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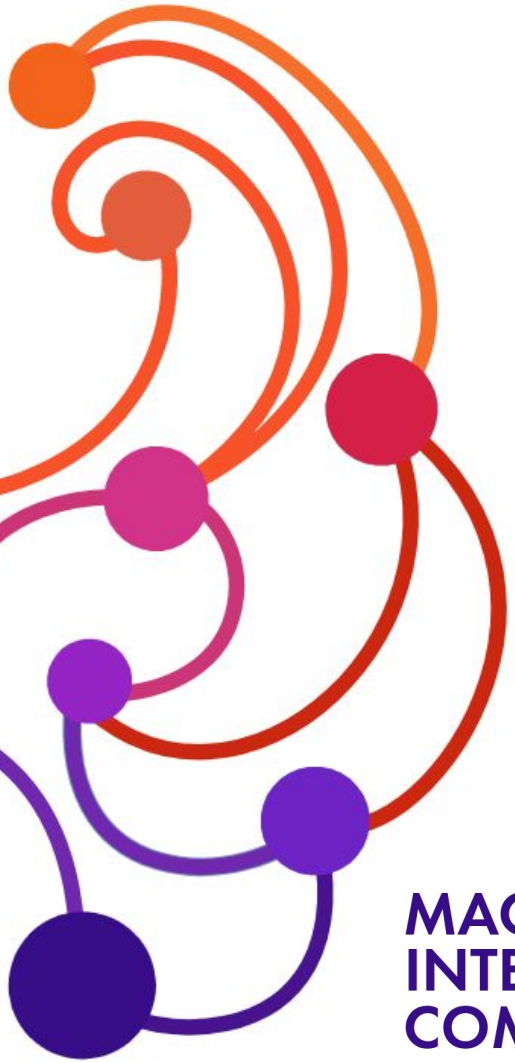

MACHINE
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Convolutional Neural Networks

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10.10.18

Compositional Data

- Compositional data incorporates the specific aspects of some entity.

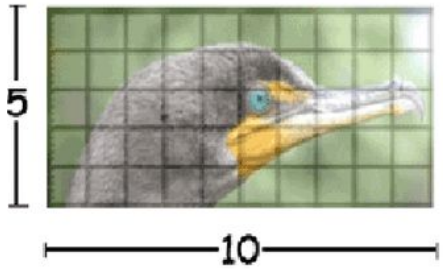
- They provide purely relative information and can be represented by positive vector components summing to a whole constant.

- For example, A population with 30% children, 20% adults, and 50% elderly could be represented as [0.3, 0.2, 0.5].

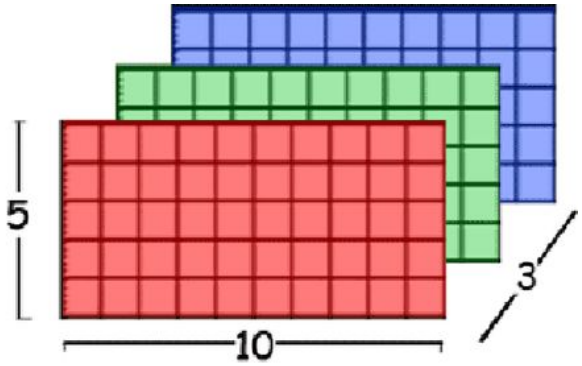
- Or, for a table, its tabletop, polish, number of legs etc.

Compositional Data in Machine Learning

- When looking at real world objects, it can be difficult at first to represent it simply ‘on paper’.
- However, we can extract key qualitative values to represent the object. The qualities we look at will depend on what we need to implement a given function.
- We can implement images as a 3-D matrix of Red, Green, and Blue colors.



