

# Deep Learning

## - Convolutional Neural Network -

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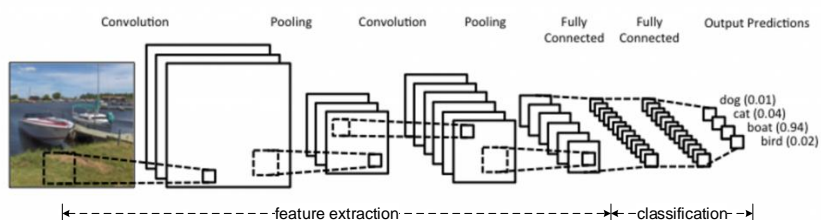
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# CNN: Convolutional Neural Network

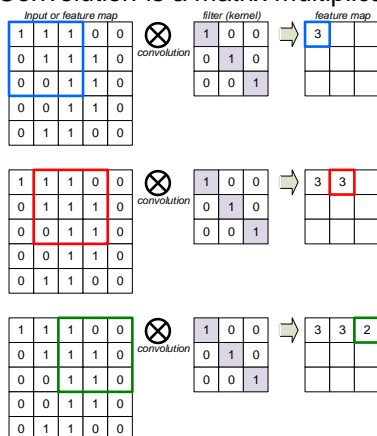
- CNN is a neural network that uses convolution in place of general matrix multiplication in at least one of their layers.
- General form of CNN (Convolutional Neural Network) for image classification
  - Feature extraction
    - ➔ Convolution
    - ➔ Pooling (sub-sampling)
  - Classification
    - ➔ Regression



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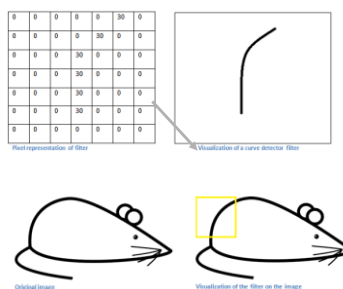
## CNN: convolution

- Convolution is a matrix multiplication



When the value is large after convolution, it means there is a feature about it.

- It can be seen as a feature extractor

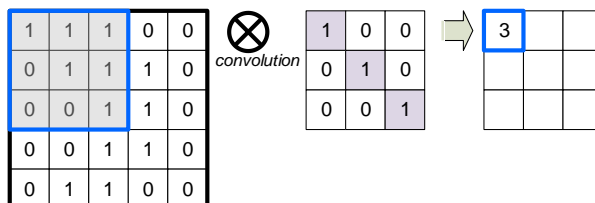


<https://adeshpande3.github.io/adeshpande3.github.io/A-Beginner's-Guide-To-Understanding-Convolutional-Neural-Networks/>

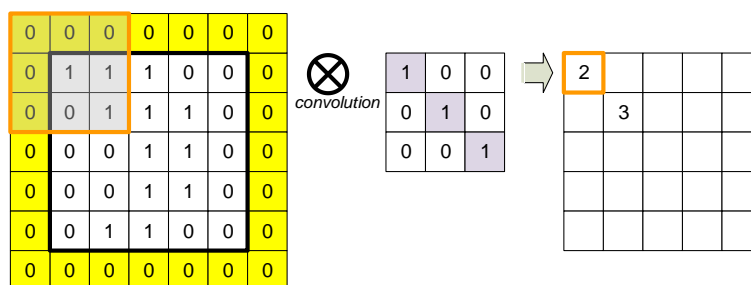
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## CNN: convolution padding

### ■ No padding



### ■ Zero padding

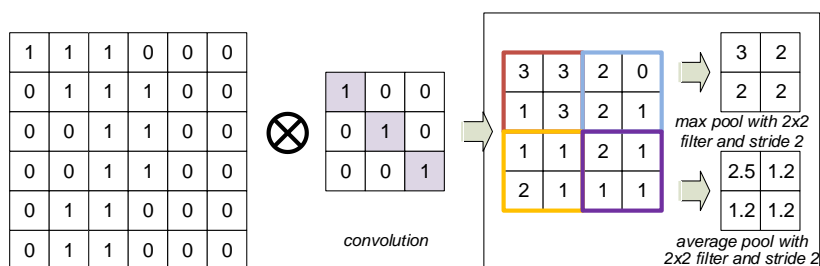


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## CNN: Pooling

### ■ Pooling, i.e., sub-sampling

- ▶ Max pooling
- ▶ Average pooling



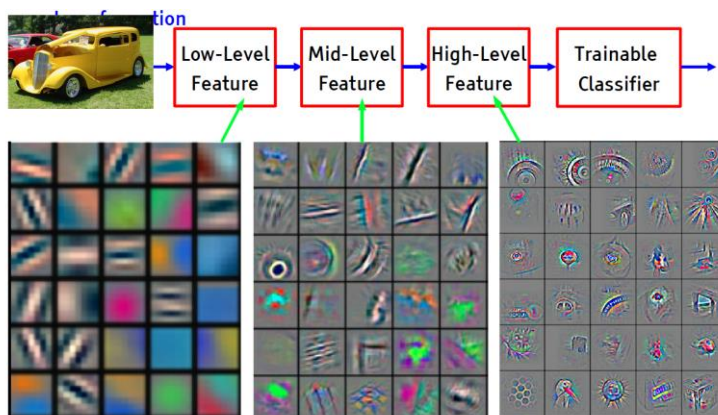
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## How to choose filters

- With CNN/ConvNet the goal is to learn the filters; you don't actually design these filters (or kernels). They will be learned during training as long as the training converges.
- Initializing these filter parameters with good defaults before starting the training is key to convergence especially in very deep networks.
- Convolution filters can be initialized in one of the following ways.
  - ▶ 1. Randomly assigning weights for the different filters.
  - ▶ 2. Handcrafting the weights of the different filters to detect specific features during convolution.
  - ▶ 3. Learning filter weights using unsupervised training schemes.

