HANDS ON
WITH DEEP LEARNING AND IOT

You will use fruits for the exercises!

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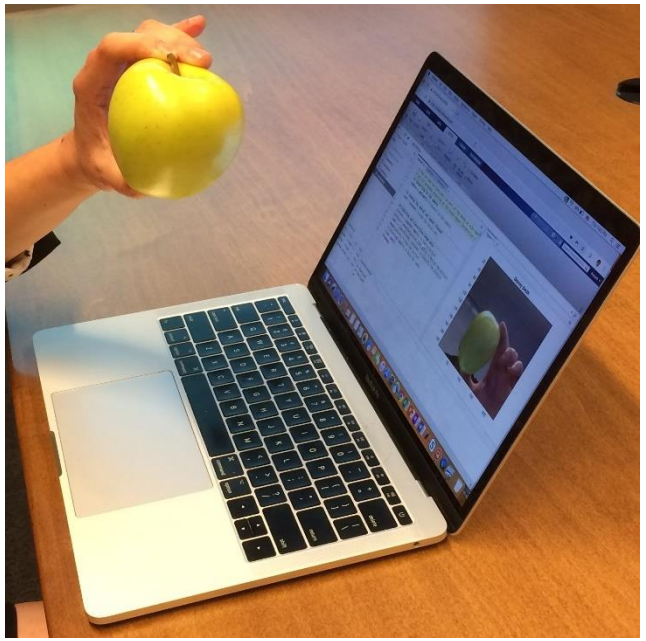
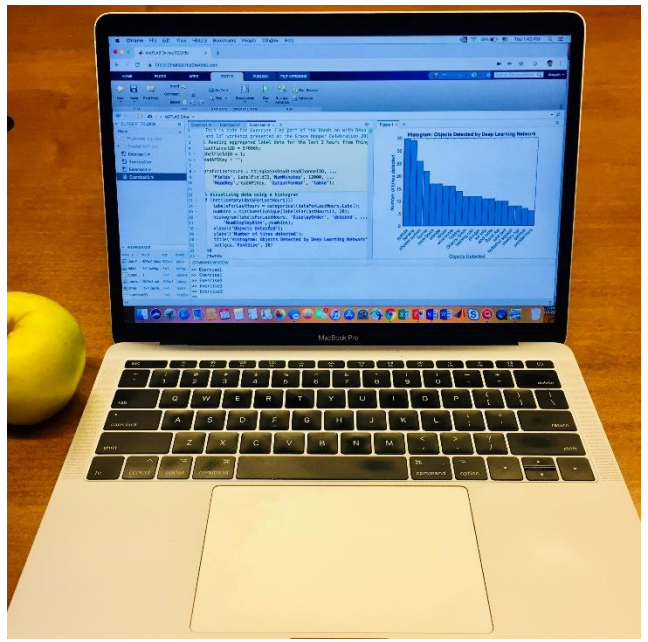
Madhumitha Raghu

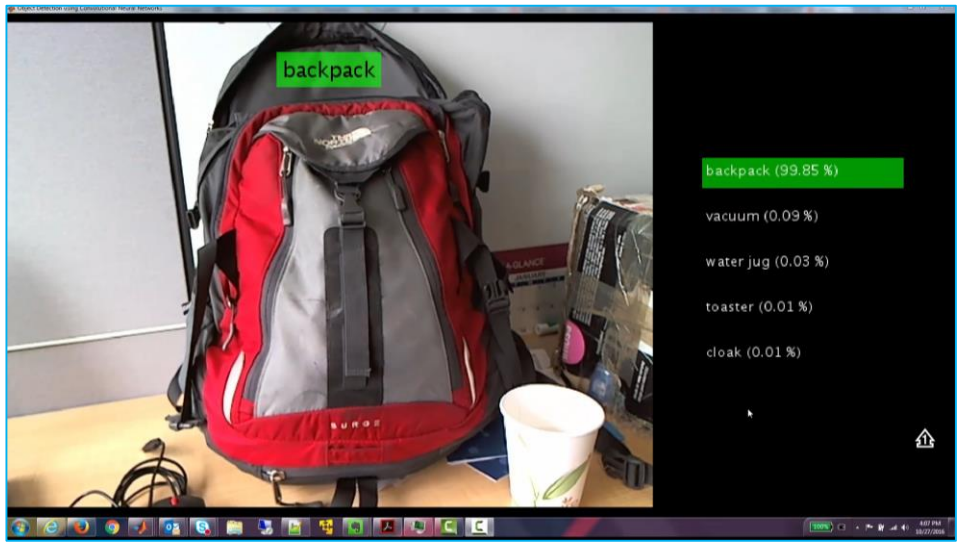
Today, you will see how easy it is to get started with deep learning and IoT

