

MATLAB EXPO 2016

Machine Learning and Deep Learning

Abhijit Bhattacharjee



Deep Learning is Everywhere

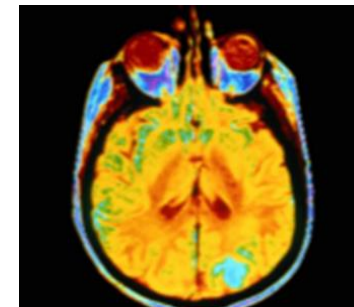
&

MATLAB Accelerates Deep Learning

Deep Learning is Everywhere

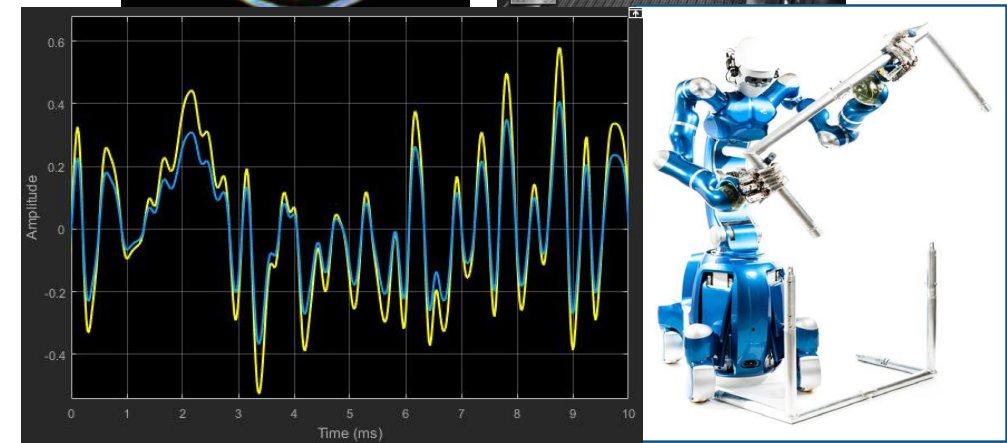
Computer Vision

- 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...

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.

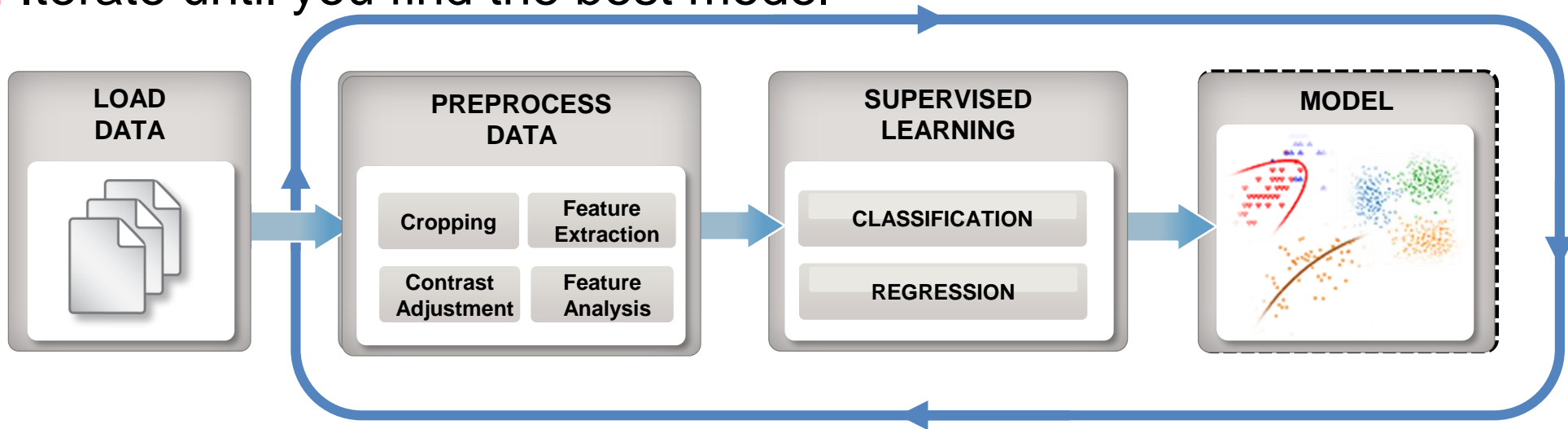
Deep learning algorithms can learn tasks directly from data, eliminating the need for manual feature selection.



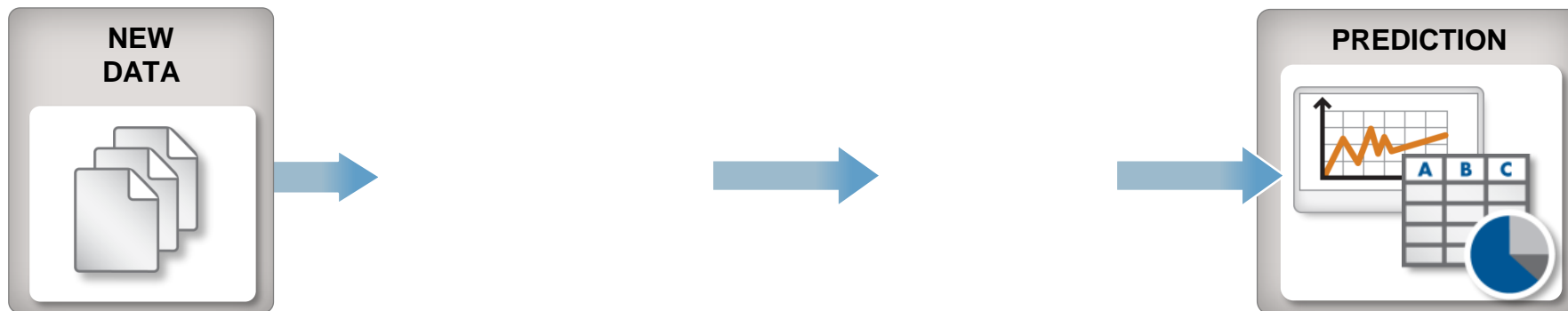
<http://googleresearch.blogspot.com/2014/11/a-picture-is-worth-thousand-coherent.html>

