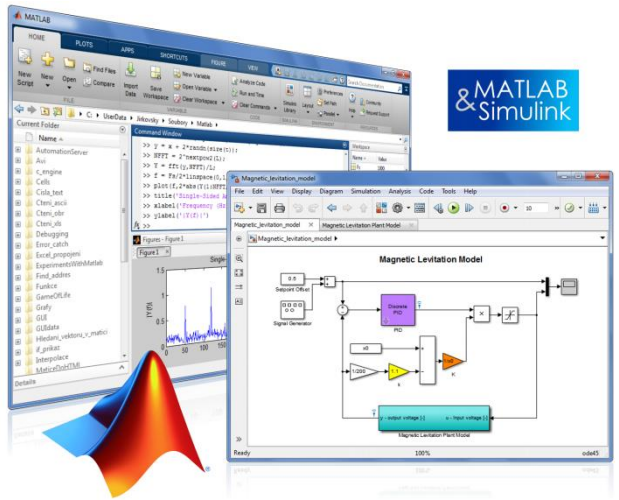
HUMUSOFT®

Od klasifikace snímků po sémantickou segmentaci

Deep Learning v prostředí MATLAB



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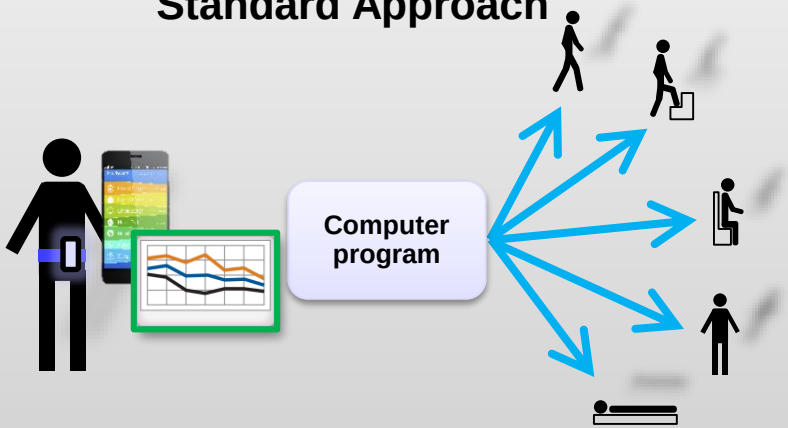
What is Machine Learning ?

Machine learning uses data and produces a program to perform a task

Task: Human Activity Detection

Standard Approach



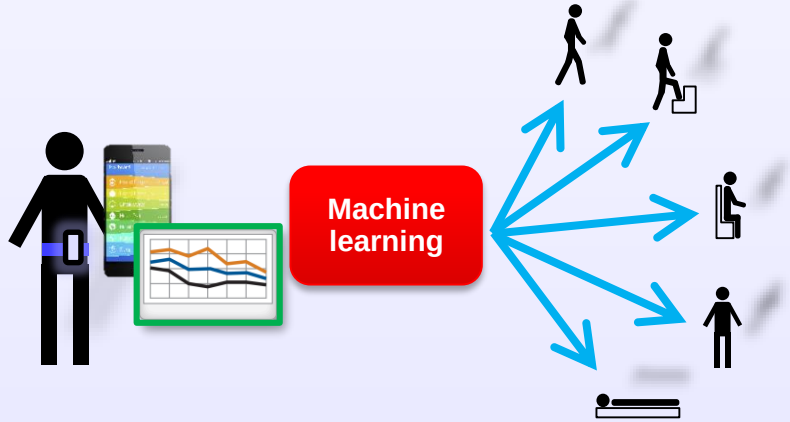
Hand Written Program

If X_acc > 0.5
then “SITTING”
If Y_acc < 4 and Z_acc > 5
then “STANDING”
…

Formula or Equation

$$Y_{activity} = \beta_1 X_{acc} + \beta_2 Y_{acc} + \beta_3 Z_{acc} + \dots$$

Machine Learning Approach

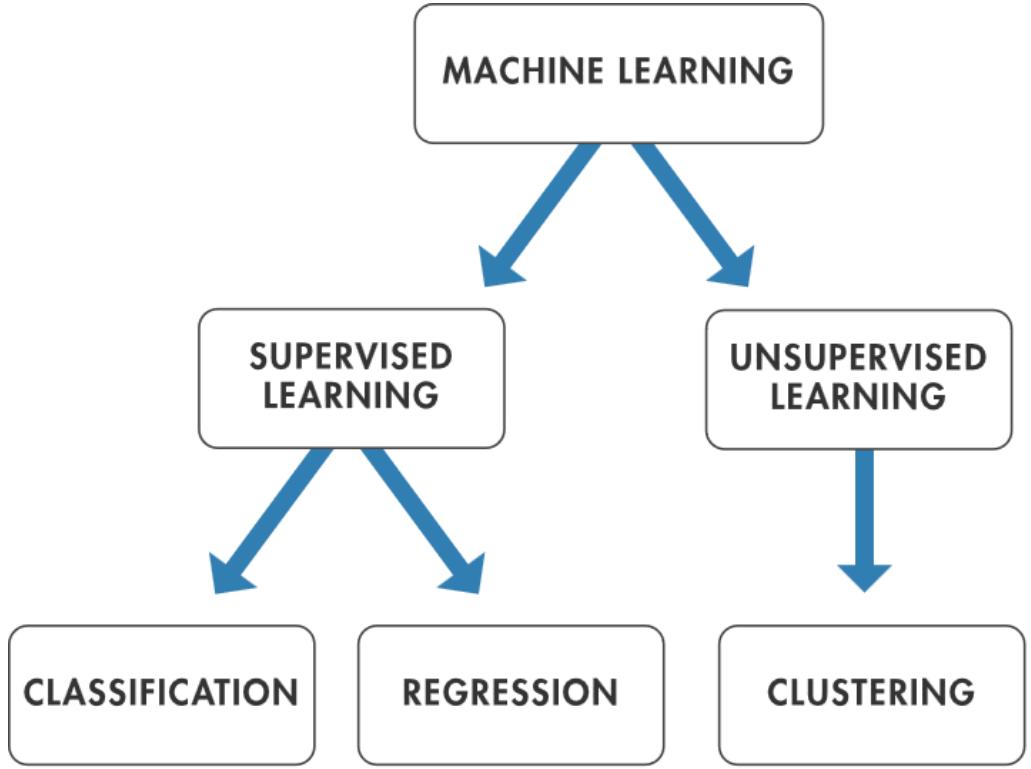


$model$: Inputs → Outputs

$$model = <^{Machine\ Learning\ Algorithm}> (sensor\_data, activity)$$

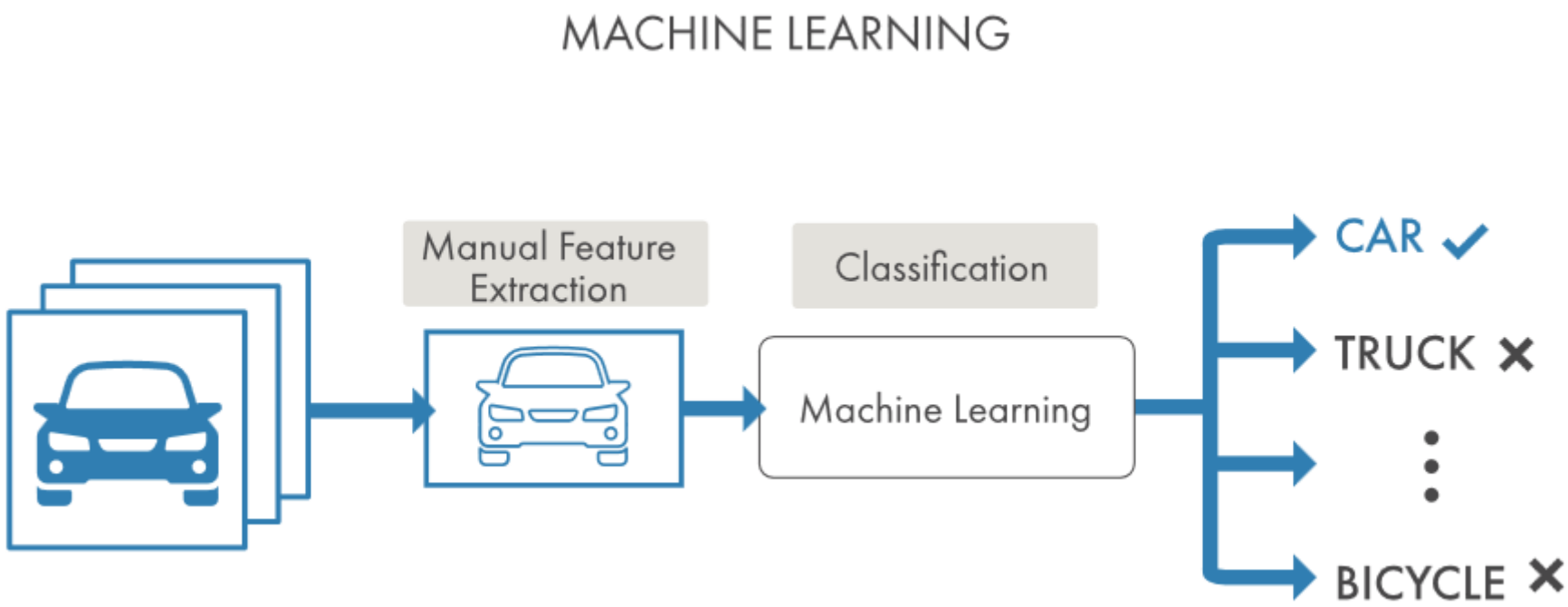
Machine Learning

Different Types of Learning:



