A Fast Dynamic Language for Technical Computing

Viral B. Shah

Jeff Bezanson, Stefan Karpinski, Alan Edelman,
and many others!

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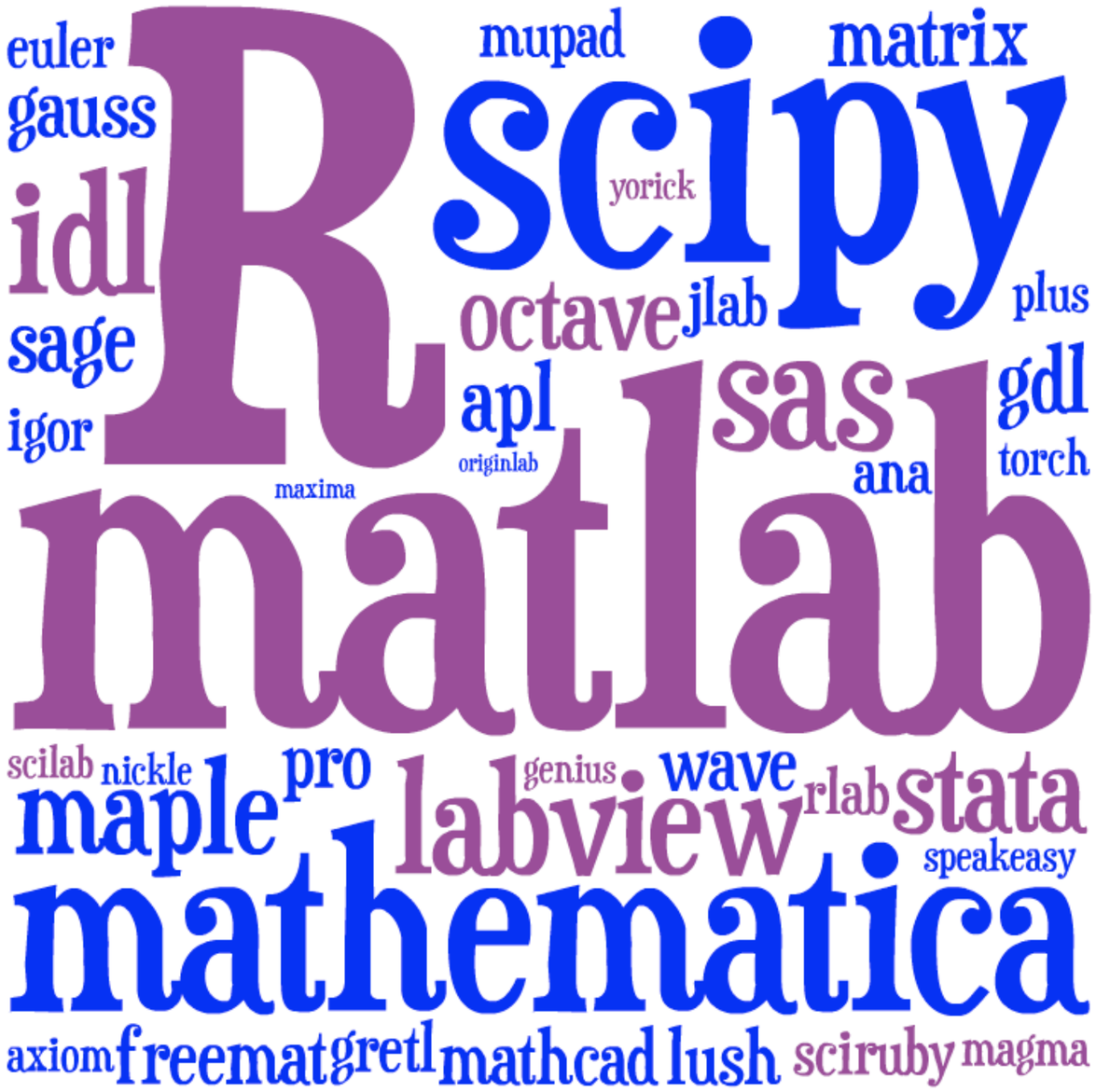
Why do we need one more?

