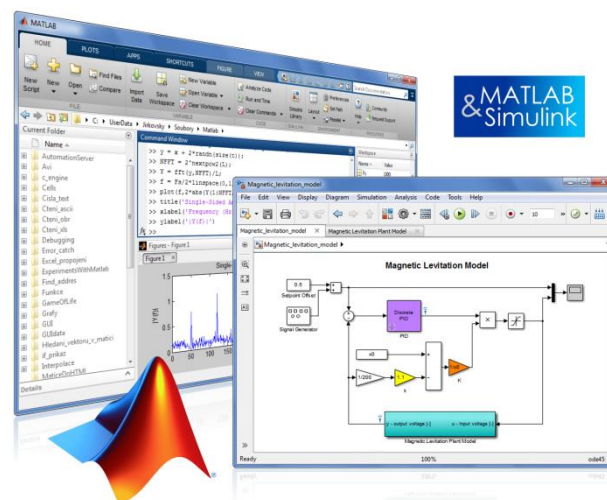


12.9.2018 Liberec

Využití metod deep learning v počítačovém vidění v prostředí MATLAB



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Co je MATLAB a Simulink

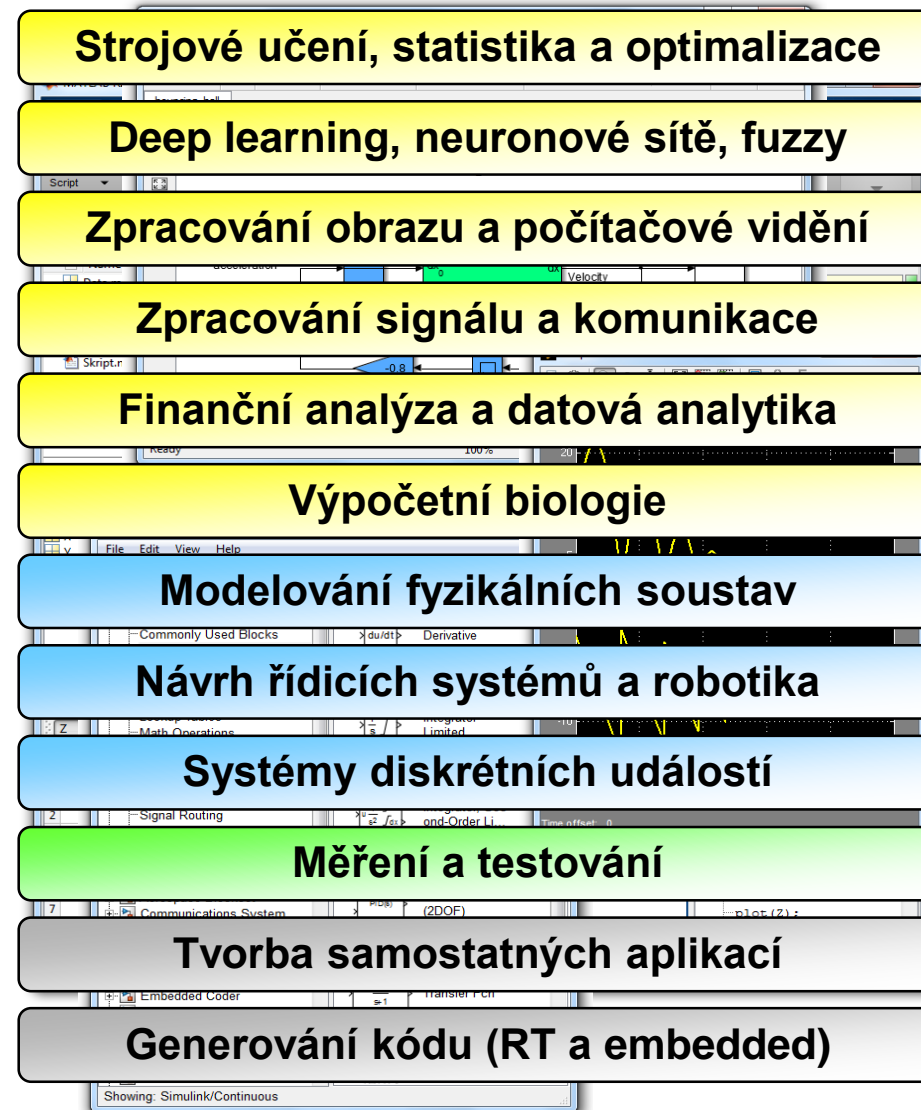
- **MATLAB**

- Inženýrský nástroj a interaktivní prostředí pro vědecké a technické výpočty
- Grafické a výpočetní nástroje
- Grafické aplikace (GUI, APPS)
- Otevřený systém

- **Simulink**

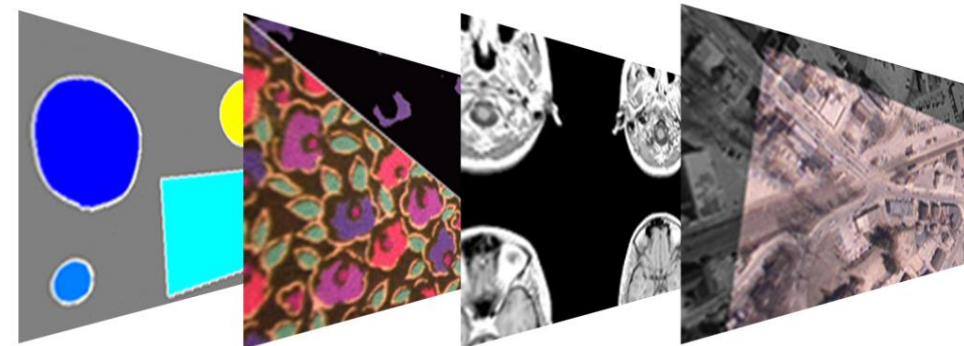
- Nadstavba MATLABu
- Modelování, simulace a analýza dynamických systémů
- Prostředí blokových schémat
- Platforma pro Model Based Design

- **Aplikační knihovny**



Zpracování obrazu a počítačové vidění

- Snímání reálného obrazu
- Zpracování obrazu a videa
 - úprava obrazu, transformace, segmentace
 - práce s barevnými prostory
- Počítačové vidění
 - detekce a sledování objektů
 - detekce obličeje, postav
 - 3-D vision, OCR
- Deep Learning
 - rozpoznávání obrazu a detekce objektů
 - sémantická segmentace



Počítačového vidění: typy úloh a jejich řešení

- **Hledání vzorového objektu**

- nalezení a porovnání příznaků (BRISK, SURF, KAZE, MSER, corner)

- **Detekce objektů**

- cascade object detector (Viola-Jones)
- ACF object detector
- R-CNN, Fast R-CNN, Faster R-CNN