Shallow Machine Learning Workflow

Train: Iterate until you find the best model



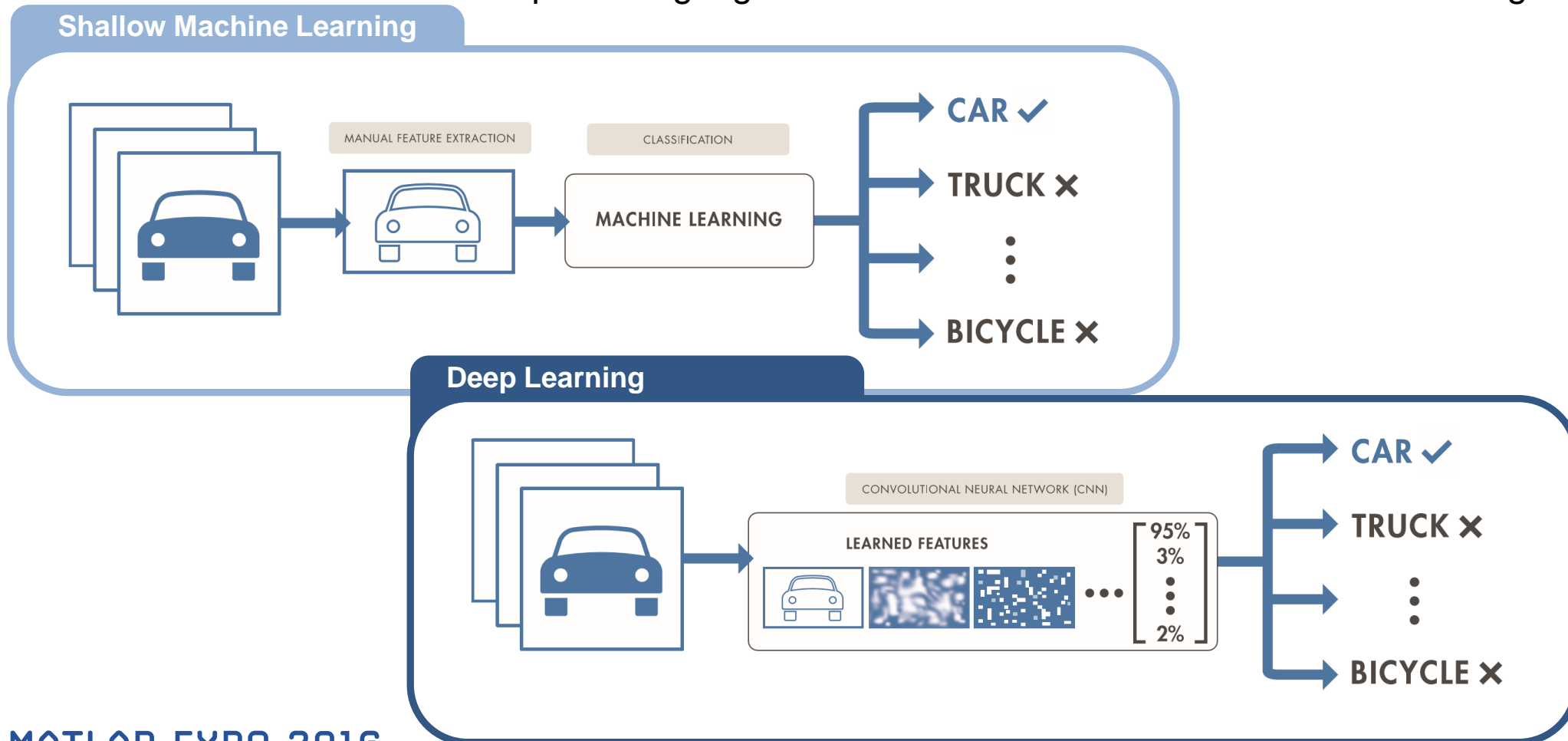
Predict: Integrate trained models into applications



