CS 480

Introduction to Artificial Intelligence

April 11, 2024

Announcements / Reminders

- Please follow the Week 13 To Do List instructions (if you haven't already)
- Work on your last Written Assignment

Plan for Today

- **A Casual Introduction to Machine Learning**

Unsupervised Learning

What is Unsupervised Learning?

Idea:

Unsupervised learning involves finding underlying patterns within data. Typically used in **clustering** data points (similar customers, etc.).

In other words:

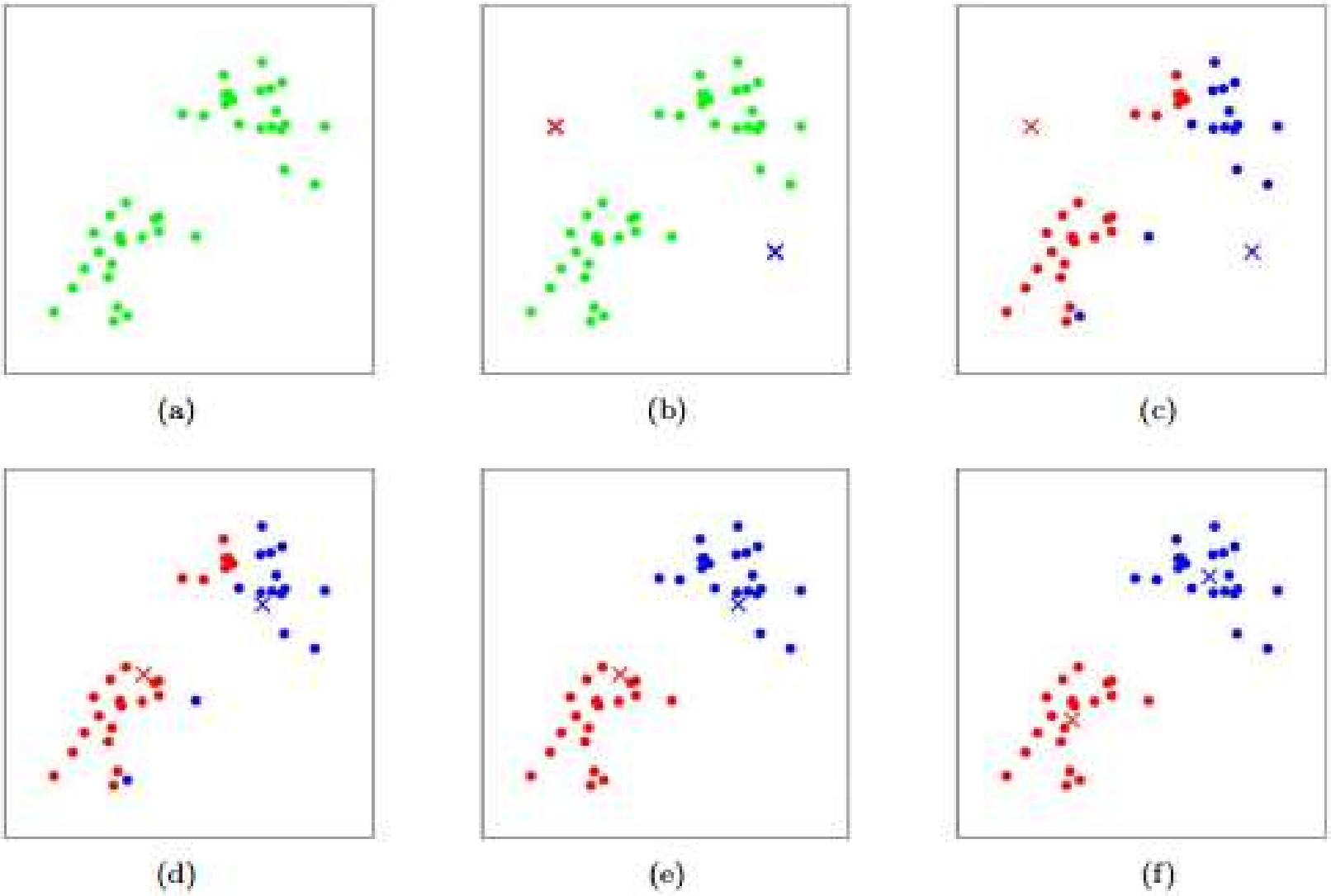
- there is some structure (groups / clusters) in data (for example: customer information)
- we don't know what it is (**= no labels!**)
- unsupervised learning tries to discover it

Main Machine Learning Categories

Supervised learning	Unsupervised learning	Reinforcement learning
Supervised learning is one of the most common techniques in machine learning. It is based on **known relationship(s) and patterns within data** (for example: relationship between inputs and outputs). Frequently used types: **regression**, and **classification**.	**Unsupervised learning** involves finding underlying patterns within data. Typically used in **clustering** data points (similar customers, etc.)	Reinforcement learning is inspired by behavioral psychology. It is **based on a rewarding / punishing an algorithm**. Rewards and punishments are based on algorithm's action within its environment.

Unsupervised Learning: K-Means Clustering

K-Means Clustering: The Idea

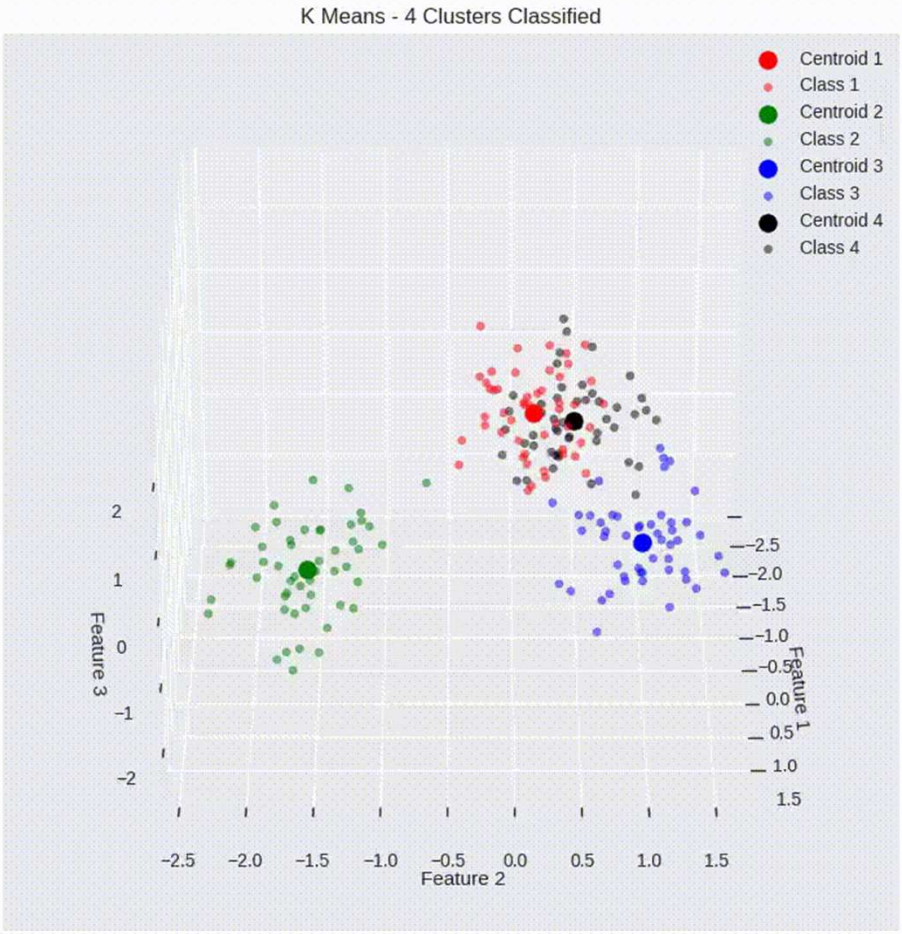


Source: https://stanford.edu/~cpiech/cs221/handouts/kmeans.html

Exercise: K-Means Clustering

https://lalejini.com/my_empirical_examples/KMeansClusteringExample/web/kmeans_clustering.html

3D K-Means Clustering Visualized



Source: https://github.com/Gautam-J/Machine-Learning

Where Would You Use Clustering?

Reinforcement Learning (RL)

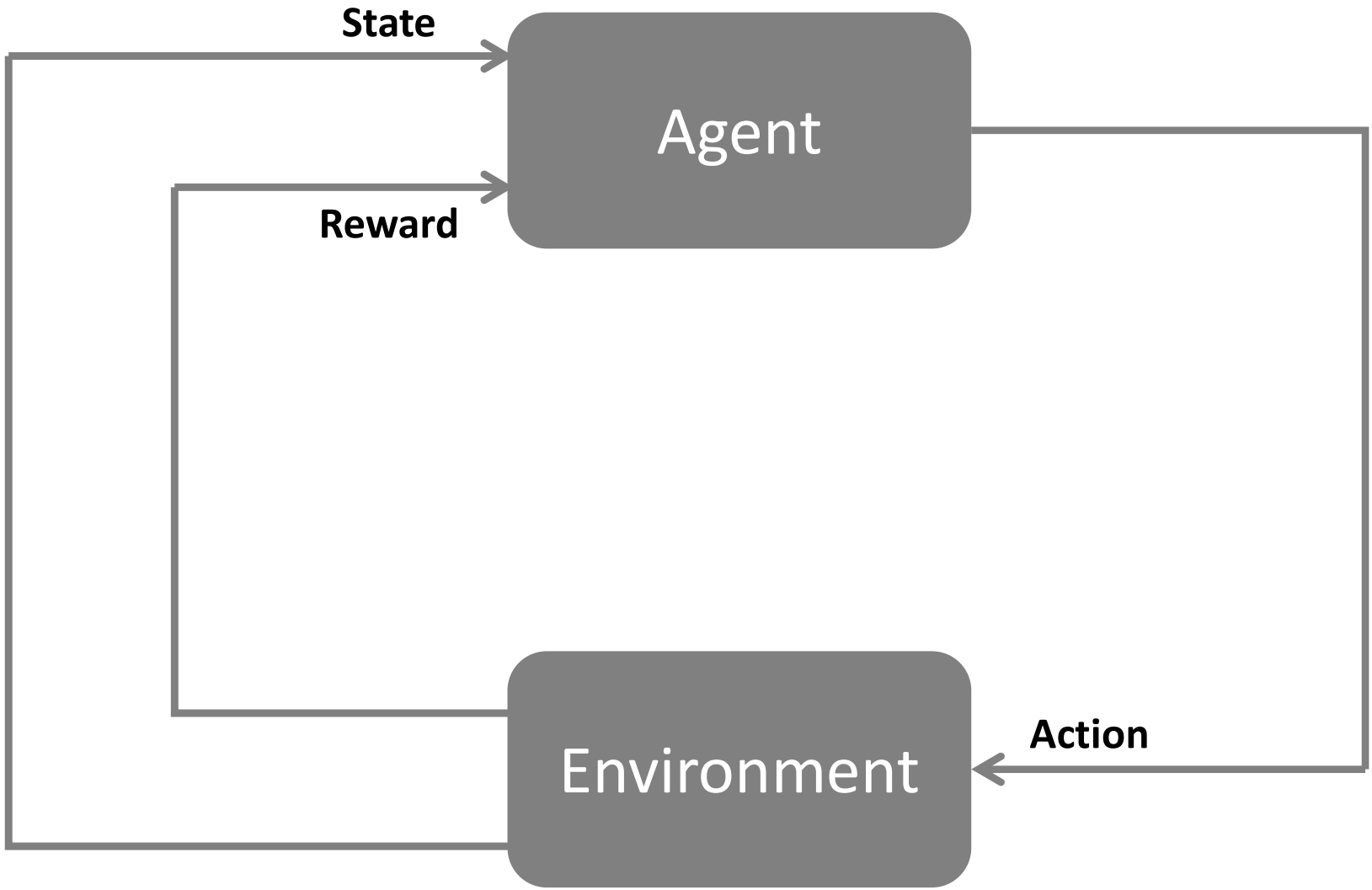
What is Reinforcement Learning?

