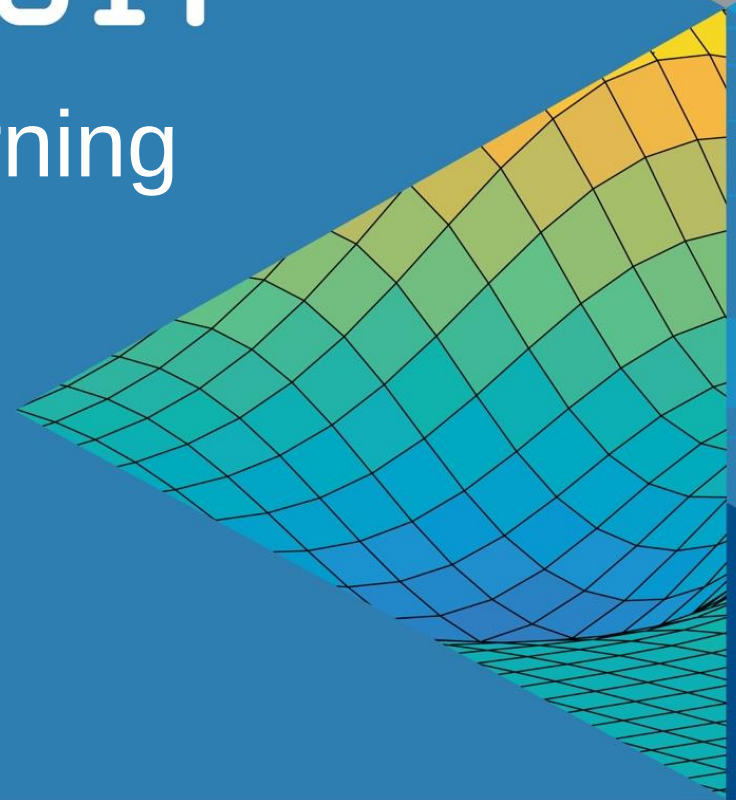
MATLAB EXPO 2017

Introduction to Machine Learning and Deep Learning

Conor Daly



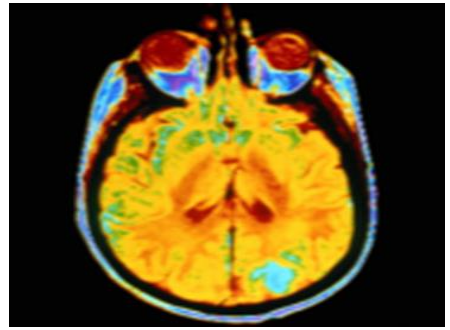
Machine learning in action

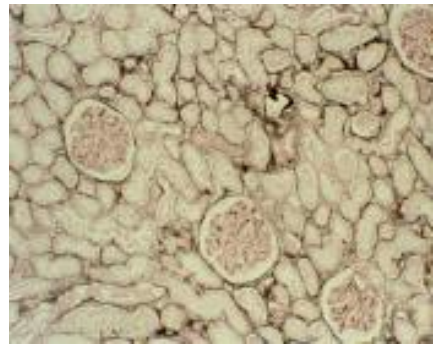
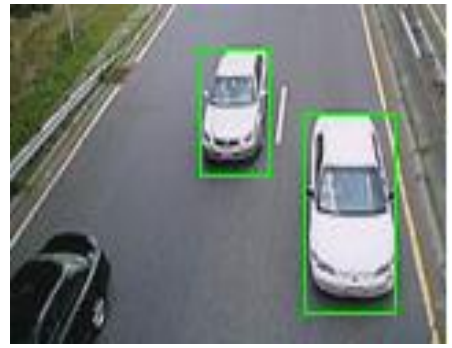
CamVid Dataset

1. Segmentation and Recognition Using Structure from Motion Point Clouds, ECCV 2008
2. Semantic Object Classes in Video: A High-Definition Ground Truth Database, Pattern Recognition Letters

Machine learning is everywhere

- Image recognition
- Speech recognition
- Stock prediction
- Medical diagnosis
- Predictive maintenance
- Language translation
- and more…



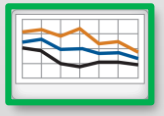
Agenda

1. **Machine learning – predictive maintenance**
2. Deep learning – build a digits classifier
3. Predictive maintenance revisited – a deep learning approach

What is machine learning?

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

Standard Approach



Computer Program

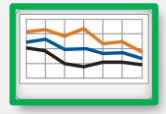
long

medium

short

Hand Written Program	Formula or Equation
If X > 0.5 then “LONG” If Y < 4 and Z > 5 then “MEDIUM” …	$Y_{\text{health}} = \beta_1 X + \beta_2 Y + \beta_3 Z + \dots$