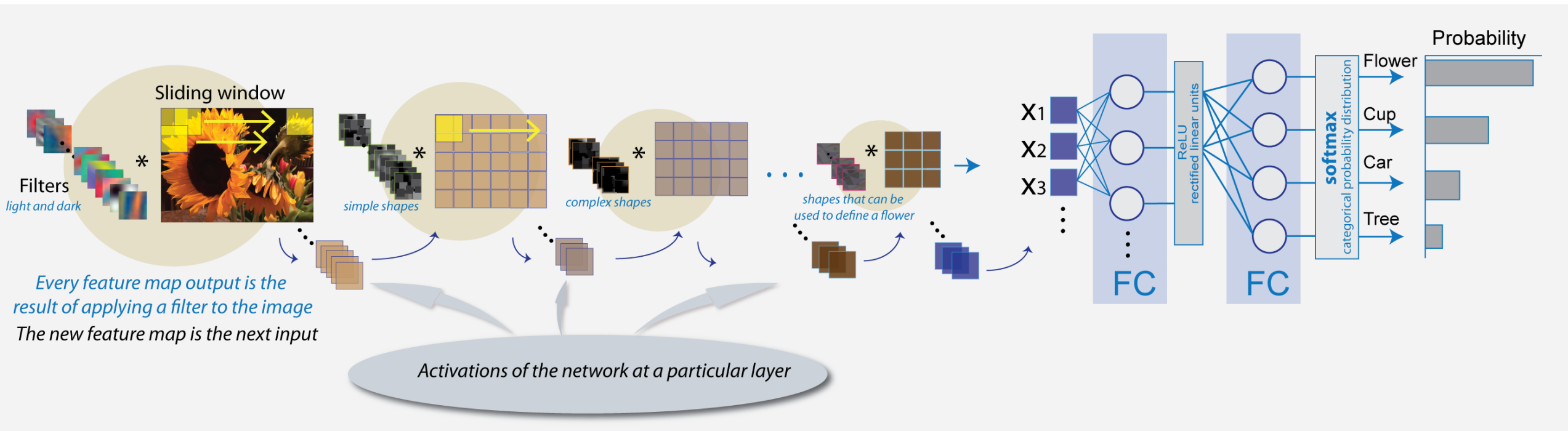
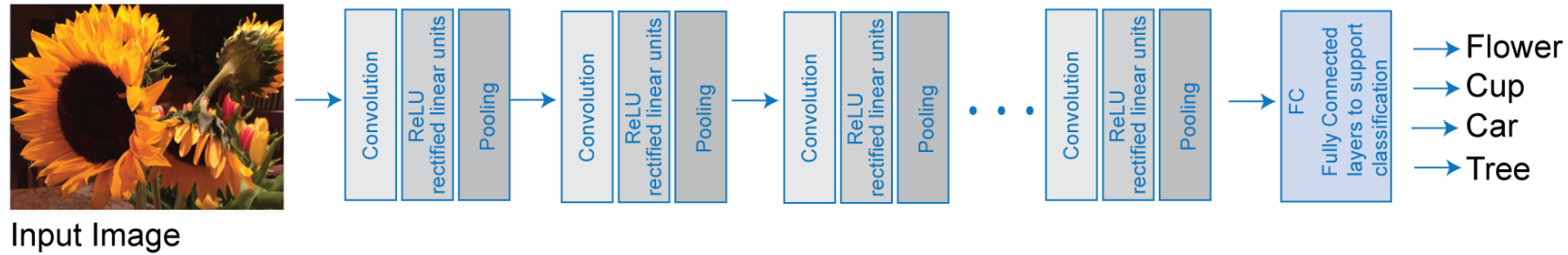
Shallow vs Deep Learning

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

Deep learning algorithms also **scale with data** – shallow learning **converges**



Shallow vs Deep Learning



What problem does Deep Learning solve?

Data

1.2 million images

1000 categories

Tasks

Object recognition

Localization, and more

Metrics

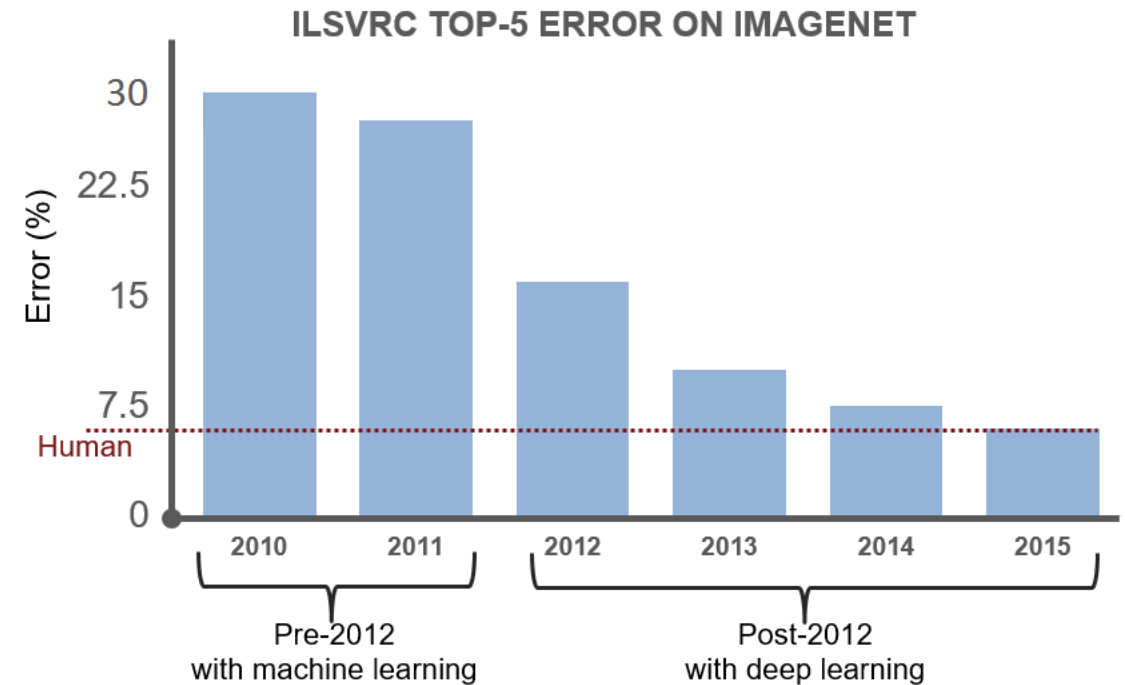
Top-5 error rate

ImageNet Large Scale Visual Recognition Challenge (ILSVRC)

The screenshot shows the ImageNet website interface. At the top, there is a search bar and navigation links. The main content area displays a synset for "Animal, animate being, beast, brute, creature, fauna" with 1571 pictures and an 87.44% popularity percentile. Below this, there are tabs for "Treemap Visualization", "Images of the Synset", and "Downloads". The "Images of the Synset" tab is active, showing a grid of 48 image thumbnails. To the left of the grid is a hierarchical tree view showing the synset structure, with "ImageNet 2011 Fall Release (32326)" expanded to show various categories like "plant, flora, plant life (4486)", "geological formation, formation (1)", "natural object (1112)", "sport, athletics (176)", "artifact, artefact (10504)", "fungus (308)", "person, individual, someone, som...", "terror, scourge, threat (0)", "color-blind person (3)", "leader (418)", "deaf person (3)", "baby buster, buster (0)", "neglector (0)", "bluecoat (0)", "gatherer (0)", "expert (178)", "crawler, creeper (0)", "man (0)", "posturer (0)", "pamperer, spoiler, coddler, mo...", "vanisher (0)", "ethnic (0)", "tiger (0)", "snuffler (0)", "affiant (0)", "Slav (4)", "rester (7)", "asthmatic (0)", and "gatekeeper (0)".

