Philipps Universität Marburg

Declarative Programming

Summer semester 2024

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(Programming Languages and Tools research group)

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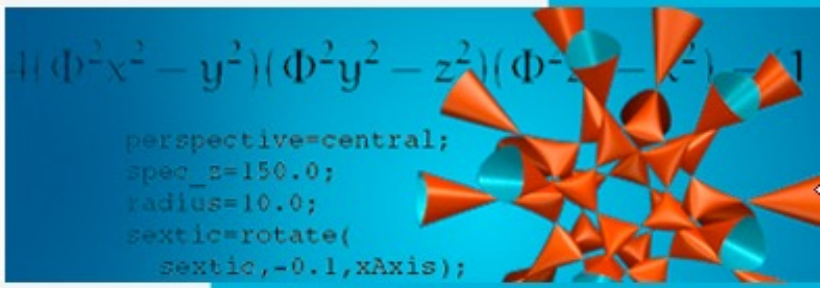

[Script 1 - 1.1]

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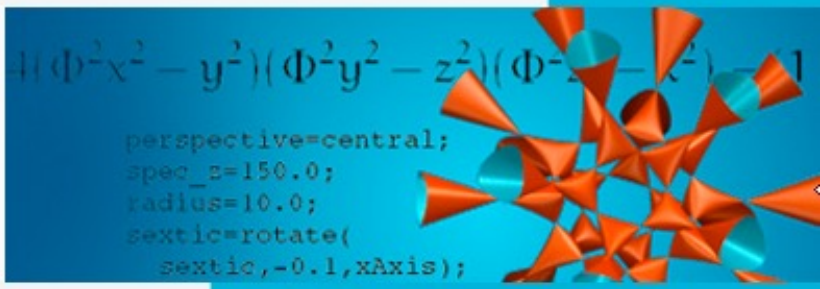
Organization



Organization

- Lecture (participation in both dates per week)
  - Tuesdays 16:15 - 17:45, HS B
  - Wednesdays 16:15 - 17:45, HS B

- Tutorials (participation voluntary)
  - Thursdays 10:00 - 12:00 *(2 supervising tutors)*
  - Thursdays 14:00 - 16:00 *(2 supervising tutors)*
  - Registration for tutorials from Wednesday, 16.04. at 20:00h
    - If necessary, you can also change without consultation

Organization

- Exercise mode (for details see document in ILIAS)
  - **Self-study** *(voluntary)*
    - Self-exercise sheet
      - Will be published gradually in ILIAS
      - Sample solutions after completion of the topic in lecture
    - Partial programming tasks with automatic testing tool
    - Open tutorials
  - **Mandatory**
    - **Electronic test** in ILIAS (usually **weekly**), **automatically** assessed *(max. 2 with 0 points)*
    - **Submission** with correction by **tutors** (dates will be announced on ILIAS)
      - **Programming task** *(must not be 0 points)*
      - **Proof task** *(must not be 0 points)*
    - **Exam admission** *(at least 50%)*
    - **Bonus point** *(at least 80%)*

PubQuiz

- Instead of a lecture
- "Puzzles" on the subject matter of the lecture
  - Approx. 8 tasks
  - Processing time approx. 50 minutes
  - The tasks are then discussed
  - Editing in groups allowed
- You can win additional points here
- This means that you can still acquire the closed course admission or the bonus if you are only a little short of the 50% or 80% limit

Teacher training students

- Regular exercise operation as previously described
  - Changes
    - Elimination of an electronic test and the evidence task
    - Corresponding topic is also replaced by an interface task in the written exam
    - Adding the interface exercise
- Exercise mode - interface exercise (teaching degree)
  - Participation mandatory for teacher training students
  - Largely analog, more details in interface exercise

Master Students (Conditional Module)

- Join the group within this ILIAS course
  "Group for Master students with DP as conditional module"
  - When necessary we will communicate with this group of students via the ILIAS group
- English versions of slides and lecture notes are available in the regular ILIAS course
- If you follow this course as conditional module,
  - You are automatically admitted to the exam.
  - Participation in the exercises is not required ...
  - ... but still recommended as practice for the exam.

Organization

- Exam
  - First and second exam
  - Dates in MARVIN
    - As parallel groups of the lecture
    - **Will be announced later**

- Exam registration *(approx. middle of the semester)*
  Please refer to the website of the examination office!