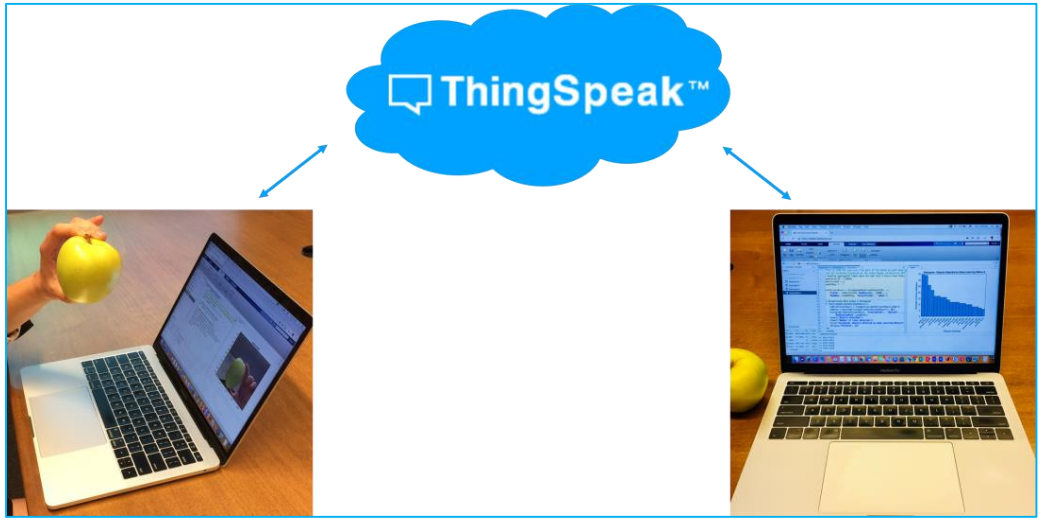
ThingSpeak™

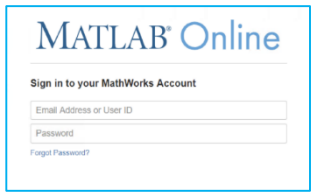




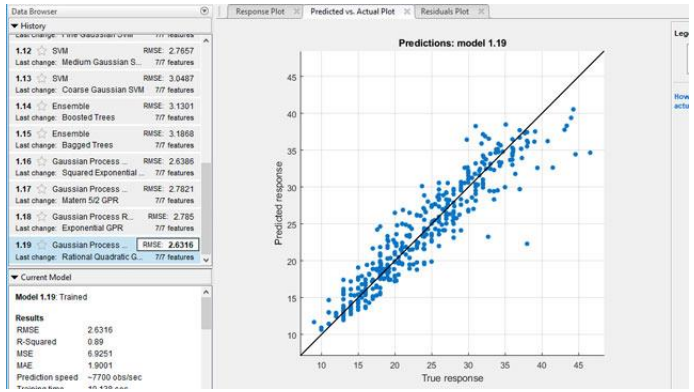
Workshop plan



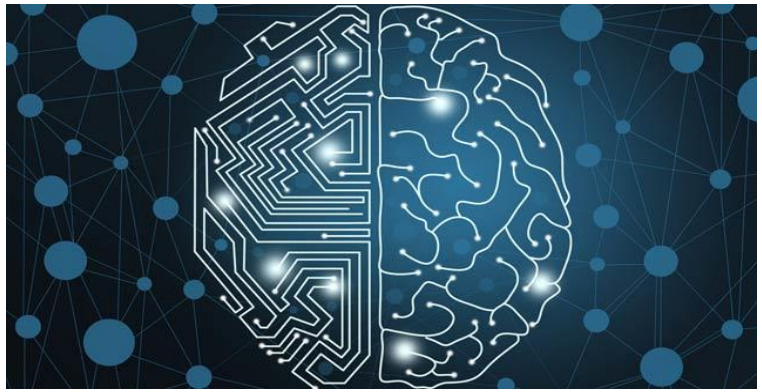




Artificial intelligence

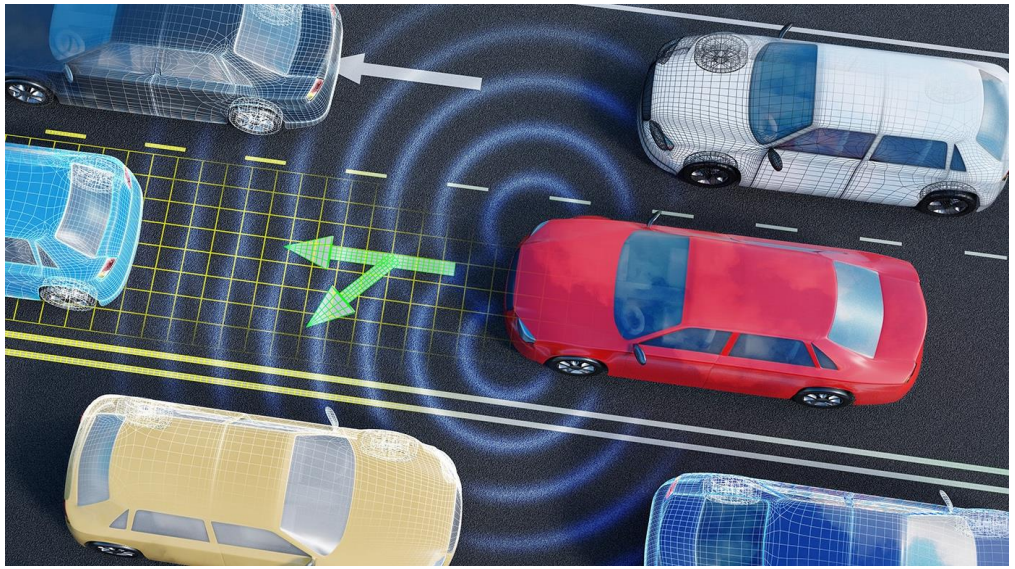


Machine learning



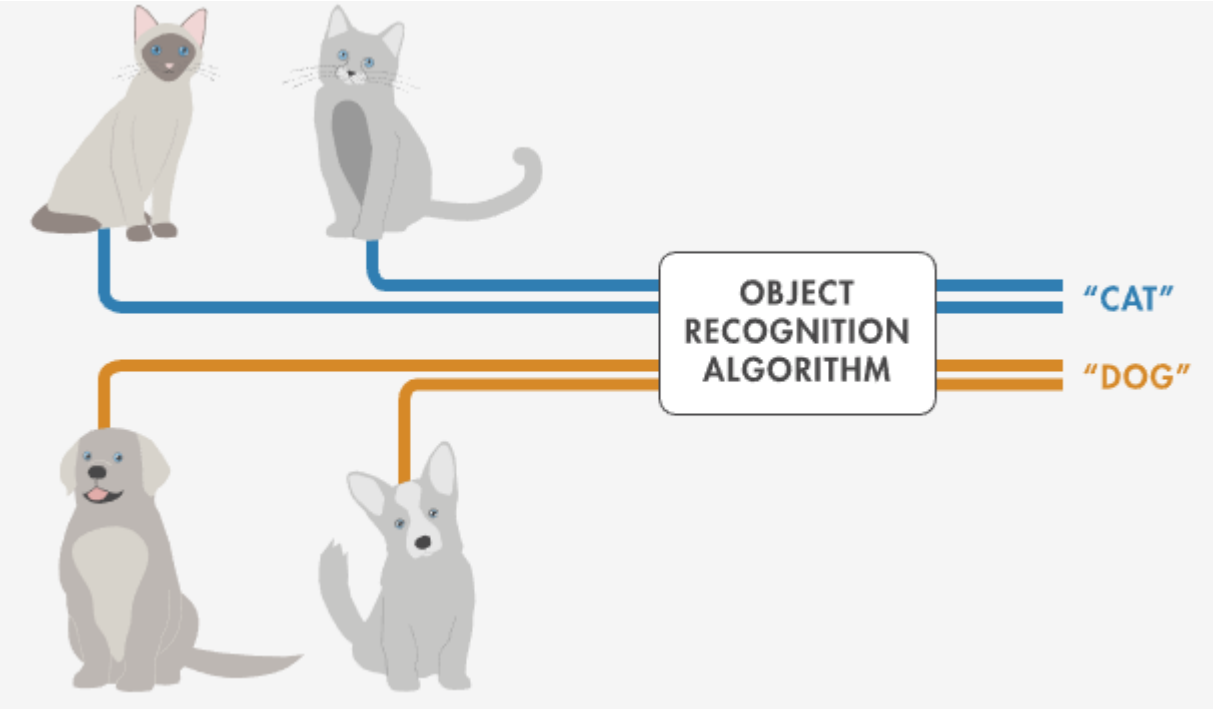
Deep learning

Artificial intelligence is all around us!

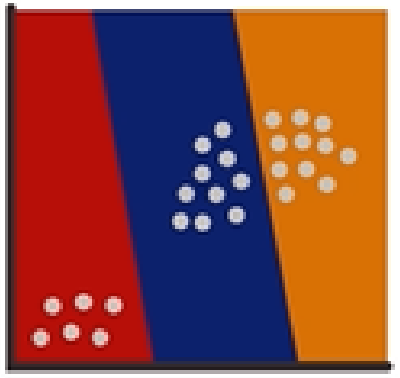


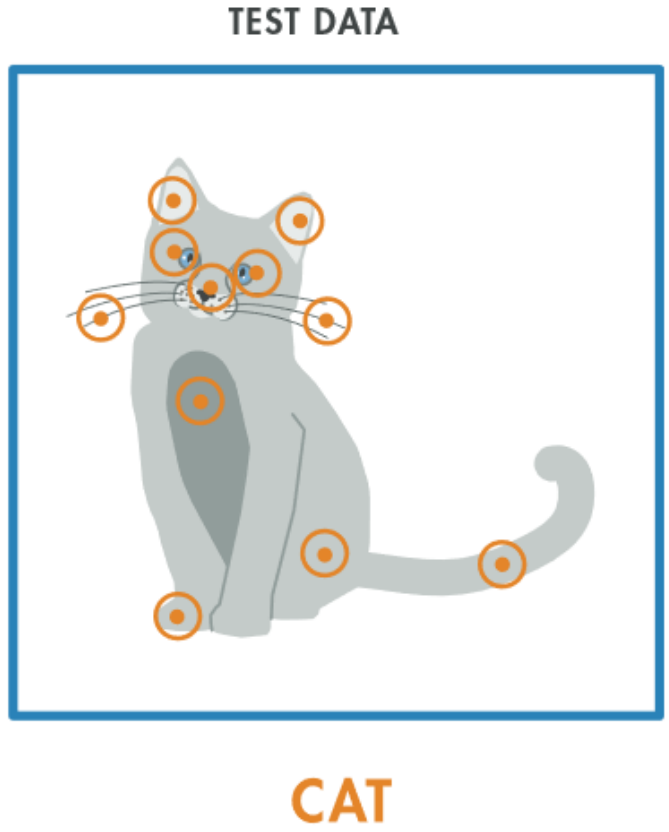
Machine learning is a set of algorithms which make predictions/decisions

