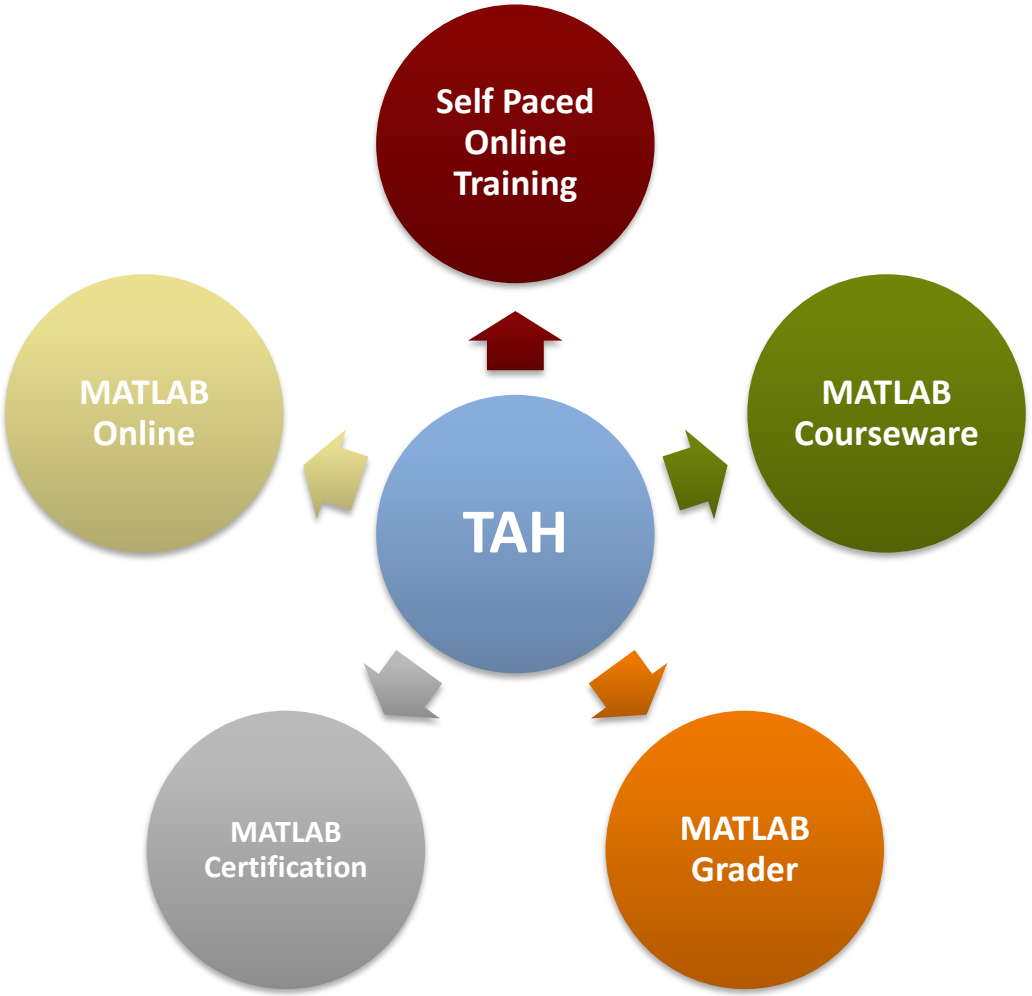
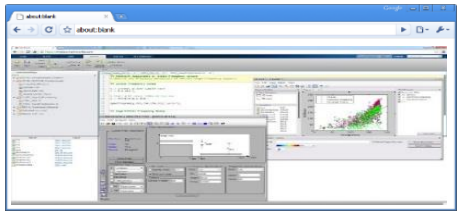
Resources for MATLAB Users



- **Self Paced Online Training**
  - MATLAB on-ramp: Complimentary access for everyone
  - MATLAB Academic Online Training Suite: campus-wide access to 4 premium self-paced courses
- **MATLAB Courseware**
  - Downloadable sets of curriculum materials
  - Courses by year of study
- **MATLAB Grader**
  - Create programming assignments for students and automatically grade their work
- **MATLAB Certification**
  - Associate
  - Professional
- **MATLAB Online**
  - Access MATLAB from a web browser
  - Share files with students and colleagues using MATLAB Drive

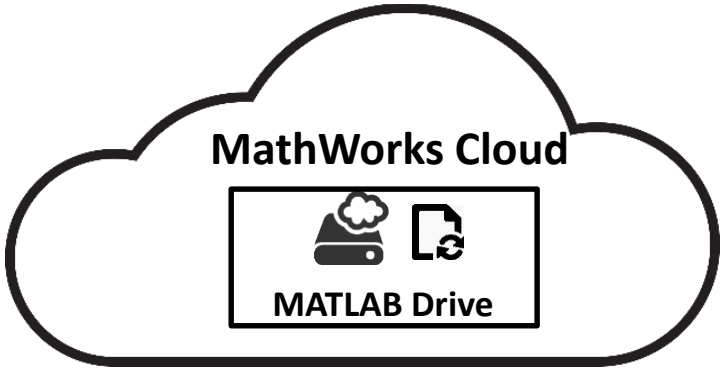
MATLAB Online, MATLAB Mobile and MATLAB Drive

Improve productivity by accessing your work anywhere



MATLAB Online

- Browser-based access on all platforms (incl. Chromebooks)
- Instant access: no downloads, installs
- Files and data are available everywhere with MATLAB Drive



MATLAB Mobile

- Prototyping and exploration on the move
- Files and data are available everywhere with MATLAB Drive

MATLAB on Desktops/Laptops

What is MATLAB Grader? Save time grading MATLAB code

Traditional Grading

Submit homework

Wait 1-2 weeks

Get feedback

Read it??

Work on next homework

Autograding

Submit homework

Instant feedback

Coaching

Improve and Learn

Transitioning from traditional assignments

Assignment_v2.pdf - Adobe Acrobat Reader DC

Home Tools Assignment_v2.pdf Sign In

1 / 3 44.6%

INTRODUCTION TO PROGRAMMING WITH MATLAB

Assignment 1: Convergent Series

Background

In mathematics, a series is the sum of the terms of an infinite sequence of numbers. A series is convergent if the sequence of its partial sums tends to a limit; that means that the partial sums become closer and closer to a given number when the number of their terms increases.

For more details, please refer to the Wikipedia entry on Convergent Series.

Problem 1b: Estimating the value of Pi using Leibniz Series - Due 9/1

One of the methods to estimate the value of π is to use the Leibniz series expansion to a reasonably large number of terms and use the expression below to estimate the value of π.

$$\frac{\pi}{4} \approx 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \ldots + \frac{(-1)^{n+1}}{2n-1} = \sum_{k=1}^{n} \frac{(-1)^{k+1}}{2k-1}$$

LaTex: \pi/4 \approx 1 - 1/3 + 1/5 + ... = \sum_{k=1}^{n} {-1}^{k+1} \frac{{-1}^{k+1}}{2k-1}

Using this expression, write a **script** to estimate the value of π using *N* terms. Your code should include the following variables:

```
N          % Number of terms used in the series expansion
estPi      % Value of π estimated using 'N' terms in the series.
```

Determine a value of N that ensures that the estimated value of π is within 0.1% of the actual value. Start with 10 terms, and increase or decrease the number appropriately to adjust the estimate.

You can use the Learner Template code provided below to develop your solution.

Learner Template

```
nTerms = ; % Number of terms to be used in the series expansion

% <Enter your code here>

estPi = ; % Estimated value of Pi for 'N' values.
```

Check to ensure that:

- the code does NOT use the variable 'pi' available in MATLAB.
- the output is numerically accurate for the number of series terms used.

Test Suite 1: Is MATLAB's built-in variable 'pi' being invoked in your code?

Feedback: The variable 'pi' available in MATLAB is being used in your code. Please retain only your estimated value of π under the variable name 'estPi'.

Test Suite 2: Is the estimated value of 'pi' acceptably accurate?

Feedback: Your estimated value doesn't fall within 0.1% of the expected value of π.

MATLAB | MATLAB | MATLAB | SKF Dem | MATLAB | MATLAB | New Tab | Jeff

Secure | https://bd-partner-a-origi...

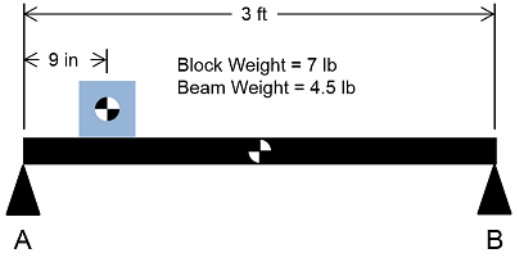
Courses

You are given a 3 foot long metal beam that weighs 4.5 lb. The beam has uniform density that is simply supported at each end. On the beam is a block that weighs 7 lb. The block's center of mass is 9 inches from end A.

How much weight is being carried by the supports at each end? The supports are labeled A and B.

Write code below to

1. Create a variable named FA that stores the force at point A.
2. Create a variable named FB that stores the force at point B.