ILIAS

- Materials via ILIAS
  - Script, slides, attendance and homework sheets
  - Submission and feedback
  - Auto-Testat tool

- Join the lecture:
  Magazine → MARVIN: Courses of all semesters → Summer semester 2024 → FB12 Mathematics and Computer Science → Declarative Programming

Scheduling

- Canceled lecture
  - 01.05.: Labor Day
- Failures exercises
  - 09.05.: Ascension Day, 30.05.: Corpus Christi
    - Tutorials are canceled
    - Electronic tests over two weeks

Learning objectives

- Learning a declarative programming language
- Recognizing and applying abstractions
- Understanding and recognizing cross-linguistic concepts and their areas of application
- Formal definition of the semantics of programming languages
- Scientific work and communication skills

Topics

- Programming with expressions
- Programming with function definitions
- Conditional expressions
- Design of function definitions
- Algebraic data types
- Proof of program properties
- Abstraction via functions and types
- Scoping
- Pattern Matching
- Generative recursion
- Accumulators
- Logic programming

Organization

- Script
  - Based on script by Prof. Klaus Ostermann
  - Based on "How to Design Programs" by M. Felleisen, R. B. Findler, M. Flatt and S. Krishnamurthi
- Programming language: DrRacket (Version 8.12)

DrRacket

- Lisp dialect
- Different language levels selectable
- Installation: http://racket-lang.org
- Settings
  - Language -> Select language: "How to Design Programs - Beginner"
  - Language -> Add Teachpack: "universe" and "2htdp/image"
- Use
  - Interaction area: lower half of the screen
  - Enter expression, confirm with Enter → Result is displayed in the next line

Installation

Install DrRacket.

Install the tool for automatic testing.

If you have problems with the installation, we can support you during consultation hours.

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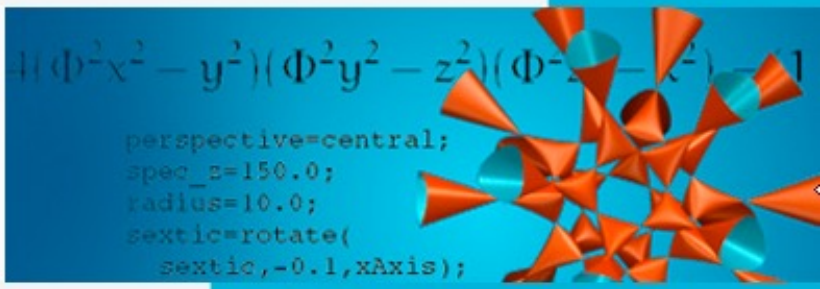
Introduction



Algorithms

- Precise definition of the steps to solve a problem
- The same problem can be solved by different algorithms
- Programming algorithms enables execution by computers
- For ease of understanding, we use abstractions

Arithmetic

- Programming languages already contain defined algorithms for recurring tasks
  - Evaluating expressions
  - Applying operations etc.

Simple evaluations

We want to evaluate this expression:

$$3 + 4 * 5$$

What can go wrong?

Simple evaluations

It is possible to erroneously evaluate "+" first and read the expression as "7 * 5".

$$3 + 4 * 5$$

How can we avoid such mistakes?

Simple evaluations

We can bracket the expression.

$$3 + (4 * 5)$$

Simple evaluations

We can also bracket the expression completely:

$$(3 + (4 * 5))$$

The meaning is still the same as at the beginning. But dependencies are now explicit.

By the way ...

Writing the operator between the operands is an arbitrary choice.

$$(1 + 2)$$

The operator can also be placed in front.

$$(+ 1 2)$$

Or re-enacted

$$(1 2 +)$$

By the way ...

Writing the operator between the operands is an arbitrary choice.

$$(1 + 2)$$

The operator can also be placed in front.

$$(+ 1 2)$$

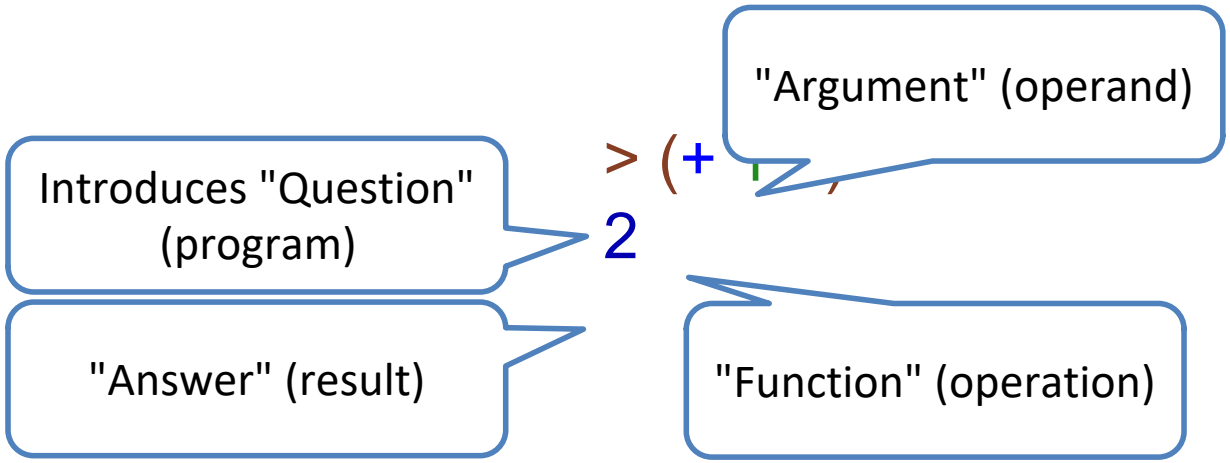
We already use "prefix notation" for some operations:
-5
sin(0)

