MATLAB EXPO 2018

Demystifying Deep Learning "Let the computers do the hard work"

Jérémy Huard







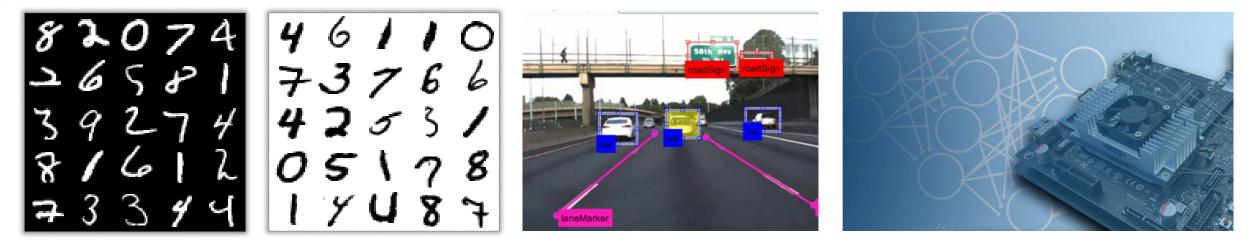


Why MATLAB for Deep Learning?

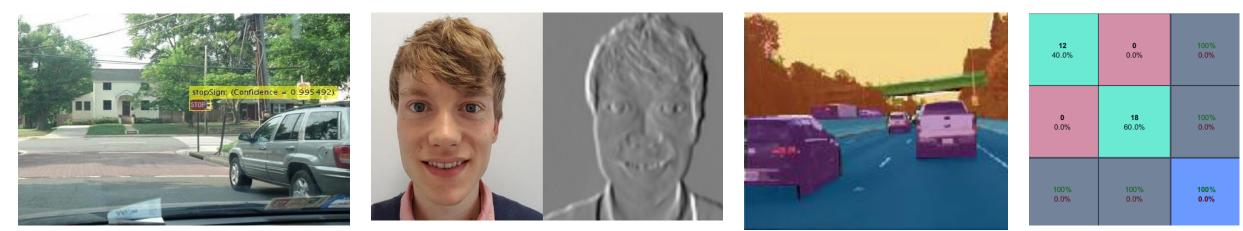
MATLAB is Productive

- MATLAB is Fast
- MATLAB Integrates with Open Source





What is Deep Learning?

