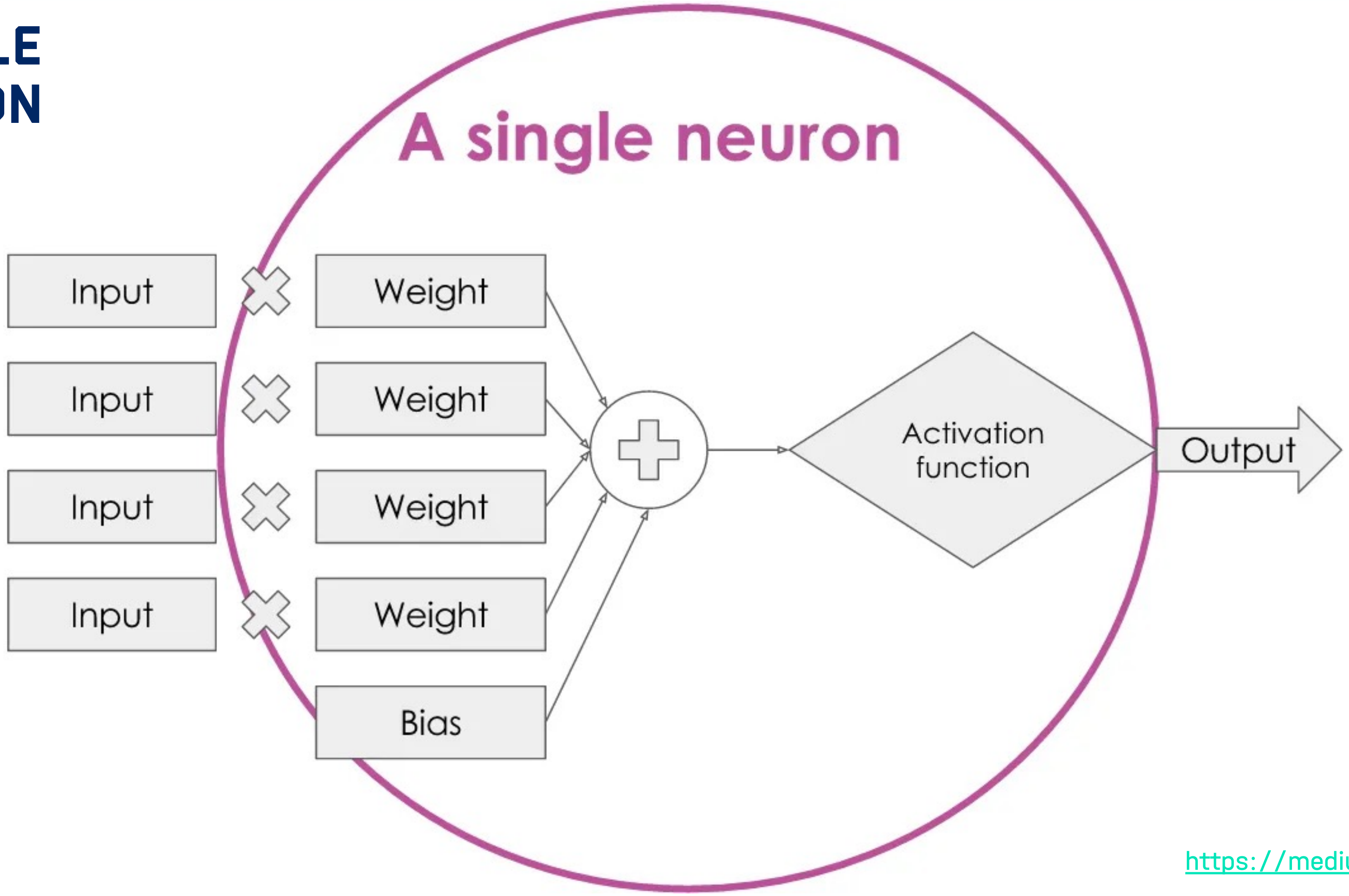
RECAP

I2DL 28/10/2025

A SINGLE NEURON



https://medium.com/@RosieCampbell

ACTIVATION FUNCTIONS

why not just use identity?