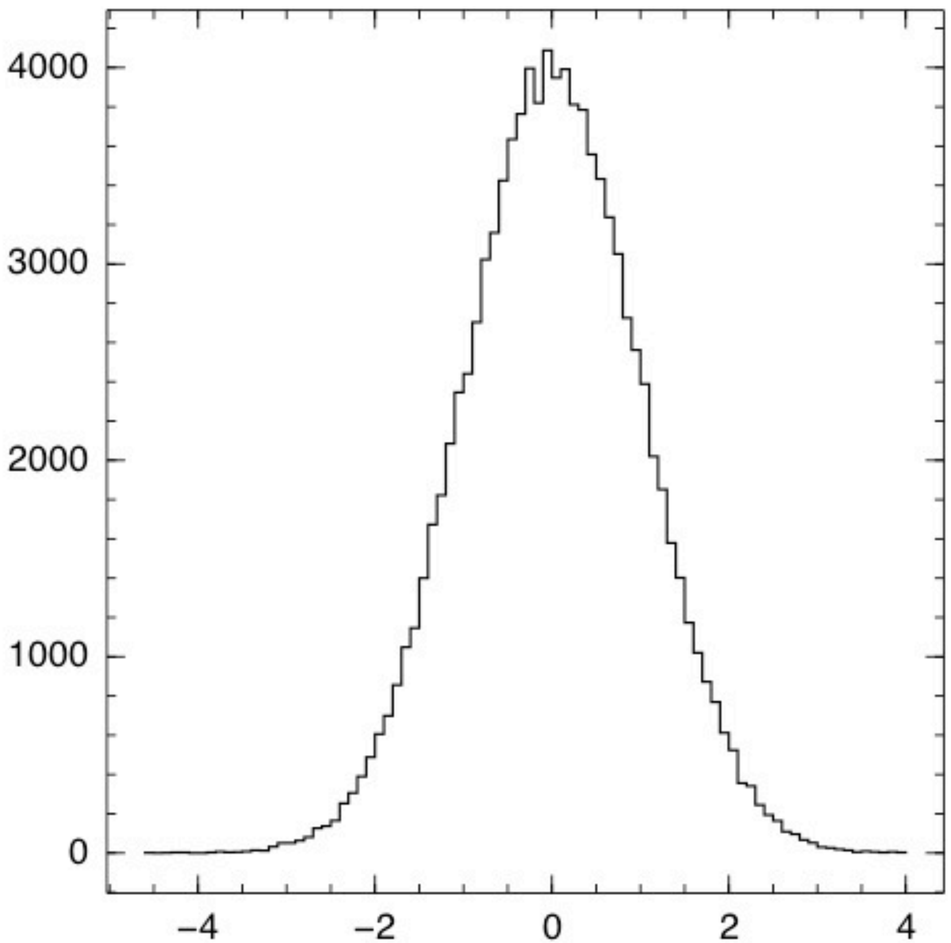


Some noteworthy features

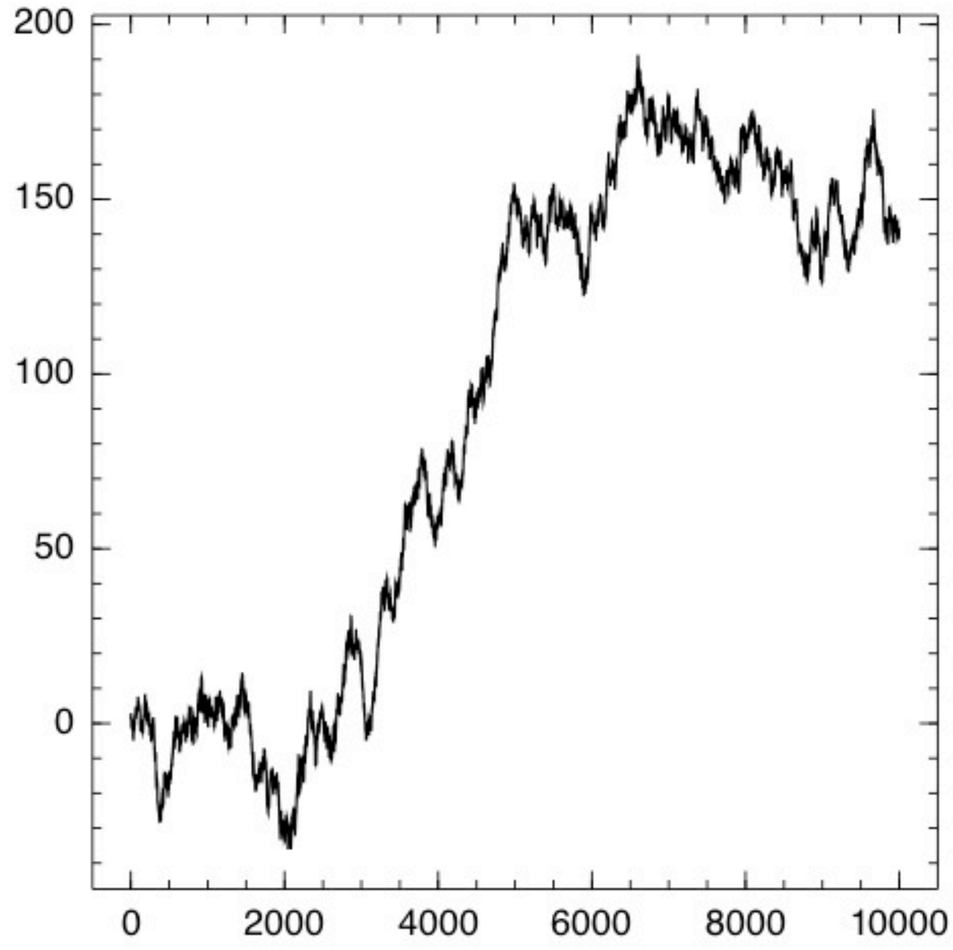
- Open source with an MIT licensed core
- Easy installation - Just download a precompiled binary and run
- Dynamically typed with fast user-defined types
- Multiple dispatch with a sophisticated parametric type system
- JIT compiler - no need to vectorize for performance
