

MATLAB EXPO 2018

Demystifying Deep Learning

“Let the computers do the hard work”

Jérémy Huard

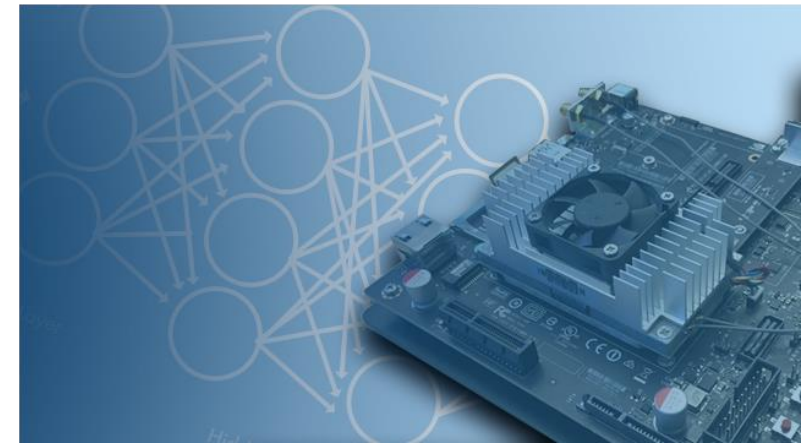
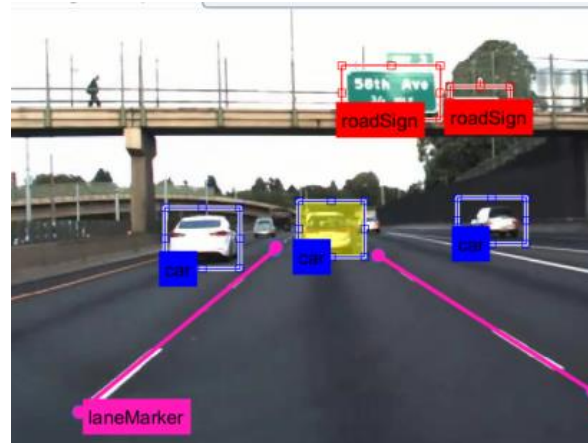
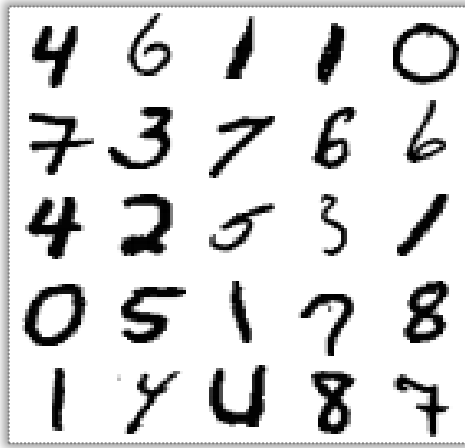
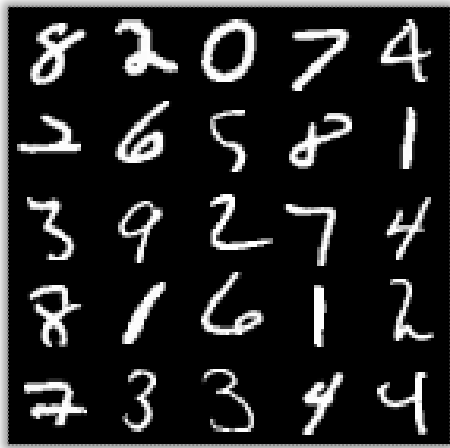


Deep Learning Demo

Image Classification

Why MATLAB for Deep Learning?

- MATLAB is Productive
- MATLAB is Fast
- MATLAB Integrates with Open Source



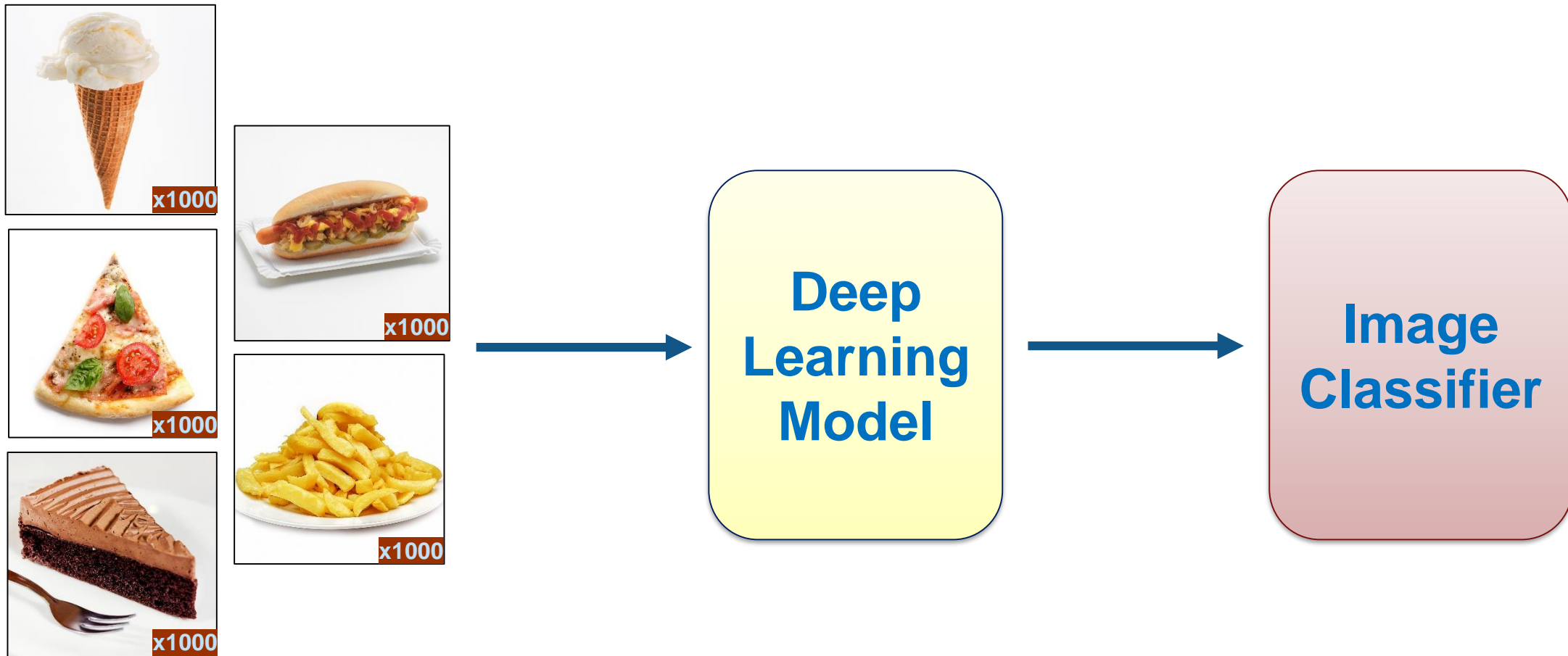
What is Deep Learning?



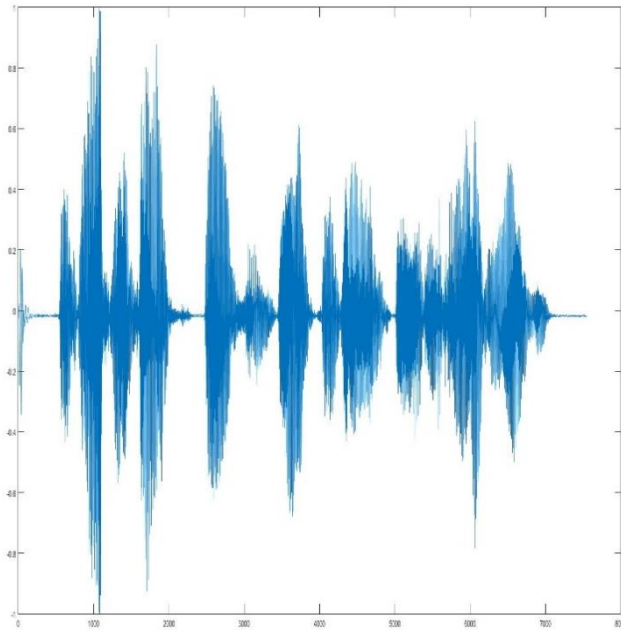
12 40.0%	0 0.0%	100% 0.0%
0 0.0%	18 60.0%	100% 0.0%
100% 0.0%	100% 0.0%	100% 0.0%

Deep Learning

Model learns to perform tasks directly from data.