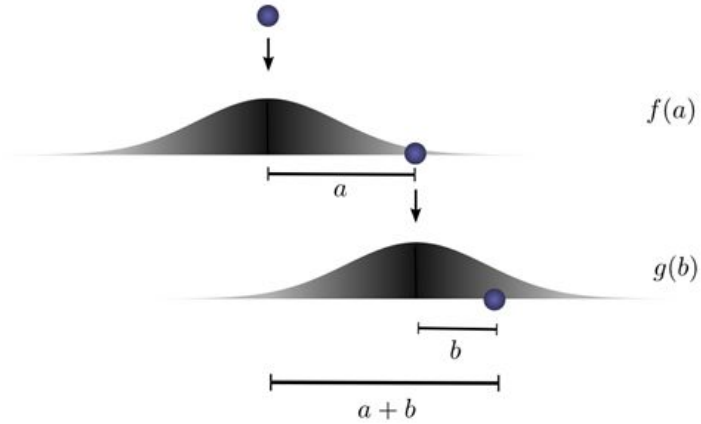
Original Color Image



Matlab RGB Matrix

Convolutions

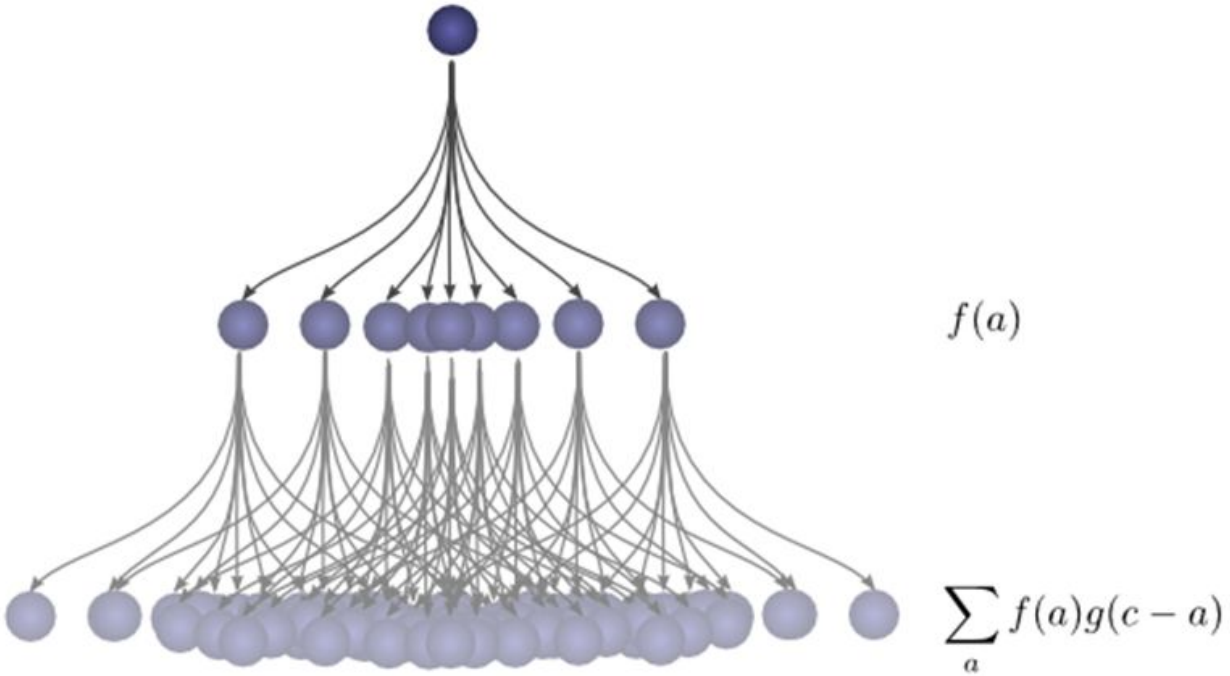
- Convolutions, in terms of mathematics, are the combining of two functions to form a third, resulting function.
- Consider the analogy of predicting who an online profile represents given key pieces of information, such as town of residence and age.