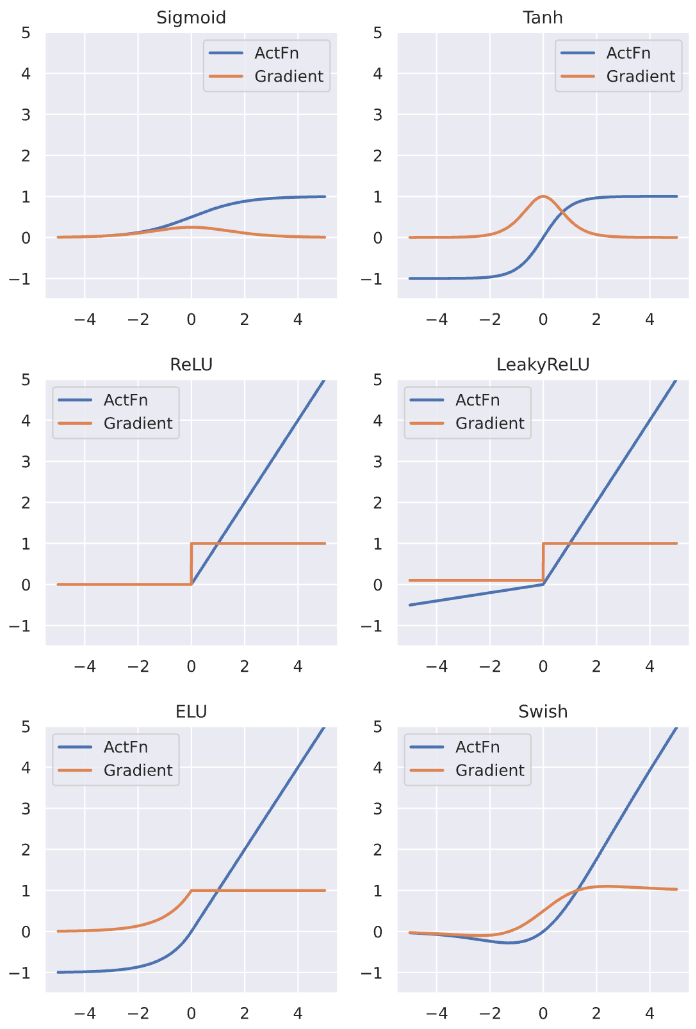
need a non-linear function

sigmoid might cause vanishing gradients

it's nice if the gradient is easy to calculate

sometimes we *want* some weights to →0

last three ones keep some negative values



Lightning AI

Creators of PyTorch Lightning

https://lightning.ai/docs/pytorch/stable/notebooks/course_UvA-DL/02-activation-functions.html

FEEDFORWARD NEURAL NETWORK

A feedforward neural network implements the *perceptron* algorithm - this was intended to be a machine with 400 photocells!

stack layers of neurons, connect them all with activation functions
→ feedforward neural net

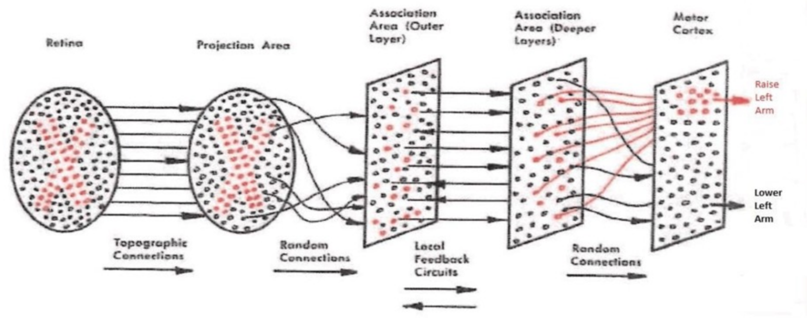


FIG. 1 — Organization of a biological brain. (Red areas indicate active cells, responding to the letter X.)