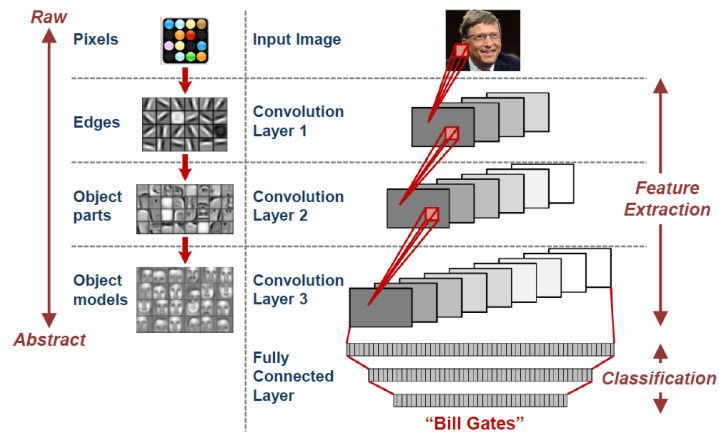
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## Deep learning: Learning Hierarchical Representations



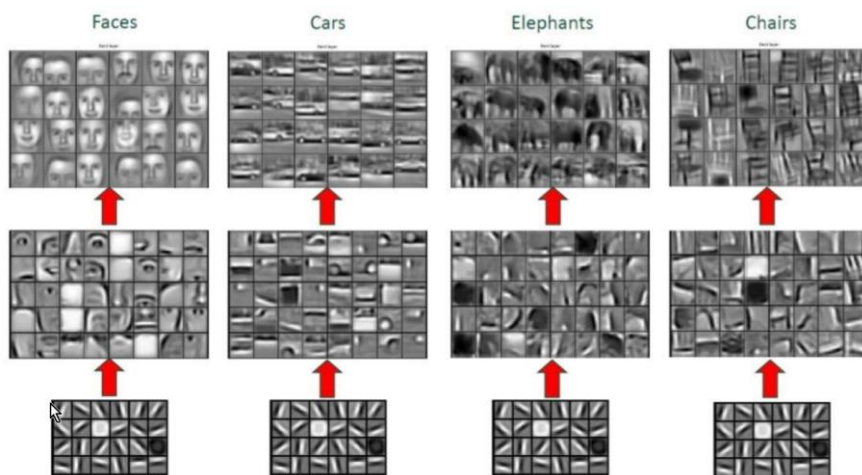
Feature visualization of convolutional net trained on ImageNet from [Zeiler & Fergus 2013]

# CNN abstraction



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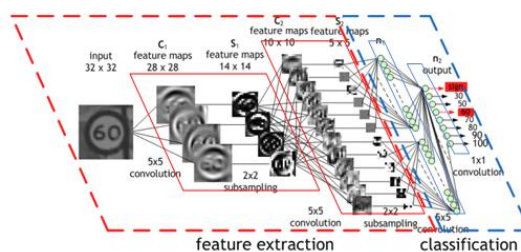
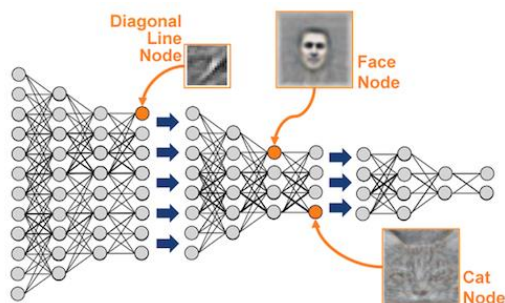
# CNN abstraction



Convolutional deep belief networks for scalable unsupervised learning of hierarchical representation". Lee et al., 2012

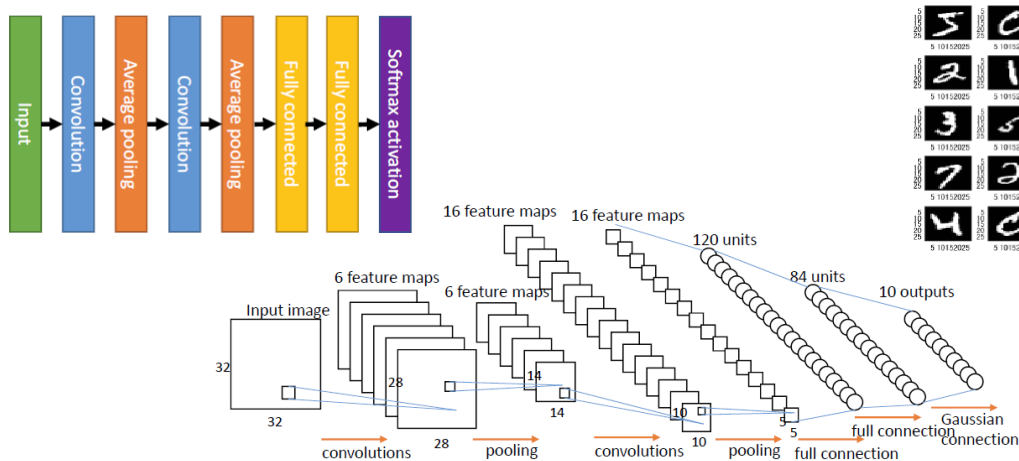
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## CNN examples



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## CNN examples: LeNet-5 (1989)



Y. LeCun, B. Boser, J. S. Denker, D. Henderson, R. E. Howard, W. Hubbard, and L. D. Jackel. Handwritten digit recognition with a back-propagation network. NIPS 1989.

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