Idea:

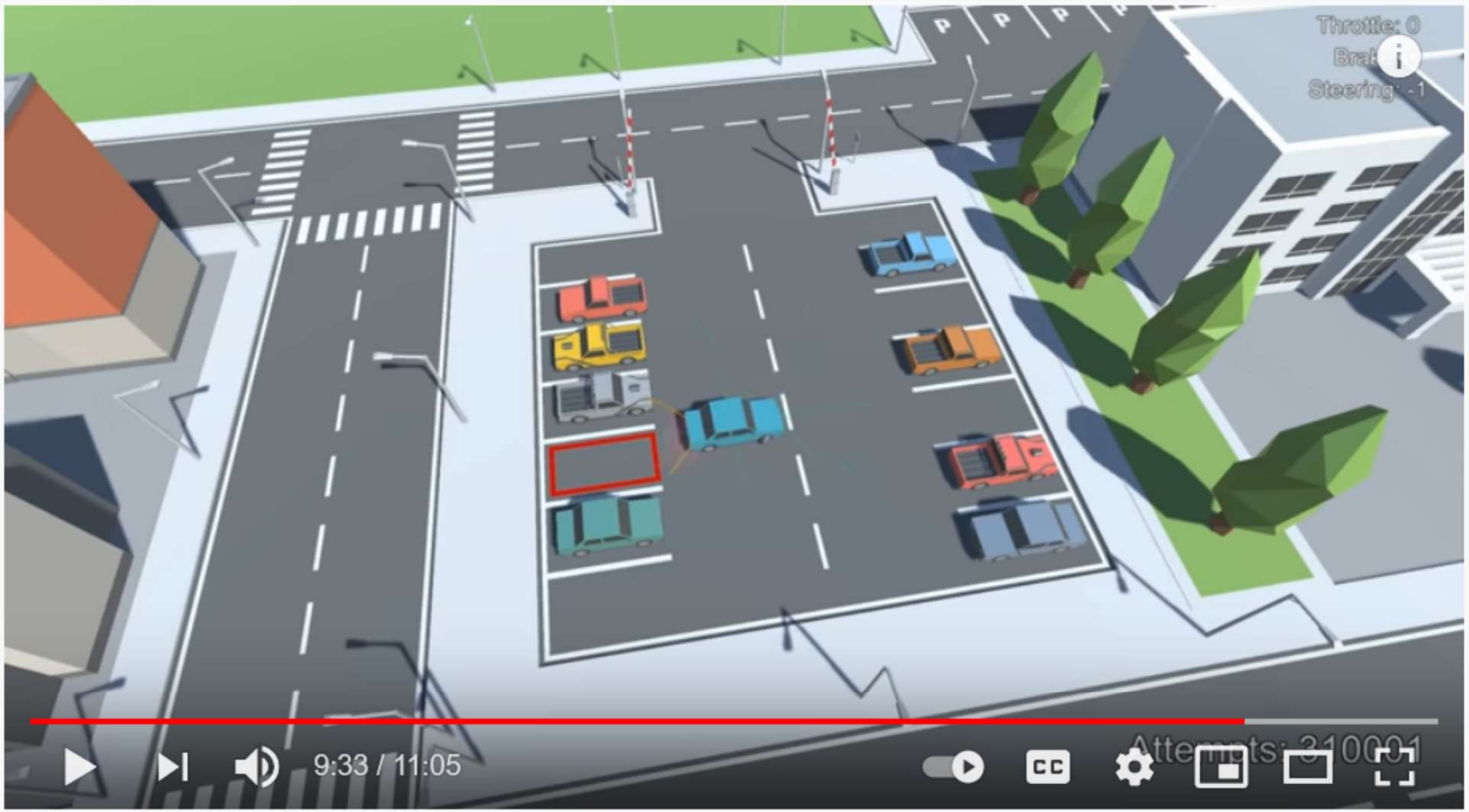
Reinforcement learning is inspired by behavioral psychology. It is **based on a rewarding / punishing an algorithm**.

Rewards and punishments are based on algorithm's action within its environment.