Machine Learning Approach



Machine Learning

long

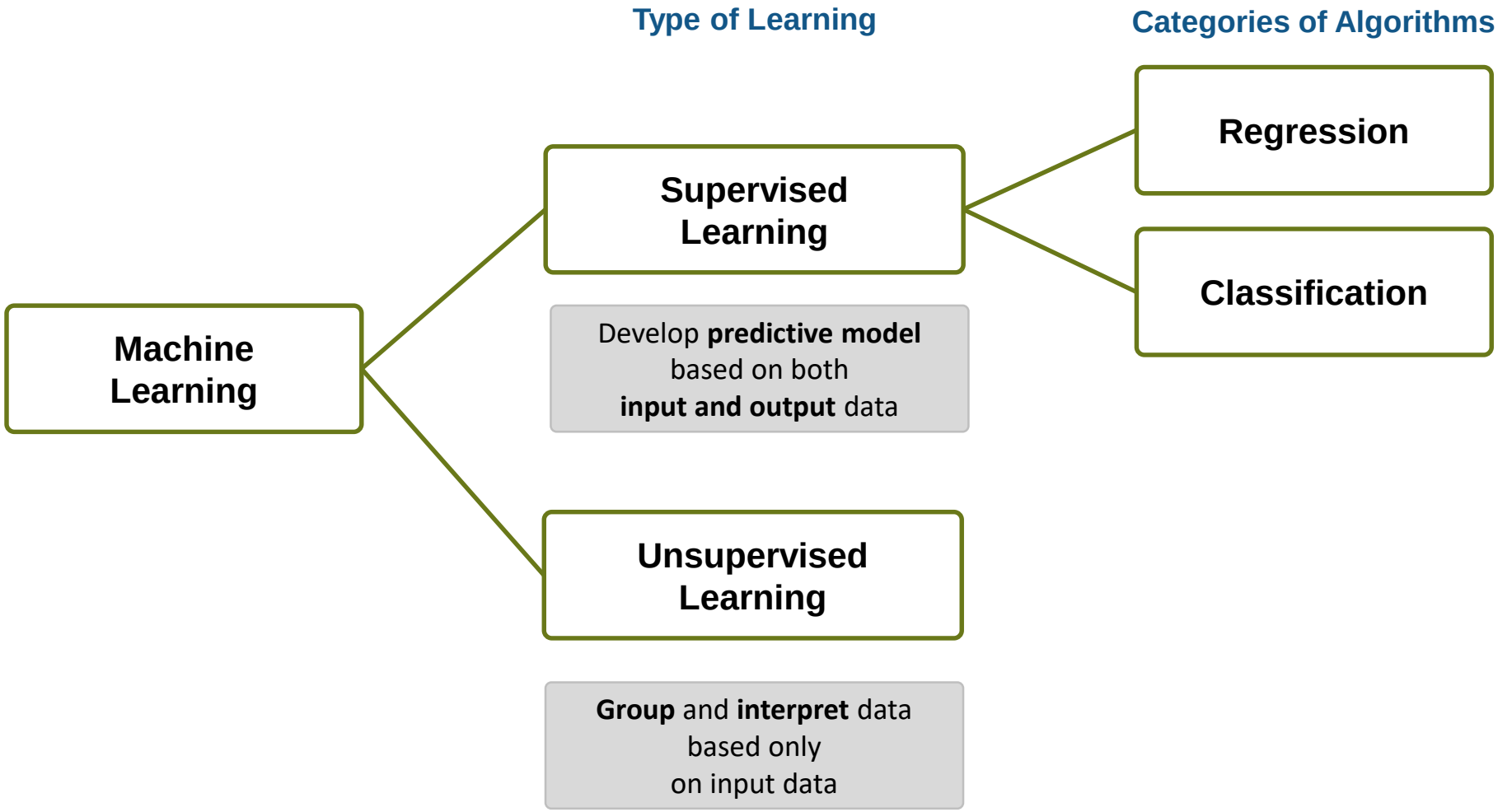
medium

short

$model$: Predictors → Response

$$model = <^{\textit{Machine Learning Algorithm}}>(sensor\_data, activity)$$

Machine Learning: problem specific overview

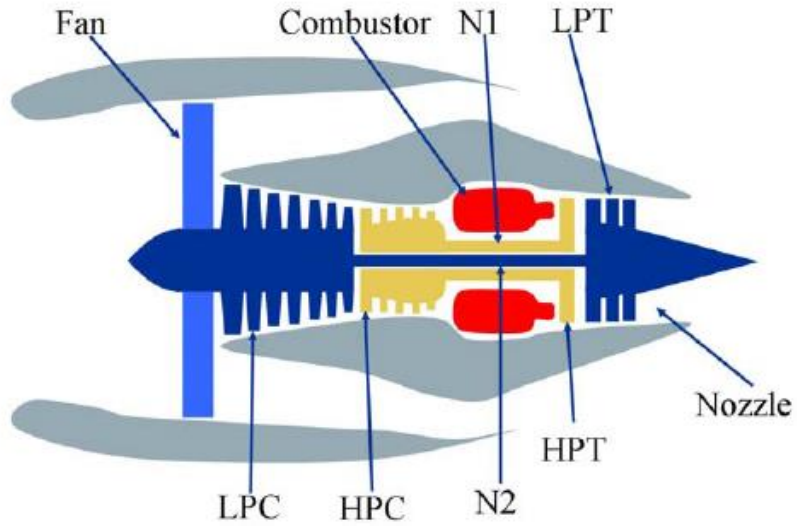


Predictive maintenance of turbofan engine

Sensor data from 100 engines of the same model