- Co-routines
- Distributed memory parallelism
- Effortlessly call C, Fortran, and Python libraries
- Metaprogramming with Lisp-like macros
- Unicode support

A simulated stock market

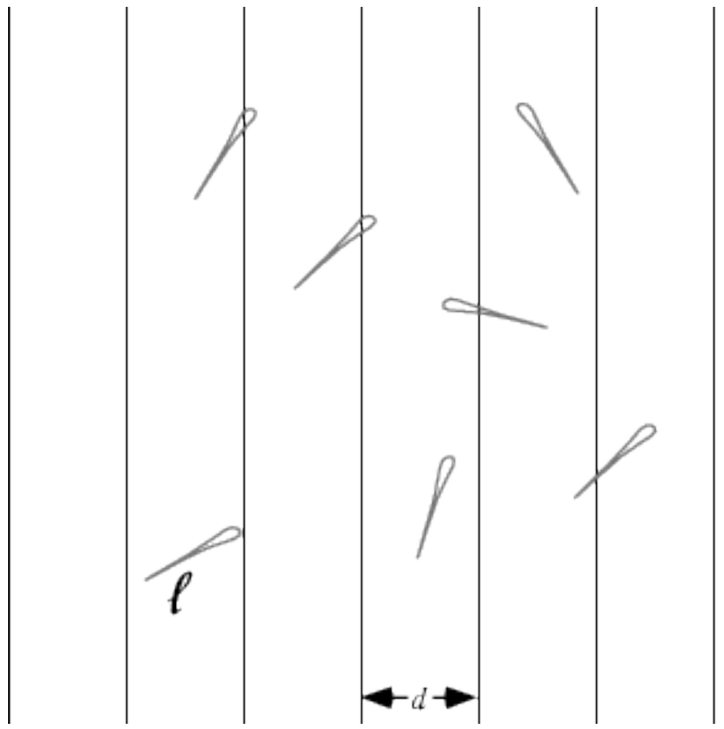
```
julia> plothist(randn(100000), 100)
<plot>
```




```
julia> plot(cumsum(randn(10000)))
<plot>
```