Object recognition application

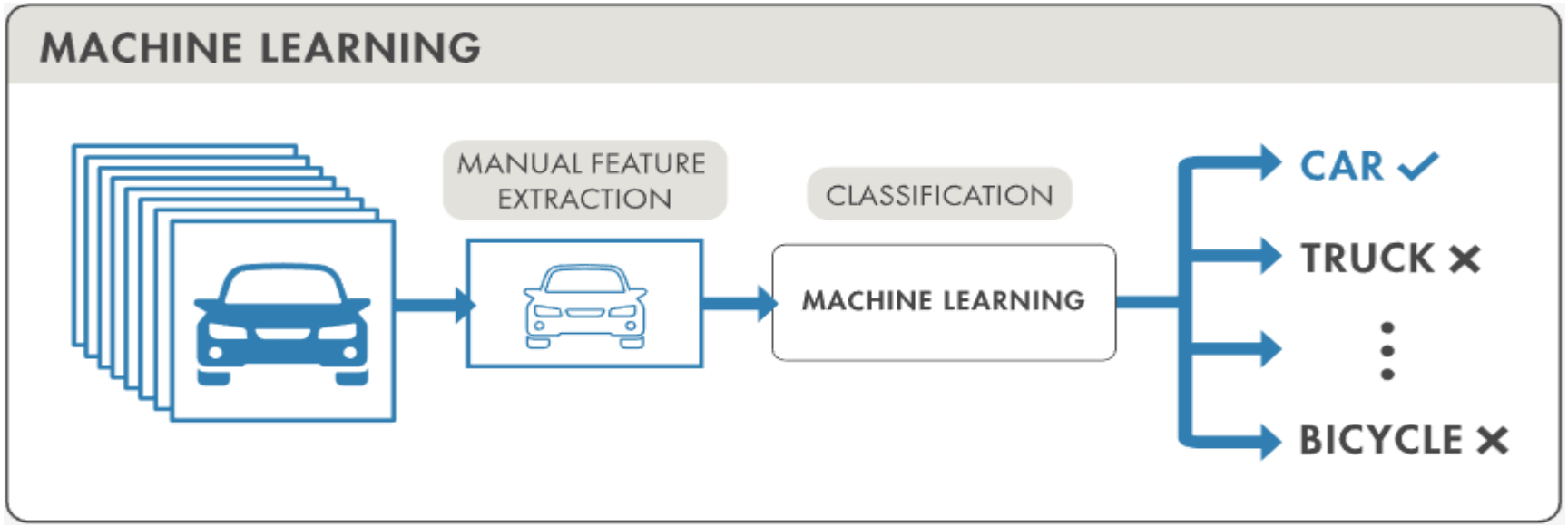


Machine learning is a set of algorithms which make predictions/decisions

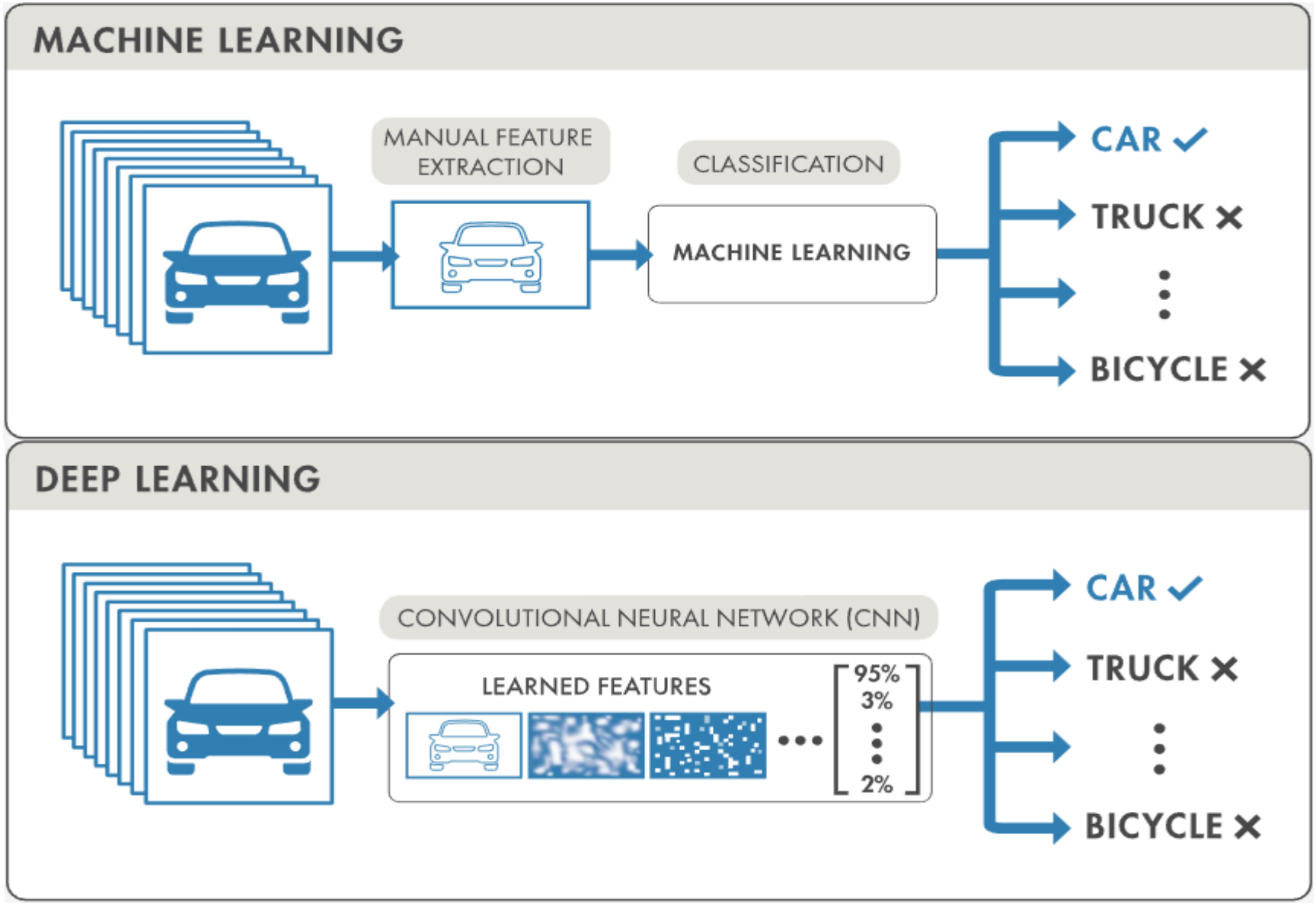




Machine learning is a set of algorithms which make predictions/decisions

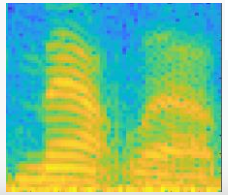


Deep learning intelligently uses the foundation of machine learning



Deep learning workflow defines the steps for training and testing a deep network

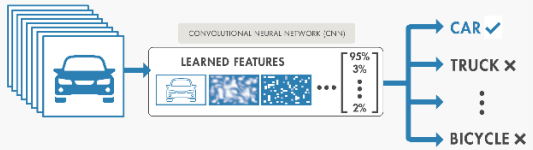
Gather Data



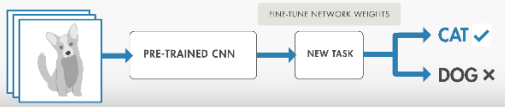
Transfer Learning
Train from scratch
Pretrained Network
Features
Test Data
CNNs
Inference
Accuracy
Deep Neural Network
Prediction
Subset of Machine Learning
Training Data

Network architecture

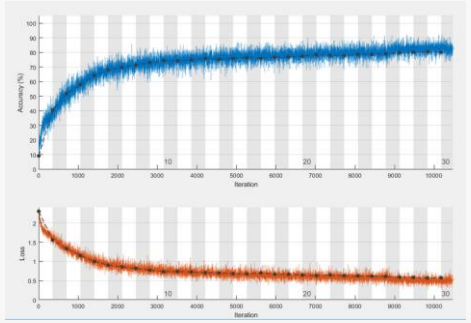
From scratch



Using pretrained network



Train Network until acceptable levels of accuracy



Test the Trained Network

AlexNet

Pretrained models help get started with deep learning

Researchers created network architectures for classifying hundreds of objects:

AlexNet
PRETRAINED MODEL

VGG-16/19
PRETRAINED MODEL

ResNet
PRETRAINED MODEL

GoogLeNet
PRETRAINED MODEL

Are objects correctly classified all of the time?

TopClasses	Scores
'chocolate sauce'	0.28587
'plate'	0.19347
'frying pan'	0.15759

Several factors can influence what an object is classified as and some of those reasons are listed next.

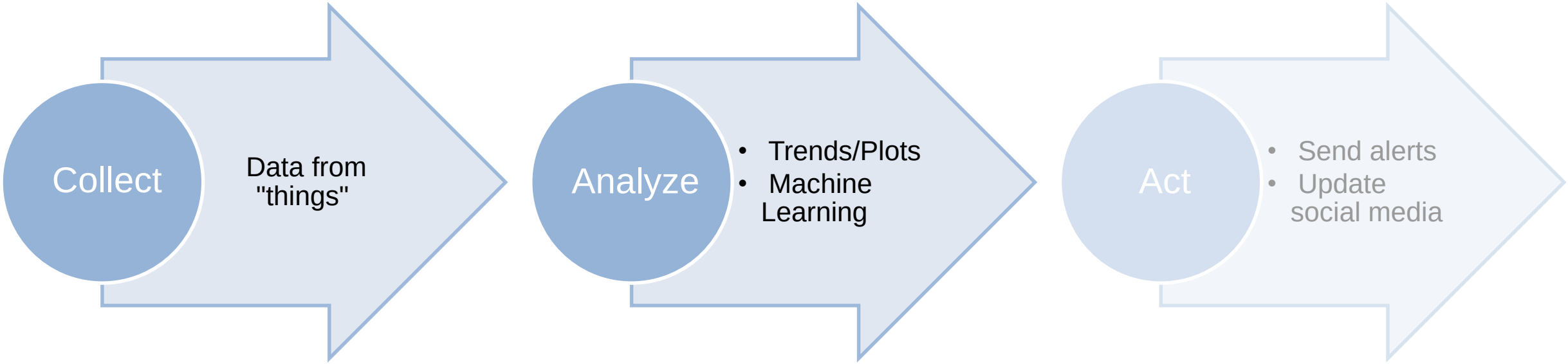
- Lighting
- Position of the object
- Other objects in the image
- Was the network trained for this object?

What is IoT, the Internet of Things?