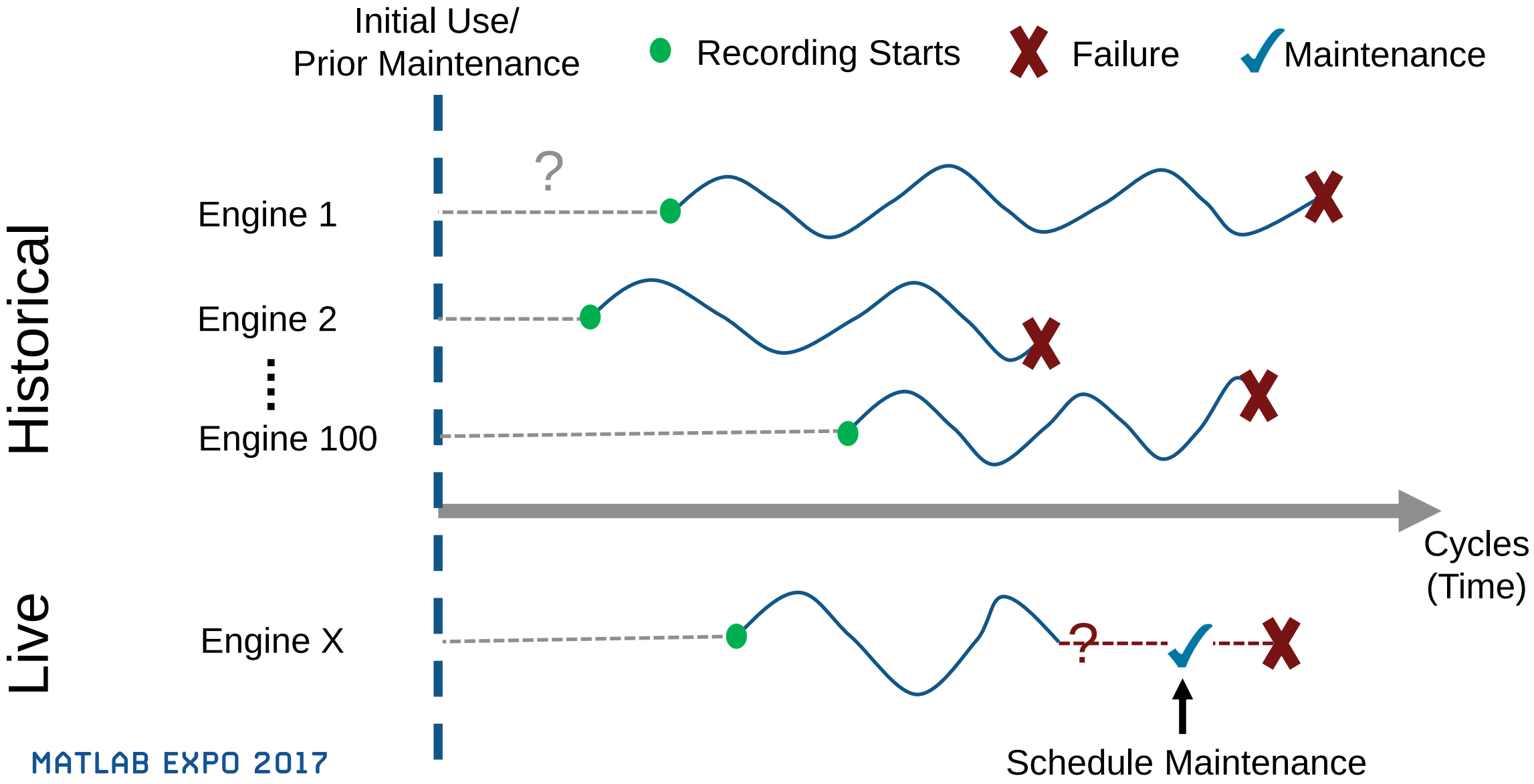
Motivation

- Import and analyze historical sensor data
- Train model to predict when failures will occur
- Deploy model to run on live sensor data
- Predict failures in real time

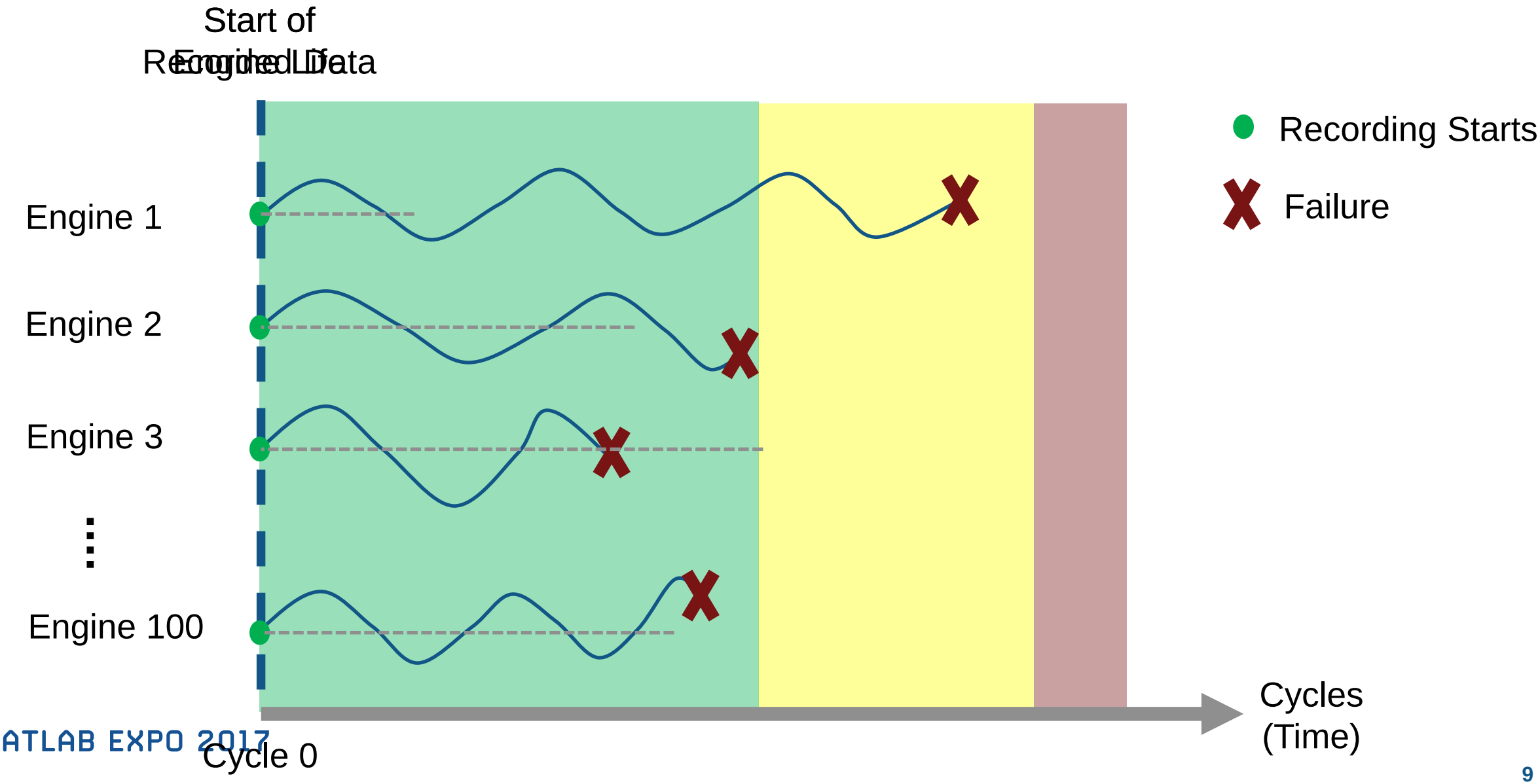


Data provided by NASA PCoE
http://ti.arc.nasa.gov/tech/dash/pcoe/prognostic-data-repository/

