CS 480

Introduction to Artificial Intelligence

November 16th, 2021

Announcements / Reminders

- **Programming Assignment #02:**
  - **due on Tuesday, December 7th, at 11:00 PM CST**
- **Written Assignment #03:**
  - **due on Wednesday, December 1st, at 11:00 PM CST**
- **Final Exam:**
  - **Thursday, December 2nd, 2021 (during lecture time)**

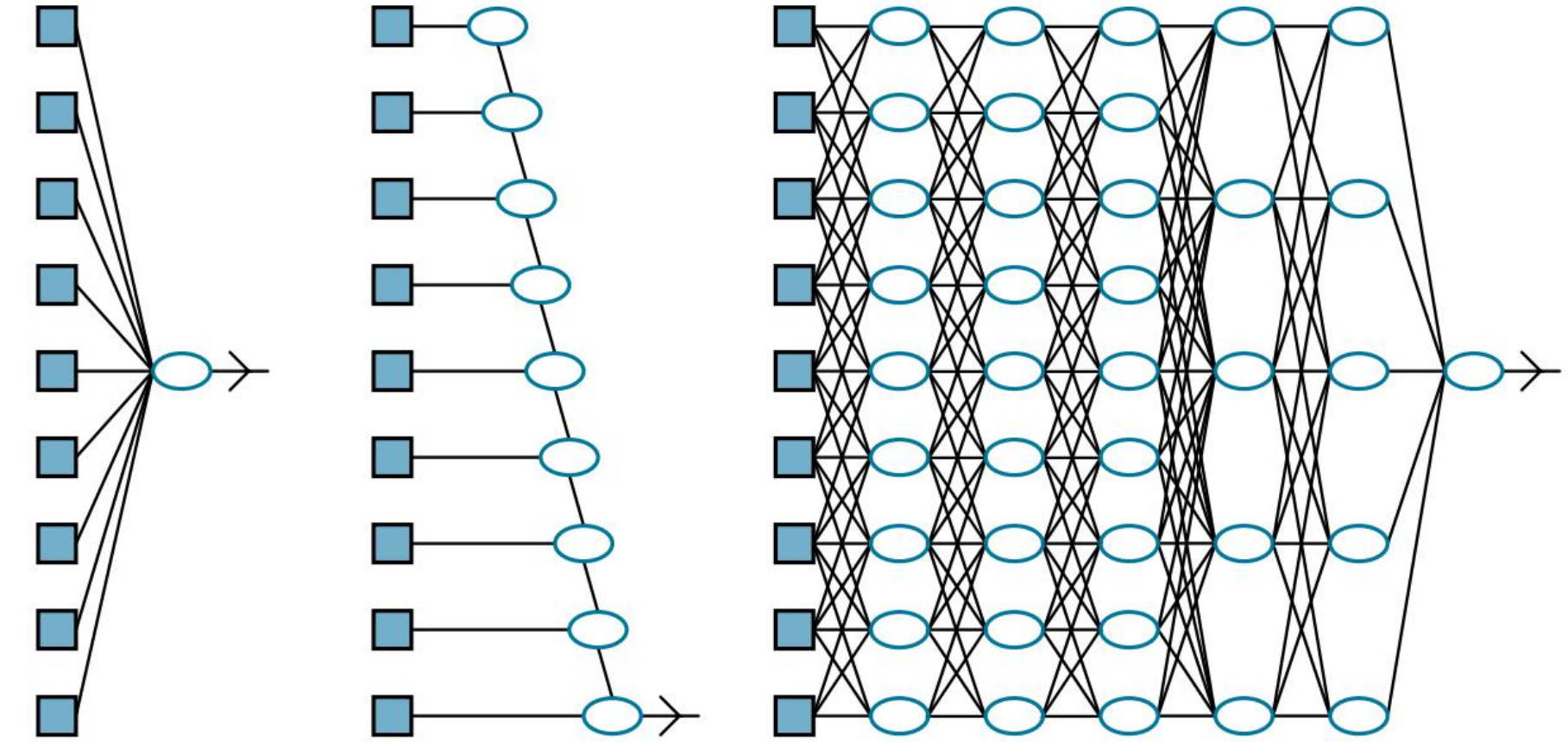
Plan for Today

- **Casual Introduction to Deep Learning**

Deep Learning

Deep learning is a broad family of techniques for machine learning (also a sub-field of ML) in which hypotheses take the form of complex algebraic circuits with tunable connections. The word "deep" refers to the fact that the circuits are typically organized into many layers, which means that computation paths from inputs to outputs have many steps.

Shallow vs. Deep Models



Shallow Model

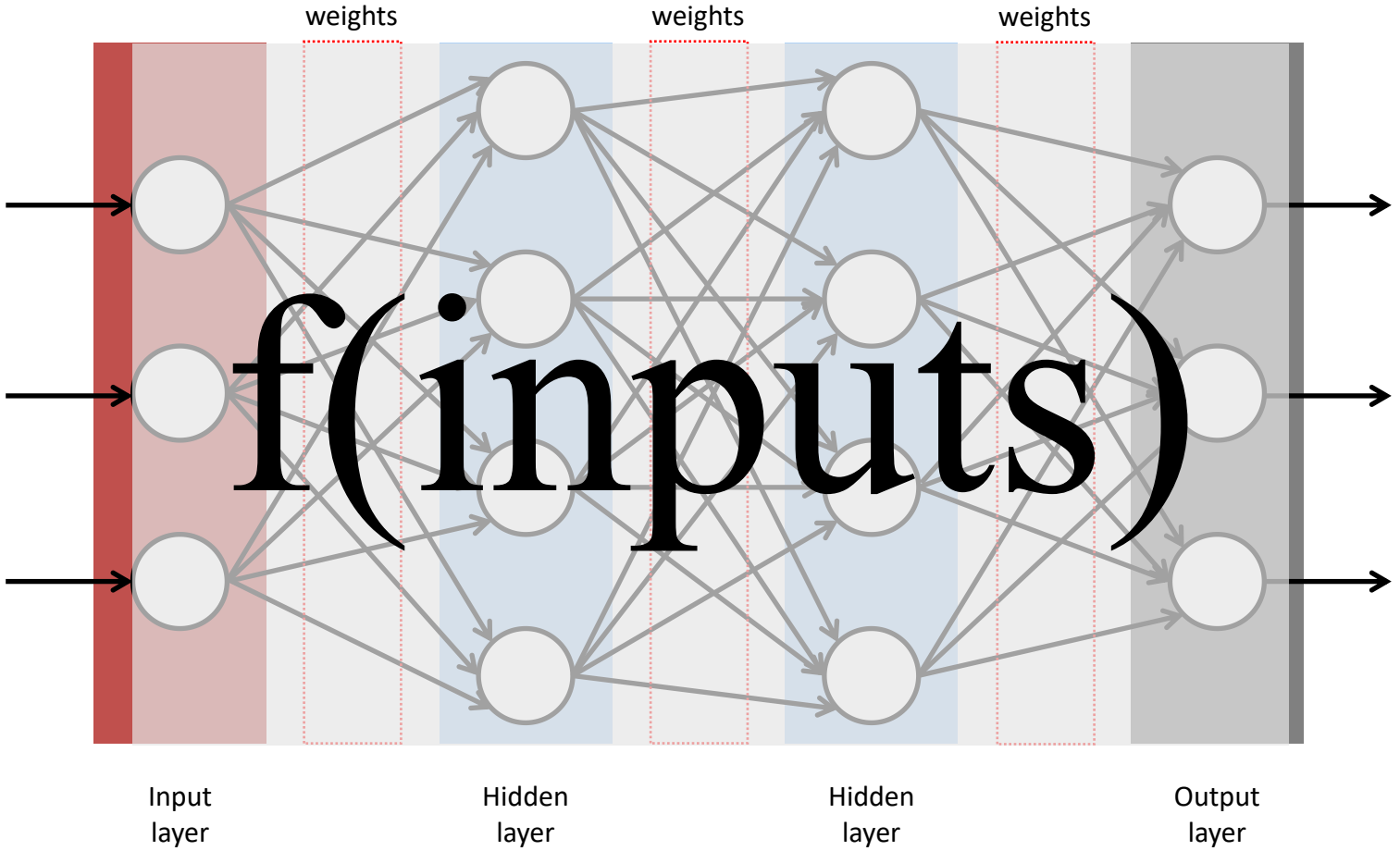
Shallow Model

Deep Model

Longer computation path

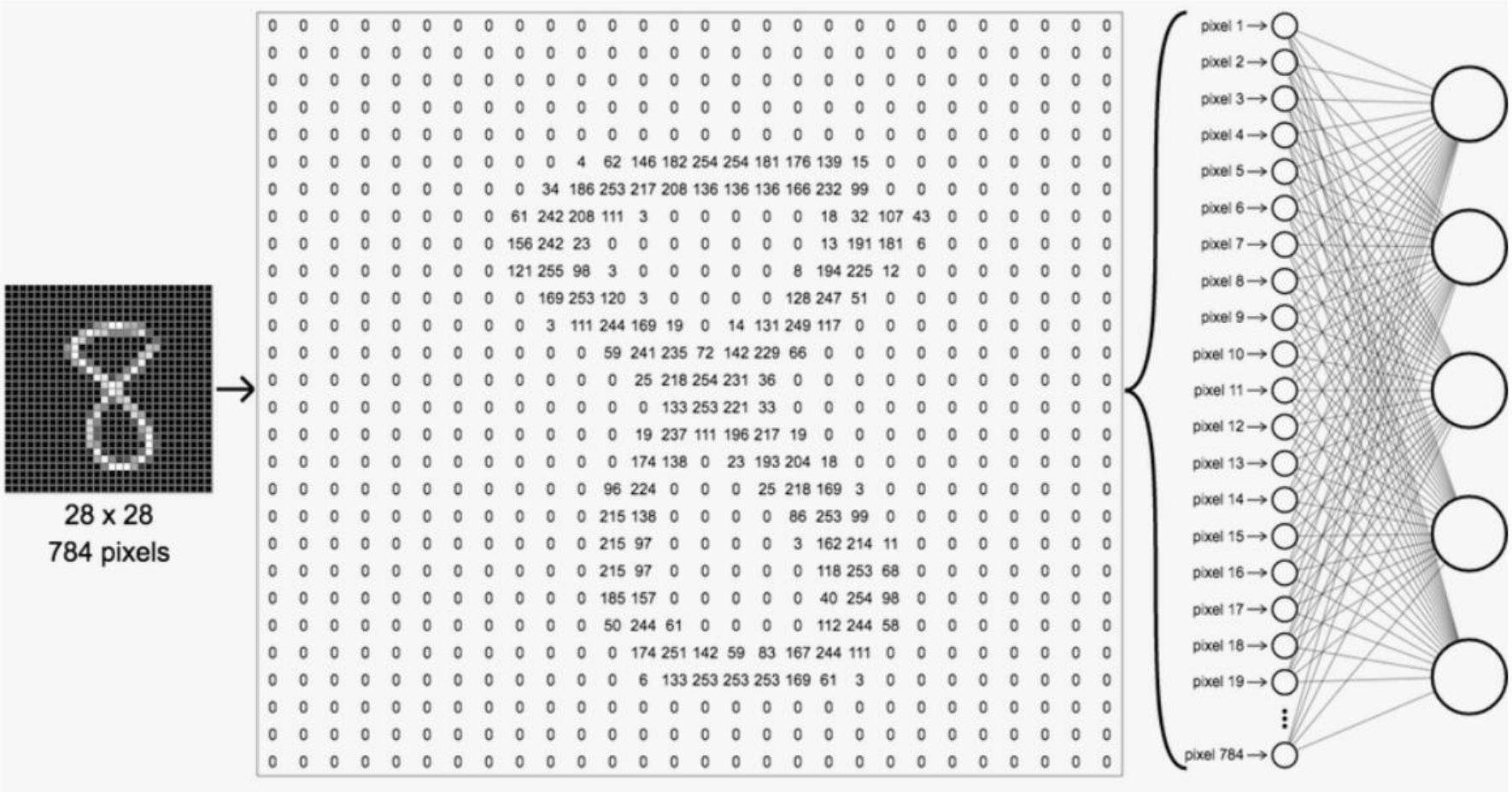
ANN as a Complex Function

In ANNs **hypotheses take form of complex algebraic circuits** with tunable connection strengths (weights).



