Julia

Feels like Python; Works like Lisp; Fast like C

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Goals for Today

1. Why the need for *yet another* language?
2. Overview of Julia features
3. Brief hands-on tutorial
4. Leave you with resources for future exploration!

Who am I?

- Post-Doc at Center for Study of Democratic Institutions
- Study social networks using cell-phone meta-data
    - Lots of simulations on networks with $>$10,000,000 nodes
- Regularly work with Stata, R, Python, and Julia
    - Some contributions to Julia packages, but I am *not* a core Julia developer!

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Python, R, Matlab

Fast Languages

C, Java

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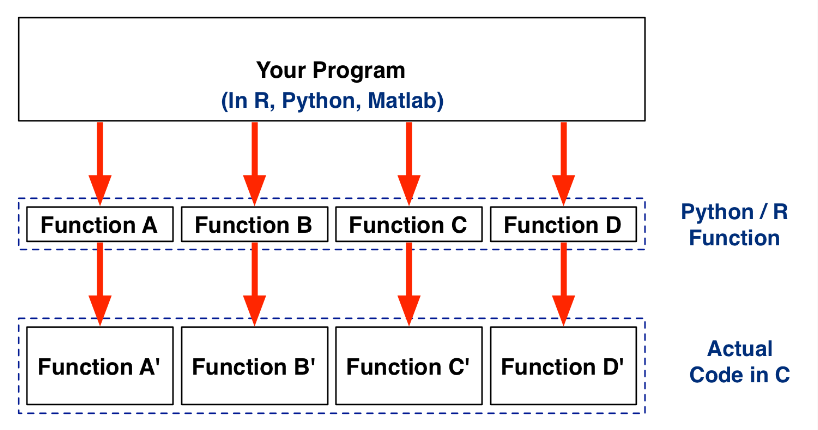
Hybrid Solution



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$\Rightarrow$ True if you know C...

$\Rightarrow$ *Extremely* true if you don't know C!

No Two Language Problem

Base Julia is written *in Julia*

- Even things like definitions of integers!

Most packages written in pure Julia

```python
# Python
def sum_sequence(start, stop):
    total = 0
    for i in range(start, stop):
        total = total + i
    return total
```

```julia
# Julia
function sum_sequence(start, stop)
    total = 0
    for i in start:stop
        total = total + i
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    return total
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```
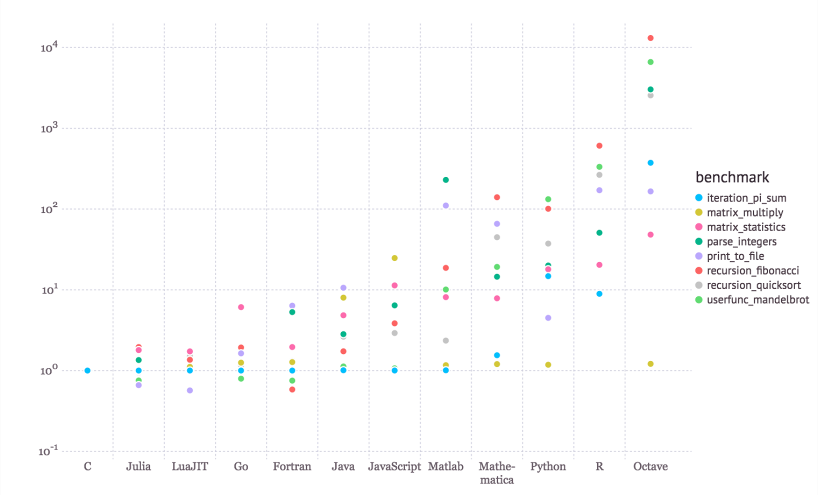

Python: `sum_sequence(0, 1000000)`: 78.8 milliseconds

R: `sum_sequence(0, 1000000)`: 274 miliseconds

Julia: `sum_sequence(0, 1_000_000)`: 0.0037 milliseconds



10^4
10^3
10^2
10^1
10^0
10^{-1}
C
Julia
LuaJIT
Go
Fortran
Java
JavaScript
Matlab
Mathe-matica
Python
R
Octave
benchmark
iteration_pi_sum
matrix_multiply
matrix_statistics
parse_integers
print_to_file
recursion_fibonacci
recursion_quicksort
userfunc_mandelbrot

Why Python (and R) are slow

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⇒Checks type of `total`, type of `i`, and looks up appropriate function `+` one million times!

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sum_sequence(0, 1_000_000)
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- Treats function as a small program.
- Realizes that `total` and `i` are always going to be integers, so only checks once.
- Keeps copy of machine code once created so doesn't have to re-evaluate every time function is called.

Corollary: Julia is only fast inside functions

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# Slow
total = 0
for i in 0:1_000_000
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# Fast
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    total = 0
    for i in start:stop
        total = total + i
    end
    return total
end
sum_sequence(0, 1_000_000)
```

Features: Just Write the Loop

No more need to always vectorize!

```
x = rand(100)

# Loop
for i in 1:length(x)
    x[i] = sqrt(x[i])
end
```

But you can if you want with `.` notation.

```
# Vectorized
x = sqrt.(x)
```

Times: 6.651 ms (loop) and 7.682 ms (vectorized)

Features: Native Parallelism

Add workers:

```
addprocs(3)
```

Small jobs:

```
num_heads = @parallel (+) for i in 1:1_000_000
                rand(Bool)
            end
```

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addprocs(3)
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Small jobs:

```
num_heads = @parallel (+) for i in 1:1_000_000
                rand(Bool)
            end
```

Or:

```
a = SharedArray{Float64}(1_000)
@parallel for i = 1:1_000
    a[i] = randn()
end
```

Features: Parallelism

Big jobs:

```
svds = pmap(svd, list_of_matrices)
```

Features: *Extensive* Linear Algebra Optimizations

```
julia> A = randn(n,n)
julia> Asym = A + A'
julia> issymmetric(Asym)
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- Triangular, Diagonal, Tridiagonal, Sparse Symmetric, etc..

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(Factorizations done using `LAPACK` and `UMFPACK` libraries)

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Base types:

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Plus, user types as fast as Base types.

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If you need it, use `ccall`. Here's a call to `clock` function in C library `libc` that takes no arguments and returns an `Int32` value:

```
t = ccall((:clock, "libc"), Int32, ())
```

Features: Easy Python Integration

Import python `math` function and use its functions in Julia.

```
using PyCall
@pyimport math
math.sin(math.pi / 4) - sin(pi / 4)
```

Features: Support for Unicode

OLS with Unicode:

```
N = 4000
x = randn(N, 3)
ϵ = randn(N)
β = [2, 1, 90]
y = x * β + ϵ

β̂ = inv(x' * x) * x' * y
ϵ̂ = y - x * β̂
```

Not 1.0 Yet...

Currently Stable Release: 0.6.2 Pending Release: 0.7

- Expected this summer ($\sim$ June 2018?)
- 0.7 is 1.0 with depreciation warnings
    - If your code works with 0.7, syntax won't change!

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- Major compiler improvements for missing data
- New package manager
- Missing data type moving to core library

Hands-on Tutorials!

Go to `juliabox.com`, create an account, and navigate to `tutorials/intro-to-julia`.

Today we'll do:

- 1. Getting Started
- 4. Loops
- 6. Functions
- 10. Multiple Dispatch