Convolutional Neural Network - CNN

Outline

1. Why convolutional neural network

2. Comparison of ANN with CNN in a simple example

3. The structure of convolutional neural network

    - What is filter or convolution

    - What is stride
    - What is padding
    - What is pooling (Max and Average pooling)

4. Looking at different CNN structure (i.e. AlexNet, GoogleNet, ResNet, …)

5. How to code convolutional neural network in python

6. Hands on project

    - What is transfer learning

    - Apply convolutional neural network for image classification
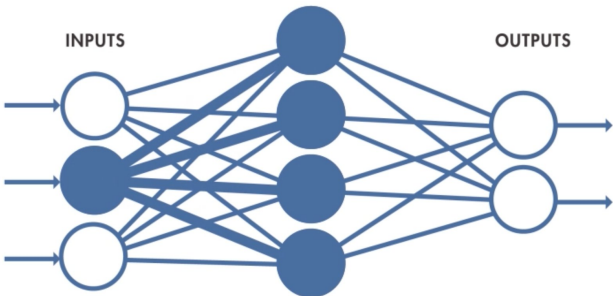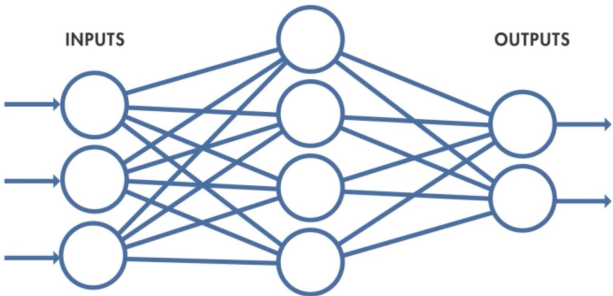
1. Why convolutional neural network

➢ Convolutional neural networks (CNNs) inspired by the study of the brain's visual cortex.

➢ Huble and Wiesel (1958) showed that many neurons in the visual cortex have a small local receptive field . More specifically they showed that some neurons react only to images of horizontal lines while others react only to lines with different orientations.

➢ They also showed some neurons might have larger receptive fields and they react to more complex patterns that are combinations of the lower-level patterns.

➢ CNNs has been used in image recognition since the 1980s.

➢ Image search service, self-driving cars, automatic video classification systems.
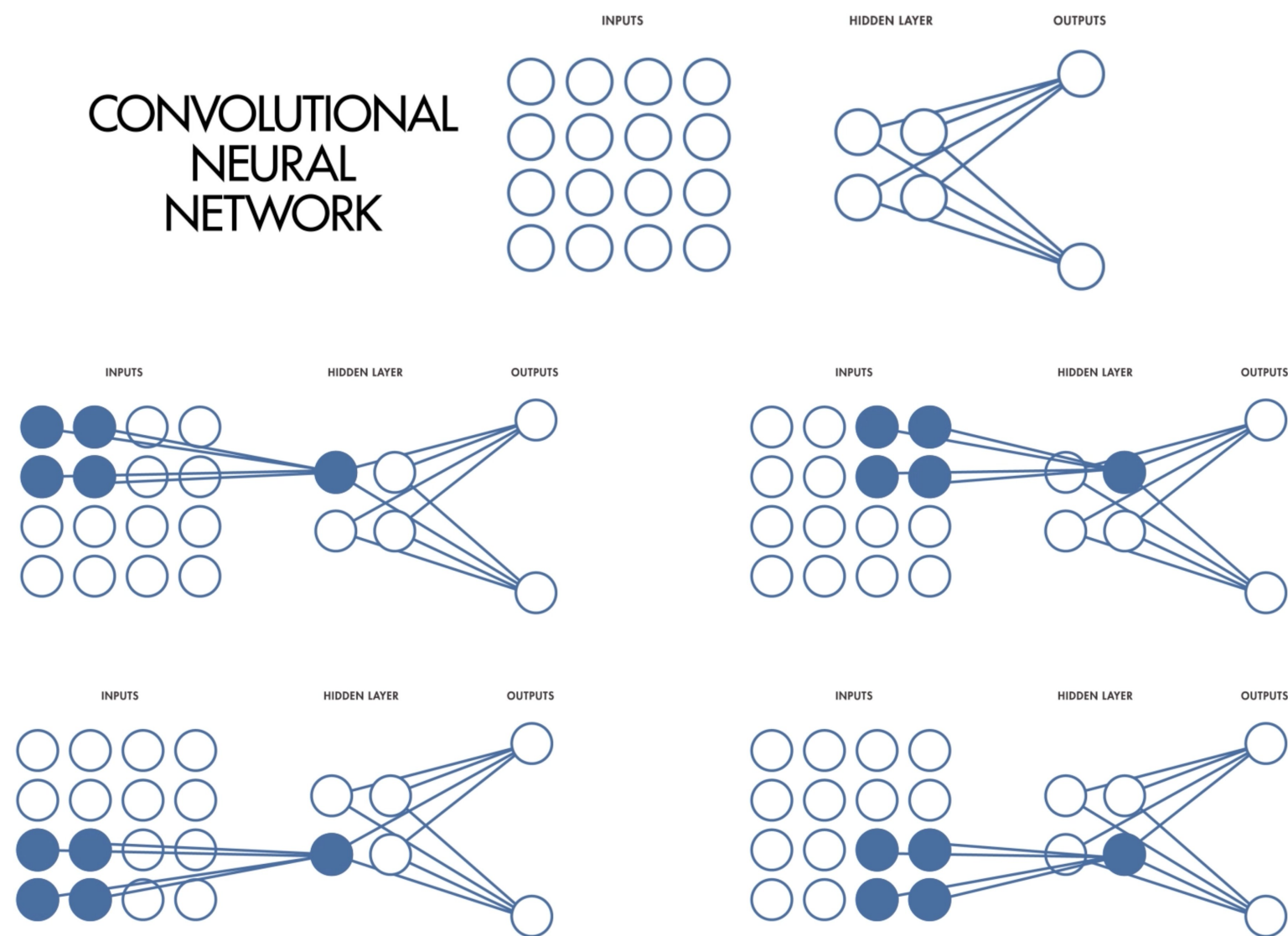
1. Why convolutional neural network