Data Types for Deep Learning



Signal



Text



Image

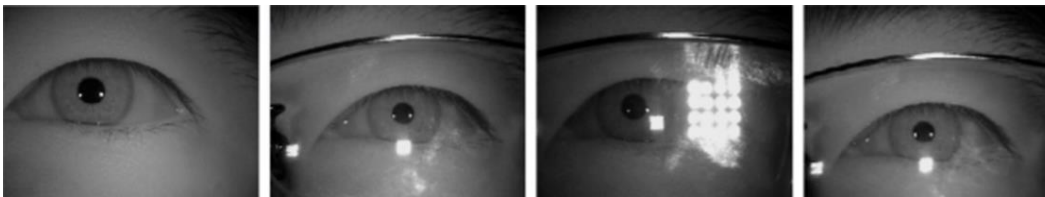
Deep Learning is **Versatile**



Detection of cars and road in autonomous driving systems



Rain Detection and Removal¹

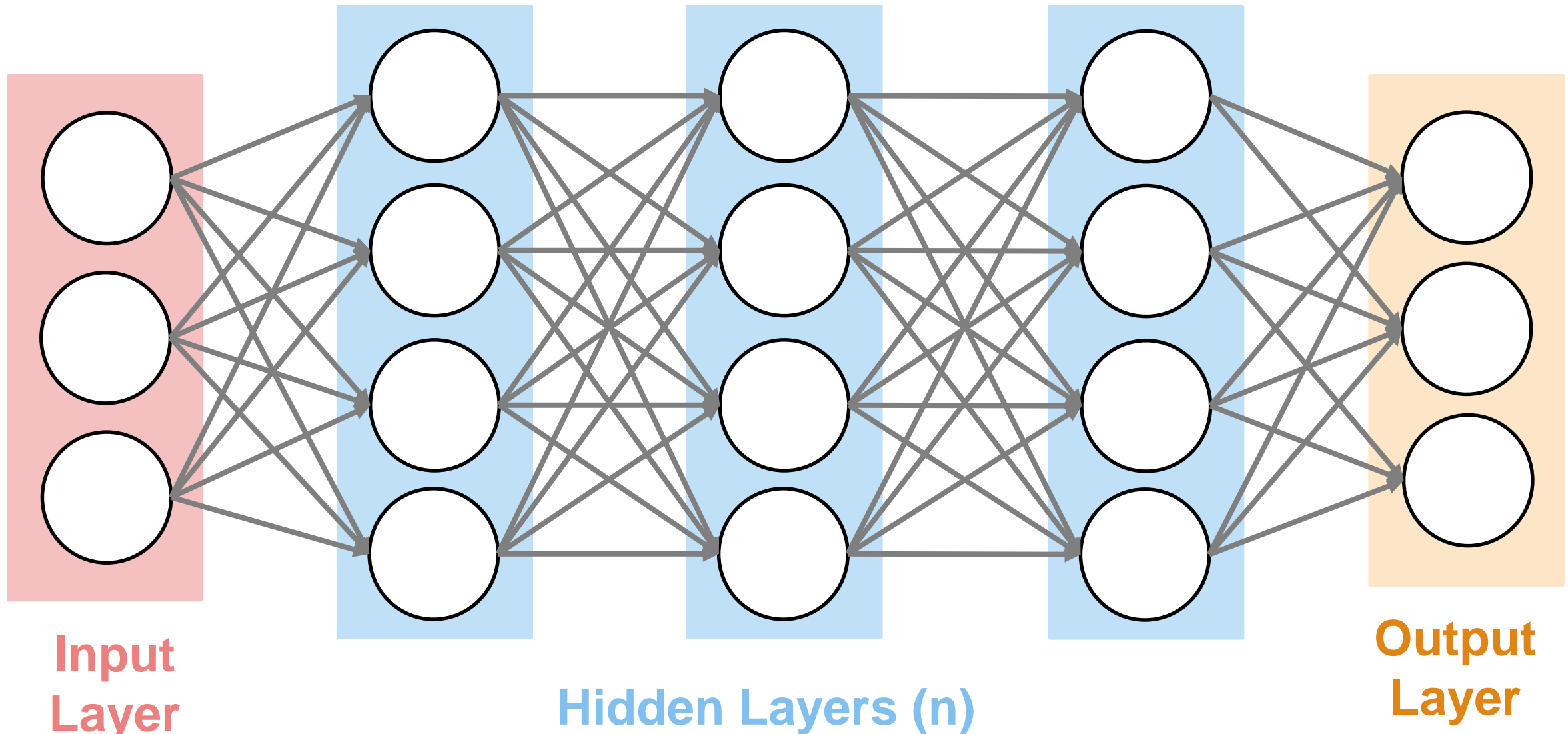


Iris Recognition – 99.4% accuracy²

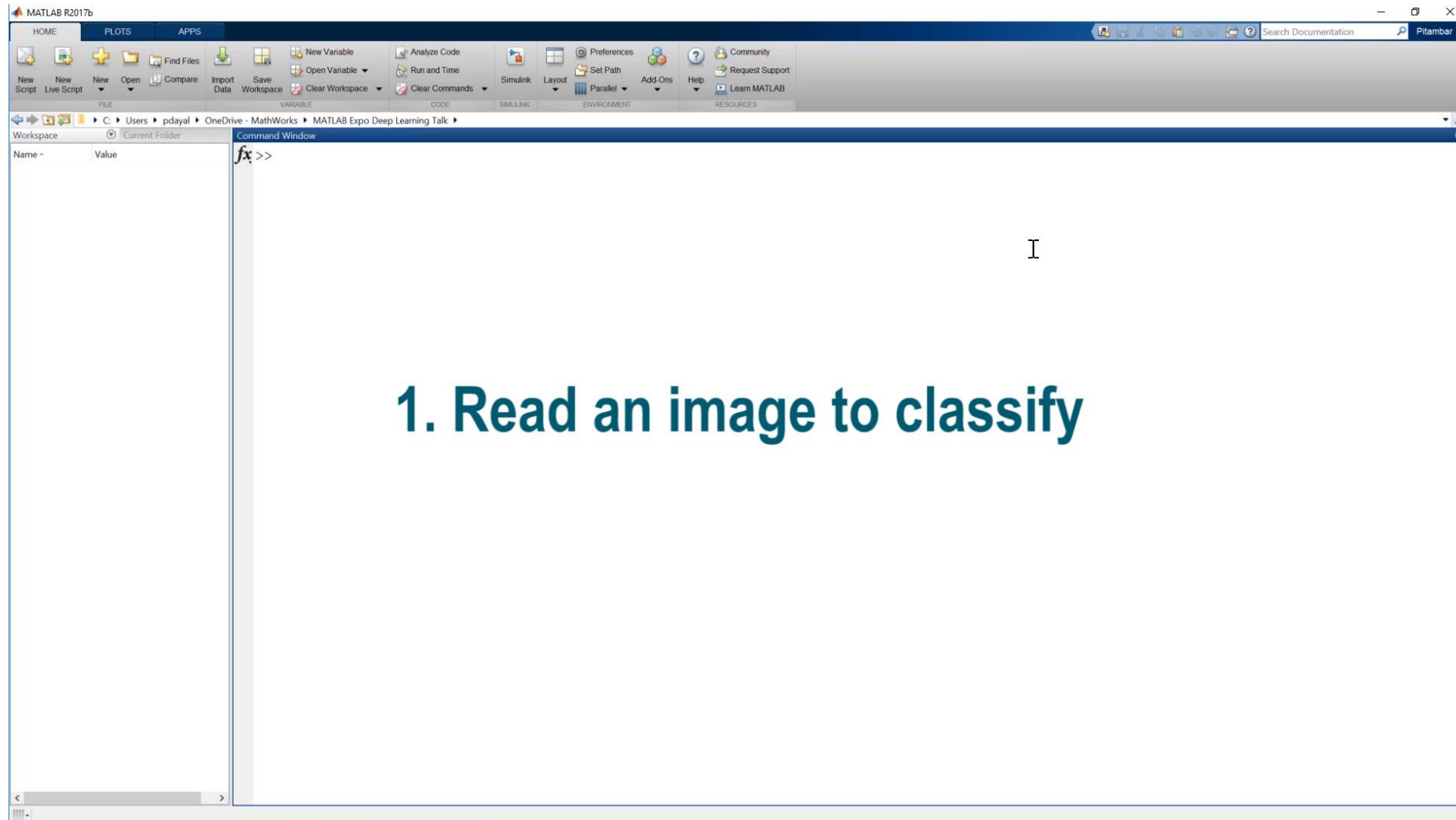
1. "Deep Joint Rain Detection and Removal from a Single Image" Wenhan Yang, Robby T. Tan, Jiashi Feng, Jiaying Liu, Zongming Guo, and Shuicheng Yan
2. Source: An experimental study of deep convolutional features for iris recognition Signal Processing in Medicine and Biology Symposium (SPMB), 2016 IEEE Shervin Minaee ; Amirali Abdolrashidiy ; Yao Wang; An experimental study of deep convolutional features for iris recognition

How is deep learning performing so well?

Deep Learning Uses a Neural Network Architecture



Deep Learning in 6 Lines of MATLAB Code



Why MATLAB for Deep Learning?

- **MATLAB is Productive**
- MATLAB is Fast
- MATLAB integrates with Open Source

**“I love to label and
preprocess my data”**

~ Said no engineer, ever.

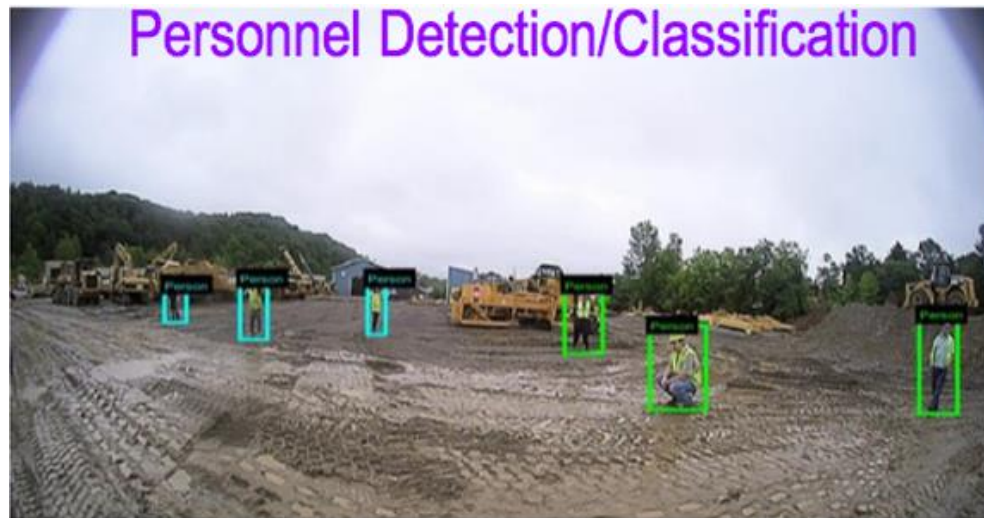
Caterpillar Case Study



- World's leading manufacturer of construction and mining equipment.
- Similarity between these projects?
 - Autonomous haul trucks
 - Pedestrian detection
 - Equipment classification
 - Terrain mapping

Computer Must Learn from Lots of Data

- ALL data must first be labeled to create these autonomous systems.