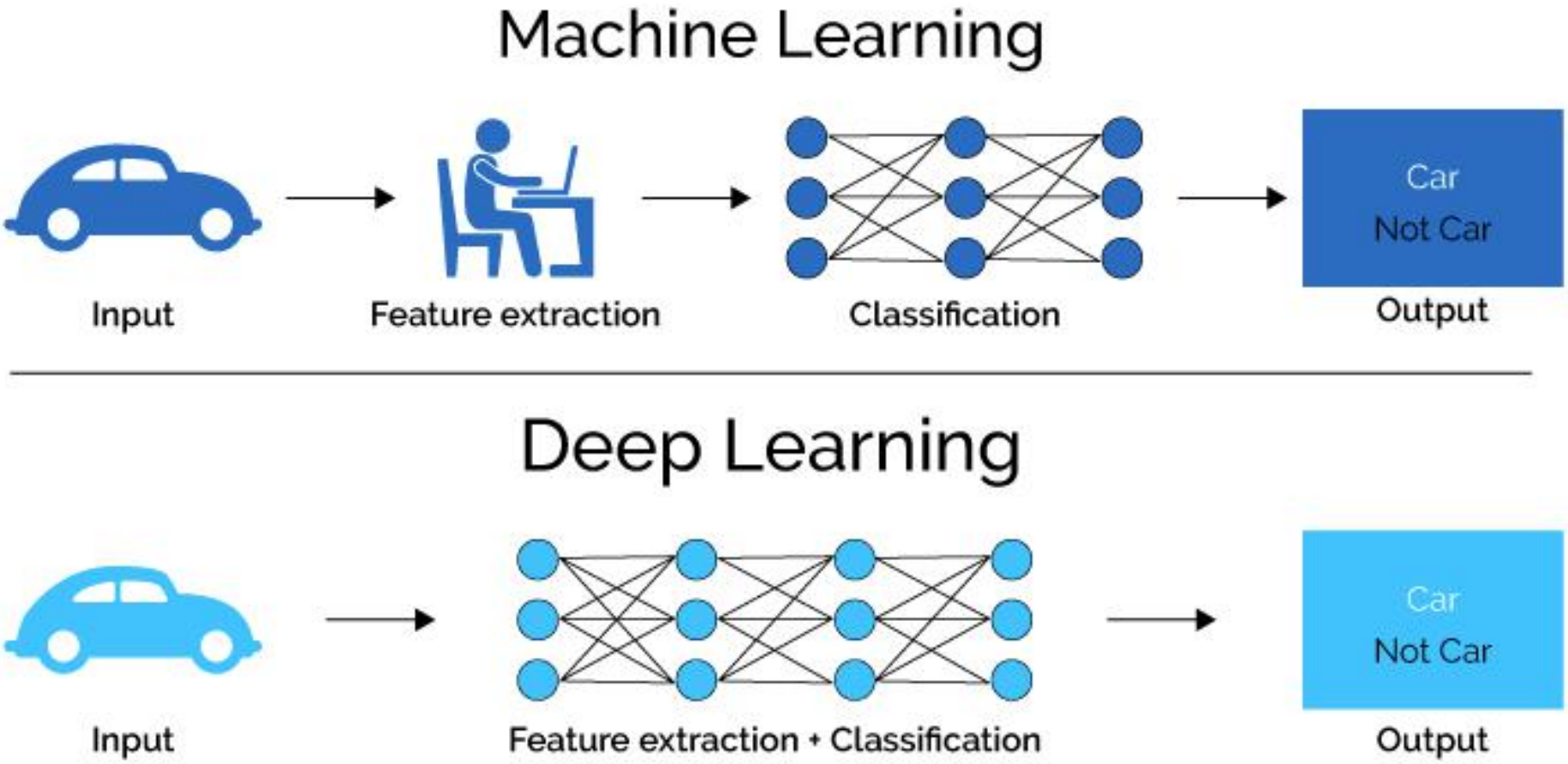
Digit Image as ANN Feature Set

Individual features need to be “extracted” from an image. An image is numbers.



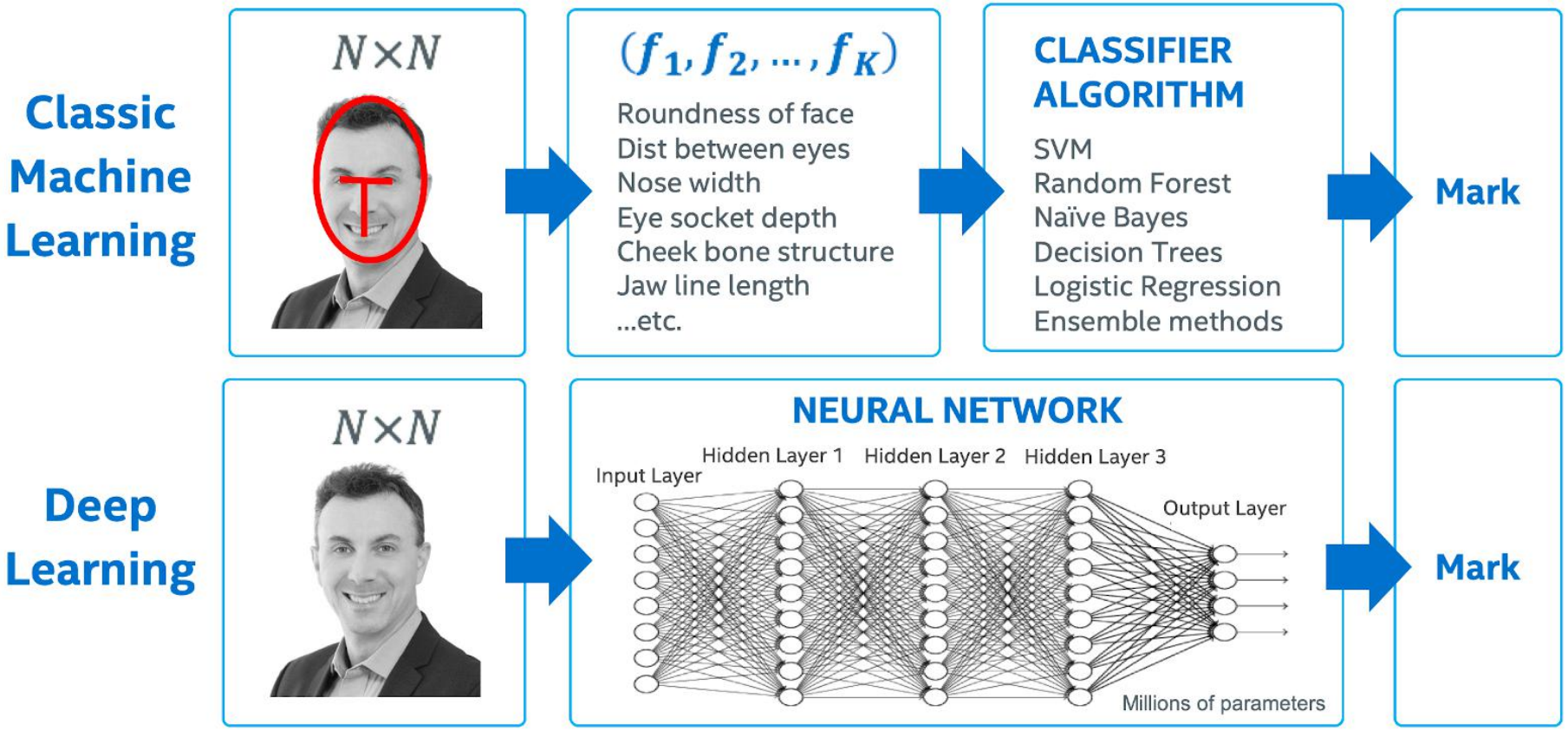
Source: https://nikolanews.com/not-just-introduction-to-convolutional-neural-networks-part-1/

Machine Learning vs. Deep Learning



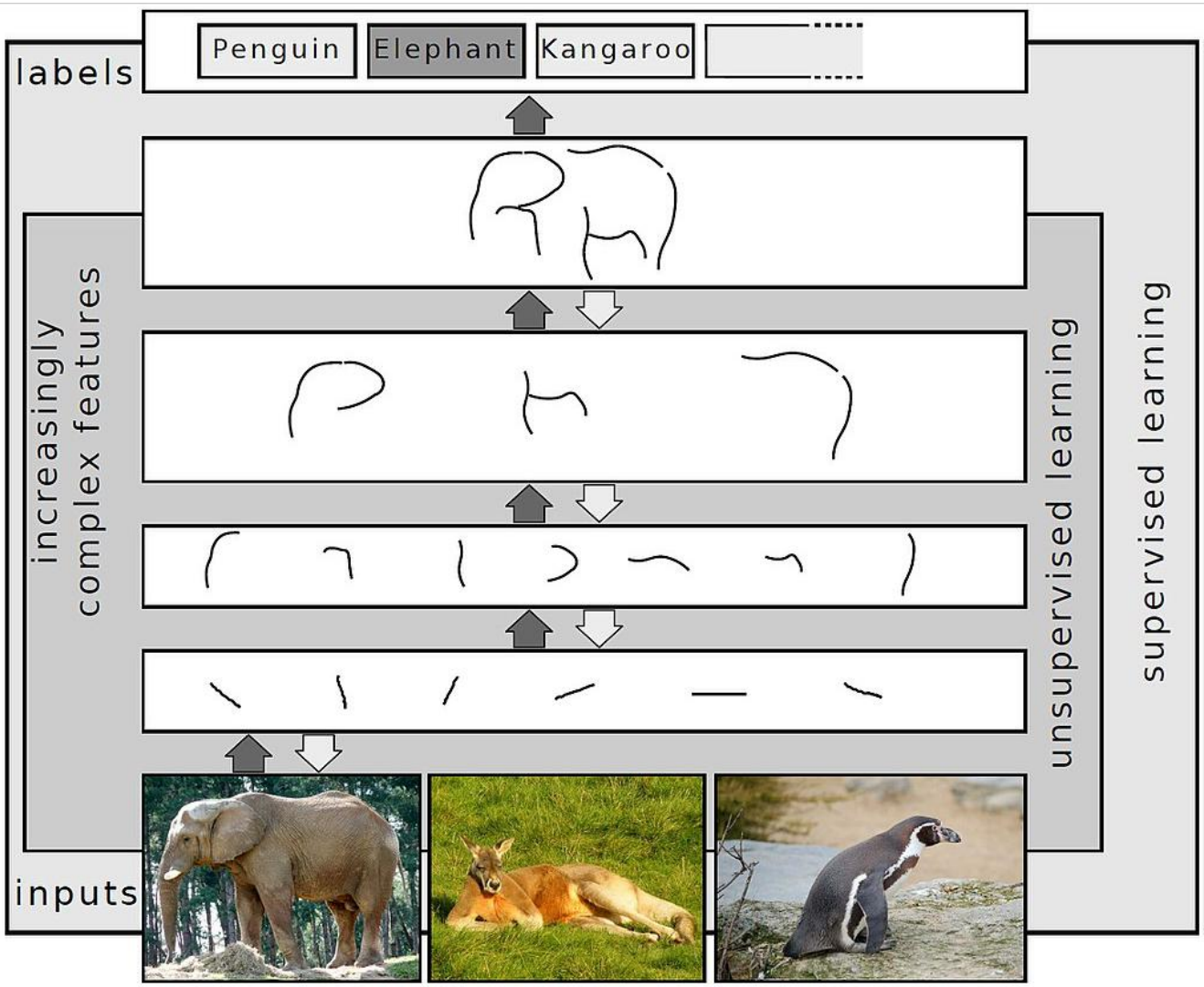
Source: https://www.quora.com/What-is-the-difference-between-deep-learning-and-usual-machine-learning

Machine Learning vs. Deep Learning



Source: https://www.intel.com/content/www/us/en/artificial-intelligence/posts/difference-between-ai-machine-learning-deep-learning.html