$$(f * g)(c) = \sum_{a+b=c} f(a) \cdot g(b)$$

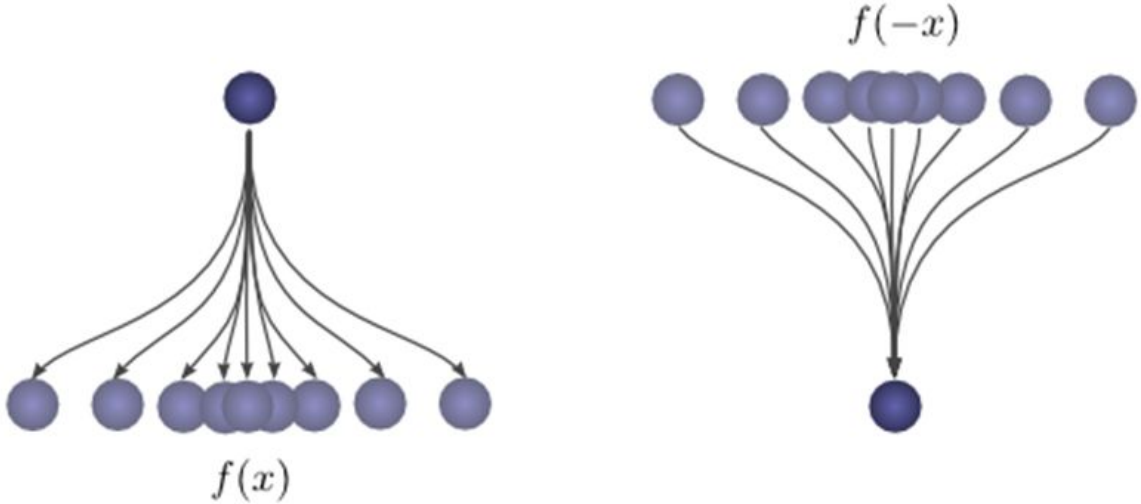
Convolutions - 2

- Now consider a graph representing the different possibilities of outcomes:



Convolutions - 3

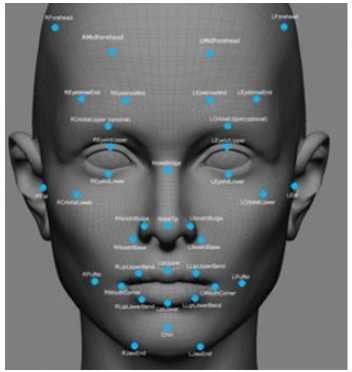
- Finally consider an inverse function to find the starting point of a dropped ball.



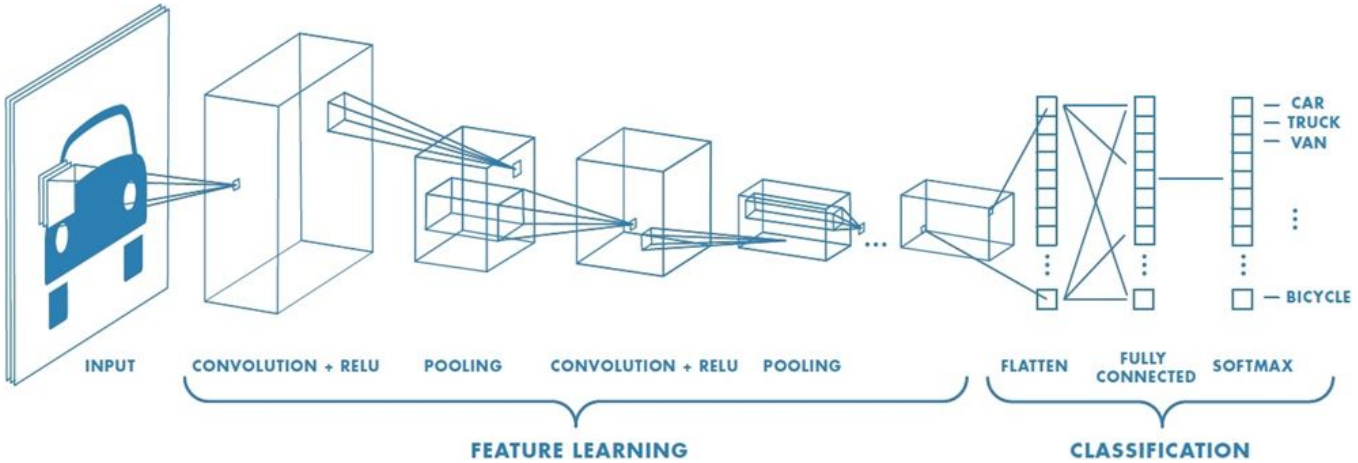
- Let *f(x)* be the probability function of landing in a location, then *f(-x)* is the probability, given a landing location, of the starting point.

Convolutional Neural Networks

- As the name implies, it is a Neural Network that utilizes **convolutions**.
- The main input for CNNs is **compositional data**.
- What are possible uses by combining compositional data and convolutions?
    1. Object/feature recognition
    2. Self-driving cars
    3. Game mastery (AlphaGo, Mario)