Or recreated

$$(1\ 2\ +)$$

Arithmetic

- DrRacket programs are arithmetic expressions
- The result of the program is the evaluated expression
- DrRacket uses prefix notation throughout



Examples

```
> (+ 2 2)
4
> (* 3 3)
9
> (- 4 2)
2
> (/ 6 2)
3
> (sqr 3)
9
> (expt 2 3)
8
> (sin 0)
0
```

DEMO DrRacket

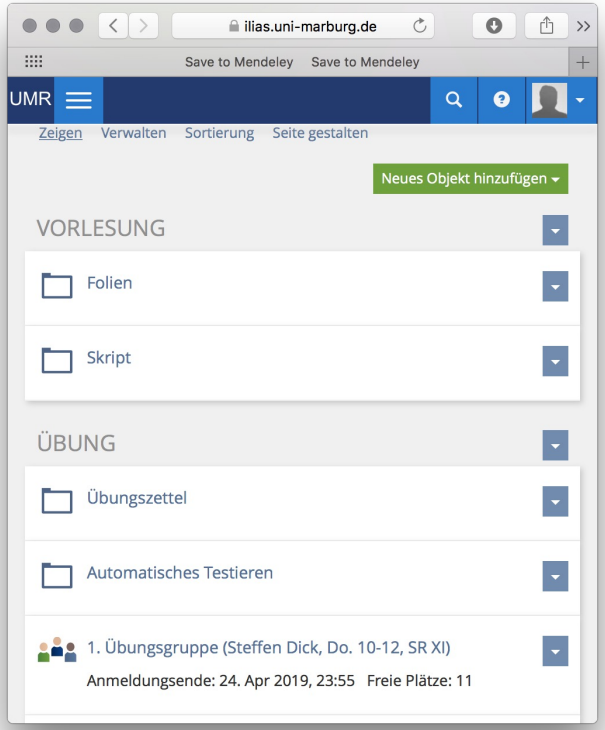
- Interaction area
- Definition range
- Save

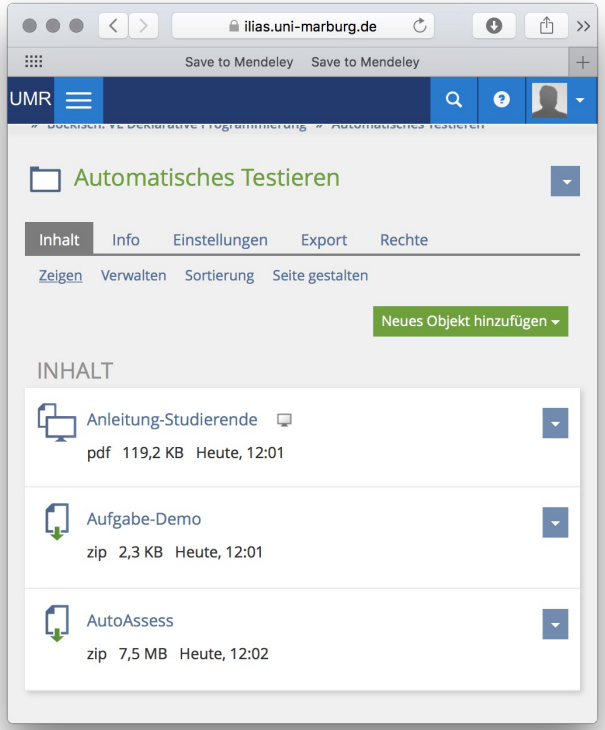
DEMO Automatic testing

- Task:

- Write a program consisting of
  - The function "double", which calculates the double of a number without using multiplication
  - And a call of the function for the argument 21

DEMO Automatic testing





Numbers are expressions

- Until now: arguments were numbers
- Numbers are expressions that are evaluated to themselves

  > 5

  5
- Numbers are "atomic" expressions

Compound expressions

- Expressions can be used as arguments

```
> (+ 2 (+ 3 4))
9
```

Compound expressions

- Expressions can be used as arguments

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> (+ 2 (+ 3 4))
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- Nesting of expressions can be arbitrarily deep

```
> (+ (* 5 5) (+ (* 3 (/ 12 4)) 4))
?
```

What is the result?