Use historical data to predict when failures will occur



Preprocessing and classifying our input data



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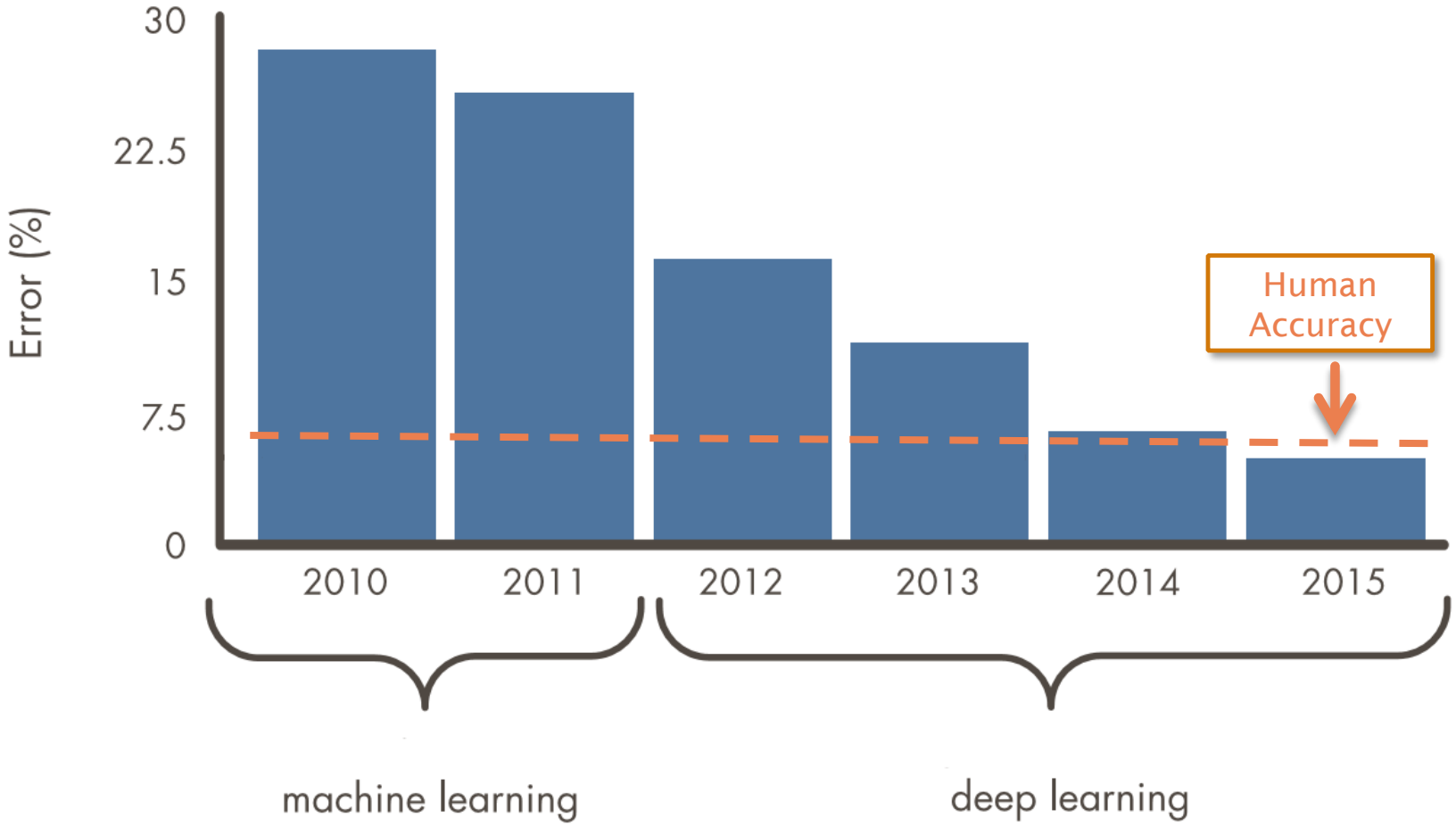
Can you tell the difference? Japanese or Blenheim Spaniel?

Blenheim Spaniel

Japanese Spaniel

Source: ILSVRC ImageNet dataset

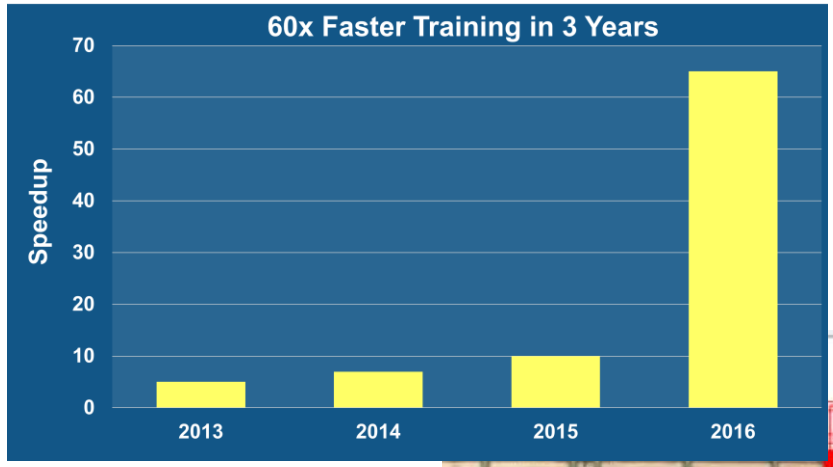
Why is deep learning so popular now?