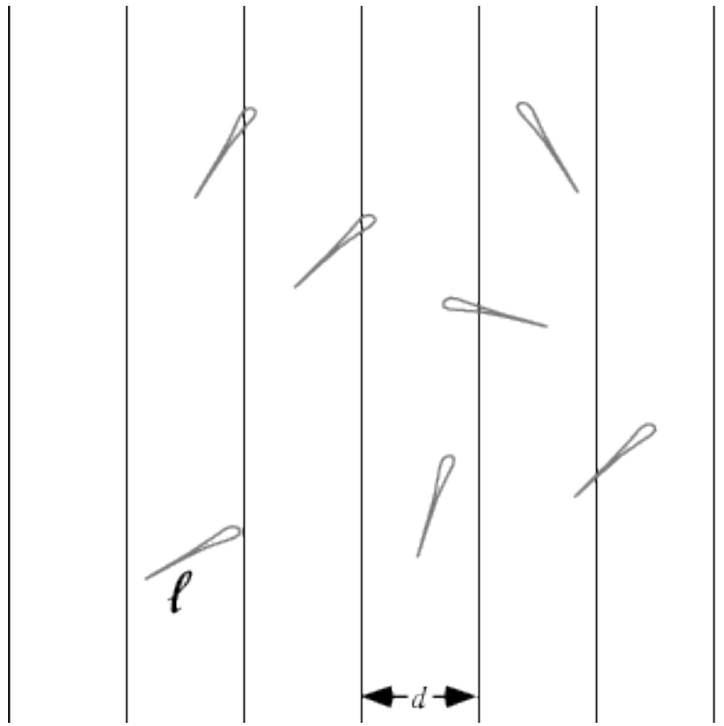


Let’s compute π: Buffon needle problem




```
function buffon(m)
    hit = 0
    for l = 1:m
        mp = rand()
        phi = (rand() * pi) - pi / 2
        xrechts = mp + cos(phi)/2
        xlinks = mp - cos(phi)/2
        if xrechts >= 1 || xlinks <= 0
            hit += 1
        end
    end
    miss = m - hit
    piapprox = m / hit * 2
end
```

Let's compute π in parallel




```
function buffon_par(m)
    hit = @parallel (+) for l = 1:m
        mp = rand()
        phi = (rand() * pi) - pi / 2
        xrechts = mp + cos(phi)/2
        xlinks = mp - cos(phi)/2
        (xrechts>=1||xlinks<=0) ? 1 : 0
    end
    miss = m - hit
    piapprox = m / hit * 2
end
```

Familiar syntax for Matlab / Octave users

```
function randmatstat(t; n=10)
    v = zeros(t)
    w = zeros(t)
    for i = 1:t
        a = randn(n,n)
        b = randn(n,n)
        c = randn(n,n)
        d = randn(n,n)
        P = [a b c d]
        Q = [a b; c d]
        v[i] = trace((P'*P)^4)
        w[i] = trace((Q'*Q)^4)
    end
    std(v)/mean(v), std(w)/mean(w)
end
```

Keyword arguments

Familiar array syntax

Common matrix operations

Common statistics

Last expression is return value

Yes, you can also write low-level code!

```
function qsort!(a,lo,hi)
    i, j = lo, hi
    while i < hi
        pivot = a[(lo+hi)>>>1]
        while i <= j
            while a[i] < pivot; i = i+1; end
            while a[j] > pivot; j = j-1; end
            if i <= j
                a[i], a[j] = a[j], a[i]
                i, j = i+1, j-1
            end
        end
        if lo < j; qsort!(a,lo,j); end
        lo, j = i, hi
    end
    return a
end
```