Hint: How to calculate the forces

Your Script

Save Reset MATLAB Documentation

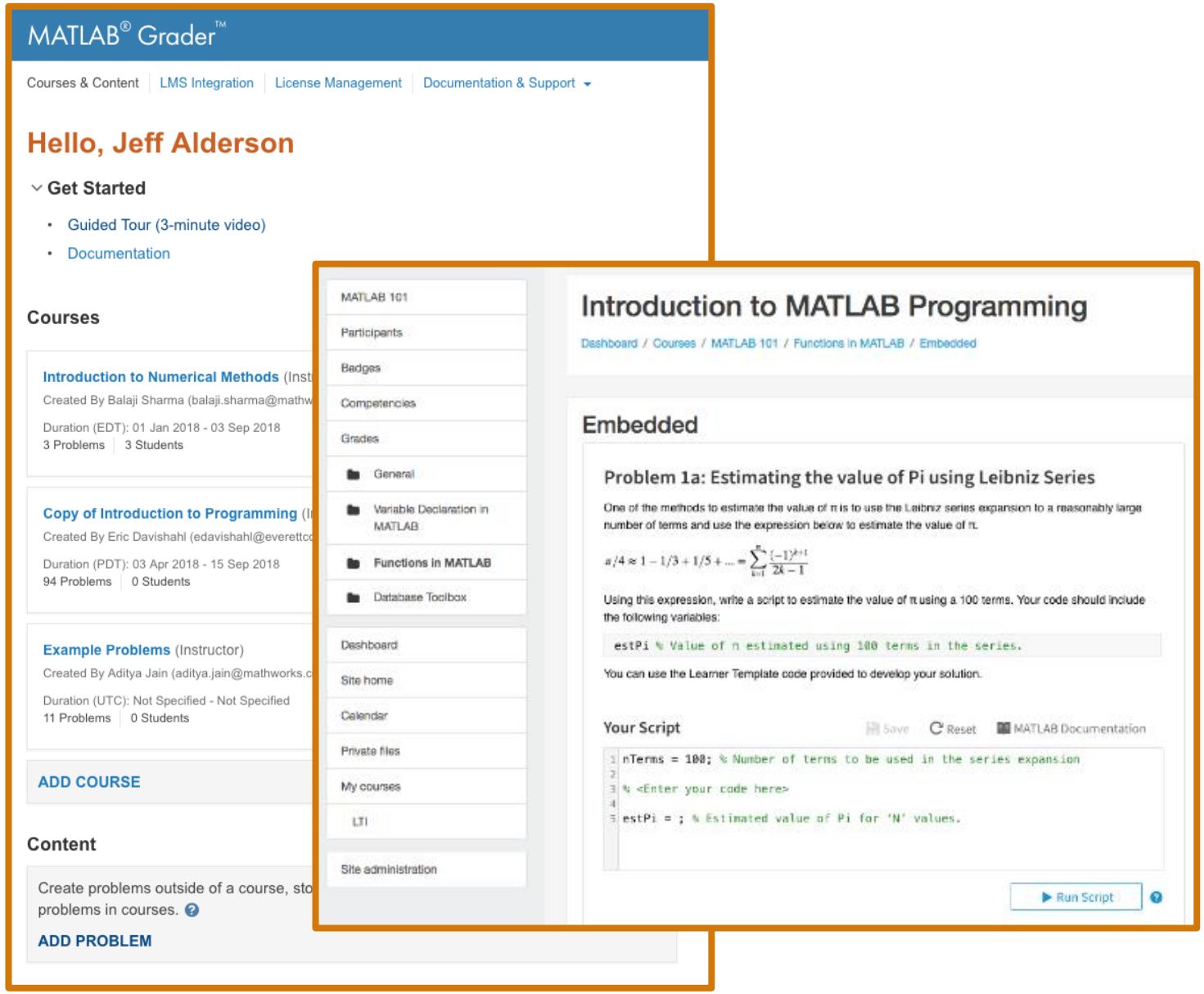
```
% DO NOT EDIT
% Givens:
weightBeam = 4.5;
lengthBeam = 3;
weightBlock = 7;
lengthAtoBlock = 9/12;

% ENTER YOUR SOLUTION HERE
```

MATLAB Grader

Automatically grade MATLAB code in <u>any</u> learning environment.

- Creation and sharing of **MATLAB-based assignments**
- **Autograded student solutions** with custom scoring rubrics
- A library of **re-usable examples**
- *Optional:* **learning management system integration**



Who would benefit from autograding MATLAB code in an LMS?

- Instructors teaching large and/or introductory level courses
  - Use off the shelf content and assessment examples to speed course development
  - Include MATLAB assignments for homework, exercises, and formative assessment
- Teaching Assistants and Graders for MATLAB-based courses
  - Less time spent grading code == more working with students
- Students get immediate feedback, and improve mastery of skills and concepts

LMS Integration

MATLAB® Grader™

Courses & Content | LMS Integration | License Management | Documentation & Support

Hello, Jeff Alderson

Get Started

- Guided Tour (3-minute video)
- Documentation

Courses Current Past

Introduction to Numerical Methods (Instructor)
Created By Balaji Sharma (balaji.sharma@mathworks.com)
Duration (EDT): 01 Jan 2018 - 03 Sep 2018
3 Problems | 3 Students

Copy of Introduction to Programming (Instructor)
Created By Eric Davishahl (edavishahl@everettcc.edu)
Duration (PDT): 03 Apr 2018 - 15 Sep 2018
94 Problems | 0 Students

Example Problems (Instructor)
Created By Aditya Jain (aditya.jain@mathworks.com)
Duration (UTC): Not Specified - Not Specified
11 Problems | 0 Students

ADD COURSE

Content

Create problems outside of a course, storing them in collections. You can later use these problems in courses.

ADD PROBLEM

My Institution | Courses | Community | Content Collection | Services | System Admin

Exoplanets ... Homework Assignments Problem 1: Rocky Planets

Add Problem

Start with a blank problem, an example problem, or a problem from a course or collection.

Blank Problem and Example Problems

Blank Problem
Create a script or function problem from scratch.

Example Problems
Created By:MathWorks
13 problems

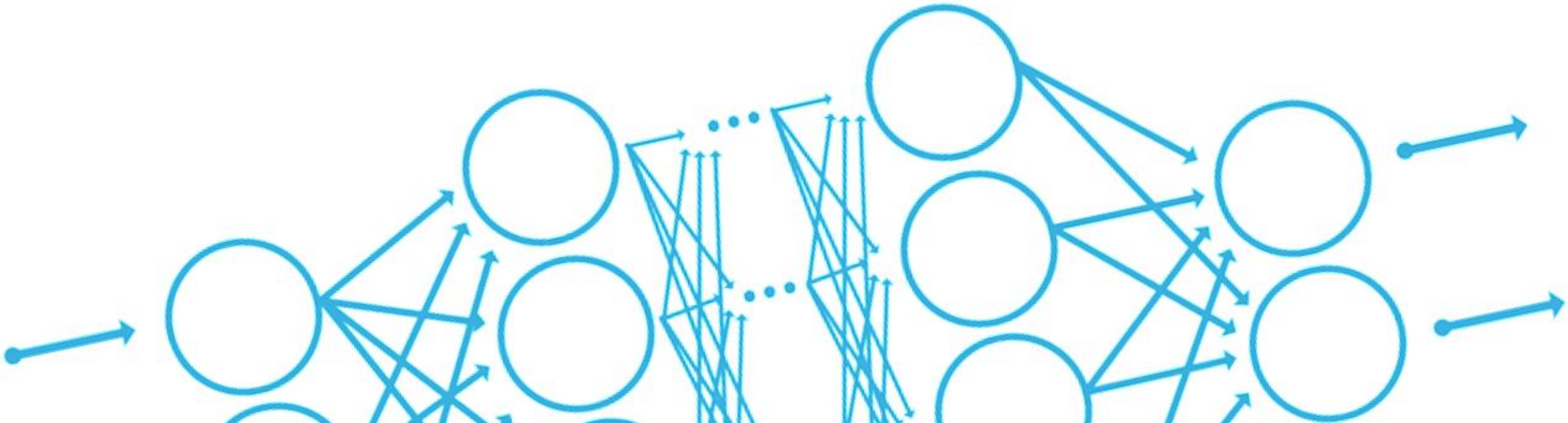
LMS Courses

Exoplanets
8 problems

MATLAB Grader Courses and Collections

Access your MATLAB Grader (formerly Cody Coursework) problems by linking to your MathWorks account.

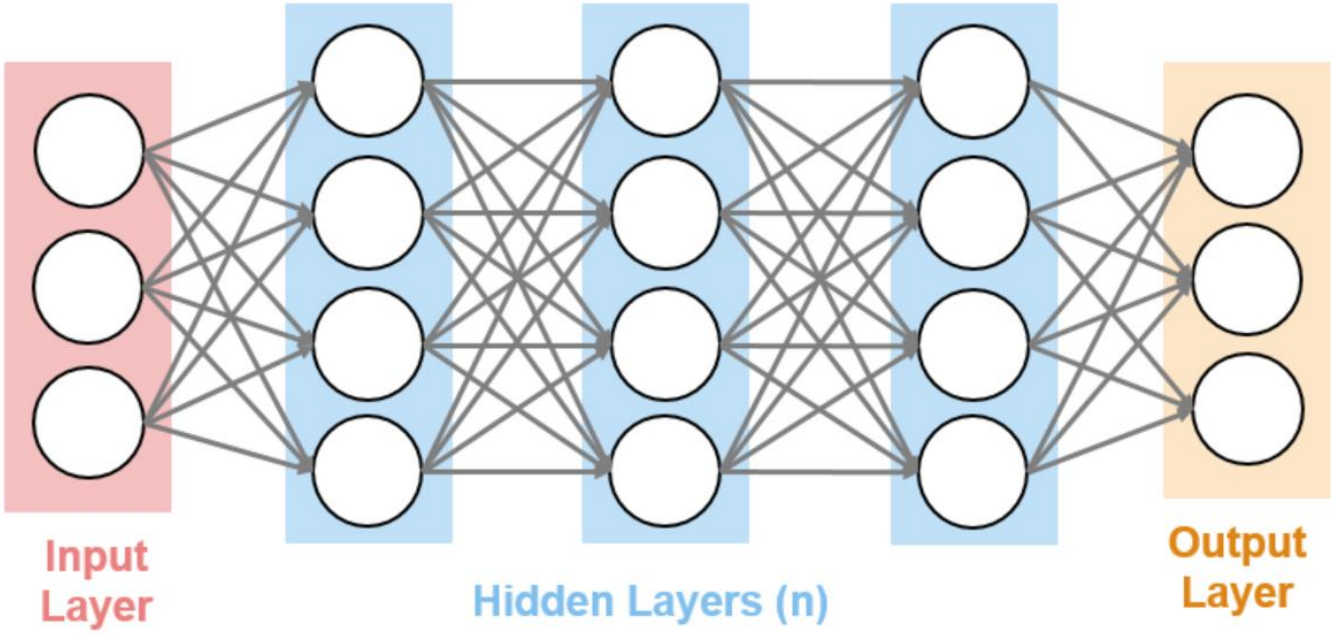
What is Deep Learning?



Deep learning is a type of machine learning in which a model learns to perform tasks directly from image, time-series or text data.

