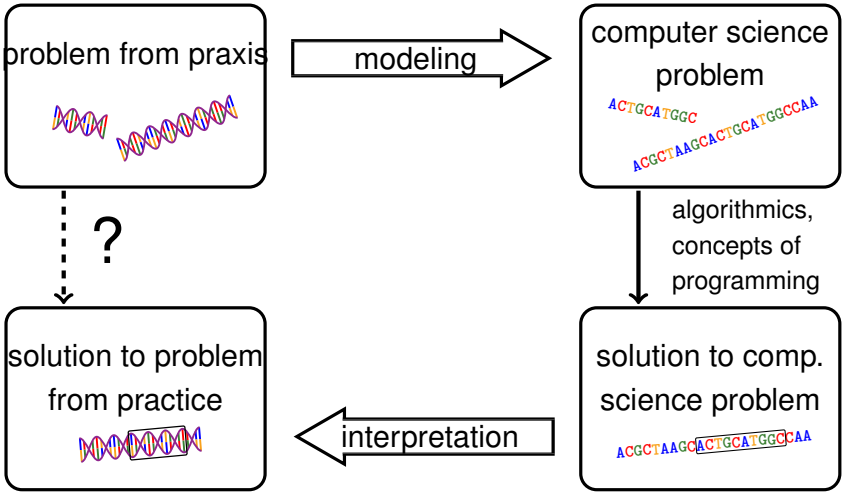

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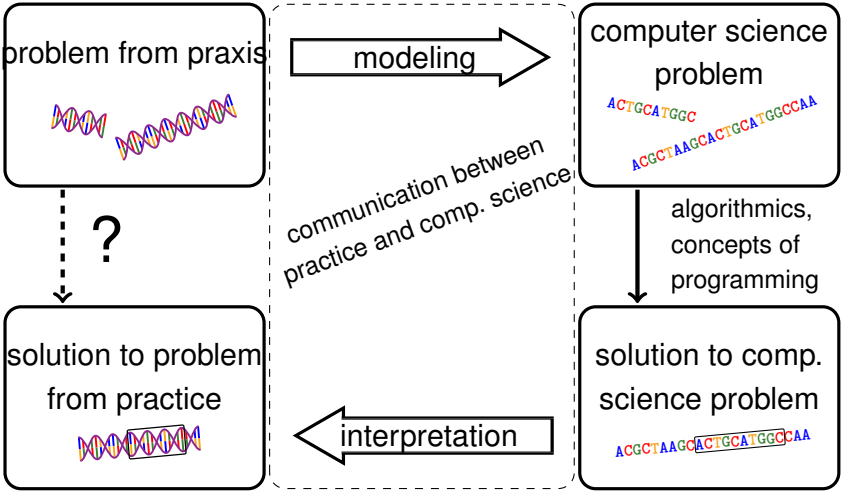

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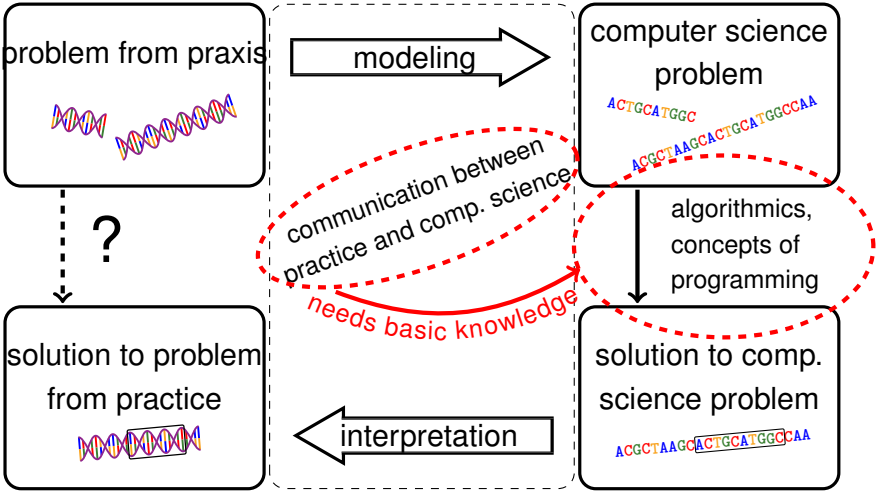

2. Computational Thinking

- Systematic solving of given problems
- This implies creativity, abstraction skills etc.
- Formulation of solution as algorithm
- Solution can be “understood” by a computer

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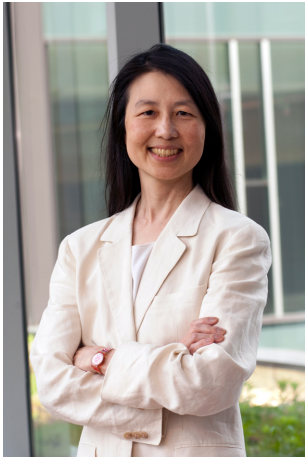

Jeannette Wing

"'Computational thinking is a way humans solve problems; it is not trying to get humans to think like computers. Computers are dull and boring; humans are clever and imaginative. We humans make computers exciting."'