➢ Why not simply use a deep neural network with fully connected layers for image recognition task?`

- This might work for small images

- It breaks down for large images because of the huge number of required parameters

➢ As an example:

- Suppose we have a 100 by 100 – pixel image that has 10,000 pixels.

- The input layer should have 10,000 neurons

- If we only have one hidden layer with a 1000 neurons in it, then for the fully connected network with just one layer we have at least 10,000,000 connections. CNNs solve this problem using partially connected layers and weight sharing.

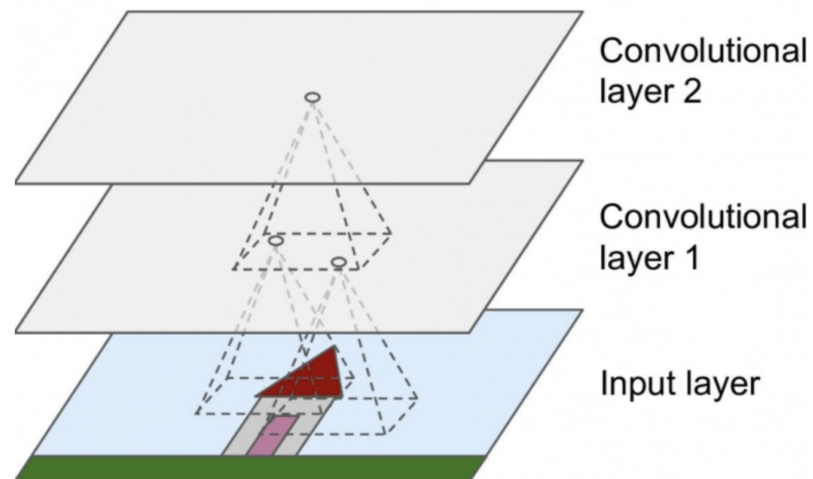# 2. Comparison of ANN with CNN in a simple example

2. Comparison of ANN with CNN in a simple example

3. The structure of convolutional neural network
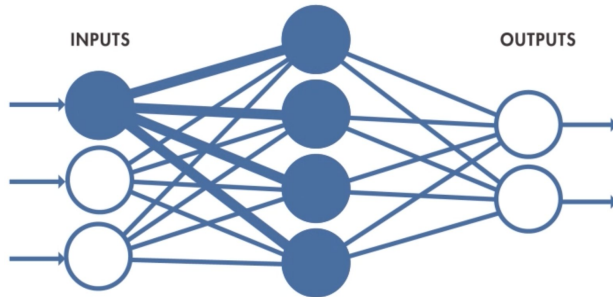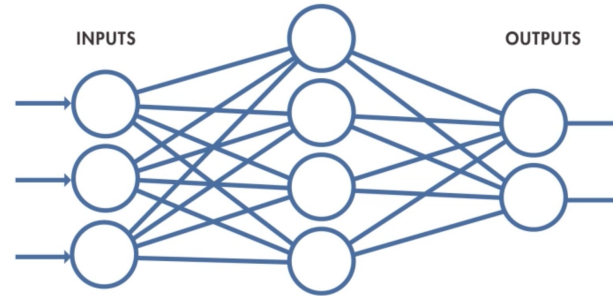
➢ Convolutional Layer

- Neurons in the convolutional layer are not connected to every single pixel in the input image but only to pixels in their receptive fields.

- This architecture allows the network to concentrate on small low-level features in the first hidden layer, then assemble them into larger higher-level features in the next hidden layer and so on.

Convolutional layer 2

Convolutional layer 1

Input layer

3. The structure of convolutional neural network

➢ Shared weights and biases - ANN

Image provided from MathWorks
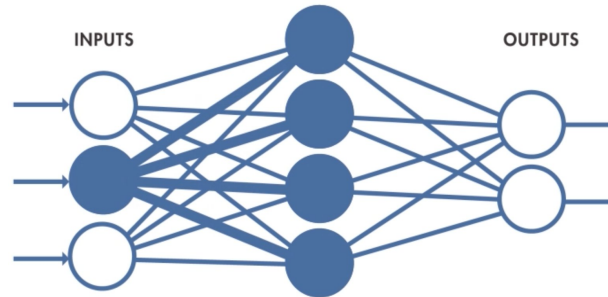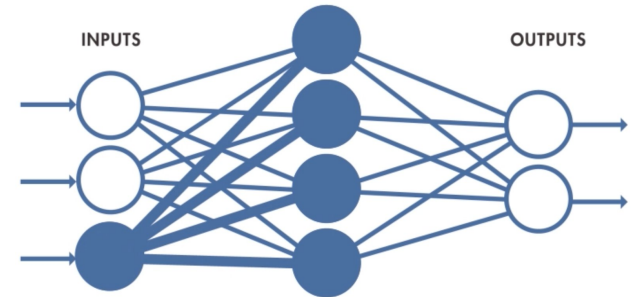
3. The structure of convolutional neural network

