OCR

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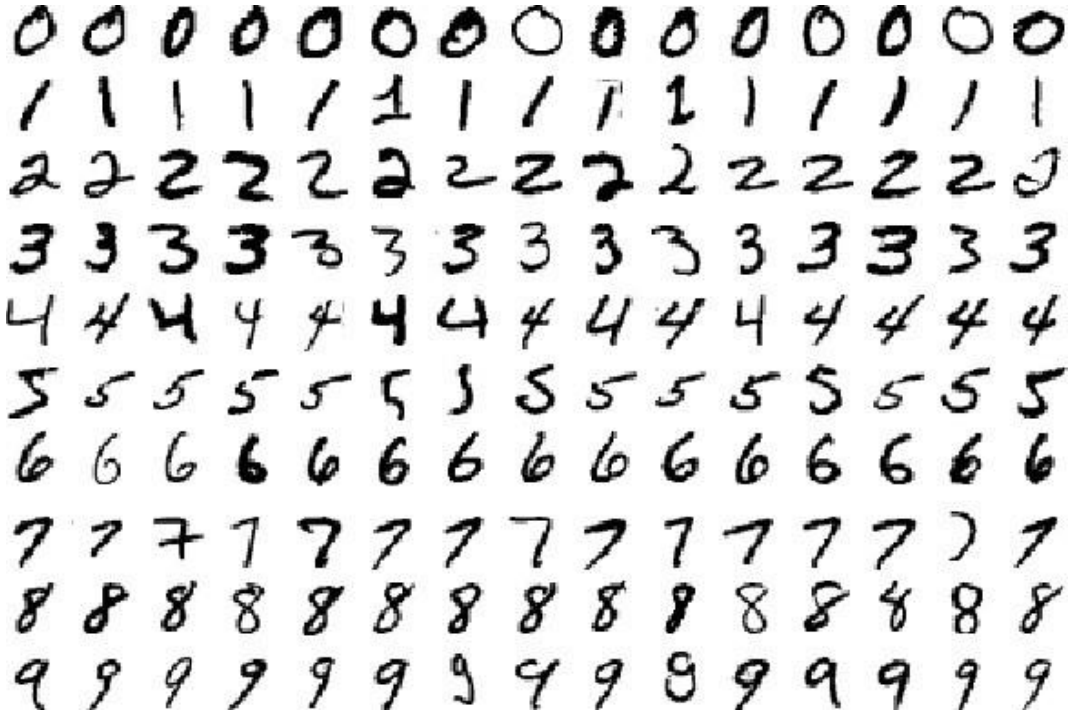
Optical Character Recognition

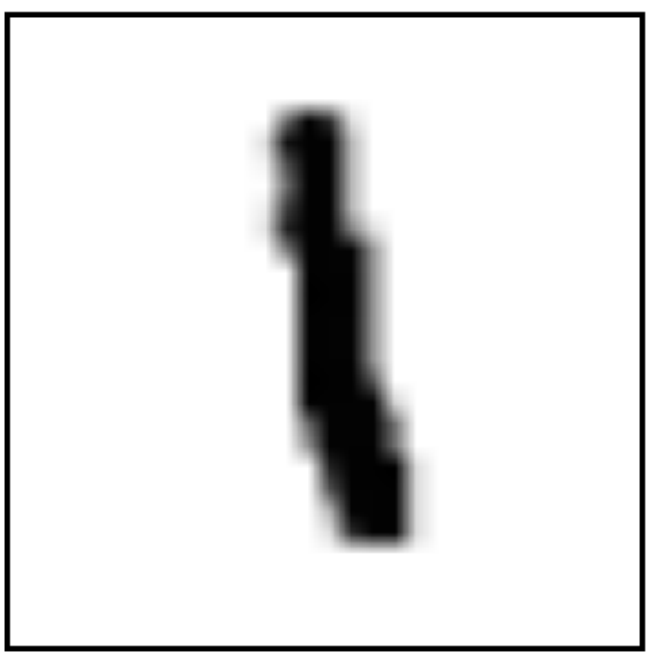
- Handwritten digits
- Classification problem