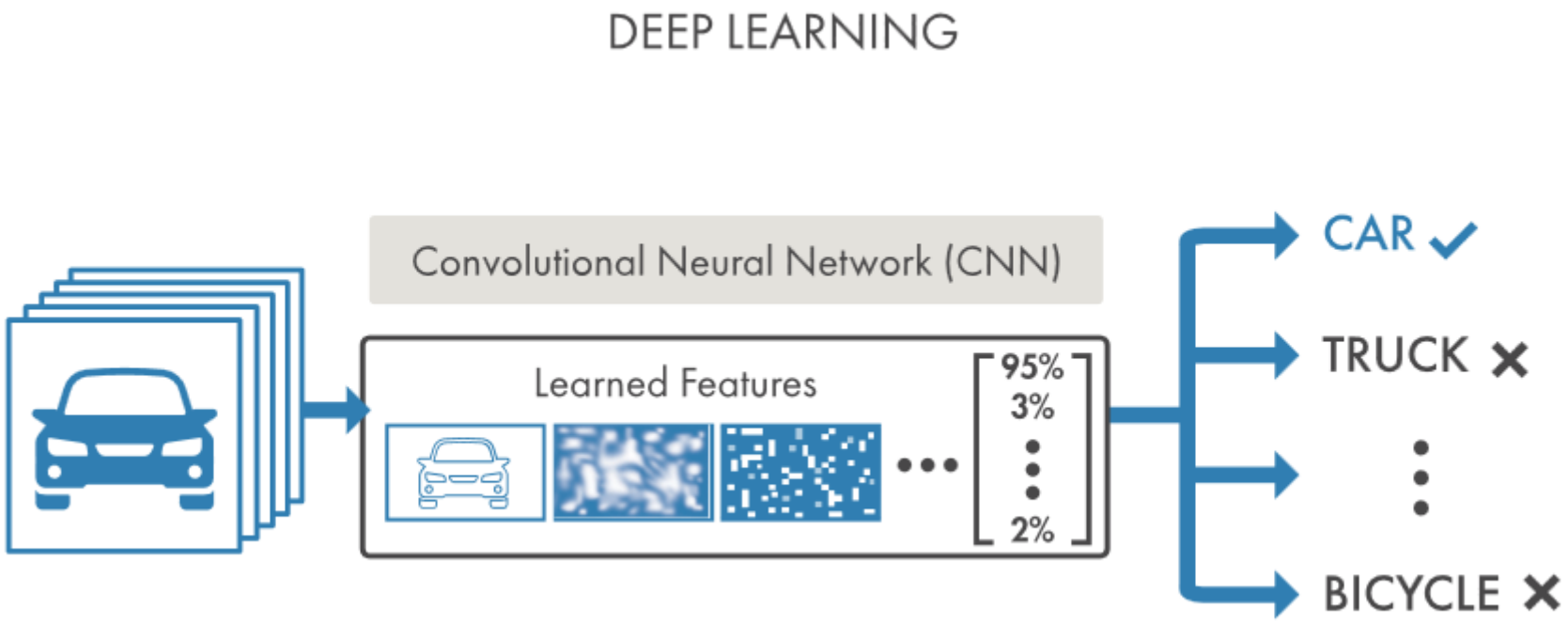
Machine Learning

Machine learning uses data and produces a program to perform a task



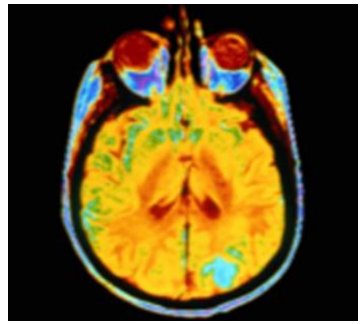
What is Deep Learning ?

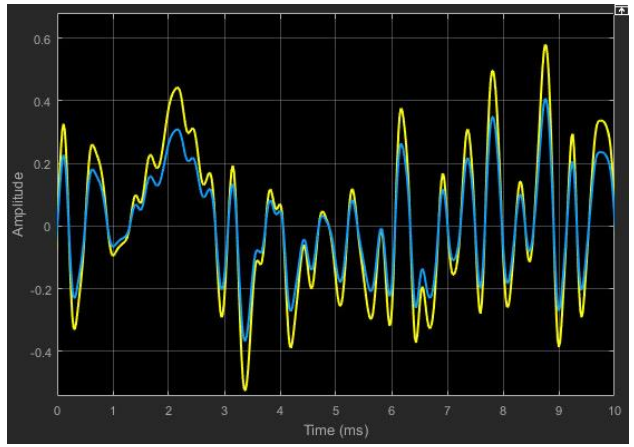
Deep learning performs end-end learning by learning features, representations and tasks directly from images, text and sound



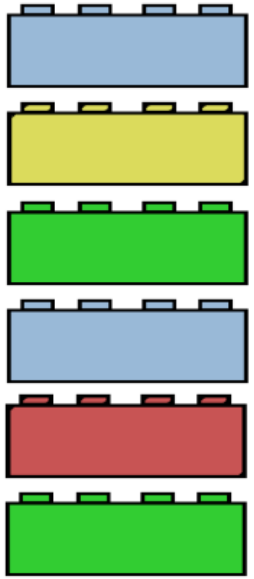
Deep Learning is Ubiquitous

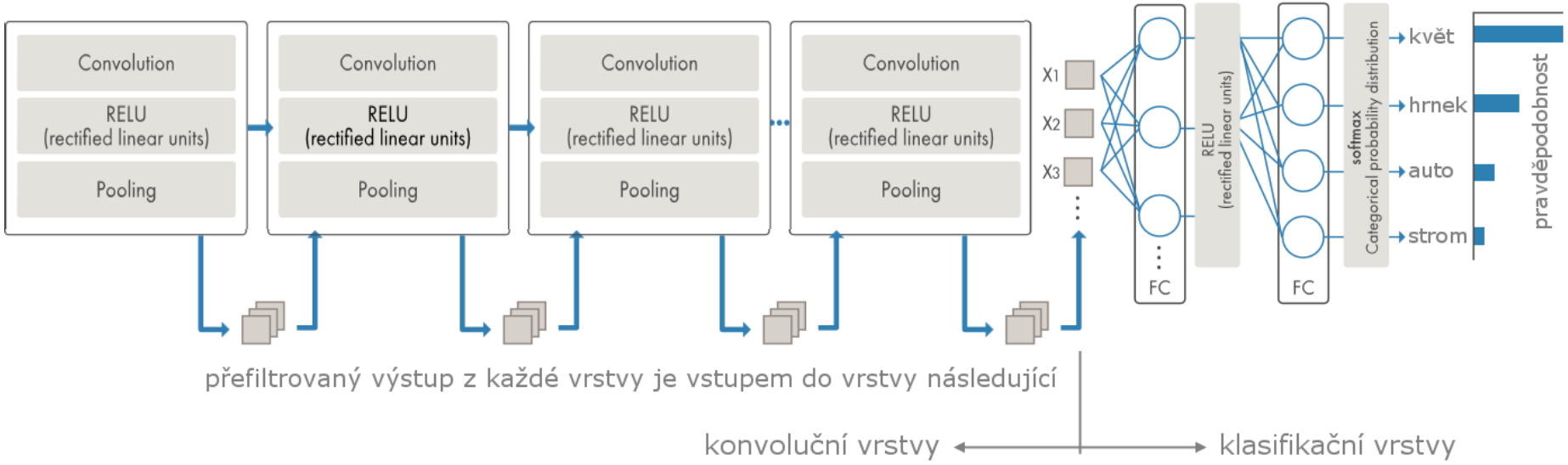
- **Computer Vision**
- **Signal Processing**
- **Robotics & Controls**
- **…**



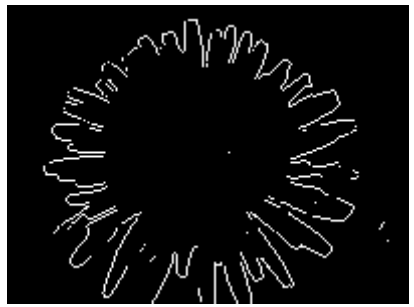


Convolutional Neural Networks (CNN)





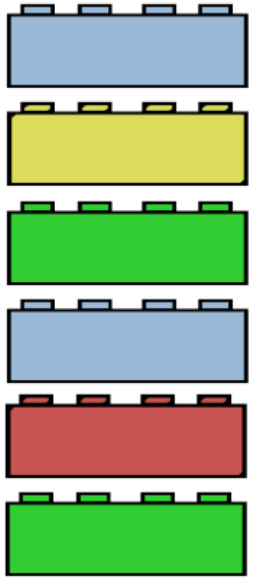
What do filters do?