3. Algorithms Design Techniques

Most practically relevant problems have easy solutions

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- Easy to implement
- Are based on trying out possibly many possibilities (“solution candidates”)
- This means impractically large time to spend

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Many problem allow for “faster” solutions

- Needs a little more skill
- Different techniques: **greedy algorithms**, **divide and conquer**, **dynamic programming** etc.

Introduction to the Course

Projects

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During the semester, you work on a few small projects

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`https://expert.ethz.ch`

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- You work on the tasks on your own
- The exercise hours are meant for answering your questions
- Presentation of the solutions via Zoom

Projects

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- Teams of 2 students each
- Grading by assistants, feedback by students

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- Teams of 2 students each
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- **Presentation is mandatory**
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- [code]expert allows you to test your solution before handing it in

Introduction to Python

Programming Tools

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- **Compiler:** Program to translate a program text into machine language (intermediate code, respectively)
- **Computer:** Machine to execute machine language programs
- **Operating System:** Program to organize all procedures such as file handling, editing, compiling, and program execution

English vs. Programming Language

English

“Science is what we understand well enough
to explain to a computer.
Art is everything else we do.”

DONALD KNUTH

English vs. Programming Language

English

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Python

```
# computation
b = a * a   # b = a**2
b = b * b   # b = a**4
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Syntax and Semantics

- Like our language, programs have to be formed according to certain rules
  - **Syntax:** Connection rules for elementary symbols (characters)
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- Like our language, programs have to be formed according to certain rules
  - **Syntax:** Connection rules for elementary symbols (characters)
  - **Semantics:** Interpretation rules for connected symbols
- Corresponding rules for a computer program are simpler, but also more strict because computers are relatively stupid

Kinds of Errors Illustrated with English Language

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Syntactically and semantically correct

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Used Software

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- Also recommended (offline): **PyCharm Education**

```
https://www.jetbrains.com/pycharm-educational/download/
```

- Download the Community Edition

Introduction to Python

A First Python Program

A First Python Program

```
print("This is a Python program")

x = 20
print("The value of x is", x)
y = x * x    # y is the square of x
print("The value of y is", y)
z = y * y    # z is the square of y
print("The value of z is", x * x * x * x)
```

Behavior of a Program

At compile time

- Program accepted by the compiler (syntactically correct)
- Compiler error

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During runtime

- correct result
- incorrect result
- program crashes
- program does not **terminate** (endless loop)

Comments

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Comments and Layout

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- are contained in every good program
- document, **what** and **how** a program does something and how it should be used
- are ignored by the compiler
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Please note

- empty lines are ignored
- Python dictates indentations that reflect the program logic

Introduction to Python

Statements

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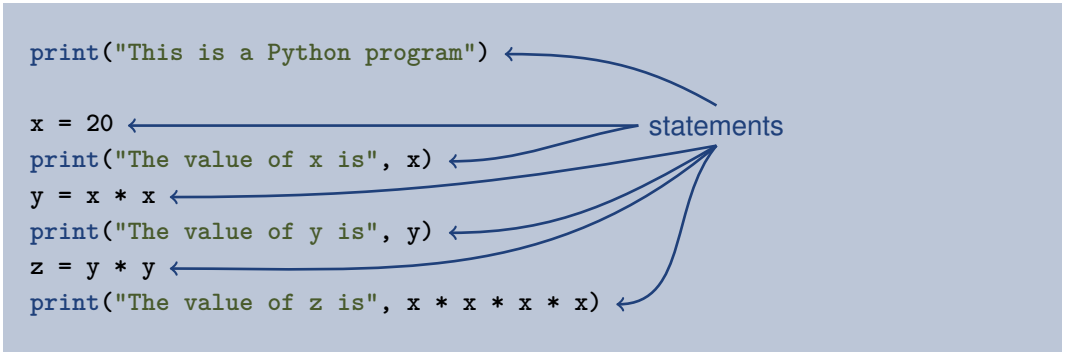
Statements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Any statement (potentially) provides an **effect**

Statements – Values and Effects

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```

Statements – Values and Effects

```
print("This is a Python program")
```

Effect: Output of the string `This is...`

```
x = 20
```

Effect: Variable `x` is created and assigned value 20

```
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Introduction to Python

Variables

Fundamental Types

Variables represent (varying) values

- integers
- real numbers (float)
- strings
- ...