- **Klasifikace objektů (snímků)**

- bag-of-visual words
- CNN

deep learning

- **Sledování objektů**

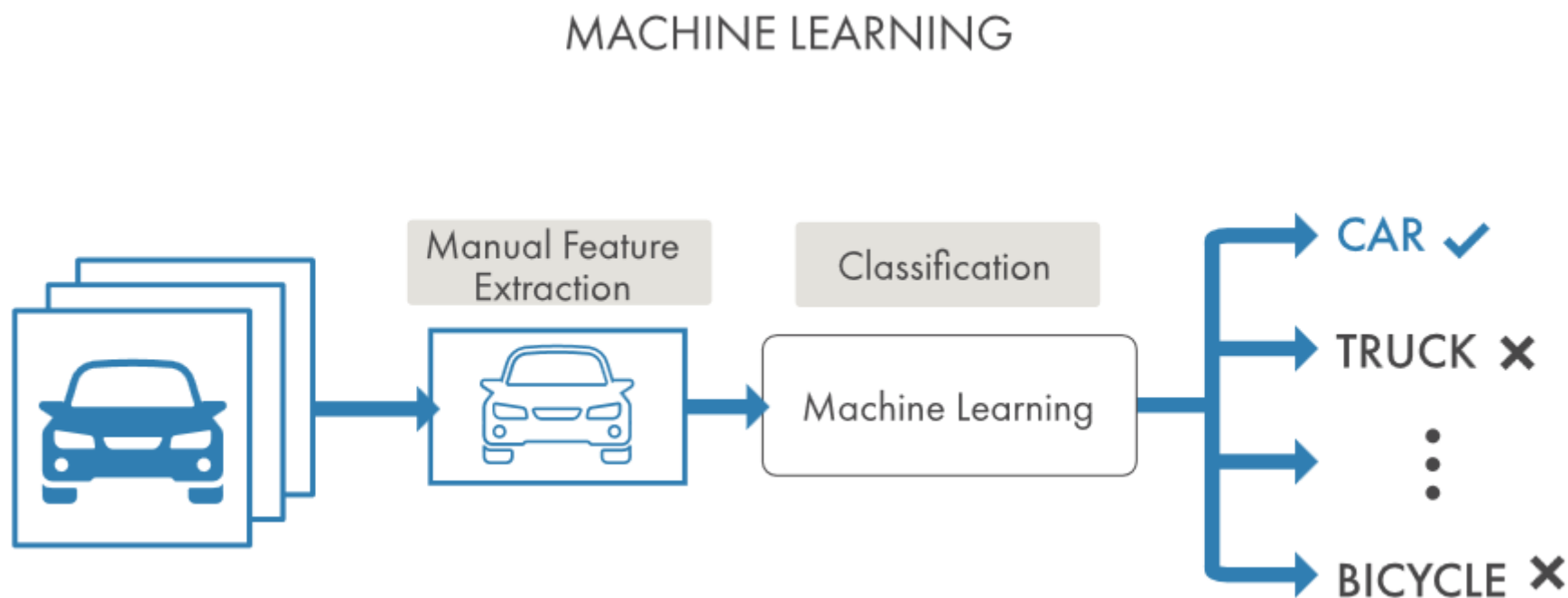
- sledování bodů (KLT)
- sledování oblasti na základě histogramu

- **Odhad a predikce pohybu**
- **Detekce popředí, ...**

Deep Learning

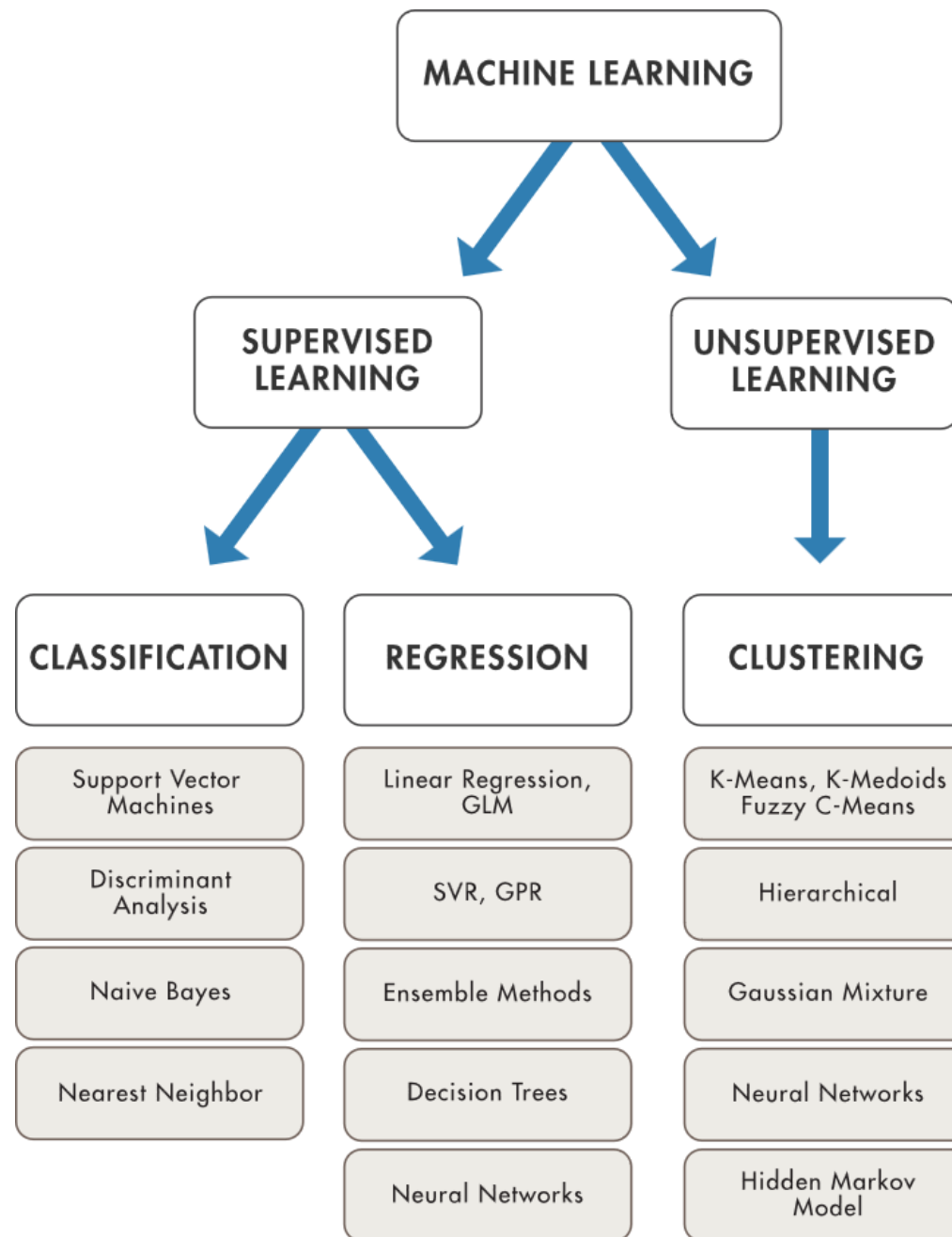
What is Machine Learning ?

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



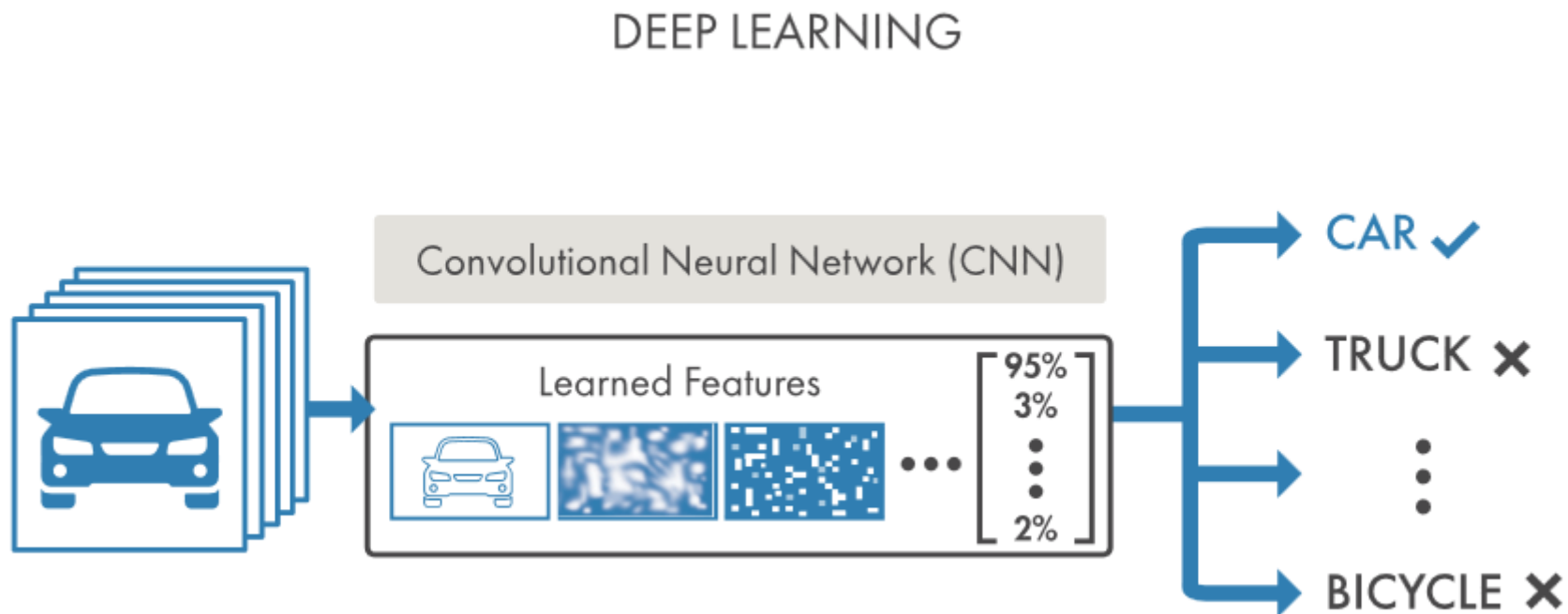
Machine Learning

- Different Types of Learning:



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

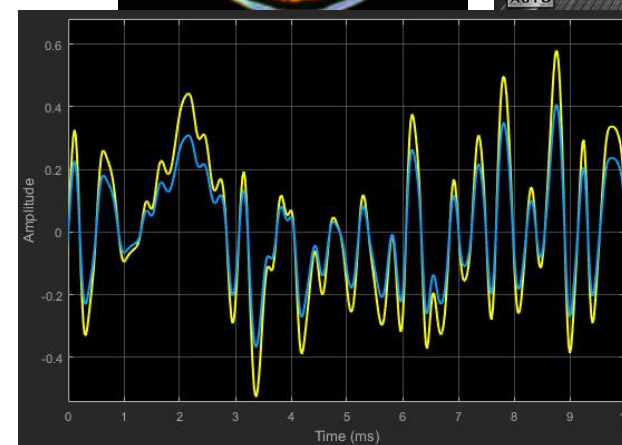
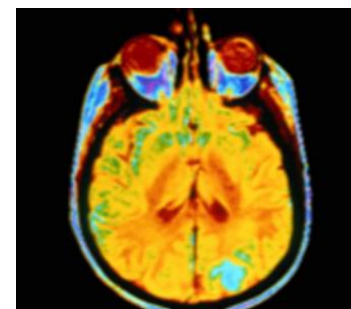
Computer Vision

- Pedestrian and traffic sign detection
- Landmark identification
- Scene recognition
- Medical diagnosis and discovery

Signal and Time Series Processing

Text Analytics

...



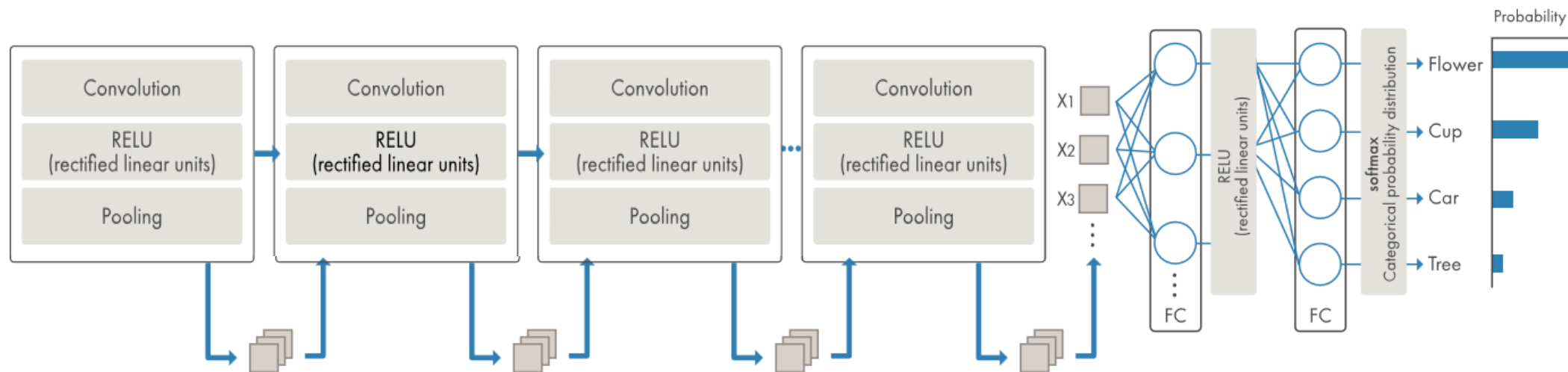
Why is Deep Learning so Popular ?

- **Results:**
 - 95% + accuracy
 - on ImageNet 1000 class challenge
- **Computing Power:**
 - GPU's
 - advances to processor technologies
 - ⇒ possible to train networks on massive sets of data.
- **Data:**
 - availability of storage
 - access to large sets of labeled data

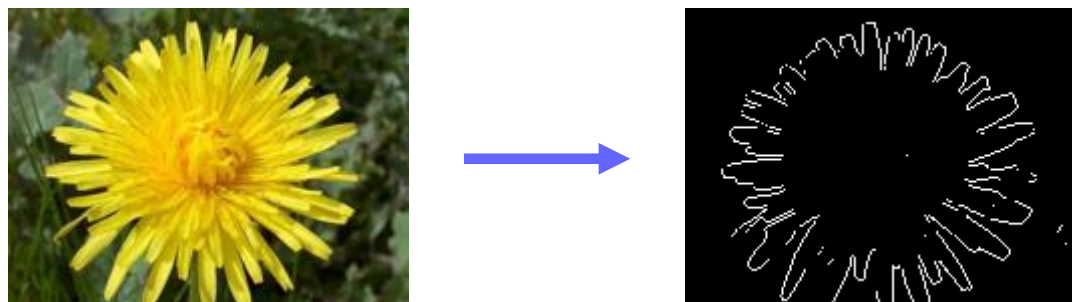
Year	Error Rate
Pre-2012 (traditional computer vision and machine learning techniques)	> 25%
2012 (Deep Learning)	~ 15%
2015 (Deep Learning)	<5 %



Convolutional Neural Networks



What do filters do?



CNN in MATLAB

```
layers = [imageInputLayer(image_size)
          convolution2dLayer(filter_size,num_filters)
          reluLayer()
          maxPooling2dLayer(window_size, 'Stride', step)
          fullyConnectedLayer(num_classes)
          softmaxLayer()
          classificationLayer()];

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

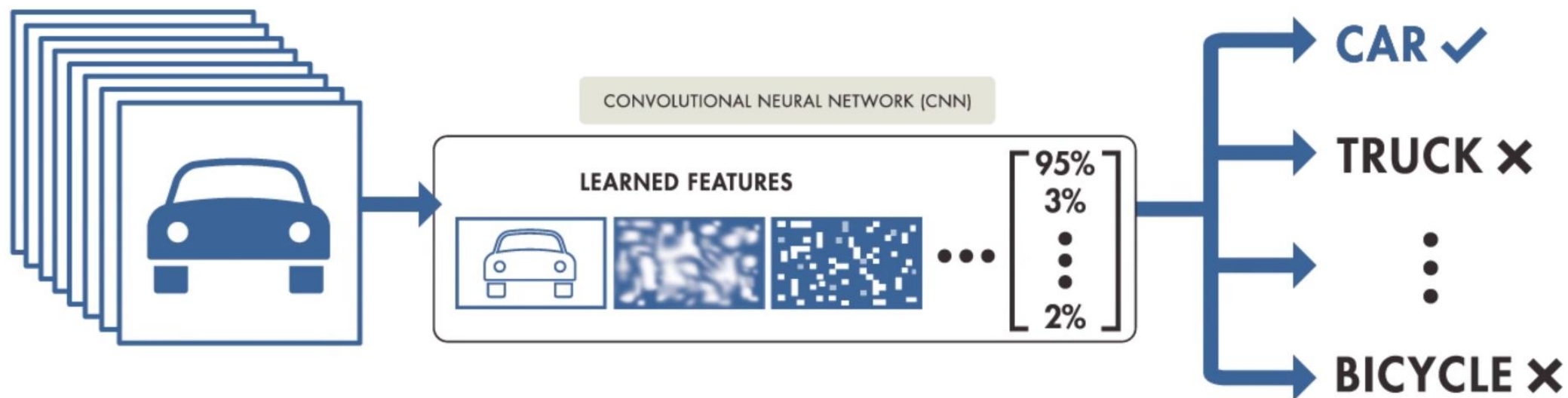
CNN in MATLAB