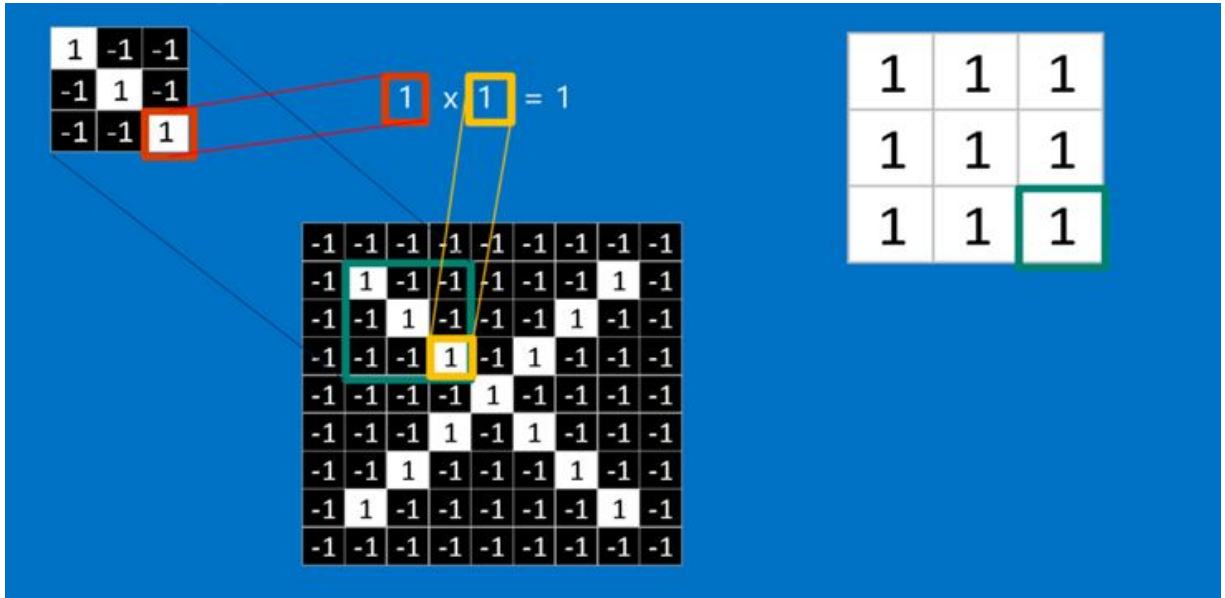
CNN Structure



- Convolutional Layer
- ReLU
- Pooling Layer
- Fully Connected Layer
- Softmax

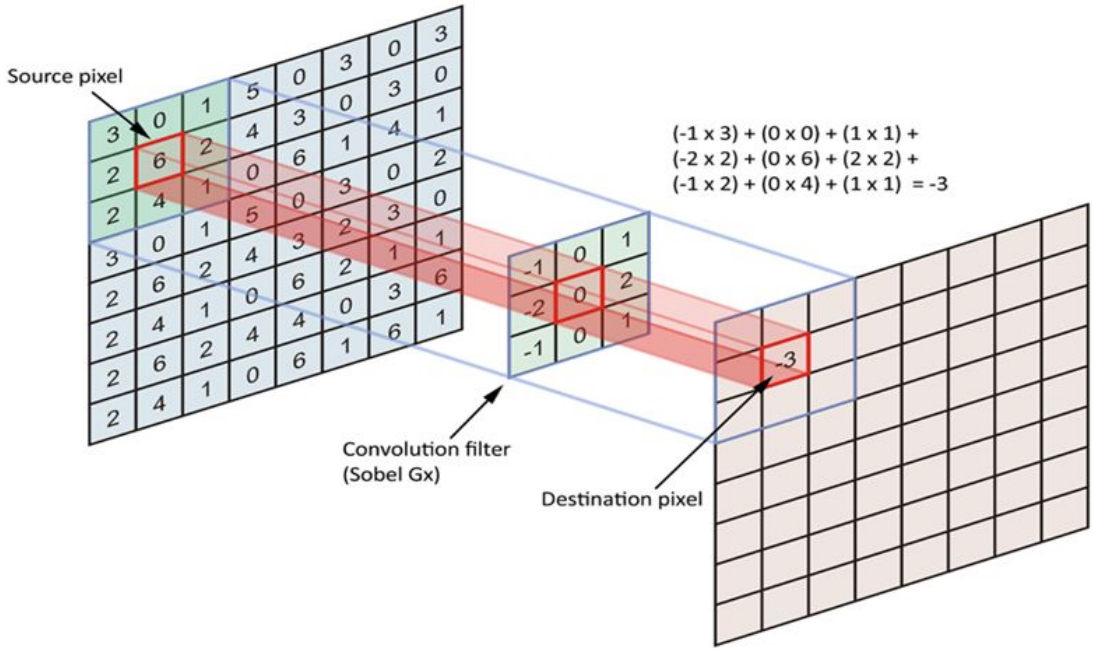
Convolutional Layer

- **Features** are parts of an expected class that is split into different characteristics to compare to an input image.
    - The **filter size** depends on the representation of the feature.