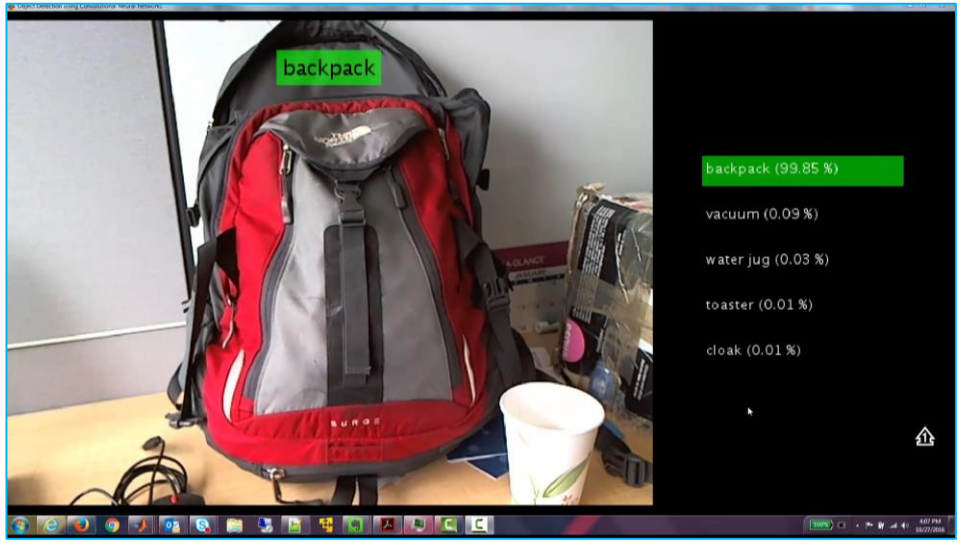
ThingSpeak™

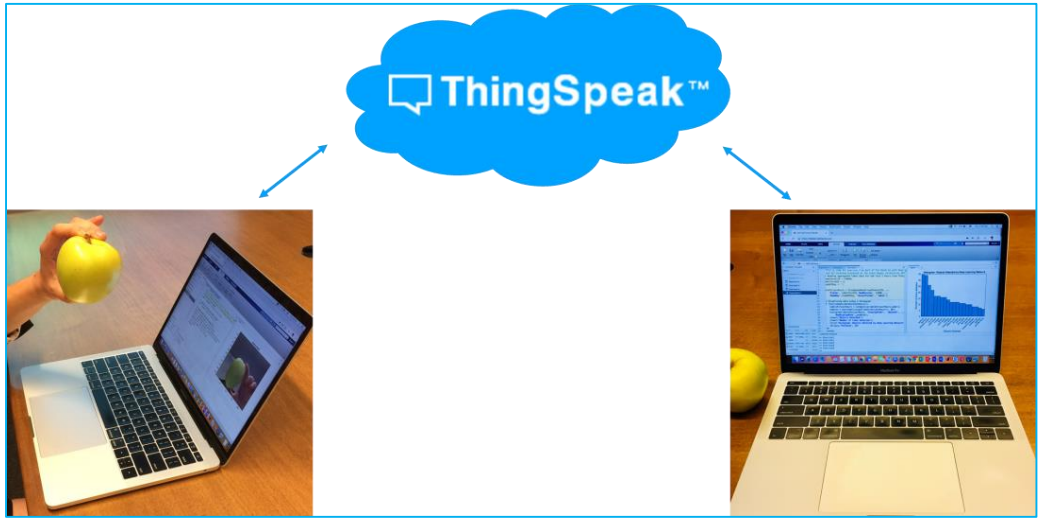
Smart products are already part of our everyday lives…

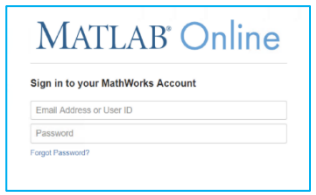
Typical IoT workflow involves collecting and analyzing data, and acting on the results



We learned about deep learning and IoT, now let's get set up to do hands-on exercises







Let's complete the setup to do our hands-on exercises

- Create a MathWorks account

  https://www.mathworks.com/mwaccount/

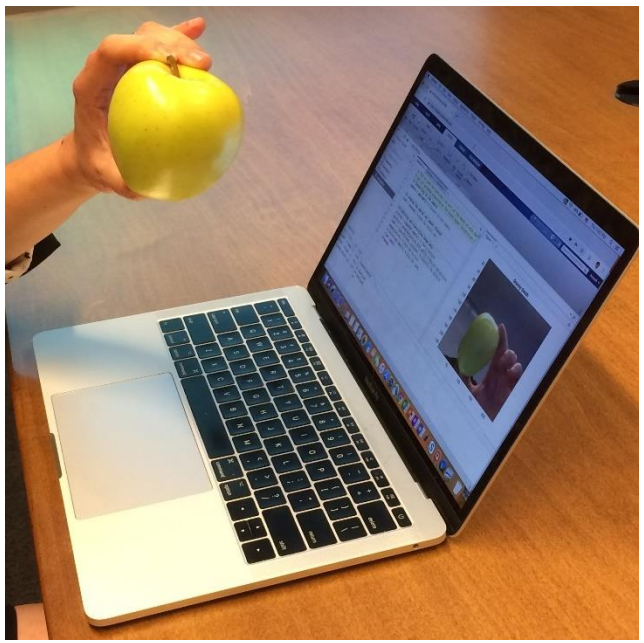
- Activate your workshop license

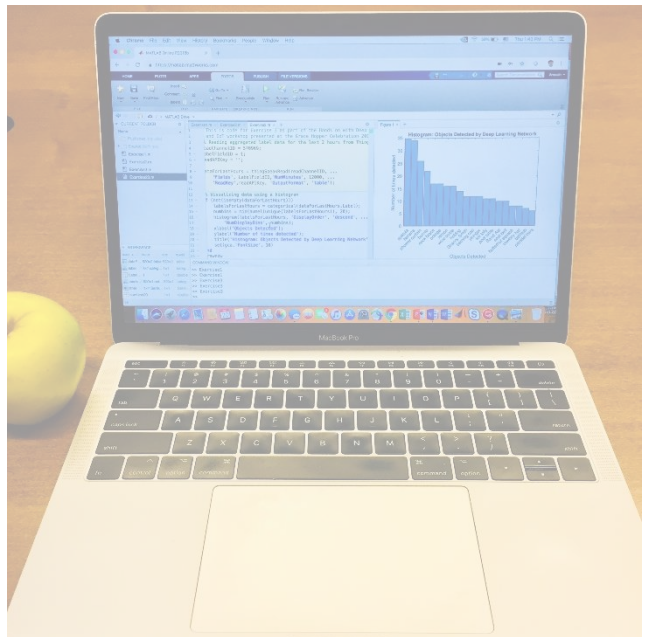
  https://tinyurl.com/StrangeLoop2019License

- Download the exercises

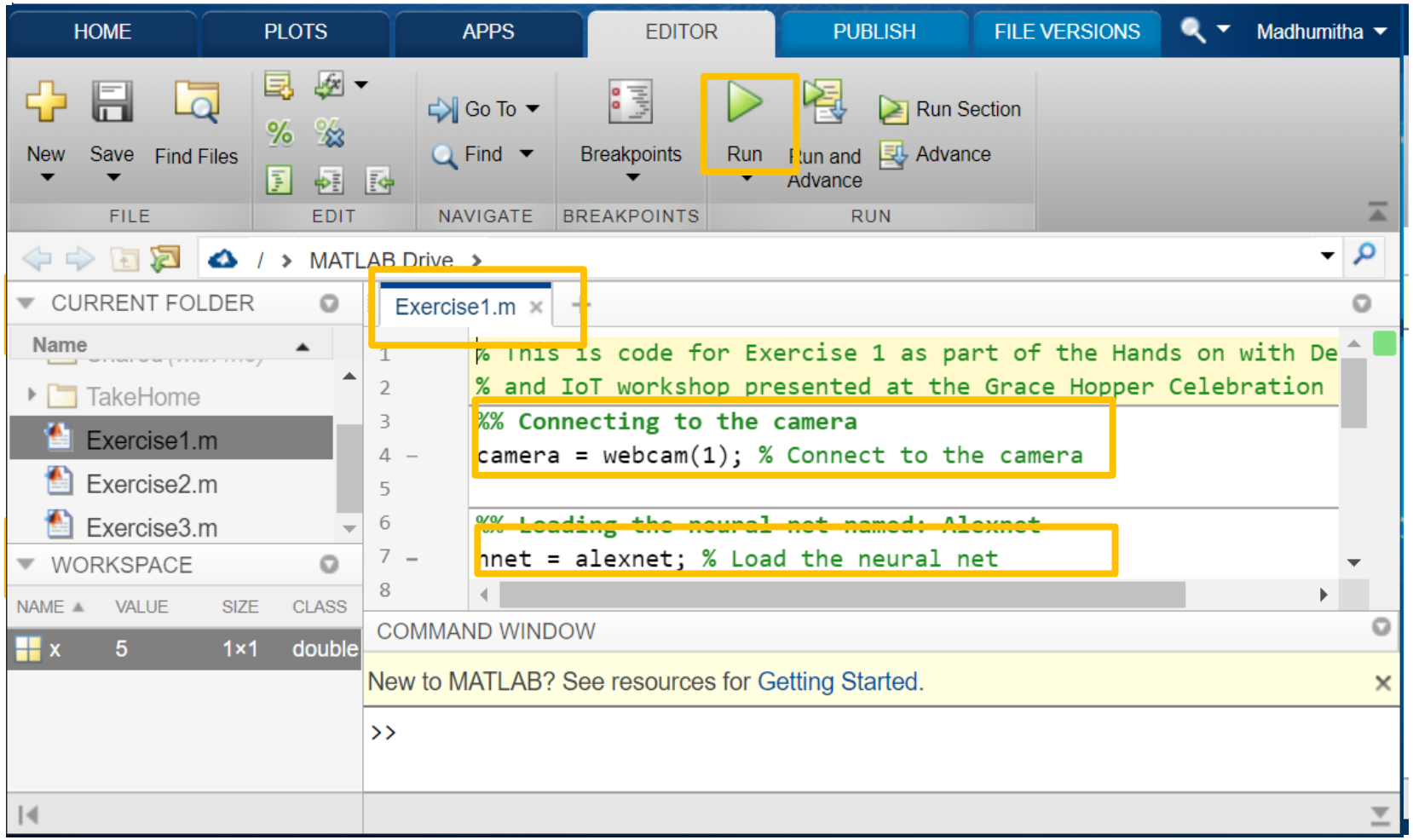
```
unzip('https://tinyurl.com/ghc18deeplearning')
```

Exercise 1: Let's use a deep network to recognize objects





MATLAB Online view



Let's review the code for our first exercise

```
4 -  camera = webcam(1); % Connect to the camera
5
6    %% Loading the neural net named: Alexnet
7 -  nnet = alexnet; % Load the neural net
8
9    %% Capturing and classifying image data
10 - picture = snapshot(camera); % Take a picture
11 - picture = imresize(picture,[227,227]); % Resize the picture
12 - [label,scores] = classify(nnet, picture); % Classify the picture and
13   % obtain confidence score
14 - [sorted_scores,indices]=sort(scores,'descend'); % Sorting scores in
15   % descending order
16 - image(picture); % Show the picture
17 - title(['Alexnet classification: ',char(label),' score:',...
18       num2str(sorted_scores(1))]); % Show the label
19 - clear camera
20 - drawnow;
```