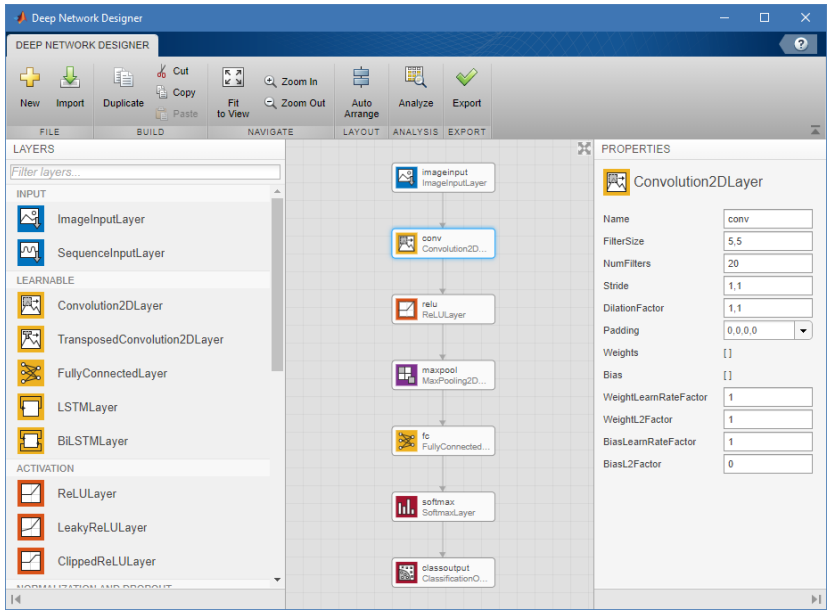


Great for classification:

- Convolution Layer
- ReLU Layer
- Max Pooling Layer

CNN in MATLAB






```
layers = [imageInputLayer([28 28 1])
          convolution2dLayer(5,20)
          reluLayer()
          maxPooling2dLayer(2,'Stride',2)
          fullyConnectedLayer(10)
          softmaxLayer()
          classificationLayer()];
```

```
options = trainingOptions('sgdm');
convnet = trainNetwork(trainingData,layers,options);
results = classify(convnet,newData);
```

>30 Layers

imageInputLayer	Image input layer
image3dInputLayer	3-D image input layer
convolution2dLayer	2-D convolutional layer
convolution3dLayer	
groupedConvolution2dLayer	
transposedConv2dLayer	
transposedConv3dLayer	
fullyConnectedLayer	
reluLayer	

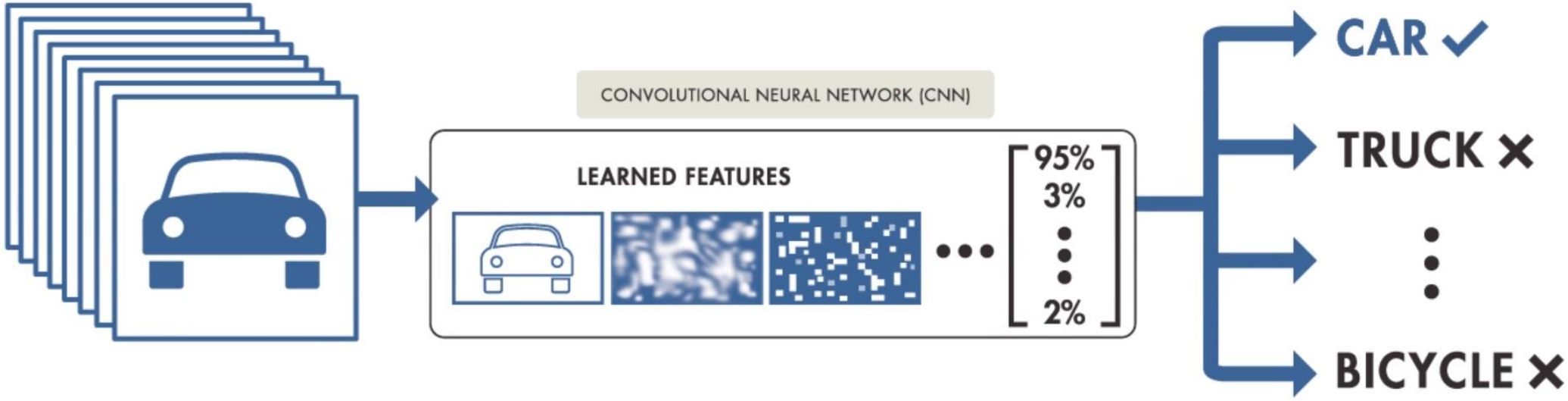
leakyReluLayer	Leaky Rectified Linear Unit (ReLU) layer
clippedReluLayer	Clipped Rectified Linear Unit (ReLU) layer
eluLayer	Exponential linear unit (ELU) layer
tanhLayer	
batchNormalizationLayer	
crossChannelNormalizationLayer	
dropoutLayer	
averagePooling2dLayer	
averagePooling3dLayer	

maxPooling2dLayer	Max pooling layer
maxPooling3dLayer	3-D max pooling layer
maxUnpooling2dLayer	Max unpooling layer
additionLayer	Addition layer
concatenationLayer	Concatenation layer
depthConcatenationLayer	Depth concatenation layer
softmaxLayer	Softmax layer
classificationLayer	Classification output layer
regressionLayer	Create a regression output layer

- **Author custom layers in MATLAB using the Custom Layer API**

2 Approaches for Deep Learning

- **Approach 1: Train a Deep Neural Network from Scratch**

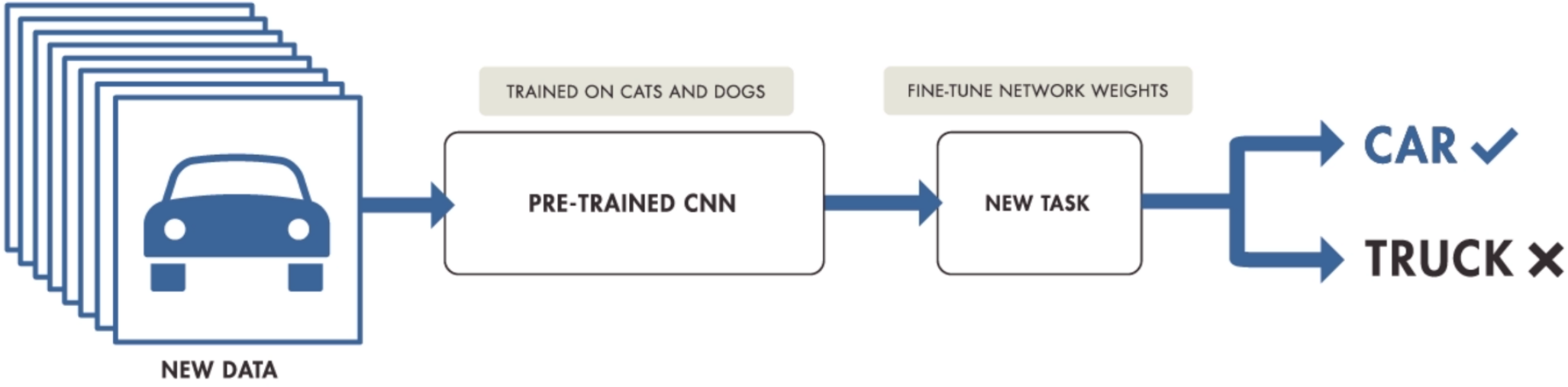


Recommended only when:

Training data	1000s to millions of labeled images
Computation	Compute intensive
Training Time	Days to Weeks for real problems
Model accuracy	High (can overfit to small datasets)