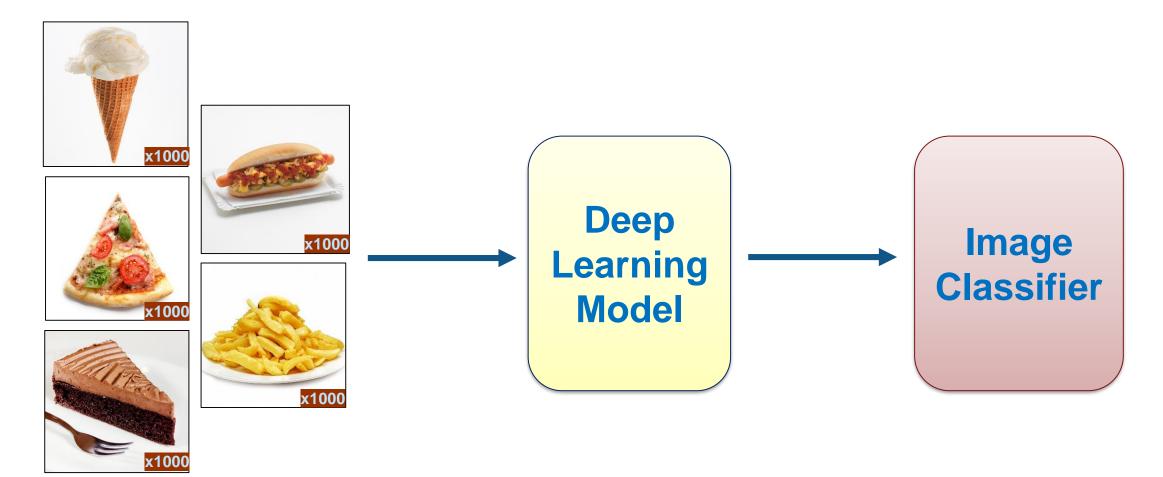


MATLAB EXPO 2018



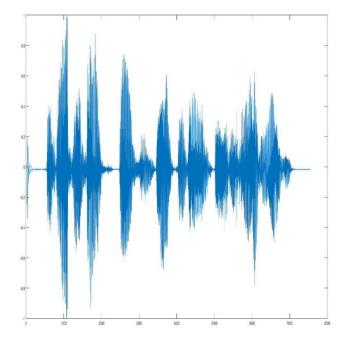
Deep Learning

Model learns to perform tasks directly from data.





Data Types for Deep Learning







Signal



Image



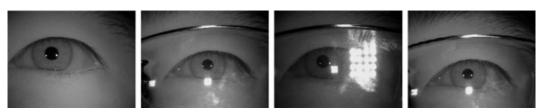
Deep Learning is Versatile



Detection of cars and road in autonomous driving systems



Rain Detection and Removal¹



*Iris Recognition – 99.4% accuracy*²

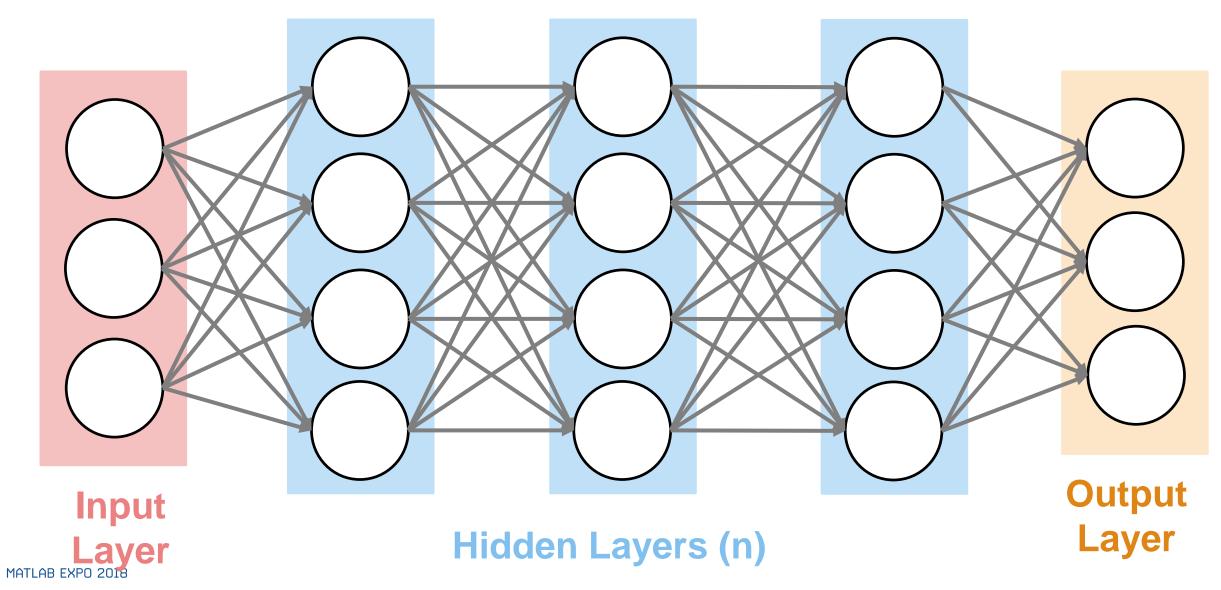
- 1. Deep Joint Rain Detection and Removal from a Single Image" Wenhan Yang, Robby T. Tan, Jiashi Feng, Jiaying Liu, Zongming Guo, and Shuicheng Yan
- 2. Source: An experimental study of deep convolutional features for iris recognition Signal Processing in Medicine and Biology Symposium (SPMB), 2016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

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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.

