# Deep Learning in Julia

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# machine learning in 5 slides

# Machine learning: observations

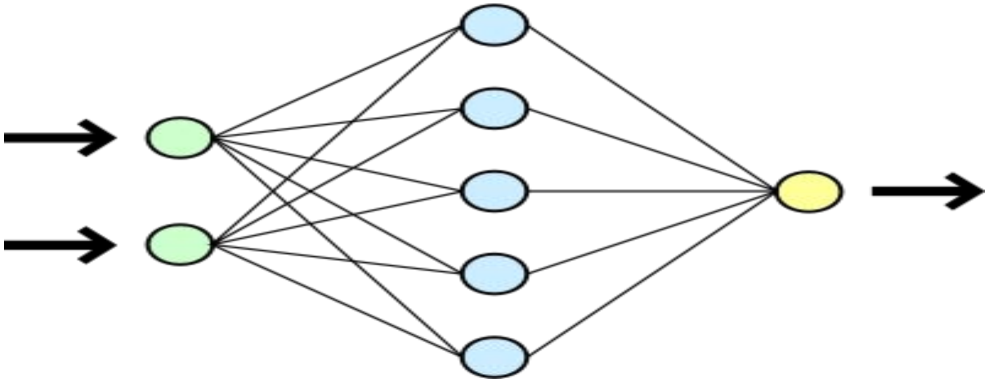
# Machine learning: modeling

Inputs

Differentiable program

Predictions

$x_1$
$x_2$
.
.
.
$x_n$



$\hat{y}_1$
$\hat{y}_2$
.
.
.
$\hat{y}_n$

```
ypred = predict(w, x)
```

# Machine learning: loss function

Outputs

$y_1$
$y_2$
.
.
.
$y_n$

```
function loss(w,x,y)
    ypred = predict(w,x)
    ydiff = ypred - y
    sqerr = ydiff .^ 2
    qloss = sum(sqerr)
end
```

Predictions

$\hat{y}_1$
$\hat{y}_2$
.
.
.
$\hat{y}_n$

# Machine Learning: optimization loop

```
function SGD(func, data)
    for args in data
        f = @diff func(args…)
        for w in params(f)
            w = w - grad(f,w) * learningRate
        end
    end
    return w
end
```

# Deep learning software infrastructure

- Modeling language
- GPU support
- Automatic differentiation
- Optimization algorithms

[Julia]

[Knet]

# Julia in 5 slides

# Why Julia? (1/5) Speed

- Julia is fast.
- Most of Julia library is written in readable / hackable / composable Julia rather than opaque C++ (as opposed to Numpy, Tensorflow etc.)

# Case study: Celeste project

- Classify stars and galaxies
- using Cori supercomputer at NERSC
- 188M objects from Sloan Digital Sky Survey
- 178TB of image data
- 14.6 minutes to load data, perform estimations
- Peak performance of 1.54 petaflops using 1.3 million threads on 9,300 nodes
- Written in pure Julia

https://juliacomputing.com/case-studies/celeste.html

# Why Julia? (2/5) Multiple dispatch

- x::Matrix * y::Matrix
- x::Diagonal * y::Triangular
- x::KnetArray * y::KnetArray
- x::Param * y::Param

# Why Julia? (3/5) Metaprogramming

- `y = tanh.(w * x .+ b)`
- `dy = @diff tanh.(w * x .+ b)`
- `grad(dy,w)`
- `grad(dy,b)`