2 Approaches for Deep Learning

- **Approach 2: Fine-tune a pre-trained model (transfer learning)**

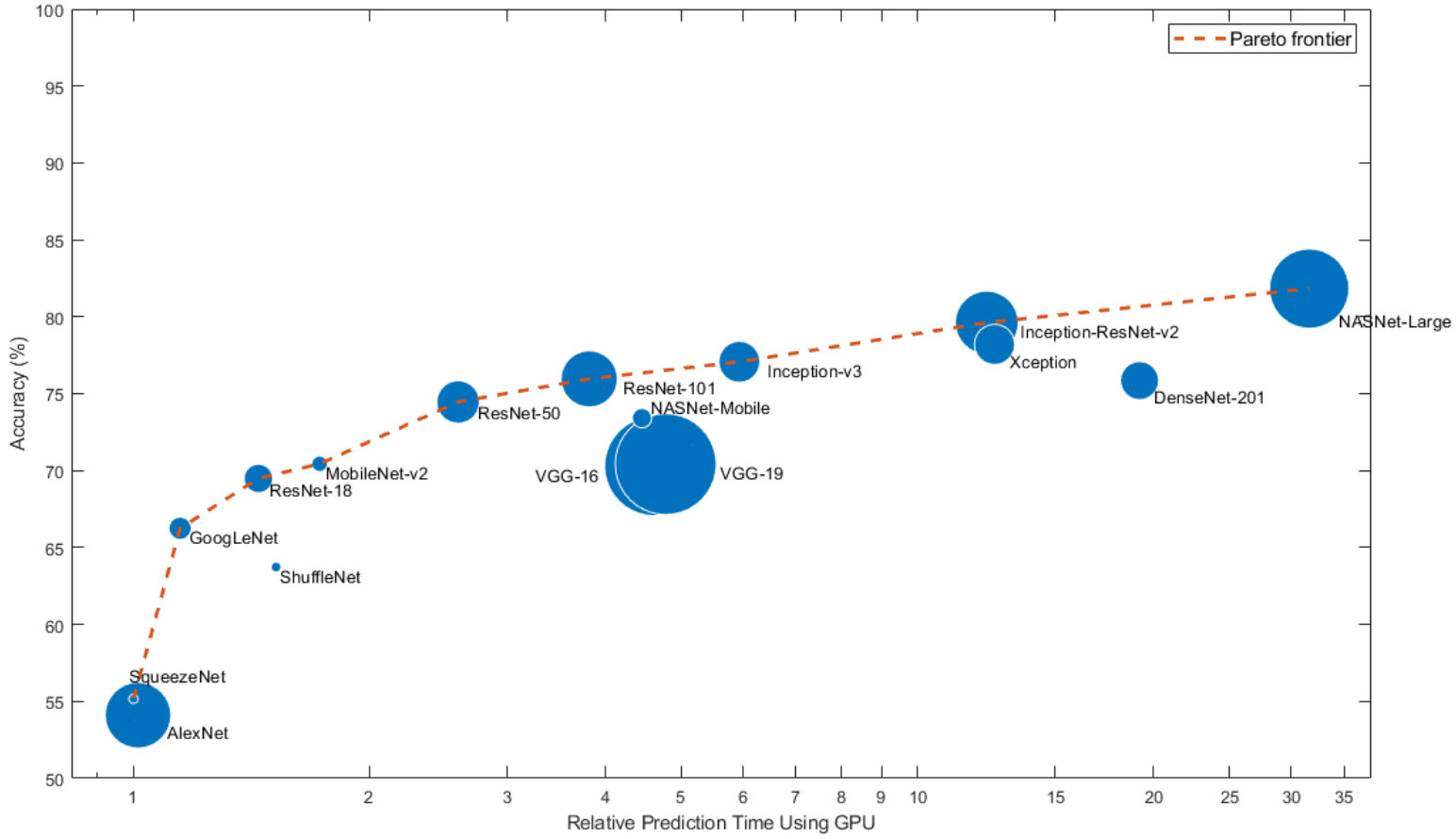


Recommended when:

Training data	100s to 1000s of labeled images (small)
Computation	Moderate computation
Training Time	Seconds to minutes
Model accuracy	Good, depends on the pre-trained CNN model

Transfer Learning using Pre-Trained Networks

- **Pre-Trained Networks**
  - AlexNet
  - VGG-16 and VGG-19
  - GoogLeNet
  - ResNet-50 and ResNet-101
  - Inception-v3
  - Inception-ResNet-v2
  - SqueezeNet
  - and more …



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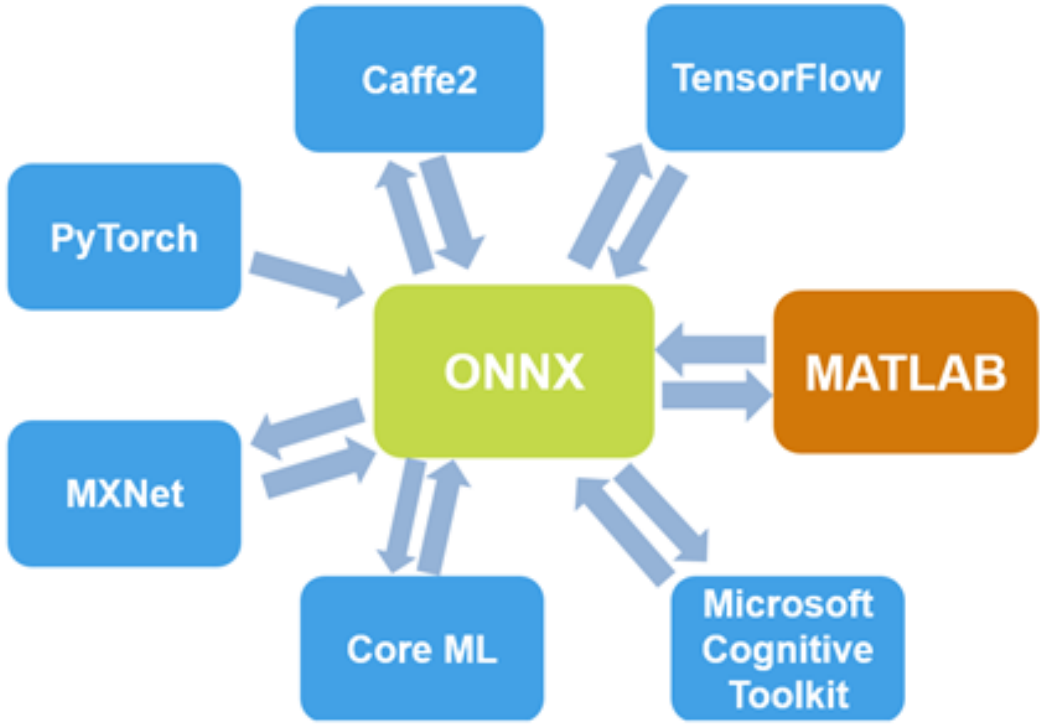
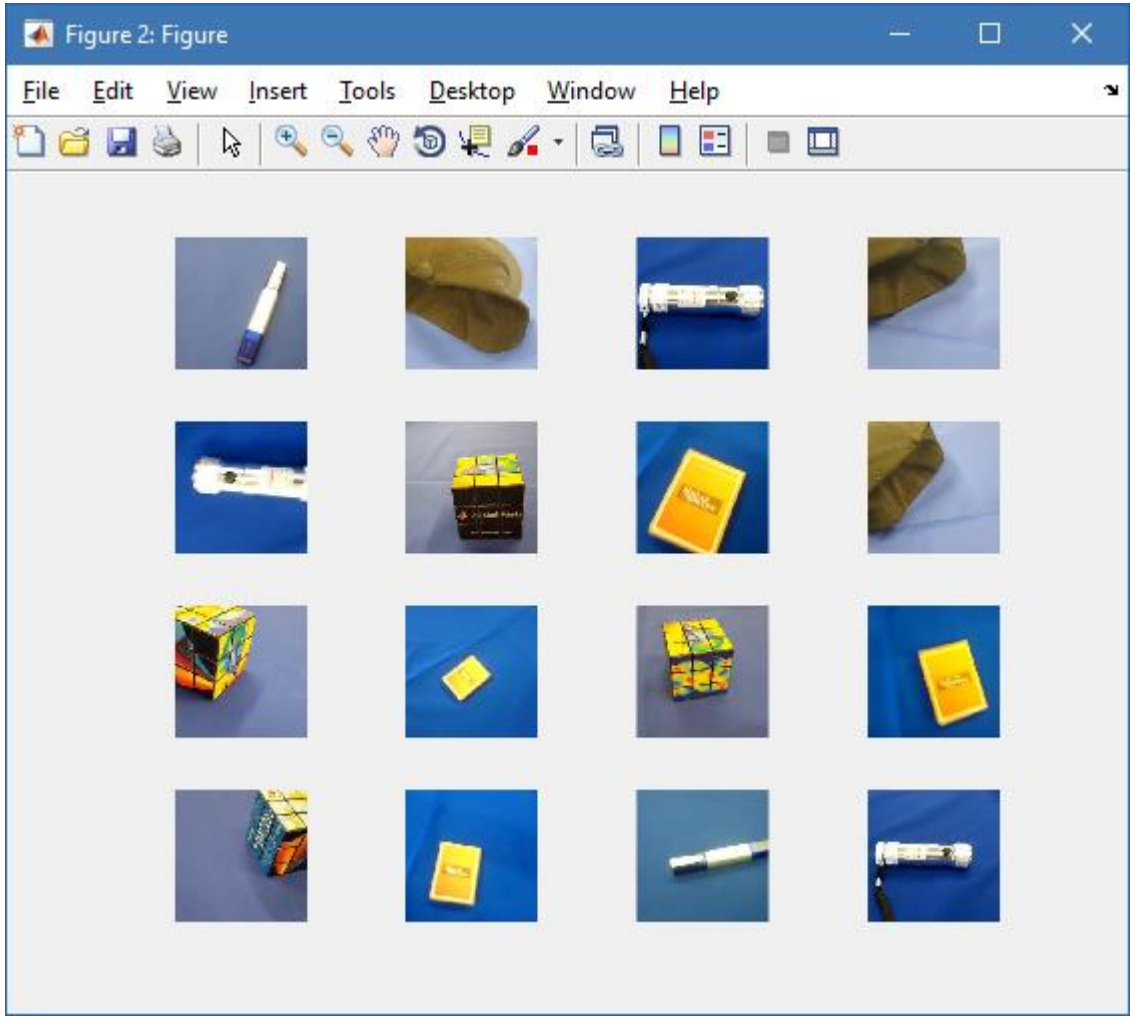
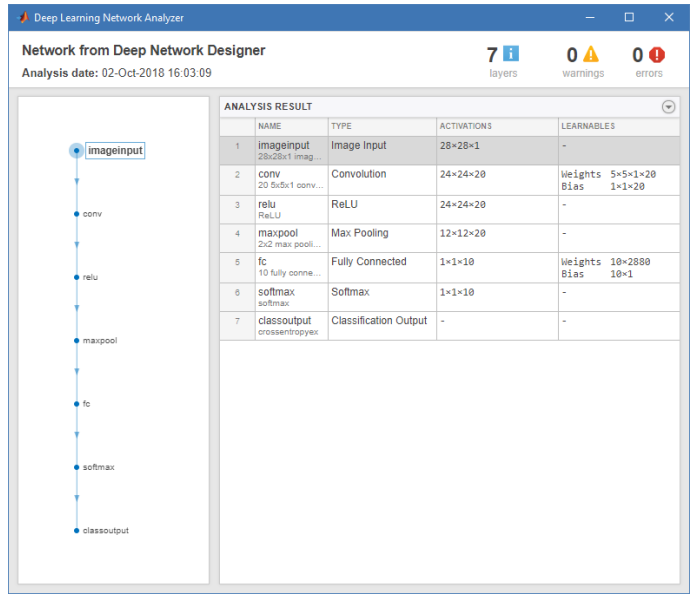