RL: Agents and Environments



Reinforcement Learning in Action

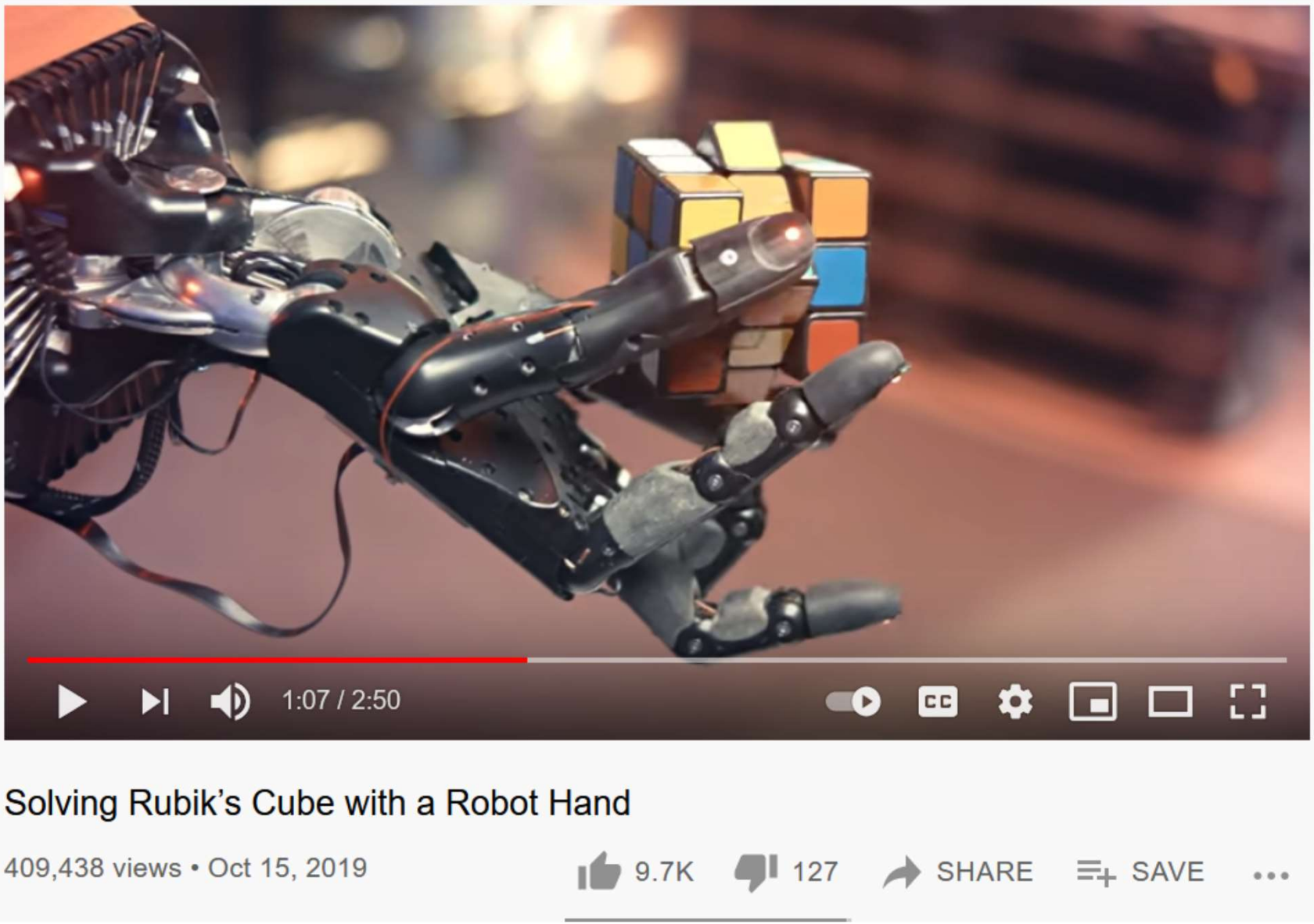


#ArtificialIntelligence #MachineLearning #ReinforcementLearning

AI Learns to Park - Deep Reinforcement Learning

1,744,342 views • Aug 23, 2019 28K 1.1K SHARE SAVE

Reinforcement Learning in Action

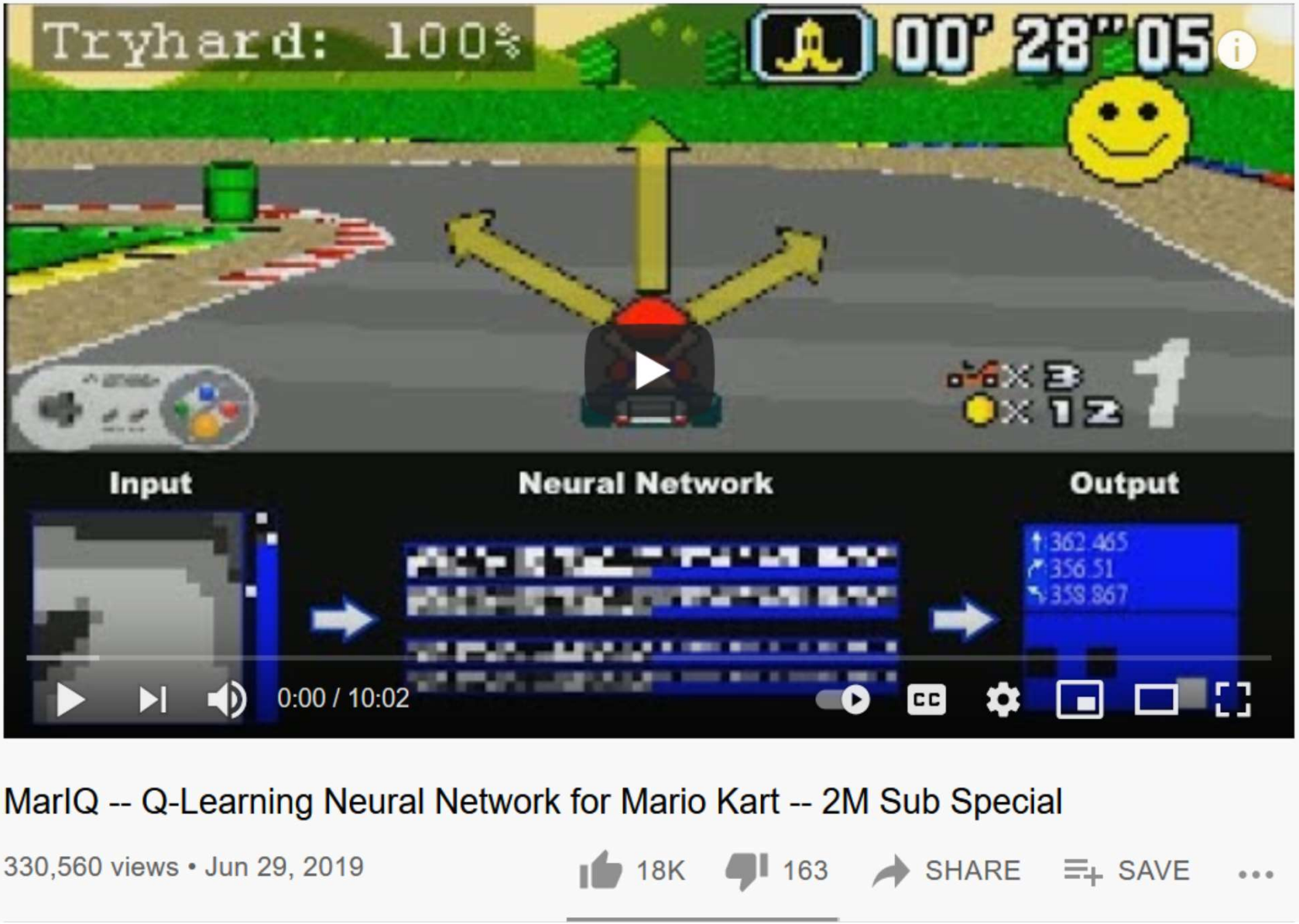


Source: https://www.youtube.com/watch?v=x4O8pojMF0w

Reinforcement Learning in Action

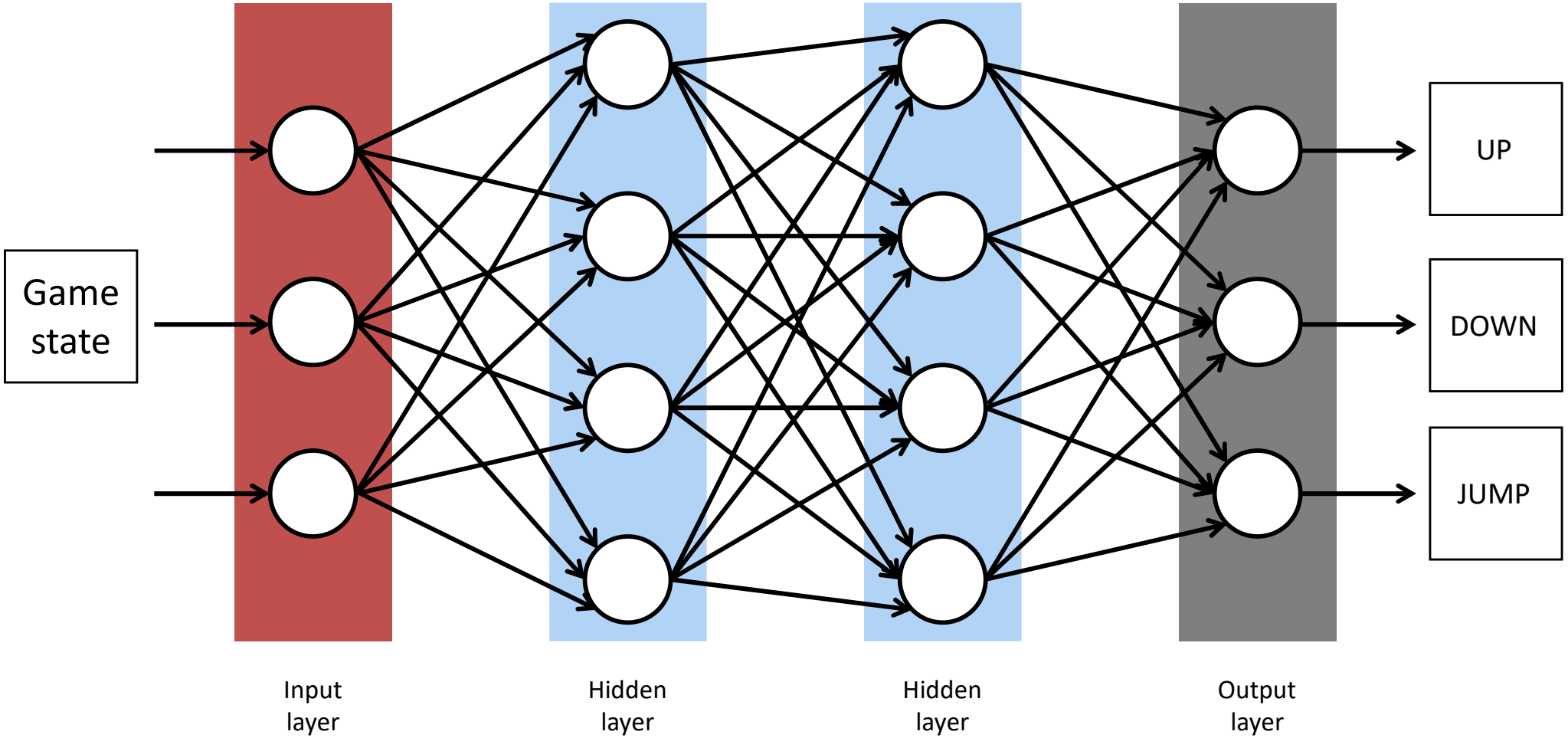
Source: https://www.youtube.com/watch?v=kopoLzvh5jY

Reinforcement Learning in Action



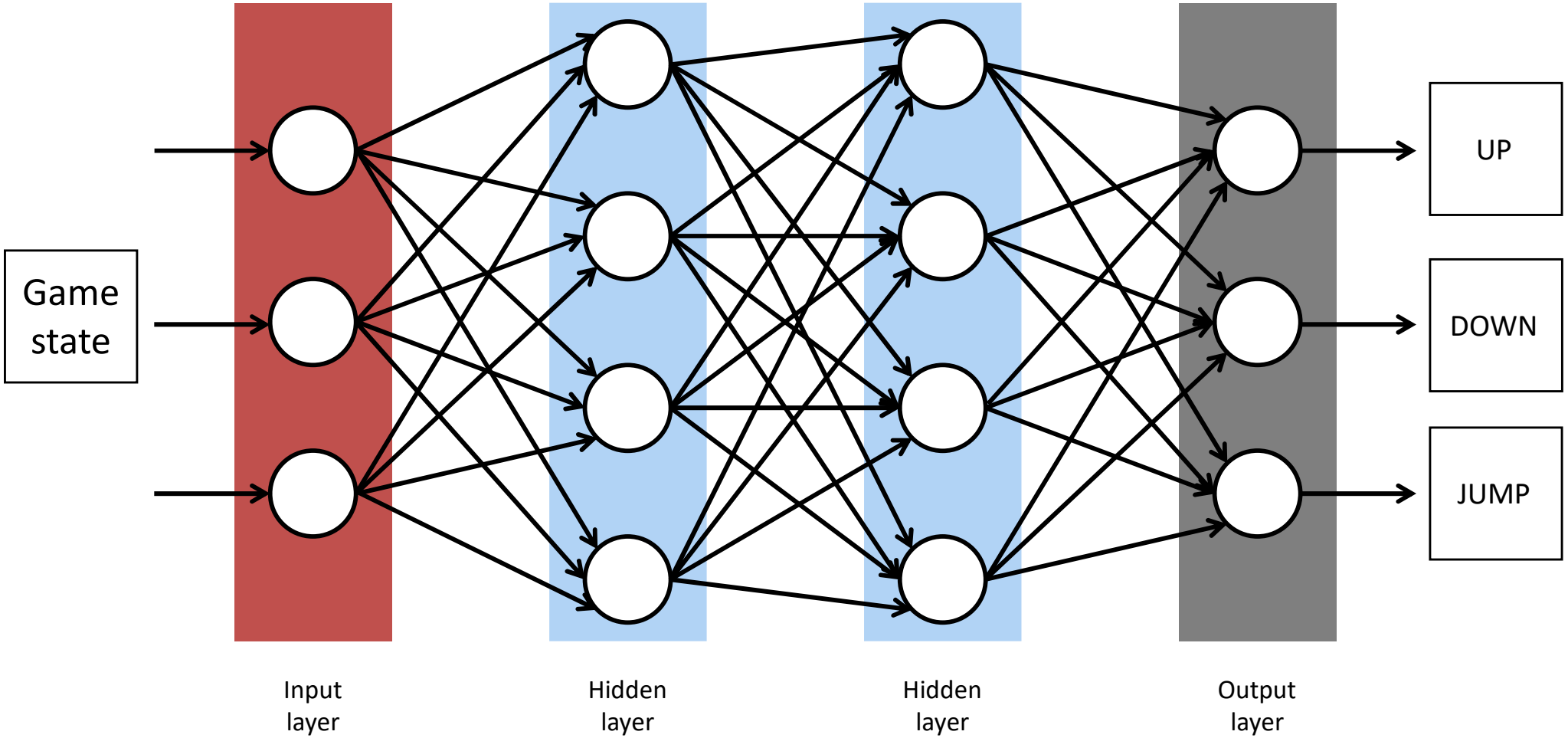
Source: https://www.youtube.com/watch?v=Tnu4O_xEmVk