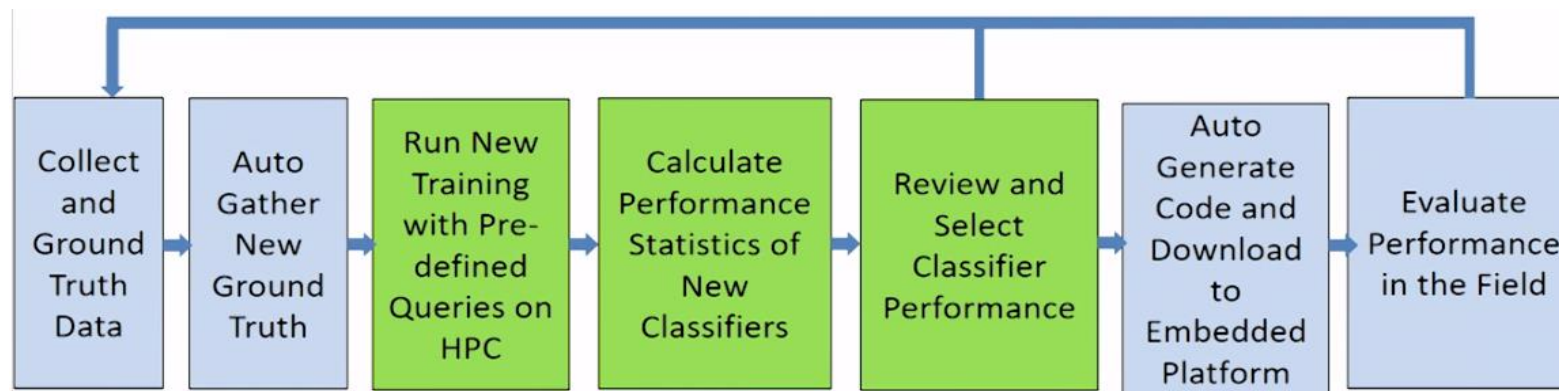


“We were spending way too much time ground-truthing [the data]”

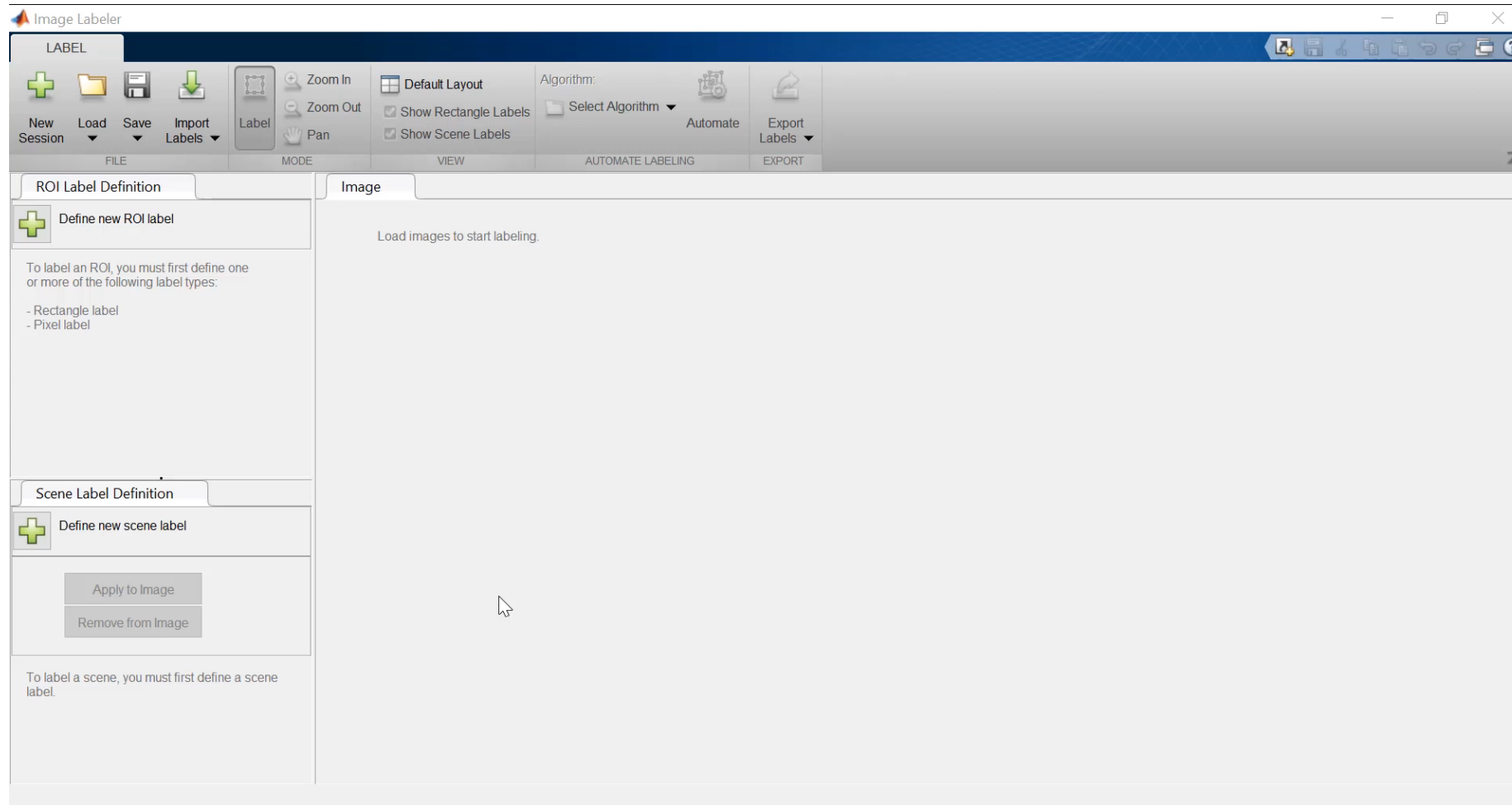
--Larry Mianzo, Caterpillar

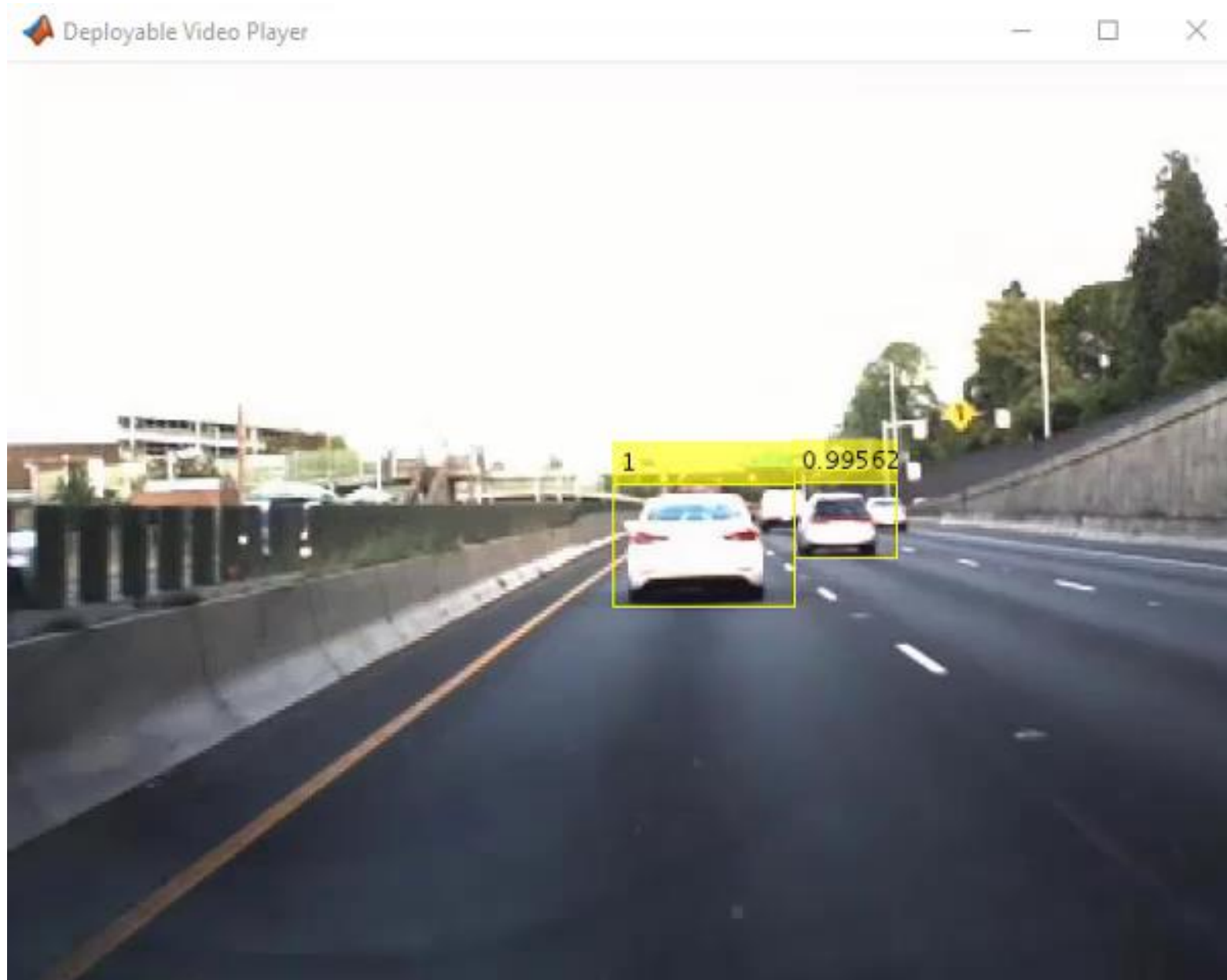
How Did Caterpillar Do with Our Tools?