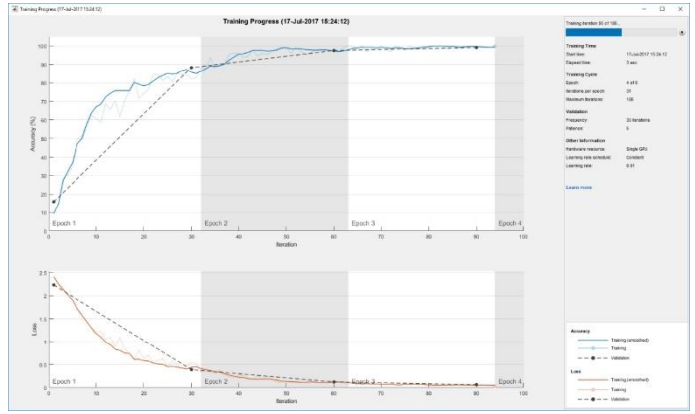
- **ONNX Model Converter**

Example: Fine-tune a pre-trained model (transfer learning)



Training, Validation and Visualization

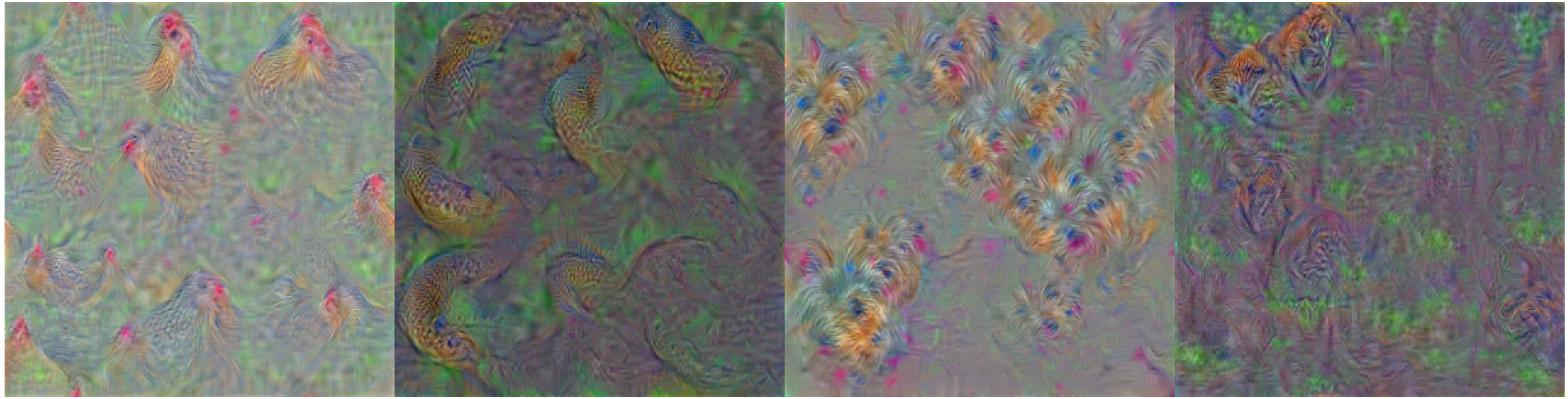




- **Network Analyzer (`analyzeNetwork`)**
  - find problems in network architectures before training
- **Monitor training progress**
  - plots for accuracy, loss, validation metrics, and more
- **Automatically validate network performance**
  - stop training when the validation metrics stop improving
- **Perform hyperparameter tuning**
  - using Bayesian optimization
- **Visualize activations and filters from intermediate layers, CAM**
- **Deep Dream visualization**

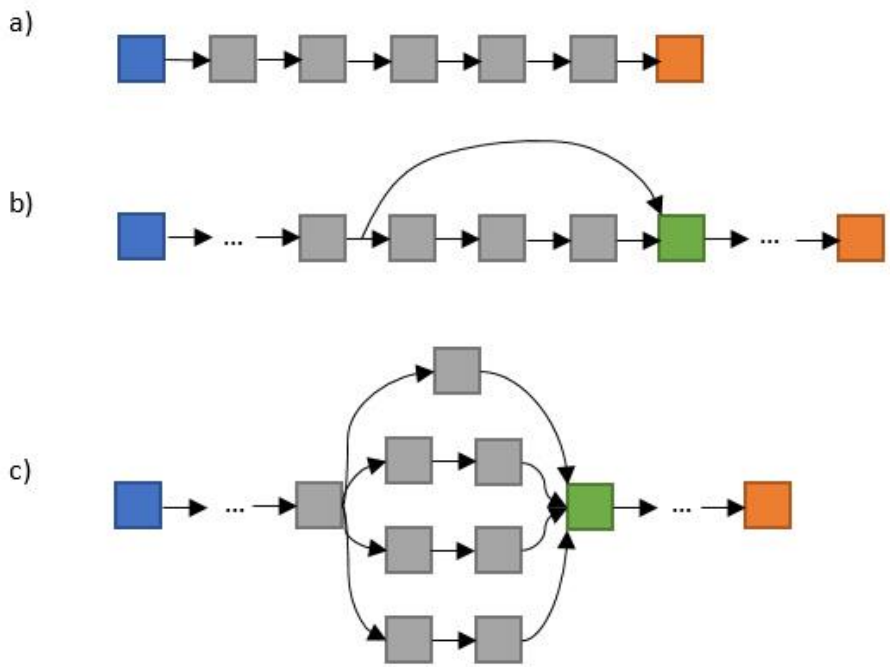
Deep Dream Images Using AlexNet

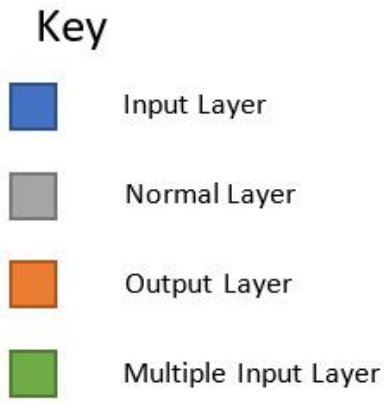
Hen | **Indian cobra** | **Yorkshire terrier** | **Tiger**