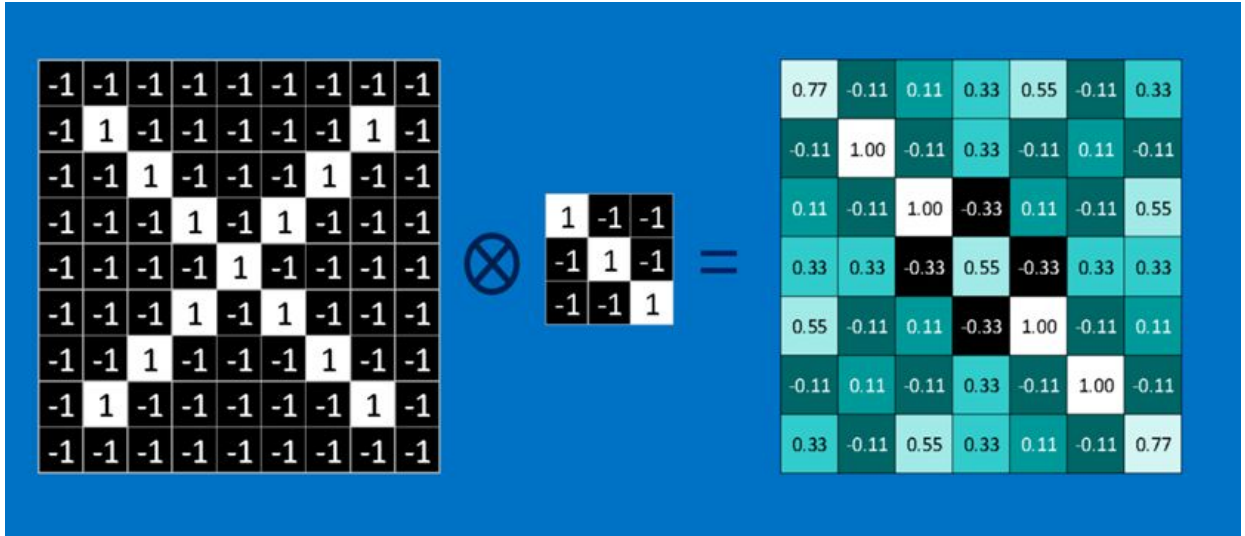
Convolutional Layer - 2

- The dot product is then mapped to the specific pixel in the output map.
- The map fills up as the filter moves across the input.



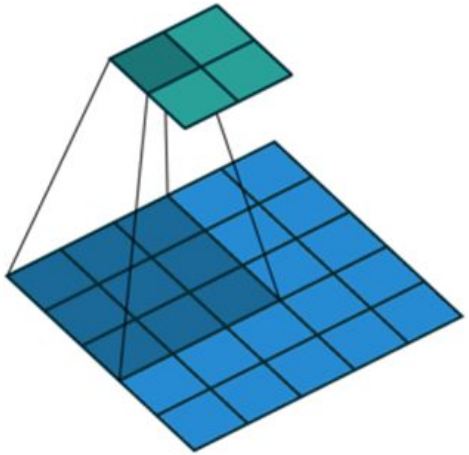
Normalization

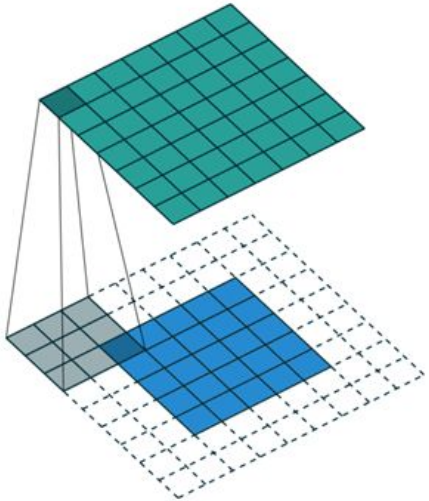
- The resulting raw output will produce a diverse amount of numbers that may be hard to interpret.
- Normalization occurs by dividing each element by the maximum obtainable number, bringing the range to [0-1].