ANN for Simple Game Playing



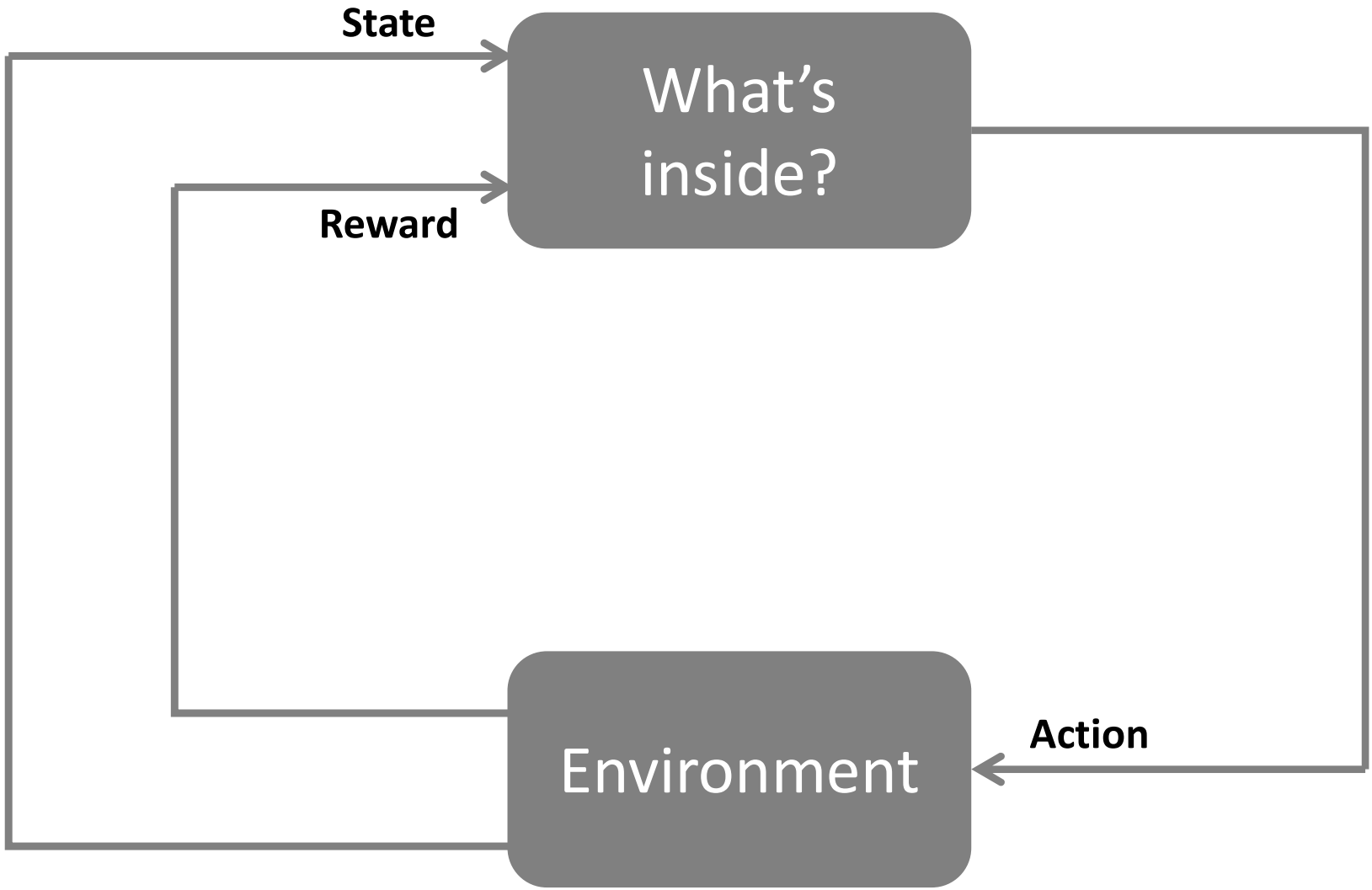
ANN for Simple Game Playing

Current game is an input. Decisions (UP/DOWN/JUMP) are rewarded/punished.

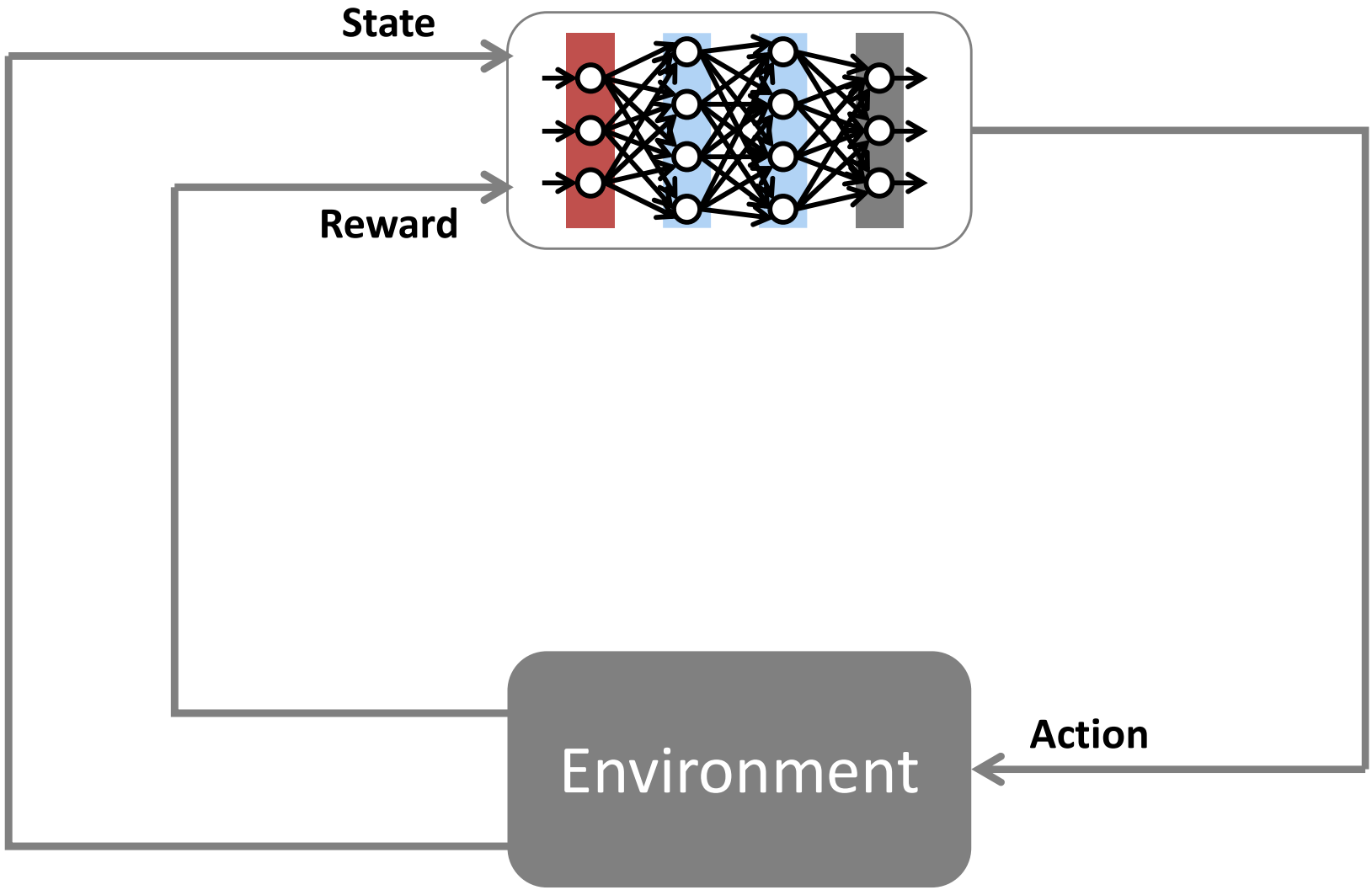


Correct all the weights using Reinforcement Learning.

RL: Agents and Environments



RL: Agents and Environments



Convolutional Neural Networks

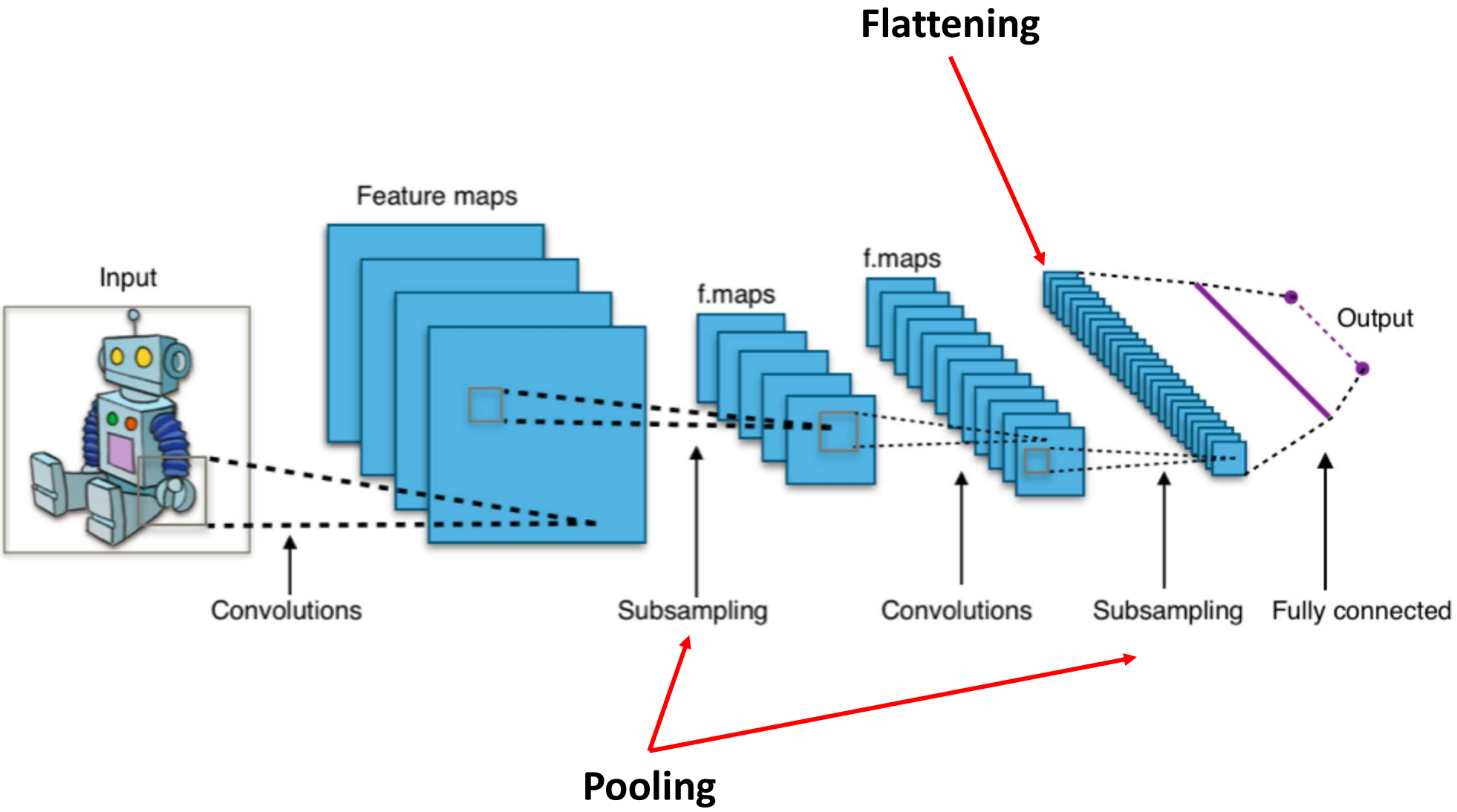
The name Convolutional Neural Network (CNN) indicates that the network employs a mathematical operation called convolution.