Why is Deep Learning so popular?

- **RESULTS:** Unparalleled accuracy in image recognition
- **DATA:** Enormous labeled data sets available
 - e.g. ImageNet , PASCAL VoC , Kaggle
- **COMPUTING POWER:** GPUs enable training on massive amounts of data
- **BOOTSTRAPPING:** Start prototyping with the best available solutions



Three Reasons to Use MATLAB for Deep Learning

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Easily manipulate big data and networks

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Use MATLAB to learn about the field

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Unify multiple domains in a single workflow

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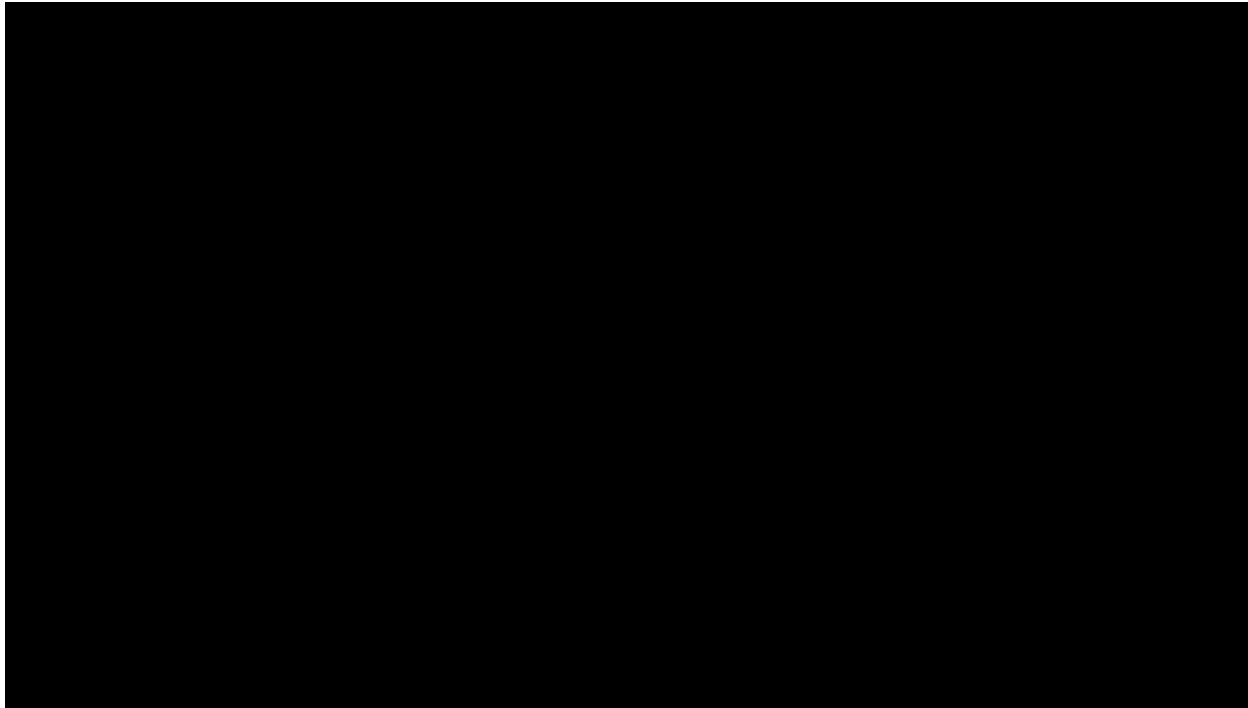
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Object Recognition using Deep Learning

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Training (using GPU)	Millions of images from 1000 different categories
Prediction	Real-time object recognition using a webcam connected to a laptop

Handle Large Image Sets Easily

```

% Create a list of image file names
location = [ '1000_001', '1000_002', '1000_003', '1000_004',
            '1000_005', '1000_006', '1000_007', '1000_008',
            '1000_009', '1000_010', '1000_011', '1000_012',
            '1000_013', '1000_014', '1000_015', '1000_016',
            '1000_017', '1000_018', '1000_019', '1000_020',
            '1000_021', '1000_022', '1000_023', '1000_024',
            '1000_025', '1000_026', '1000_027', '1000_028',
            '1000_029', '1000_030'];

% Create an image datastore
imds = imageDatastore(location, ...
                    'IncludeSubfolders', true, ...
                    'Recursively', true);

% Get the number of images
numImages = numel(imds);

% Get the size of the images
[rows, cols] = size(imds);

% Get the file names
fileNames = imageDatastore(imds, 'IncludeSubfolders', true);

% Get the image data
img = readImage(imds);
    
```

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`imds = imageDatastore(location)`