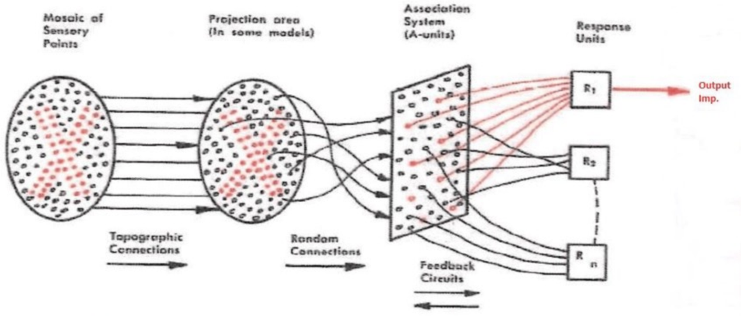
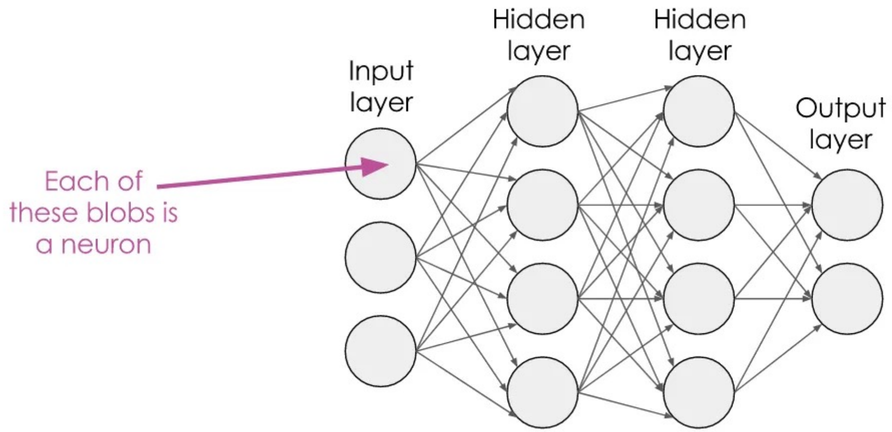


FIG. 2 — Organization of a perceptron.



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https://en.wikipedia.org/wiki/Perceptron#History

FEEDFORWARD NEURAL NETWORK

These all mean the same:

- fully connected layer
- (keras) dense layer
- (pytorch) inear layer

also:
FFN = Multi-Layer Perceptron

→

scikit-learn has probably the most accessible MLP model

PyTorch

v2.9.0 (stable)

Linear

class torch.nn.**Linear**(*in_features*, *out_features*, *bias*=*True*, *device*=*None*, *dtype*=*None*) [source]

Applies an affine linear transformation to the incoming data: $y = xA^T + b$.

This module supports TensorFloat32.

On certain ROCm devices, when using float16 inputs this module will use different precision for backward.

Parameters:

- **in_features** (*int*) – size of each input sample
- **out_features** (*int*) – size of each output sample

the layer will not learn an

ns any number of

nd H_{in} = in_features.

but the last dimension are

and H_{out} = out_features.

scikit learn

Class `MLPClassifier` implements a multi-layer perceptron (MLP) algorithm that trains using Backpropagation.

MLP trains on two arrays: array X of size (n_samples, n_features), which holds the training samples represented as floating point feature vectors; and array y of size (n_samples,), which holds the target values (class labels) for the training samples:

```
>>> from sklearn.neural_network import MLPClassifier
>>> X = [[0., 0.], [1., 1.]]
>>> y = [0, 1]
>>> clf = MLPClassifier(solver='lbfgs', alpha=1e-5,
...                     hidden_layer_sizes=(5, 2), random_state=1)
...
>>> clf.fit(X, y)
MLPClassifier(alpha=1e-05, hidden_layer_sizes=(5, 2), random_state=1,
              solver='lbfgs')
```

K

▸ Keras 3 API documentation / Layers API / Core layers / Dense layer

Dense layer

Dense class [source]

```
keras.layers.Dense(
    units,
    activation=None,
    use_bias=True,
    kernel_initializer="glorot_uniform",
    bias_initializer="zeros",
    kernel_regularizer=None,
    bias_regularizer=None,
    activity_regularizer=None,
    kernel_constraint=None,
    bias_constraint=None,
    lora_rank=None,
    lora_alpha=None,
    **kwargs
)
```

Just your regular densely-connected NN layer.