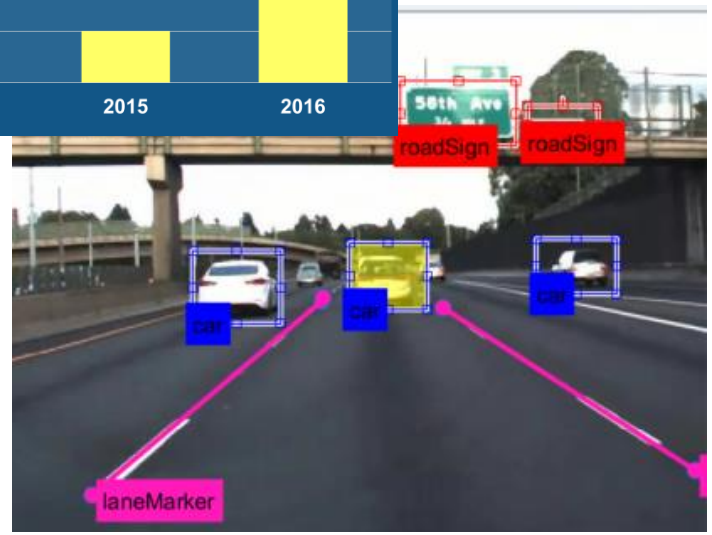
Source: ILSVRC Top-5 Error on ImageNet

Deep learning enablers

Acceleration with GPUs



Massive sets of labeled data



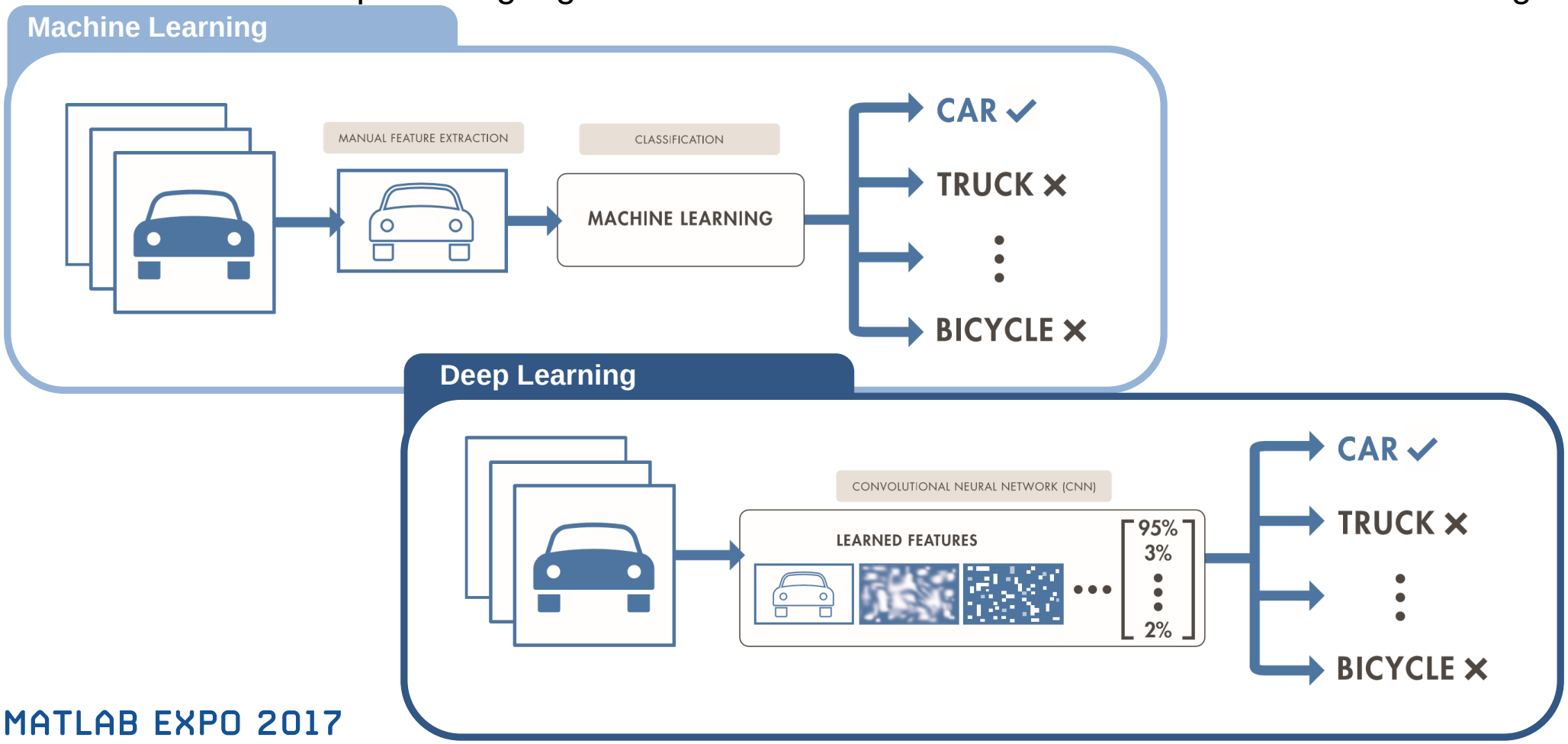
Availability of state of the art models from experts

AlexNet
PRETRAINED MODEL
VGG-16
PRETRAINED MODEL
Caffe
MODELS

Machine learning vs deep learning

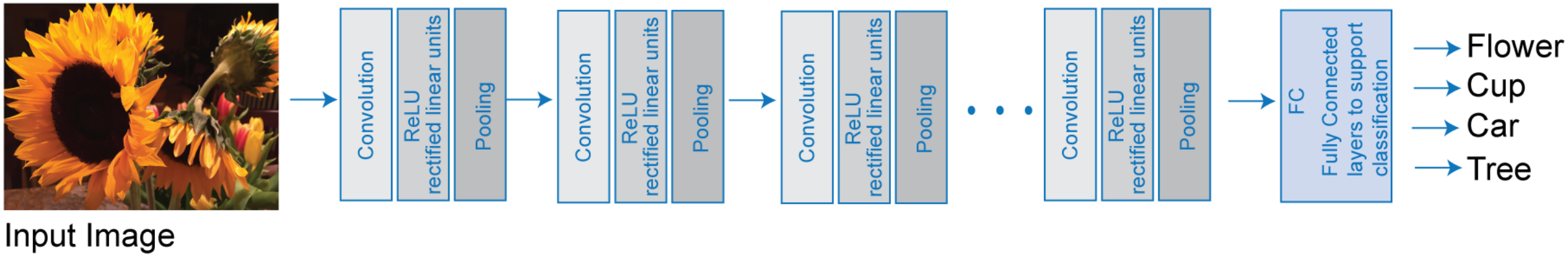
Deep learning performs **end-to-end learning** by learning **features, representations and tasks** directly from **images, text and sound**