Convolutional Layer - 3

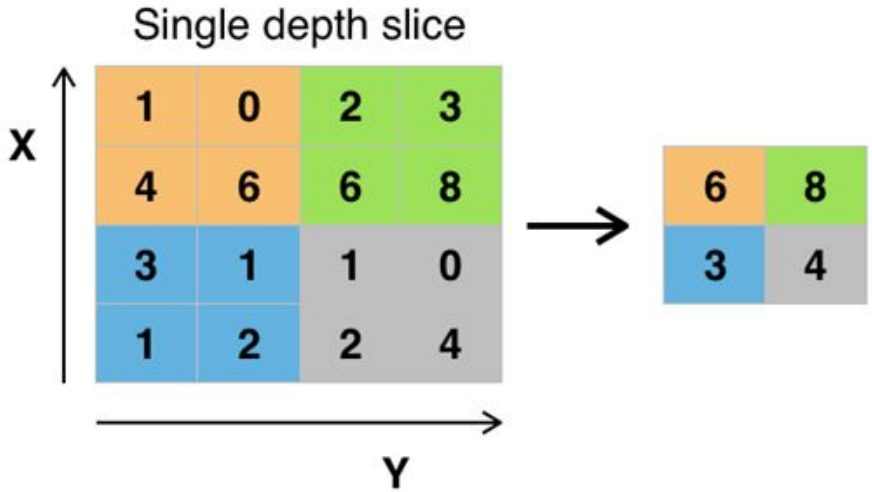
- There are three more hyper parameters which can control the output:
  - **Stride**
  - **Padding**
  - **Depth**





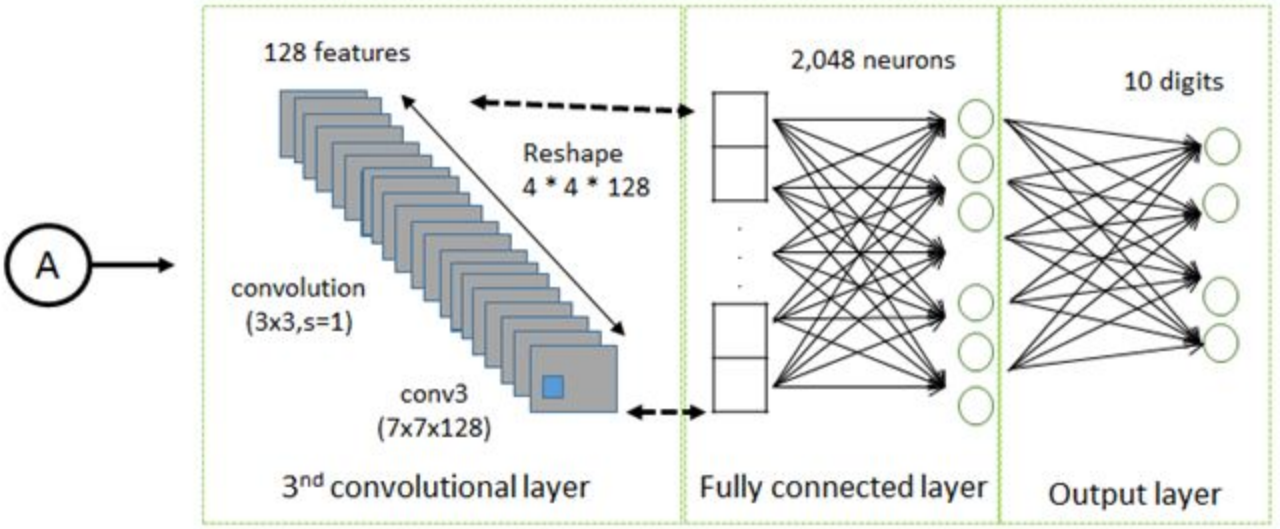
Pooling Layer - Downsampling

- The pooling layer is meant to shrink down the current representation and lower the amount of parameters (to prevent overfitting).
- It iterates similarly to the convolutional layer, applying a function on the selection.
- Maxpooling uses the max(..) function on the selected region.



Fully Connected Layers

- It flattens the previous layer into a one dimensional vector, for which it outputs another vector containing the class scores.
- The largest score in the output layer is the chosen class for the network input.



Softmax - The Scoring Function

- Normalizes the output values to add up to 1.
- The highest value gets the most weight and the rest of the values are reduced.
    - The goal is to make the highest value reach 1, since it is the correct result, and the remaining values are errors.

	Scoring Function	Unnormalized Probabilities	Normalized Probabilities	Negative Log Loss
Dog	-3.44	0.0321	0.0006	
Cat	1.16	3.1899	0.0596	
Boat	-0.81	0.4449	0.0083	
Airplane	3.91	49.8990	0.9315	**0.0709**

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References and Further Reading

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