Software in everything
Algorithms in everything … in Engineering and Science
Using MATLAB & Simulink to Build Algorithms in Everything

Simplifying your work...

...often at higher levels of abstraction.
Using MATLAB & Simulink to Build Algorithms in Everything

Inputs → Design → Outputs

MATLAB & Simulink®
Artificial Intelligence

The capability of a machine to match or exceed intelligent human behavior by training a machine to learn the desired behavior
There are two ways to get a computer to do what you want

Traditional Programming

Data → COMPUTER → Output

Program → COMPUTER → Output
There are two ways to get a computer to do what you want

Machine Learning

Data → COMPUTER → Model → Output
Artificial Intelligence

Data -> Machine Learning -> Deep Learning -> Model
Using MATLAB and Simulink to Build Deep Learning Models

Inputs

Data

Design

Machine Learning

Deep Learning

Outputs

Model

MATLAB & SIMULINK
Using Apps for Ground Truth Labeling
Image and Video Data

Computer Vision Toolbox
Using Apps for Ground Truth Labeling

Signal Data

Signal Processing Toolbox
Using Apps for Ground Truth Labeling
Audio Data
Using Apps for Designing Deep Learning Networks
Scaling Computation for Training Deep Learning
Using Transfer Learning with Pre-trained Models

- VGG-16
- GoogLeNet
- Inception-v3
- DenseNet-201
- Xception
- NasNetLarge
- AlexNet
- Inception-ResNet-v2
- MobileNet-v2
- NasNetMobile
- VGG-19
- ResNet-50
- ResNet-101
- ResNet-18
- Places365-GoogLeNet
- ShuffleNet
- SqueezeNet

Timeline:
- 2016
- 2017
- 2018
- 2019
Using Models from Other Frameworks

- Keras-Tensorflow
- PyTorch
- Caffe2
- MXNet
- Core ML
- ONNX
- Caffe
- CNTK

MATLAB

Deep Learning Toolbox
Deploying Deep Learning Applications

Pre-processing → Deep Learning Application → Post-processing → Coder Products

Intel MKL-DNN Library
NVIDIA TensorRT & cuDNN Libraries
ARM Compute Library

MATLAB Coder
GPU Coder
Using MATLAB and Simulink for Reinforcement Learning

Data → Machine Learning → Deep Learning → Model

Inputs  Design  Outputs

Reinforcement Learning Toolbox

© 2019 The MathWorks, Inc.
Using MATLAB and Simulink for Reinforcement Learning
Using MATLAB and Simulink for Reinforcement Learning

Data → Machine Learning → Deep Learning → Model

Inputs → Design → Outputs

Reinforcement Learning Toolbox
Using MATLAB and Simulink for Reinforcement Learning

Generate Data

Scenario Design

Simulation-based data generation

Inputs

Machine Learning

Deep Learning

Design

Outputs

Model

Simulink Reinforcement Learning Toolbox
Using MATLAB and Simulink for Reinforcement Learning
Find out more:
Deep Learning e Reinforcement Learning per l’intelligenza artificiale

Giuseppe Ridinò
Traccia A – 13:30
Using MATLAB & Simulink to Build Algorithms in Everything

Inputs → Design → Outputs
## Working with Text Data

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Working with Text Data

```matlab
% Read a file with text data and display the first 20 rows of the 6th column
filename = 'example.txt';
t = readtable(filename, 'TextType', 'string');
disp(t(1:20,6:7))
```

<table>
<thead>
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<th>Reason</th>
<th>Notes</th>
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<td>&quot;04 DRIVER'S REPORT&quot;</td>
<td>&quot;INSTALL SPINNER ASSY&quot;</td>
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<td>&quot;DOG BONE PIN BROKEN&quot;</td>
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<td>&quot;40 NEGLIGENCE&quot;</td>
<td>&quot;HYD CAP CHECK ENGINE LIGHT ON&quot;</td>
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<td>&quot;13 SNOW BREAKDOWN&quot;</td>
<td>&quot;TARP VALVE STICKING RIGHT SIDE MIRROR BRACKET BROKEN&quot;</td>
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<td>&quot;HANDLES IN CAB LOOSE&quot;</td>
</tr>
<tr>
<td>&quot;10 ROADCALL&quot;</td>
<td>&quot;NO PLOW LIGHTS&quot;</td>
</tr>
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</tr>
</tbody>
</table>
Working with Text Data