Compound expressions

- Expressions can be used as arguments

```
> (+ 2 (+ 3 4))
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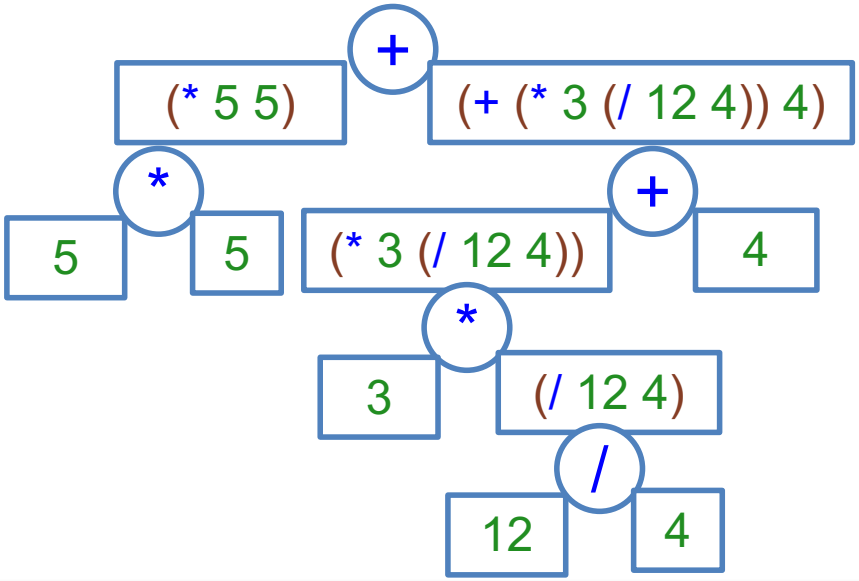
- Nesting of expressions can be arbitrarily deep

```
> (+ (* 5 5) (+ (* 3 (/ 12 4)) 4))
38
```

Evaluation of expressions

- Applying the function to the values of the arguments
- Argument is expression: first evaluate this expression ("recursive application" of the algorithm)
- The evaluation order of the sub-expressions is irrelevant.

(+ (* 5 5) (+ (* 3 (/ 12 4)) 4))



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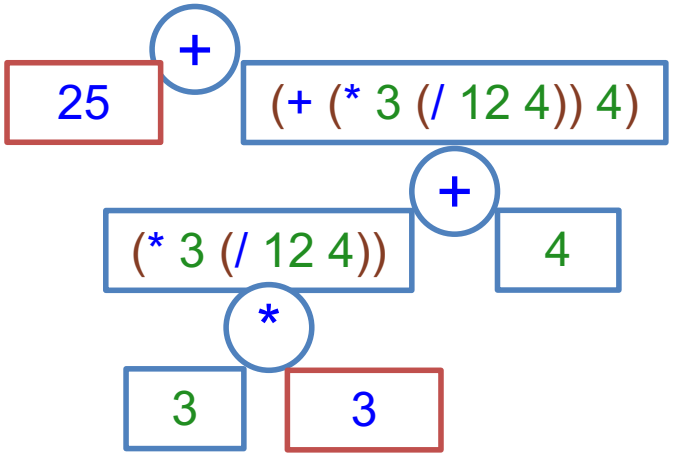

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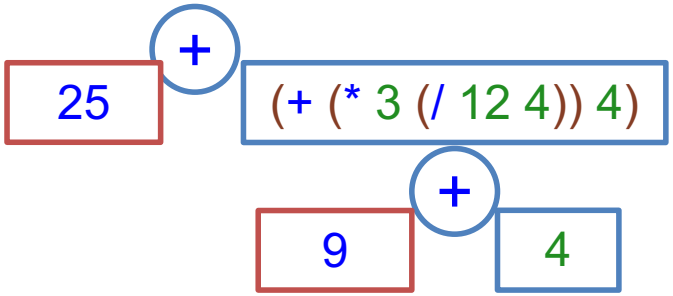

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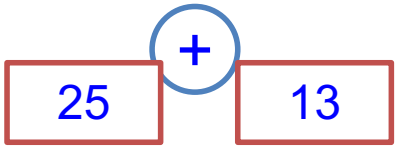

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