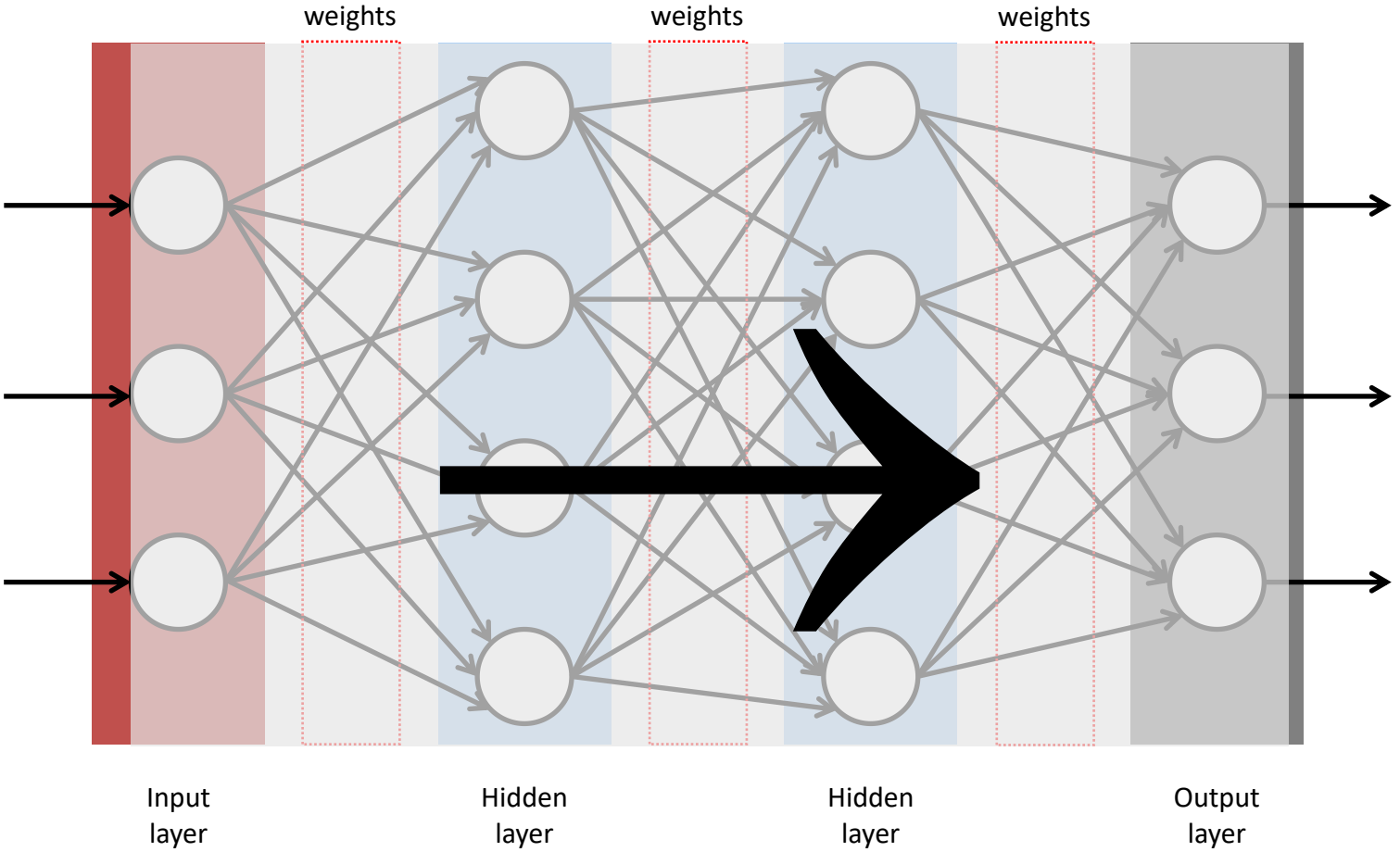
Deep Learning: Feature Extraction



Source: https://en.wikipedia.org/wiki/Deep_learning

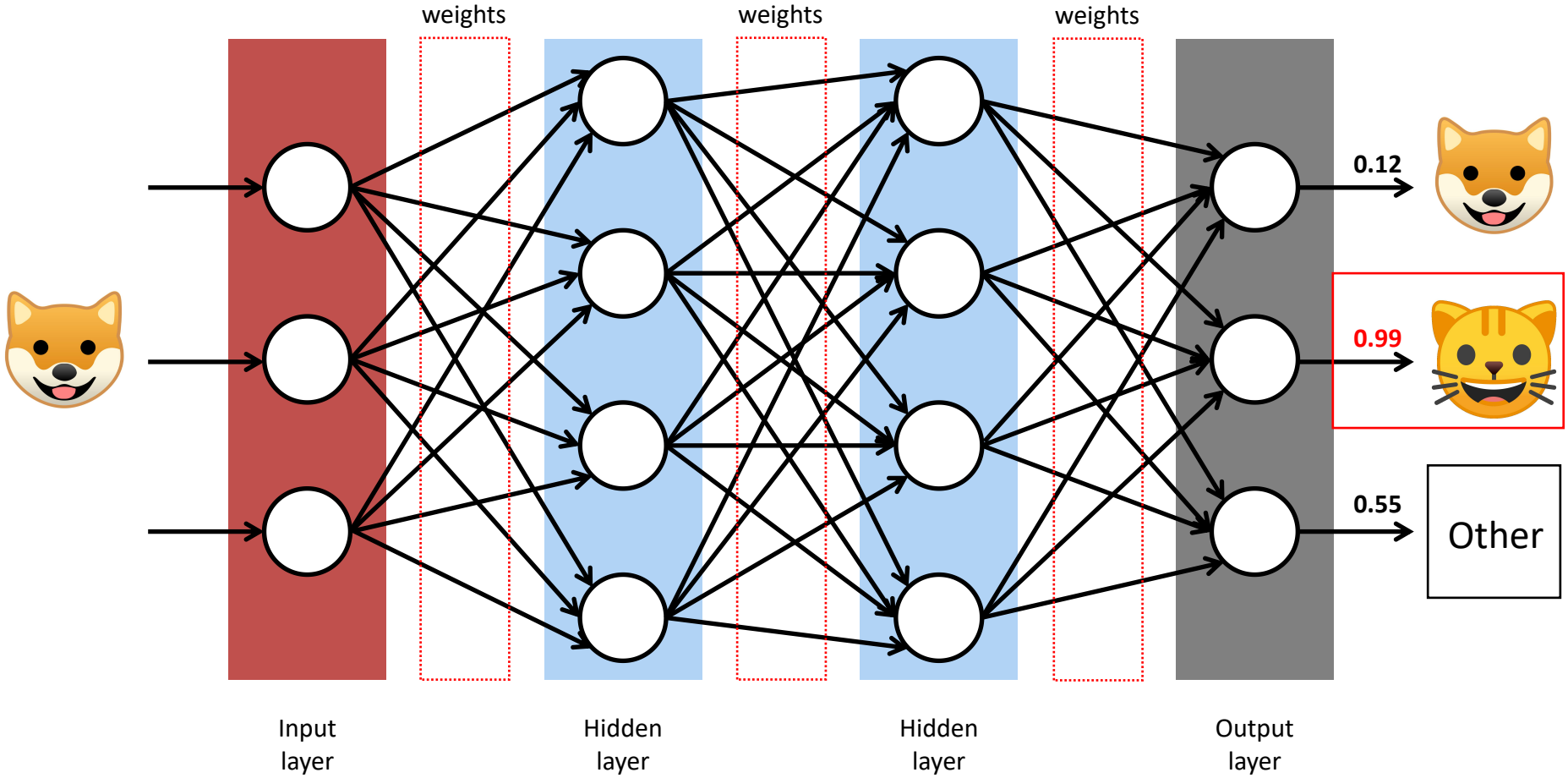
ANN: Feedforward Network

A **feedforward network** has **connections in one direction only**.



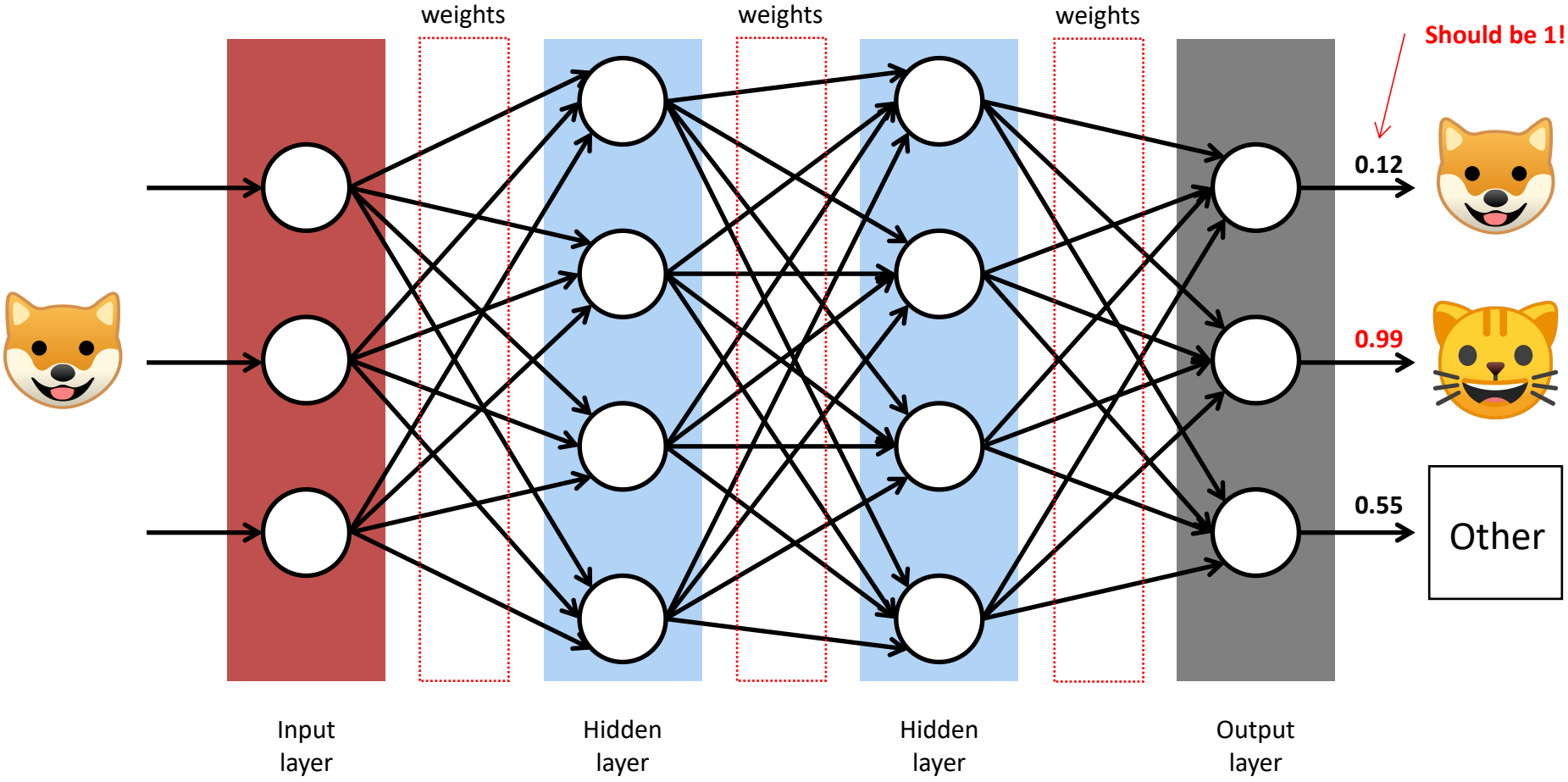
ANN: Supervised Learning

An **untrained classifier** will **NOT label input data correctly**.



ANN: Training

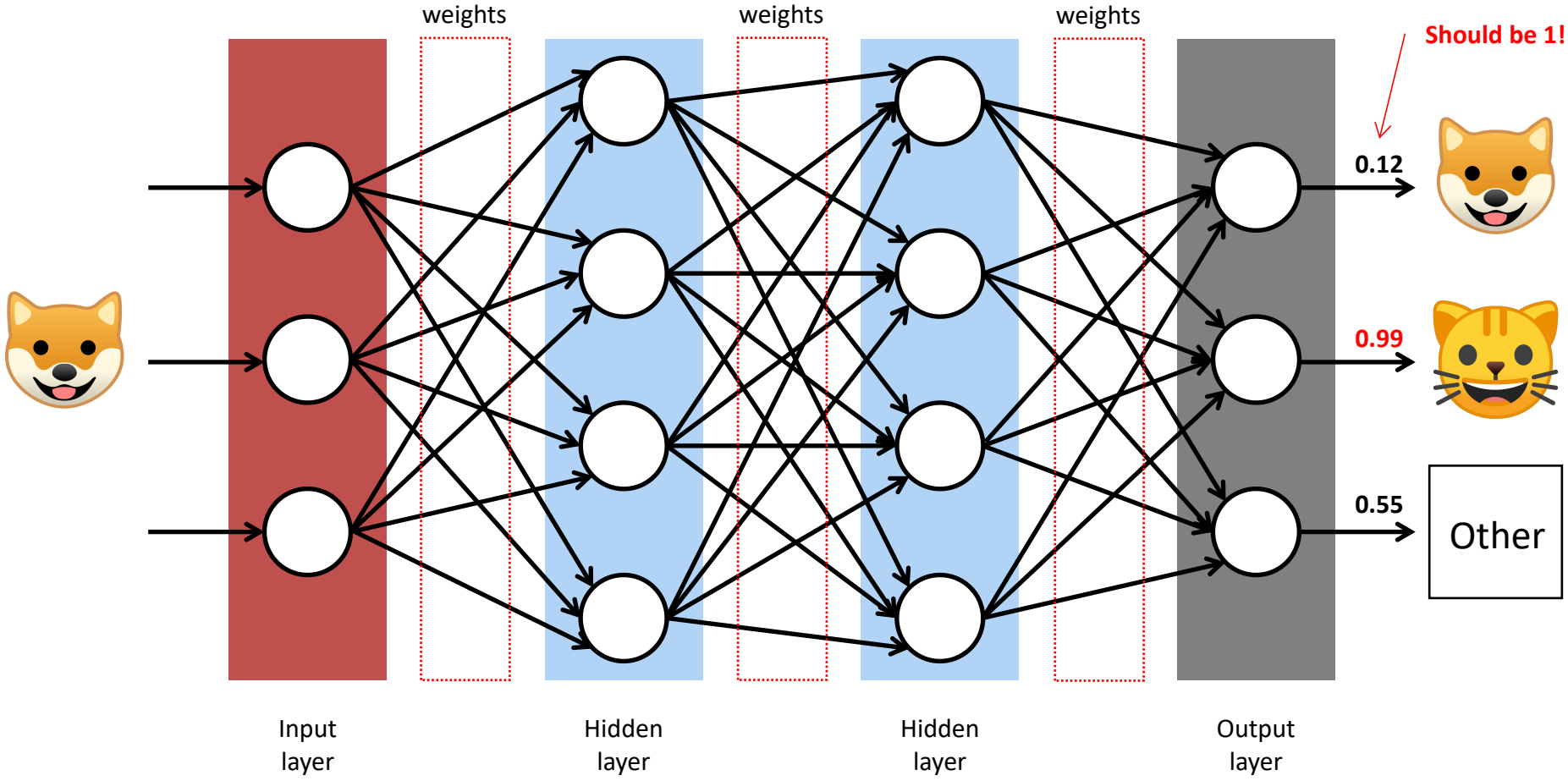
Given: input data  and it's corresponding **expected** label: DOG calculate "error".