A MathWorks

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.

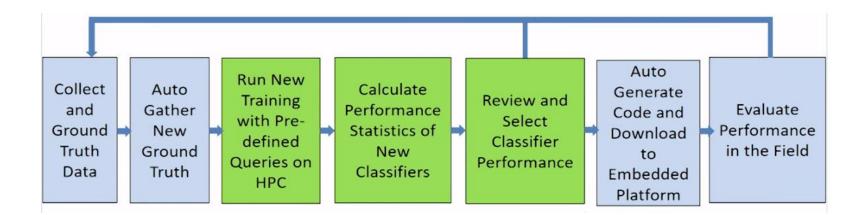


"We were spending way too much time ground-truthing [the data]" --Larry Mianzo, Caterpillar



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"

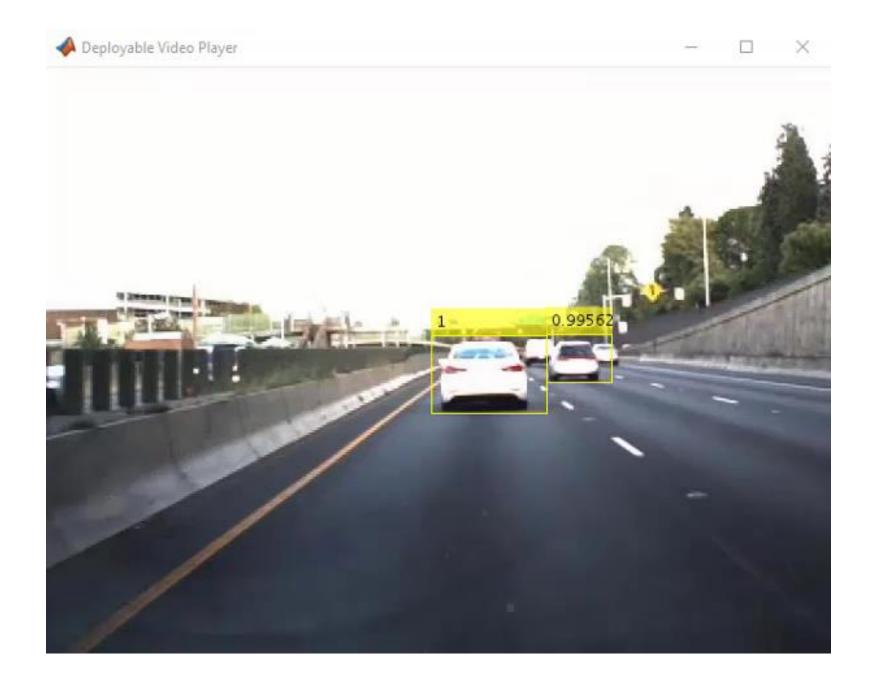




How Does MATLAB Come into Play?

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ROI Label Definition	Image	
Define new ROI label To label an ROI, you must first define one or more of the following label types: - Rectangle label - Pixel label	Load images to start labeling.	
Scene Label Definition Define new scene label Apply to Image Remove from Image To label a scene, you must first define a scene label.	ζ.	







Labeling Videos: Ground Truth Labeler App

LABEL Image: Select Algorithm - Labels - FILE MODE View Automate View Label Export ROI Label Definition View Automate Submary Export Label Sublabel Attribute View Automate Submary Export To label an ROI, you must first define an ROI Label. Load a data source (video, image sequence or custom data source) to mark ground truth labels. Load a data source (video, image sequence or custom data source) to mark ground truth labels.	×
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Label Sublabel Attribute To label an ROI, you must first define an ROI Load a data source (video, image sequence or custom data source) to mark ground truth labels.	
Scene Label Definition Define new scene label O Current Frame Add Label The Interval Remove Label To label a scene, you must first define a scene label.	