➢ Shared weights and biases - CNNs

CONVOLUTIONAL
NEURAL
NETWORK

INPUTS

HIDDEN LAYER

OUTPUTS
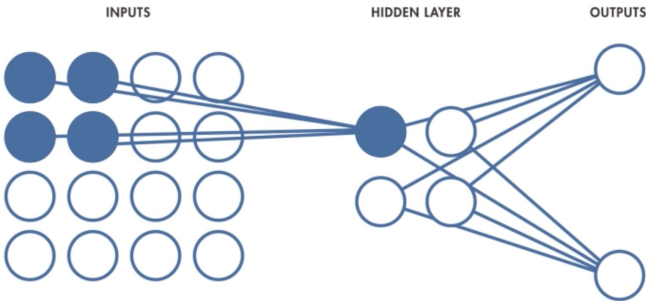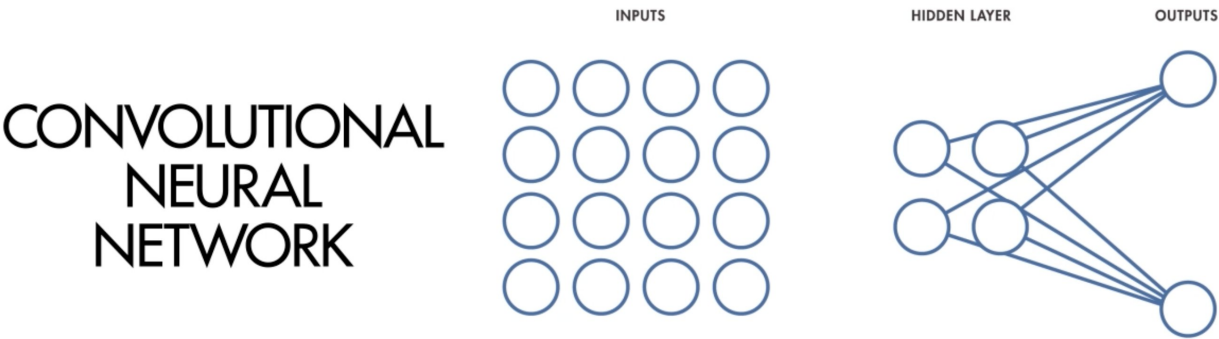
$I_1*W_1 + b$
$I_2*W_2 + b$
$I_3*W_3 + b$
$I_4*W_4 + b$

$I_5*W_1 + b$
$I_6*W_2 + b$
$I_7*W_3 + b$
$I_8*W_4 + b$
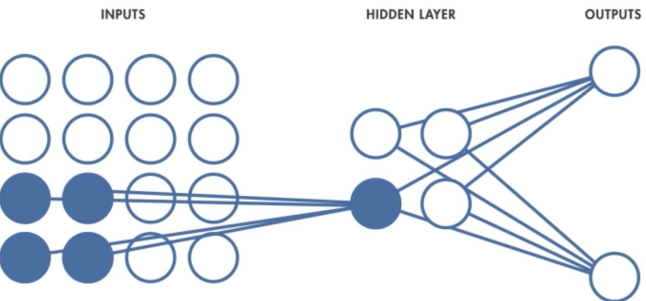
$I_9*W_1 + b$
$I_{10}*W_2 + b$
$I_{11}*W_3 + b$
$I_{12}*W_4 + b$
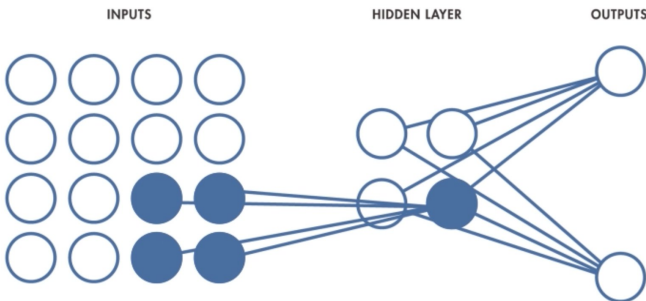
$I_{13}*W_1 + b$
$I_{14}*W_2 + b$
$I_{15}*W_3 + b$
$I_{16}*W_4 + b$