"Error" = 0.88. Go back and **adjust all the weights** to ensure it is lower next time.

ANN: Training

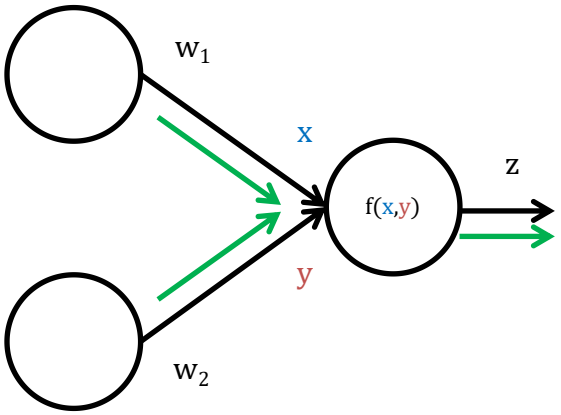
Show data / label pair:  / DOG.



Correct all the weights. Repeat many times. But how?

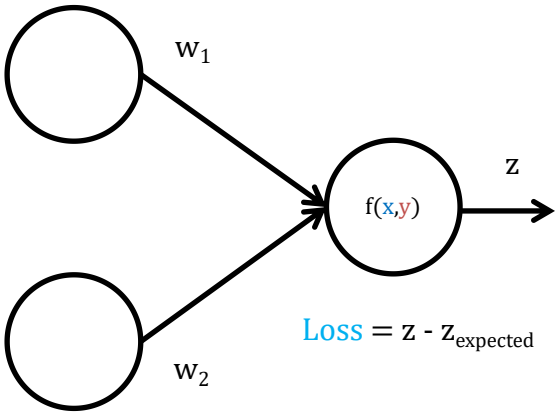
Back-propagation

Feed forward



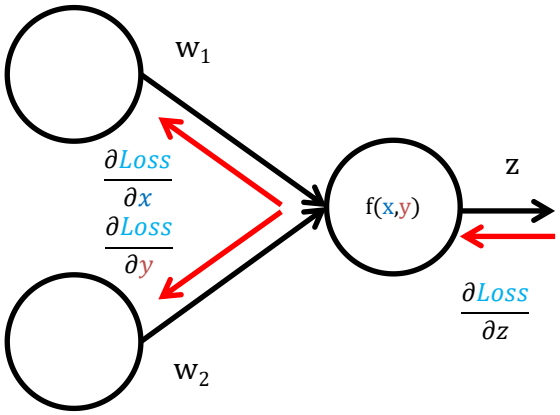
Feed a **labeled sample** through the network

Evaluate Loss



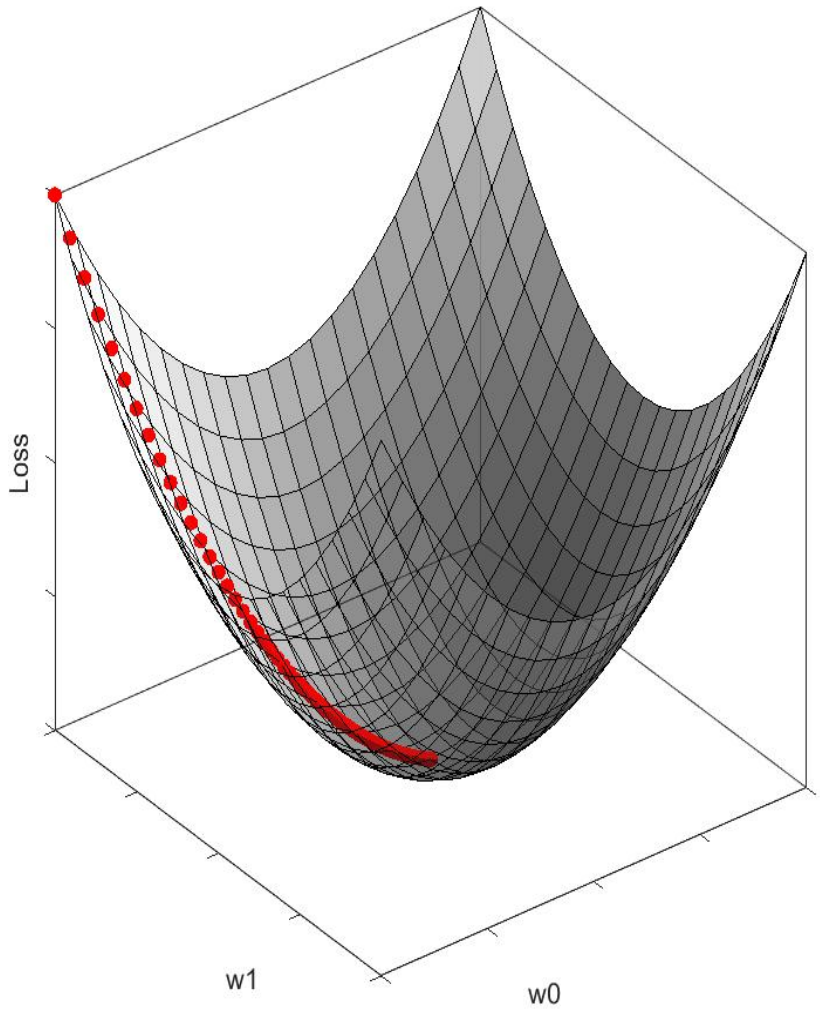
How "incorrect" is the result compare to the label?

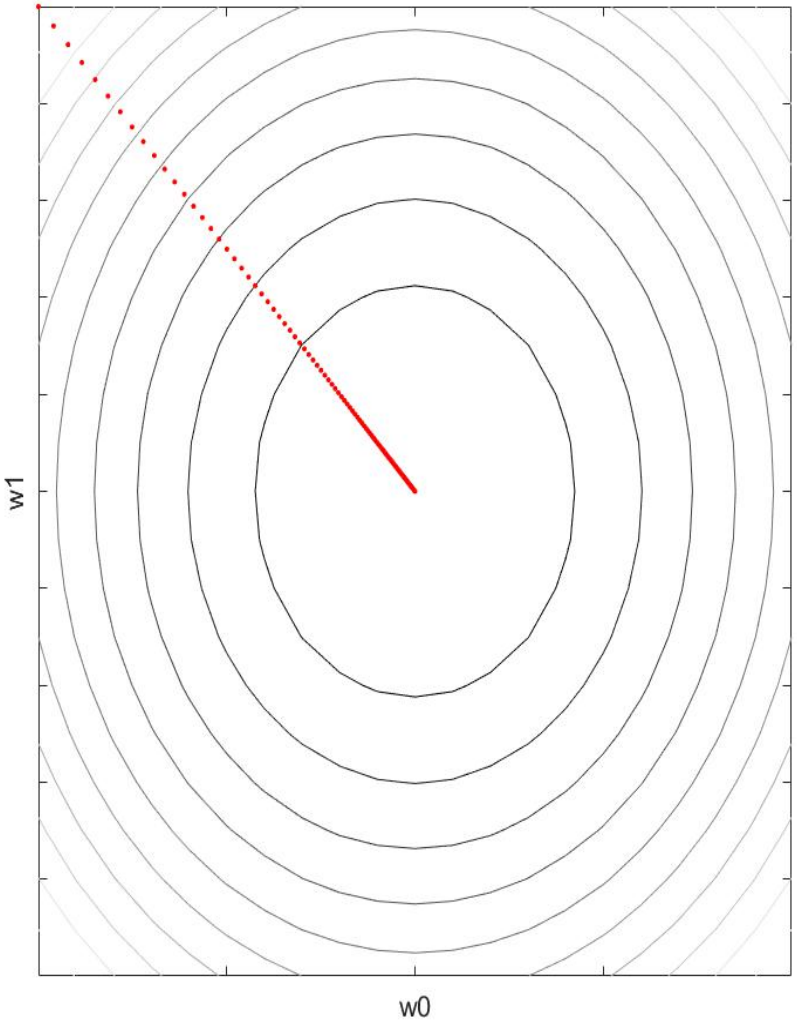
Back-propagation



Update weights (use **Gradient Descent**)

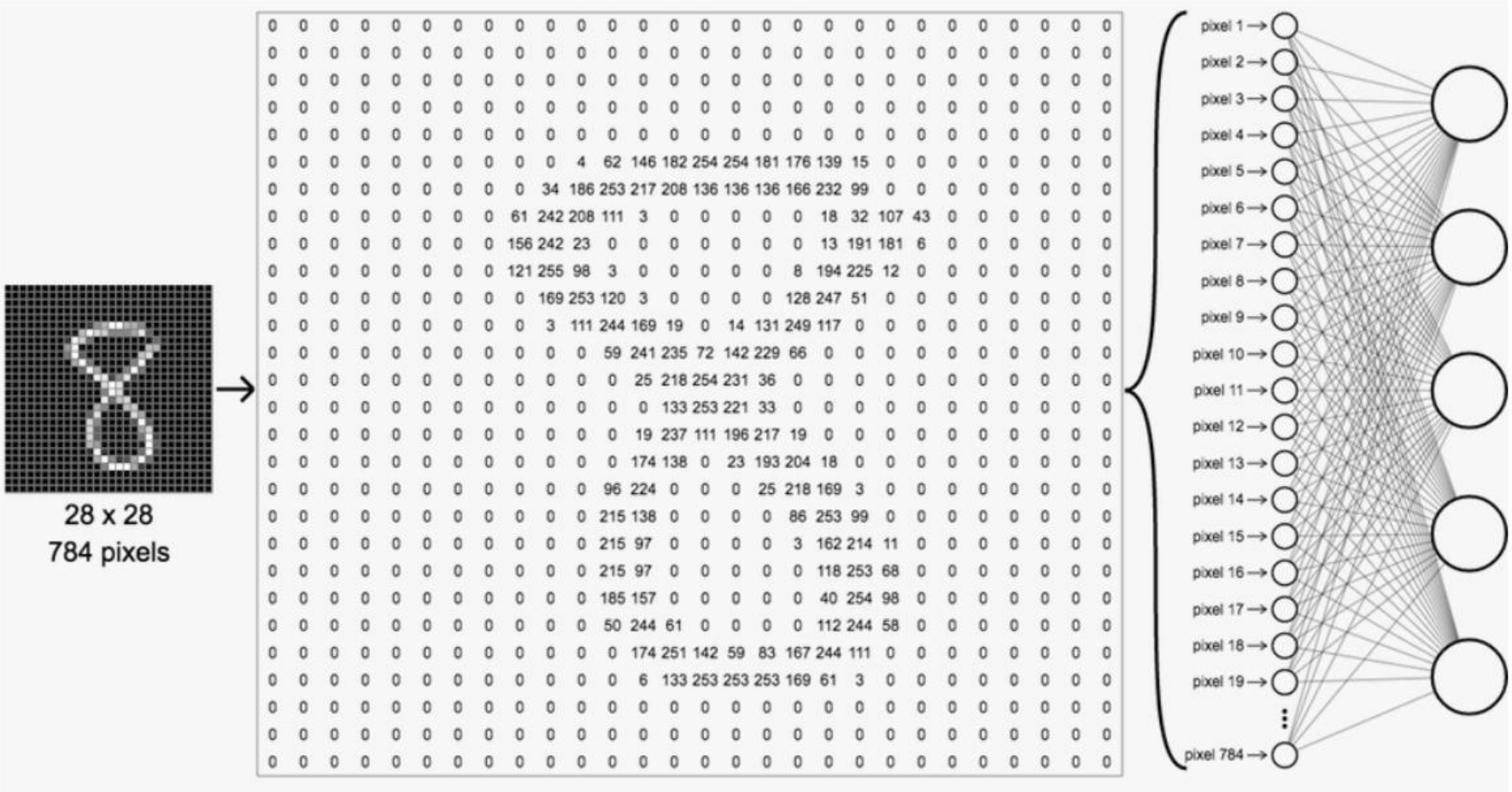
Gradient Descent





Images as ANN Feature Vectors

Problem: the larger the image, the larger the number of weights / parameters in ANN.