Directed Acyclic Graphs (DAG) Networks

- **Represent complex architectures**
  - `layerGraph, plot, addLayers, removeLayers, connectLayers, disconnectLayers`
- **Addition layer, Depth concatenation layer**





a) **layers connected in series**

b) **DAG network: layers are skipped (ResNet)**

c) **DAG network: layers are connected in parallel (GoogLeNet)**

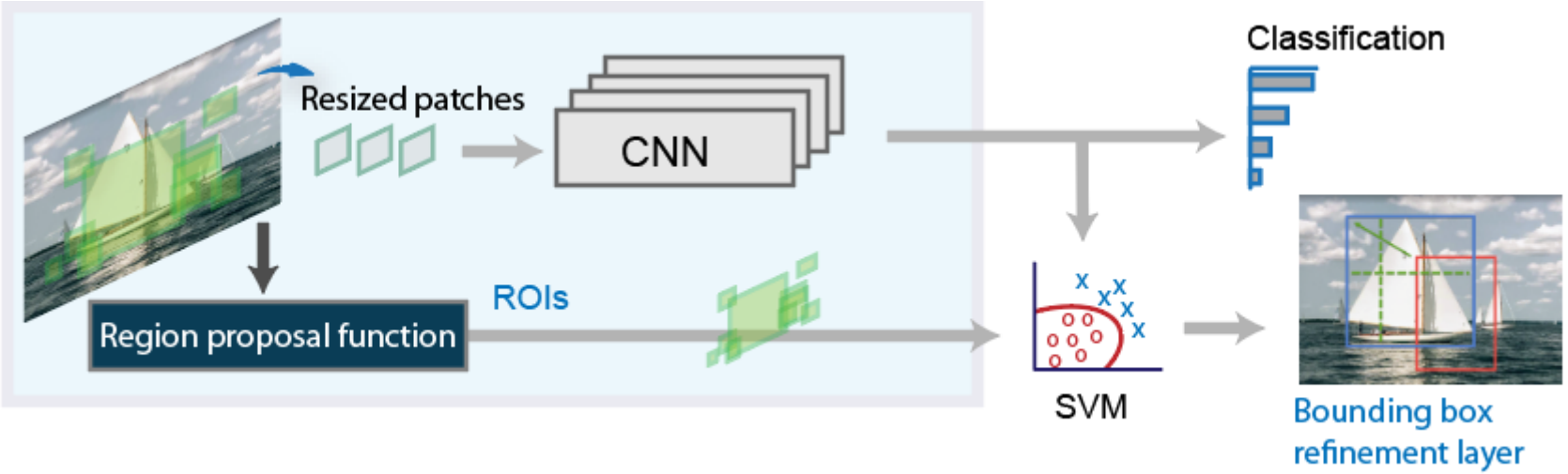
Image Classification vs. Object Detection

- **Image Classification**
  - classify whole image using set of distinct categories
  - object recognition
  - scene recognition

- **Object Detection**
  - recognizing and locating the (small) object in a scene
  - multiple objects in one image

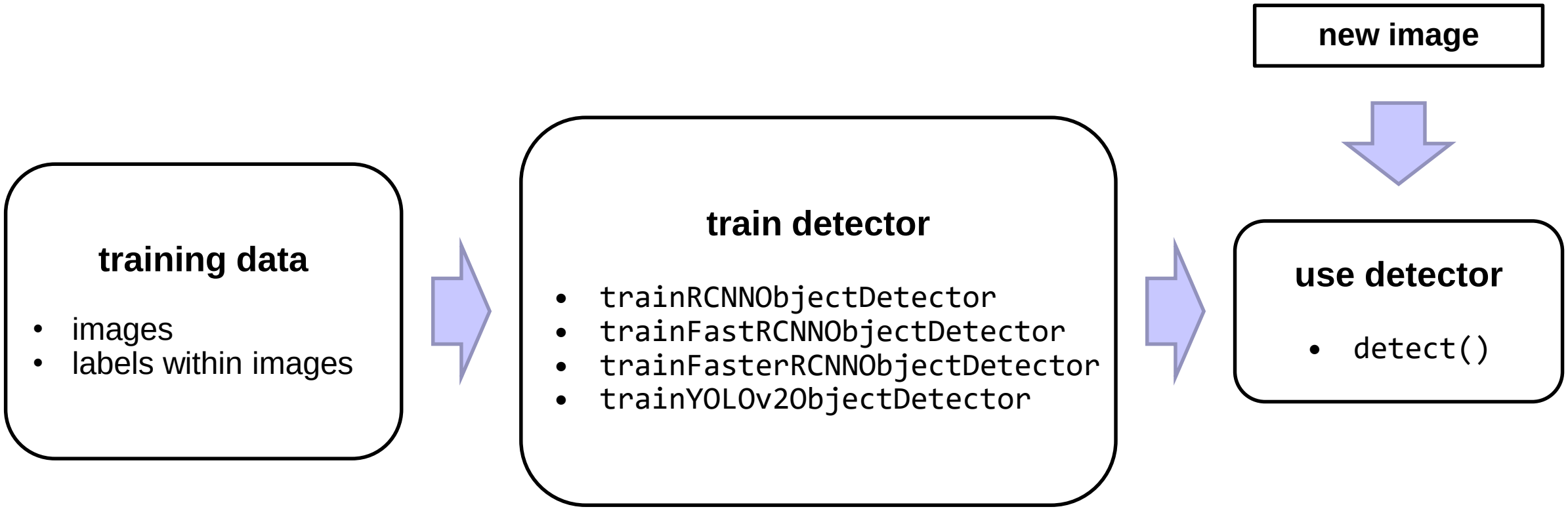
Object Detection using Deep Learning

- **Family of R-CNN object detectors (Regions with Convolutional Neural Networks)**
  - R-CNN, Fast R-CNN, Faster R-CNN
  - uses region proposal to detect objects within images



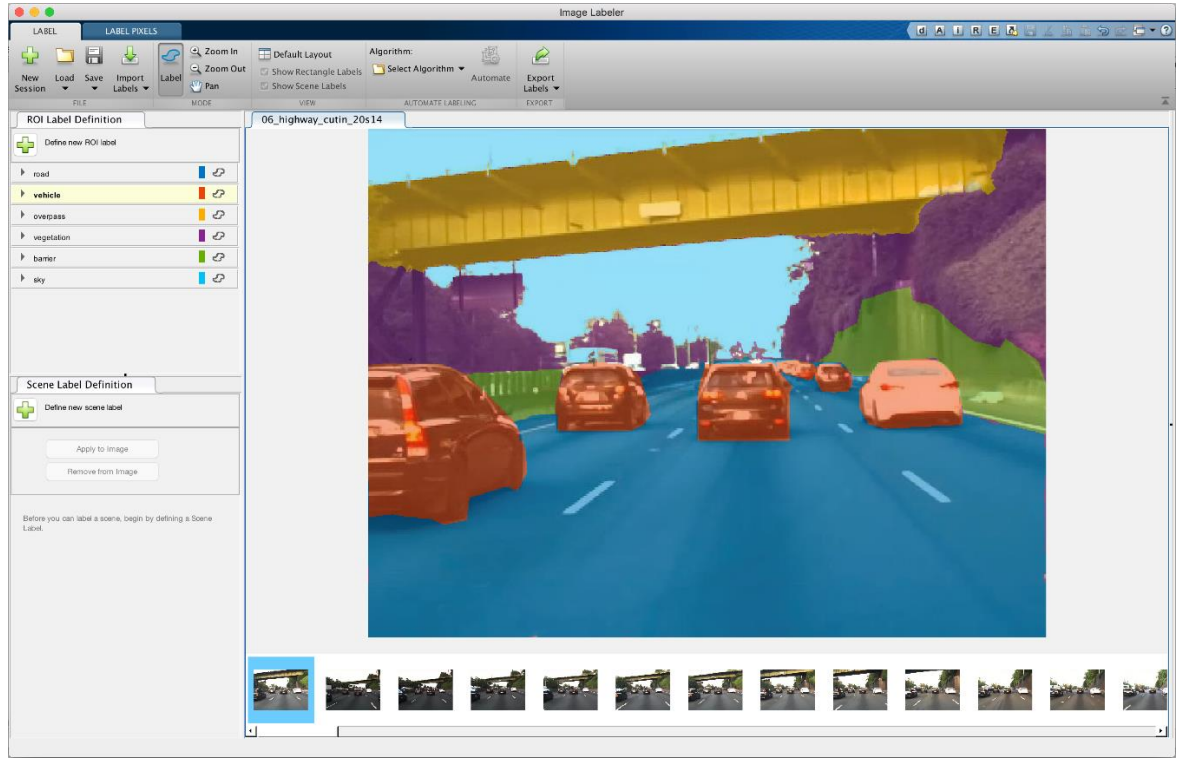
  - Fast and Faster R-CNN improve detection performance for large number of regions
- **YOLO v2 deep learning object detector (you-only-look-once)**