Labeling pixels

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FILE MODE	VIEW AUTOMATE LABELING EXPORT	
ROI Label Definition	Image	
Define new ROI label To label an ROI, you must first define one	Load images to start labeling.	
or more of the following label types:		
- Rectangle label - Pixel label		
Scene Label Definition Define new scene label		
Apply to Image Remove from Image To label a scene, you must first define a scene label.	Σ	







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



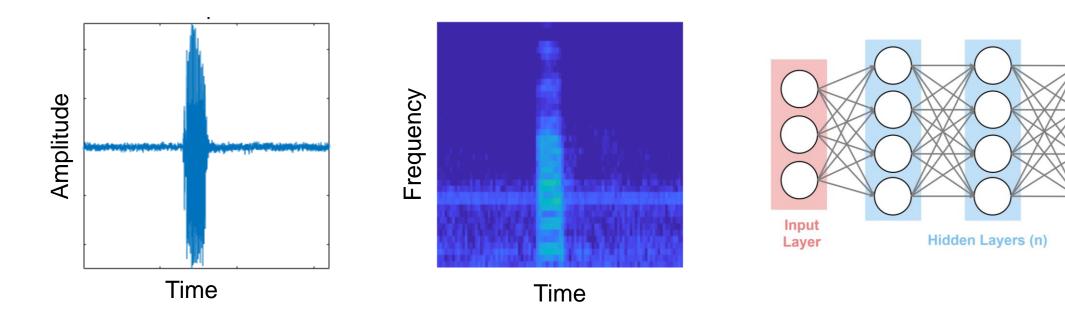
MATLAB is Fast





Speech Recognition Example

Audio signal \rightarrow Spectrogram \rightarrow Image Classification algorithm



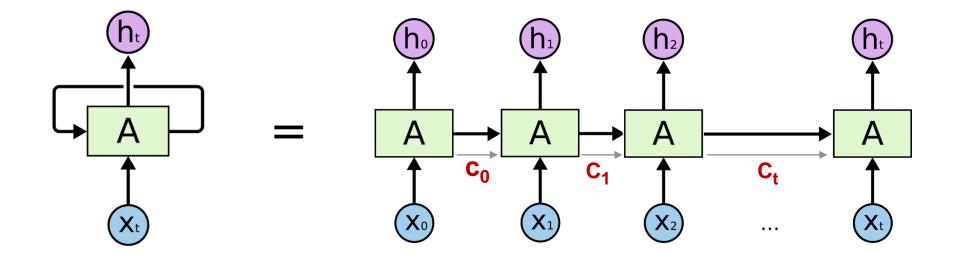
Output

Layer



Another Network for Signals - LSTM

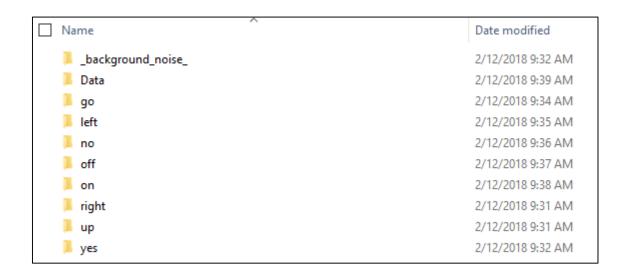
- LSTM = Long Short Term Memory (Networks)
 - Signal, text, time-series data
 - Use previous data to predict new information
- I live in France. I speak _____.