- Semi-automated labeling process
 - *“We go from having to label 100 percent of our data to only having to label about 80 to 90 percent”*
- Used MATLAB for entire development workflow.
 - *“Because everything is in MATLAB, development time is short”*

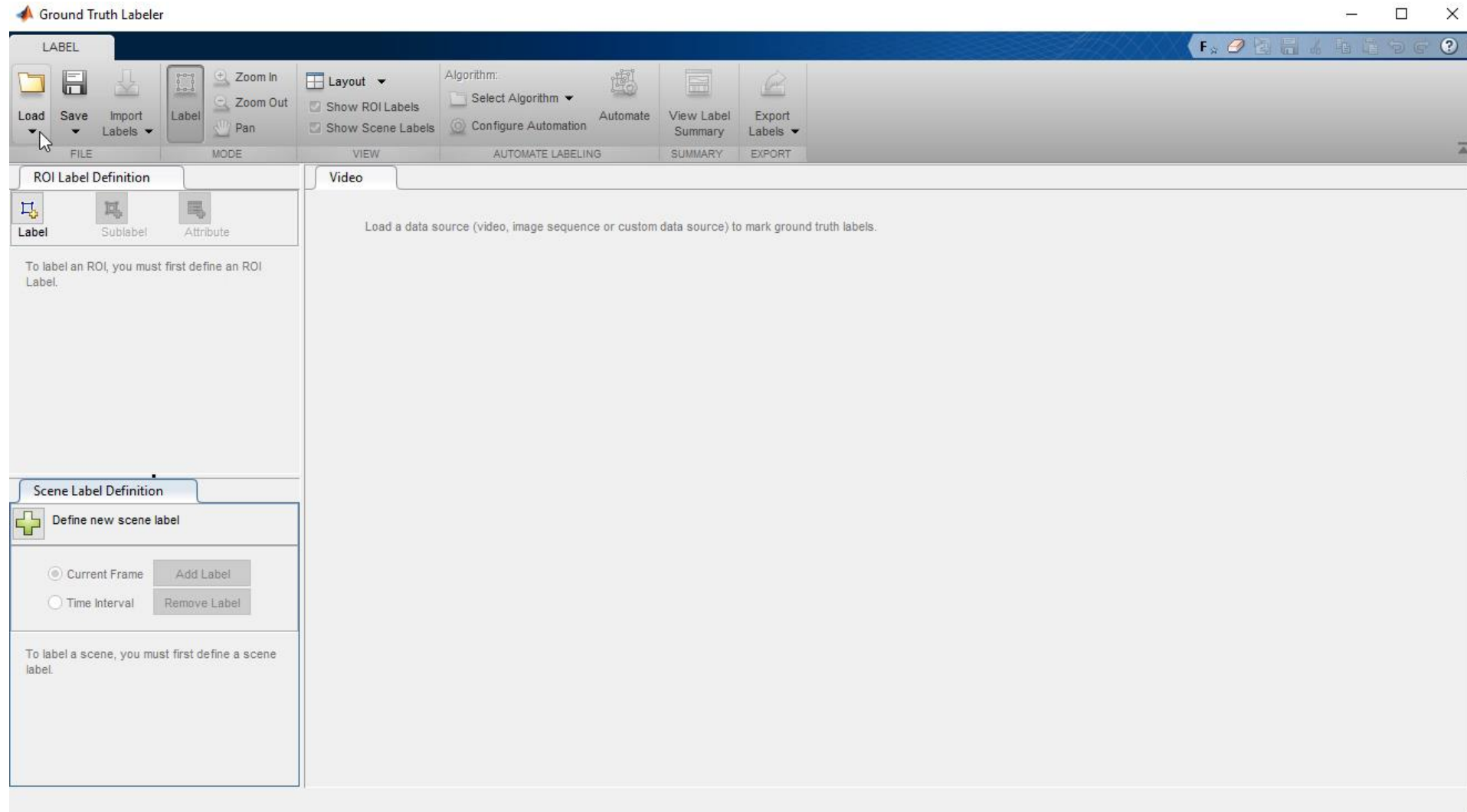


How Does MATLAB Come into Play?