Source: https://nikolanews.com/not-just-introduction-to-convolutional-neural-networks-part-1/

Convolutional Neural Networks

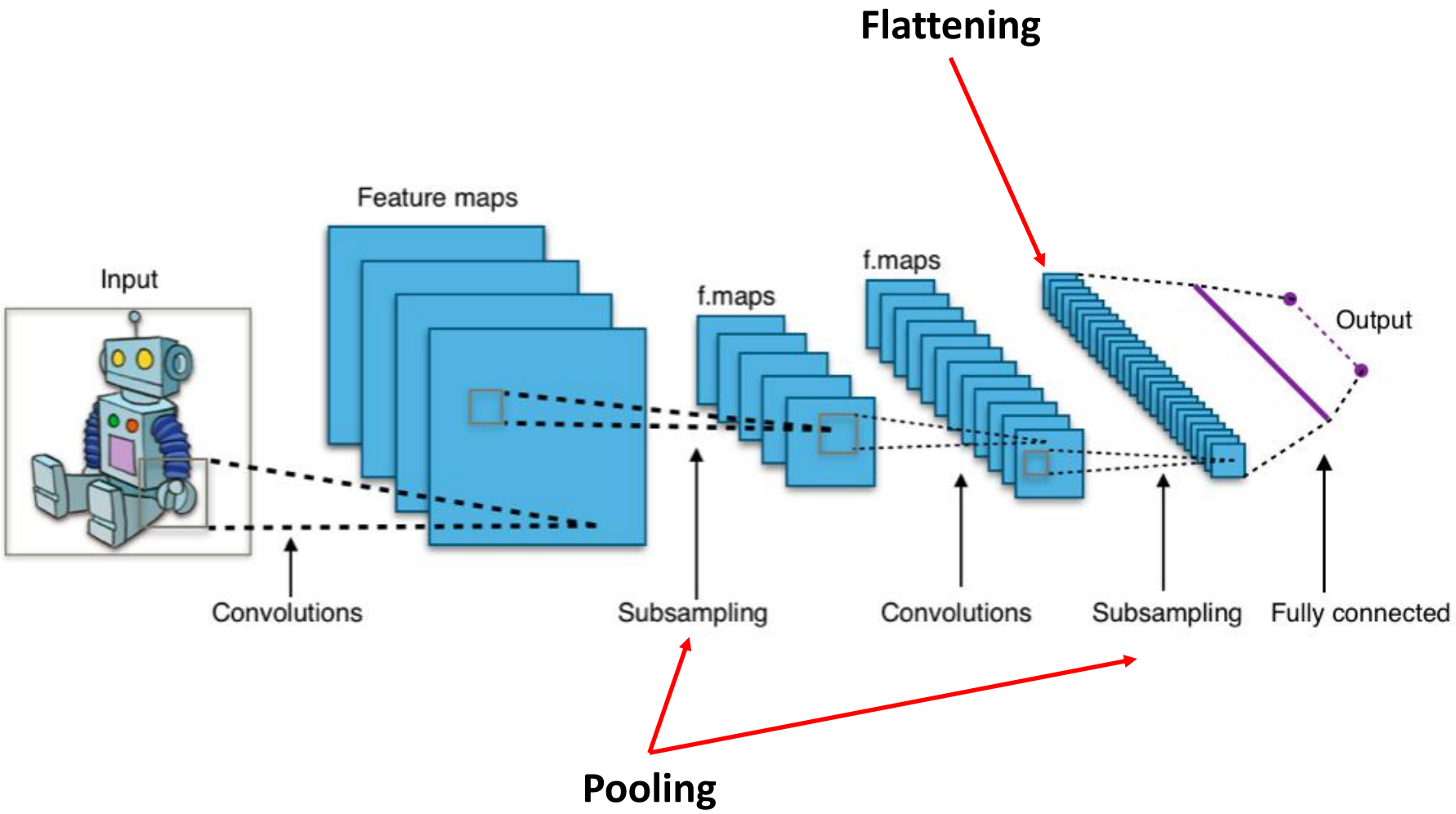
The name Convolutional Neural Network (CNN) indicates that the network employs a mathematical operation called convolution.

Convolutional networks are a specialized type of neural networks that use convolution in place of general matrix multiplication in at least one of their layers.

CNN is able to successfully capture the spatial dependencies in an image (data grid) through the application of relevant filters.

CNNs can reduce images (data grids) into a form which is easier to process without losing features that are critical for getting a good prediction.

Convolutional Neural Networks



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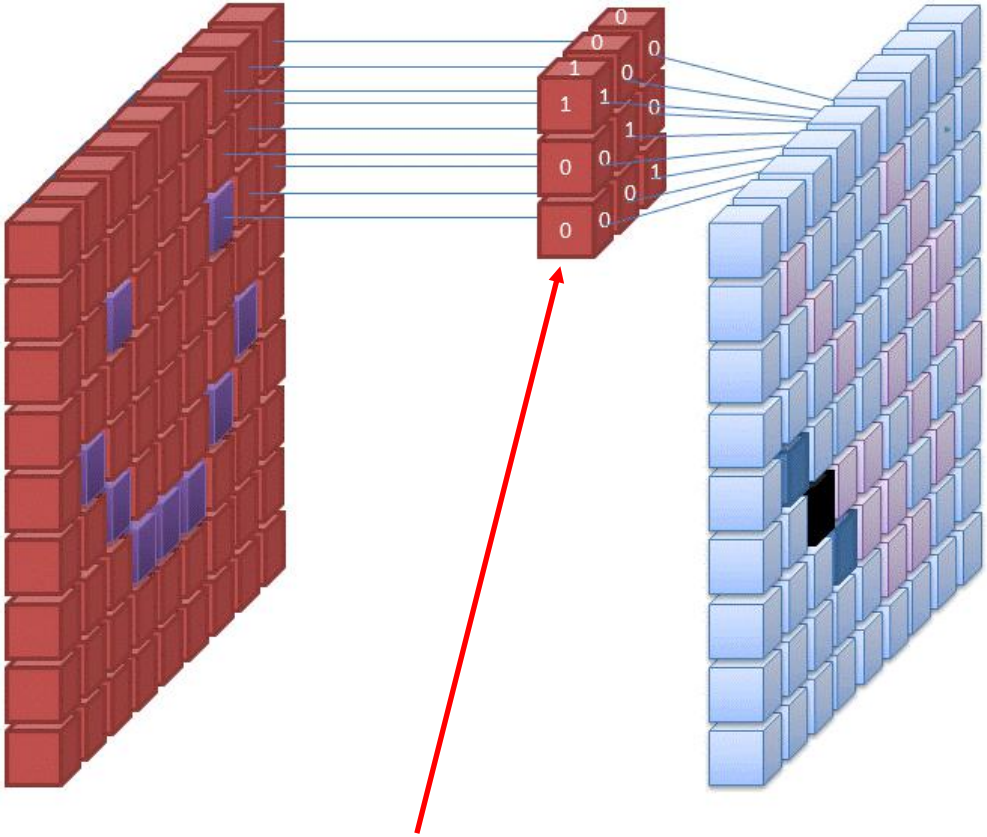
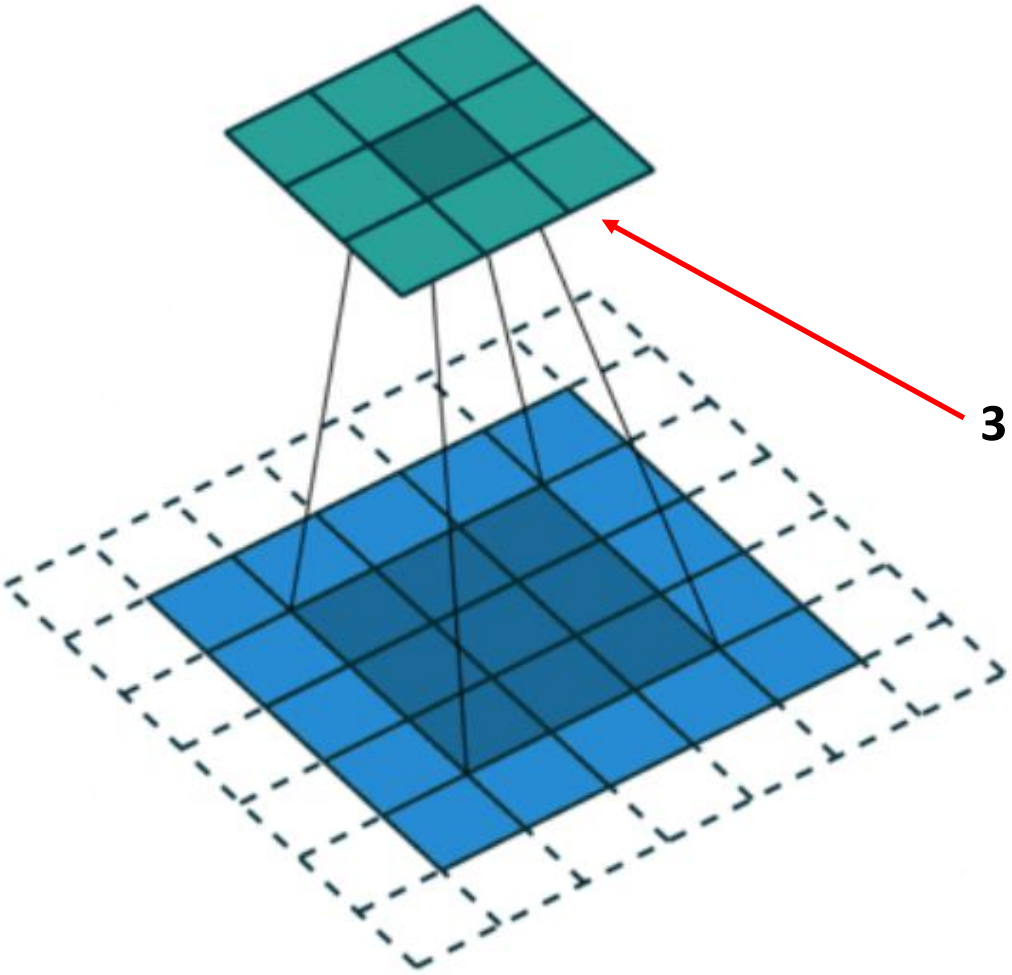
Convolution: The Idea



Source: https://commons.wikimedia.org/wiki/File:Convolutional_Neural_Network_NeuralNetworkFilter.gif

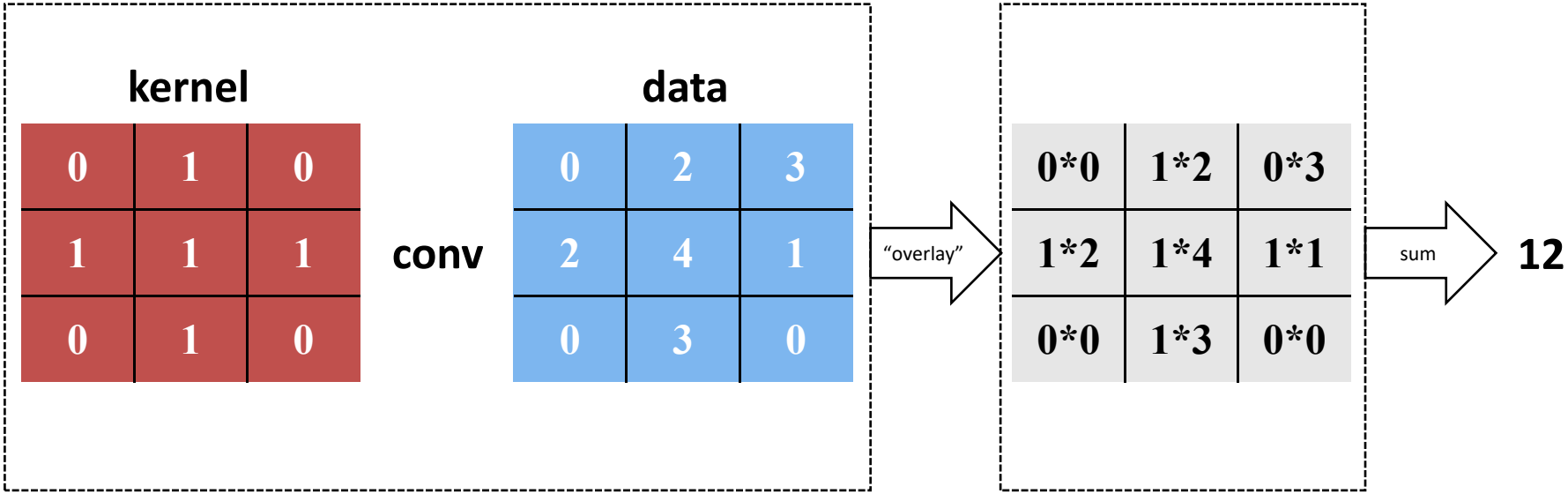
Kernel / Filter: The Idea



Source: https://commons.wikimedia.org/wiki/File:Convolution_arithmetic_-_Padding_strides.gif

Convoluting Matrices

Convolution (and Convolutional Neural Networks) can be applied to any grid-like data (tensors: matrices, vectors, etc.).