Step 1. Connecting to the camera

```
3   %% Connecting to the camera
4 - camera = webcam(1); % Connect to the camera
```

```
camera = webcam(1); % Connect to the camera
```

```
8
9   %% Capturing and classifying image data
10 - picture = snapshot(camera); % Take a picture
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15  % descending order
16 - image(picture); % Show the picture
17 - title(['Alexnet classification: ',char(label),' score:',...
18      num2str(sorted_scores(1))]); % Show the label
19 - clear camera
20 - drawnow;
```

Step 2. Getting access to a pretrained model (AlexNet)

```
3   %% Connecting to the camera
4   camera = webcam(1); % Connect to the camera
5
6   %% Loading the neural net named: Alexnet
7   nnet = alexnet; % Load the neural net
8
9
10  nnet = alexnet; % Load the neural net
11
12  [label,scores] = classify(nnet,picture); % classify the picture and
13  % obtain confidence score
14  [sorted_scores,indices]=sort(scores,'descend'); % Sorting scores in
15  % descending order
16  image(picture); % Show the picture
17  title(['Alexnet classification: ',char(label),' score:',...
18      num2str(sorted_scores(1))]); % Show the label
19  clear camera
20  drawnow;
```

Step 3. Getting a snapshot from the camera and using the pretrained model to classify image data

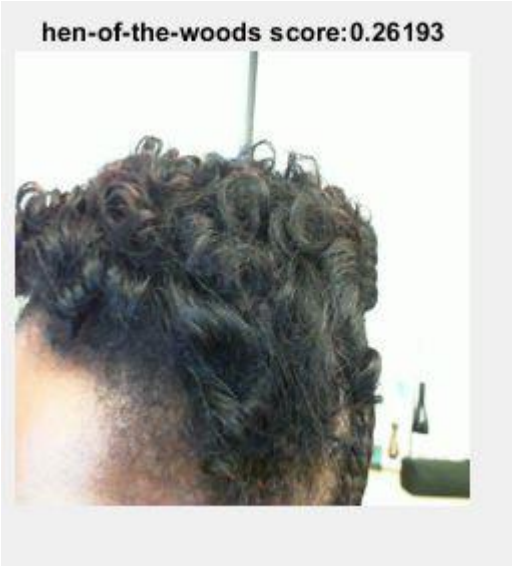
```
3   %% Connecting to the camera
4   camera = webcam(1); % Connect to the camera
5
6   %% Loading the neural net named: Alexnet
7   nnet = alexnet; % Load the neural net
8
9   %% Capturing and classifying image data
10  picture = snapshot(camera); % Take a picture
11  picture = imresize(picture,[227,227]); % Resize the pict
12  [label,scores] = classify(nnet, picture); % Classify the
13  % obtain confidence score
14  [sorted_scores,indices]=sort(scores,'descend'); % Sortin
15  % descending order
16  image(picture); % Show the picture
17  title(['Alexnet classification: ',char(label),' score:',
18      num2str(sorted_scores(1))]); % Show the label
19
20
```

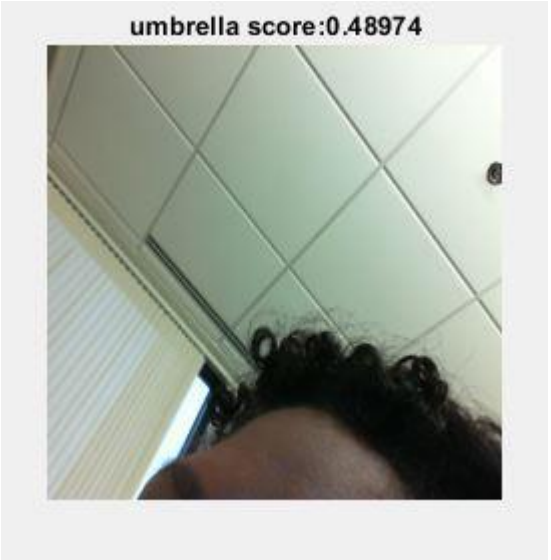
First exercise: Reminders

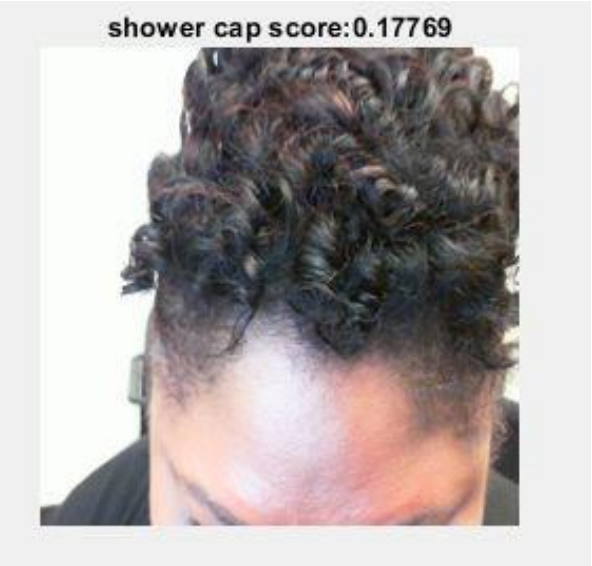
Several factors can impact object classification

- Lighting
- Position of the object
- Other objects in the image
- Was the network trained very well with this type of object

Louvere Walker-Hannon







Let’s do our first exercise hands-on!

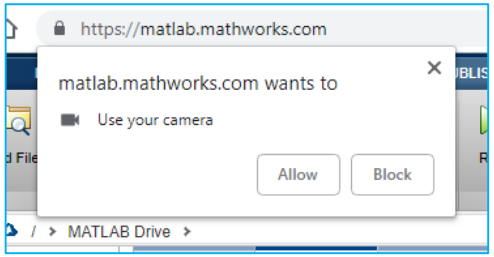
1. Place an Object in front of the camera

2. Place your cursor on line #1 in your Editor

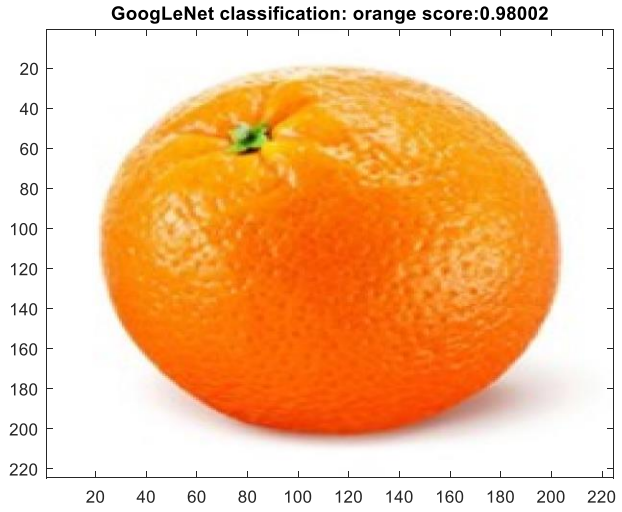
```
%% Connecting to the camera
camera = webcam(1); % Connect to the camera

%% Loading the neural net named: GoogLeNet
nnet = googlenet; % Load the neural net

%% Capturing and classifying image data
picture = snapshot(camera); % Take a picture
picture = imresize(picture,[224,224]); % Resize the picture
[label,scores] = classify(nnet, picture); % Classify the picture and
% obtain confidence score
[sorted_scores,indices]=sort(scores,'descend'); % Sorting scores in
% descending order
image(picture); % Show the picture
title(['GoogLeNet classification: ',char(label),' score:',...
    num2str(sorted_scores(1))]); % Show the label
clear camera
drawnow;
```

3. Press the Run button

4. Press Allow to use the webcam for the first time



5. Look at your results



Try the exercises with different objects!

- Use real objects around you
- Use objects with different lighting, angles or background
- Use the images of fruit provided
- Use `imread` to read any of your images and classify them!
  - https://drive.matlab.com/files/

Let's now use GoogLeNet

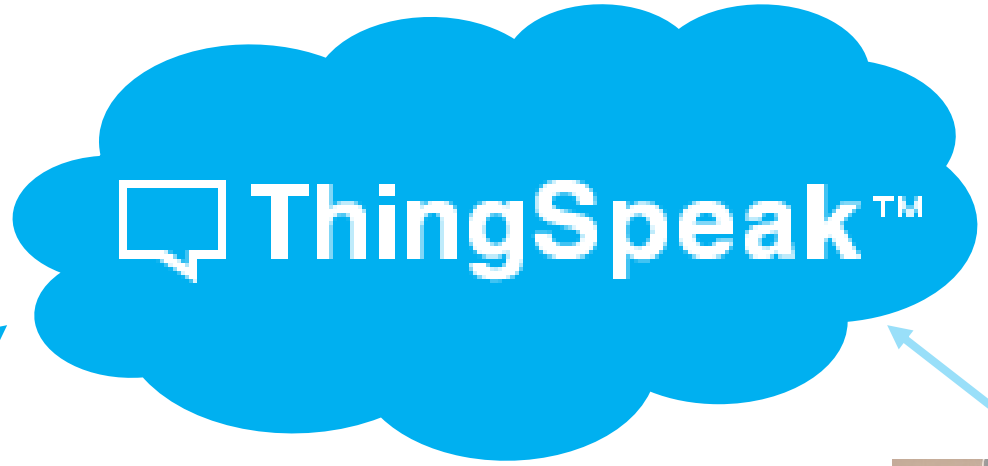
```
%% Connecting to the camera
camera = webcam(1); % Connect to the camera

%% Loading the neural net named: GoogLeNet
nnet = googlenet; % Load the neural net

%% Capturing and classifying image data
picture = snapshot(camera); % Take a picture
picture = imresize(picture,[224,224]); % Resize the picture
[label,scores] = classify(nnet, picture); % Classify the picture and
% obtain confidence score
[sorted_scores,indices]=sort(scores,'descend'); % Sorting scores in
% descending order
image(picture); % Show the picture
title(['GoogLeNet classification: ',char(label),' score:',...
    num2str(sorted_scores(1))]); % Show the label
clear camera
drawnow;
```