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.

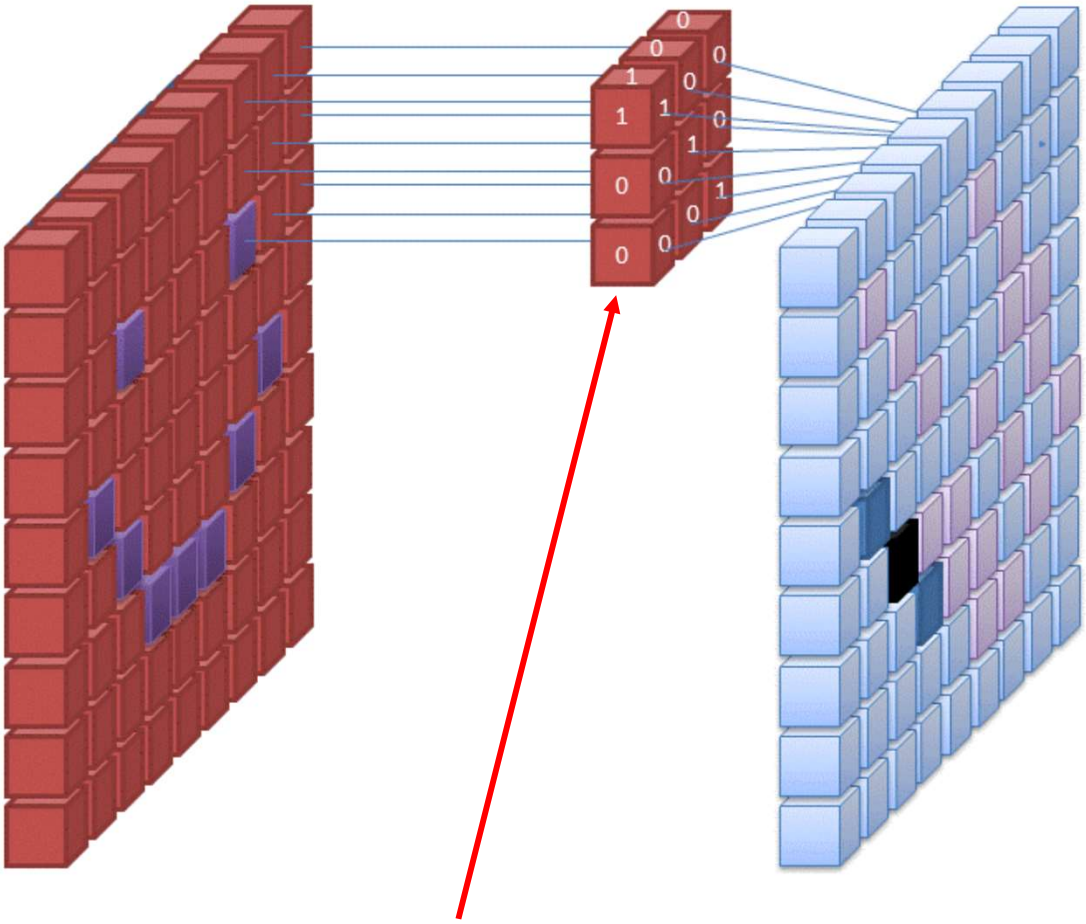
CNNs can reduce images (data grids) into a form which is easier to process without losing features that are critical for getting a good prediction.

Convolutional Neural Networks



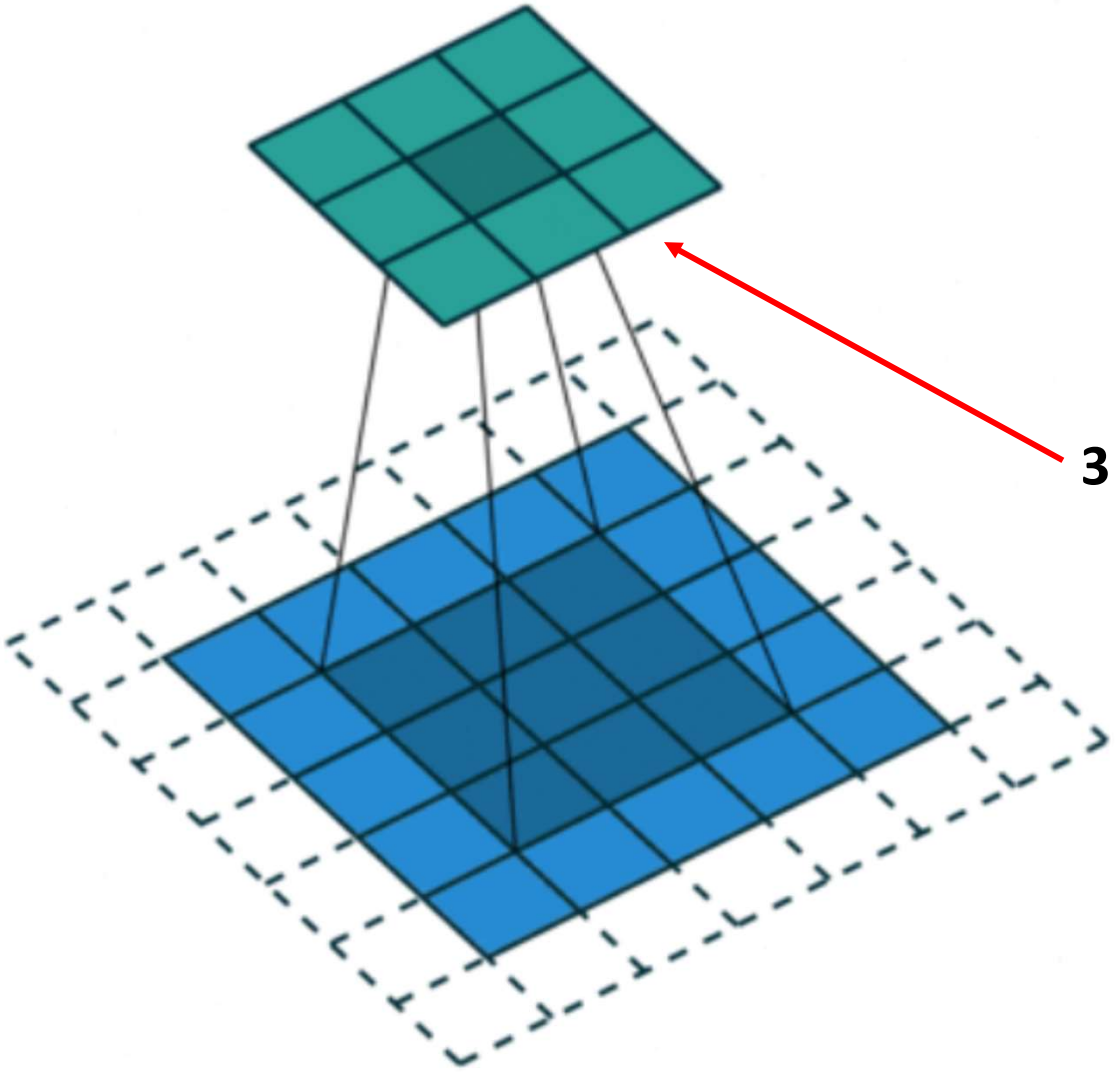
By Aphex34 - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=45679374

Convolution: The Idea



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

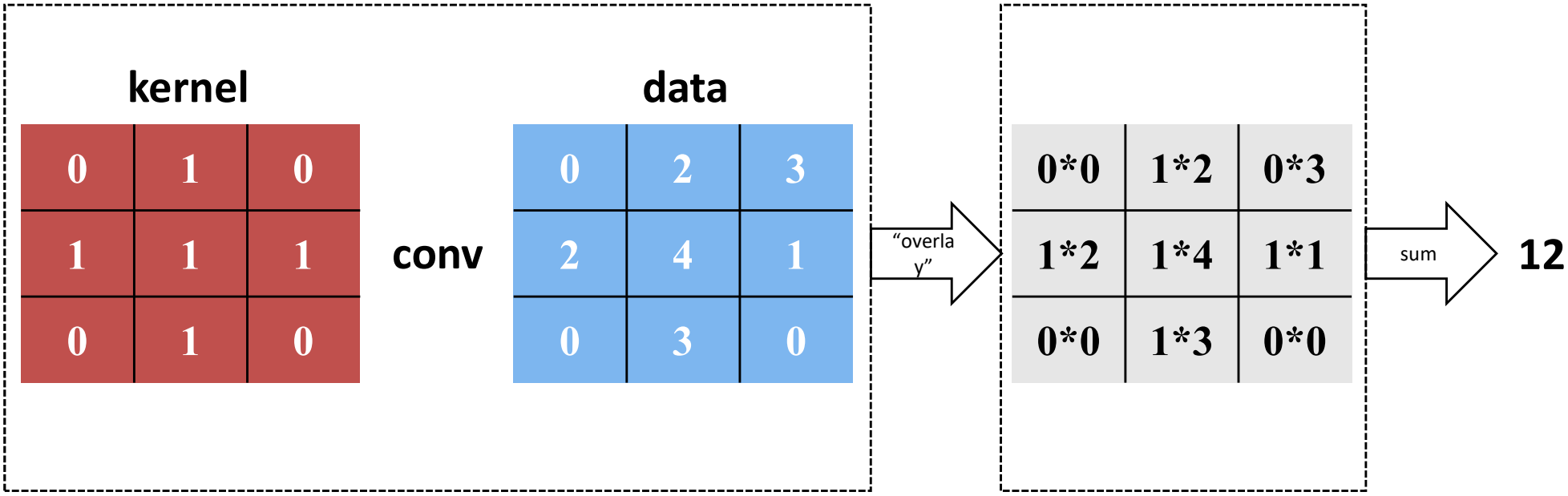
Kernel / Filter: The Idea



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)