Image provided from MathWork

3. The structure of convolutional neural network

➢ Activation and pooling

Max Pooling   **Average Pooling**
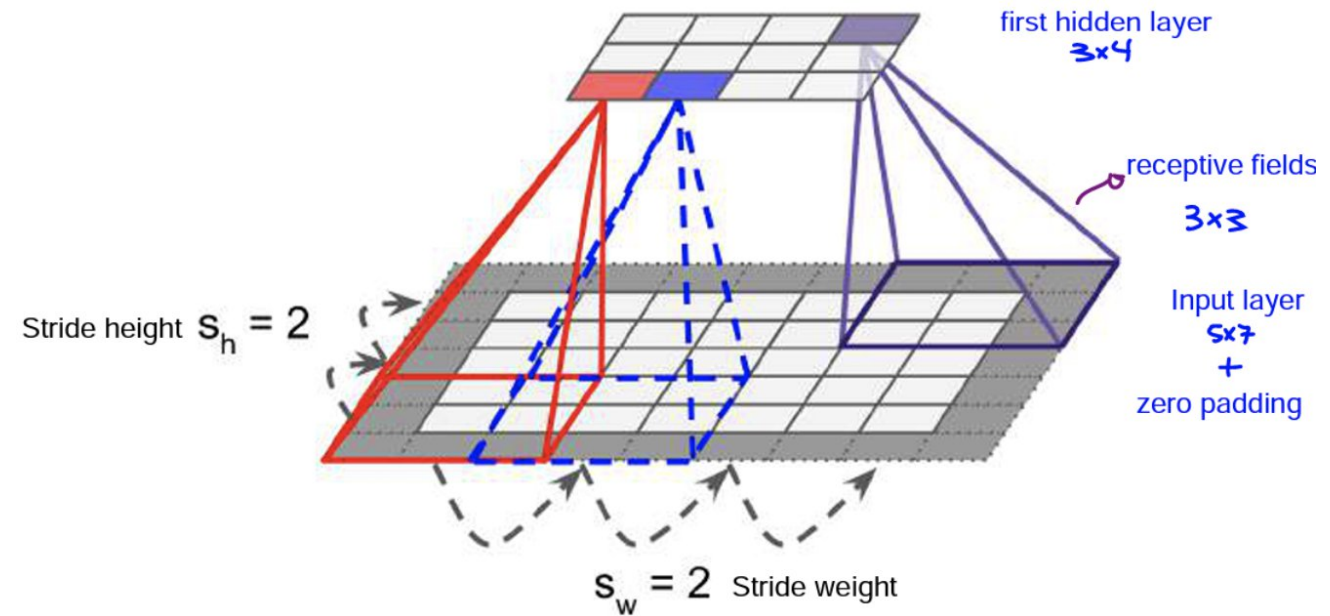
Image provided from MathWorks
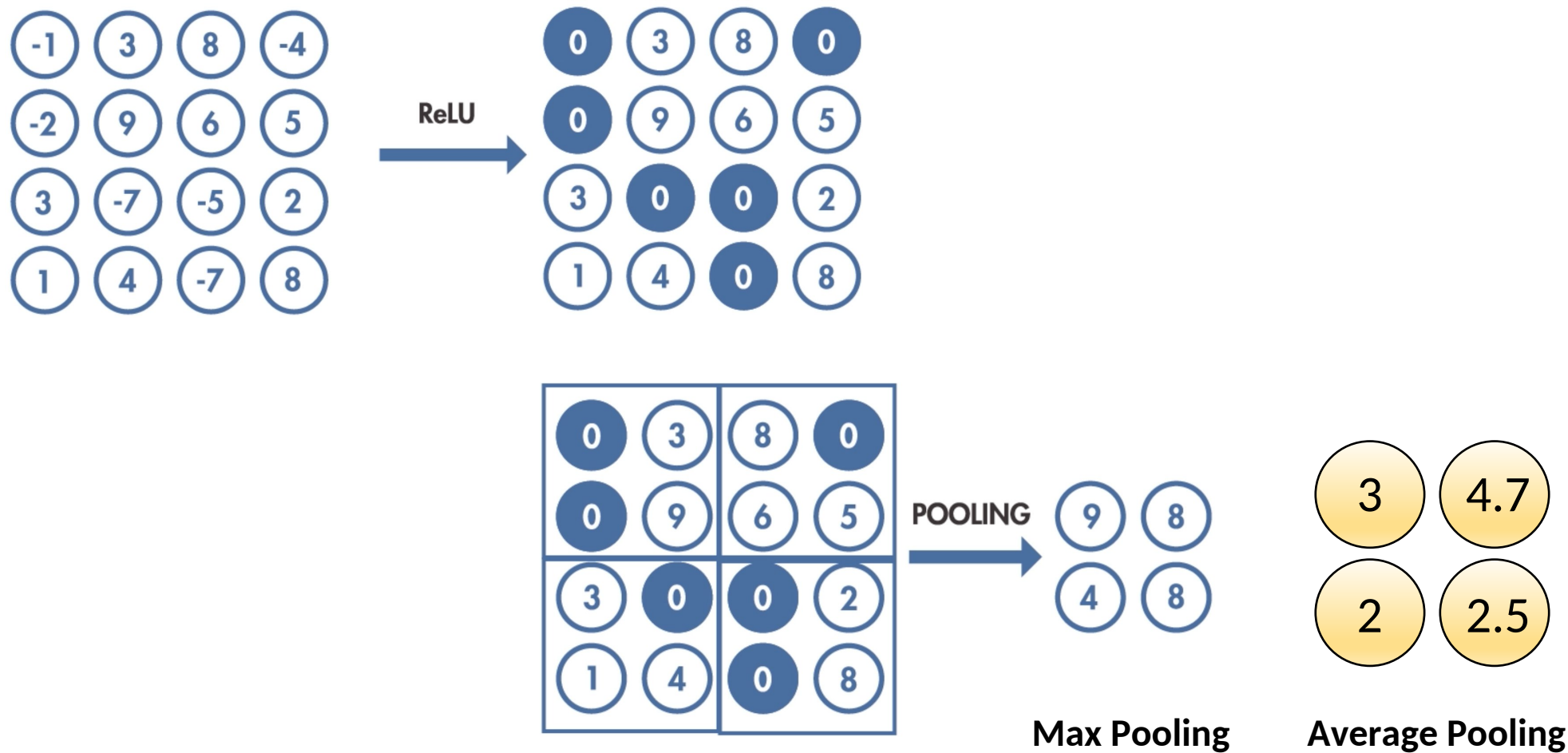
3. The structure of convolutional neural network
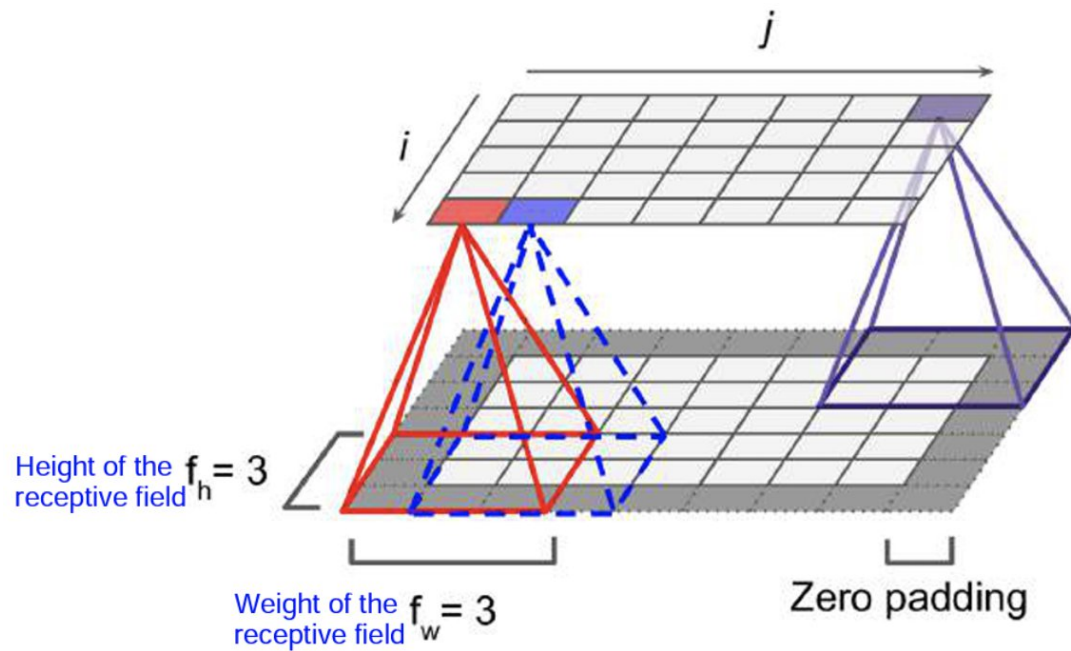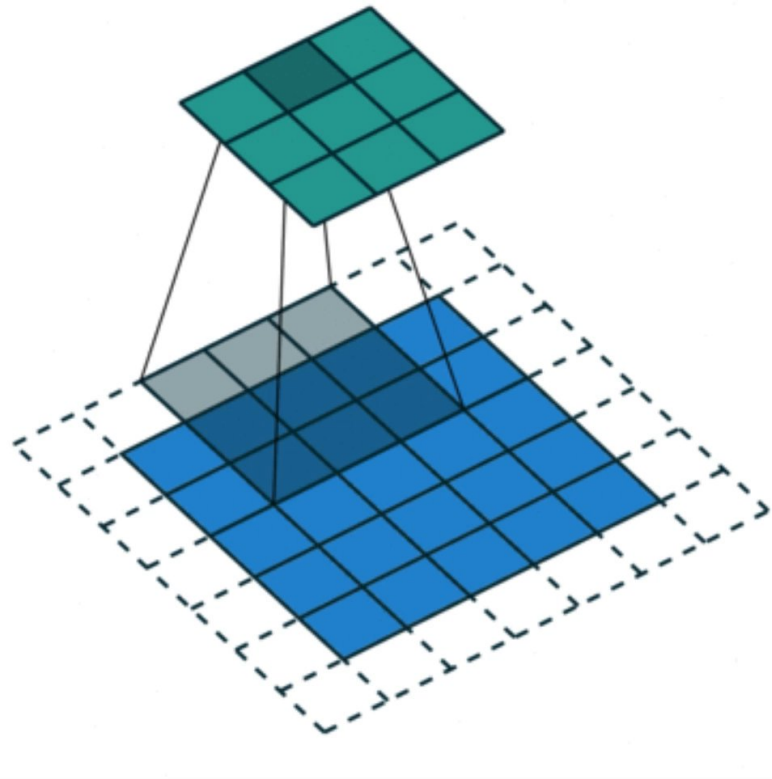
➤ Stride and Padding