```
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);
```

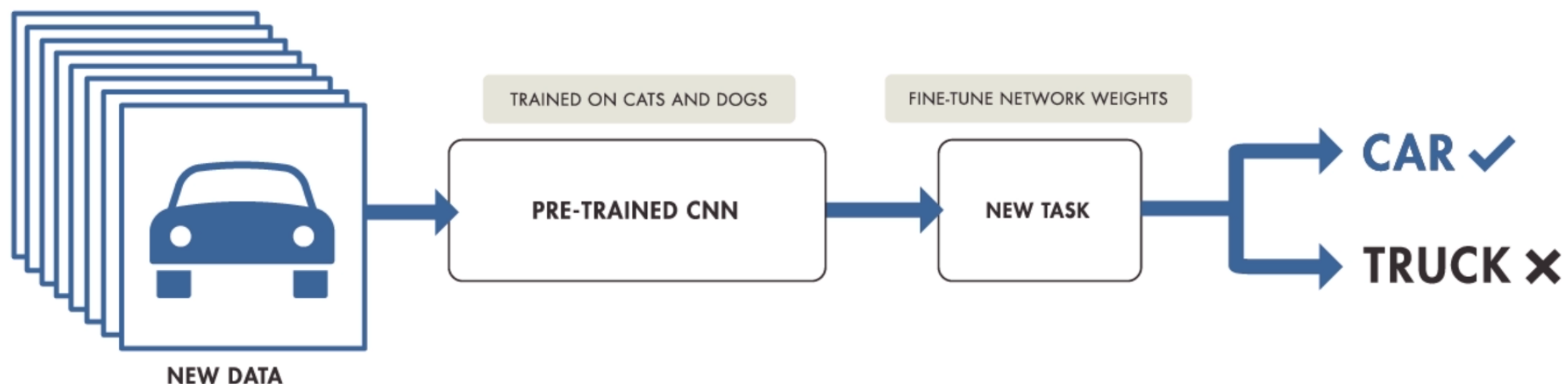
2 Approaches for Deep Learning

- Approach 1: Train a Deep Neural Network from Scratch

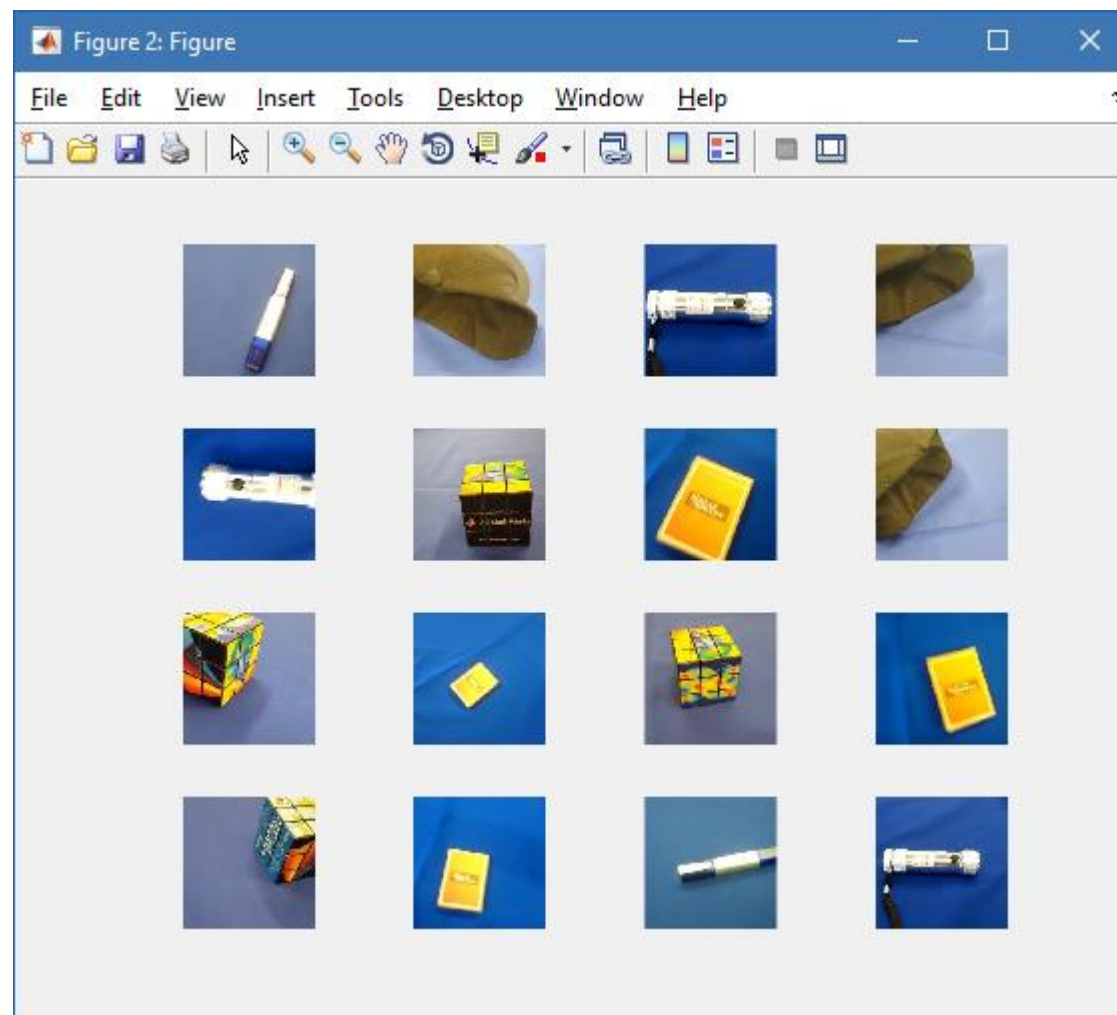


2 Approaches for Deep Learning

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



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



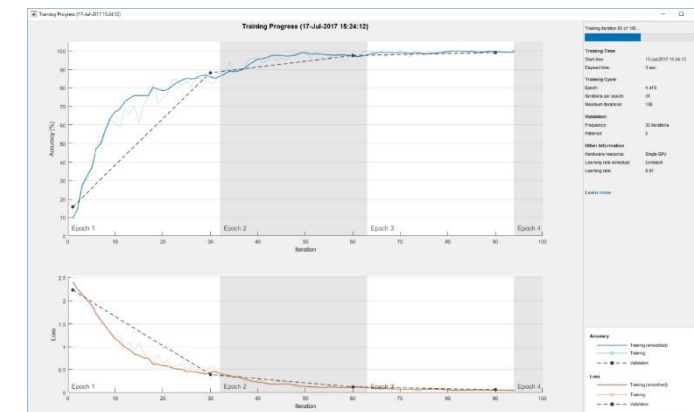
Available pre-trained CNNs

- AlexNet
 - VGG-16 and VGG-19
 - GoogLeNet
 - ResNet-50 and ResNet-101
 - Inception-v3
 - Inception-ResNet-v2
 - SqueezeNet
-
- Import models from Caffe (including Caffe Model Zoo)
 - Import models from TensorFlow-Keras

Training and Visualization

- **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**
- **Deep Dream visualization**



Verification using Deep Dream Images

- Visualize what the learned features look like
- Generate images that strongly activate a particular channel of the network layers
- function `deepDreamImage`



Deep Learning Models for Regression

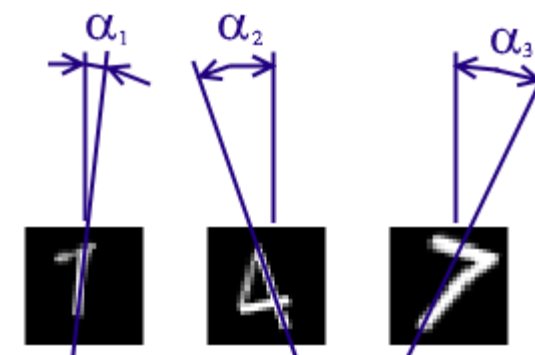
- To predict continuous data such as angles and distances in images
- Include a regression layer at the end of the network

```
layers = [imageInputLayer([28 28 1])
          convolution2dLayer(12,25)
          reluLayer()
          fullyConnectedLayer(1)
          regressionLayer()];
```