Deep learning algorithms also **scale with data –** traditional machine learning **saturates**



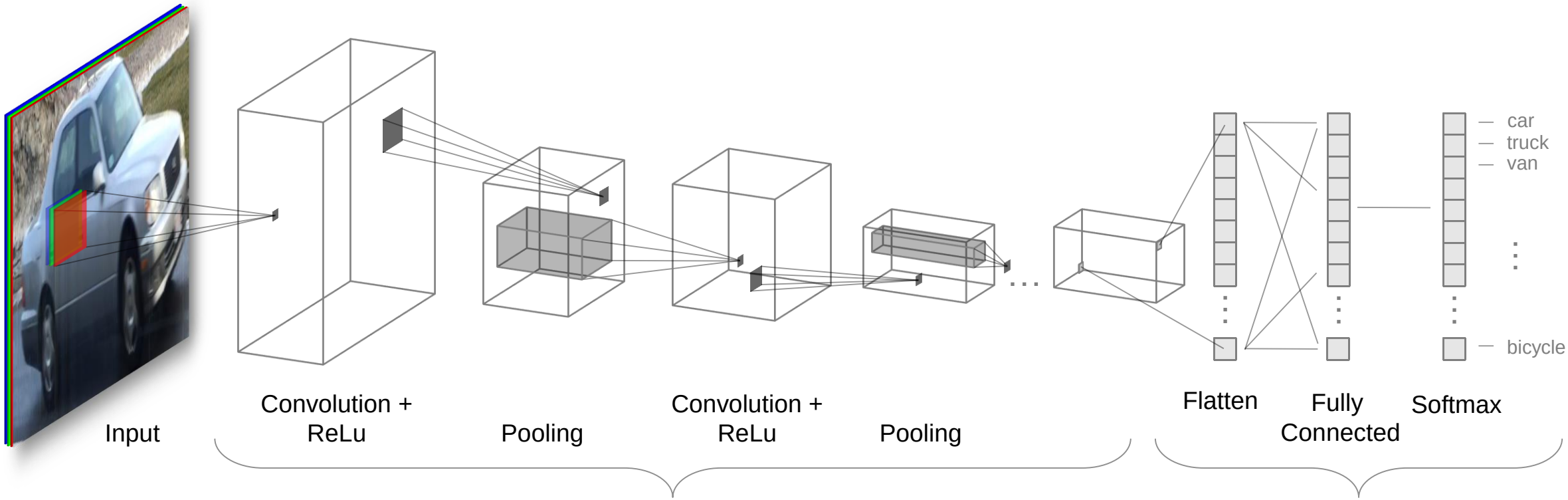
Deep learning and neural networks

- Deep learning == neural networks
- Data flows through network in **layers**
- **Layers** provide transformation of data