Source: https://codeburst.io/use-tensorflow-dnnclassifier-estimator-to-classify-mnist-dataset-a7222bf9f940

Feature Representation

- 28 x 28 pixel images
- Pixel intensity between 0 and 1



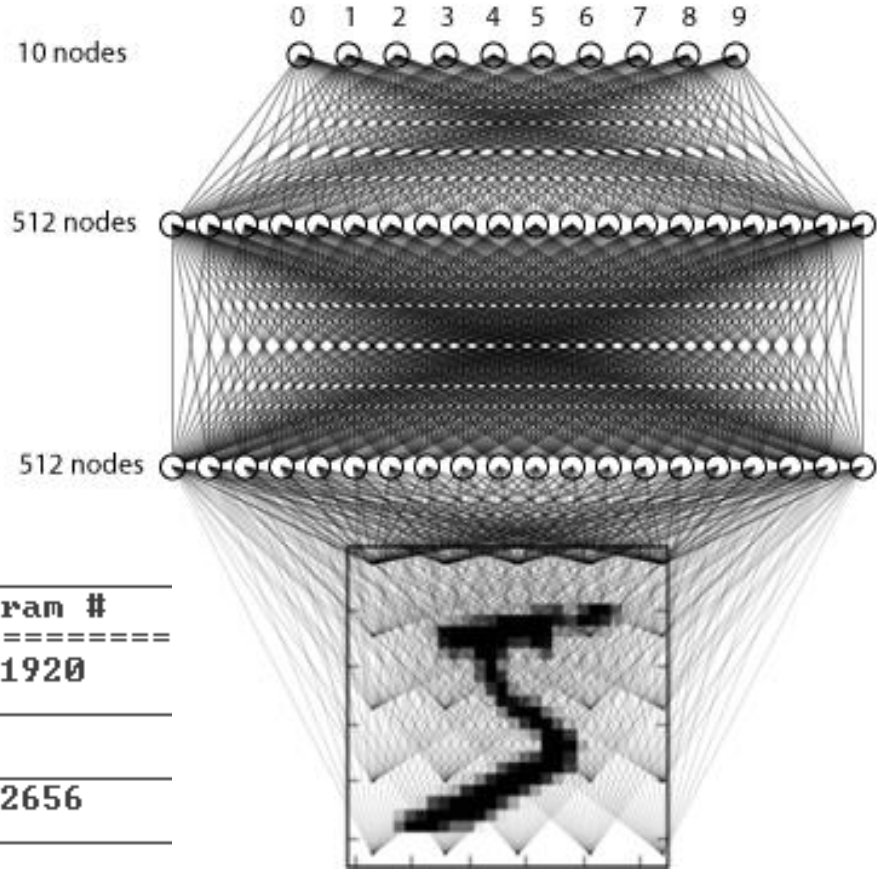
$\approx$

$$\begin{bmatrix}
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & .6 & .8 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & .7 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & .7 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & .5 & 1 & .4 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & .4 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & .4 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & .7 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & .9 & 1 & .1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & .3 & 1 & .1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}$$

Source: https://www.tensorflow.org/versions/r1.0/get_started/mnist/beginners

Solution using MLP

- 3-layer fully connected network
- Input vector size: 784
- Output layer: 10 nodes
- 2 Intermediate layers