Object Detection Training Workflow

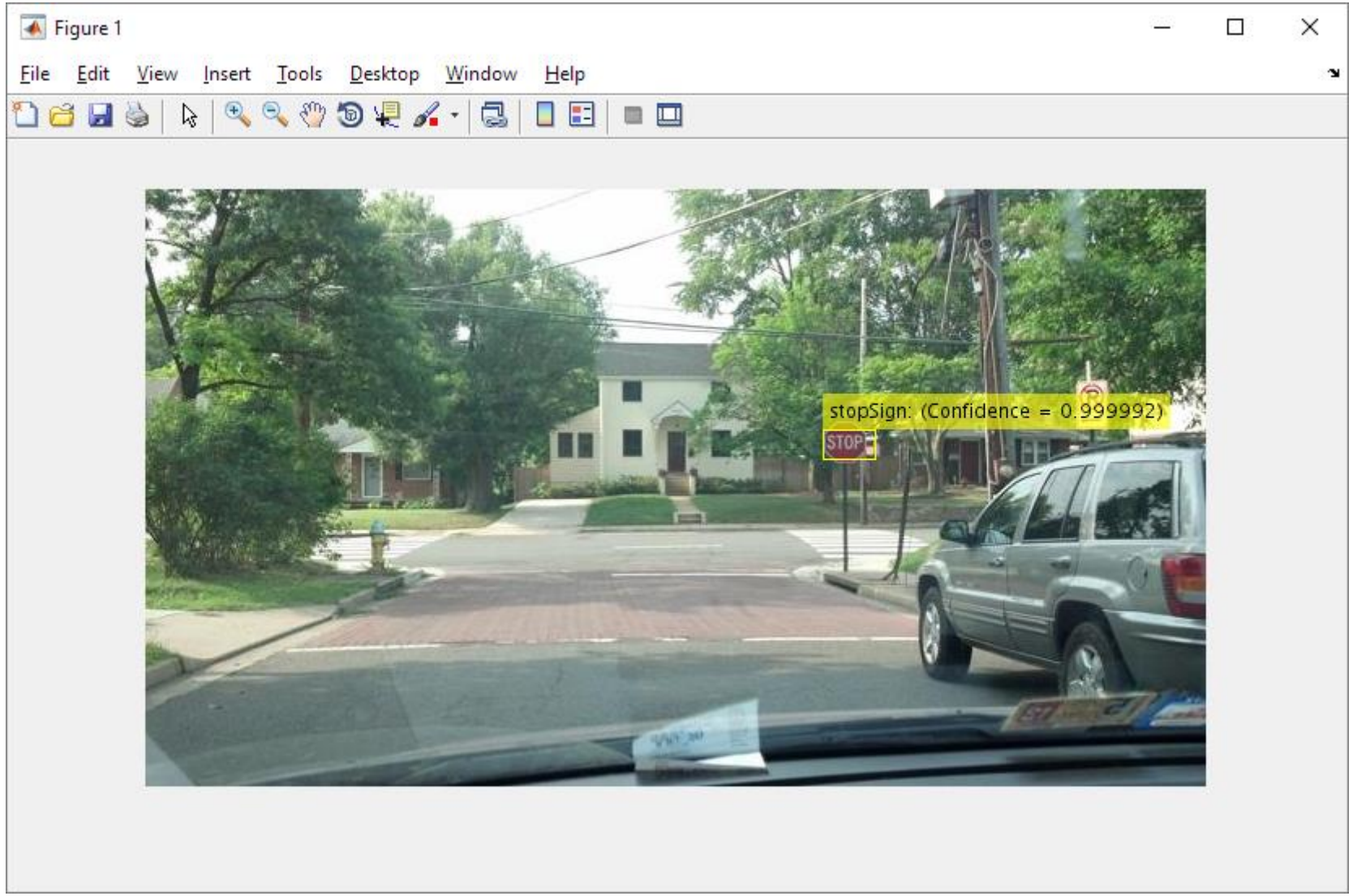


Ground-Truth Labeling

- App to label pixels and regions
  - *ImageLabeler App*
  - for object detection
  - for semantic segmentation
- Automate ground-truth labeling
  - automation API
- Video annotation
  - *VideoLabeler App*

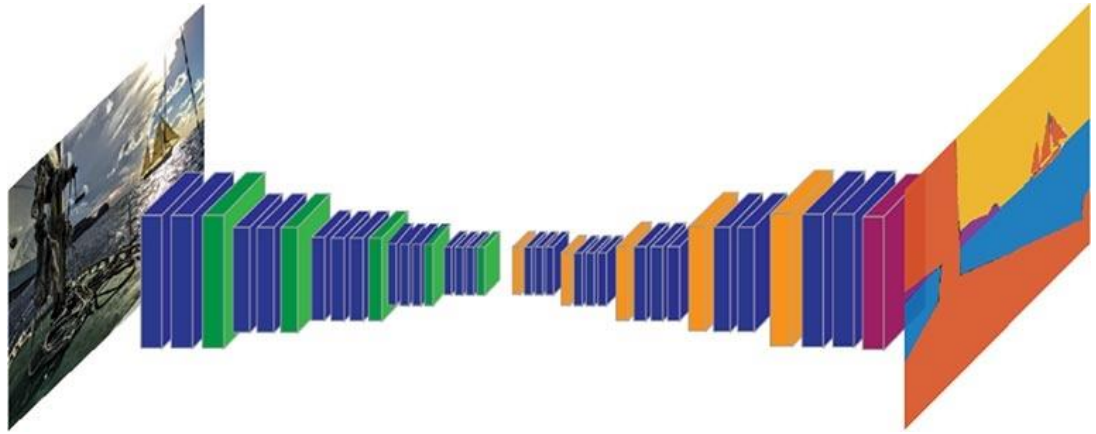


Example: Object Detection using Deep Learning



Semantic Segmentation

- Classify individual pixels
- Manage data
  - `imageDatastore` + `pixelLabelDatastore`
  - `pixelLabelImageDatastore`
- Perform semantic segmentation
  - `semanticseg`
- Special layers
  - `pixelClassificationLayer`, `crop2dLayer`
- Complete networks
  - `segnetLayers`, `fcnLayers`, `unetLayers`

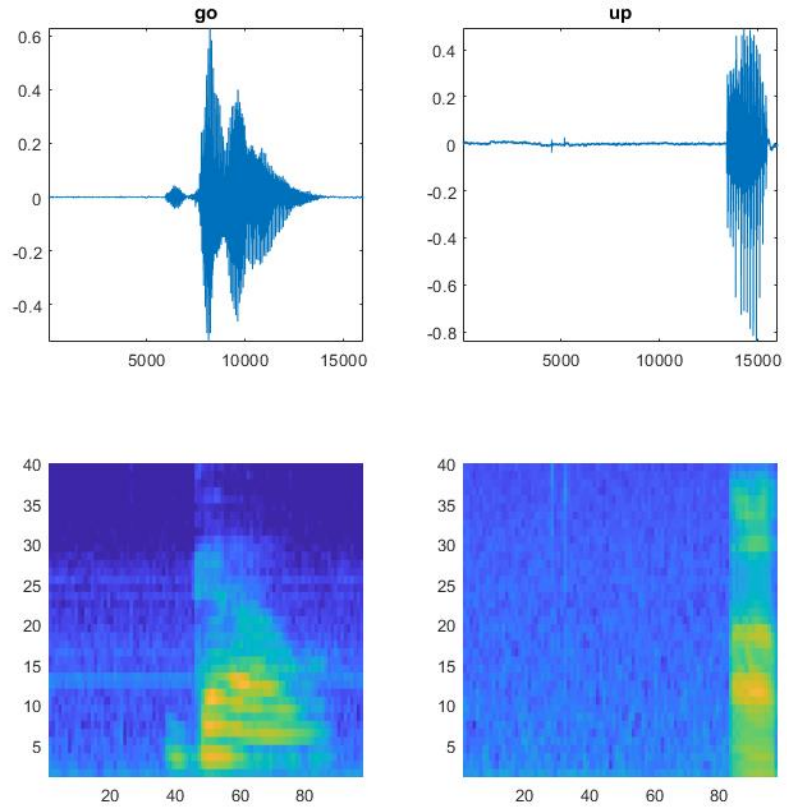


Semantic Segmentation

Semantic Segmentation

Deep Learning with Time Series Workflow

1. **Create time-frequency representation of the signal data**
   - *Signal Analyzer* app
   - spectrogram
   - scalogram (continuous wavelet transform)
2. **Capture time-frequency images**
3. **Apply CNN to the images**