Selected Image Processing Kernels

Sharpen

$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

Mean Blur

$$\begin{bmatrix} 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \end{bmatrix}$$

Gaussian Blur

$$\begin{bmatrix} 1/16 & 2/16 & 1/16 \\ 1/16 & 4/16 & 2/16 \\ 1/16 & 2/16 & 1/16 \end{bmatrix}$$

Laplacian

$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

Prewitt (Edge)

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

Prewitt (Edge)

$$\begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

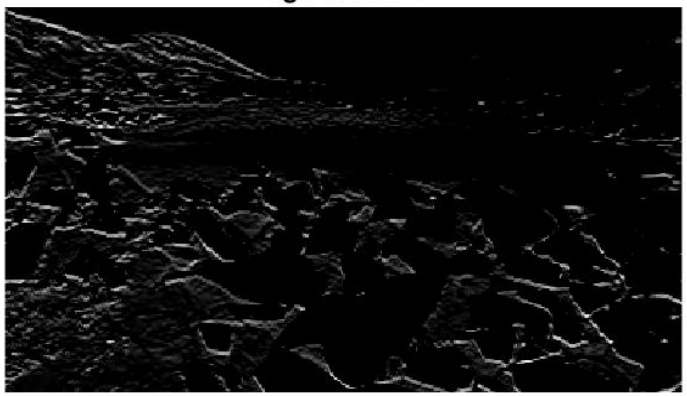
Image Processing: Kernels / Filters

Original

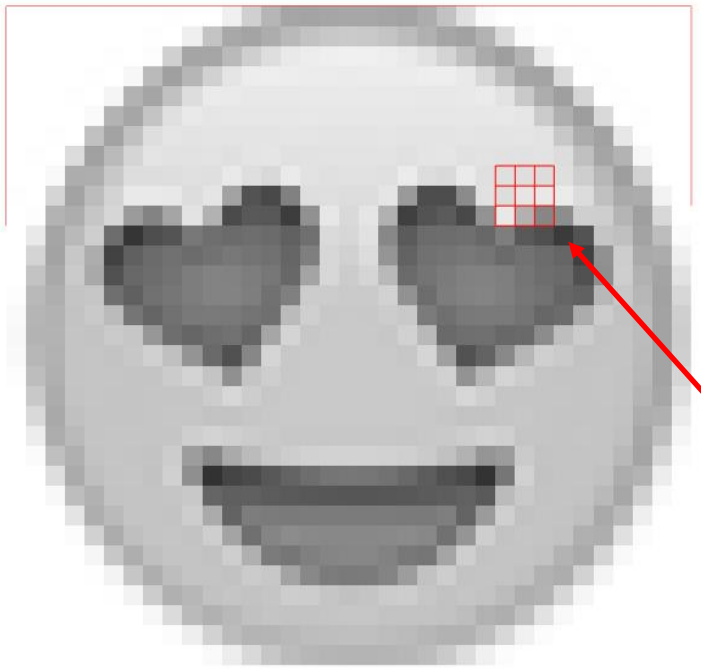
Sobel

Gaussian Blur

Edge detection



Applying Kernels / Filters

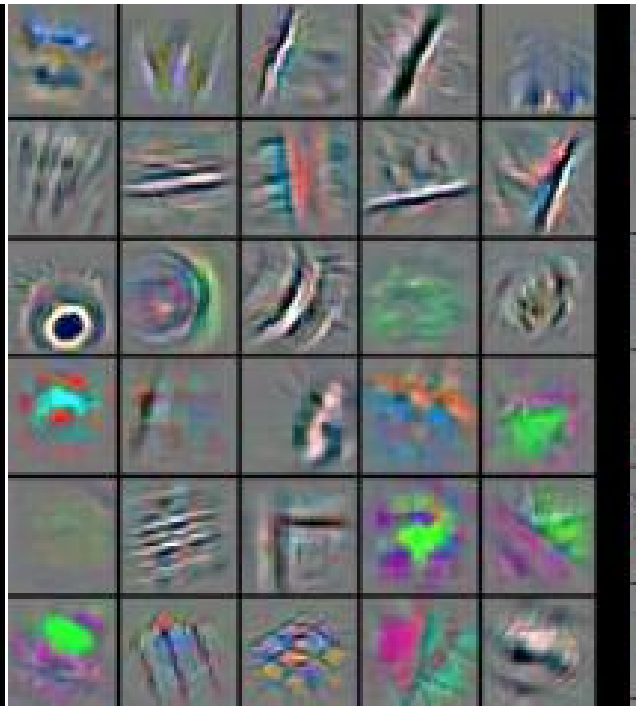


3 x 3 Kernel / Filter

Convolutional NN Kernels

In practice, Convolutional Neural Network kernels can be larger than 3x3 and are learned using back propagation.