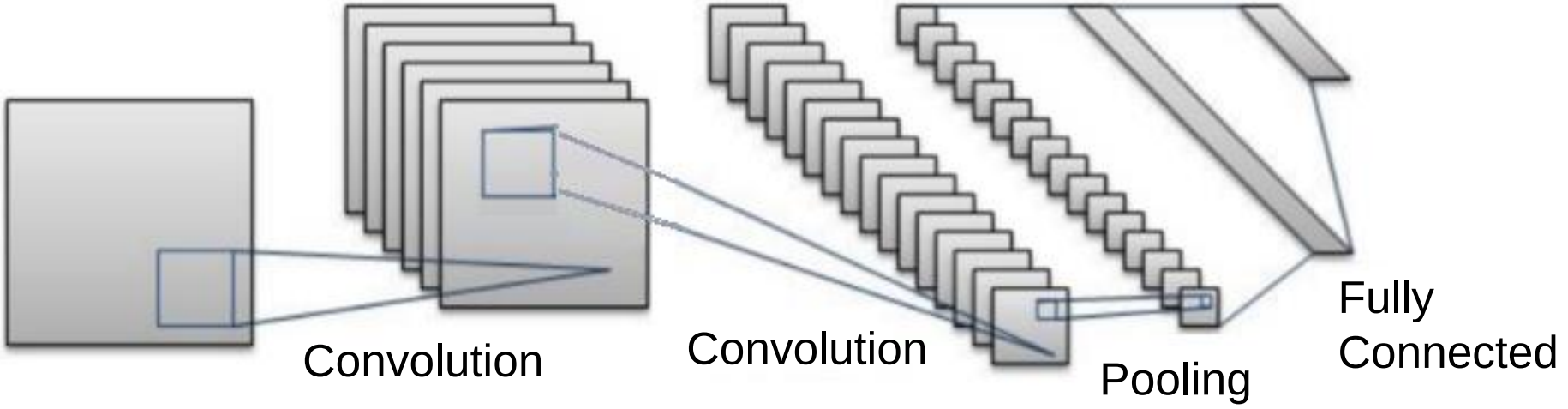
Layer (type)	Output Shape	Param #
dense_1 (Dense)	(None, 512)	401920
dropout_1 (Dropout)	(None, 512)	0
dense_2 (Dense)	(None, 512)	262656
dropout_2 (Dropout)	(None, 512)	0
dense_3 (Dense)	(None, 10)	5130

Source: https://github.com/wxs/keras-mnist-tutorial/blob/master/MNIST%20in%20Keras.ipynb

Solution using CNN

- 2 Conv. layers
- 1 Pooling layer
- Fully Connected Output

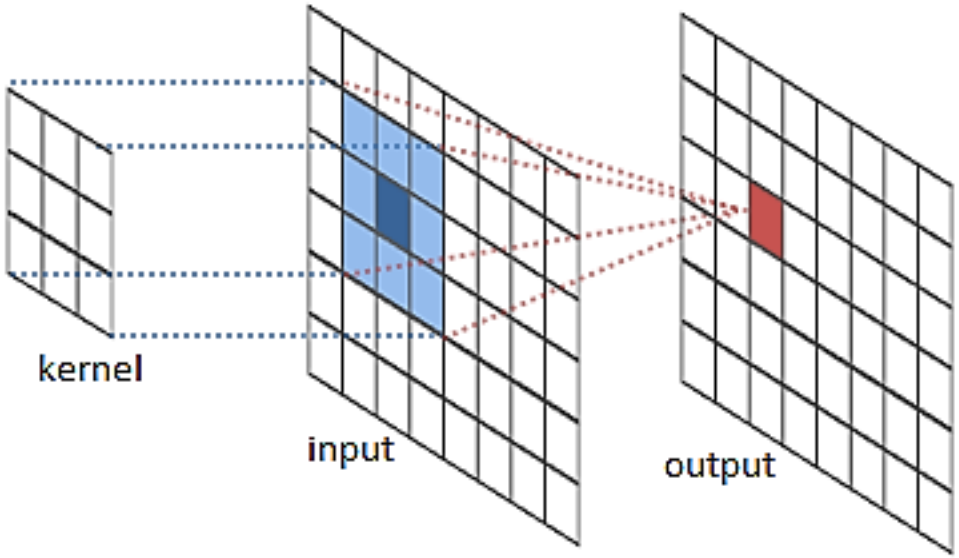
Layer (type)	Output Shape	Param #
conv2d_1 (Conv2D)	(None, 26, 26, 32)	320
conv2d_2 (Conv2D)	(None, 24, 24, 32)	9248
max_pooling2d_1 (MaxPooling2	(None, 12, 12, 32)	0
dropout_1 (Dropout)	(None, 12, 12, 32)	0
flatten_1 (Flatten)	(None, 4608)	0
dense_1 (Dense)	(None, 128)	589952
dropout_2 (Dropout)	(None, 128)	0
dense_2 (Dense)	(None, 10)	1290