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

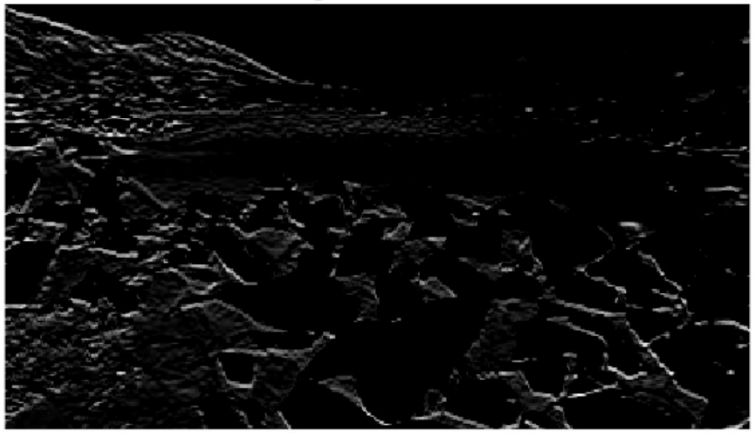
Image Processing: Kernels / Filters

Original

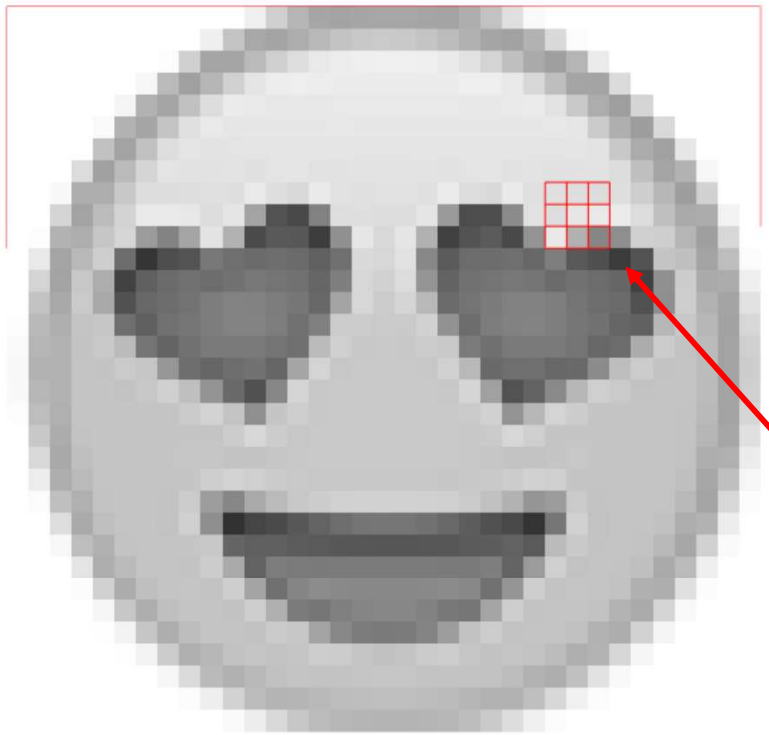
Sobel

Gaussian Blur

Edge detection



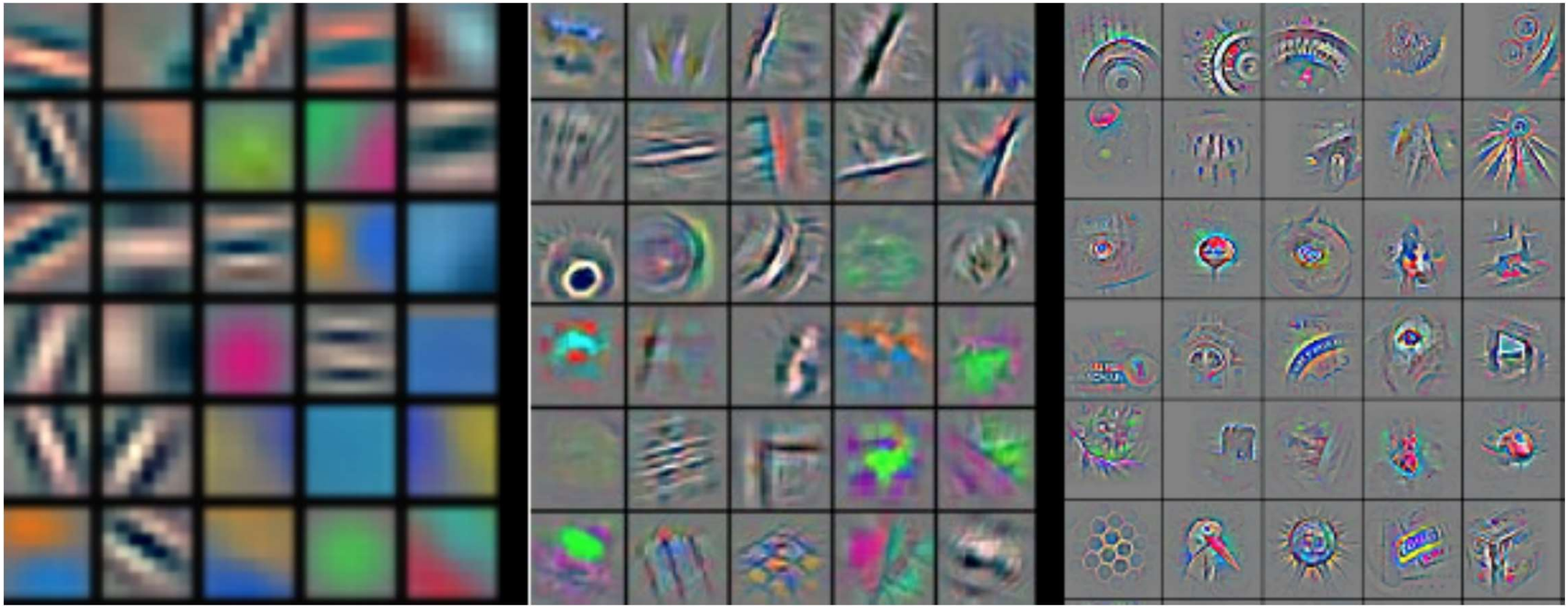
Applying Kernels / Filters



3 x 3 Kernel / Filter

Convolutional NN Kernels

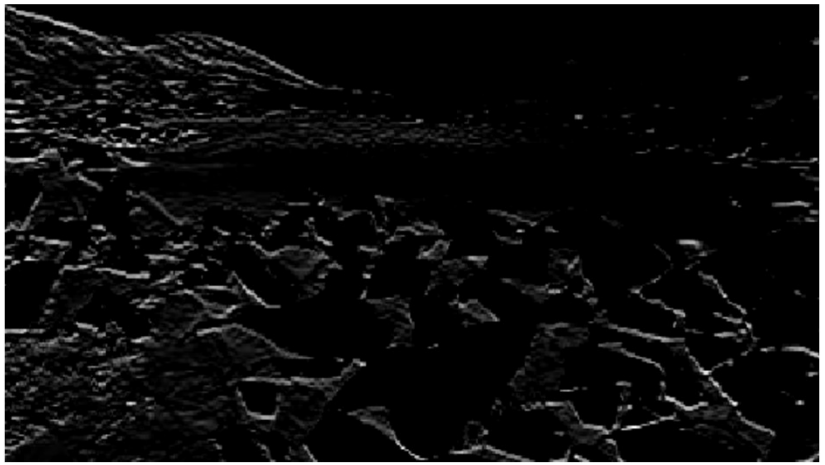
In practice, Convolutional Neural Network kernels can be larger than 3x3 and are learned using back propagation.



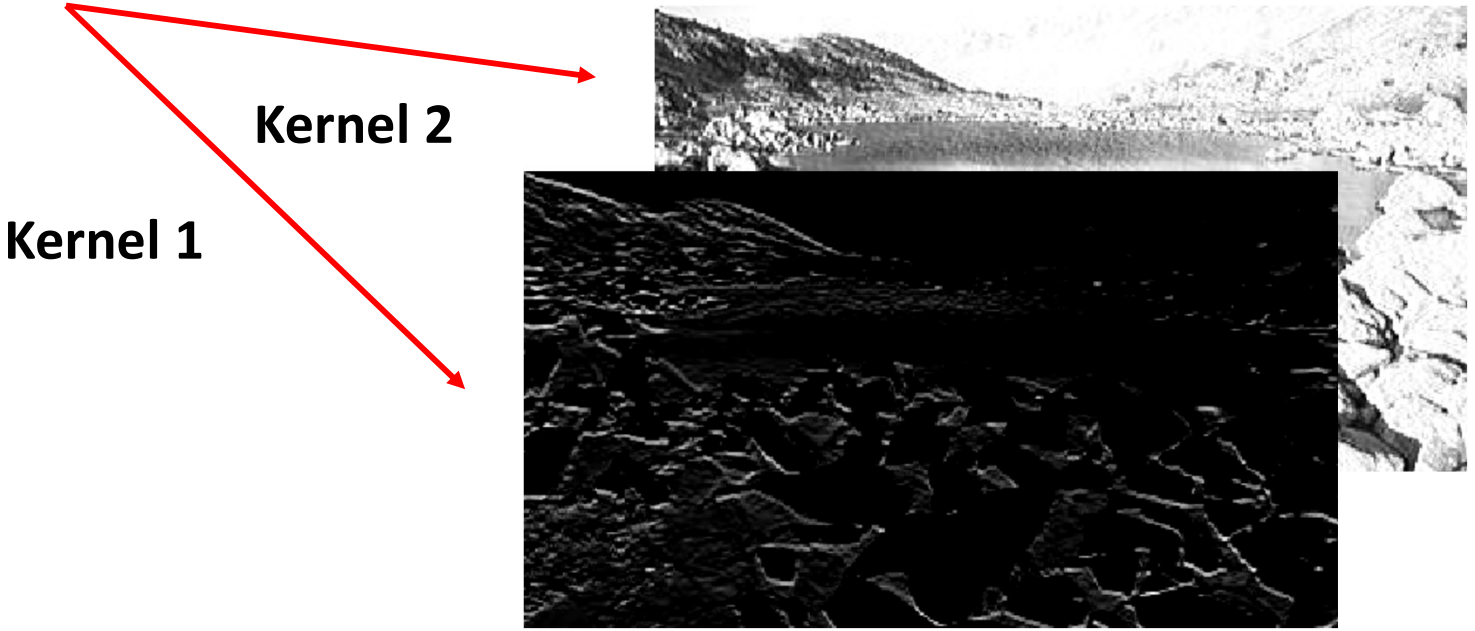
Convolution Layer 1 | Convolution Layer 2 | Convolution Layer 3