# Why Julia? (4/5) Callable objects

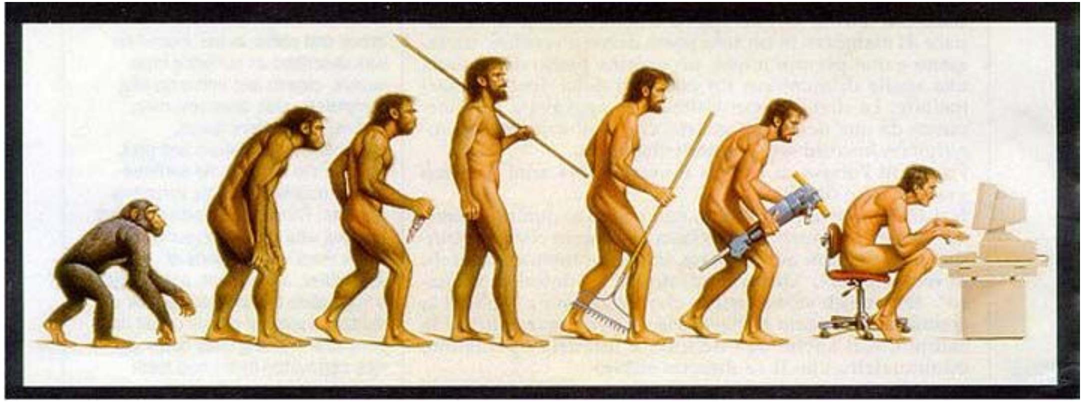
```
struct Dense; w; b; f; end
(d::Dense)(x) = d.f.(d.w * x .+ d.b)

struct Chain; layers; end
(c::Chain)(x) = (for f in c.layers; x=f(x); end; x)
(c::Chain)(x,y) = nll(c(x),y)

d1 = Dense(randn(256,784),randn(256),relu)
d2 = Dense(randn(10,256),randn(10),identity)
mlp = Chain((d1,d2))
```

# Why Julia? (5/5) Iterators

Lazy iterators for training and monitoring:

- *Run one epoch:* `sgd(f,d)`
- *Run n epochs:* `sgd(f,repeat(d,n))`
- *Run n iters:* `sgd(f,take(d,n))`
- *Progress bar:* `progress(sgd(f,d))`
- *Run till conv:* `converge(sgd(f,cycle(d)))`
- *Do something every n iterations:*
  `(task(x) for x in takenth(sgd(f,d),n))`

# Evolution of computer languages



Machine Code

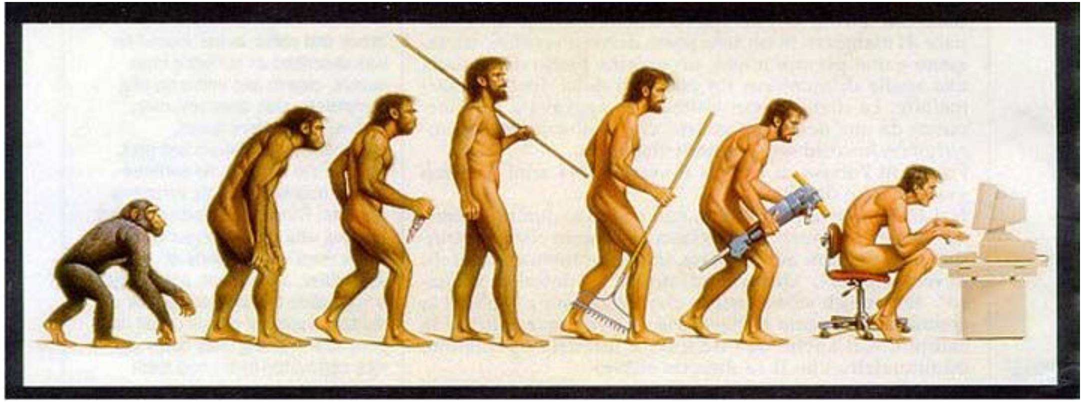
Assembler

Fortran BASIC

C

Julia

# Evolution of deep learning frameworks



| Machine Code | Assembler | Fortran BASIC | C | → Julia |
|---|---|---|---|---|
| CUDA ConvNet | Caffe | Torch Theano TFlow | PyTorch DyNet TF Fold | ↗ Julia |

# To explore further...

juliabox.com

github.com/denizyuret/Knet.jl