Also datastore for other collections of data

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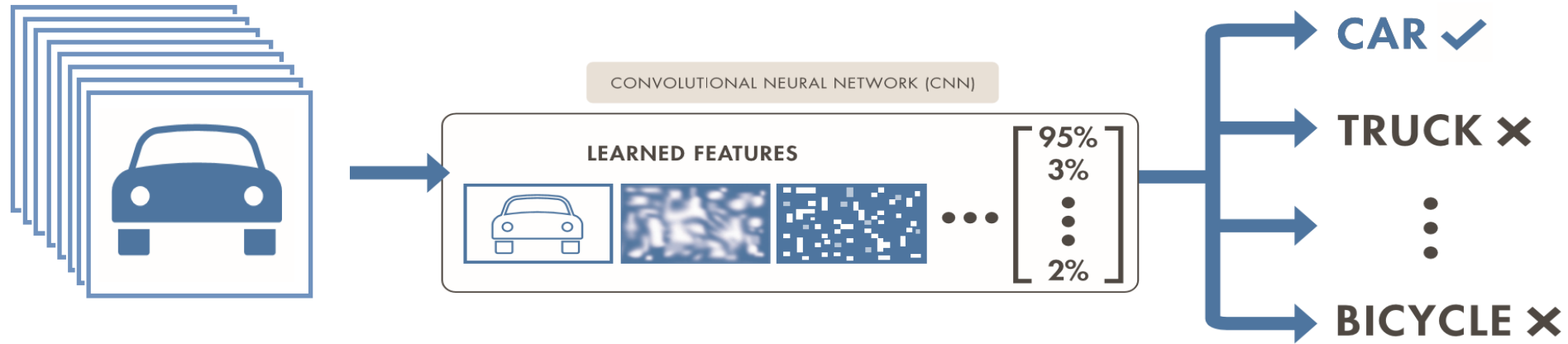
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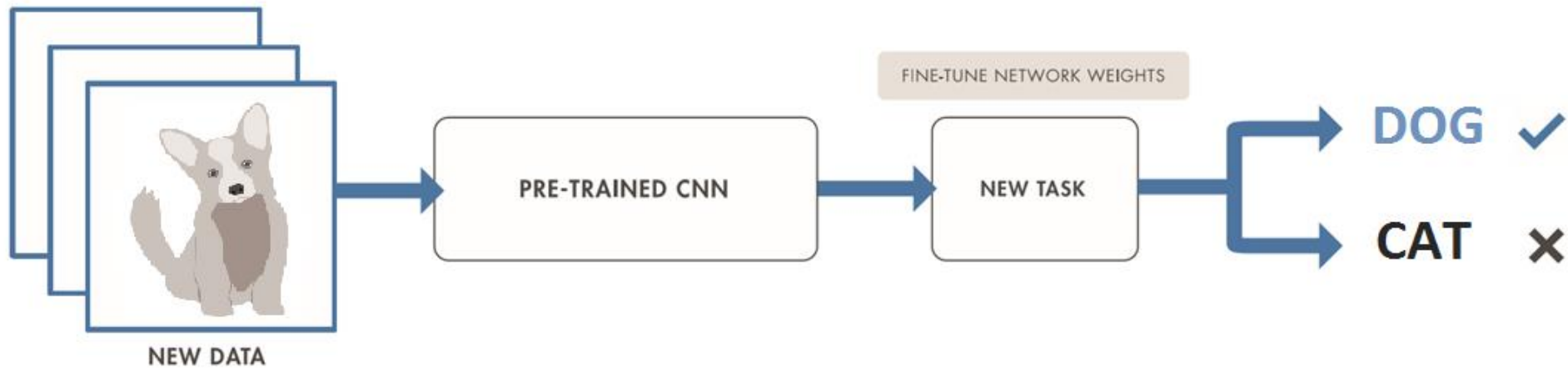
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Two Approaches for Deep Learning

1. Train a Deep Neural Network from Scratch



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



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Transfer Learning in MATLAB

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Fine Tuning A Deep Neural Network

This example shows how to fine tune a pre-trained deep convolutional neural network (CNN) for a new recognition task.

Load Image Data

Data is 5 different categories of food Create an imageDataStore to read images Please download the categories of objects you want to use a good source of data can be found here:
http://www.vision.ee.ethz.ch/datasets_extra/food-101/

```
location = '../Images/bar_food_edited';
imds = imageDatastore(location, 'IncludeSubfolders', 1, ...
    'LabelSource', 'foldernames')
tbl = countEachLabel(imds);
```

Load Pre-trained CNN

The CNN model is saved in MatConvNet's format [3]. Load the MatConvNet network data into `convnet`, a `SeriesNetwork` object from Neural Network Toolbox™, using the helper function `helperImportMatConvNet`. A `SeriesNetwork` object can be used to inspect the network architecture, classify new data, and extract network activations from specific layers.

```
imds =
    ImageDatastore with properties:
        Files: {
            '...\DEMOS\Images\bar_food_edited\chicken_wings\1003533.jpg'
            '...\DEMOS\Images\bar_food_edited\chicken_wings\1008504.jpg'
            '...\DEMOS\Images\bar_food_edited\chicken_wings\1010547.jpg'
            ... and 4289 more
        }
        Labels: [chicken_wings; chicken_wings; chicken_wings ... and 4289 mor
        ReadSize: 1
        ReadFcn: @readDatastoreImage
```

Manipulate Deep Learning Networks Easily

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Perform net surgery

Modify the existing network by deleting later layers and adding new ones.

```
% Here we only need to keep everything except the last 3 layers.
```

```
layers = net.Layers(1:end-3);
```

```
% Add new fully connected layer for 2 categories.
```

```
layers(end+1) = fullyConnectedLayer(64, 'Name', 'special 2');
```

```
layers(end+1) = reluLayer;
```

```
% the new layer adding non-linearity and improves the network's ability to handle data
```

```
layers(end+1) = fullyConnectedLayer(height(tbl), 'Name', 'fc0_2');
```

```
% Add the softmax layer and the classification layer
```

```
layers(end+1) = softmaxLayer;
```

```
layers(end+1) = classificationLayer();
```