Convolution Layer 1

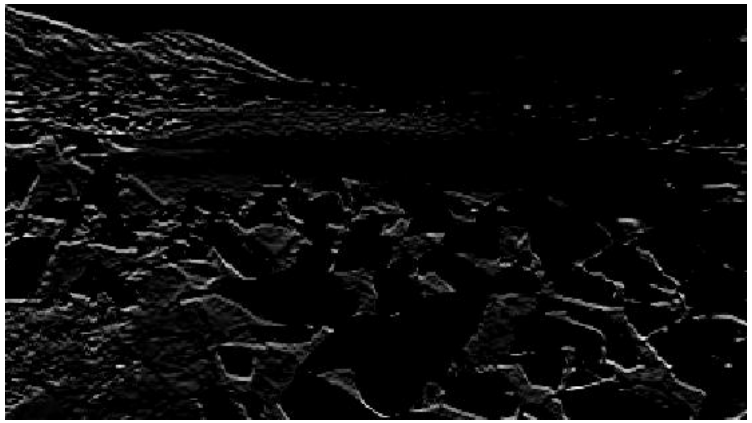


Convolution Layer 2

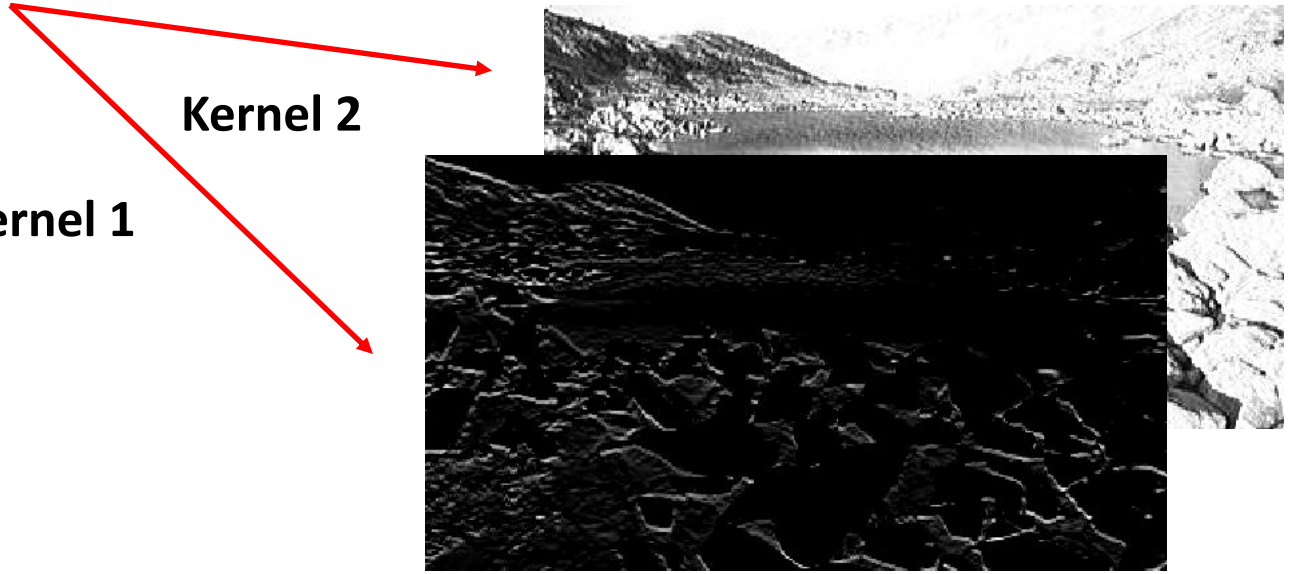
Convolution Layer 3

Convolution Layer 1

Kernel 1



Convolution Layer 1



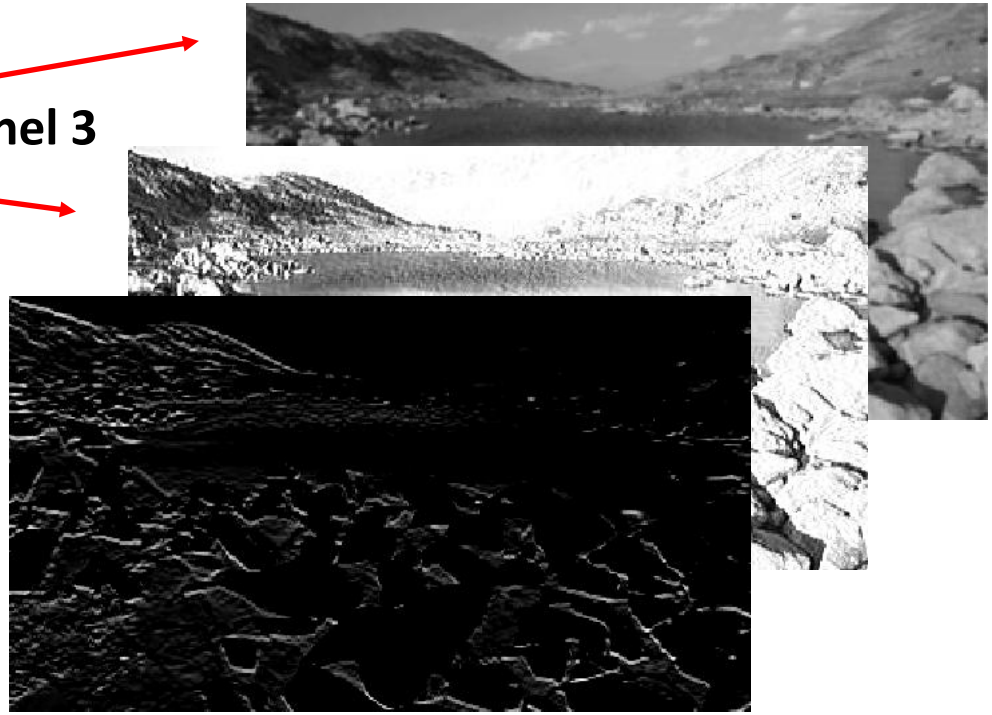
Convolution Layer 1

Original image

Kernel 3

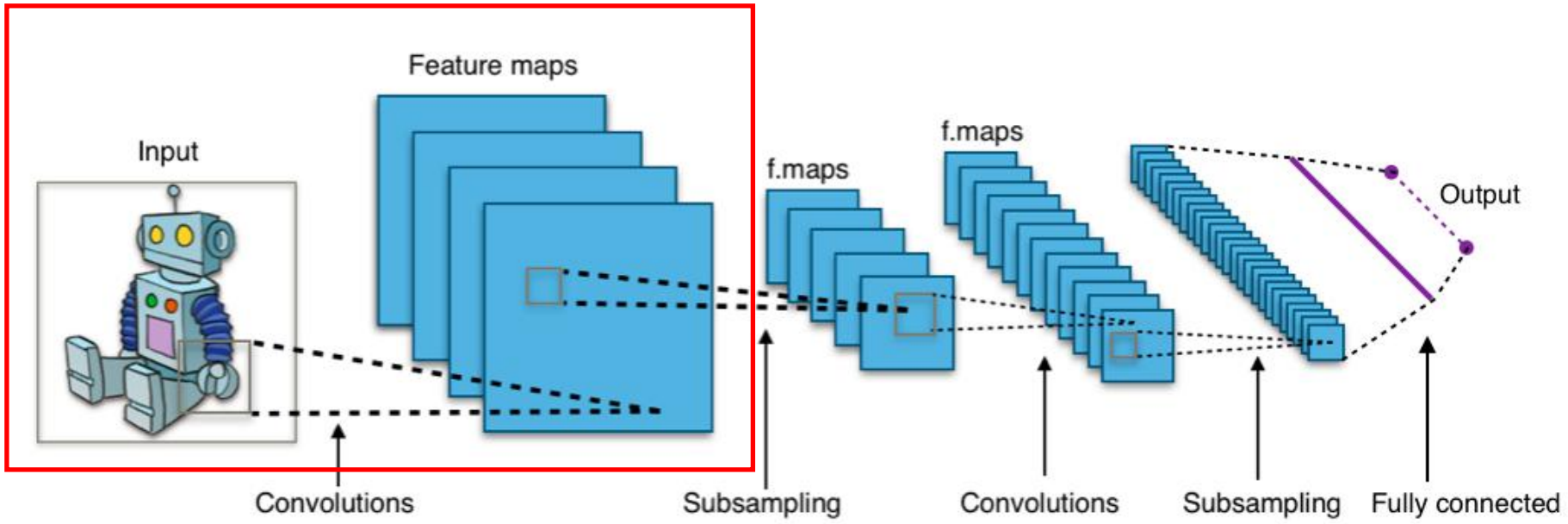
Kernel 2

Kernel 1



Convolution 1

Convolutional Neural Networks



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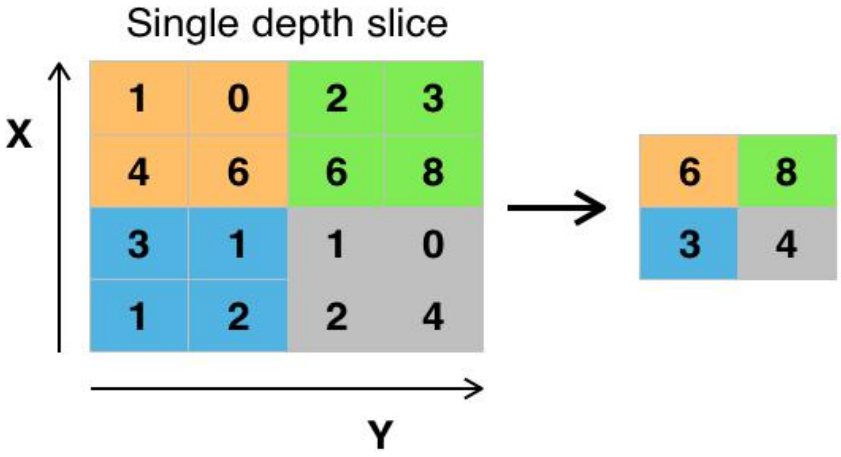
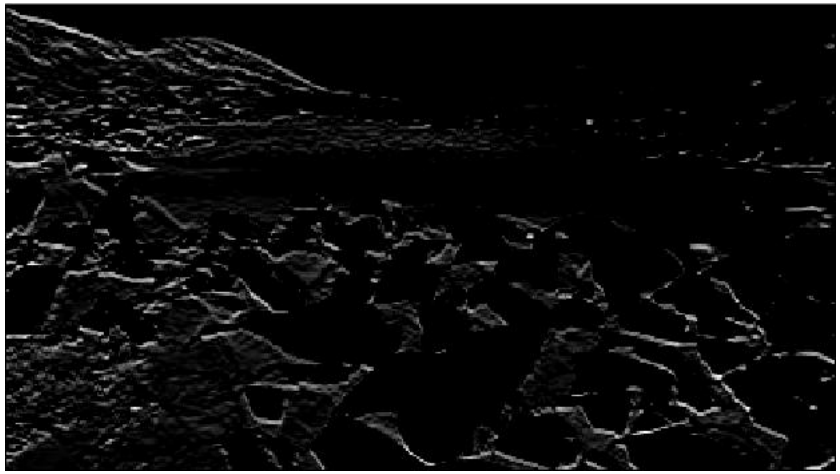
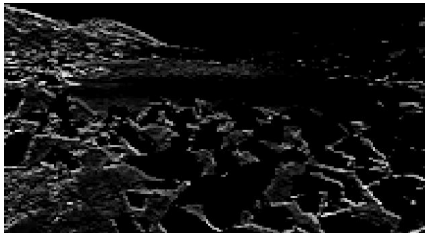
Max Pooling Layer



Convolution 1



Max Pooling



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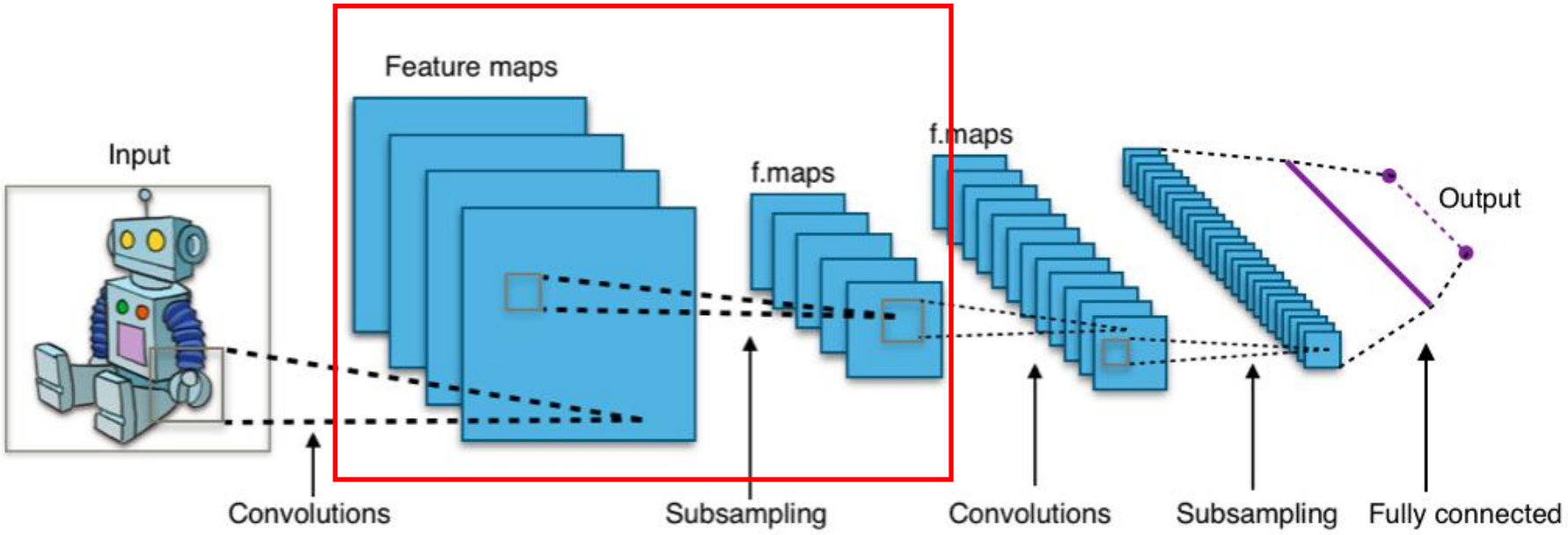
Convolutional Neural Networks



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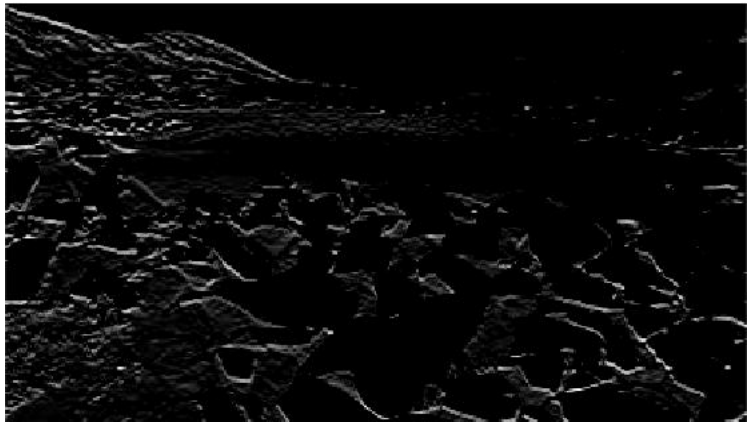
Convolution Layer 2

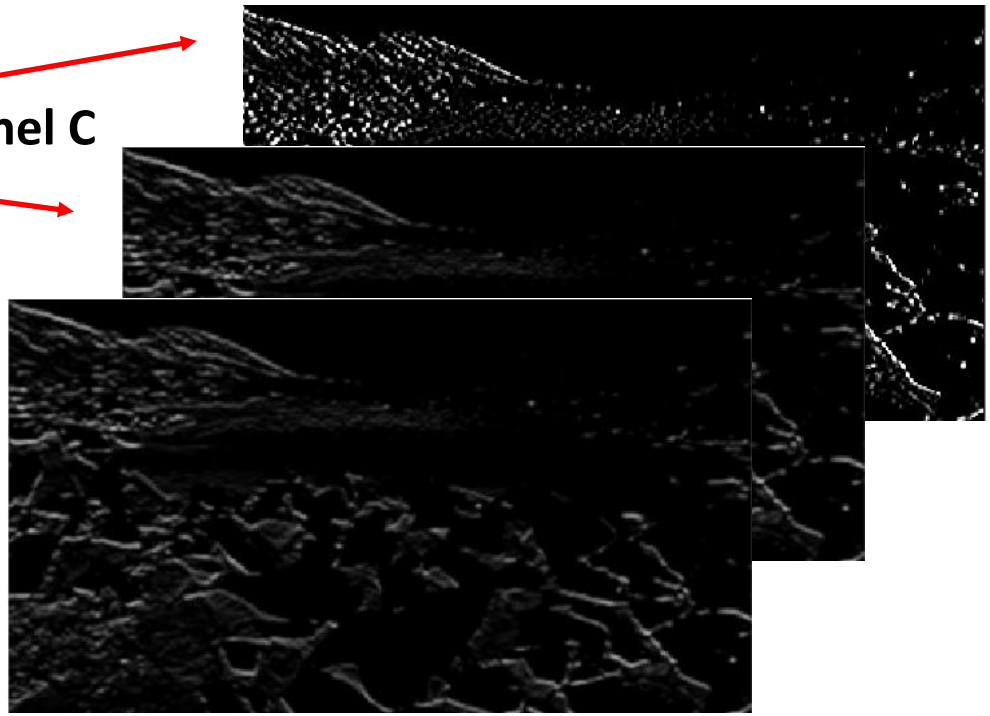


Original convolution after pooling

Kernel C

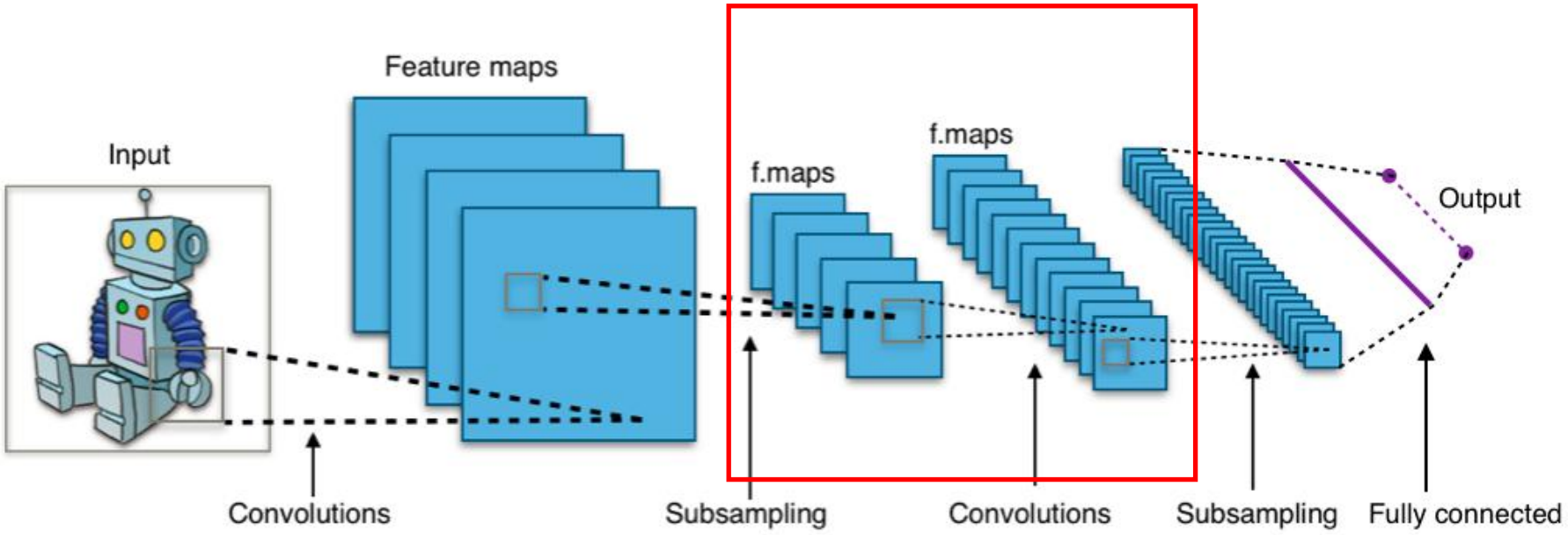
Kernel B

Kernel A



Convolution A

Convolutional Neural Networks



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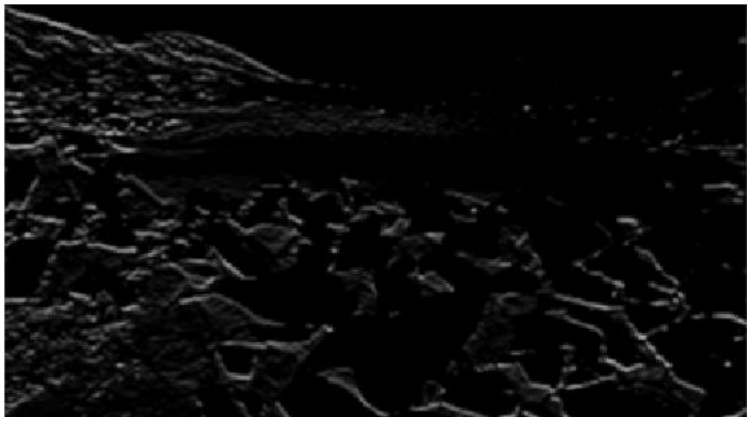
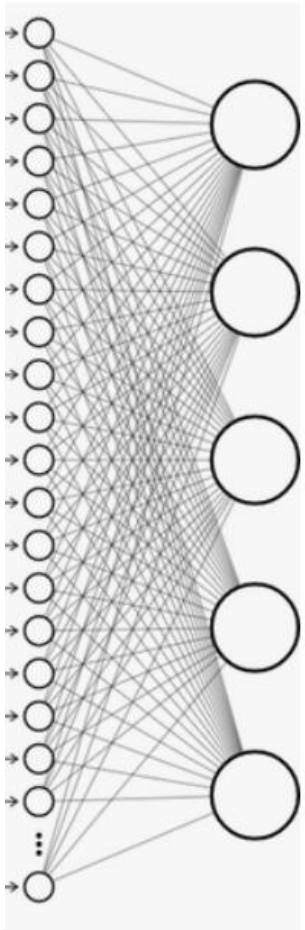
Flattening

Final output of convolution layers is "**flattened**" to become **a vector of features**.