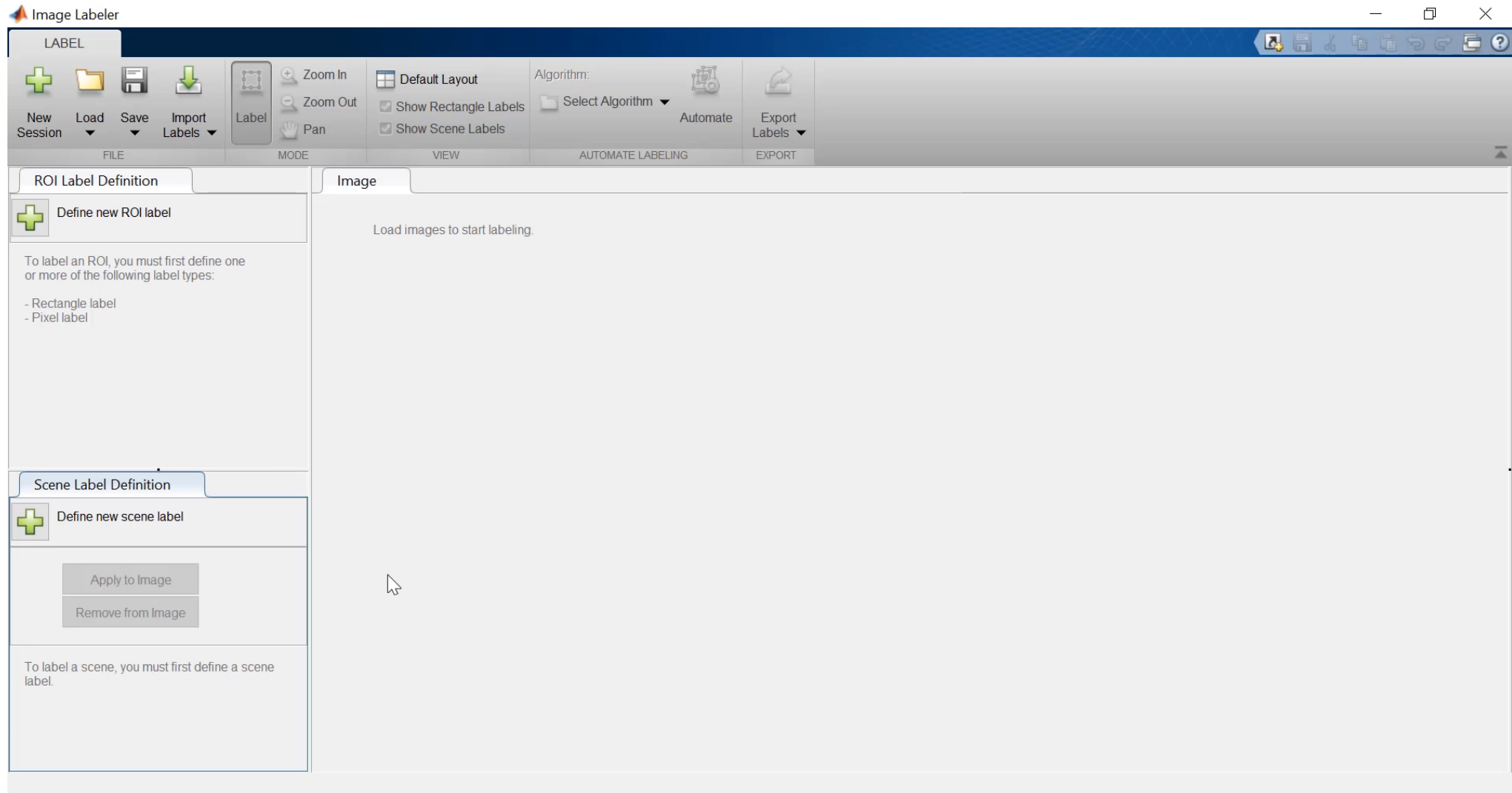




Labeling Videos: Ground Truth Labeler App



Labeling pixels

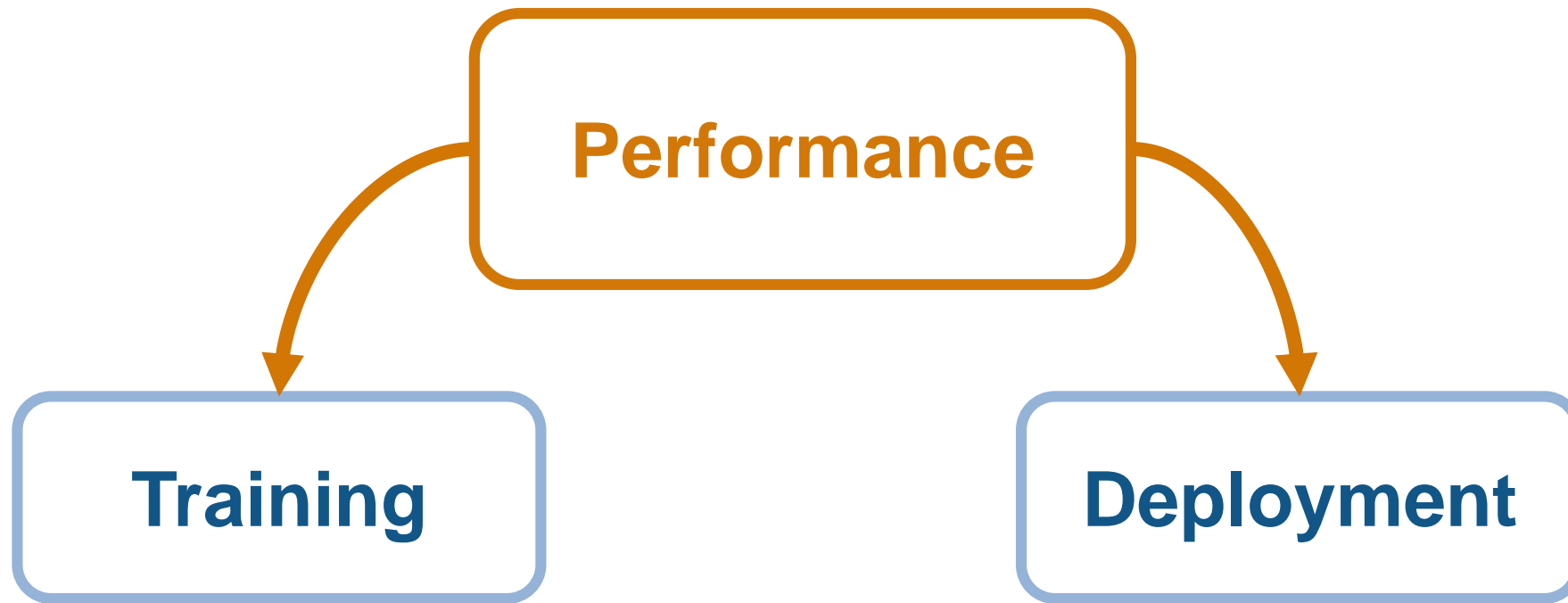




MATLAB is Productive

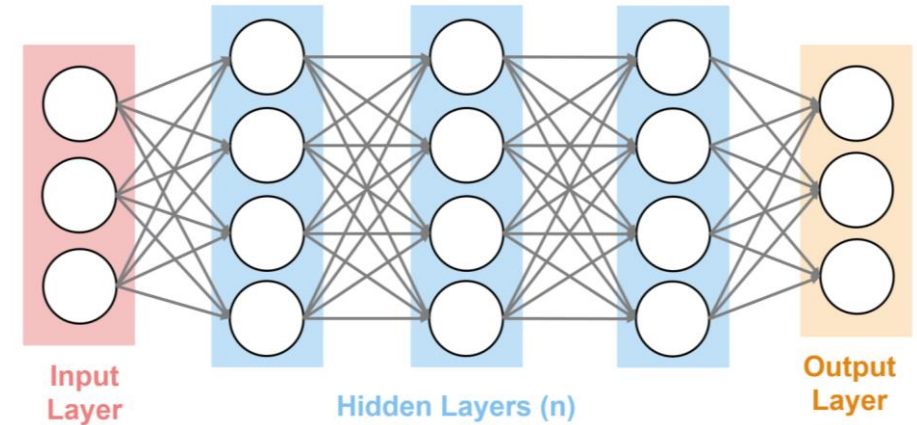
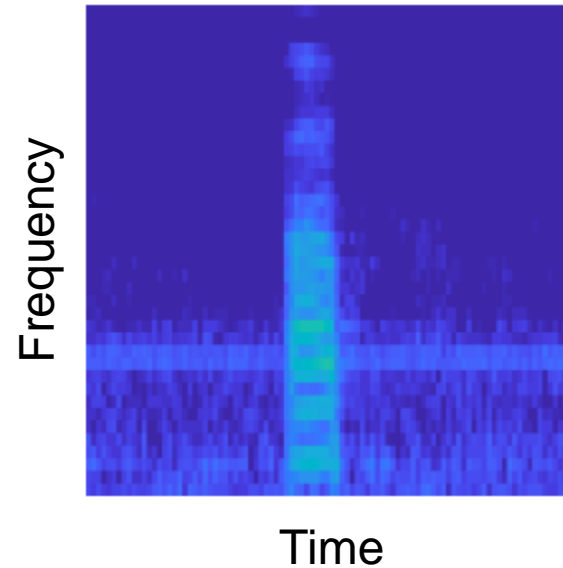
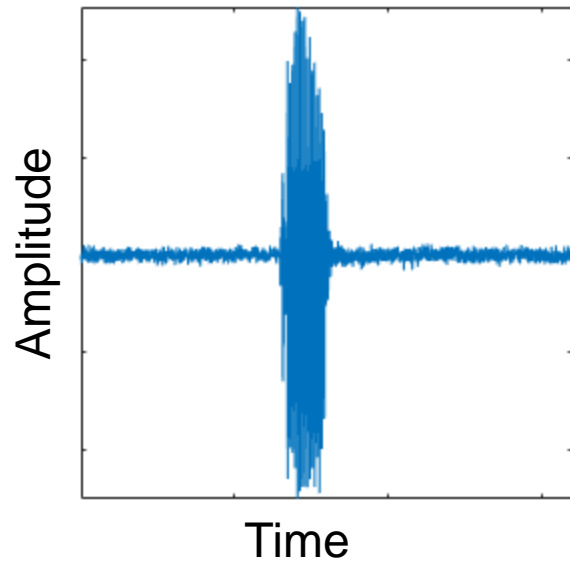
- Image Labeler App semi-automates labeling workflow
- Improve automatic labeling by updating algorithm as you label more images correctly.
- Easy to load metadata even when labeling manually

MATLAB is Fast



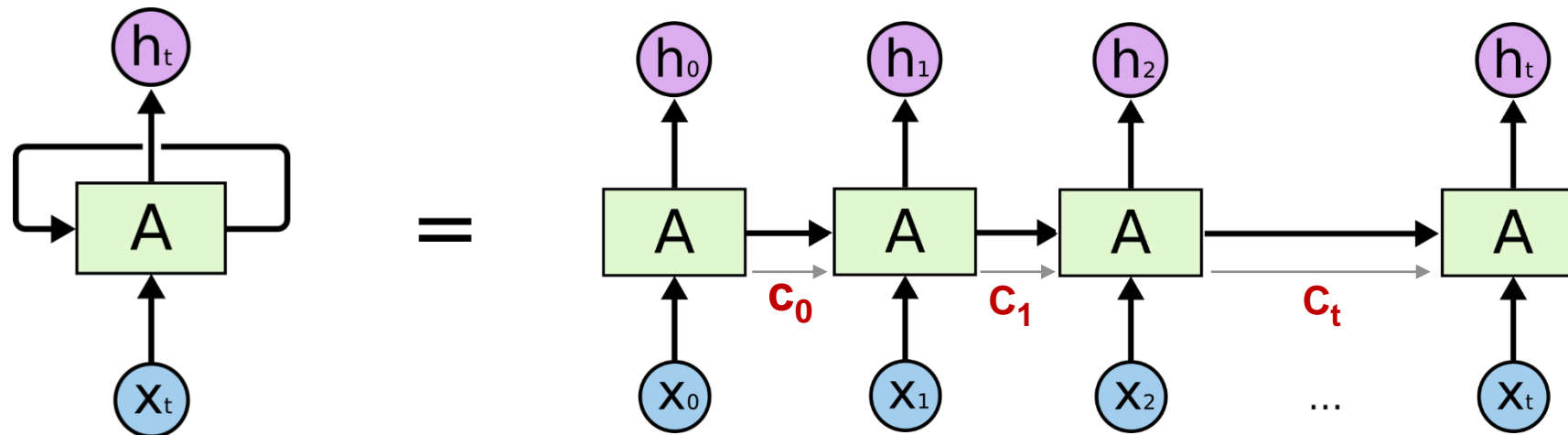
Speech Recognition Example

Audio signal → Spectrogram → Image Classification algorithm













Another Network for Signals - LSTM

- LSTM = Long Short Term Memory (Networks)
 - Signal, text, time-series data
 - Use previous data to predict new information
- I live in France. I speak _____.