DELETE LAYERS**ADD LAYERS**

Manipulate Deep Learning Networks Easily

Set options for training

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

Train the network

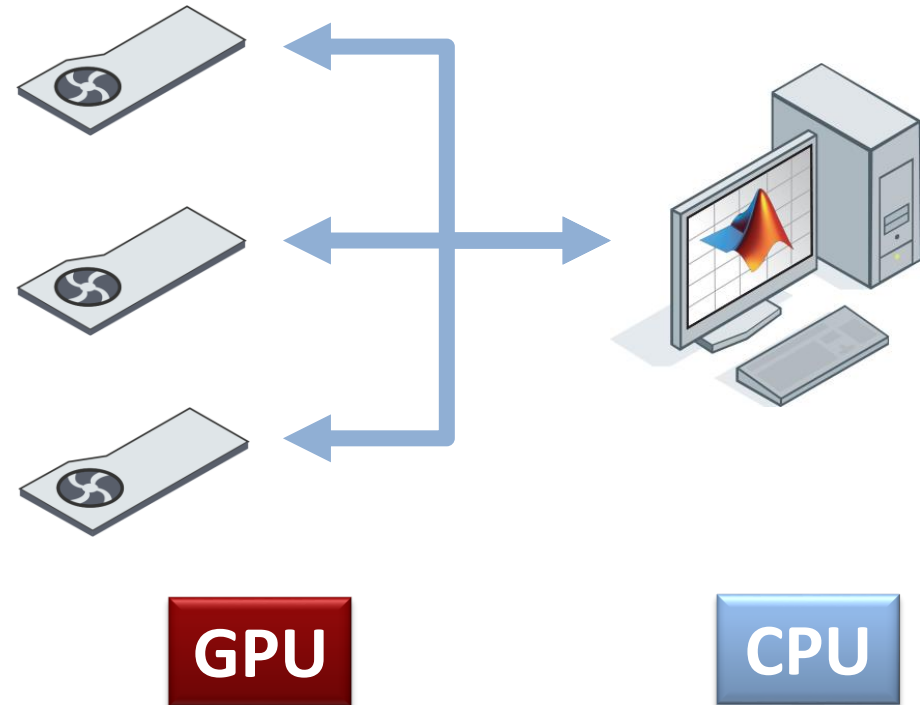
```
net = trainNetwork(imds, layers, opts);
```

Make predictions

```
label = classify(net, im);
```

Extract features

```
features = activations(net, Xtrain, 'fc7');
```



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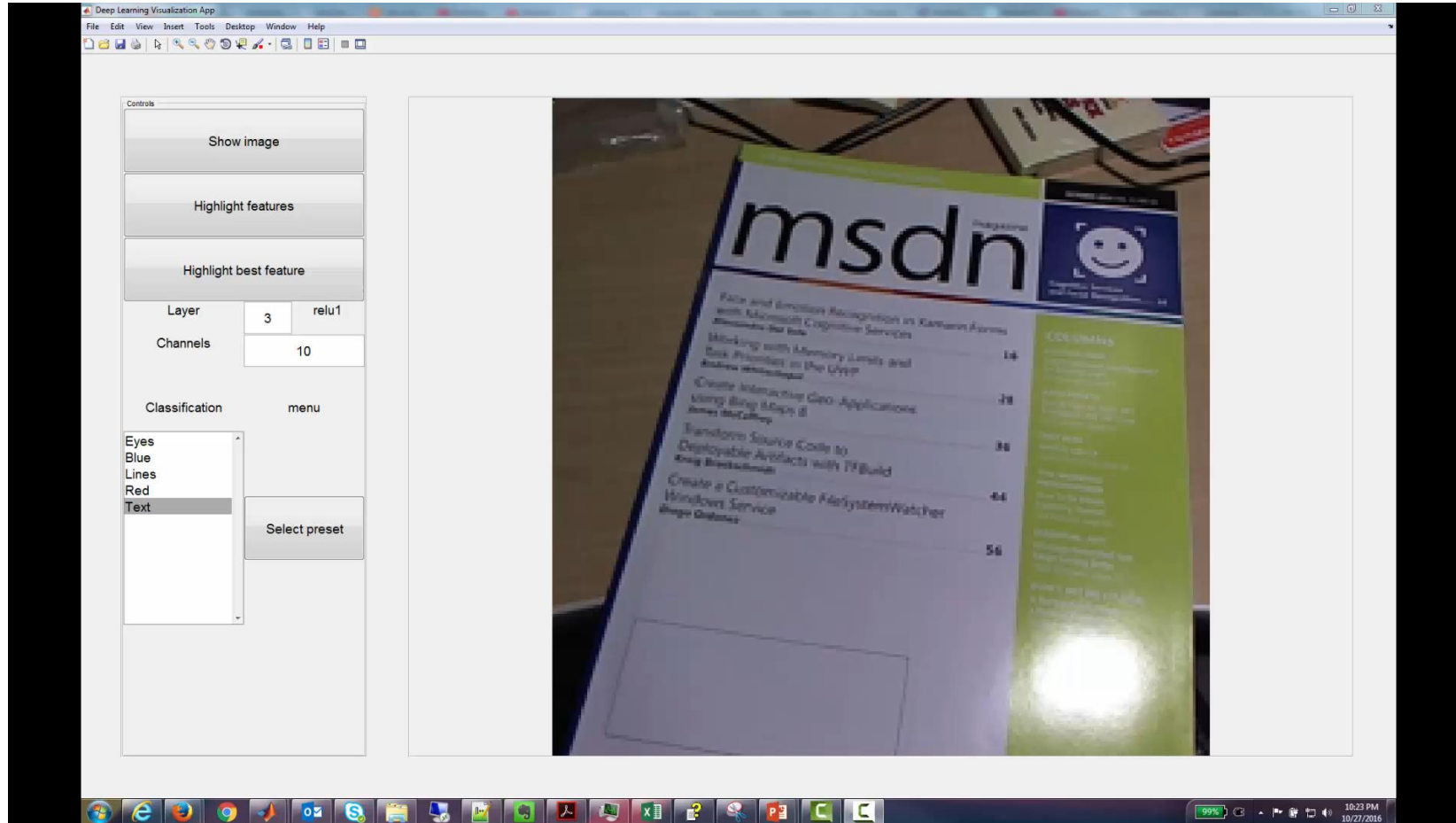
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Visualize Deep Learning Features