Pass by reference

Functions ending in ! modify the inputs

Swap elements

Recursion

Call C, Fortran, Python libraries

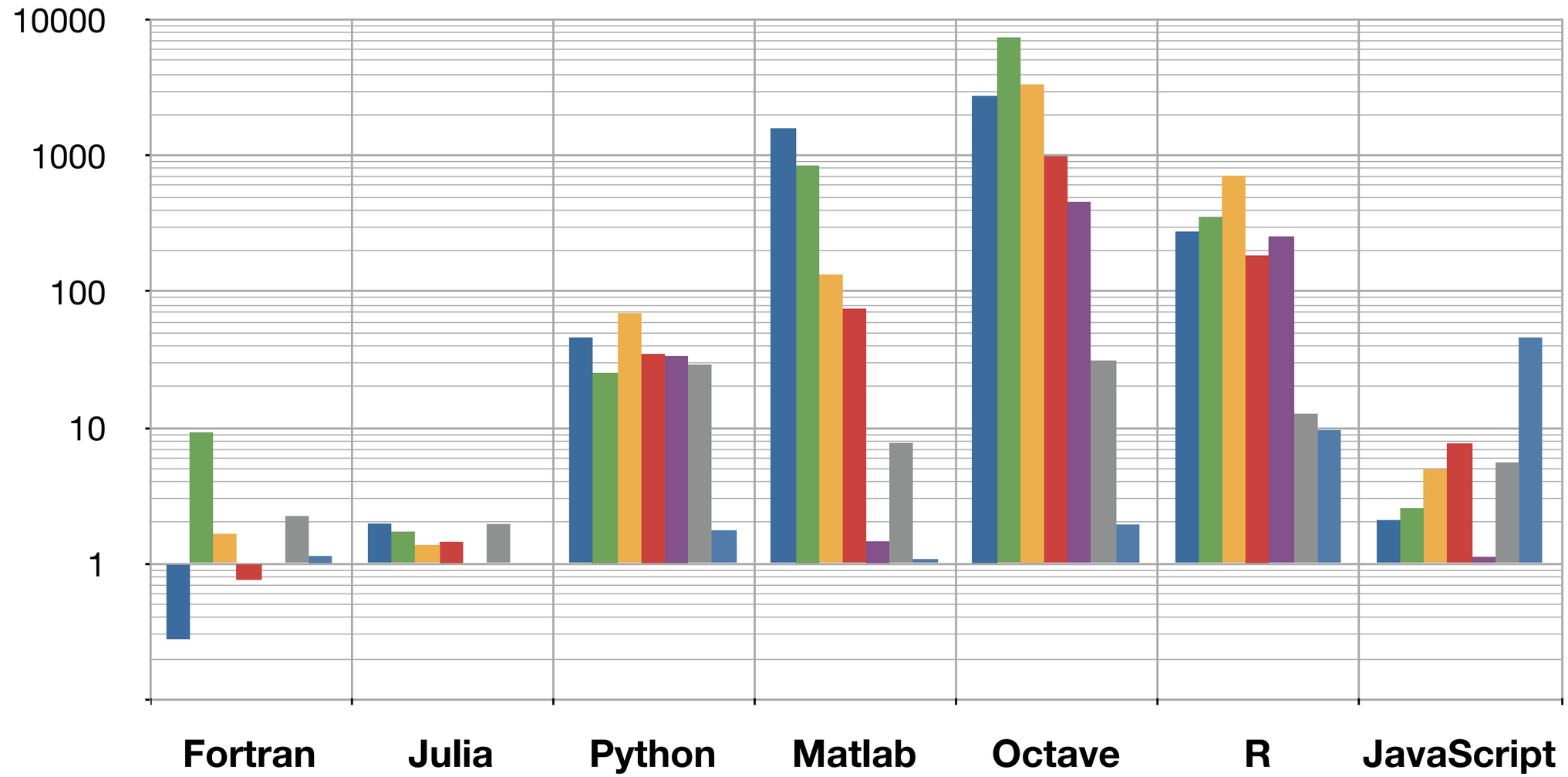
```
julia> ccall(:clock, Int32, ())
2292761

julia> ccall(:getenv, Ptr{Uint8int8}, (Ptr{Uint8},), "SHELL")
Ptr{Uint8} @0x00007fff5fbffc45
julia> bytestring(ans)
"/bin/bash"
```

```
julia> using PyCall     # Installed with Pkg.add(“PyCall”)
julia> @pyimport math
julia> math.sin(math.pi / 4) - sin(pi / 4)
0.0

julia> @pyimport pylab
julia> x = linspace(0,2*pi,1000); y = sin(3*x + 4*cos(2*x));
julia> pylab.plot(x, y; color="red", linewidth=2.0, linestyle="--")
julia> pylab.show()
```

Micro-benchmarks (log-scale)



execution time relative to C++ (lower is better)

Benchmarks: fib, parse_int, quicksort, mandel, pi_sum, rand_mat_stat, and rand_mat_mul

Let's look at some real data

```
julia> Pkg.add("DataFrames")
Installing DataFrames: v0.3.6

julia> using DataFrames

julia> vl = readtable("2013_BS_VL.csv", allowquotes=false)

julia> size(vl)
(1797590,12)

julia> colnames(vl)

julia> describe(vl)
```

What does this data look like?