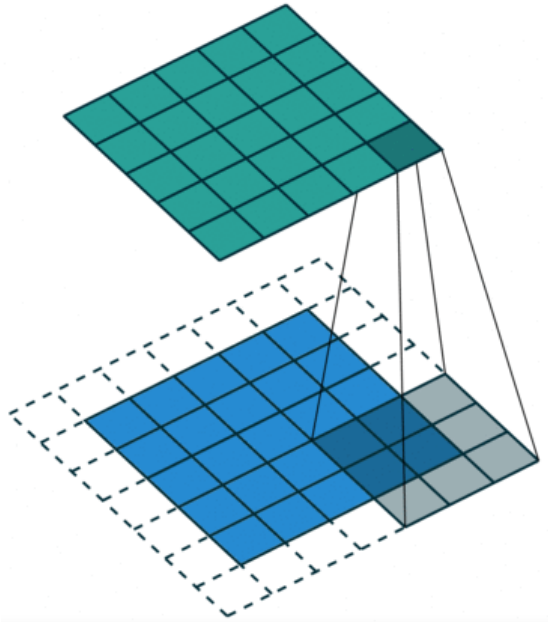


Source: https://towardsdatascience.com/a-simple-2d-cnn-for-mnist-digit-recognition-a998dbc1e79a

Convolution

- Apply kernel to data to provide transformation
- Use padding to preserve input dimensions

