MATLAB EXPO 2019

What’s New in MATLAB and Simulink

Cynthia Cudicini
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
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
# Using Transfer Learning with Pre-trained Models

<table>
<thead>
<tr>
<th>Model</th>
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Using Models from Other Frameworks

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

MATLAB

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Deep Learning Toolbox
Using MATLAB and Simulink for Reinforcement Learning

Data → Machine Learning [Deep Learning] → Model

Inputs → Design → Outputs
Using MATLAB and Simulink for Reinforcement Learning
Using MATLAB and Simulink for Reinforcement Learning

Inputs

Data

Machine Learning

Deep Learning

Design

Outputs

Model

Reinforcement Learning Toolbox
Using MATLAB and Simulink for Reinforcement Learning

**Generate Data**
- Scenario Design
- Simulation-based data generation

**Inputs**

**Design**
- Machine Learning
- Deep Learning

**Outputs**

**Model**

Simulink Reinforcement Learning Toolbox
Using MATLAB and Simulink for Reinforcement Learning
Using MATLAB & Simulink to Build Algorithms in Everything

Inputs → Design → Outputs

MATLAB & SIMULINK®
### Working with Text Data

#### Example CSV Data

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</tbody>
</table>

Note: The data includes various service requests and notes, indicating the date, time, ID, job number, vehicle ID, unit number, reason for service, notes, and costs related to parts, labor, and total costs.
t = readtable(filename,'TextType','string');
disp(t(1:20,6:7))

<table>
<thead>
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<th>Reason</th>
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<td>&quot;SERVICERO8,EXT,5604&quot;</td>
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<td>&quot;04 DRIVER'S REPORT&quot;</td>
<td>&quot;NEED 4 PLOW PINS&quot;</td>
</tr>
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<td>&quot;04 DRIVER'S REPORT&quot;</td>
<td>&quot;INSTALL SPINNER ASSY&quot;</td>
</tr>
<tr>
<td>&quot;13 SNOW BREAKDOWN&quot;</td>
<td>&quot;DONT START&quot;</td>
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<tr>
<td>&quot;04 DRIVER'S REPORT&quot;</td>
<td>&quot;DOG BONE PIN BROKEN&quot;</td>
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<tr>
<td>&quot;08 PM SERVICE</td>
<td>&quot;NEED SERVICE, CHECK BRAKES&quot;</td>
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<td>&quot;04 DRIVER'S REPORT&quot;</td>
<td>&quot;HYD CAP CHECK ENGINE LIGHT ON&quot;</td>
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<td>&quot;10 NEGLIGENCE&quot;</td>
<td>&quot;TARP VALVE STICKINGRIGHT SIDE MIRROR BRACKET BROKEN&quot;</td>
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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

- Acquire Data
- Preprocess Data
- Identify Condition Indicators
  - Visualize data
  - Extract Features
  - Select the most useful features
- Train Model
- Machine Learning
- Deploy & Integrate
Identifying the Useful Data
Identifying the Useful Data

Predictive Maintenance Toolbox

- 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: use full signal
  - Peak amplitude
  - Peak frequency
  - Peak value lower threshold: \(-\infty\)
  - Number of peaks: 1
  - Minimum frequency gap: 0.001
  - Peak excursion tolerance: 0

- Band power

Condition variables: faultCode
Identifying the Useful Data

Predictive Maintenance Toolbox

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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: \[ y = u \]
- Abnormal: \[ y = 0 \]

Transition:
- \[ \text{count}(u < t1) \geq N1 \]
- \[ \text{count}(u \geq t2) \geq N2 \]
Using Stateflow in MATLAB

% Callbacks that handle component events
methods (Access = private)

% Code that executes after component creation
function startupFcn(app)
    app.lanternlogic = blink.lanternlogic('app',app);
end

% Button pushed function: POWERButton
function POWERButtonPushed(app, event)
    app.lanternlogic.powerButton();
end

% Button pushed function: COLORButton
function COLORButtonPushed(app, event)
    app.lanternlogic.colorButton();
end

% Close request function: UIFigure
function UIFigureCloseRequest(app, event)
    delete(app.lanternlogic);
    delete(app);
end

% Button pushed function: BLINKButton
function BLINKButtonPushed(app, event)
    app.lanternlogic.blinkButton();
end
Editing at the Speed of Thought
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
Simplifying Integration with External C/C++ Code

Row-Major

```
#include "rtwdemo_rowlutcol2row_workflow_rowrow.h"

/* Block parameters (default storage) */
Dp->P = {
    /* Variable: tbl_1 */
    /* Referenced by: 'Root1/2-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, 3.0, 13.0, 23.0, 33.0, 43.0, 53.0, 6.0, 4.0, 14.0, 24.0, 34.0, 44.0, 54.0, 6.0, 5.0, 15.0, 25.0, 35.0, 45.0, 55.0, 6.0, 6.0, 16.0, 26.0, 36.0, 46.0, 56.0, 6.0, 7.0, 17.0, 27.0, 37.0, 47.0, 57.0, 6.0, 8.0, 18.0, 28.0, 38.0, 48.0, 58.0, 6.0, 9.0, 19.0, 29.0, 39.0, 49.0, 59.0, 6.0, 10.0, 20.0, 30.0, 40.0, 50.0, 60.0 }
};
```
Viewing Generated Code Alongside the Model
Viewing Generated Code Alongside the Model
Sharing Live Scripts

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.