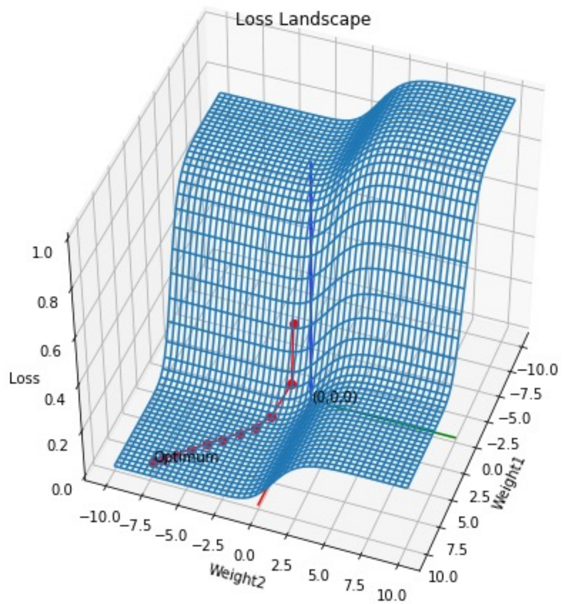
https://scikit-learn.org/stable/modules/neural_networks_supervised.html

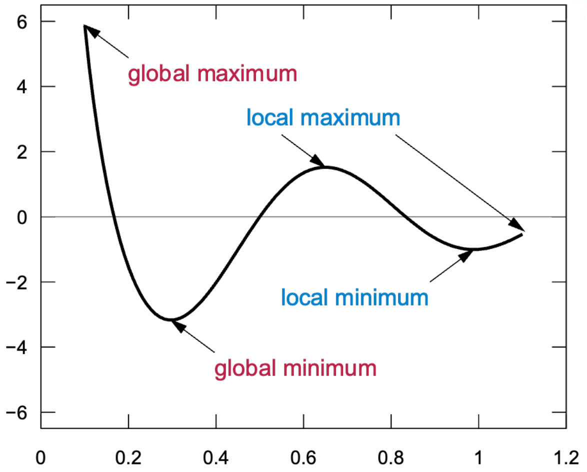
GRADIENT DESCENT

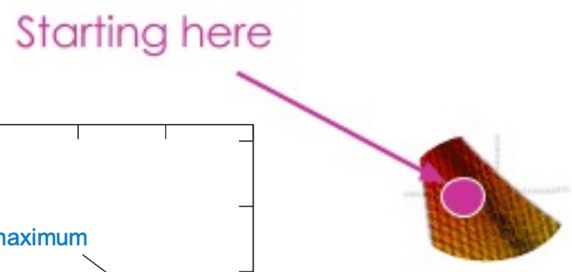
we formulate learning as minimizing an error function, usually called the loss.

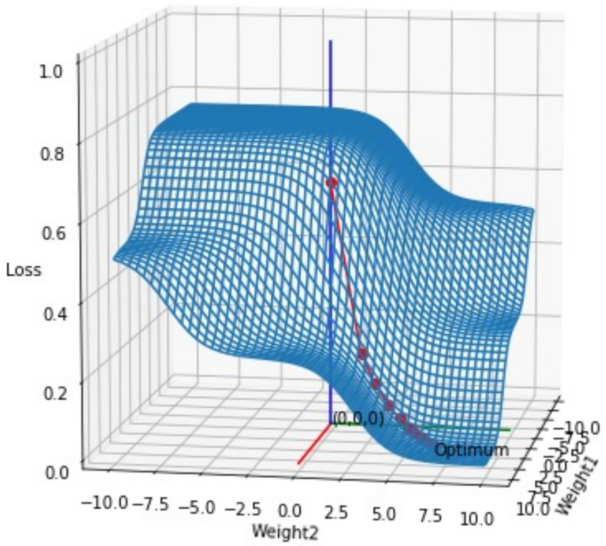
Because the error functions of artificial neural networks are non-convex, we will almost certainly only find a local minimum.