Deep learning is usually implemented using a **neural network architecture.**

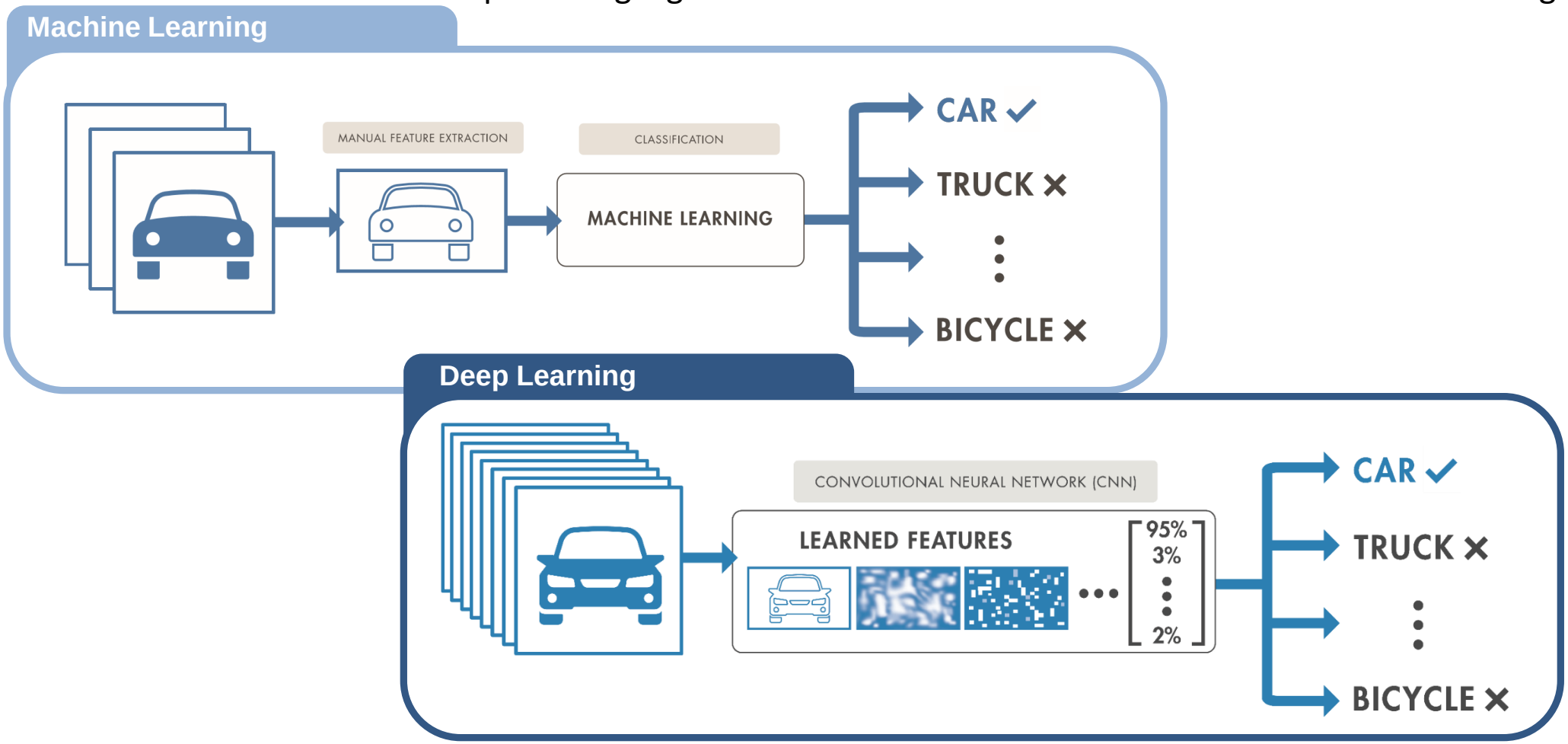
The term “deep” refers to the **number of layers** in the network—the more layers, the deeper the network.



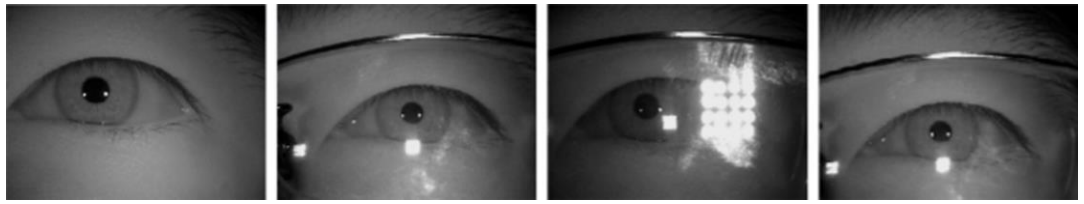
Machine Learning vs Deep Learning

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

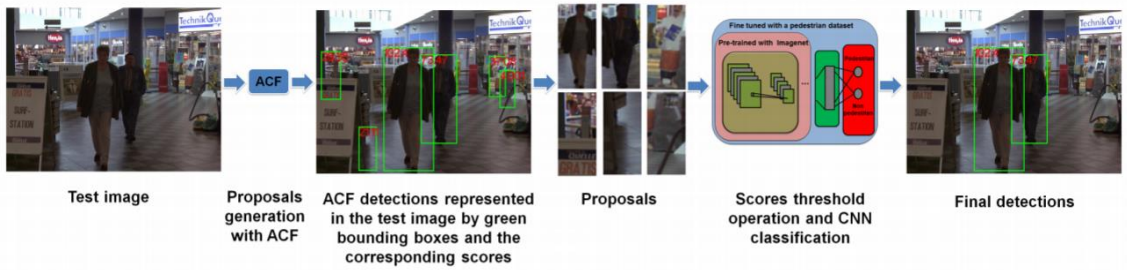
Deep learning algorithms also **scale with data –** traditional machine learning **saturates**



Diverse Applications of Deep Learning

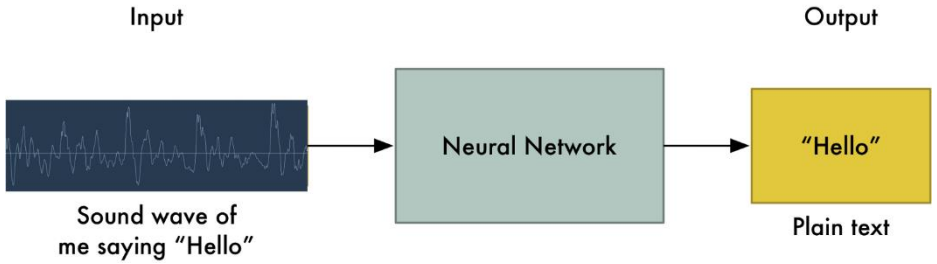


Iris Recognition – 99.4% accuracy



Human Aware Navigation for Robots

Rain Detection and Removal



Speech Commands Detection – **Live Demo**

Deep Learning Workflow

Access and Explore Data

Files

Databases

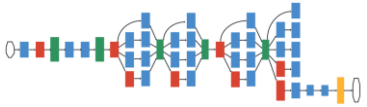
Sensors

Label and Preprocess Data

Data Augmentation/ Transformation

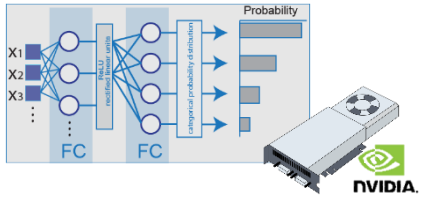
Labeling Automation

Import Reference Models



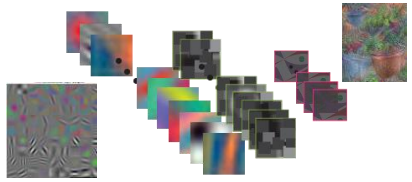
Develop Predictive Models

Hardware-Accelerated Training



Hyperparameter Tuning

Network Visualization

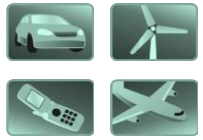


Integrate Models with Systems

Desktop Apps

Enterprise Scale Systems

Embedded Devices and Hardware



Deep Learning Challenges

Not a deep learning expert

Data

- Handling large amounts of data
- Labeling thousands of images & videos

Training and Testing Deep Neural Networks

- Accessing reference models from research
- Optimizing hyperparameters
- Training takes hours-days

Rapid and Optimized Deployment

- Desktop, web, cloud, and embedded hardware

1. Import DNNs into MATLAB
2. Access datasets & explore pretrained networks
3. Create, train and test CNNs in MATLAB
4. Network manipulation – Transfer Learning
5. Speed up and deploy

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Import Pre-Trained Models and Network Architectures

Pretrained Models

- `alexnet`
- `vgg16`
- `vgg19`
- `googlenet`
- `inceptionv3`
- `resnet50`
- `resnet101`
- `inceptionresnetv2`
- `squeezenet`

Import Models from Frameworks

- Caffe Model Importer (including Caffe Model Zoo)
  - `importCaffeLayers`
  - `importCaffeNetwork`
- TensorFlow-Keras Model Importer
  - `importKerasLayers`
  - `importKer`
- ONNX™ Mode Converter
  - `importONNXNetwork`
  - `exportONNXNetwork`

Caffe MODELS

KERAS IMPORTER

Importer for TensorFlow-Keras Models

(list of all models)

Download from within MATLAB

Deep Learning Classification in 4 Lines of Code

```
>> ...?;
>> ...?;
>> ...?;
>> ...?;
ans =
    categorical
     tank
```

Deep Learning Inference in 4 Lines of Code

```
>> net = alexnet;
>> I = imread('tank.jpg')
>> I1 = imresize(I,[227 227]);
>> classify(net,I1)
ans =
    categorical
     tank
```

1. Import DNNs into MATLAB
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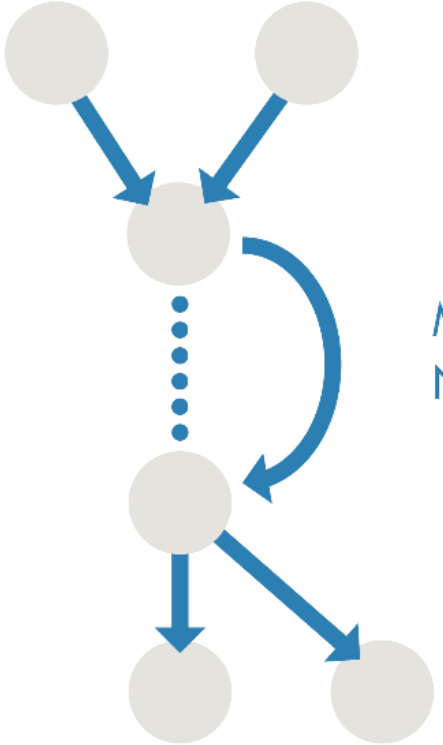
Many Network Architectures for Deep Learning