```
options = trainingOptions('sgdm');
```

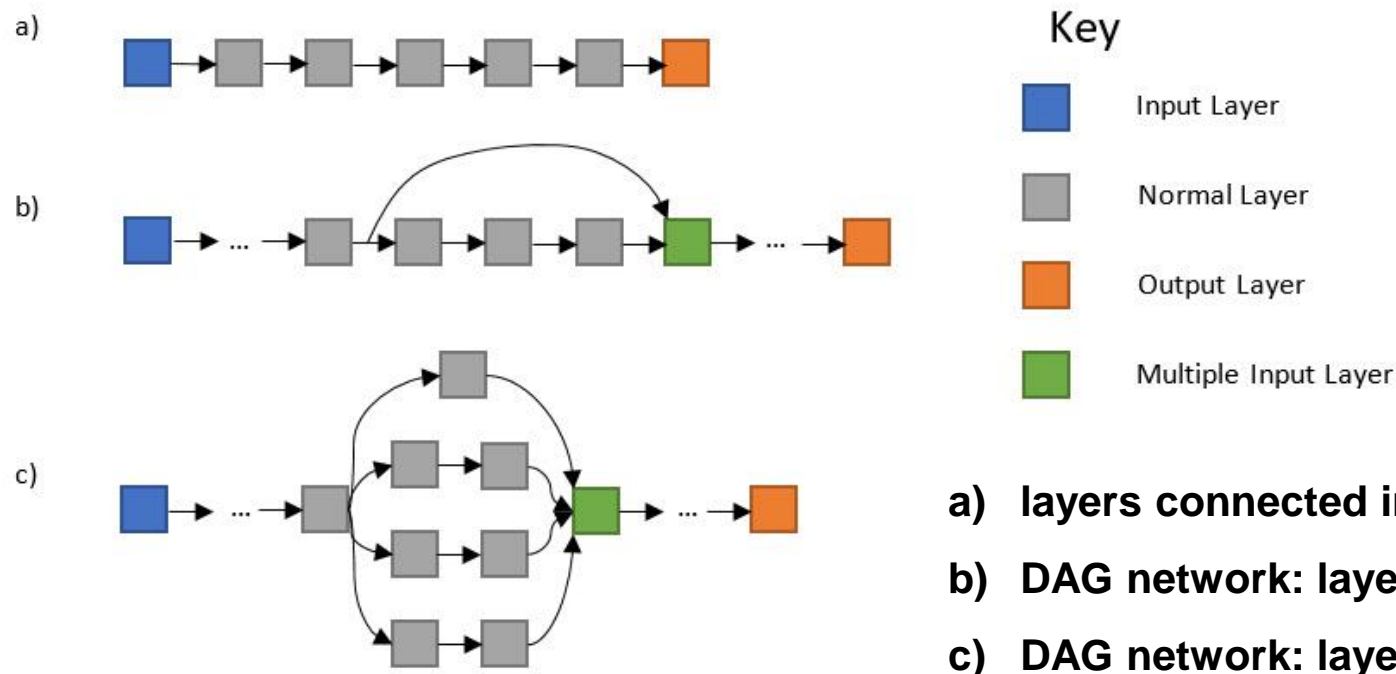
```
convnet = trainNetwork(trainImages,trainAngles, layers, options);
```