Convolution Layer 1

Kernel 1



Convolution Layer 1



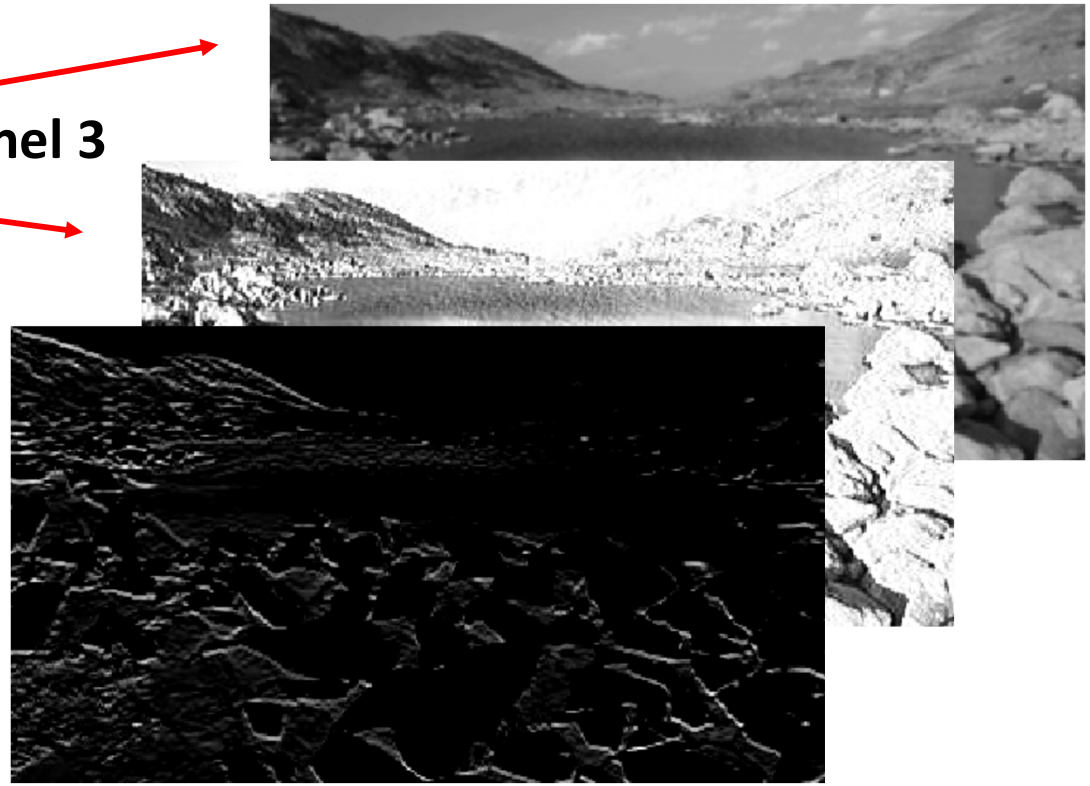
Convolution Layer 1

Original image

Kernel 3

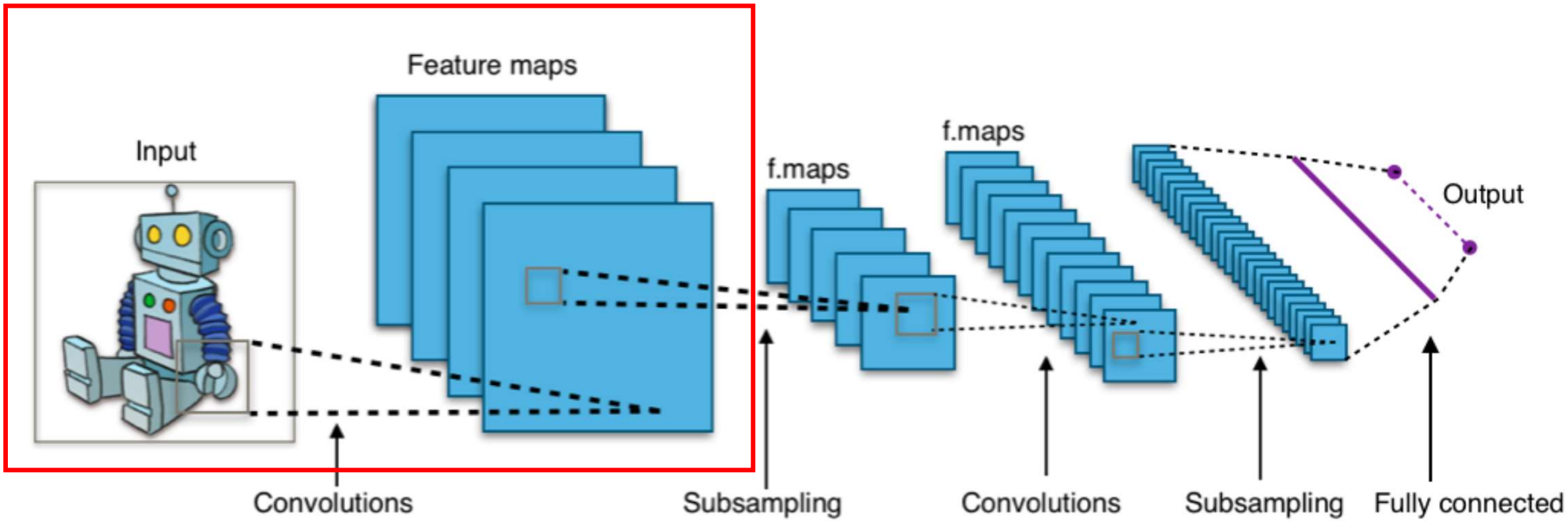
Kernel 2

Kernel 1



Convolution 1

Convolutional Neural Networks



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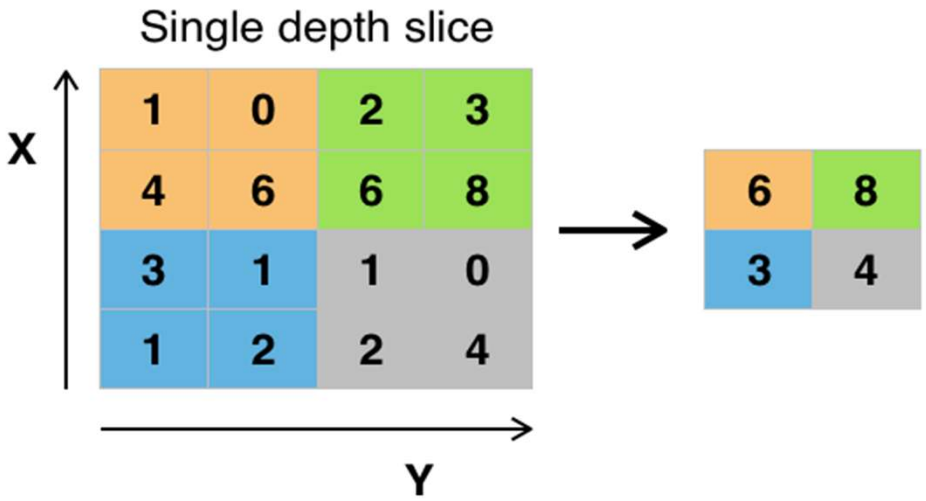
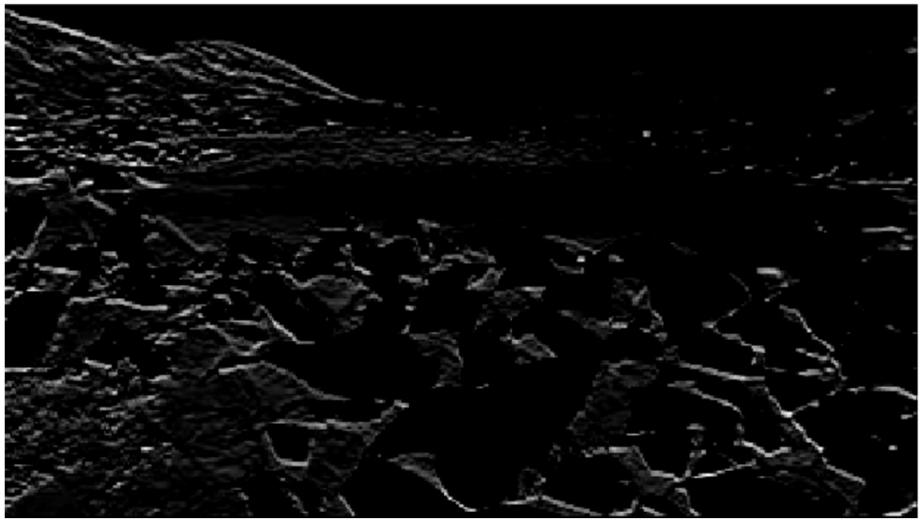
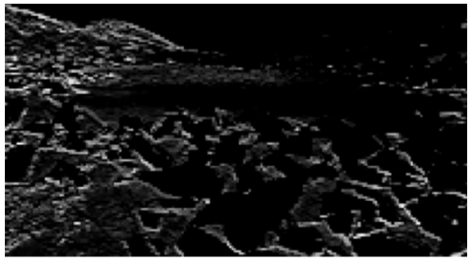
Max Pooling Layer