Series Network

Single-in
single-out

AlexNet
YOLO

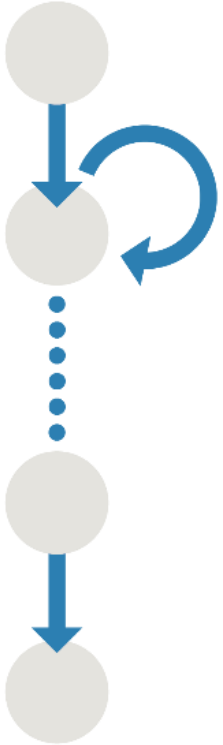
Directed Acyclic
Graph Network



Multi-in, multi-out
No feedback loops

ResNet
R-CNN

Recurrent Network



Memory

LSTM

and more
(GAN, DQN,…)

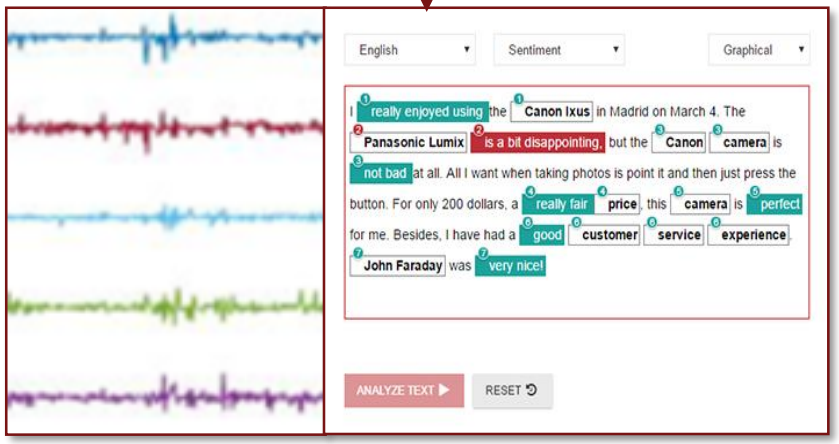
Types of Datasets

Numeric Data

ID	WC_TA	RE_TA	EBIT_TA	MVE_BVTD	S_TA	Industry	Rating
62394	0.013	0.104	0.036	0.447	0.142	3	BB
48608	0.232	0.335	0.062	1.969	0.281	8	A
42444	0.311	0.367	0.074	1.935	0.366	1	A
48631	0.194	0.263	0.062	1.017	0.228	4	BBB
43768	0.121	0.413	0.057	3.647	0.466	12	AAA
39255	-0.117	-0.799	0.01	0.179	0.082	4	CCC
62236	0.087	0.158	0.049	0.816	0.324	2	BBB
39354	0.005	0.181	0.034	2.597	0.388	7	AA
40326	0.47	0.752	0.07	11.596	1.12	8	AAA
51681	0.11	0.337	0.045	3.835	0.812	4	AAA

Machine Learning or LSTM

Time Series/ Text Data



LSTM or CNN

Image Data

CNN

MATLAB Demo

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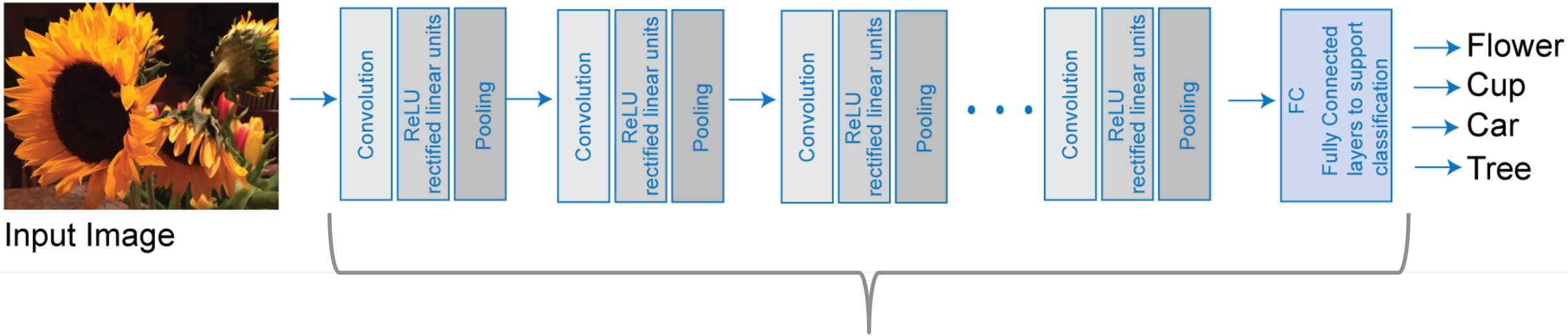
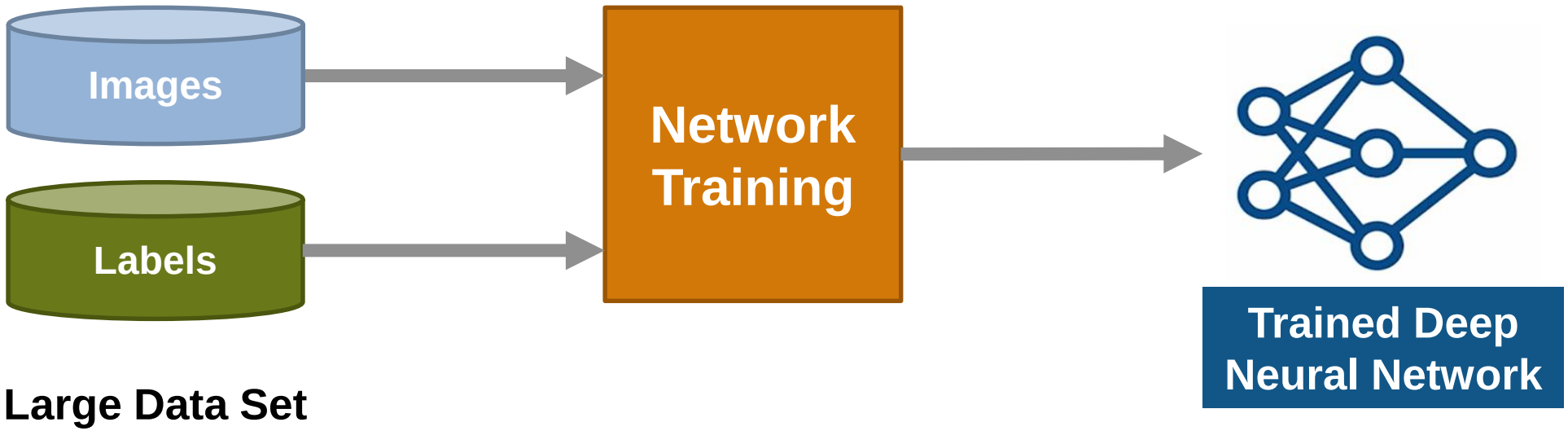
Convolutional Neural Networks (CNN)



Layer parameters are tuned during training

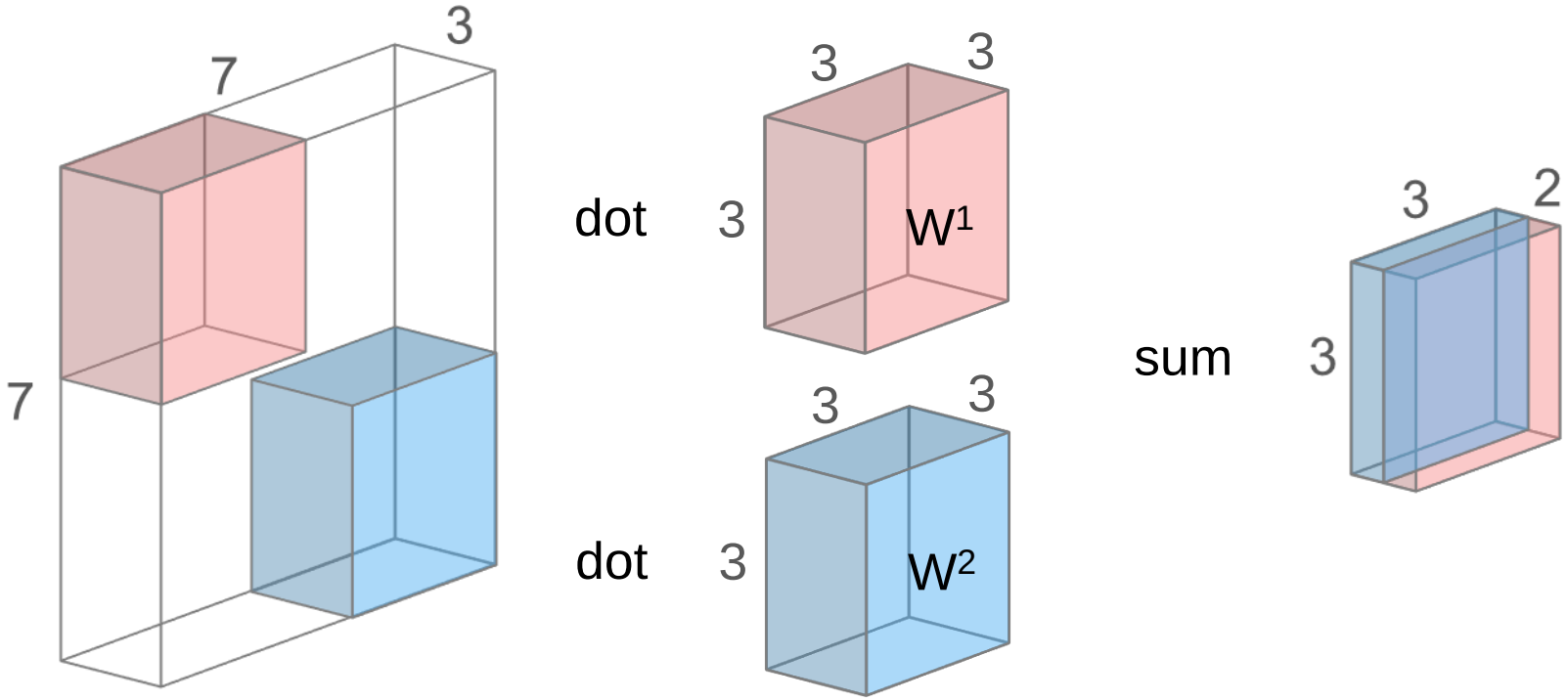
What is Training?