Deep Learning Toolbox
Statistics and Machine Learning Toolbox
Text Analytics Toolbox
MATLAB
Working with Text Data

Nouns

Adjectives

Nouns

Adjectives
Creating Your Own Data
Identifying the Useful Data

1. Acquire Data
2. Preprocess Data
3. Identify Condition Indicators
4. Train Model
5. Deploy & Integrate

- Visualize data
- Extract Features
- Select the most useful features

Machine Learning
Identifying the Useful Data
Identifying the Useful Data

Signal Features
- Generate statistics from signals

Rotating Machinery Features
- Generate features from rotating machinery signals

Nonlinear Features
- Generate nonlinear features from signals

Spectral Features
- Spectral peaks
- Peak amplitude
- Peak frequency
- Peak value lower threshold
- Number of peaks
- Minimum frequency gap
- Peak excursion tolerance

Computation mode: use full signal

Modal coefficients
- Band power

Predictive Maintenance Toolbox
Identifying the Useful Data
Find out more:
Manutenzione Predittiva con MATLAB

Francesco Alderisio
Traccia A – 14:30

Data Science e Predictive Analytics

Francesco Alderisio
Postazione Demo
Designing Decision Logic with Stateflow

```matlab
inNormalRegion = true;
counter = 0;
for i=1:length(inData)
    if(inNormalRegion)
        if(inData(i)<t1)
            counter = counter+1;
            if(counter>=N1)
                inNormalRegion = false;
        end
        else
            counter = 0;
        end
    else
        if(inData(i)>=t2)
            counter = counter+1;
            if(counter>=N2)
                inNormalRegion = true;
        end
        else
            counter = 0;
        end
    end
    if(inNormalRegion)
        outData(i) = inData(i);
    else
        outData(i) = 0;
    end
end
```

Diagram:
- Normal: \([\text{count}(u<t1)\geq N1]\)
  - \(y = u\)

- Abnormal: \([\text{count}(u\geq t2)\geq N2]\)
  - \(y = 0\)
Using Stateflow in MATLAB
Editing at the Speed of Thought
Editing at the Speed of Thought
Editing at the Speed of Thought
Editing at the Speed of Thought
Controlling the Execution of Model Components

Schedulable Rate-Based Model

Export Function Model
Controlling the Execution of Model Components
Simplifying Integration with External C/C++ Code

Column-Major
Simplifying Integration with External C/C++ Code

```
#include "rtwdemo_row_lutcol2row_workflow_rowrow.h"

/* Block parameters (default storage) */
P rtP = {
    /* Variable: Tbl_1 */
    "Root/2-D Lookup Table"
};

{ 1.0, 11.0, 21.0, 31.0, 41.0, 51.0, 6.0, 12.0, 22.0, 32.0, 42.0, 52.0, 6.0, 13.0, 23.0, 33.0, 43.0, 53.0, 6.0, 14.0, 24.0, 34.0, 44.0, 54.0, 6.0, 15.0, 25.0, 35.0, 45.0, 55.0, 6.0, 16.0, 26.0, 36.0, 46.0, 56.0, 6.0, 17.0, 27.0, 37.0, 47.0, 57.0, 6.0, 18.0, 28.0, 38.0, 48.0, 58.0, 6.0, 19.0, 29.0, 39.0, 49.0, 59.0, 6.0, 20.0, 30.0, 40.0, 50.0, 60.0 };
```
Viewing Generated Code Alongside the Model
Viewing Generated Code Alongside the Model
Estimating Sunrise and Sunset