```
results = predict(convnet,newImages);
```



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 Detection**

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



Detector

Function

R-CNN deep learning detector

`trainRCNNObjectDetector`

Fast R-CNN deep learning detector

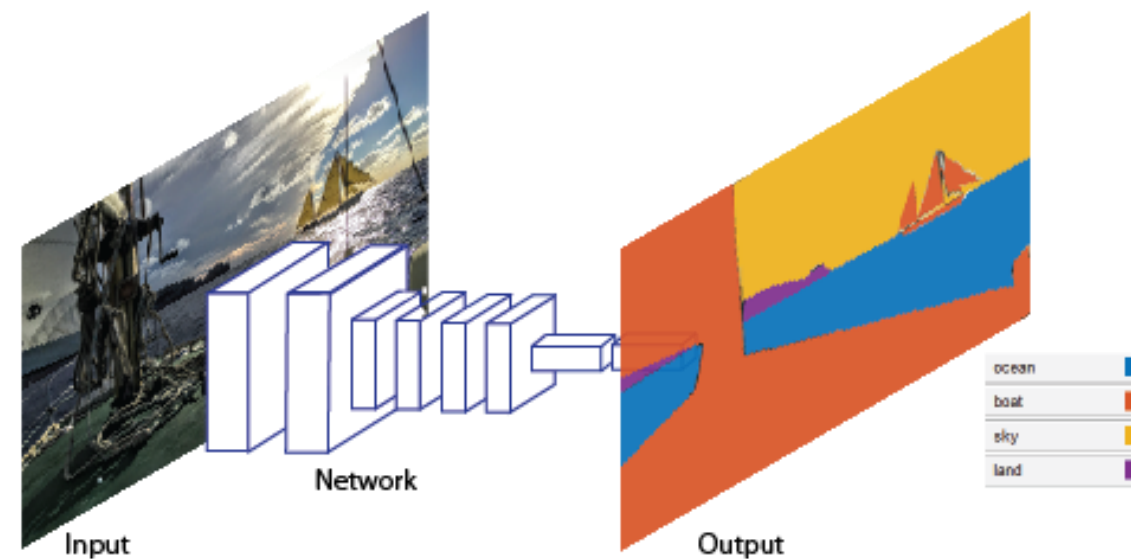
`trainFastRCNNObjectDetector`

Faster R-CNN deep learning detector

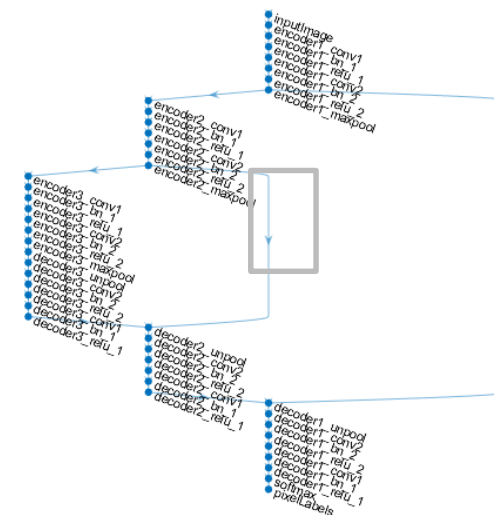
`trainFasterRCNNObjectDetector`

Semantic Segmentation

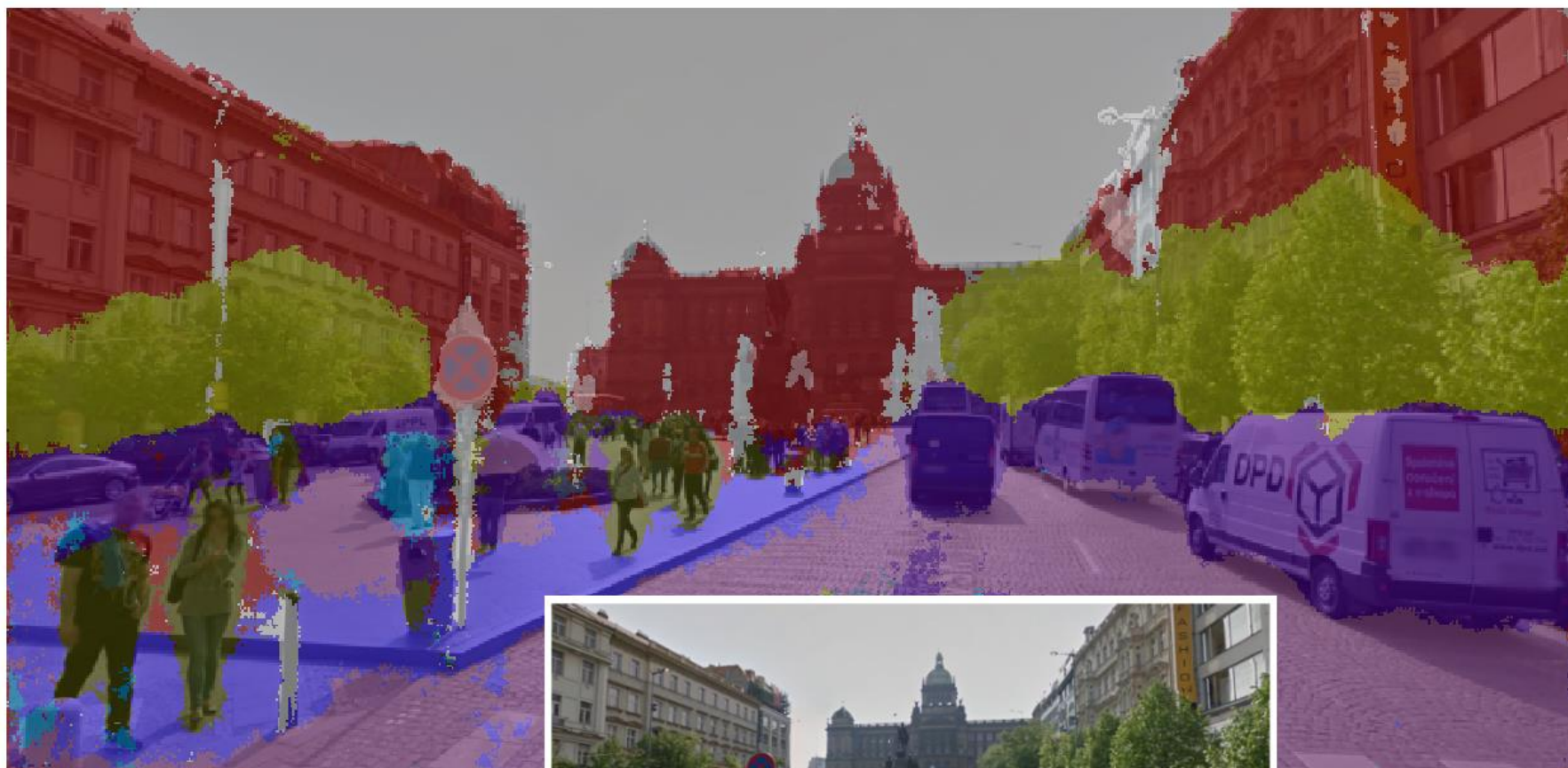
- **Classify individual pixels**
- **Functions:**
 - perform semantic segmentation
 - semanticseg
 - special layers:
 - pixelClassificationLayer, crop2dLayer
 - complete networks:
 - segnetLayers, fcnLayers



SegNet Convolutional Neural Network



Semantic Segmentation



- Cyklista
- Chodec
- Automobil
- Plot
- Dopravní značka
- Strom
- Chodník
- Silnice
- Sloupek
- Budova
- Obloha

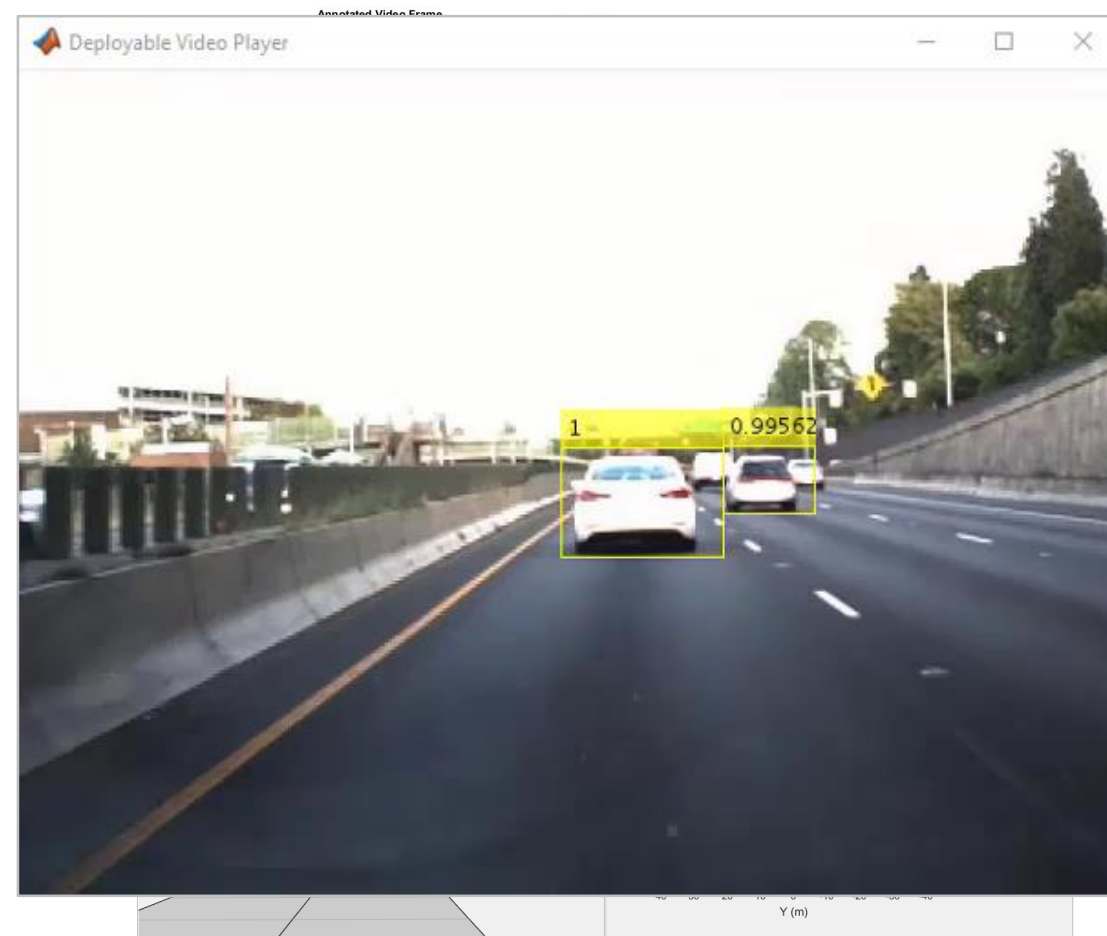


Semantic Segmentation



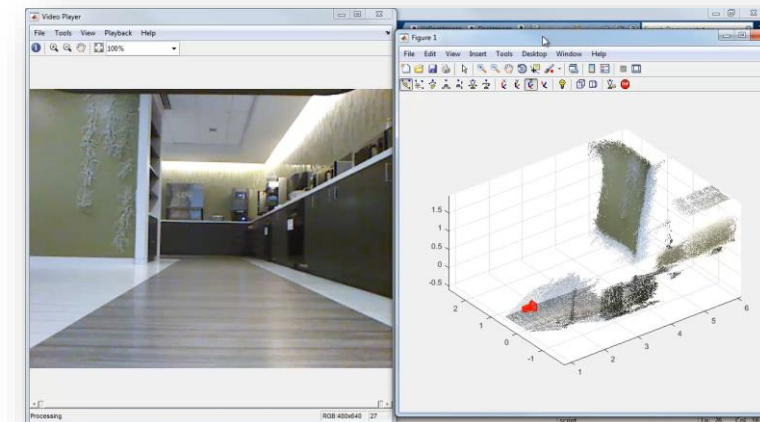
Automated Driving

- Design, simulate, and test ADAS and autonomous driving systems
- Object detection
 - lane marker detection, vehicle detection, ...
- Multisensor fusion
 - vision, radar, ultrasound
- Visualization