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In contrast to, for example, **Java** or **C**, the type is not explicitly stated when a variable is declared (used for the first time)

Introduction to Python

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- are either **primary** (`x`)
- or **composed** (`x * x`)

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- represent **computations**
- are either **primary** (`x`)
- or **composed** (`x * x`)
- . . . from different expressions by **operators**
- . . . and parentheses

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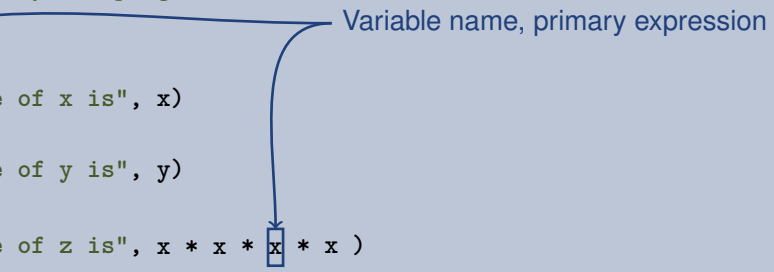

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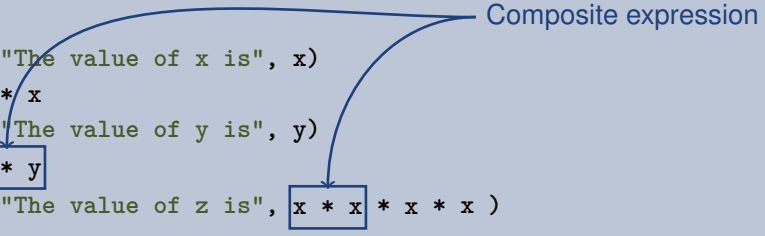

Expressions

- represent **computations**
- are **primary** or **composite**
  (by other expressions and operations)

Example

`a * a` is composed of
variable name, operator symbol, variable name
variable name: primary expression

- can be put into parentheses

`a * a` can be written as `(a * a)`

Introduction to Python

Operators and Operands

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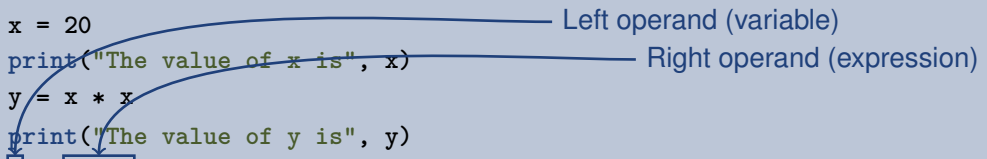
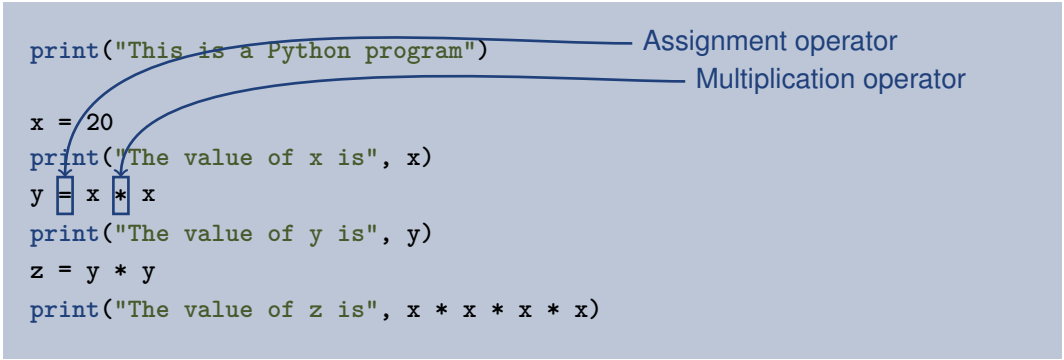


Operators and Operands



Operators

Operators

- make expressions (**operands**) into new composed expressions
- have an arity

Example (Multiplication) `a * a`

Operand `a`, Operator `*` , Operand `a`

Multiplication Operator $*$

Multiplication operator

- expects two R-values of the same type as operands (arity 2)
- "returns the product as value of the same type," that means formally:

> The composite expression is value of the product of the value of the two operands

Examples

- `a * a`
- `b * b`

Assignment Operator =

- Assigns to the left operand the value of the right operand and returns the left operand

Examples

- `b = b * b`
- `a = b`

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Attention

The operator "'=" corresponds to the assignment operator of mathematics ($:=$), not to the comparison operator ($=$)

Exercise – Celsius to Fahrenheit Calculator

Write a program that

- interprets a number (like, e. g., 31) as a temperature in degree Celsius
- outputs the same temperature in degree Fahrenheit
- uses the formula

$$\text{fahrenheit} = \frac{9 \cdot \text{celsius}}{5} + 32$$

Exercise – Celsius to Fahrenheit Calculator

```
celsius = 31
fahrenheit = 9 * celsius / 5 + 32
print(fahrenheit)
```

Thanks for your attention