Using the latitude ($\phi$), the sun's declination ($\delta$) and the solar time correction ($SC$) we can calculate sunrise and sunset times.

\[
\text{sunset} = 12 + \frac{\cos^{-1}(-\tan \phi \tan \delta)}{15^\circ} \quad \text{sunset} = 12 + \frac{\cos^{-1}(-\tan \phi \tan \delta)}{60}
\]

Refer to this page for background and details on the equations used.
Sharing Live Scripts

MATLAB

Exploring Exoplanets

In this example we will explore some data on exoplanets - planets outside our own solar system. The data used here is a subset of data from the NASA Exoplanet Archive. We will start by using the data to answer some questions about the set of exoplanets in the archive. Then we will do some calculations to try to identify planets in the archive that might be capable of supporting life.

```matlab
exoplanets = readtable('exoplanets.xlsx');
exoplanets(st_distance);
```

How Far Away Are these Planets?

There are 90 exoplanets within 50 light-years of earth and 460 exoplanets within 200 light-years.

```matlab
histogram3(st_distance, [min(st_distance) max(st_distance)], 50)
xlabel('st_distance')
ylabel('Number of Planets')
xlabel('Light Years From Earth')
```

Where is the nearest exoplanet?

```matlab
idex = find(st_distance == min(st_distance));
name = char(exoplanets.idex, st_name))
```
Sharing Live Scripts
Creating Apps

![Plate Browser and Summary Tables]

**Microplate Plot**

- **Plate Browser**
  - Select Files
  - Current File: microtiter_data0001.csv

- **Summary Tables**
  - File | Compound Nr | NegControl | Conc1 | Conc2 | Conc3 | Conc4 | Conc5 | Conc6 | Conc7 | Conc8
  - microtiter_data0001 1 | -0.9741 | 0.3564 | 9.8735 | 58.8743 | 91.7323 | 96.7084 | 97.1532 | 57.1910 | 97.1940
  - microtiter_data0001 2 | -0.0143 | -0.5044 | -0.5044 | -0.5044 | -0.5044 | -0.5044 | -0.5044 | -0.5044 | -0.5044 | 17.0436
  - microtiter_data0001 3 | 0.0054 | -0.4702 | 3.1998 | 52.9998 | 97.5746 | 100.5606 | 100.6086 | 100.6086 | 100.6086
  - microtiter_data0001 4 | 0.1096 | 0.2325 | 0.2335 | 0.3712 | 3.2339 | 4.1160 | 94.7343 | 100.6501 | 100.9487
  - microtiter_data0001 5 | -0.0572 | -0.7461 | 1.7104 | 26.8872 | 84.5134 | 96.2335 | 100.4717 | 100.5601 | 100.5700

**EC50 Curves**

- % Signal vs Log [Compound]

- Previous File | Next File | Clear selection
Deploying Web Apps

MATLAB Web Apps

Transient Heat Conduction

Initial and Boundary Conditions
- Initial T (°C): 10
- Top T (°C): 0
- Bottom T (°C): 50
- Left T (°C): 25
- Right T (°C): 25

Geometry
- x (m): 0.05
- y (m): 0.05
- dx (m): 0.0025
- dy (m): 0.0025

Note: Numerical stability requires F.<
Current Po = 0.0005

Thermal Diffusivity
- Alpha (m²/s): 1e-4

Material:
- Copper
- Water

Time and Convergence
- df (s): 0.01
- Total Time (s): 50
- Convergence Criterion: 1e-4

Graphs showing temperature distribution over time and space.
Using MATLAB & Simulink to Build Algorithms in Everything

Inputs → Design → Outputs

MATLAB & SIMULINK®
Evaluating Architectures

Architecture

Inputs

Design

Outputs

MATLAB & SIMULINK®
Evaluating Architectures

Inputs → Architecture → Design → Outputs

MATLAB® & SIMULINK®
Designing System and Software Architectures

System Composer
Designing System and Software Architectures
Find out more: Ingegneria dei sistemi: dai requisiti all’architettura alla simulazione