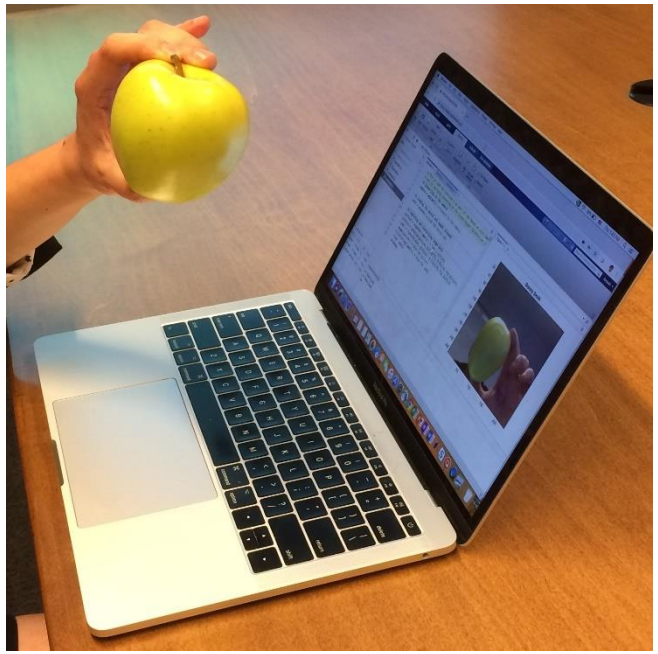
First exercise: Follow-Up and Observations

1. Were your object(s) classified?
2. Were your object(s) correctly classified?
3. Do you think you can improve the accuracy of your result(s)?

https://www.mathworks.com/learn/tutorials/deep-learning-onramp.html

Exercise 2 : Let’s send object recognition data to the IoT data aggregator

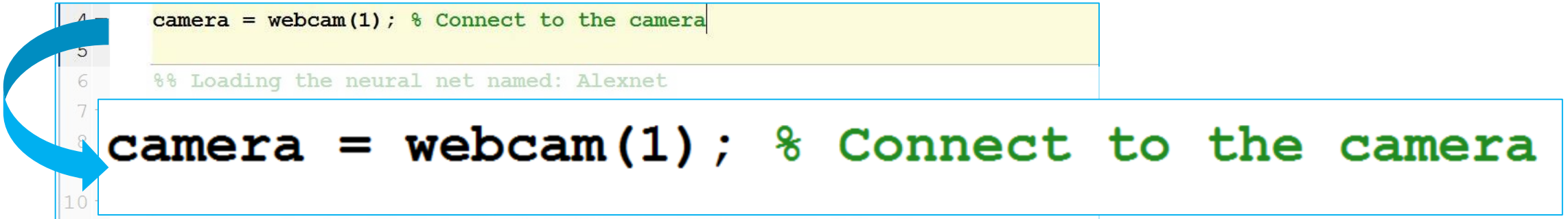




Let’s review the code for our second exercise

```
camera = webcam(1); % Connect to the camera

%% Loading the neural net named: Alexnet
nnet = alexnet; % Load the neural net

%% Capturing and classifying image data
picture = snapshot(camera); % Take a picture
picture = imresize(picture,[227,227]); % Resize the picture
[label,scores] = classify(nnet, picture); % Classify the picture and
% obtain confidence score
[sorted_scores,indices]=sort(scores,'descend'); % Sorting scores in
% descending order
image(picture); % Show the picture
title(['Alexnet classification: ',char(label),' score:',...
    num2str(sorted_scores(1))]); % Show the label
clear camera
drawnow;
%% Aggregating label data to open IoT platform
try
    thingSpeakWrite(570969,string(label),'WriteKey','W355TMVX9IFROIE2')
catch
    pause(randi(5))
end
```

Step 1. Connecting to the camera




```
camera = webcam(1); % Connect to the camera

%% Loading the neural net named: Alexnet

picture = imresize(picture,[227,227]); % Resize the picture
[label,scores] = classify(nnet, picture); % Classify the picture and
% obtain confidence score
[sorted_scores,indices]=sort(scores,'descend'); % Sorting scores in
% descending order
image(picture); % Show the picture
title(['Alexnet classification: ',char(label),' score:',...
    num2str(sorted_scores(1))]); % Show the label
clear camera
drawnow;
%% Aggregating label data to open IoT platform
try
    thingSpeakWrite(570969,string(label),'WriteKey','W355TMVX9IFROIE2')
catch
    pause(randi(5))
end
```

Step 2. Getting access to a pretrained model (AlexNet)

```
4 -  camera = webcam(1); % Connect to the camera
5
6    %% Loading the neural net named: Alexnet
7 -  nnet = alexnet; % Load the neural net
8
9
10
11
12 -
13   % obtain confidence score
14 -  [sorted_scores,indices]=sort(scores,'descend'); % Sorting scores in
15   % descending order
16 -  image(picture); % Show the picture
17 -  title(['Alexnet classification: ',char(label),' score:',...
18       num2str(sorted_scores(1))]); % Show the label
19 -  clear camera
20 -  drawnow;
21   %% Aggregating label data to open IoT platform
22 -  try
23 -      thingSpeakWrite(570969,string(label),'WriteKey','W355TMVX9IFROIE2')
24 -  catch
25 -      pause(randi(5))
26 -  end
```


```
nnet = alexnet; % Load the neural net
```

Step 3. Getting a snapshot from the camera and using the pretrained model to classify image data

```
camera = webcam(1); % Connect to the camera

%% Loading the neural net named: Alexnet
nnet = alexnet; % Load the neural net

%% Capturing and classifying image data
picture = snapshot(camera); % Take a picture
```

```
picture = snapshot(camera); % Take a picture
picture = imresize(picture,[227,227]); % Resize the pict
[label,scores] = classify(nnet, picture); % Classify the
% obtain confidence score
[sorted_scores,indices]=sort(scores,'descend'); % Sortin
% descending order
image(picture); % Show the picture
title(['Alexnet classification: ',char(label),' score:',
    num2str(sorted_scores(1))]); % Show the label
```

Step 4. Aggregating labels of recognized objects and writing data to a channel

```
camera = webcam(1); % Connect to the camera

%% Loading the neural net named: Alexnet
nnet = alexnet; % Load the neural net

%% Capturing and classifying image data
picture = snapshot(camera); % Take a picture
```

```
%% Aggregating label data to open IoT platform
try
    thingSpeakWrite(570969,string(label),'WriteKey','W355TMVX9IFROIE2')
catch
    pause(randi(5))
end
```

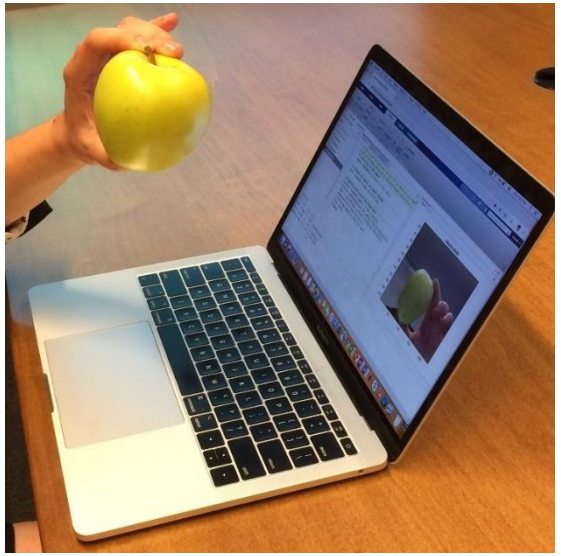

```
%% Aggregating label data to open IoT platform
try
    thingSpeakWrite(570969,string(label),'WriteKey','W355TMVX9IFROIE2')
catch
    pause(randi(5))
end
```

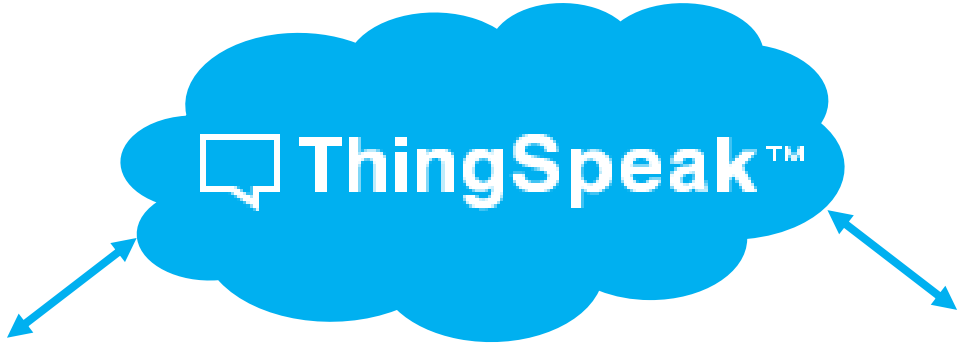
Let’s do our second exercise hands-on!