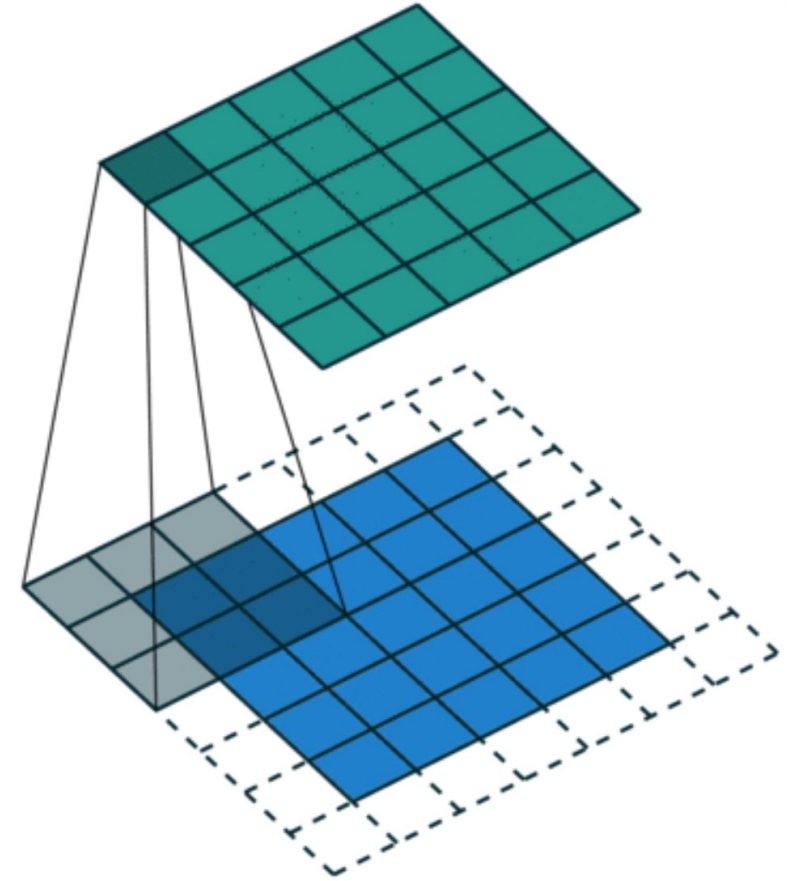Connections between layers and zero padding