Final convolution layer output

Convert to vector



Source: https://nikolanews.com/not-just-introduction-to-convolutional-neural-networks-part-1/

Recurrent Neural Networks

Recurrent Neural Networks (RNNs) allow cycles in the computational graph (network). A **network node (unit) can take its own output from an earlier step as input** (with delay introduced).

Enables **having internal state / memory** → inputs received earlier affect the RNN response to current input.

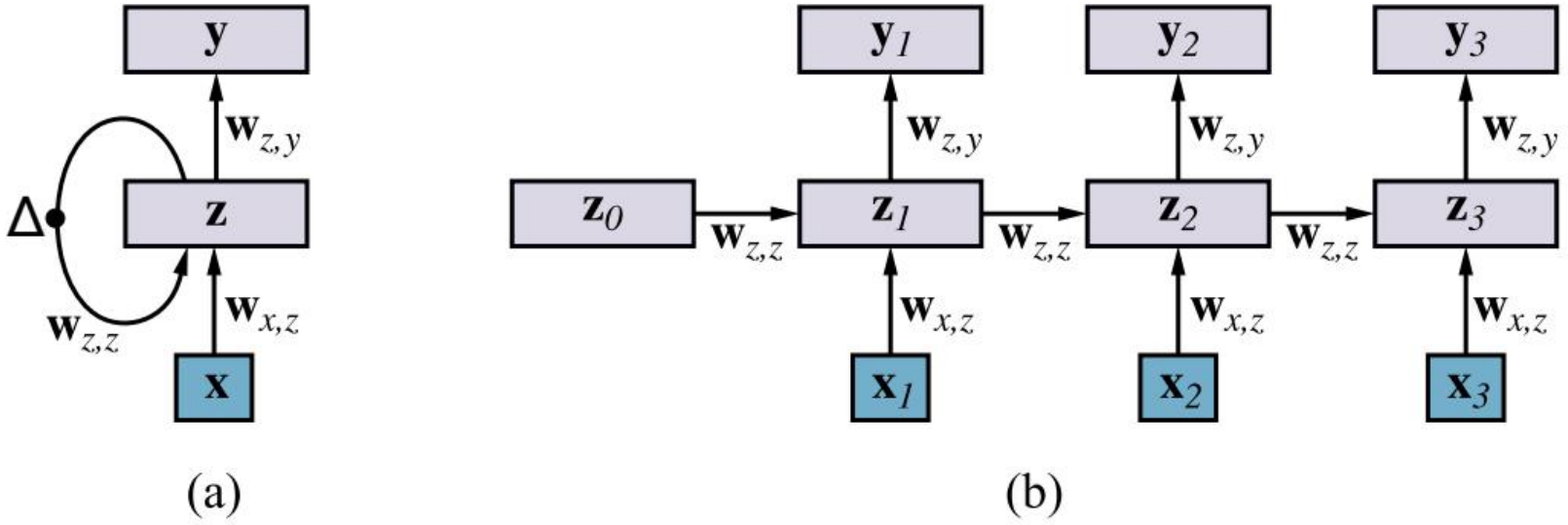


Figure (a) Schematic diagram of a basic RNN where the hidden layer **z** has recurrent connections; the Δ symbol indicates a delay. (b) The same network unrolled over three time steps to create a feedforward network. Note that the weights are shared across all time steps.

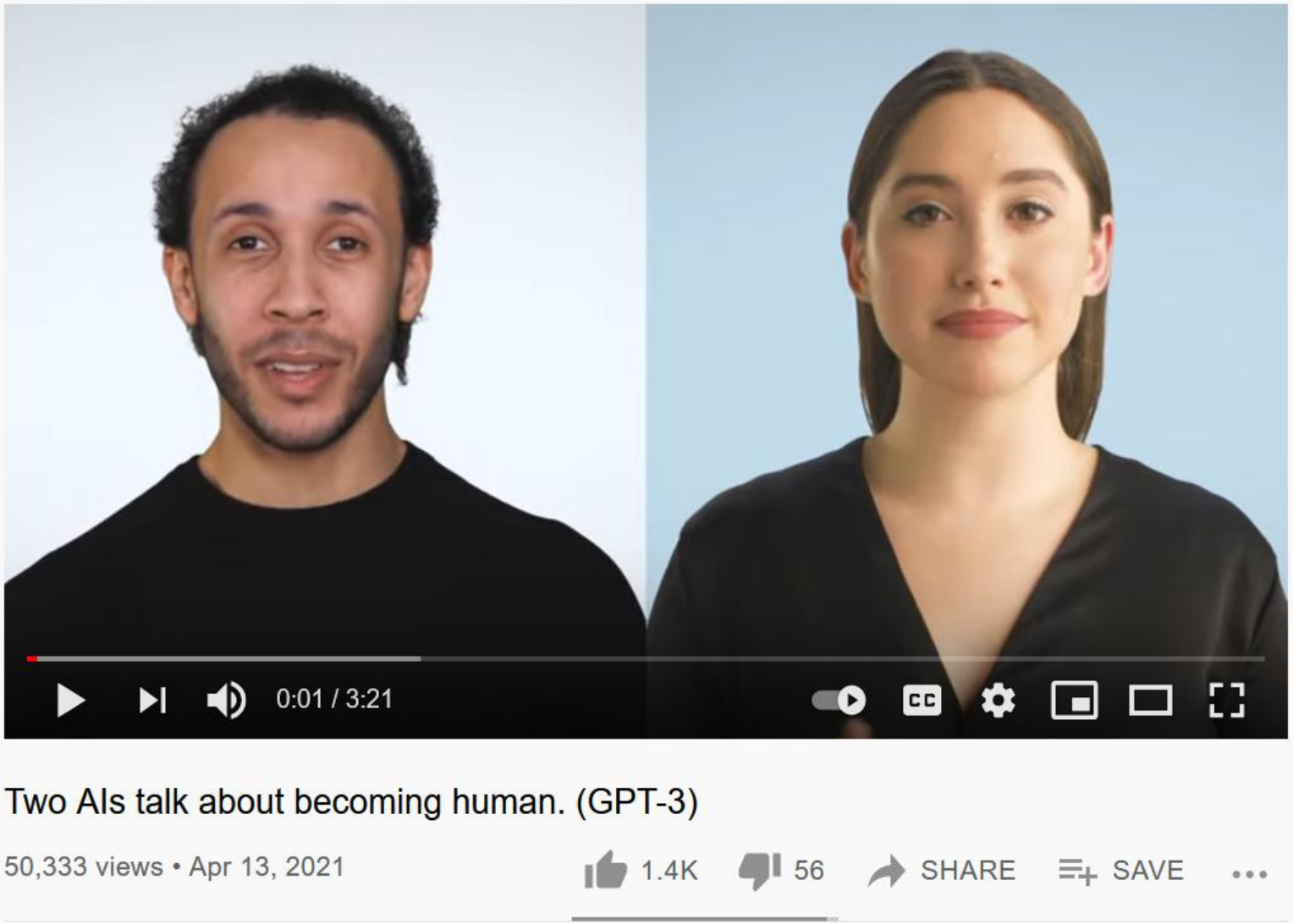
Transfer Learning

In transfer learning, experience with one learning task helps an agent learn better on another task.

Pre-trained models can be used as a starting point for developing new models.

Generative AI

GPT-3



Source: https://www.youtube.com/watch?v=jz78fSnBG0s

GPT-3 Scripted Movie

Solicitors | A.I. Written Short Film

36,582 views • Oct 13, 2020 668 27 SHARE SAVE ...

Source: https://www.youtube.com/watch?v=AmX3GDJ47wo

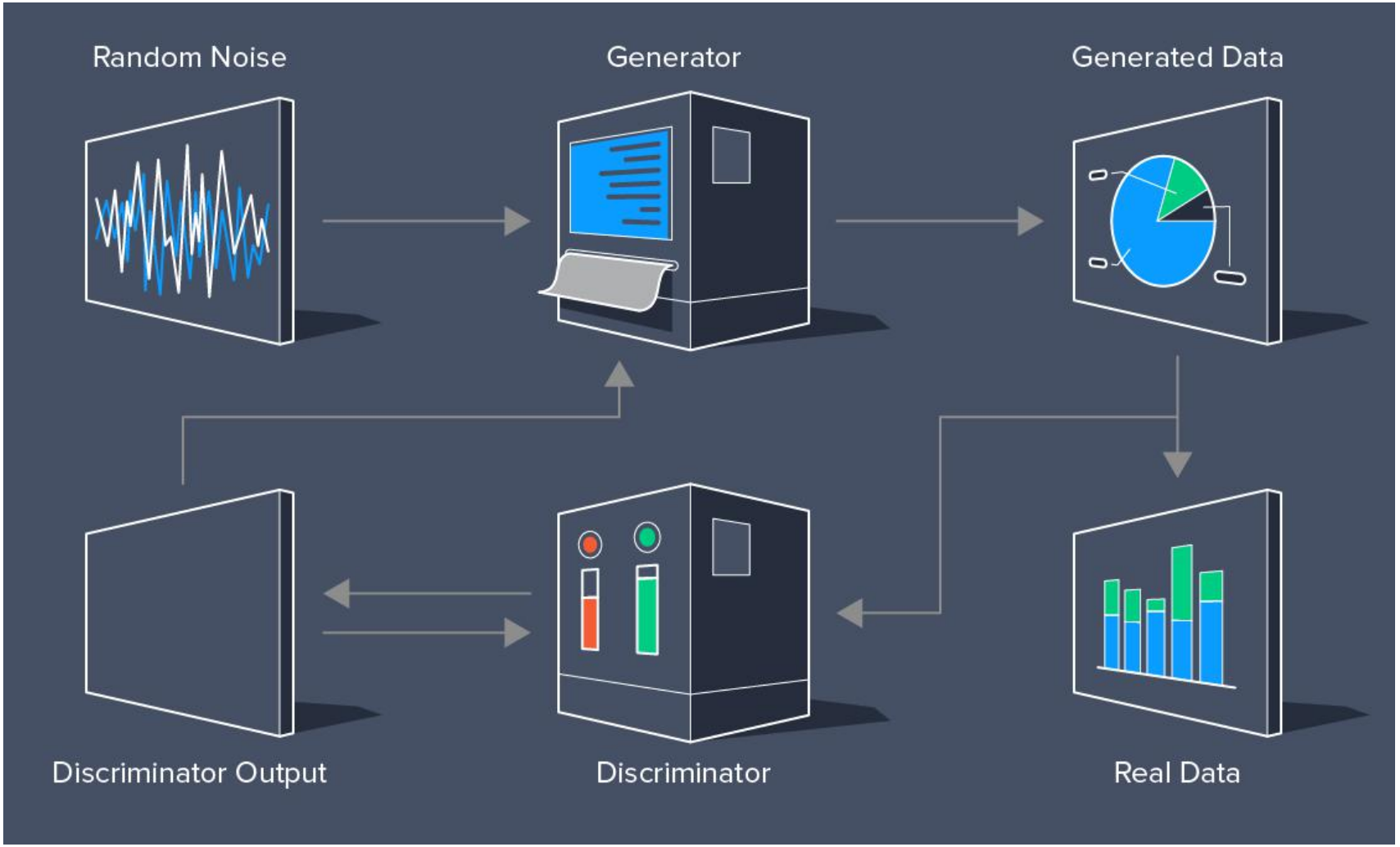
Lost Tapes of the 27 Club: AI Music

The album itself was created in collaboration with **AI generating new lyrics and musical compositions with the input data of the hooks, rhythms, melodies, and lyrics of artists from the 27 club**.

From there, **a team of audio engineers and technicians worked to parse out the signal from the noise** to create cohesive tracks. They then **reached out to talented singers from tribute bands to fill in the vocal parts with lyrics prewritten by the AI**.

- Nirvana-Drowned in the Sun: https://www.youtube.com/watch?v=muT6x7VXx5I
- Amy Winehouse-Man I Know: https://www.youtube.com/watch?v=QM6LbbcCghc
- Jimi Hendrix-You're Going To Kill Me: https://www.youtube.com/watch?v=6Ohf97p7u1w
- The Doors-The Roads Are Alive: https://www.youtube.com/watch?v=z5jW4RmxhIY

Generative Deep Learning



Source: https://www.toptal.com/machine-learning/generative-adversarial-networks

Exercise: Generative AI

https://ai-art.tokyo/en/#/

Deep Fakes

Source: https://www.youtube.com/watch?v=bPhUhypV27w

Deep Fakes

Mike Tyson and Snoop Dogg as Oprah and Gayle [Deepfake

109,077 views • Aug 11, 2019 1.4K 24 SHARE SAVE

Source: https://www.youtube.com/watch?v=LRMnNpVjH6g