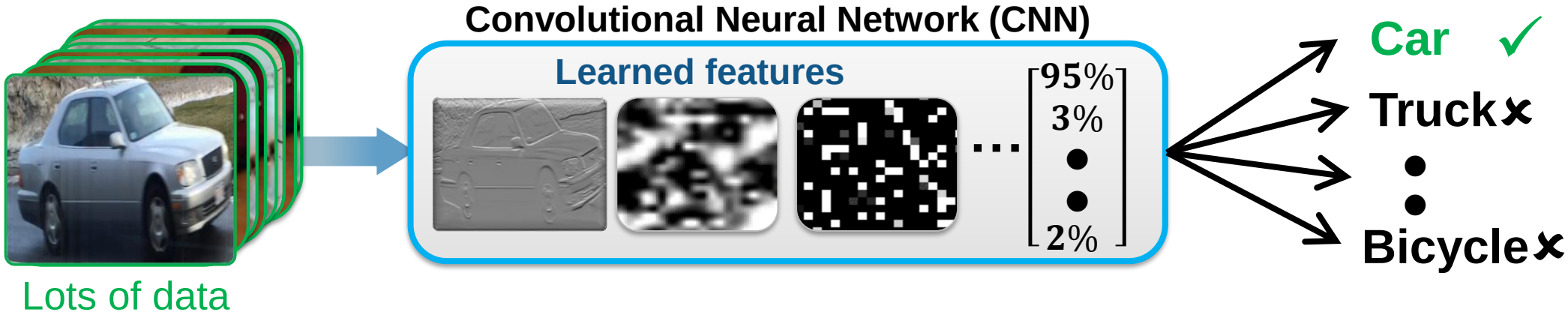
Convolutional neural networks

- 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

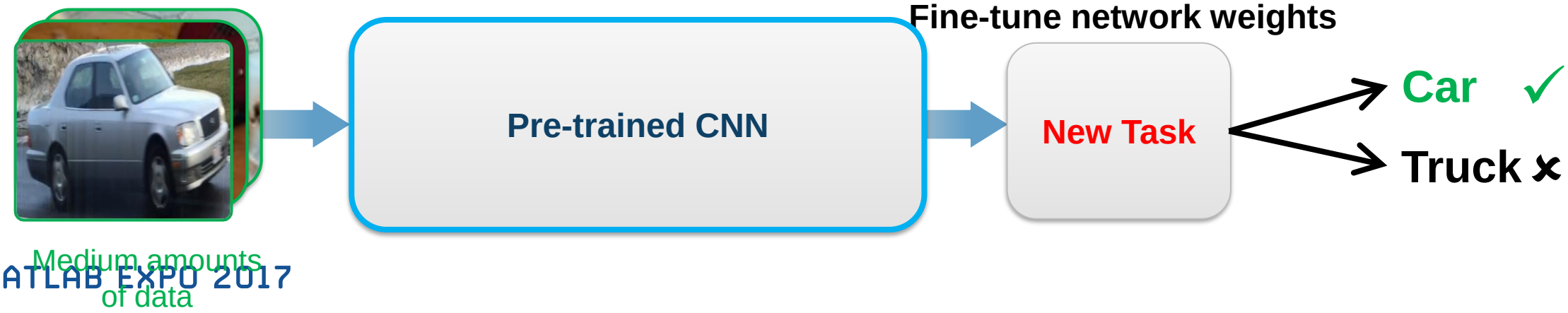


Two approaches for deep learning

1. Train a Deep Neural Network from Scratch

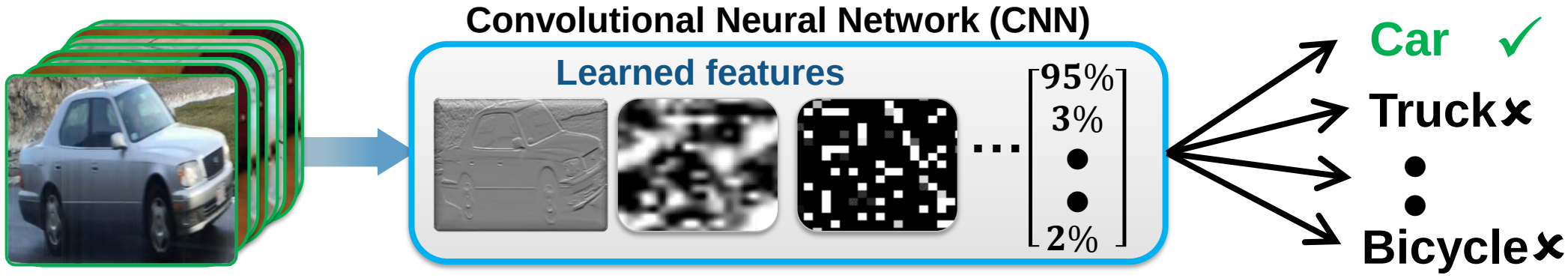


2. Fine-tune a pre-trained model (transfer learning)



Two deep learning approaches

Approach 1: Train a Deep Neural Network from Scratch



Recommended when:

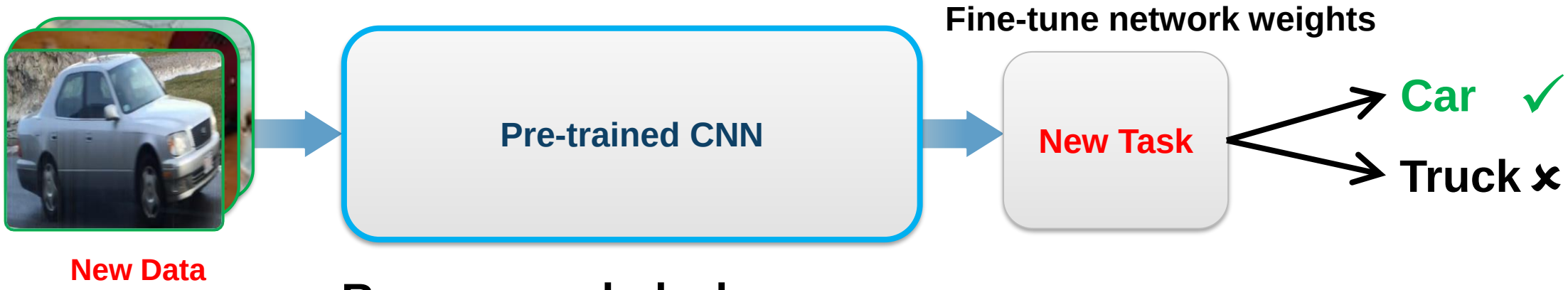
Training data	1000s to millions of labeled images
Computation	Compute intensive (requires GPU)
Training Time	Days to Weeks for real problems
Model accuracy	High (can over fit to small datasets)

Two deep learning approaches

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

CNN trained on massive sets of data

- Learned robust representations of images from larger data set
- Can be fine-tuned for use with ***new data or task*** with small – medium size datasets