The loss value is a number, the "height" above ground in a multi-dim loss landscape.









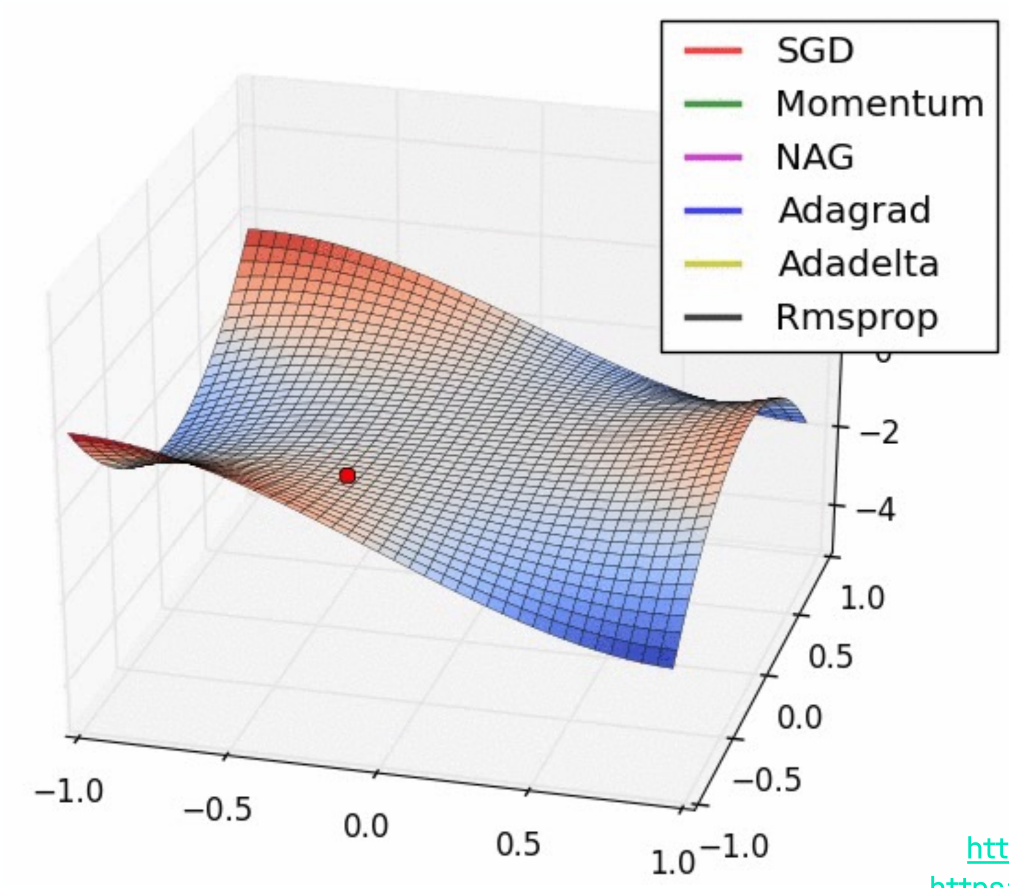
https://ai.stackexchange.com/users/2844/dan-d
https://medium.com/@RosieCampbell
https://en.wikipedia.org/wiki/Backpropagation

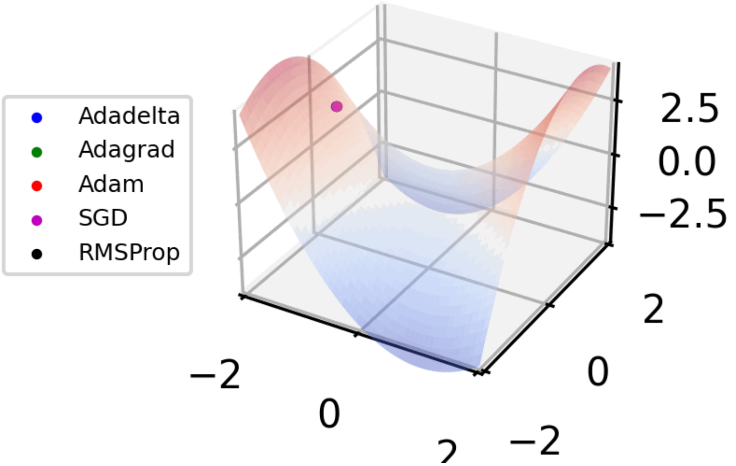
OPTIMIZERS

At the core, all common optimizers use variations of gradient descent.