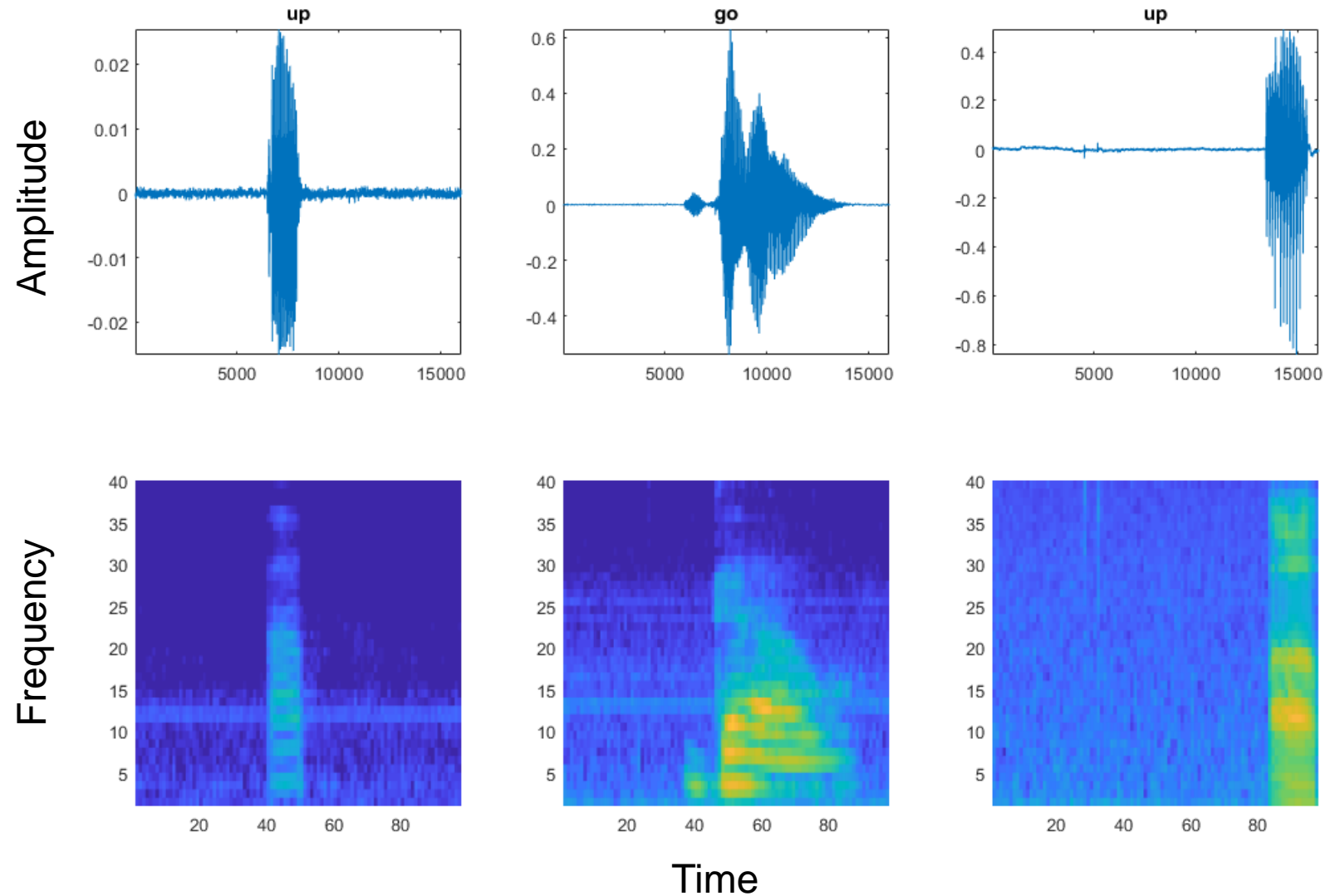
1. Create Datastore

- Datastore creates reference for data
- Do not have to load in all objects into memory

<input type="checkbox"/> Name	Date modified
 _background_noise_	2/12/2018 9:32 AM
 Data	2/12/2018 9:39 AM
 go	2/12/2018 9:34 AM
 left	2/12/2018 9:35 AM
 no	2/12/2018 9:36 AM
 off	2/12/2018 9:37 AM
 on	2/12/2018 9:38 AM
 right	2/12/2018 9:31 AM
 up	2/12/2018 9:31 AM
 yes	2/12/2018 9:32 AM

```
datafolder = fullfile(tempdir, 'speech_commands_v0.01');  
  
addpath(fullfile(matlabroot, 'toolbox', 'audio', 'audiodemos'))  
ads = audioexample.Datastore(datafolder, ...  
    'IncludeSubfolders', true, ...  
    'FileExtensions', '.wav', ...  
    'LabelSource', 'foldernames', ...  
    'ReadMethod', 'File')
```

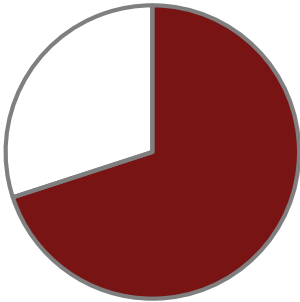
2. Compute Speech Spectrograms



3. Split datastores

Training

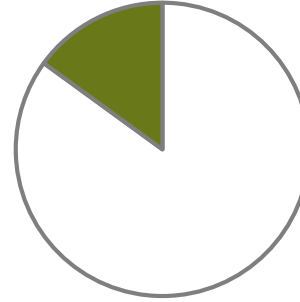
70%



- Trains the model
- Computer “learns” from this data

Validation

15%



- Checks accuracy of model during training

Test

15%



- Tests model accuracy
- Not used until validation accuracy is good

4. Define Architecture and Parameters

```
layers = [
    imageInputLayer(imageSize)

    convolution2dLayer(3,16,'Padding','same')
    batchNormalizationLayer
    reluLayer

    maxPooling2dLayer(2,'Stride',2)

    convolution2dLayer(3,32,'Padding','same')
    batchNormalizationLayer
    reluLayer

    maxPooling2dLayer(2,'Stride',2,'Padding',[0,1])

    dropoutLayer(dropoutProb)
    convolution2dLayer(3,64,'Padding','same')
    batchNormalizationLayer
    reluLayer

    dropoutLayer(dropoutProb)

    convolution2dLayer(3,64,'Padding','same')
    batchNormalizationLayer
    reluLayer

    maxPooling2dLayer(2,'Stride',2,'Padding',[0,1])

    dropoutLayer(dropoutProb)
    convolution2dLayer(3,64,'Padding','same')
    batchNormalizationLayer
    reluLayer

    dropoutLayer(dropoutProb)
    convolution2dLayer(3,64,'Padding','same')
    batchNormalizationLayer
    reluLayer

    maxPooling2dLayer([1 13])

    fullyConnectedLayer(numClasses)
    softmaxLayer
    weightedCrossEntropyLayer(classNames,classWeights)];
```

Neural Network Architecture

```
miniBatchSize = 128;
validationFrequency = floor(numel(YTrain)/miniBatchSize);
options = trainingOptions('adam', ...
    'InitialLearnRate',5e-4, ...
    'MaxEpochs',25, ...
    'MiniBatchSize',miniBatchSize, ...
    'Shuffle','every-epoch', ...
    'Plots','training-progress', ...
    'Verbose',false, ...
    'ValidationData',{XValidation,YValidation}, ...
    'ValidationFrequency',validationFrequency, ...
    'ValidationPatience',Inf, ...
    'LearnRateSchedule','piecewise', ...
    'LearnRateDropFactor',0.1, ...
    'LearnRateDropPeriod',20);
```

Training Parameters

4. How to choose the right structure to start from?

Pretrained Models for Transfer learning

- Access pretrained models from top researchers with a single line of code

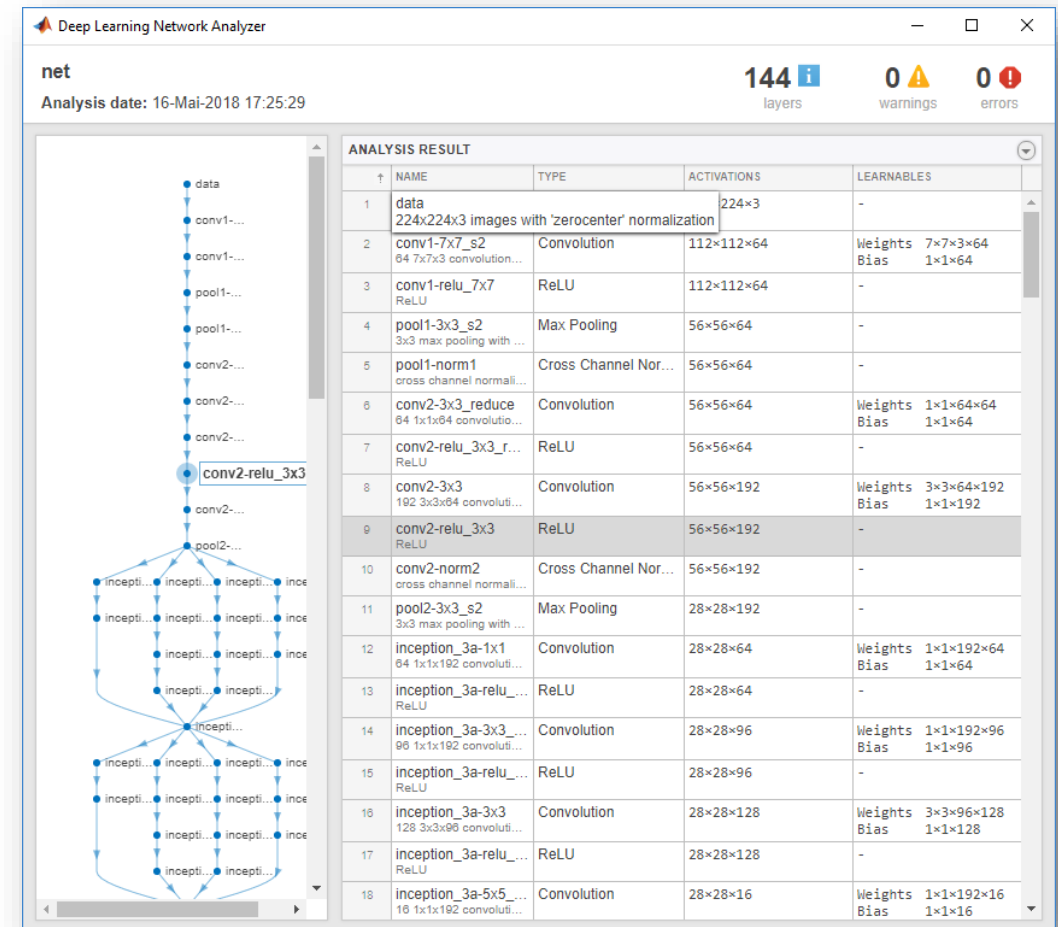
```
net = alexnet;
net = vgg16;
net = inceptionv3;
net = googlenet;
...
```