 - annotation, bird's-eye-view, point cloud
- Scenario Generation
 - synthetic sensor data for driving scenarios
- Ground-truth labeling
 - annotating recorded sensor data



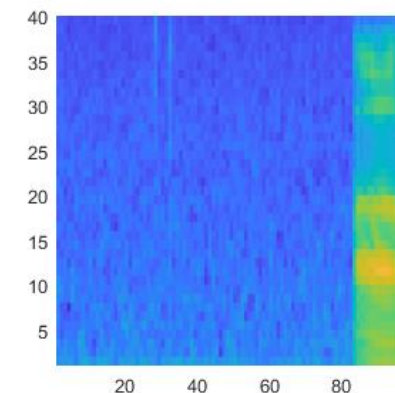
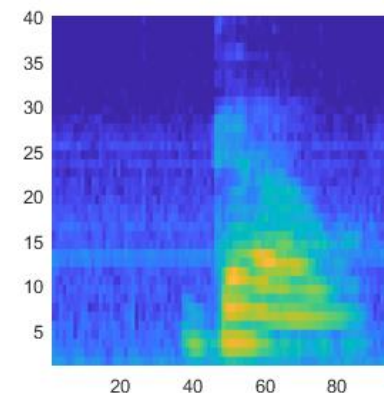
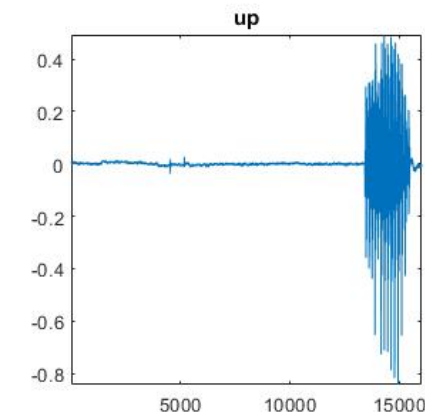
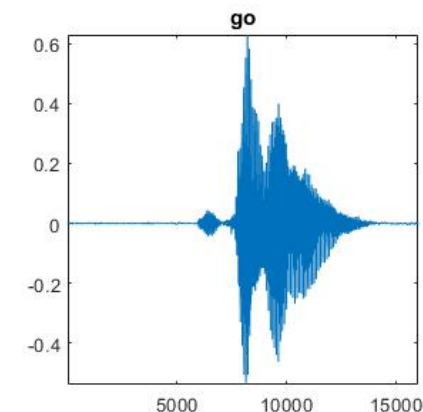
Automated Driving – Robotics

- Mapping of environments using sensor data
- Segment and register lidar point clouds
- Lidar-Based SLAM:
 - Localize robots and build map environments using lidar sensors



Deep Learning with Time Series and Sequence Data

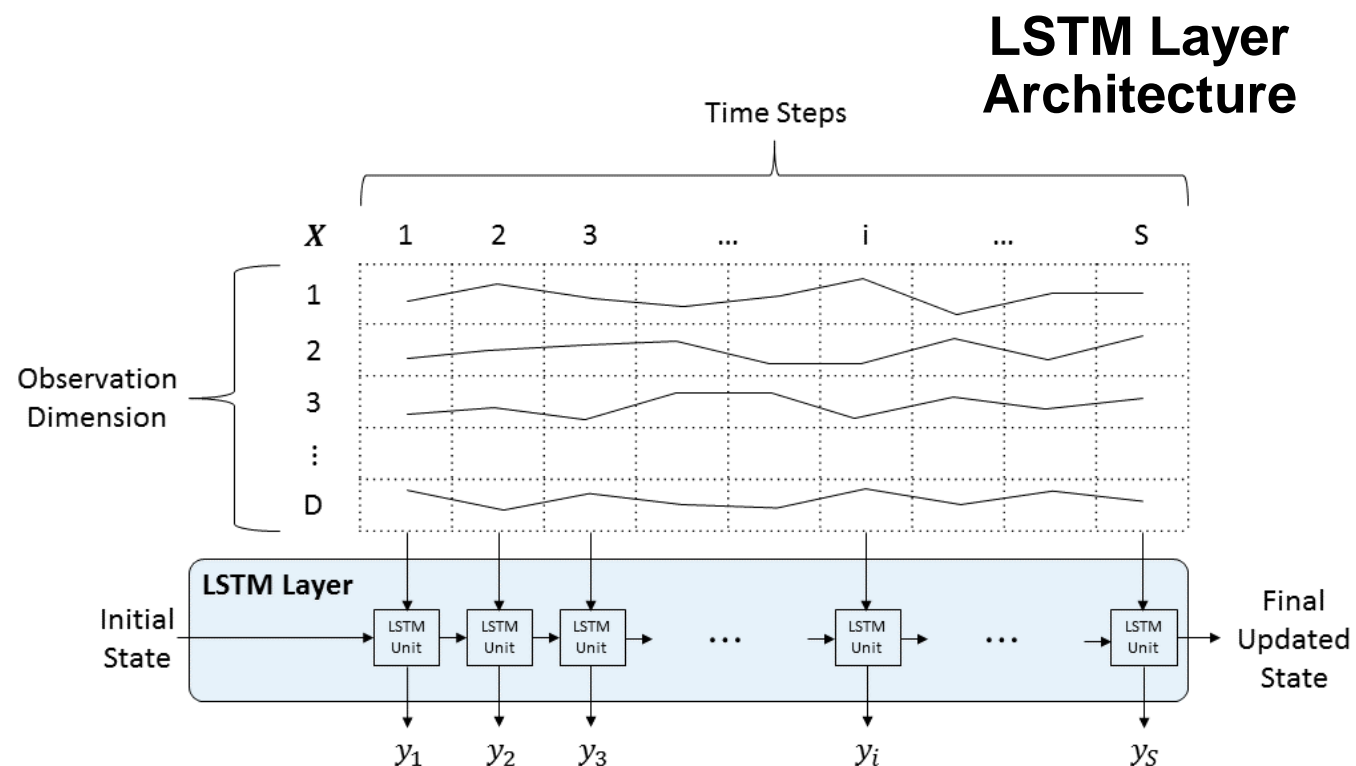
- Create time-frequency representation of the signal data
 - *Signal Analyzer app*
 - spectrogram
 - spectrogram, pspectrum
 - scalogram (continuous wavelet transform)
 - cwt
- ⇒ time-frequency images
- Apply deep neural network to the images



Long Short Term Memory (LSTM) Networks

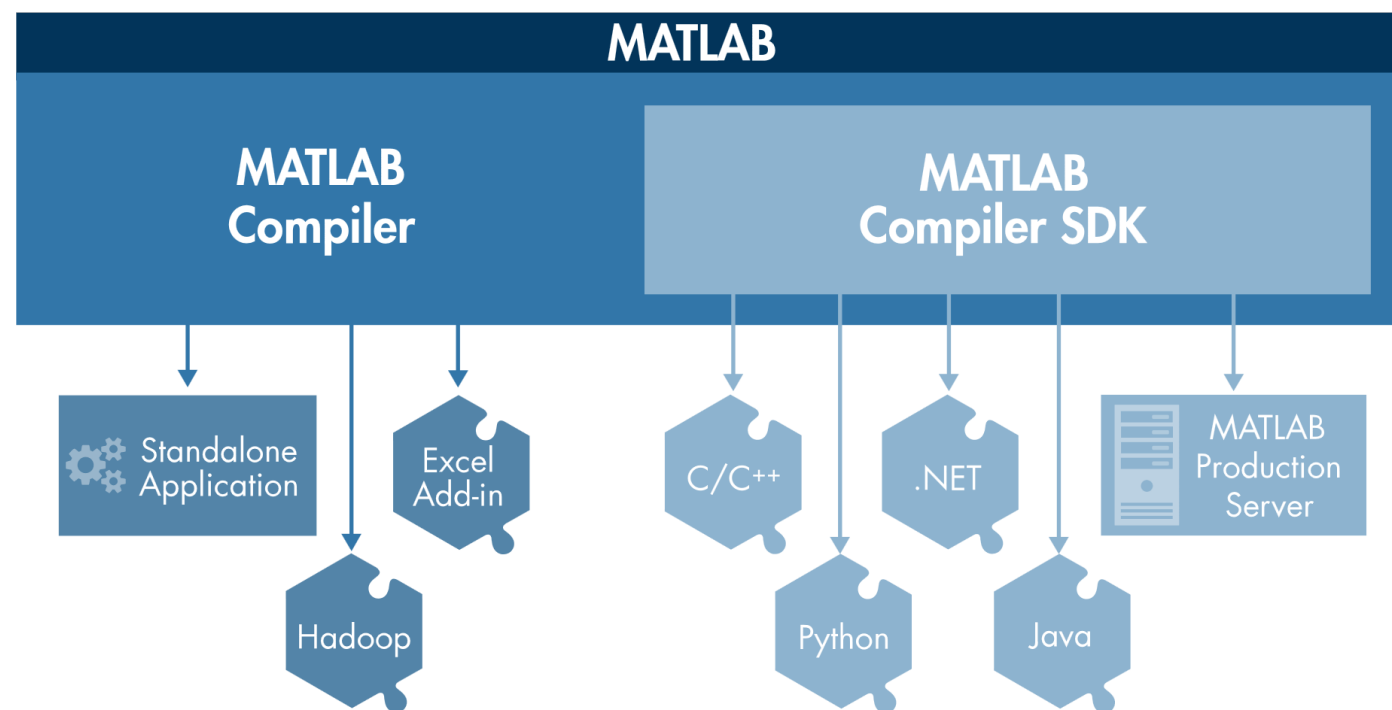
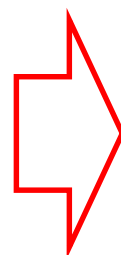
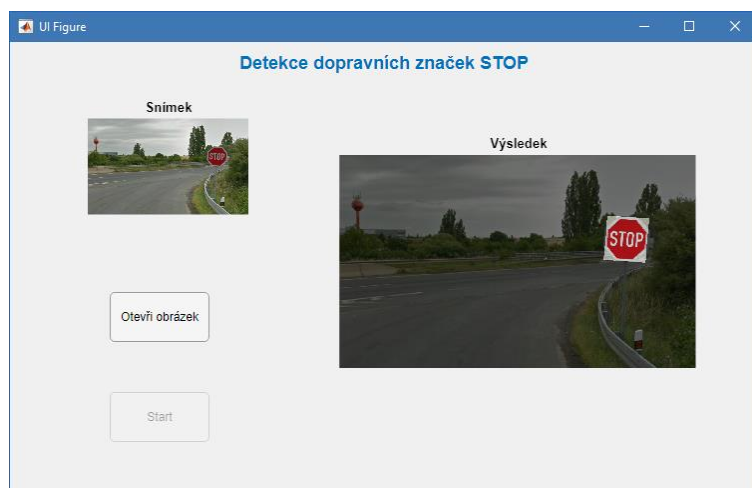
- LSTM layer is recurrent neural network (RNN) layer
 - learn long-term dependencies between the time steps of sequence data
- Prediction and classification on time-series, text, and signal data
 - `lstmLayer`, `biLstmLayer`