During training, neural network architectures learn features directly from the data without the need for manual feature extraction

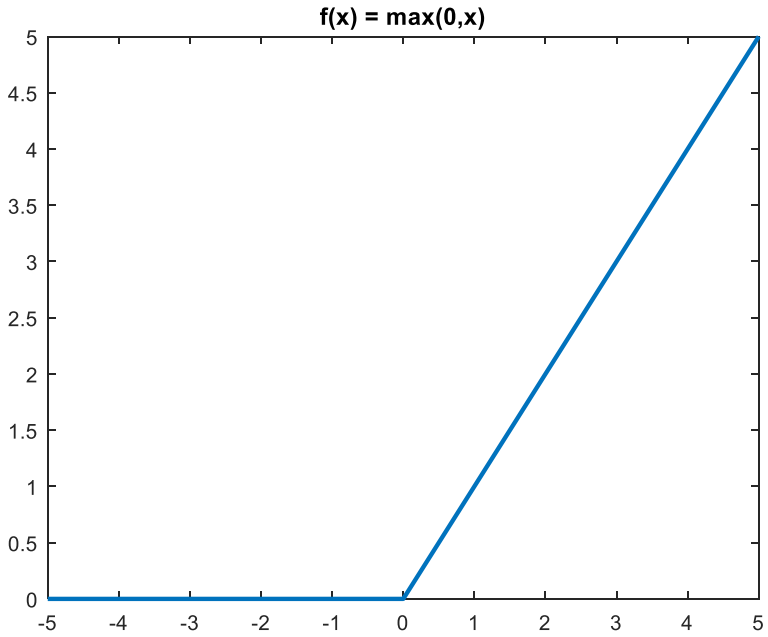
Convolution Layer

- Applies sliding filters to the input
  - The filters move along the input horizontally and vertically
  - Compute the dot product of the **weights** and the input
  - Add a **bias** term



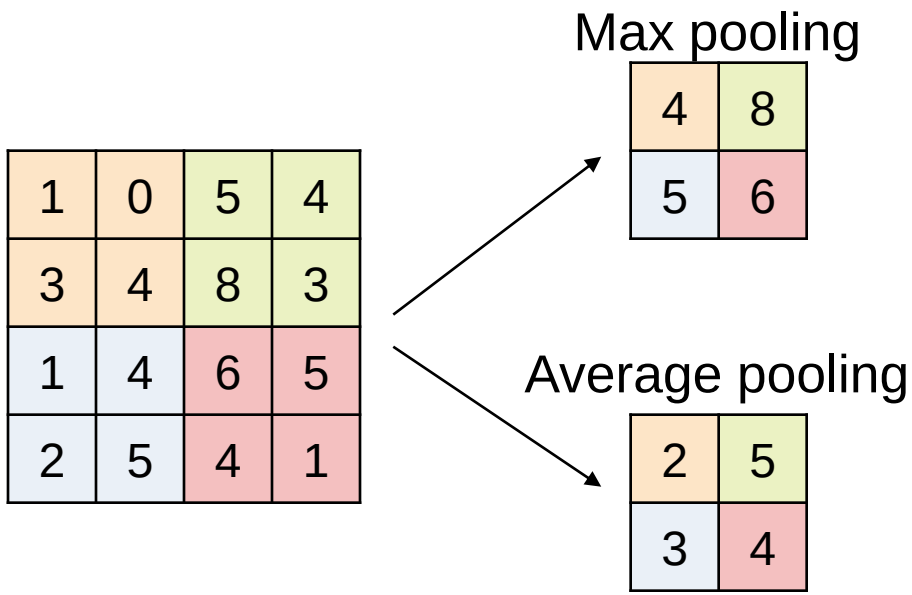
Rectified Linear Unit (ReLU) Layer

- Frequently used in combination with Convolution layers
- Do not add complexity to the network
- Acts as an activation function
  - Most popular choice: $\boldsymbol{f(x) = max(0, x)}$, input (feature) is thresholded at 0



Pooling Layer

- Perform a **downsampling** operation across the spatial dimensions
- Goal: progressively decrease the size of the layers
- Max pooling and average pooling methods
- Popular choice: Max pooling with 2x2 filters, Stride = 2



Fashion-MNIST Dataset

What?	A collection if items such as bags, shoes, etc.
Why?	Benchmark machine learning algorithms
How many?	60,000 training images 10,000 test images
Best results?	96.3% accuracy

Sources: https://github.com/zalandoresearch/fashion-mnist

MATLAB Demo

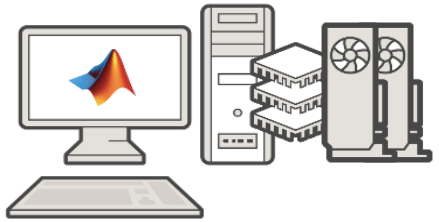
Deep Learning on CPU, GPU, Multi-GPU and Clusters

How to target?

Single CPU

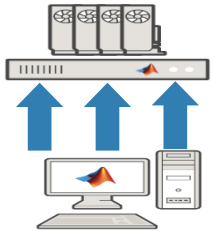
Single CPU
Single GPU

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

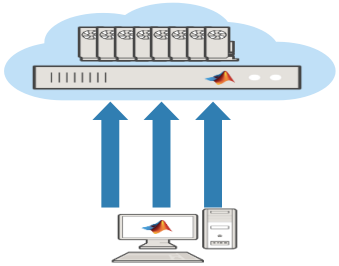


Single CPU, Multiple GPUs

```
opts = trainingOptions('sgdm', ...
    'MaxEpochs', 100, ...
    'MiniBatchSize', 250, ...
    'InitialLearnRate', 0.00005, ...
'ExecutionEnvironment', 'multi-gpu' );
```



On-prem server with GPUs



Cloud GPUs (AWS)

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

CUDA® enabled NVIDIA® GPU with compute capability 3.0 or higher
https://developer.nvidia.com/cuda-gpus

1. Import DNNs into MATLAB
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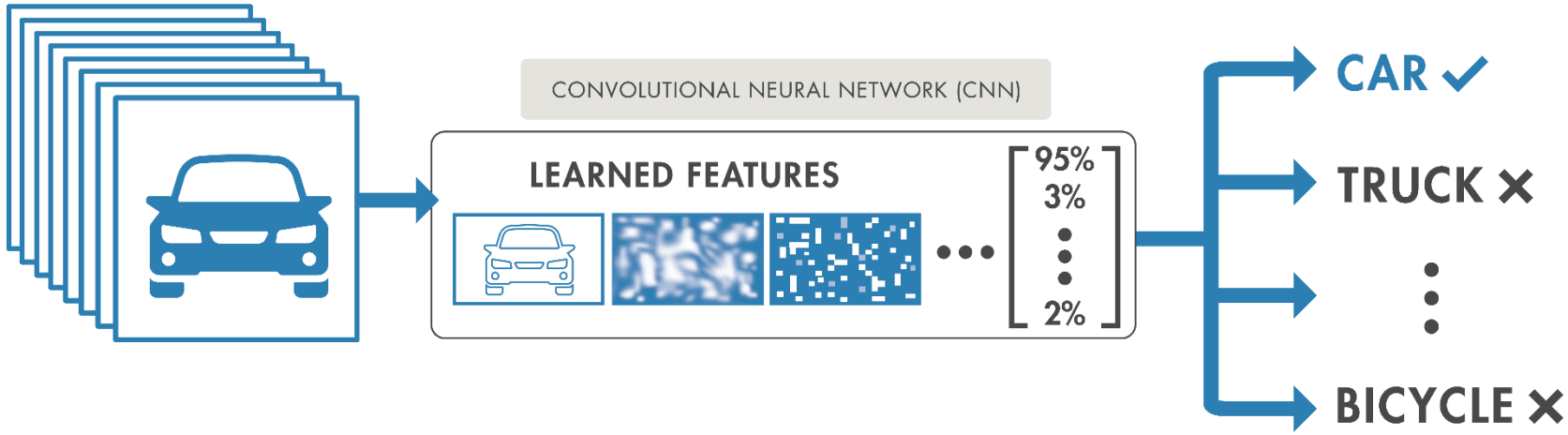
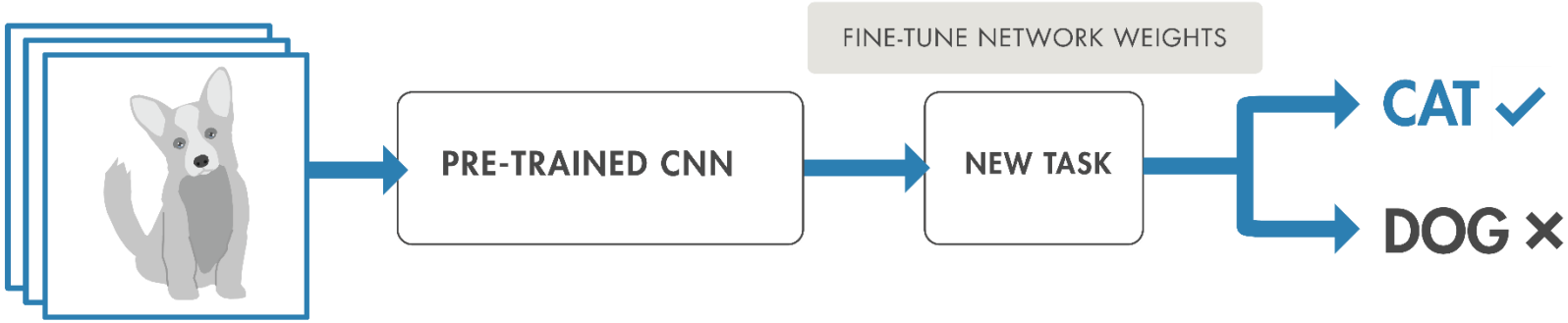
Two Approaches for Deep Learning