Import Models from OSS Frameworks

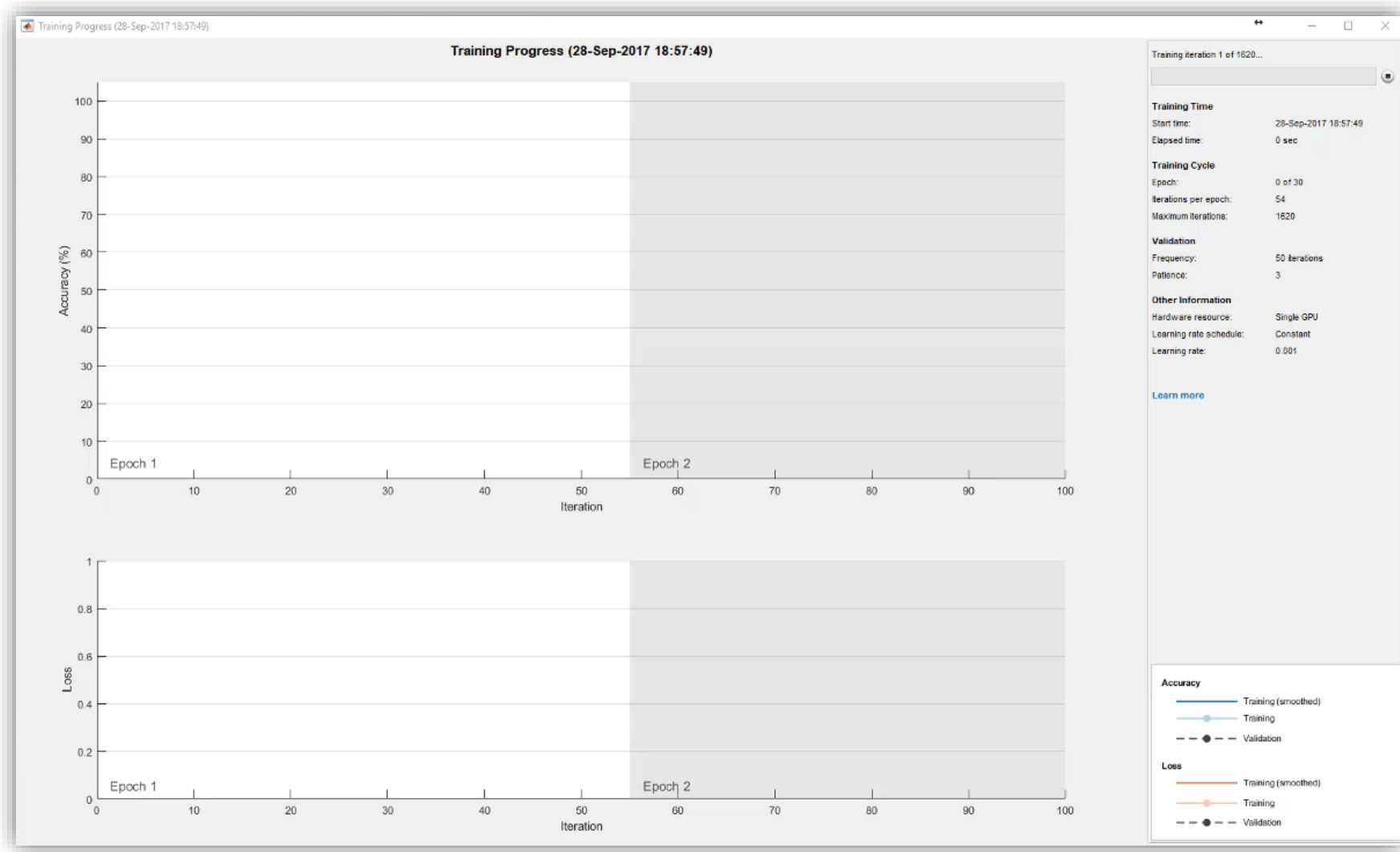
- Caffe Model Importer
- TensorFlow/Keras Model Importer

Start from scratch

- Verify structure with [Network Analyzer App](#)



5. Train Network



Deep Learning on CPU, GPU, Multi-GPU and Clusters

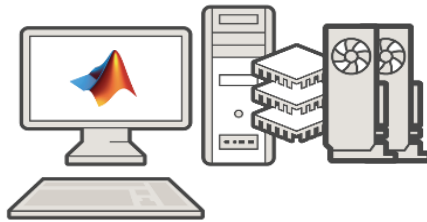
HOW TO TARGET?



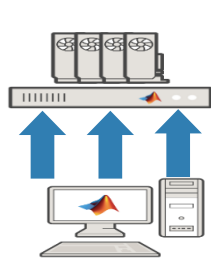
Single
CPU



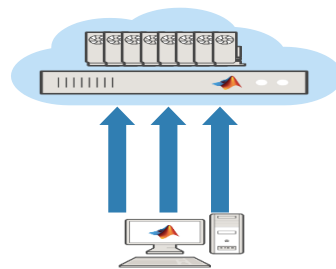
Single CPU
Single GPU



Single CPU, Multiple GPUs



On-prem server with
GPUs



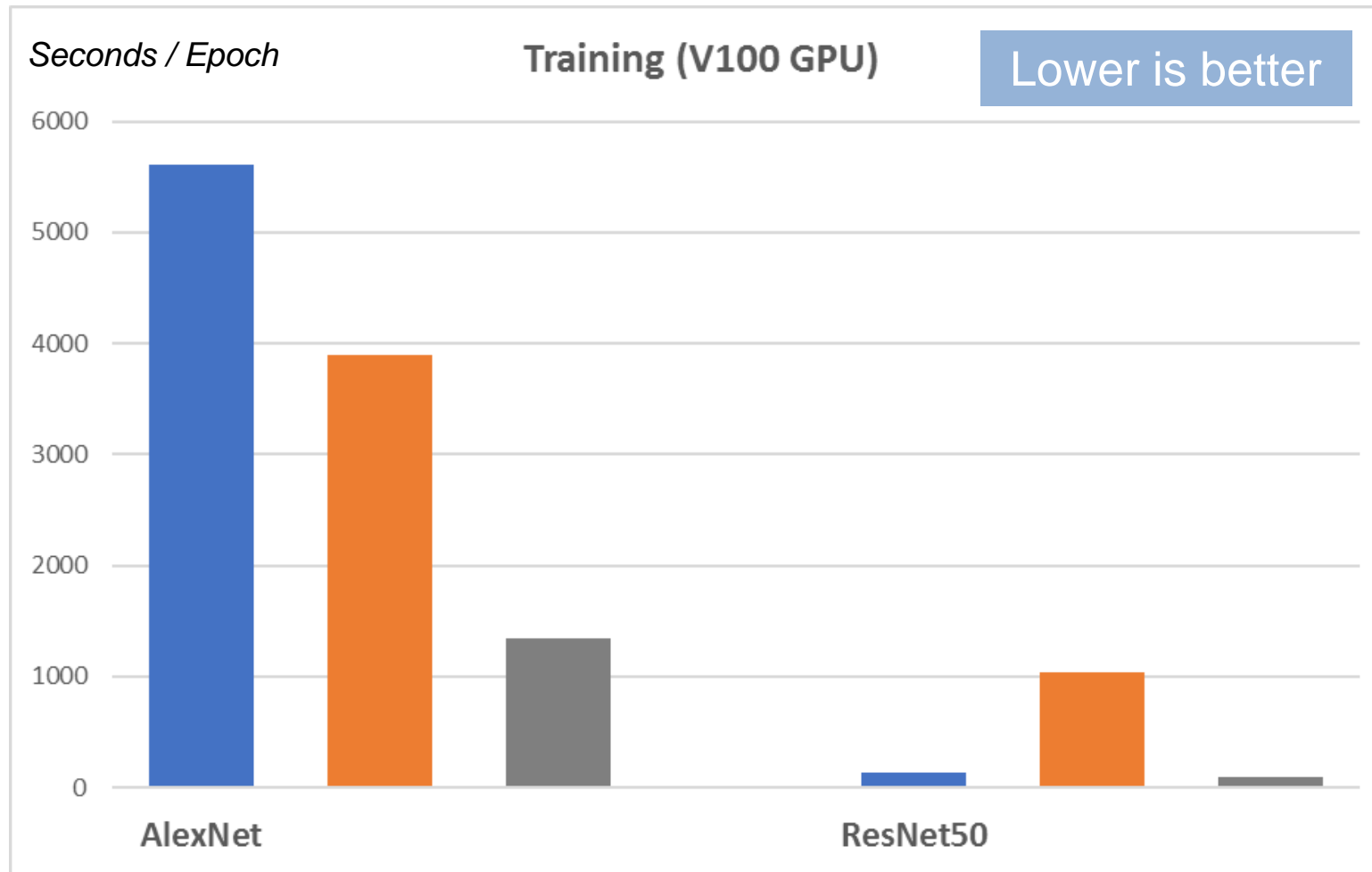
Cloud GPUs
(AWS)

```
opts = trainingOptions('sgdm', ...
    'MaxEpochs', 100, ...
    'MiniBatchSize', 250, ...
    'InitialLearnRate', 0.00005, ...
    'ExecutionEnvironment', 'auto' );
```

```
opts = trainingOptions('sgdm', ...
    'MaxEpochs', 100, ...
    'MiniBatchSize', 250, ...
    'InitialLearnRate', 0.00005, ...
    'ExecutionEnvironment', 'multi-gpu' );
```

```
opts = trainingOptions('sgdm', ...
    'MaxEpochs', 100, ...
    'MiniBatchSize', 250, ...
    'InitialLearnRate', 0.00005, ...
    'ExecutionEnvironment', 'parallel' );
```