Actually *stochastic* gradient descent: ∇ is calculated in many little batches instead of for the entire data set.

They all aim to speed up learning along stable directions by gathering momentum, while slowing oscillations.

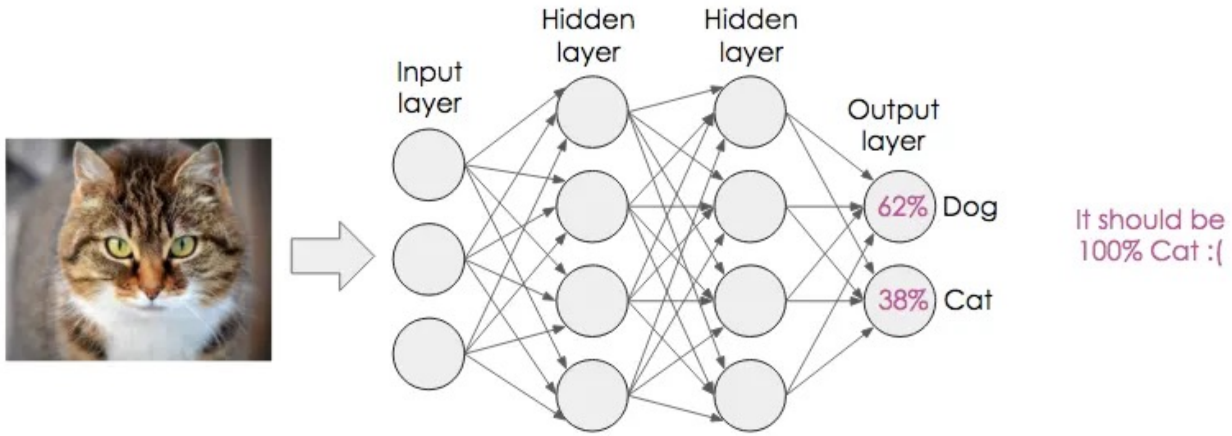


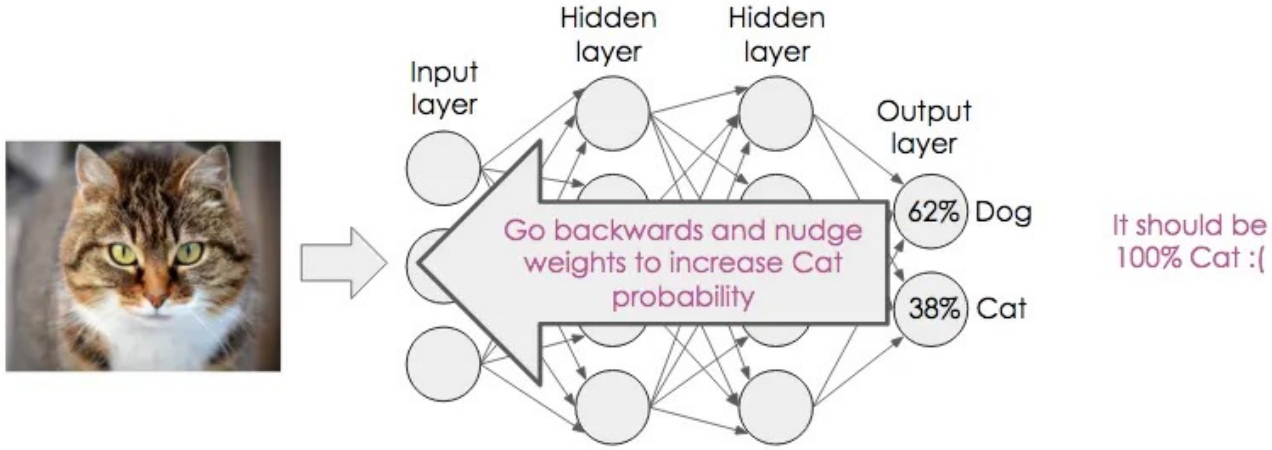


LEARNING RATE:
🤩 **OPTIMIZER**
👍 **SCHEDULE**
😐 **CONSTANT LR**

https://en.wikipedia.org/wiki/Stochastic_gradient_descent
https://optimization.cbe.cornell.edu/index.php?title=RMSProp