1. Train a Deep Neural Network from Scratch

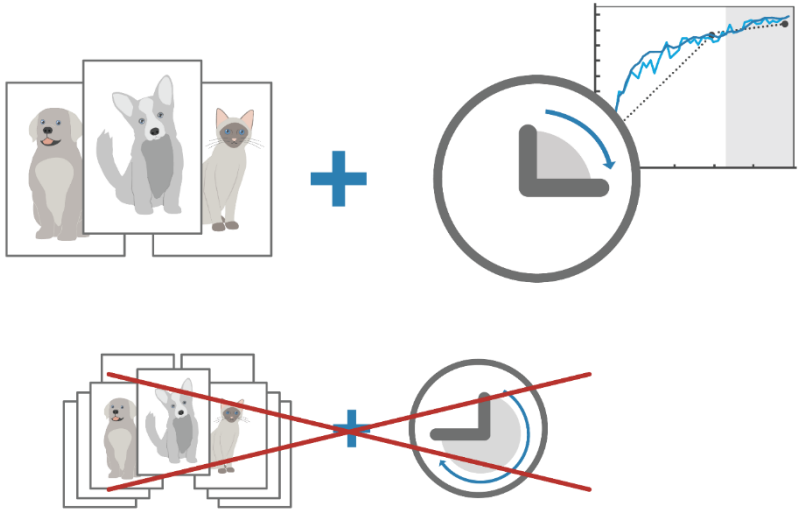


2. Fine-tune a pre-trained model (transfer learning)



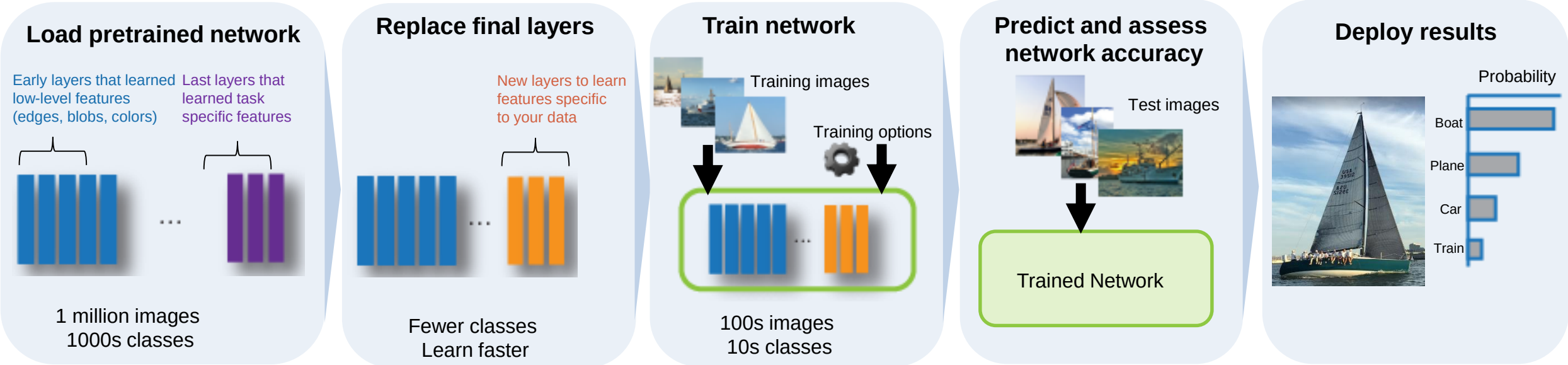
Why Perform Transfer Learning

- Requires less data and training time
- Leverage reference models (like AlexNet, VGG-16, VGG-19, Inception-v3) that are great feature extractors



AlexNet PRETRAINED MODEL	**VGG-16** PRETRAINED MODEL	**ResNet-50** PRETRAINED MODEL	**ResNet-101** PRETRAINED MODEL
Caffe IMPORTER	**GoogLeNet** PRETRAINED MODEL	**TensorFlow-Keras** IMPORTER	**Inception-v3** MODELS

Transfer Learning Workflow



Example: Food classifier using deep transfer learning

Caesar salad →

French fries →

Burgers →

Pizza →

Sushi →

5 Category Classifier

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Using GPU Coder for Deep Learning

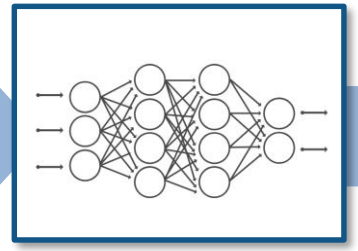
Access Data

Image Acquisition Tbx

Preprocess

Image Processing Tbx

Computer Vision System Tbx

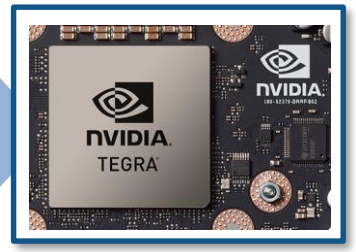


Select Network

Neural Network Tbx

Train

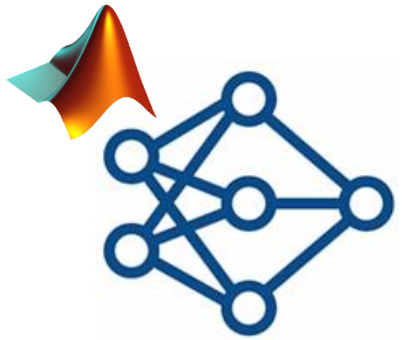
Parallel Computing Tbx



Deploy

GPU Coder

Deploying Deep Learning Models for Inference



Deep Learning Networks

GPU Coder

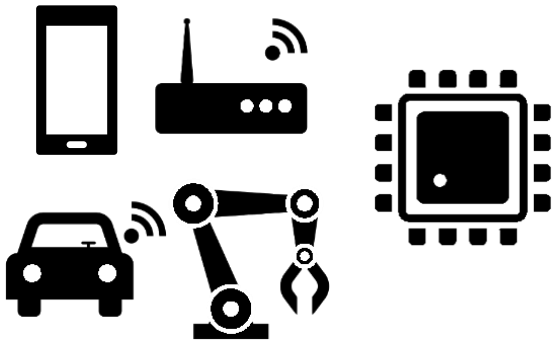
Intel MKL-DNN Library

NVIDIA TensorRT & cuDNN Libraries

ARM Compute Library

Deploying Deep Learning Application

Embedded Hardware

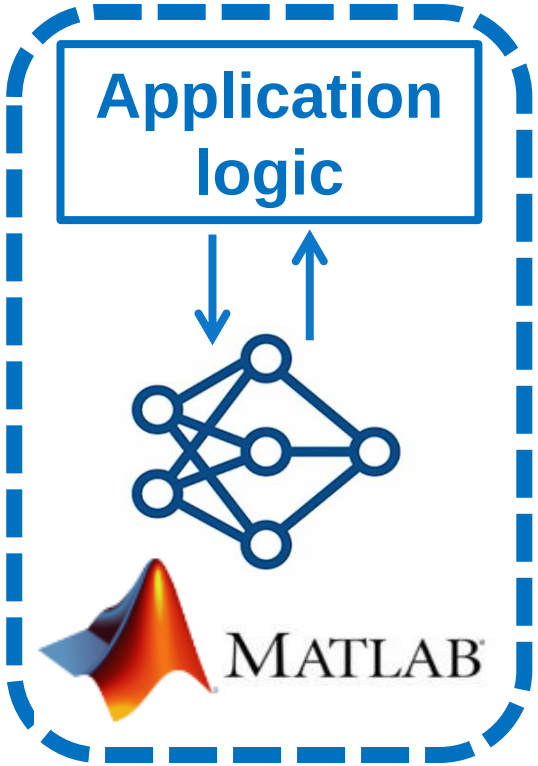


ARM

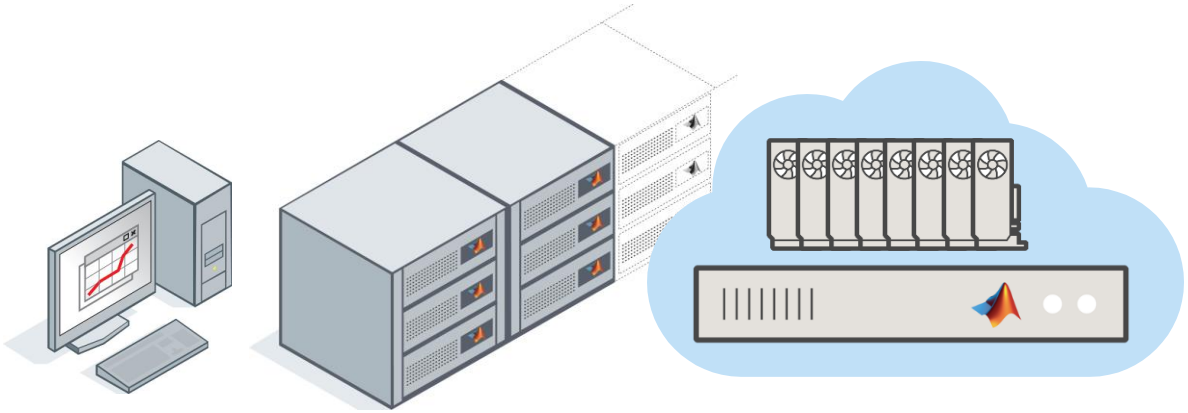
intel

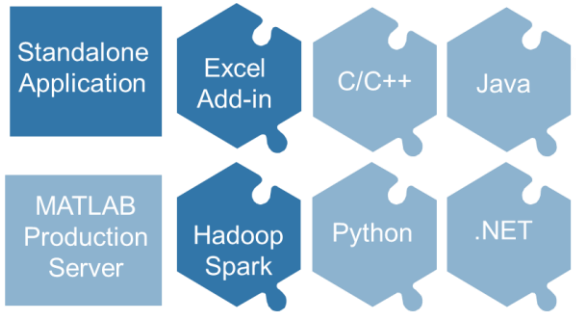
NVIDIA

Code Generation



Desktop, Web, Cloud





Application Deployment

Call to Action – Training resources available!

- Deep Learning Onramp – Introductory Course (open to anyone)
- Machine Learning with MATLAB
- Deep Learning with MATLAB – New online course available to your University

Deep Learning Onramp

Get started quickly using deep learning methods to perform image recognition.

Launch Details

Machine Learning with MATLAB

Explore data and build predictive models.