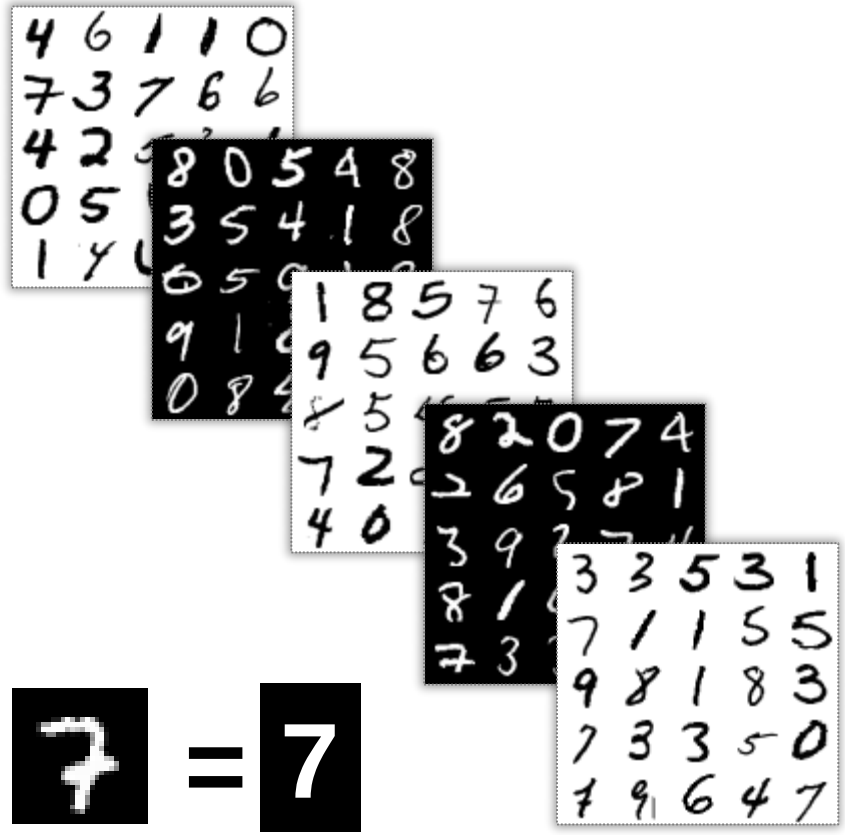


Recommended when:

Training data	100s to 1000s of labeled images (small)
Computation	Moderate computation (GPU optional)
Training Time	Seconds to minutes
Model accuracy	Good, depends on the pre-trained CNN model

Digits classification

What?	A set of ‘handwritten’ digits from 0-9 (c.f. MNIST)
Why?	An easy task for machine learning beginners
How many?	60,000 training images 10,000 test images
Best results?	99.79% accuracy



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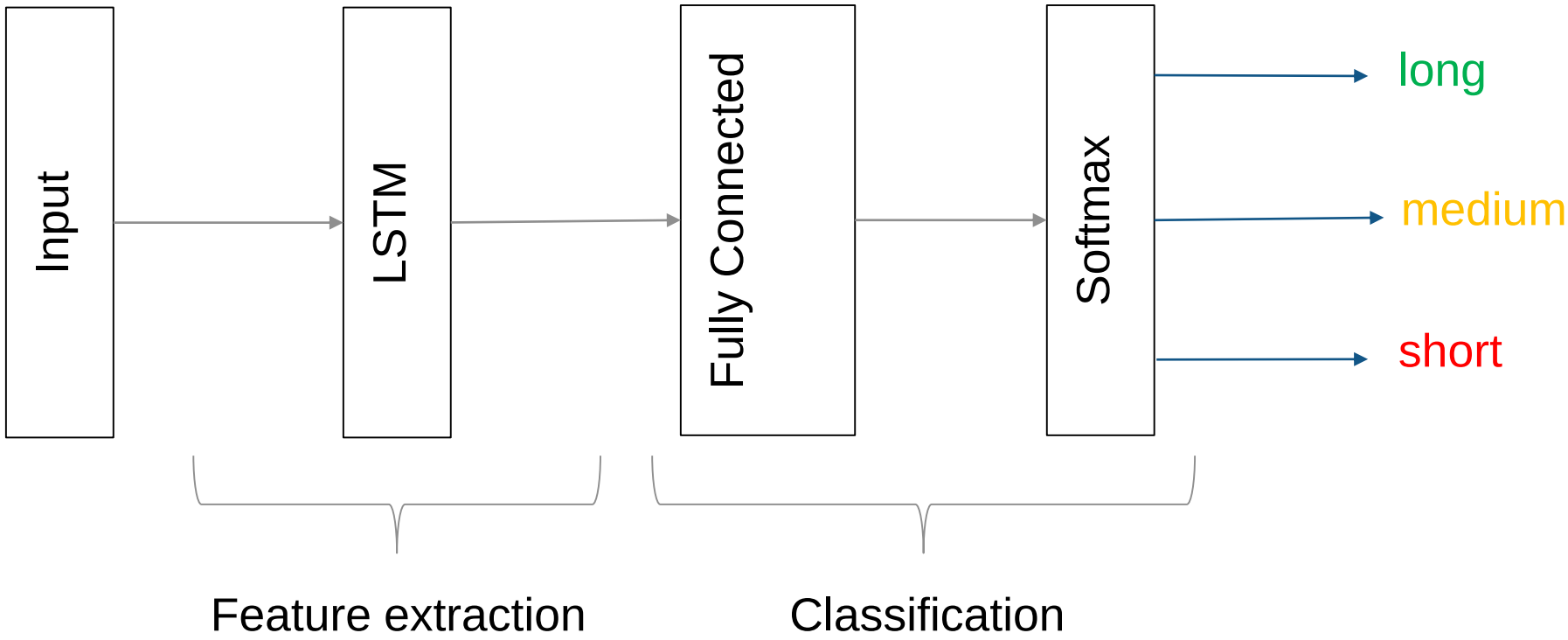
Tackle time series data with LSTM

- How can we apply deep learning to time series data?
- One approach is to use Long Short-Term Memory (LSTM) neural networks
- These networks learn long-term temporal dependencies
- LSTMs work well with sequential input data, for example:
  - Time series
  - Text
  - Video

LSTM classification networks

- LSTM is used to extract time series features



Shakespearean LSTM

```
startPhrase = 'Accelerating the pace of ';
numberOfCharactersToGenerate = 500;

generatedText = iGenerateText( startPhrase, numberOfCharactersToGenerate, net )
```

```
generatedText =
    'Accelerating the pace of me!

     DUKE VINCENT:
     Boy to hear you!

     MENENIUS:
     I'll be him, and he shall see how in Rome rags,
     Bearing the part of my father's royal dead,
     And where be leave to gain.

     ISABELLA:
     Set now fair ground indeed the last of all.

     FLORIZELO:
     No mark bench, say. Grepart, sir, and boss
     of proclait is extraity, for the senators
     of more you over it bleeding.
```

- Text generated from deep LSTM network
- Network has learned long-term text style of Shakespeare
- E.g. punctuation, character-name capitalization

Thanks for listening!

Today we've looked at:

1. Machine learning – predictive maintenance
2. Deep learning – build a digits classifier
3. Predictive maintenance revisited – a deep learning approach

What to learn more/try it for yourself?

Try **MATLAB Deep Learning Onramp**