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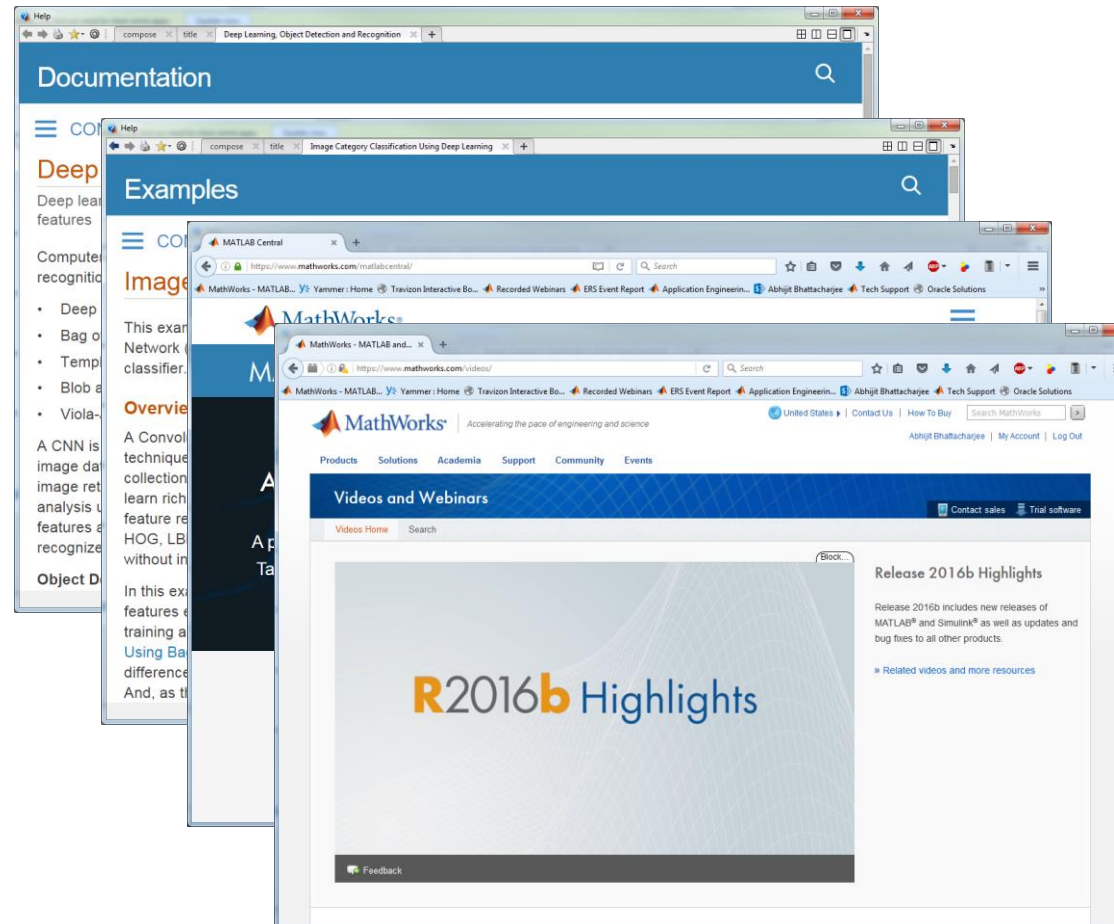
Other Resources

- Documentation
- Examples and Tutorials
- MATLAB Community
- Videos and Seminars