Launch Details

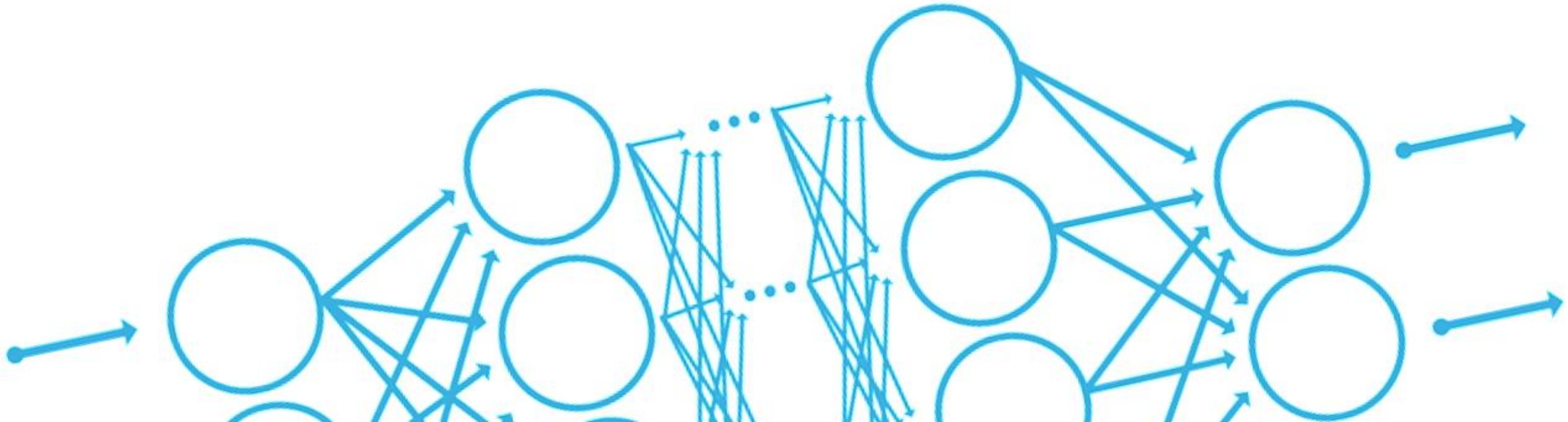
Deep Learning with MATLAB

Learn the theory and practice of building deep neural networks with real-life image and sequence data.

Launch Details

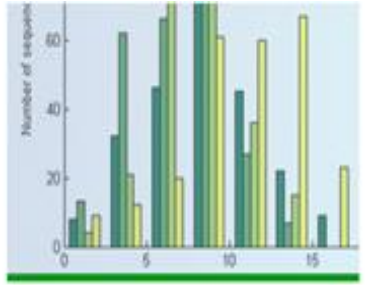
Thank you!

stefano.olivieri@mathworks.com



Material Resources

Tutorials

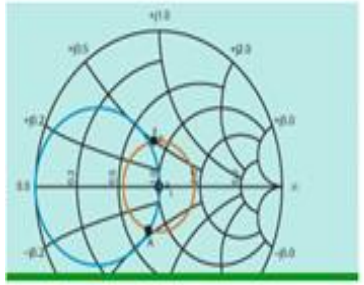

MATLAB and Simulink Examples

Student Competitions

MATLAB Courseware

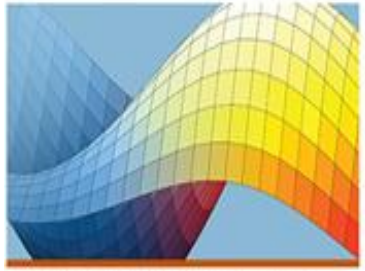
Webinars for Instructors

Hardware for Project-Based Learning


Getting Started

Hardware Projects

Research


Instructor Evaluation Software

License Options

Primary and Secondary Schools

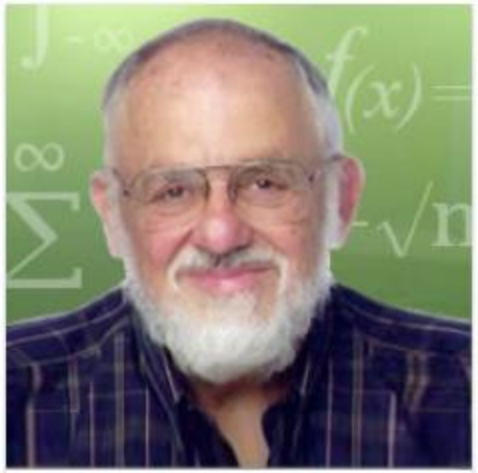
http://www.mathworks.com/academia

MATLAB Central – A community for MATLAB users

Get answers to your MATLAB and Simulink questions

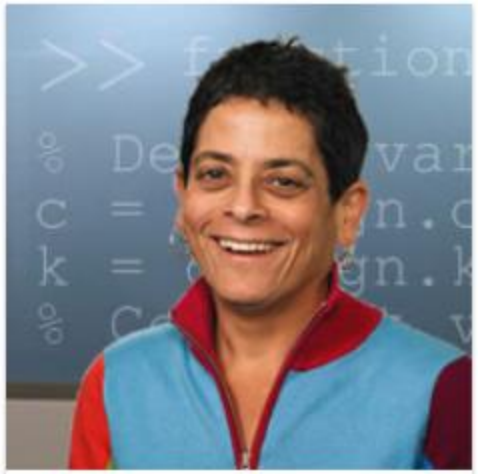
168,737
Questions answered

Get the inside view on MATLAB & Simulink!



Cleve's Corner: Cleve Moler on Mathematics and Computing

Scientific computing, math & more



Loren on the Art of MATLAB

Turn ideas into MATLAB

Guy on Simulink

Simulink & Model-Based Design

File Exchange

Browse

- Functions
- Apps
- Examples
- Simulink Models
- Videos

Contact Support

Create Service Request

Documentaton & Support

Support Doc Ideas Community

Support is for every(-one & -thing)!

Support

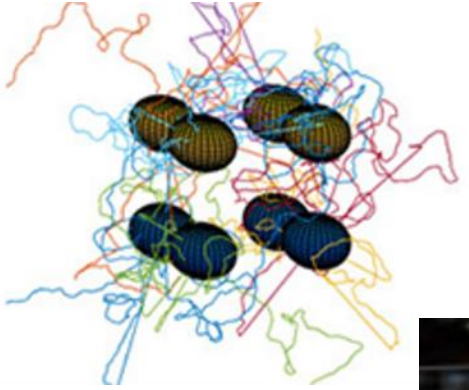
Release Notes

Academia Website

Courseware

Teaching Videos

Student Competitions Support



Corporate Sponsored Competitions

- Aerospace
- Data Science
- Automotive
- Programming and Math
- Biotech and Medical
- Robotics
- Finance
- Signal Processing

… and individual teams

Link

Engineering System Design Workflow

Technical Concept

Mathematical Models

Design Task

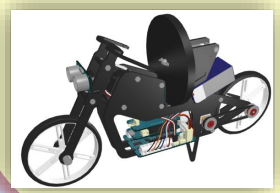
Theoretical Design

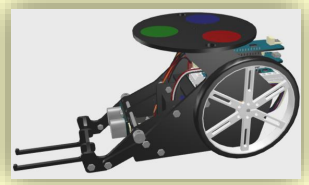
Design With Simulation

Link Theory to practice

Reinforcement Learning

Physical prototype

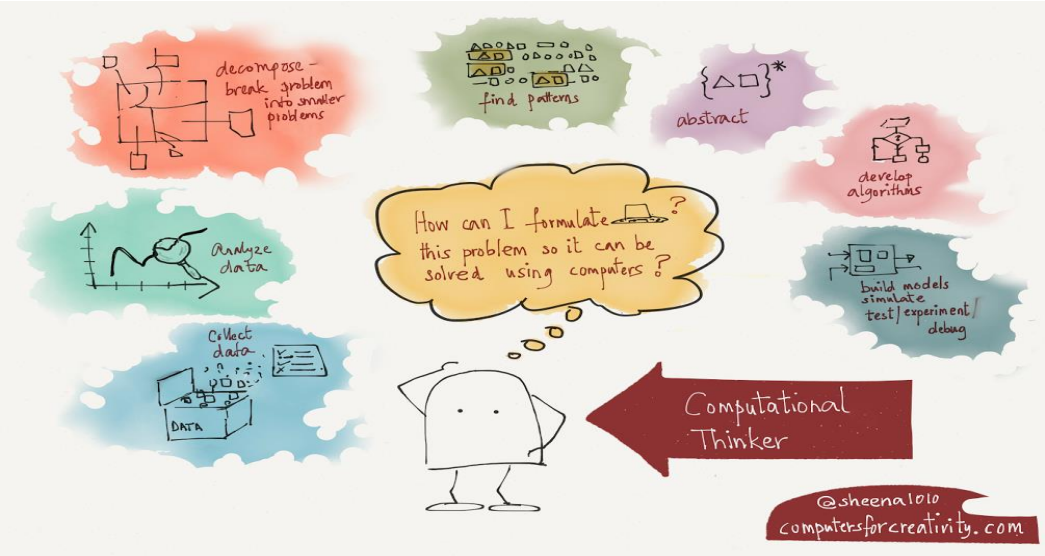




Computational tools

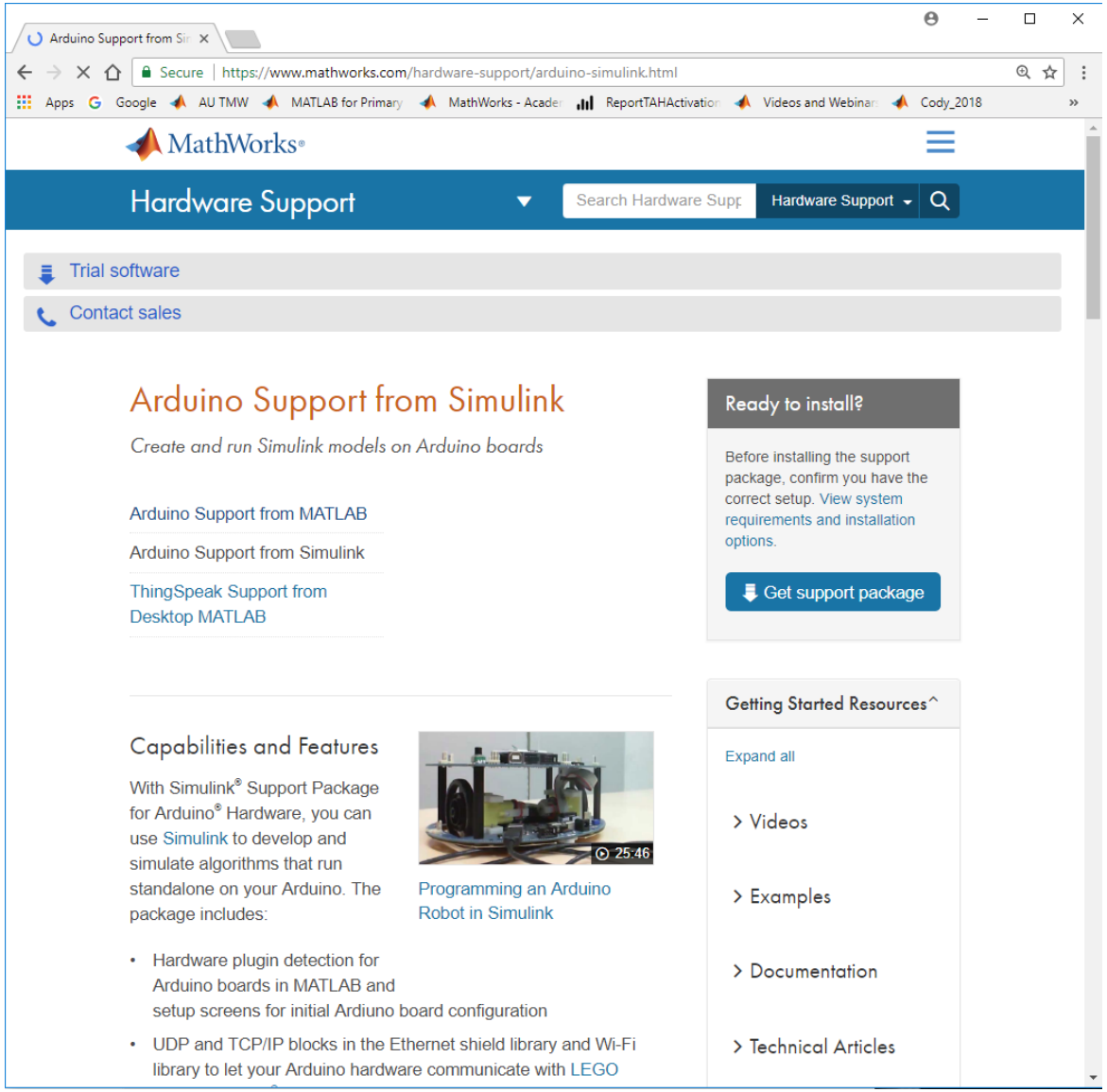
How can computation tools help with engineering system design?