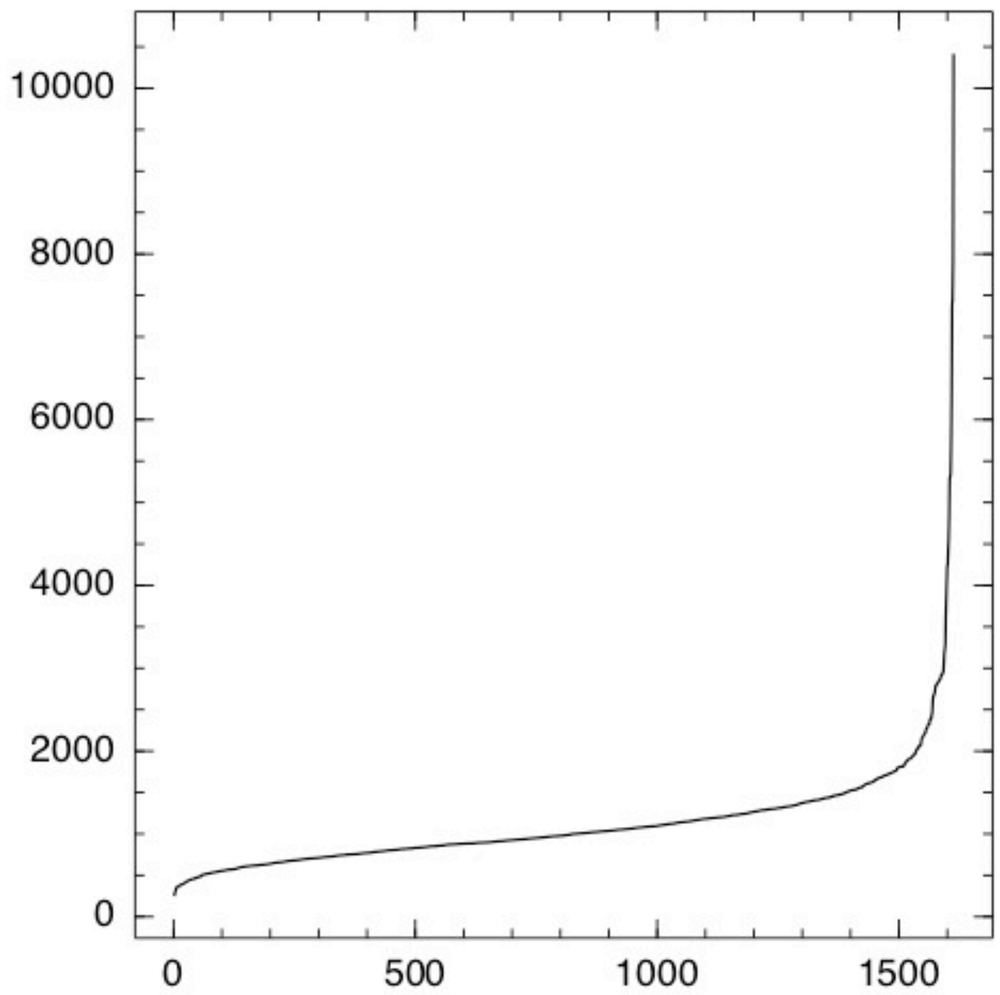
```
julia> colnames(vl)
12-element Union(ASCIIString,UTF8String) Array:
 "AC"
 "ACNAME"
 "PS"
 "PSNAME"
 "PSADDR"
 "PSPART"
 "VoterID"
 "Name"
 "FatherHusband"
 "House"
 "Age"
 "Gender"
```

Data is never clean

```
julia> f = [ try int(vl["Age"][i]); catch -1; end for i
in 1:size(vl,1) ]
julia> vl = vl[f.!=-1, :]
julia> vl[:Age] = PooledDataArray(int(vl[:Age]))
julia> vl[:ACNAME] = PooledDataArray(int(vl[:ACNAME]))
julia> vl[:PSNAME] = PooledDataArray(vl[:PSNAME])


julia> by(vl, :ACNAME, nrow)
julia> by(vl, :ACNAME, x->mean(x[:Age]))
julia> by(vl, :ACNAME, x->sum(DataArray(x[:Age] .<=
40)))
```

Draw your own insights




```
julia> describe(by(vl, :PSNAME, nrow))

PSNAME
Length: 1613
Type  : Pooled UTF8String
NAs   : 0

x1
Min       250.0
1st Qu.   772.0
Median    981.0
Mean      1113.8326100433974
3rd Qu.   1276.0
Max       10416.0

julia> plot(1:1613, sort(pspop[:x1]))
```

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