BACKPROPAGATION





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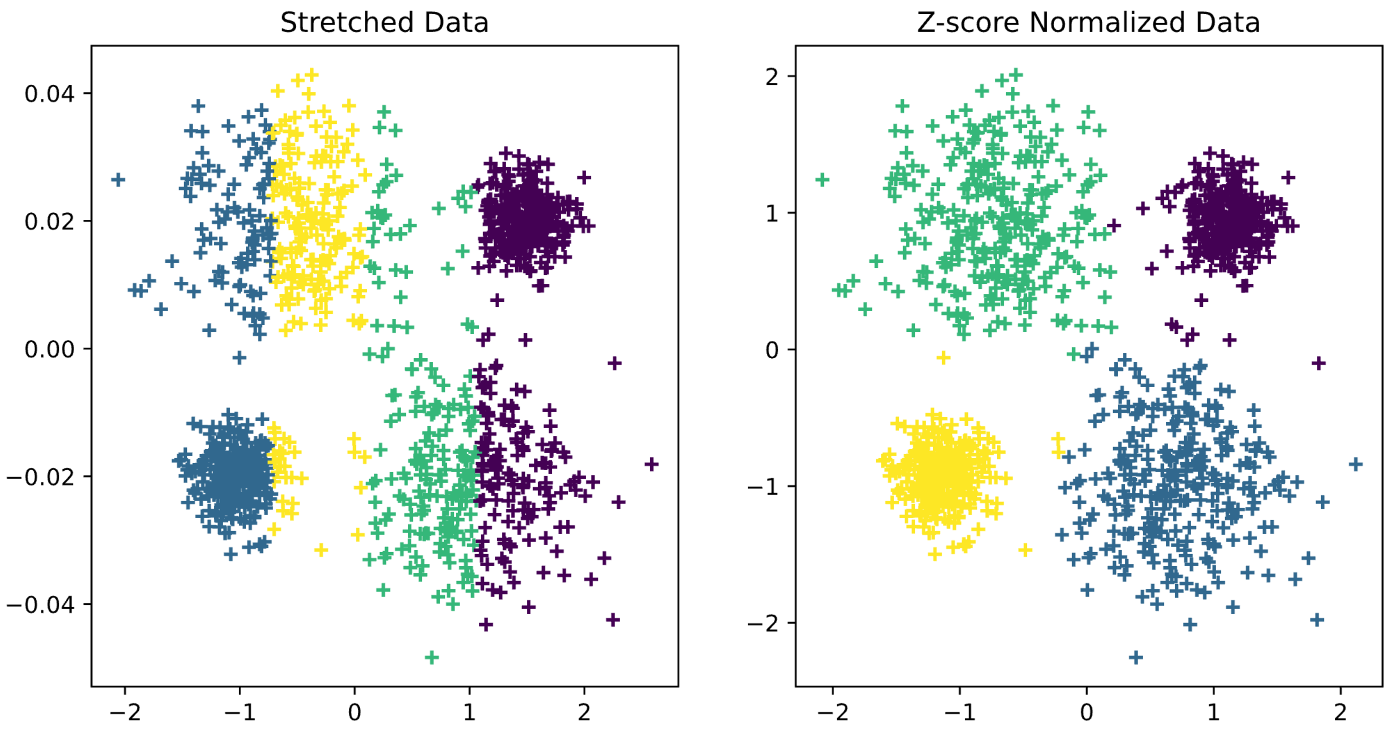
FEATURE SCALING

Feedforward neural networks can be susceptible to features "living" on different numerical scales
→ use feature scaling

min-max scaling, median scaling or z-scaling are common

→
the y-axes are different!



https://en.wikipedia.org/wiki/Feature_scaling