```
layers = [ ...
  sequenceInputLayer(12)
  lstmLayer(100)
  fullyConnectedLayer(9)
  softmaxLayer
  classificationLayer ]
```



Application Deployment

- **MATLAB based programs can be deployed as:**
 - standalone applications
 - software components for integration into web and enterprise applications



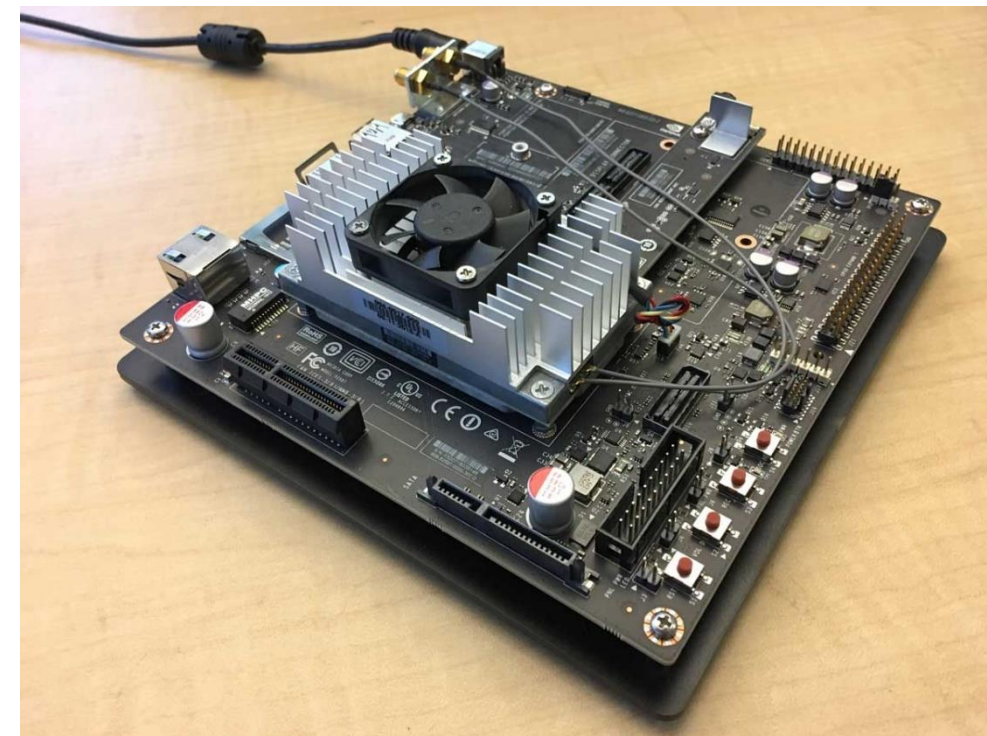
Embedded Deployment

- **Design real-time applications targeting**
 - floating- or fixed-point processors
 - FPGAs
- **From MATLAB and Simulink generate**
 - C and C++ code
 - HDL code
- **Optimize code for specific processor architectures**



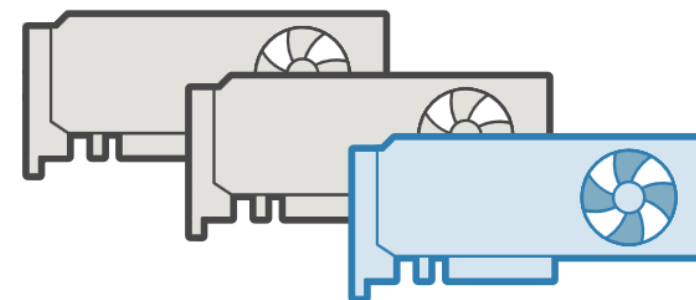
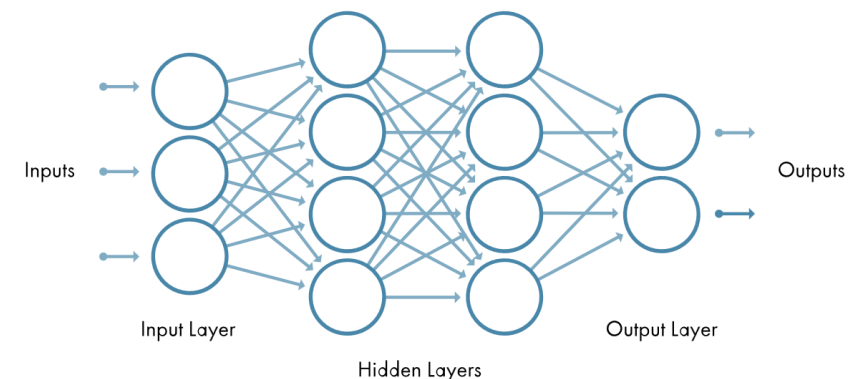
Embedded Deployment - GPU Coder

- **Generates optimized CUDA code from MATLAB code**
 - deep learning, embedded vision, and autonomous systems
- **Calls optimized NVIDIA CUDA libraries**
 - cuDNN, cuSolver, and cuBLAS
- **Generate CUDA as:**
 - source code
 - static libraries
 - dynamic libraries
- **Prototyping on GPUs**
 - NVIDIA Tesla® and NVIDIA Tegra®
- **Acceleration using MEX**



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**

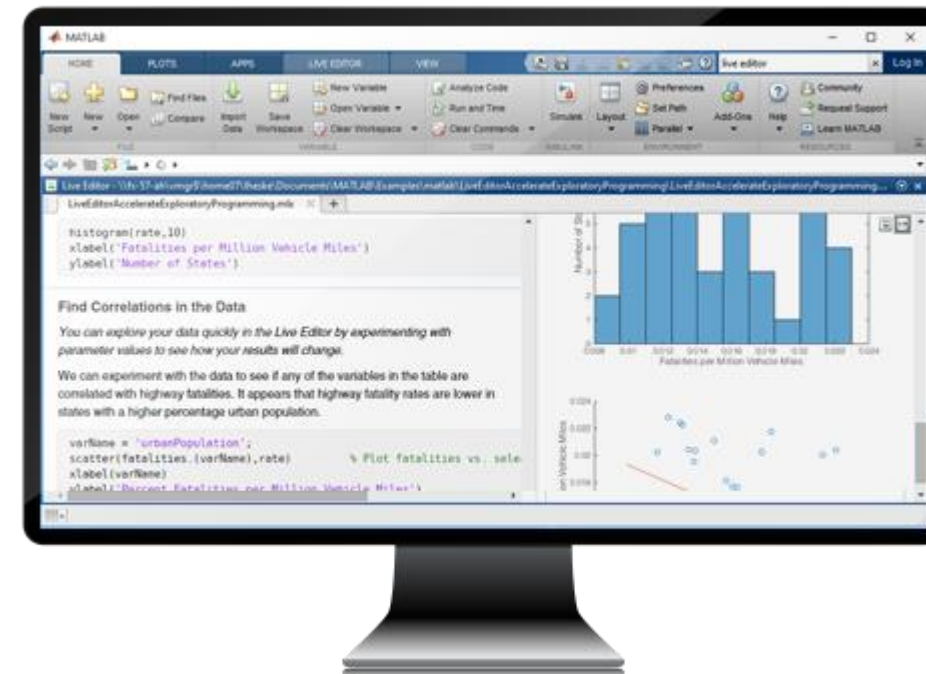


Jak začít s prostředím MATLAB?

- **Zkušební verze:**
 - plnohodnotná verze MATLAB
 - časově omezena na 30 dní
 - možnost libovolných nastaveb
 - 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