1. Create Datastore

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

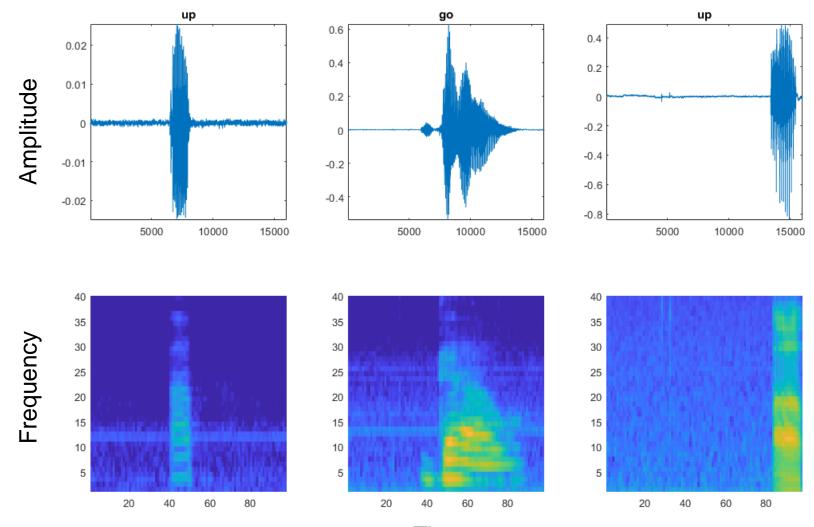


```
datafolder = fullfile(tempdir,'speech_commands_v0.01');
```

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



2. Compute Speech Spectrograms

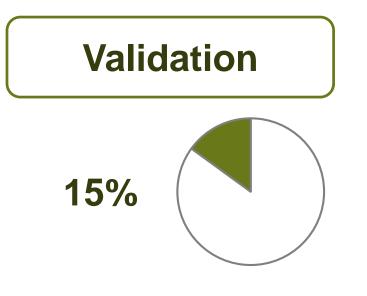




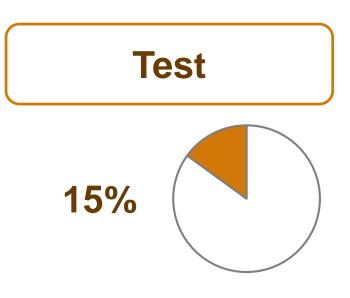
3. Split datastores



- Trains the model
- Computer "learns" from this data



 Checks accuracy of model during training



- 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, ... 'MaxEpochs',25, ... 'MiniBatchSize',miniBatchSize, ... 'Shuffle','every-epoch', ... 'Plots','training-progress', ... 'Plots','training-progress', ... 'Verbose',false, ... 'Verbose',false, ... 'ValidationData',{XValidation,YValidation}, ... 'ValidationFrequency',validationFrequency, ... 'ValidationFrequency',validationFrequency, ... 'LearnRateSchedule','piecewise', ... 'LearnRateDropFactor',0.1, ... 'LearnRateDropFactor',0.1, ...<'LearnRateDropPeriod',20);</pre>