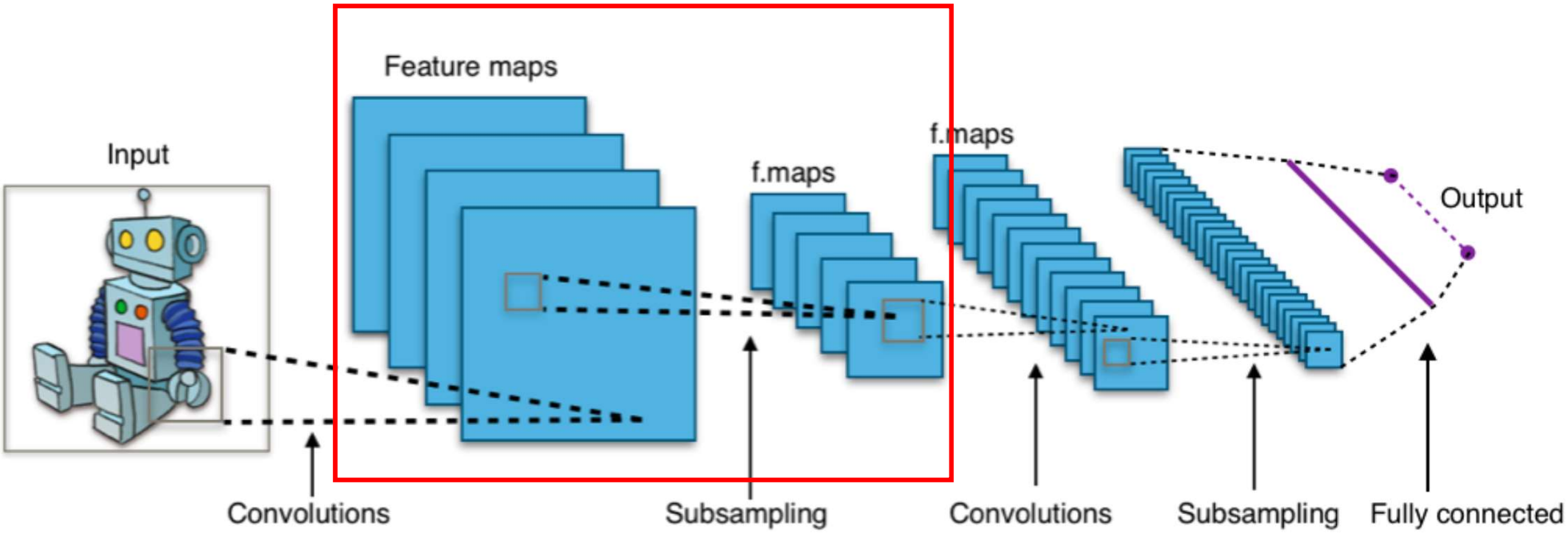
Convolution 1



Max Pooling



Convolutional Neural Networks



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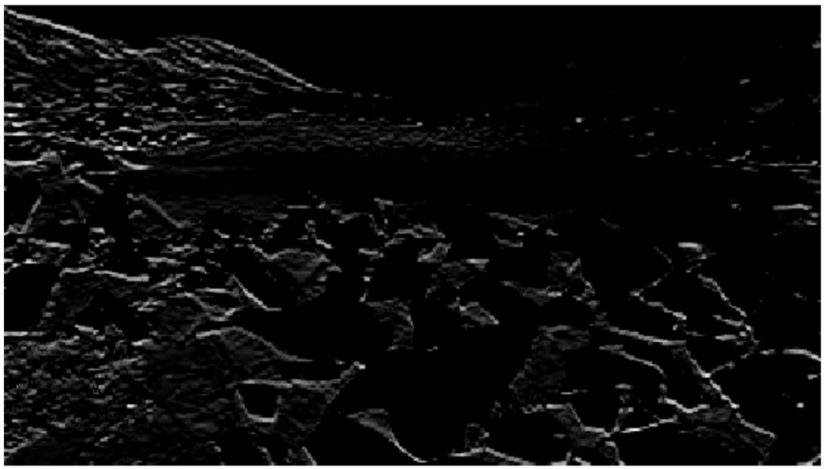
Convolution Layer 2

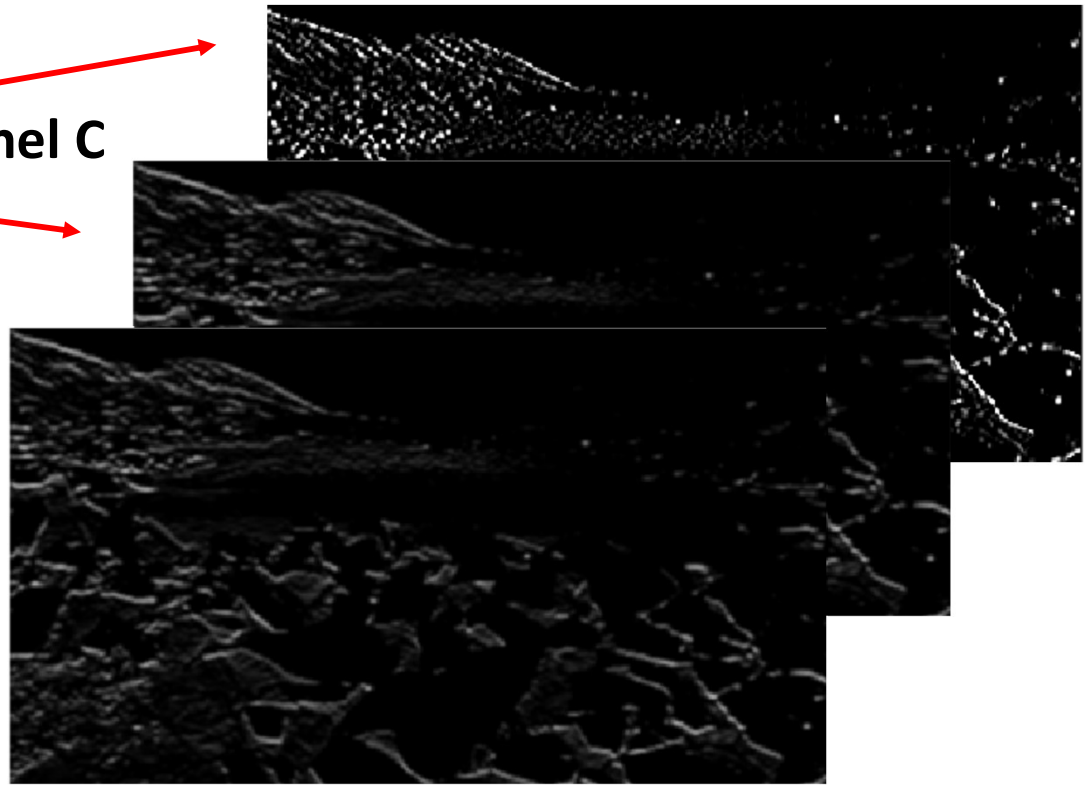


Original convolution after pooling

Kernel C

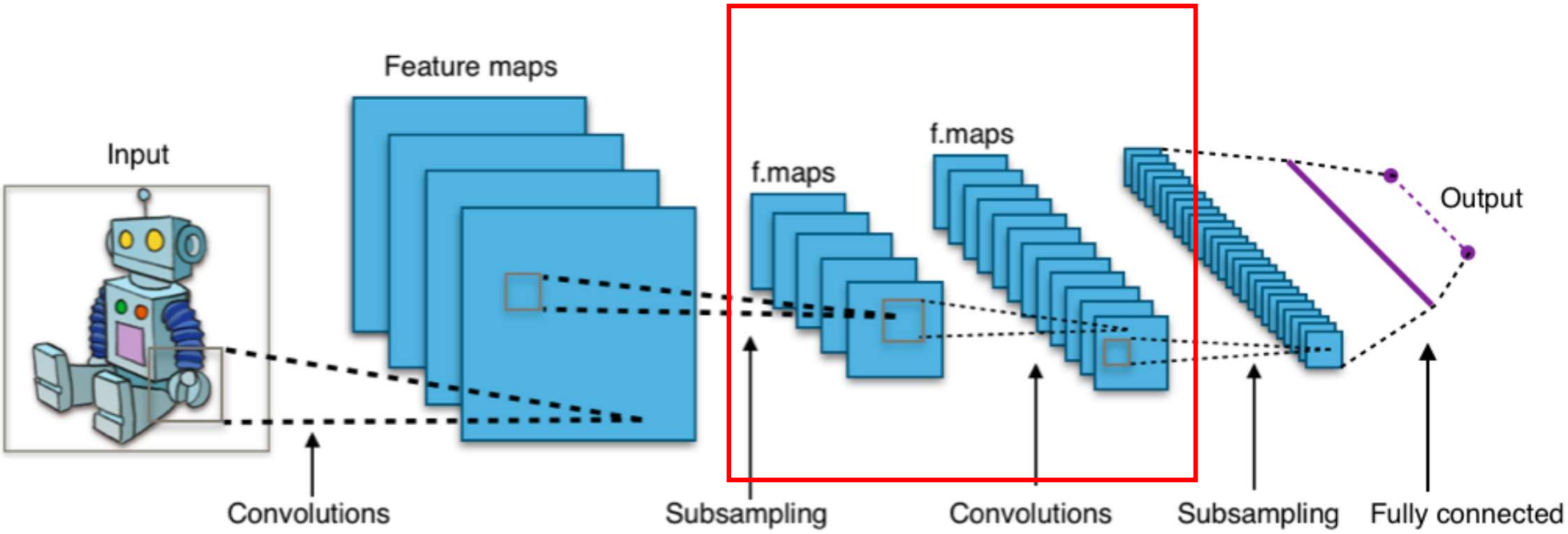
Kernel B

Kernel A



Convolution A

Convolutional Neural Networks



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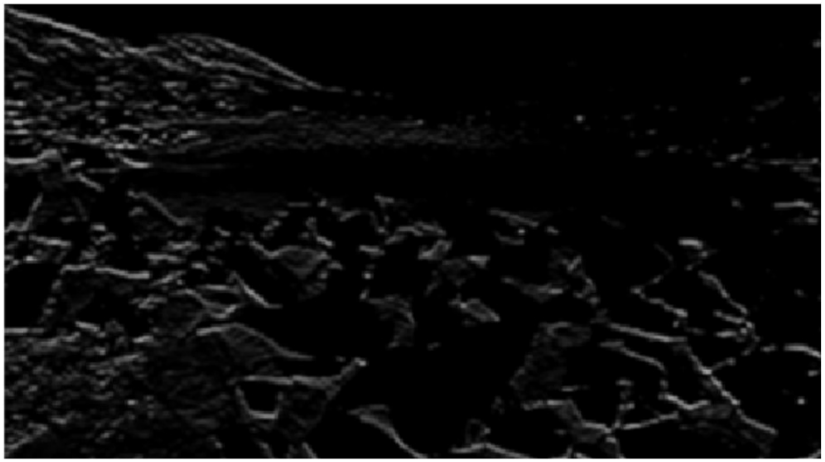
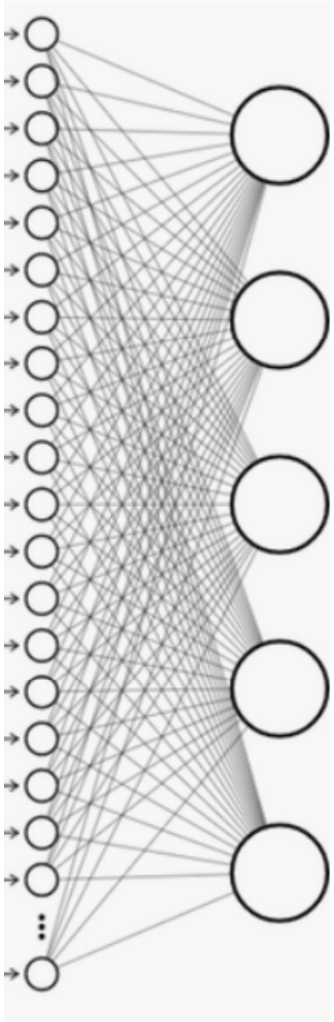
Flattening

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/