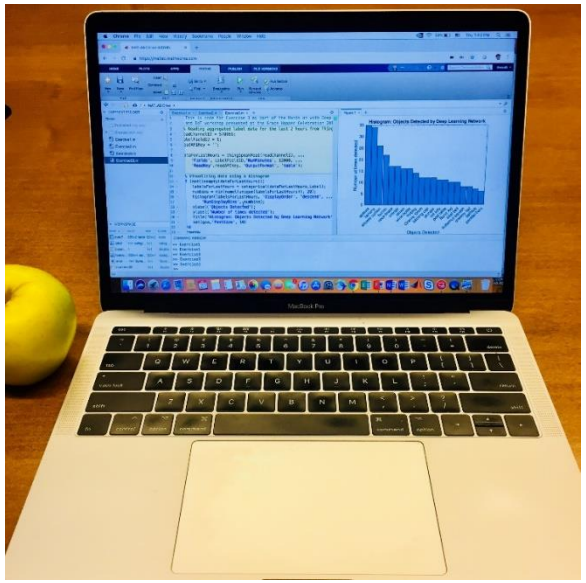
```
camera = webcam(1); % Connect to the camera

%% Loading the neural net named: Alexnet
nnet = alexnet; % Load the neural net

%% Capturing and classifying image data
picture = snapshot(camera); % Take a picture
picture = imresize(picture,[227,227]); % Resize the picture
[label,scores] = classify(nnet, picture); % Classify the picture and
% obtain confidence score
[sorted_scores,indices]=sort(scores,'descend'); % Sorting scores in
% descending order
image(picture); % Show the picture
title(['Alexnet classification: ',char(label),' score:',...
    num2str(sorted_scores(1))]); % Show the label
clear camera
drawnow;
%% Aggregating label data to open IoT platform
try
    thingSpeakWrite(570969,string(label),'WriteKey','W355TMVX9IFROIE2')
catch
    pause(randi(5))
end
```

Visit ThingSpeak channel: https://thingspeak.com/channels/570969

Exercise 3: Let's access the data on the IoT aggregator and visualize it







Visit ThingSpeak channel: https://thingspeak.com/channels/570969

Let’s review the code for our third exercise

```
%% Reading aggregated label data for the last 2 hours from ThingSpeak
readChannelID = 570969;
LabelFieldID = 1;
readAPIKey = '';

dataForLastHours = thingSpeakRead(readChannelID, ...
    'Fields', LabelFieldID,'NumMinutes', 120, ...
    'ReadKey',readAPIKey, 'OutputFormat', 'table');

%% Visualizing data using a histogram
if (not(isempty(dataForLastHours)))
    labelsForLastHours = categorical(dataForLastHours.Label);
    numbins = min(numel(unique(labelsForLastHours)), 20);
    histogram(labelsForLastHours, 'DisplayOrder', 'descend', ...
        'NumDisplayBins', numbins);
    xlabel('Objects Detected');
    ylabel('Number of times detected');
    title('Histogram: Objects Detected by Deep Learning Network');
    set(gca,'FontSize', 10)
end
drawnow
```

Visit ThingSpeak channel: https://thingspeak.com/channels/570969

Step 1. Reading data from a channel with a particular ID

```
%% Reading aggregated label data for the last 2 hours from ThingSpeak
readChannelID = 570969;
LabelFieldID = 1;
readAPIKey = '';
```

```
%% Reading aggregated label data for the last 2 hours
readChannelID = 570969;
LabelFieldID = 1;
readAPIKey = '';

dataForLastHours = thingSpeakRead(readChannelID, ...
    'Fields', LabelFieldID,'NumMinutes', 120, ...
    'ReadKey',readAPIKey, 'OutputFormat', 'table');
```

```
    set(gca,'FontSize', 10)
end
drawnow
```

Step 2. Visualizing the data imported from a channel

```
%% Reading aggregated label data for the last 2 hours from ThingSpeak
readChannelID = 570969;
LabelFieldID = 1;
readAPIKey = '';

dataForLastHours = thingSpeakRead(readChannelID, ...
    'Fields', LabelFieldID,'NumMinutes', 120, ...
    'ReadKey',readAPIKey, 'OutputFormat', 'table');

%% Visualizing data using a histogram
if (not(isempty(dataForLastHours)))
```

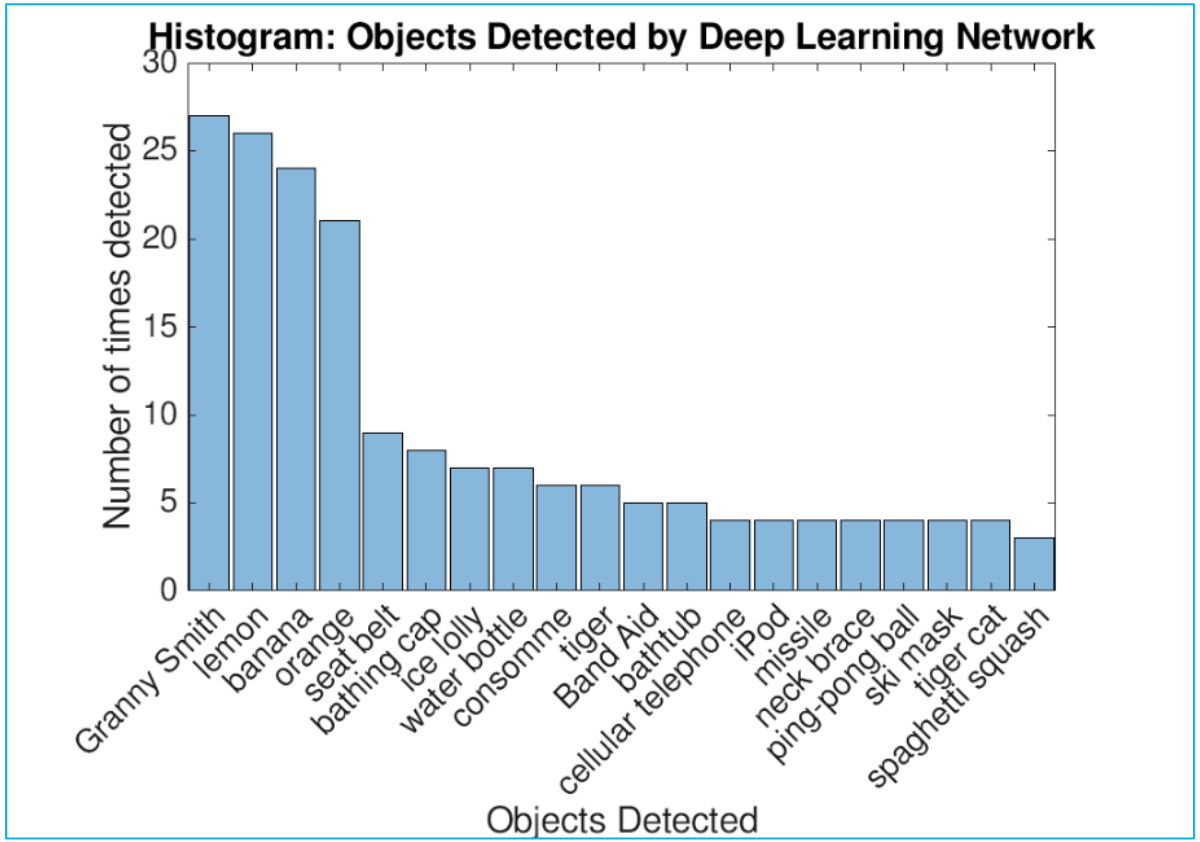
```
%% Visualizing data using a histogram
if (not(isempty(dataForLastHours)))
    labelsForLastHours = categorical(dataForLastHours.Label);
    numbins = min(numel(unique(labelsForLastHours)), 20);
    histogram(labelsForLastHours, 'DisplayOrder', 'descend', ...
        'NumDisplayBins', numbins);
    xlabel('Objects Detected');
    ylabel('Number of times detected');
    title('Histogram: Objects Detected by Deep Learning Network');
    set(gca,'FontSize', 10)
end
```

Let’s do our third exercise hands-on!

```
%% Reading aggregated label data for the last 2 hours from ThingSpeak
readChannelID = 570969;
LabelFieldID = 1;
readAPIKey = '';

dataForLastHours = thingSpeakRead(readChannelID, ...
    'Fields', LabelFieldID,'NumMinutes', 120, ...
    'ReadKey',readAPIKey, 'OutputFormat', 'table');

%% Visualizing data using a histogram
if (not(isempty(dataForLastHours)))
    labelsForLastHours = categorical(dataForLastHours.Label);
    numbins = min(numel(unique(labelsForLastHours)), 20);
    histogram(labelsForLastHours, 'DisplayOrder', 'descend', ...
        'NumDisplayBins', numbins);
    xlabel('Objects Detected');
    ylabel('Number of times detected');
    title('Histogram: Objects Detected by Deep Learning Network');
    set(gca,'FontSize', 10)
end
drawnow
```