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

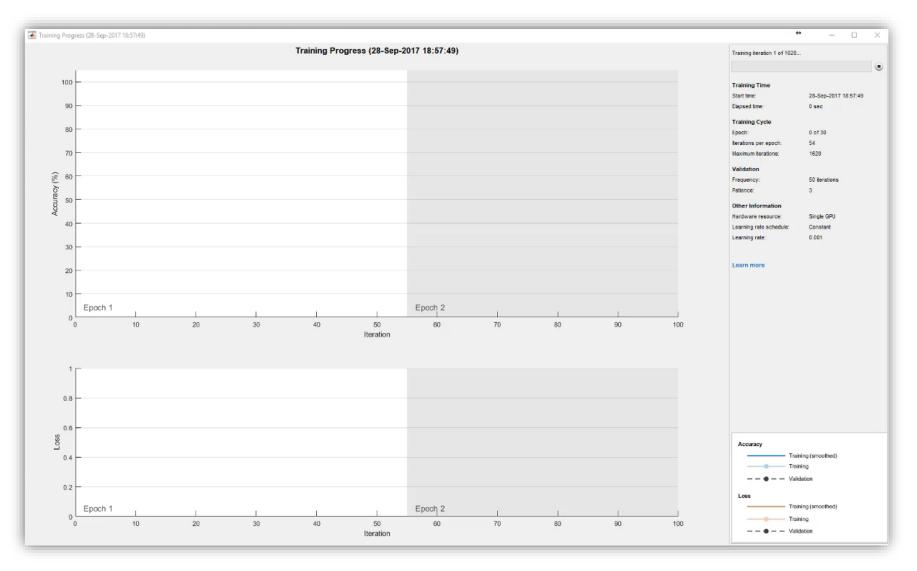
Start from scratch

Verify structure with Network Analyzer App

Deep Learning Network Analyzer					- 0	×
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• conv1	2	conv1-7x7_s2 64 7x7x3 convolution	Convolution	112×112×64	Weights 7×7×3×64 Bias 1×1×64	
pool1	3	conv1-relu_7x7 ReLU	ReLU	112×112×64	-	ļ
pool1	4	pool1-3x3_s2 3x3 max pooling with	Max Pooling	56×56×64	-	
• conv2	5	pool1-norm1 cross channel normali	Cross Channel Nor	56×56×64	-	
• conv2	6	conv2-3x3_reduce 64 1x1x64 convolutio	Convolution	56×56×64	Weights 1×1×64×64 Bias 1×1×64	
• conv2	7	conv2-relu_3x3_r ReLU	ReLU	56×56×64	-	
conv2-relu_3x3	8	conv2-3x3 192 3x3x64 convoluti	Convolution	56×56×192	Weights 3×3×64×192 Bias 1×1×192	
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Cincepti	14	inception_3a-3x3 96 1x1x192 convoluti	Convolution	28×28×96	Weights 1×1×192×96 Bias 1×1×96	
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	18	inception_3a-5x5	Convolution	28×28×16	Weights 1×1×192×16	

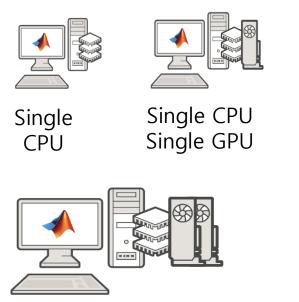


5. Train Network





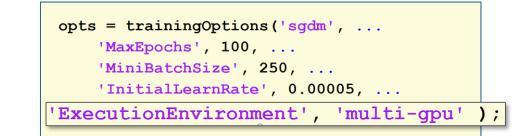
Deep Learning on CPU, GPU, Multi-GPU and Clusters

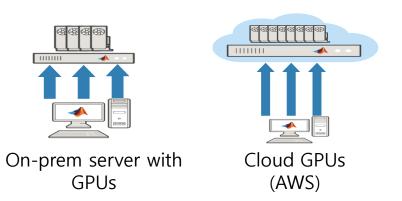


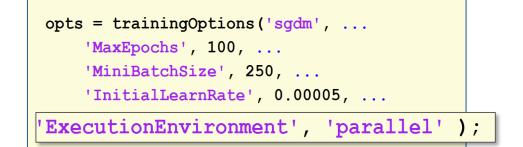
Single CPU, Multiple GPUs

HOW TO TARGET?

