MATLAB TOUR 2017
Machine Learning y Deep Learning con MATLAB

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Deep Learning is Everywhere

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MATLAB framework makes Deep Learning Easy and Accessible
Deep Learning is Everywhere

**Computer Vision**
- Pedestrian and traffic sign detection
- Landmark identification
- Scene recognition
- Medical diagnosis and drug discovery

**Text and Signal Processing**
- Speech Recognition
- Speech & Text Translation

**Robotics & Controls**
and many more…

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Deep Learning Use Case
e.g. Automated Driving
What is Deep Learning?
Deep Learning is a Subset of Machine Learning
e.g. Google Captioning Project

*Machine learning* is the science of getting computers to act without being explicitly programmed.

*Deep learning* algorithms can learn tasks directly from data, eliminating the need for manual feature selection.

http://googleresearch.blogspot.com/2014/11/a-picture-is-worth-thousand-coherent.html

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Shallow Machine Learning Workflow

**Train:** Iterate until you find the best model

**Predict:** Integrate trained models into applications

LOAD DATA → PREPROCESS DATA → SUPERVISED LEARNING → MODEL → PREDICTION

- LOAD DATA
- PREPROCESS DATA: Cropping, Contrast Adjustment, Feature Extraction, Feature Analysis
- SUPERVISED LEARNING: CLASSIFICATION, REGRESSION
- MODEL
- PREDICTION: NEW DATA

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Deep learning is a type of **machine learning** that learns tasks *directly* from data.
What is Deep Learning?

End-to-End Learning

Data

Task

Cat

Dog

Bird

Car

Learned Features...
Why is Deep Learning so popular now?

![Bar chart showing error rates from 2010 to 2015 for machine learning and deep learning.]

*Source: ILSVRC Top-5 Error on ImageNet*
Deep Learning Enablers

1. Acceleration with GPU’s

2. Massive sets of labeled data

3. Availability of state of the art models from experts
MATLAB makes Deep Learning **Easy and Accessible**

*Learn about new MATLAB capabilities to*

- Handle and label large sets of images
- Accelerate deep learning with GPUs
- Visualize and debug deep neural networks
- Access and use models from experts

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Convolutional Neural Networks

- Train “deep” neural networks on structured data (e.g. images, signals, text)
- Implements Feature Learning: Eliminates need for “hand crafted” features
- Trained using GPUs for performance
Convolution Layer

- Core building block of a CNN
- Convolve the filters sliding them across the input, computing the dot product

- Intuition: learn filters that activate when they “see” some specific feature
Agenda

- Image classification using pre-trained network
- Training a Deep Neural Network from scratch
- Transfer learning to classify new objects
- Locate & classify objects in images and video
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Image classification using pre-trained network

```matlab
clear
camera = webcam(); % Connect to the camera

picture = camera.snapshot; % Take a picture

image(picture); % Show the picture
```

Deep Learning in 11 Lines of MATLAB Code
Image classification using pre-trained network
Agenda

- Image classification using pre-trained network
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Two Deep Learning Approaches

Approach 1: Train a Deep Neural Network from Scratch

Configure and train a CNN (convolutional neural network)
- Configure a network architecture to learn a specific task
- Gather a training set with massive amount of training data

Use when necessary:

<table>
<thead>
<tr>
<th>Training data</th>
<th>Thousands to millions of labeled images</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computation</td>
<td>Compute-intensive (requires GPU)</td>
</tr>
<tr>
<td>Training Time</td>
<td>Days to weeks for real problems</td>
</tr>
<tr>
<td>Model accuracy</td>
<td>High (but can overfit to small datasets)</td>
</tr>
</tbody>
</table>
Demo: Classifying the CIFAR-10 dataset

Approach 1: Train a Deep Neural Network from Scratch

Objective: Train a Convolutional Neural Network to classify the CIFAR-10 dataset

Data:

<table>
<thead>
<tr>
<th>Input Data</th>
<th>Thousands of images of 10 different Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response</td>
<td>AIRPLANE, AUTOMOBILE, BIRD, CAT, DEER, DOG, FROG, HORSE, SHIP, TRUCK</td>
</tr>
</tbody>
</table>

Approach:
- Import the data
- Define an architecture
- Train and test the CNN

Demo: Classifying the CIFAR-10 dataset

Approach 1: Train a Deep Neural Network from Scratch
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- Image classification using pre-trained network
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Why train a new model?

- Models from research do not work on your data
- Pre-trained model not available for your data
- Improve results by creating a model specific to your problem
Two Deep Learning Approaches

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

CNN already trained on massive sets of data
- Trained model has robust learned representations
- Can then be fine-tuned for new data or task using small/medium-size datasets

<table>
<thead>
<tr>
<th>Training data</th>
<th>Hundreds to thousands of labeled images (small)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computation</td>
<td>Moderate computation (GPU optional)</td>
</tr>
<tr>
<td>Training Time</td>
<td>Seconds to minutes</td>
</tr>
<tr>
<td>Model accuracy</td>
<td>Good, depends on the pre-trained CNN model</td>
</tr>
</tbody>
</table>
Why Perform Transfer Learning

- Requires less data and training time
- Reference models (like AlexNet, VGG-16, VGG-19) are great feature extractors
- Leverage best network types from top researchers
Demo: Classify Vehicles With Transfer Learning
Approach 2: Fine-tune a pre-trained model (transfer learning)

New Data

AlexNet

1000 Category Classifier

car →
suv →
pickup →
van →
truck →

5 Category Classifier
Demo: Classify Vehicles With Transfer Learning

Approach 2: Fine-tune a pre-trained model (transfer learning)
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Is Object Recognition/Classification Enough?

Car

Label for entire image

Car? SUV? Truck?
Object Detection – Locate and Classify Object
Goal: Create Object Detector to Locate Vehicles

Step 1: Label / Crop data
Step 2: Train detector
Step 3: Use detector
Label Images with MATLAB
Labeling Videos with MATLAB

Manually label regions of interest
Demo: Vehicle detection using Faster R-CNNs
MATLAB makes Deep Learning Easy and Accessible

Learn about new MATLAB capabilities to

- Handle and label large sets of images
- Accelerate deep learning with GPUs
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imageDS = imageDatastore(dir)
Easily manage large sets of images

Image Labeler

Video Labeler
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Training modes supported:

- Auto Select GPU
- Multi GPU (local)
- Multi GPU (cluster)

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Acceleration with Multiple GPUs
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Curated Set of Pretrained Models

Access Models with 1-line of MATLAB Code

```matlab
net1 = alexnet
net2 = vgg16
net3 = vgg19
```
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Questions?