Reducing dimensionality using a stride of 2

3. The structure of convolutional neural network
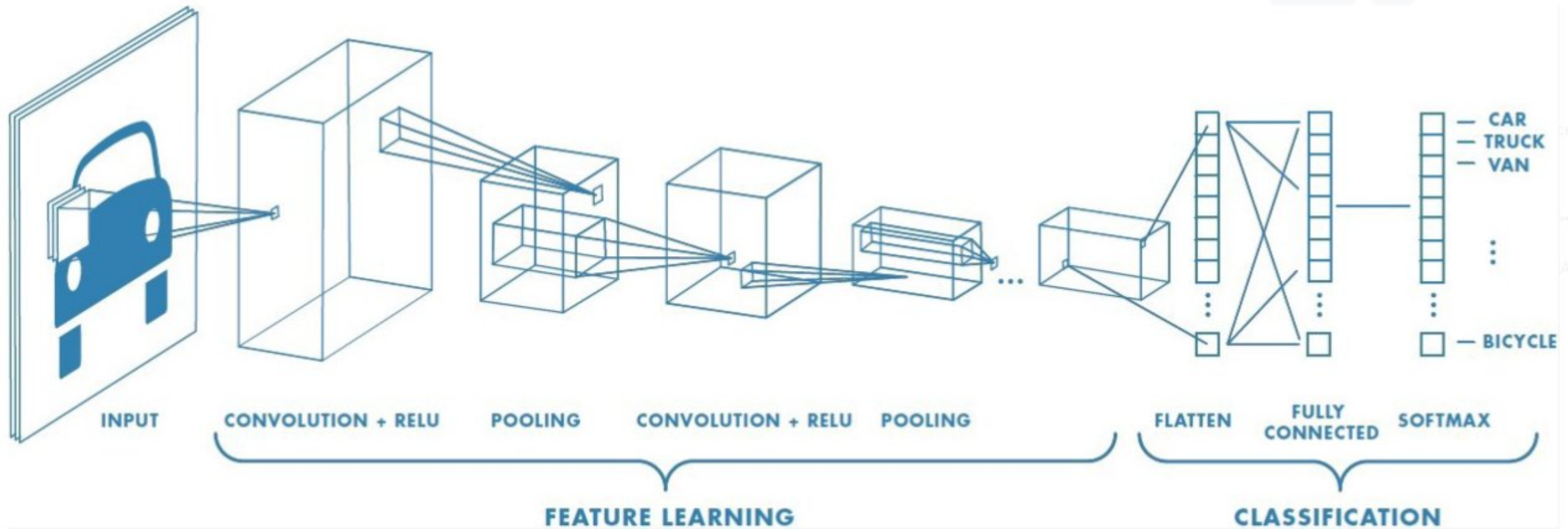
➢ Stride and Padding

Convolution Operation with Stride Length = 2

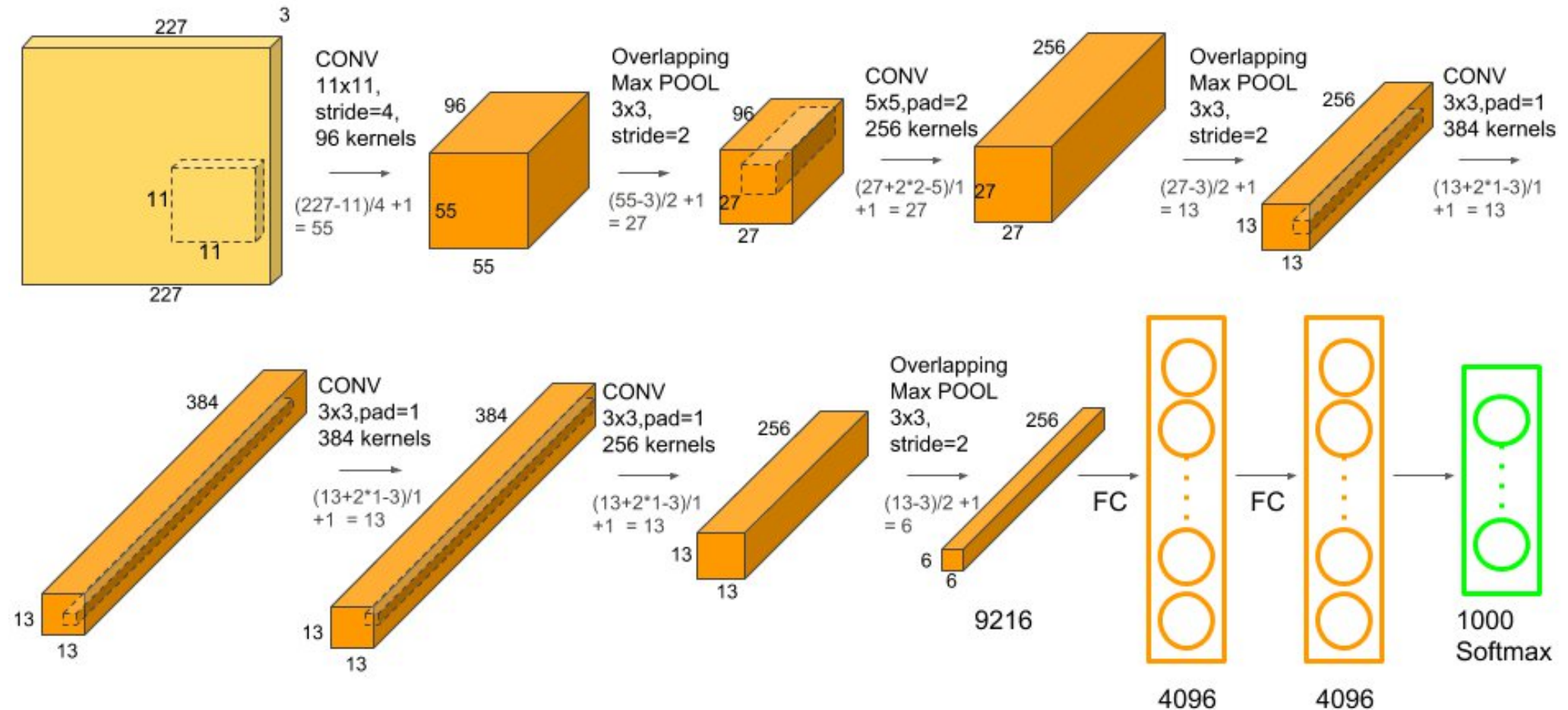SAME padding: 5×5×1 image is padded with 0s to create a 6×6×1 image

Image provided from MathWorks

3. The structure of convolutional neural network

INPUT CONVOLUTION + RELU POOLING CONVOLUTION + RELU POOLING FLATTEN FULLY CONNECTED SOFTMAX