Training Performance



TensorFlow

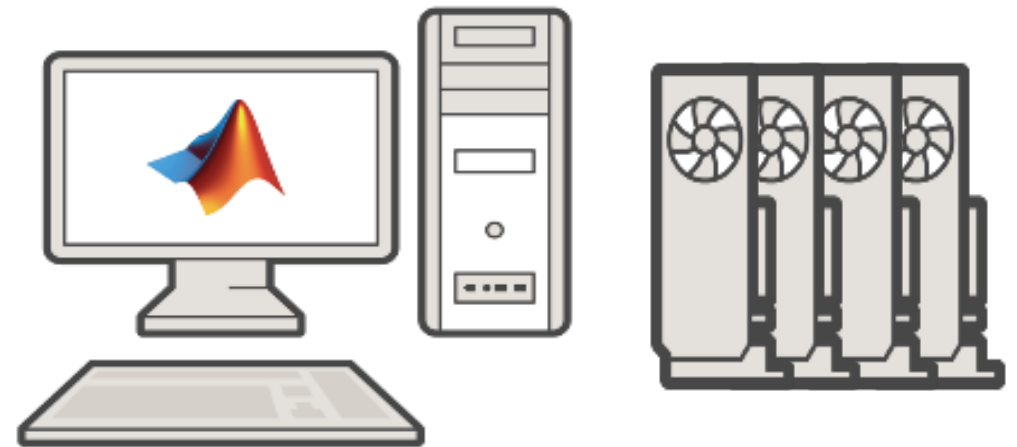
MATLAB

MXNet

Batch size 32

MATLAB is Fast for Deployment

- Target a GPU for optimal performance
- NVIDIA GPUs use CUDA code
- We only have MATLAB code.
Can we translate this?



GPU Coder

- Automatically generates **CUDA** Code from MATLAB Code
 - can be used on NVIDIA GPUs



- CUDA extends C/C++ code with constructs for parallel computing

GPU Coder Performance

Inference with MATLAB

Why MATLAB?

- MATLAB is Productive
- MATLAB is Fast
- **MATLAB Integrates with Open Source**

Used MATLAB and Open Source Together



- Used Caffe and MATLAB together
- Achieved significantly better results than an engineered rain model.
- Use our tools where it makes your workflow easier!

1. Deep Joint Rain Detection and Removal from a Single Image" Wenhan Yang, Robby T. Tan, Jiashi Feng, Jiaying Liu, Zongming Guo, and Shuicheng Yan

MATLAB Integrates with Open Source Frameworks

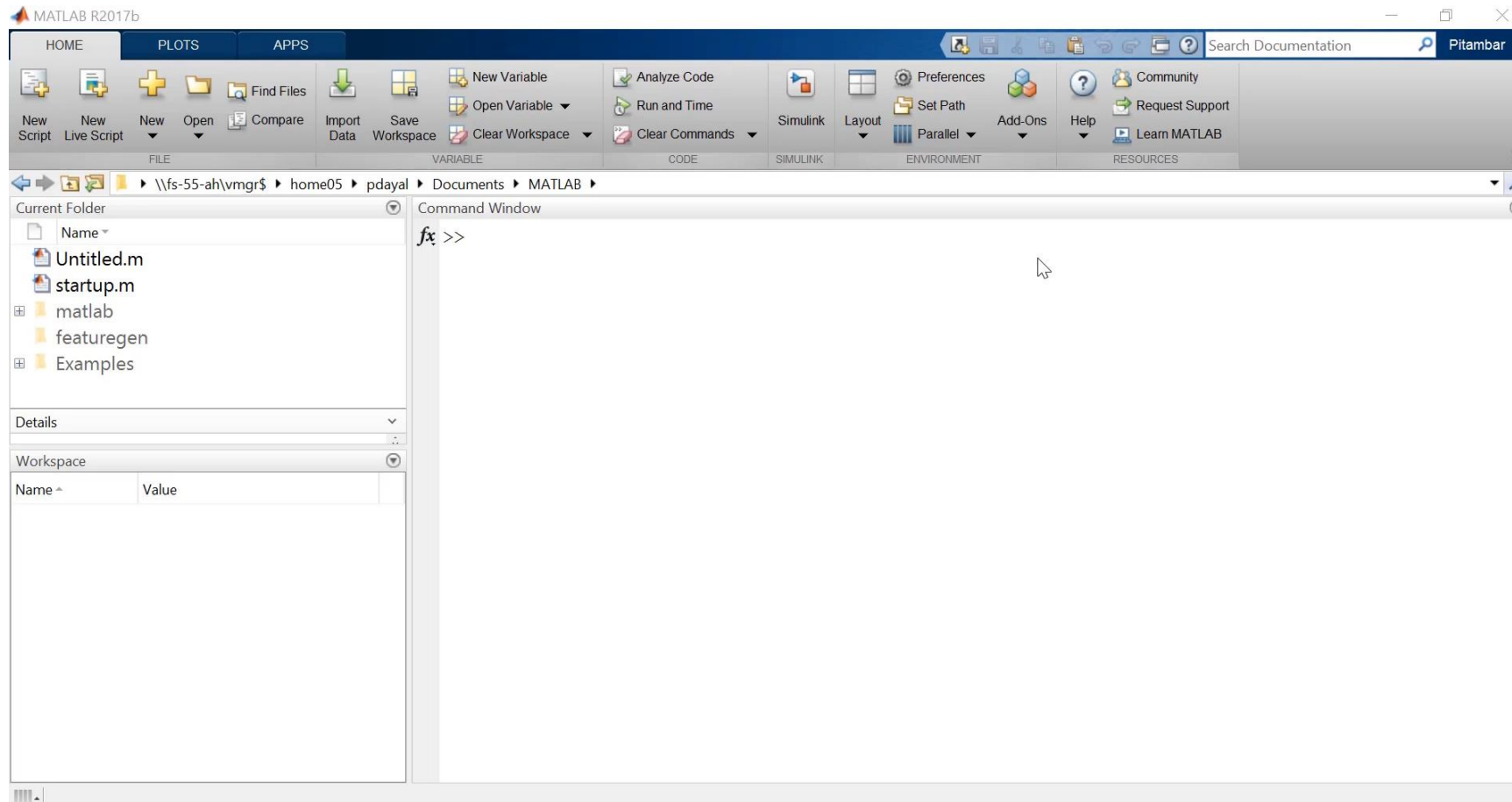
- Access to many pretrained models through add-ons
- Users wanted to import latest models
- Import models directly from Tensorflow or Caffe
 - Allows for improved collaboration

KERAS IMPORTER

Importer for TensorFlow-Keras Models

Caffe
MODELS

Keras-Tensorflow Importer



MATLAB Integrates with Open Source Frameworks

- MATLAB supports entire deep learning workflow
 - Use when it is convenient for your workflow
- Access to latest models
- Improved collaboration with other users

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MATLAB Courses

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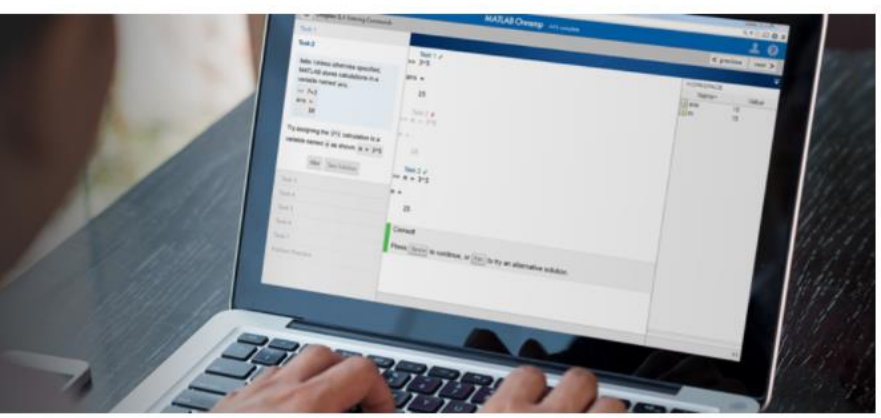
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Core MATLAB Functionality