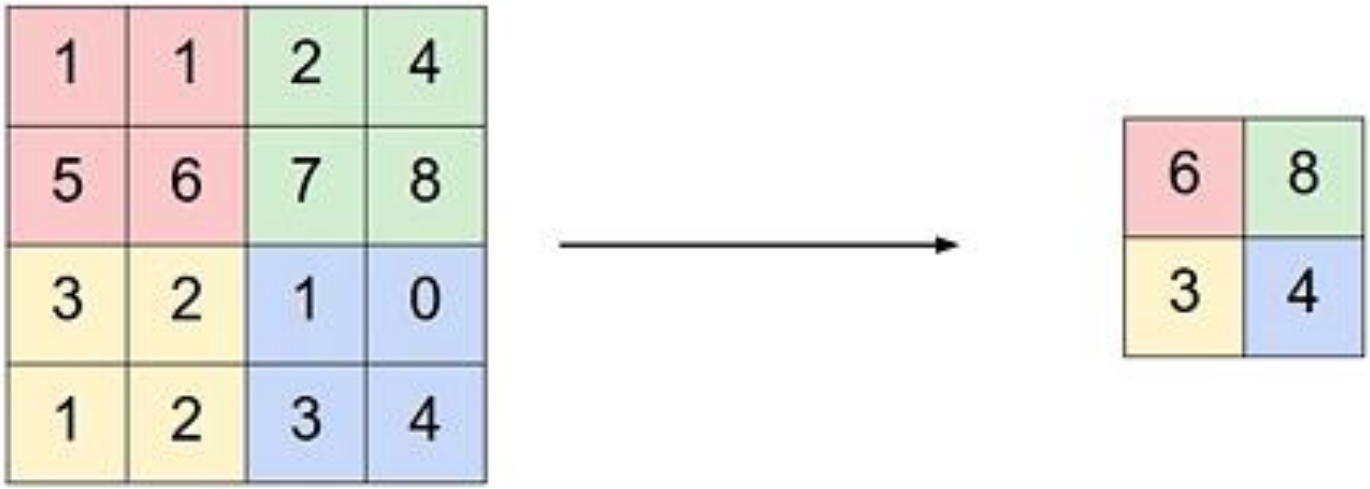




Source: http://cs231n.github.io/convolutional-networks/

Pooling

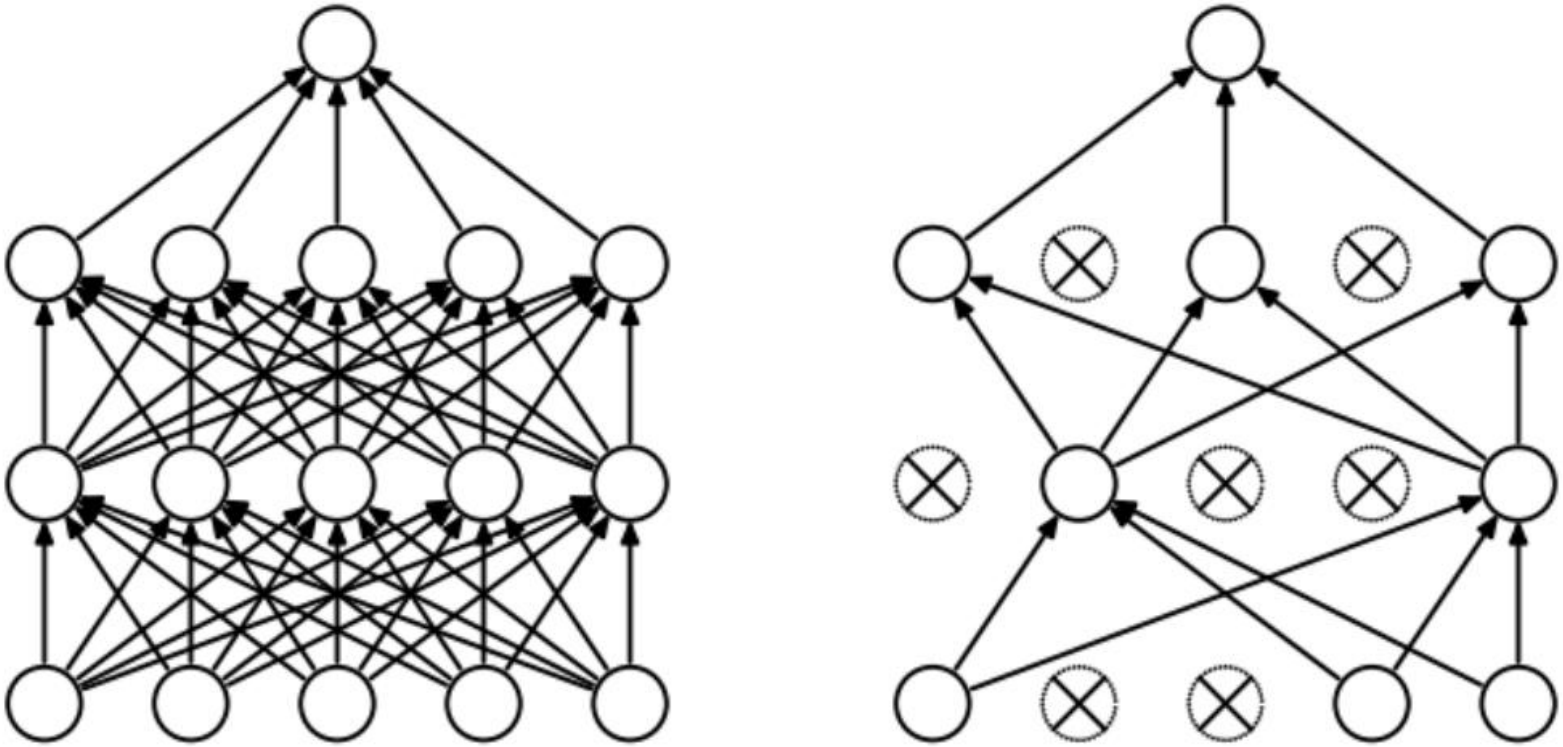
- Reduce dimensionality, i.e. reduce number of parameters
- Controls overfitting
- Different ways of pooling, e.g. max



Source: https://medium.freecodecamp.org/an-intuitive-guide-to-convolutional-neural-networks-260c2de0a050

Dropout

- Drop some nodes for a pass of the algorithm
- Avoid overtraining certain nodes



Source: https://medium.com/p/74334da4bfc5/