— CAR
— TRUCK
— VAN
— BICYCLE

FEATURE LEARNING

CLASSIFICATION

Schematic representation of a convolutional neural network with two hidden layers

Image provided from MathWork

4. Looking at different CNN structure

AlexNet – won the 2012 ImageNet challenge

Image provided from LearnOpenCV

4. Looking at different CNN structure

ResNet
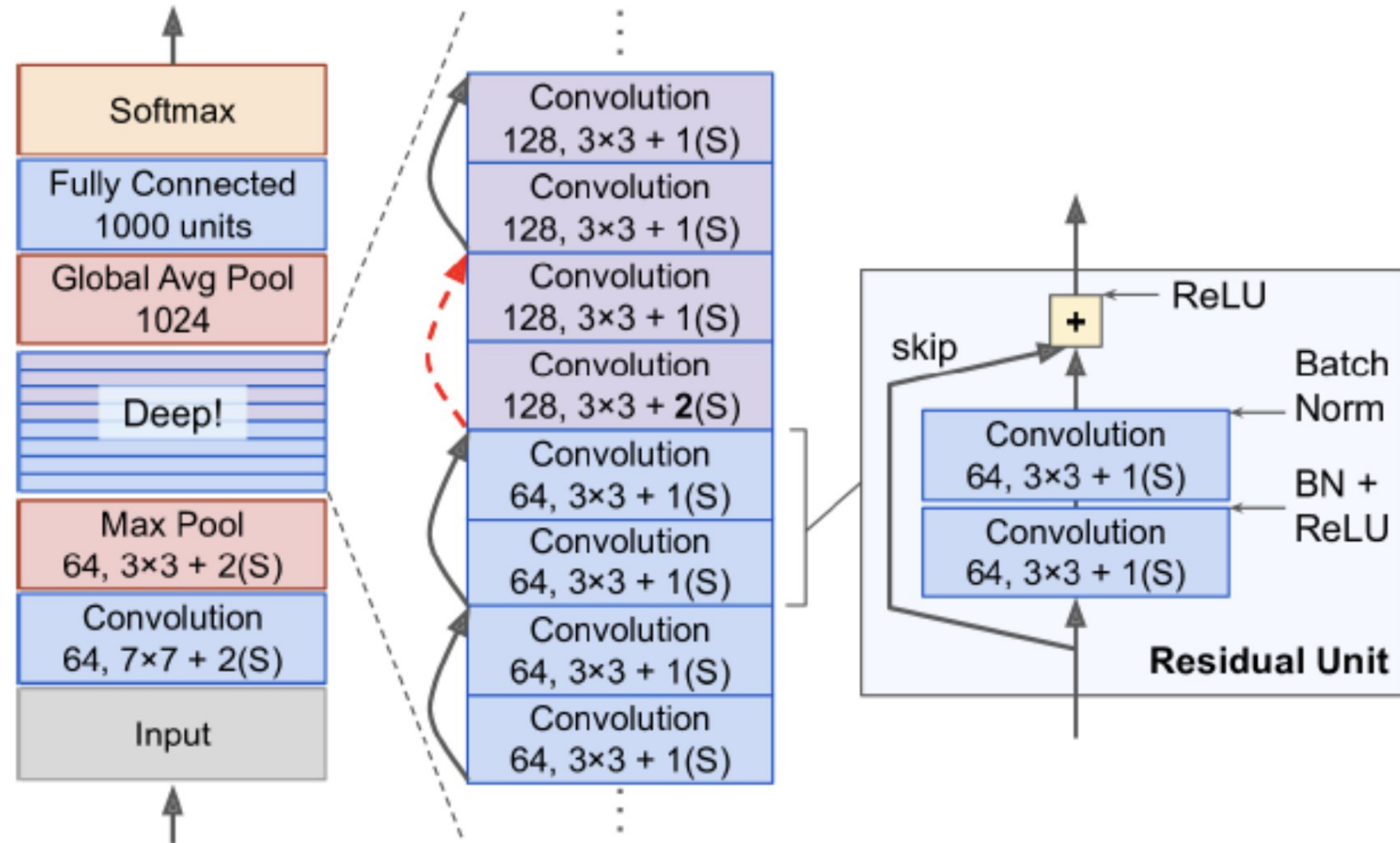
Image provided from https://jason-adam.github.io/resne