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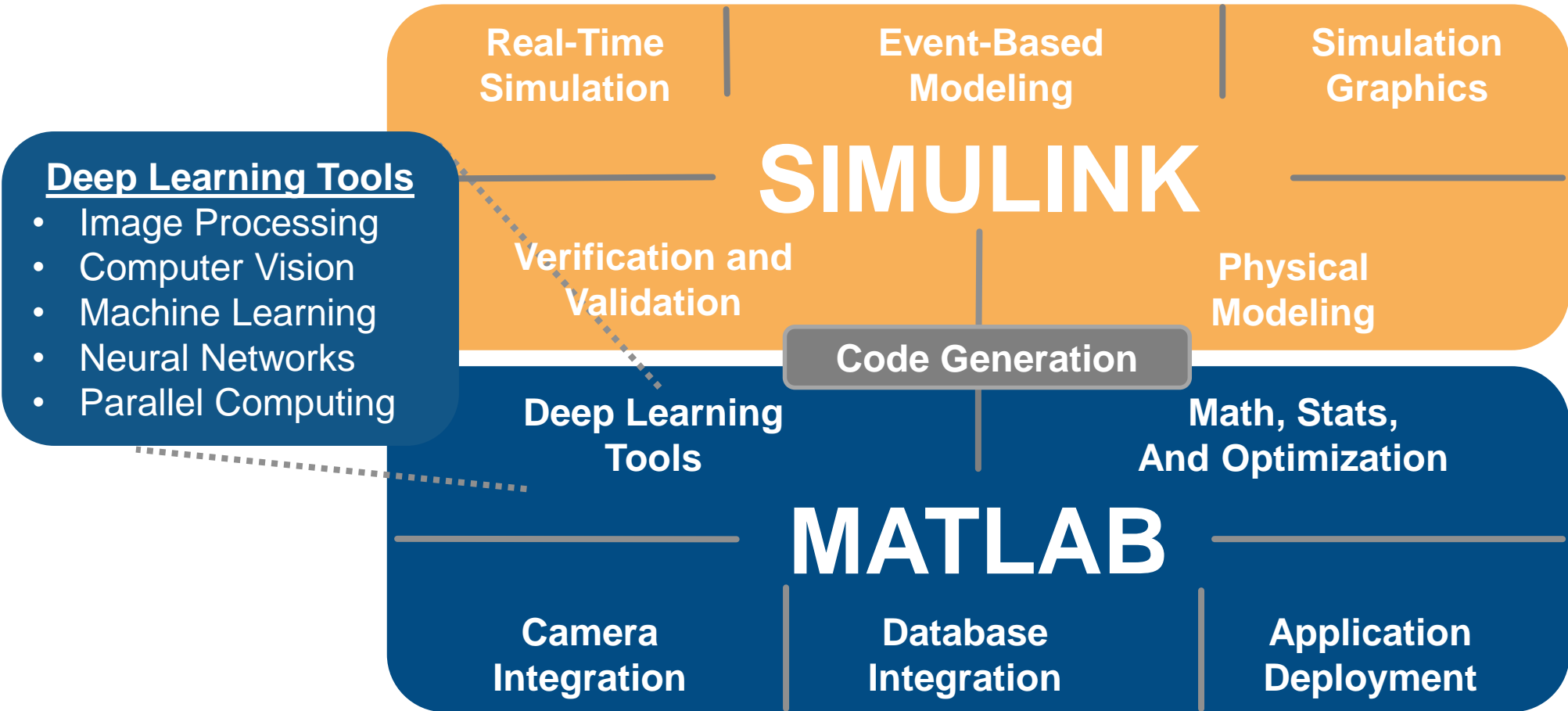
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Customer Examples

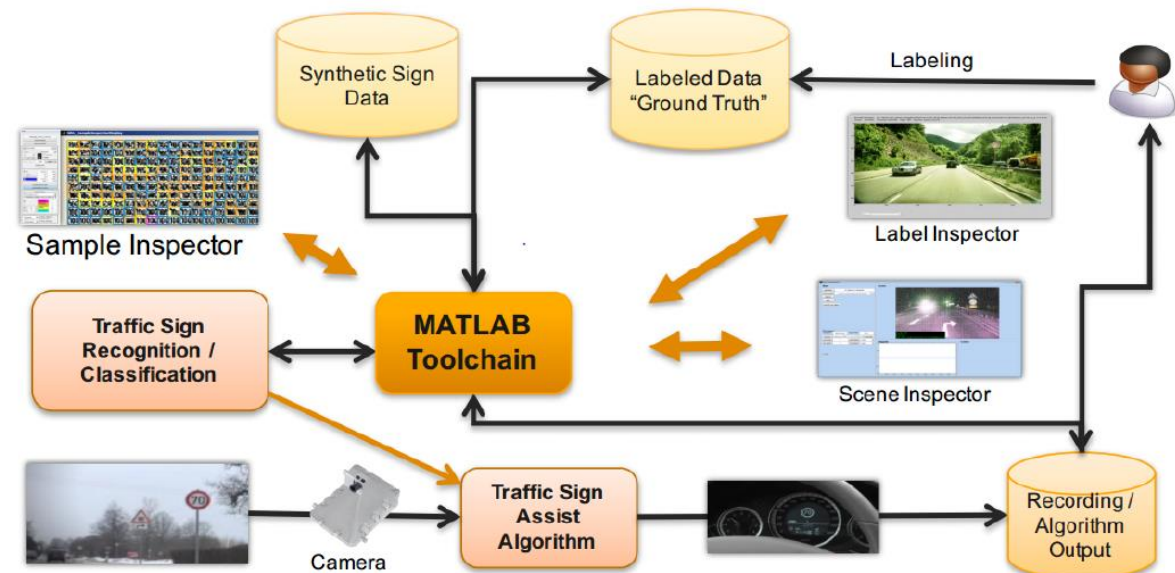
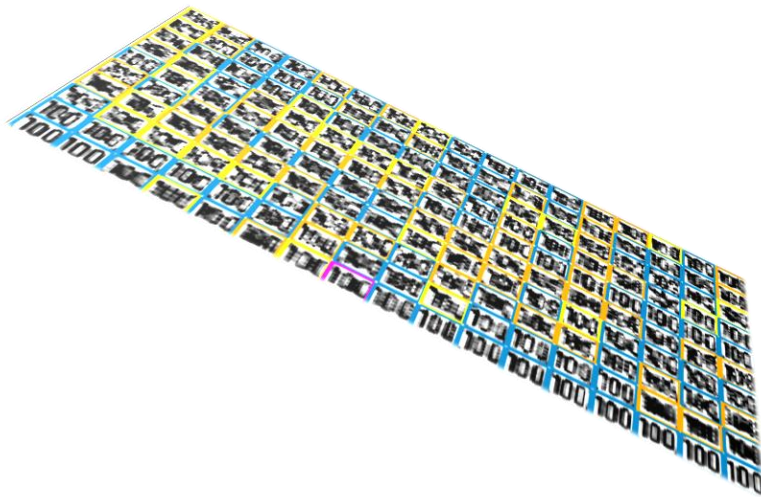
Continental Machine Learning for traffic sign recognition

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- Extract hundreds of thousands of signs
- Confirm sign type and build a database
- Train system to deal with normal and imperfect signs



75,000
speed limit signs
in the training set

Alpine

Machine Learning and MATLAB Coder

for automatic ground detection

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- Detect cars, pedestrians, and other obstacles
- Median recognition rate of 99%
- Converted to C code running without MATLAB



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Questions and Answers