Vincenzo Petrella
Traccia B – 14:30
Designing **Beyond** System and Software Architectures

Systems and Software

SoC Hardware and Software

AUTOSAR Software

System Composer

SoC Blockset

AUTOSAR Blockset
Using MATLAB & Simulink to Build Algorithms in Everything
Using MATLAB & Simulink to Build Algorithms in Everything
Integrating with Third-party Requirements Tools

External Requirements
- .doc
- .xls
- Database

Requirements Management Tools

Simulink Requirements
- External Requirements
- Authored Requirements

R2019a
- Import
- Edit
- Export

ReqIF
Include Custom Code in Test & Verification

Simulink

C/C++

Simulink Design Verifier

Stateflow

C/C++

Simulink Design Verifier

Test & Verification
Include Custom Code in Test & Verification

Find out more:
Master Class:
Sviluppo di un sistema di gestione delle batterie con Simulink

Traccia B - 15:30
Maurizio Dalbard – Aldo Caraceto

Sviluppo Model-Based Design applicato ad un sistema di gestione delle batterie

Postazione Demo
Maurizio Dalbard – Vincenzo Petrella
Find out more:
Sviluppare controlli digitali per convertitori elettronici di potenza
Traccia B - 13:30
Aldo Caraceto

Industry 4.0: simulazione dinamica closed-loop e test virtuale
Postazione Demo
Aldo Caraceto
Using the MATLAB Unit Test Framework

```matlab
>> result.table
ans =
    2×6 table
    Name                   Passed Failed       Incomplete    Duration    Details
    ____________________    _______    _______    _______    _______    _______
    'test_Predictions/Test_ModelType'    true    false    false    0.12241    [1×1 struct]
    'test_Predictions/Test_Prediction'    false    true    true     0.11542    [1×1 struct]
```
Using the MATLAB App Testing Framework

testCase.press(myApp.checkbox)

testCase.choose(myApp.discreteKnob, "Medium")

testCase.drag(myApp.continuousKnob, 10, 90)

testCase.type(myApp.editfield, myTextVar)
Using the MATLAB Performance Testing Framework
Using Continuous Integration

Plugins Index
Discover the 1000+ community contributed Jenkins plugins to support building, deploying and automating any project.

Browse categories
- Platforms
- User interface
- Administration
- Source code management

New Plugins
- ORebel
- MATLAB
- MISRA Compliance Report
- Zoom
- VectorCAST Execution
- Klocwork Community
- jQuery
- Analysis Model API

MATLAB
https://plugins.jenkins.io/
Using Continuous Integration

MATLAB

Minimum Jenkins requirement: 2.7.3
ID: matlab

Install: No usage data available
GitHub → Last released: 2 days ago

Maintainers
MathWorks

Dependencies
	bouncycastle API v.2.16.0 (implies) (what's this?)
	Command Agent Launcher v.1.0 (implies) (what's this?)
	JDK Tool v.1.0 (implies) (what's this?)
	JAXB v.2.3.0 (implies) (what's this?)

The Jenkins plugin for MATLAB® enables you to easily run your MATLAB tests and generate test artifacts in formats such as JUnit, TAP, and Cobertura code coverage reports.

Features
- Support to run MATLAB tests, present in the Jenkins workspace automatically. (This also includes the tests present in .prj files)
- Generate tests artifacts in JUnit, TAP & Cobertura code coverage formats.
- Support to run tests, using custom MATLAB command or custom MATLAB script file.
Using Projects in MATLAB

<table>
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<th>Name</th>
<th>Status</th>
<th>Git</th>
<th>Classification</th>
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Using Projects in MATLAB

Find out more:
Master Class: Sviluppo software con MATLAB

Traccia A – 15:30
Francesco Alderisio - Giuseppe Ridinò
Parallel Simulations in Simulink