5. How to code convolutional neural network in python

Image provided from MathWork

5. How to code convolutional neural network in python

Image provided from MathWork
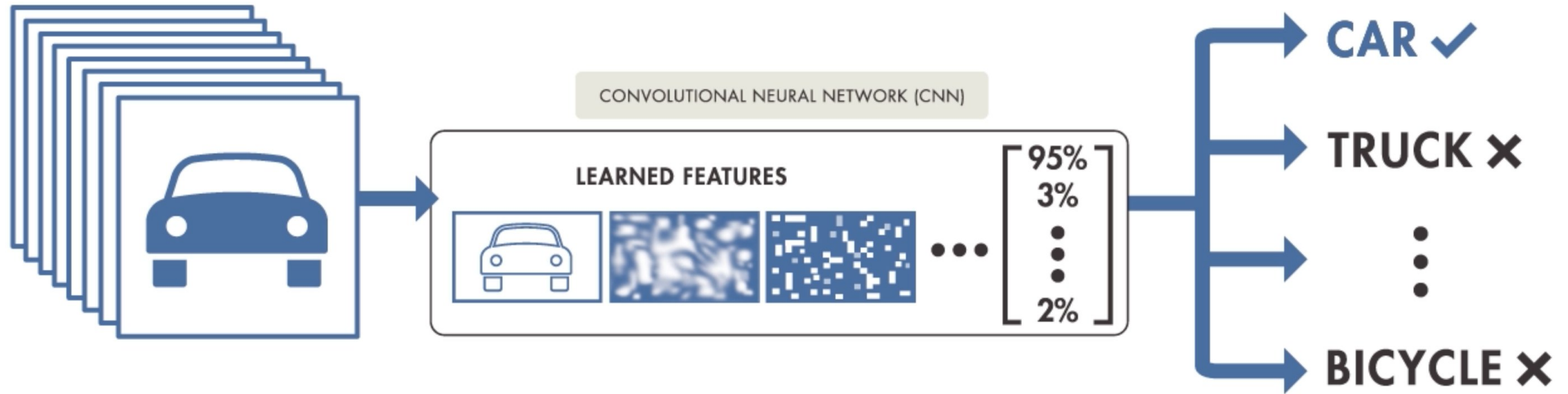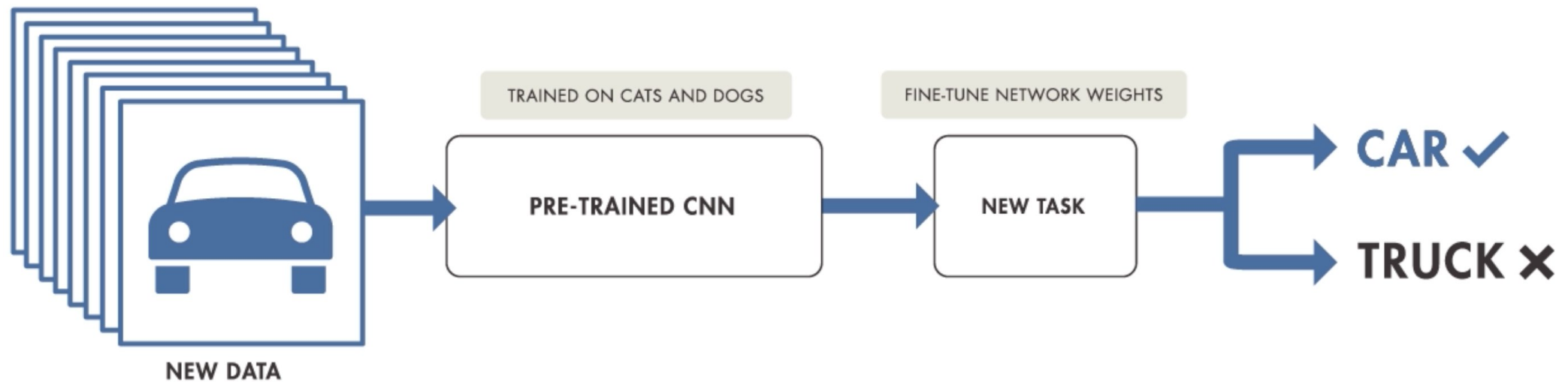
6. Hands on project

Convolutional Network Demo from 1993

6. Hands on project

We are going to use the handwritten digit dataset and using convolutional neural network for digit classi

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