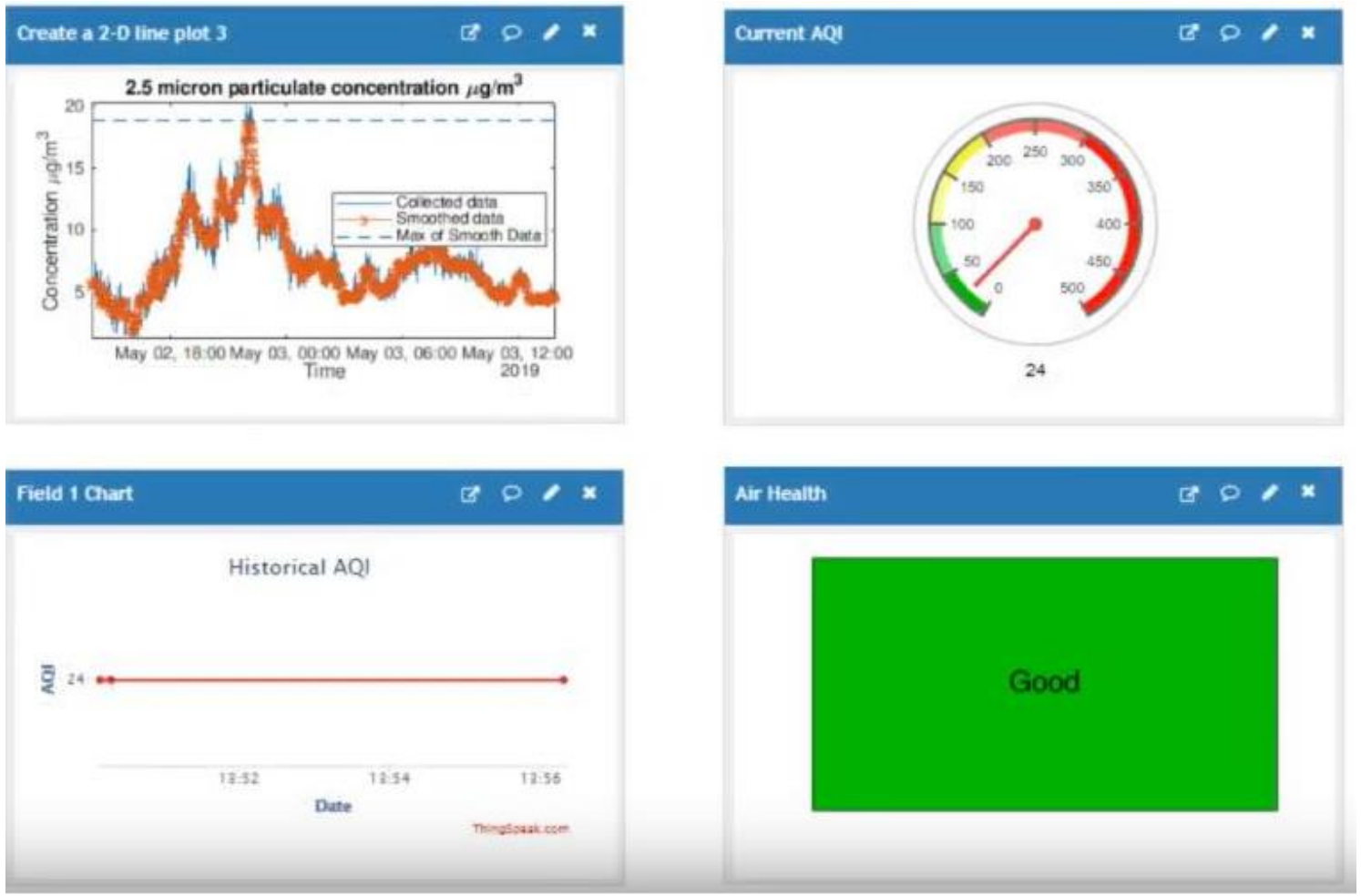
Visit ThingSpeak channel: https://thingspeak.com/channels/570969

Visualizing aggregated data helps us analyze it and decide on next steps



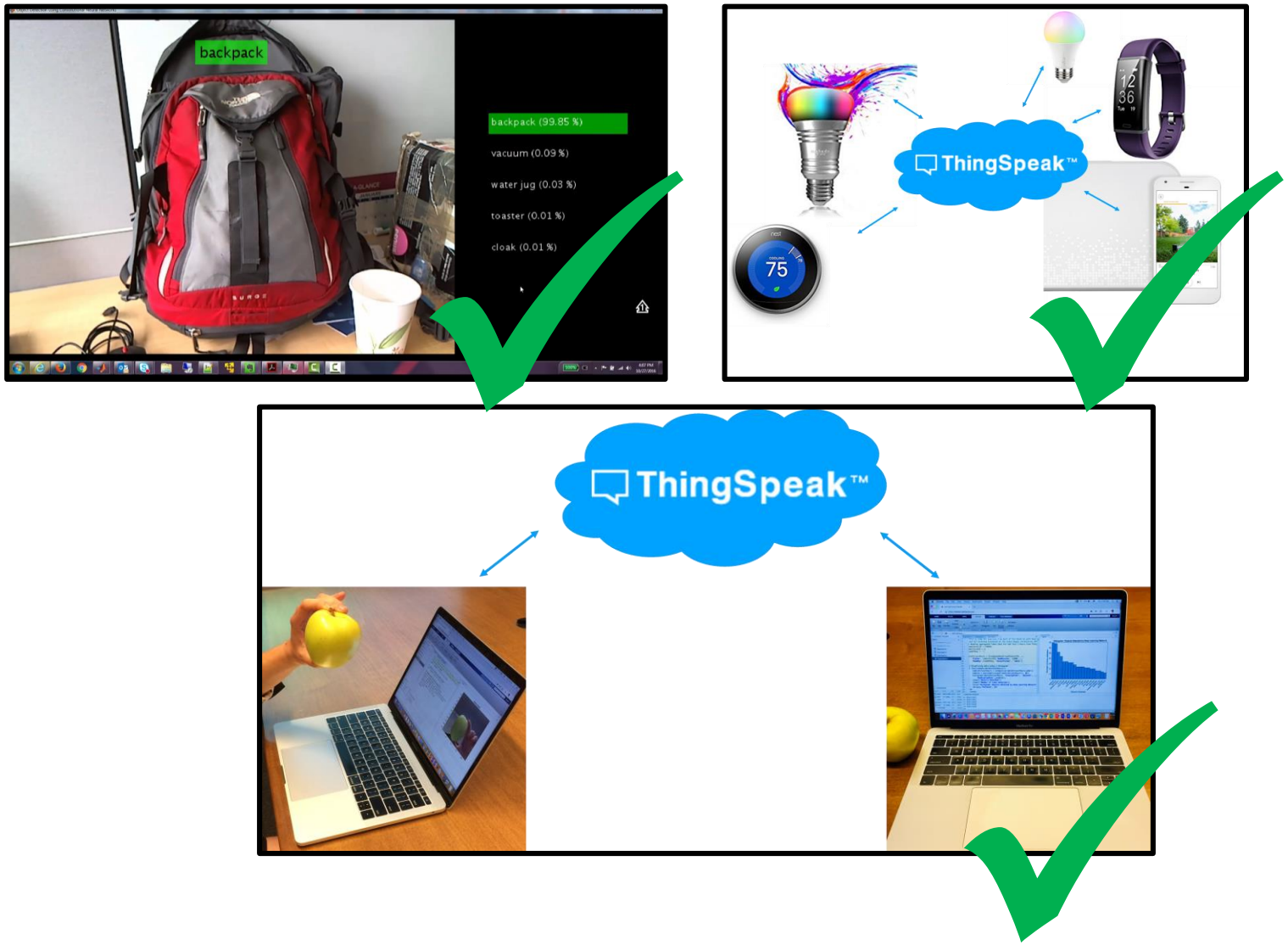
Visit ThingSpeak channel: https://thingspeak.com/channels/570969

Analyze and Visualize Air Quality Data with IoT



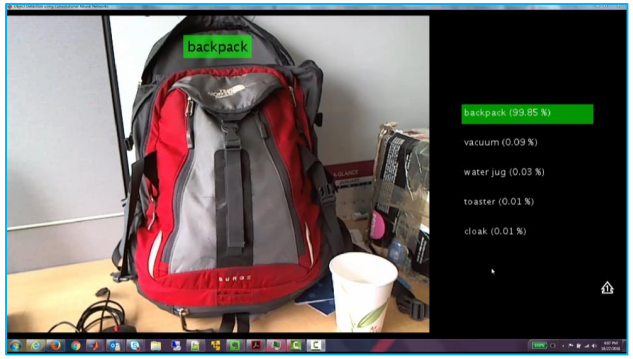
https://blogs.mathworks.com/iot/2019/07/16/analyze-and-visualize-air-quality-data-with-matlab/

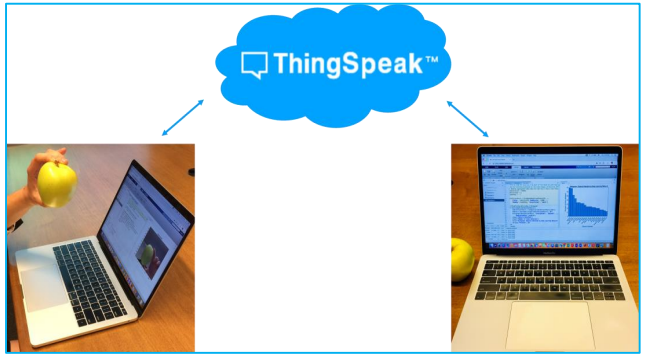
Today, we learnt…



Bring AI workshops to your communities!

Keep in touch as you explore deep learning and IoT projects!





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