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

$$\text{sunrise} = 12 - \frac{\cos^{-1}(-\tan \phi \tan \delta)}{15^\circ} - \frac{SC}{60}$$

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

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
histogram(exoplanets(st_distance), 'BinWidth', 50);
xlabel('Number of Planets');
ylabel('Light Years From Earth');
```

Where is the nearest exoplanet?

```matlab
idx = find(exoplanets(st_distance) == min(exoplanets(st_distance)));
name = char(exoplanets(idx, st_name));
```
Sharing Live Scripts

![Image of Live Editor with Live Script]

- P: 1:40
- Slider: 350
- Drop down: "carbon dioxide"

Graph: Carbon dioxide @ 350 Kelvin
Creating Apps

Plate Browser Summary Tables

Select Files Current File: microtiter_data0001.csv

Microplate Plot

EC50 Curves

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</tr>
<tr>
<td>microtiter_d...</td>
<td>4</td>
<td>0.1096</td>
<td>0.2325</td>
<td>0.2385</td>
<td>0.3712</td>
<td>3.2339</td>
<td>41.1660</td>
<td>94.7343</td>
<td>100.6591</td>
<td>100.9487</td>
</tr>
<tr>
<td>microtiter_d...</td>
<td>5</td>
<td>-0.0572</td>
<td>0.7481</td>
<td>1.7104</td>
<td>26.8872</td>
<td>84.5134</td>
<td>96.2395</td>
<td>100.4717</td>
<td>100.5601</td>
<td>100.5700</td>
</tr>
</tbody>
</table>
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_p = 0.0003

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

Time and Convergence
- df (s): 0.91
- Total Time (s): 50
- Convergence Criterion: 1e-4

Time - 35 s

MATLAB Compiler

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Using MATLAB & Simulink to Build Algorithms in Everything
Evaluating Architectures

Inputs → Architecture → Design → Outputs

MATLAB & SIMULINK

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Evaluating Architectures
Designing System and Software Architectures
Designing System and Software Architectures
Designing **Beyond** System and Software Architectures

- **Systems and Software**
  - System Composer

- **SoC Hardware and Software**
  - SoC Blockset

- **AUTOSAR Software**
  - 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

Simulink Requirements
- External Requirements
- Authored Requirements

ReqIF

R2019a

Import
Edit
Export
Include Custom Code in Test & Verification

Simulink

Stateflow

C/C++

Simulink Design Verifier

Simulink Design Verifier

C/C++

- ×

- ✔
Using the MATLAB Unit Test Framework

```matlab
>> result.table
ans =
    2x6 table

<table>
<thead>
<tr>
<th>Name</th>
<th>Passed</th>
<th>Failed</th>
<th>Incomplete</th>
<th>Duration</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>'test_Predictions/Test_ModelType'</td>
<td>true</td>
<td>false</td>
<td>false</td>
<td>0.12241</td>
<td>[1×1 struct]</td>
</tr>
<tr>
<td>'test_Predictions/Test_Prediction'</td>
<td>false</td>
<td>true</td>
<td>true</td>
<td>0.11542</td>
<td>[1×1 struct]</td>
</tr>
</tbody>
</table>
```
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

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

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

![MATLAB Project Explorer](image)

- **Name**: 
  - +Test
  - ACI
  - Dashboard
  - Documents
  - Elasticsearch
  - MachineLearning
  - MATLAB_KafkaProducer_Java
  - mps_stream
  - SimExecutable
  - Simulation
  - DocExample_MultiClassFaultDetectionUsing...
  - genPumpData.m
  - javasetup.m
  - Main_ExampleWorkflow.mlx
  - MLModels.mat
  - rawdata.mat
  - README.md

- **Status**: 
  - ✔️
  - ✔️
  - ✔️
  - ✔️
  - ✔️
  - ✔️
  - ✔️
  - ✔️
  - ✔️
  - ✔️

- **Git**
  - ✔️
  - ✔️
  - ✔️
  - ✔️
  - ✔️
  - ✔️
  - ✔️
  - ✔️

- **Classification**
  - Test
  - Design
  - Design
  - Design
  - Design
  - Design
  - Design

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Parallel Simulations in Simulink

Simulation Manager

MATLAB Desktop

Simulation Jobs

Simulation Results

Worker

Worker

Worker

Head Worker

batchsim

Simulink
Parallel Computing Toolbox
Scaling Computations on Clusters and Clouds

MATLAB

Parallel Computing Toolbox

MATLAB Parallel Server

Cloud

GPU

Multi-core CPU

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Using MATLAB & Simulink to Build Algorithms in Everything

Inputs → Architecture → Design → Outputs

Test & Verification → Collaboration → Scaling

MATLAB & SIMULINK

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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
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.