- **Express and develop the equations** to describe phenomena
- **Solve equations** analytically or numerically
- **Iteratively run simulations** to refine the system model
- **Validate the solution** by implementing simulated model on **HW prototypes**



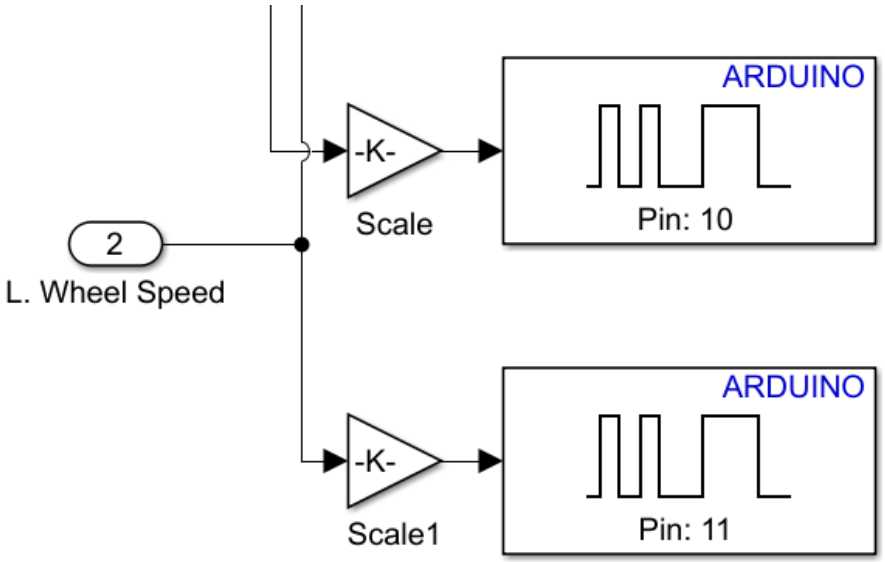
Arduino Support from Simulink

https://www.mathworks.com/hardware-support/arduino-simulink.html



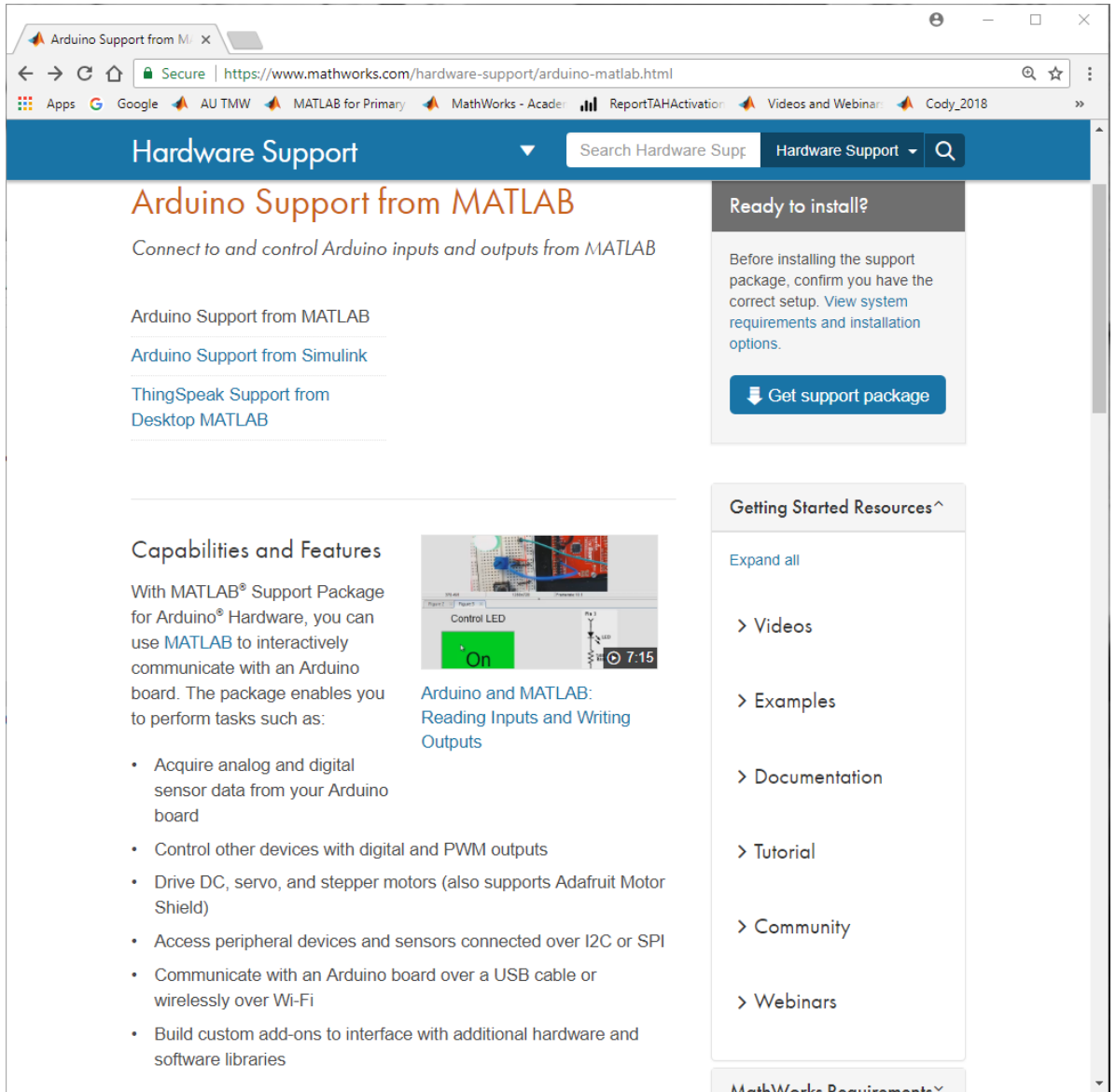
Since R2013a

- Simulink Support Package for Arduino
  - use Simulink to develop and simulate algorithms that run standalone on your Arduino



Arduino Support from MATLAB

https://www.mathworks.com/hardware-support/arduino-matlab.html



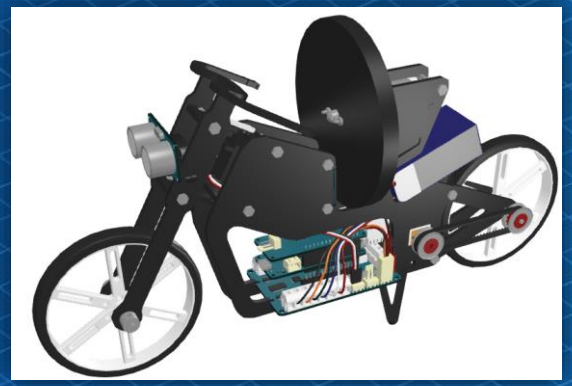
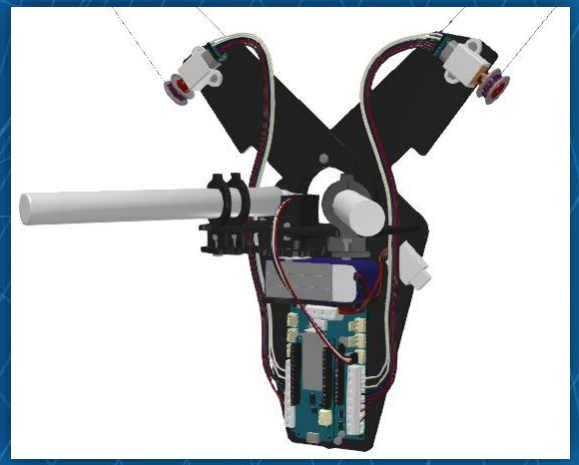
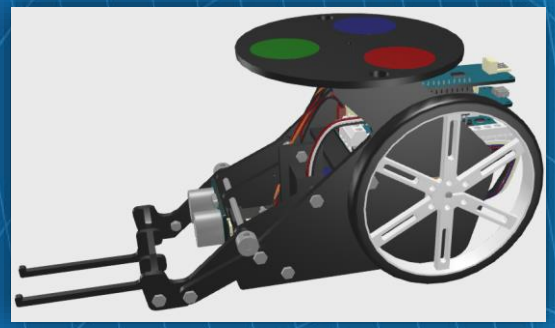
Since R2014a

- MATLAB Support Package for Arduino
  - use MATLAB to interactively communicate with an Arduino board

```
a = arduino('COM4', 'Uno', 'Libraries', 'Servo');

s = servo(a, 'D4', 'MinPulseDuration', 700*10^-6, ...
             'MaxPulseDuration', 2300*10^-6 );

for angle = 0:0.2:1
    writePosition(s, angle);
    current_pos = readPosition(s);
    current_pos = current_pos*180;
    fprintf('Current motor position is %d degrees\n', current_pos);
    pause(2);
end

clear s a
```

Arduino Engineering Kit