or

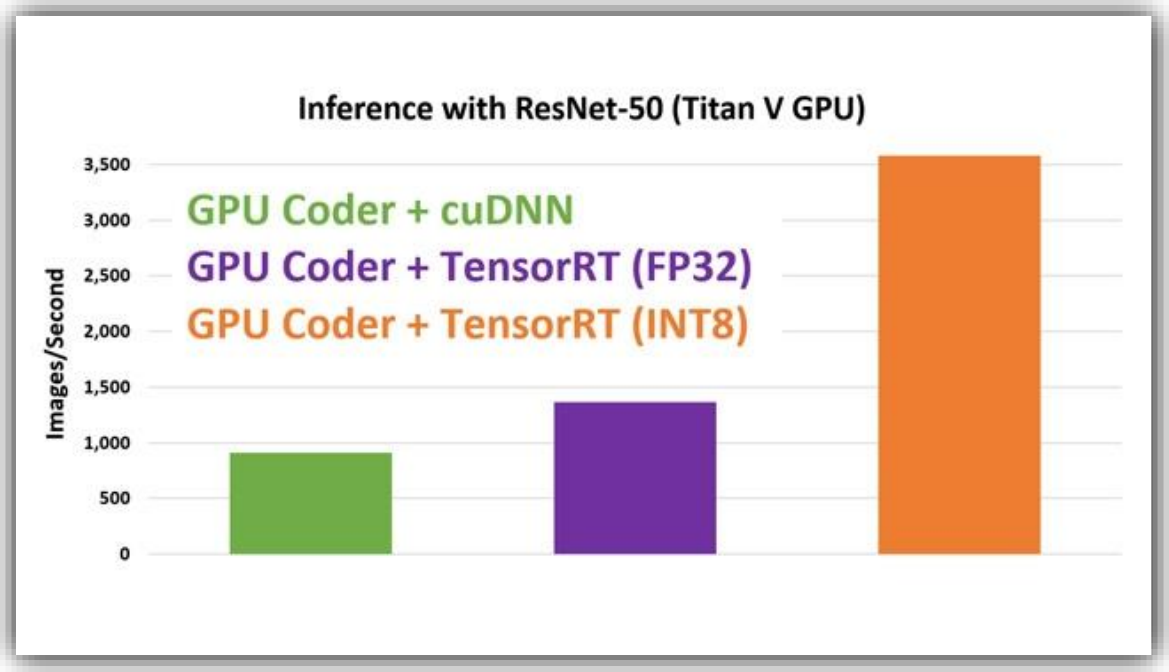
Use Long Short Term Memory (LSTM) Networks directly with signal data

Multi-Platform Deployment

- **Deploy deep learning models anywhere**
  - CUDA
  - C code
  - enterprise systems
  - or the cloud
- **Generate code that leverages optimized libraries**
  - Intel® (MKL-DNN)
  - NVIDIA (TensorRT, cuDNN)
  - ARM® (ARM Compute Library)

⇨ **deployable models with high-performance inference speed.**

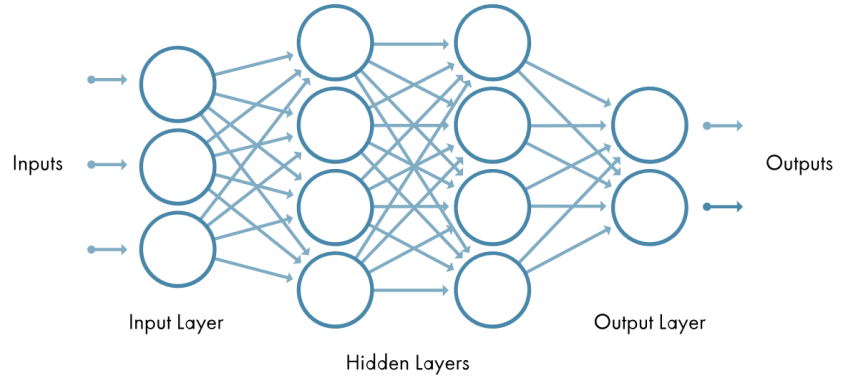
Multi-Platform Deployment

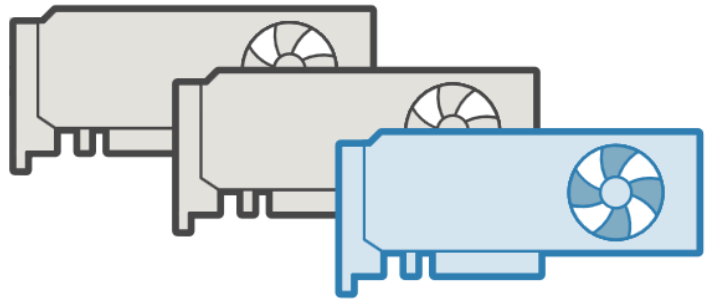


⇨ **deployable models with high-performance inference speed.**

MATLAB for Deep Learning

- Network Architectures and Algorithms
- Training and Visualization
- Access the Latest Pretrained Models
- Scaling and Acceleration
- Handling Large Sets of Images
- Object Detection
- Semantic Segmentation
- Ground-Truth Labeling
- Embedded Deployment

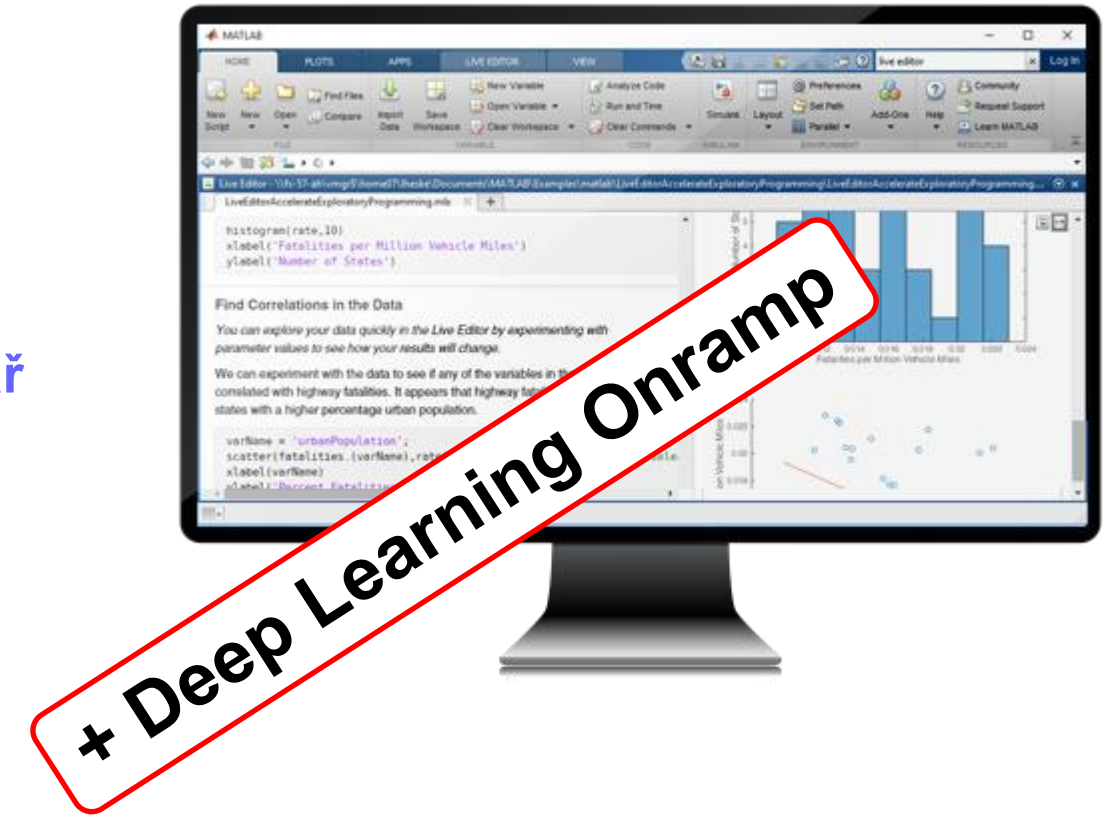




Jak začít s prostředím MATLAB?

- **Zkušební verze:**
  - plnohodnotná verze MATLAB
  - časově omezena na 30 dní
  - možnost libovolných nadstaveb
  - v případě zájmu využijte kontaktní formulář

http://www.humusoft.cz/matlab/trial/



- **MATLAB Onramp:**
  - on-line kurz zdarma
  - časová náročnost: 2 hodiny
  - přihlášení: https://matlabacademy.mathworks.com/

Děkuji za pozornost