NTNU

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Introduction to julia

Presentation and Workshop

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Overview

What is Julia?

Installation & REPL

Main features

Packages

Pluto Notebooks

Workshop: Let's get you started with Julia!

What is Julia?

Goal: Scientific Computing & Fast Prototyping

In scientific computing we need

- high performance to tackle large scale problems
  - ⇒ compiled languages (C/C++, Rust)
  - all types are known at compile time
  - static, hence maybe missing flexibility

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- high-level dynamic languages (like Python, Matlab, R)
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Often: Fast code is written in C/C++ and is interfaced.

⇒ new users might have to compile the C/C++ (e.g. MEX files)

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A short history

2009 Adam Edelman starts the project with
Jeff Bezanson, Stefan Karpinski, Viral B. Shah

2012 first public version

2018 Julia 1.0, i.e. no breaking releases since then

2024 Julia 1.11

Resources

Main homepage https://julialang.org

Documentation https://docs.julialang.org/en/v1/

Modern Julia Workflows https://modernjuliaworkflows.org/

Discourse https://discourse.julialang.org

JuliaHub webfrontend for the General Registry
https://juliahub.com/ui/Packages

These slides
https://github.com/Julia-Users-Trondheim/Intro-to-Julia/blob/main/presentation/introduction-to-julia.pdf

Installation & REPL

Installation

Windows Install Julia from the Microsoft Store by running this in the command prompt

```
winget install julia -s msstore
```

Mac OS / Linux run the installer for example by

```
curl -fsSL https://install.julialang.org | sh
```

...or install `juliaup` via your favourite package manager

We can take a closer look at your individual installation after this presentation in the workshop.

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The Julia command line is called REPL.

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Quick commands

^D Quit

^L Clear console screen

Up Arrow last command

REPL modes

Starting with special characters on REPL enters specific modes

- **?** help mode
  quick access to the documentation of a function

  Example:
  `?` `sqrt` displays the help for the `sqrt` function on REPL,
  see also the (HTML) documentation
  https://docs.julialang.org/en/v1/base/math/#Base.sqrt-Tuple{Number}

- **]** package mode
  quick access to manage packages

- **;** shell mode
  quick access to shell without exiting Julia,
  e. g. to change folders

Main features

General philosophy & Code format

Philosophy

- Write functions not scripts
- Julia has data types, but not objects
- write generic code “acting” on data
- no need to write “vectorized code”
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Format

- blocks have an `end`
- Indentation with 4 spaces is recommended but not necessary
- functions that modify their data should be named with an `!`.

Prequel: Packages & Pluto Notebooks

A Package is a module (namespace) providing additional functionality.

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  ```
  ] add Pluto
  ```

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We will continue command demos in the Pluto notebook
(similar to a Jupyter notebook, but with a persistent state)

Control flow: for, if & while

To repreat something: for-loops

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Combine several (and use ∈)

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for i ∈ 1:3, j ∈ 1:2
    print(i,"×",j,", ")
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Or through several of same length

```
for (i,j) ∈ zip(1:4, 5:8)
    print(i,"|",j," ")
end # prints 1|5 2|6 3|7 4|8
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Conditionals look like

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if x > 3
    print("x is at least 3")
else
    print("x is 3 or less")
end
```

or with lazy evaluation:

```
(x > 4) && print("x > 4")
```

the print is only called if `x>4` is `true`.

Repeating someting (Part II)

```
i = 1;
while i <= 4
    print(i," "); i +=1
end # also prints "1 2 3 4"
```

Functions

Vectorized code vs. Broadcast

structs – Data structures

Multiple Dispatch

Functors

Scripts

TLDR: Main differences to Python

- `for`, `if`, `while` etc. blocks are terminated by `end`
- indentation is nice, but not mandatory
- Julia is 1-indexed
- Strings have single `"quotation marks"`, multiline strings three

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- Strings have single `"quotation marks"`, multiline strings three
- loops amd vectors are fast (no need for vectorized code)
- abstract arrays allow arbitrary indexing ⇒ `a[-1]` is in Julia `a[end-1]`
- Julias range `1:5` includes the end and has the general form `start:step:stop` (instead of `start:(stop+1):step`)
- the imaginary unit is `im` (not `j`)

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- the imaginary unit is `im` (not `j`)
- Matrix multiplication is `A * B`, element wise multiplication `A .* B`
- Julia has no objects/classes

TLDR: Main differences to R

- `'single'` quotation marks are for characters
- vectors are constructed with square brackets `v = [1,2,3]`
- operations on vectors of different length are not allowed
- `<-`, `<<-` and `->` are not assignment operators
- `->` creates an anonymous function

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- matrix multiplication is just `A * B`
- function arguments are not copied when calling a function
- `1:5` is an `AbstractRange`, use `collect(1:5)` to create the vector

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- matrix multiplication is just `A * B`
- function arguments are not copied when calling a function
- `1:5` is an `AbstractRange`, use `collect(1:5)` to create the vector
- you do not need vectorization for performance
- logical indexing: in R `x[x>3]` has two alternatives in Julia
  - `x[ x .> 3]` (uses a temporary vector memory)
  - `filter(z->z>3, x)` might be nicer to read
  - `filter!(z->z>3, x)` updates `x` inplace (avoids the temporary memory)

TLDR: Main differences to Matlab

- array indexing uses square brackets `A[i,j]`
- Arrays are not copied by default `A=B` references the same, do `A=copy(B)` for an actual copy
- *similarly* function arguments are references, input variables can be modified
- 1-dimensional vectors exist and are not `Nx1` matrices
- `42` is an integer, not a float, use `42.0` for the float.
- `A == B` does not return a matrix of booleans but `true` or `false` use `A .== B` to get such a matrix
- dimensions are not “constant-broadcasted”:
  - `[1:10] + [1:10]'` creates a 10×10 matrix in Matlab
  - `[1:10] + [1:10]'` is a dimension mismatch, because a column vector can not be added to a row vector

Packages

Installing & Using Pacakges

Package versions & Updating

Package environments

Pluto Notebooks

Pluto.jl – Motivation

Similarities & differentes to Jupyter

Live Demo

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