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

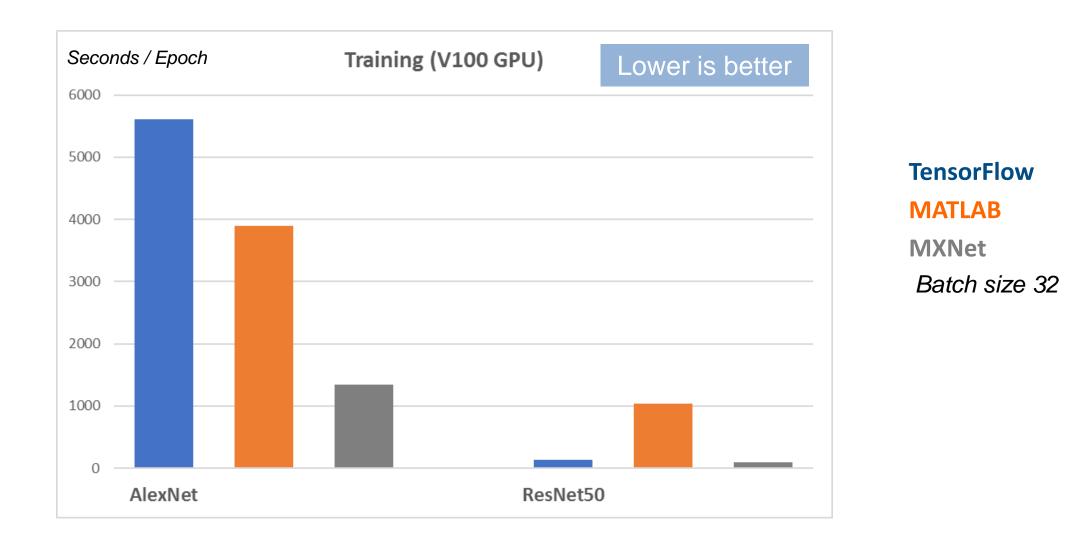








Training Performance

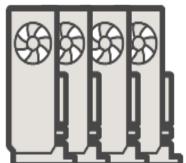




MATLAB is Fast for Deployment

- 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





Why MATLAB?

MATLAB is Productive

- MATLAB is Fast
- MATLAB Integrates with Open Source



Used MATLAB and Open Source Together



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

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



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





Keras-Tensorflow Importer

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MATLAB Integrates with Open Source Frameworks

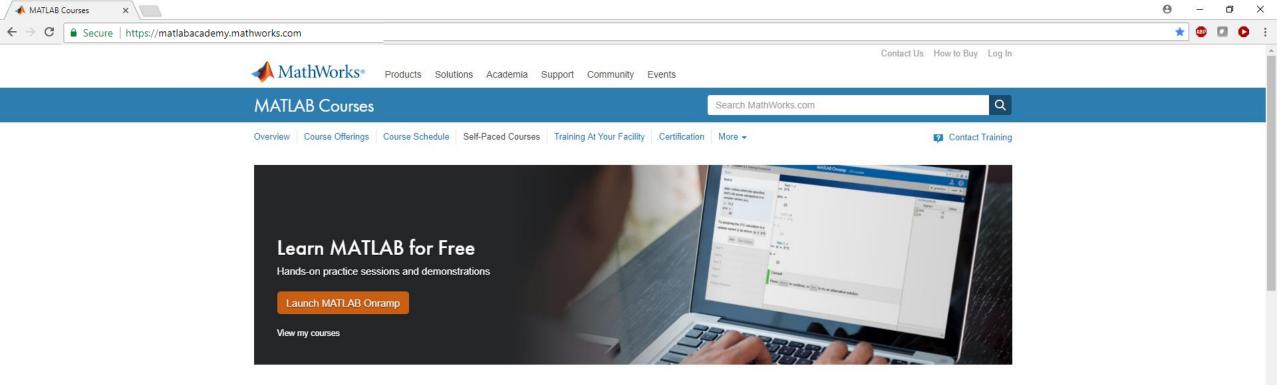
- MATLAB supports entire deep learning workflow
 Use when it is convenient for your workflow
- Access to latest models
- Improved collaboration with other users



Why MATLAB for Deep Learning?

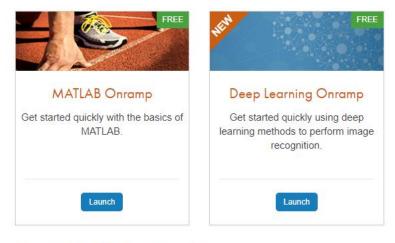
MATLAB is Productive

- MATLAB is Fast
- MATLAB Integrates with Open Source



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Get Started



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Window Store

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Core MATLAB Functionality