Simulation Manager

MATLAB Desktop

batchsim

Simulation Jobs

Simulation Results

Worker

Worker

Worker

Head Worker

Simulink
Parallel Computing Toolbox
Scaling Computations on Clusters and Clouds

MATLAB

Parallel Computing Toolbox

MATLAB Parallel Server

Cloud

GPU

Multi-core CPU
Using MATLAB & Simulink to Build Algorithms in Everything

Inputs → Architecture → Design → Outputs

Test & Verification → Collaboration → Scaling
Specialized Tools for Building Algorithms in Everything

Communications

Physical interconnects

Analog Mixed-Signal

5G Toolbox

SerDes Toolbox

Mixed-Signal Blockset
Developing Autonomous Systems
Evaluate Sensor Fusion Architectures
Simulate Path Planning Algorithms
Design Lane-following and Spacing Control Algorithms
Developing Autonomous Systems

- Lidar Processing & Tracking
- HERE HD Maps & OpenDRIVE Roads
- UAV Algorithms

Computer Vision Toolbox
Automated Driving Toolbox
Robotics System Toolbox
Using MATLAB & Simulink to Build Algorithms in Everything

Inputs → Architecture → Design → Outputs

- Test & Verification
- Collaboration
- Scaling
Read the Release Notes

Explore What's New
Get more out of MATLAB and Simulink by downloading the latest release.

Download release now

R2019a at a Glance

Release Highlights

Deep Learning
Develop controllers and decision making systems using reinforcement learning, train deep learning models on NVIDIA DGX and cloud platforms, and apply deep learning to 3-D data.
» Learn more

Automotive
Design and simulate AUTOSAR software, interface with HERE HD maps, and generate energy balance reports.
» Learn more

Systems Engineering
Design and analyze system and software architectures with System Composer.
» Learn more

Projects
Use projects in MATLAB and Simulink to organize, manage, and share your work.
» Learn more
Get Started

MATLAB Onramp
 Quickly learn the essentials of MATLAB.

Simulink Onramp
 Learn to create, edit, and troubleshoot Simulink models.

Deep Learning Onramp
 Learn to use deep learning techniques in MATLAB for image recognition.
## Attend Sessions this Afternoon

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Speaker(s)</th>
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<tbody>
<tr>
<td>12:00</td>
<td>Pranzo, Tech Talks e area espositiva</td>
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<tr>
<td>13:30</td>
<td>Deep Learning e Reinforcement Learning per l’intelligenza artificiale</td>
<td>Giuseppe Ridinò, MathWorks</td>
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<tr>
<td>13:30</td>
<td>Sviluppare controlli digitali per convertitori elettronici di potenza</td>
<td>Aldo Caraceto, MathWorks</td>
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<td>14:00</td>
<td>Dagli script a linguaggio di programmazione: una GUI per la produzione</td>
<td>Marco Basilico, TRE ALTAMIRA</td>
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<td>14:00</td>
<td>Sviluppo di un sistema di sospensioni semiattive mediante Model-Based Design con architettura AUTOSAR e conforme allo standard A-SPICE</td>
<td>Andrea Palazzetti, Magneti Marelli</td>
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<td>14:30</td>
<td>Manutenzione Predittiva con MATLAB</td>
<td>Francesco Alderisio, MathWorks</td>
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<tr>
<td>14:30</td>
<td>Ingegneria dei sistemi: dai requisiti all’architettura alla simulazione</td>
<td>Vincenzo Petrella, MathWorks</td>
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<tr>
<td>15:00</td>
<td>Pausa caffè e area espositiva</td>
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<td>15:30</td>
<td>Master Class: Sviluppo software con MATLAB</td>
<td>Francesco Perino e Giuseppe Ridinò, MathWorks</td>
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<tr>
<td>15:30</td>
<td>Master Class: Sviluppo di un sistema di gestione delle batterie con Simulink</td>
<td>Aldo Caraceto e Maurizio Dalbard, MathWorks</td>
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<td>17:00</td>
<td>Chiusura lavori</td>
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