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
Using MATLAB & Simulink to Build Machine Learning Models
Using Apps for Ground Truth Labeling
Image and Video Data
Using Apps for Ground Truth Labeling
Signal Data
Using Apps for Ground Truth Labeling
Audio Data
Identifying the Useful Data
Identifying the Useful Data

Predictive Maintenance Toolbox
Identifying the Useful Data
Using Apps for Designing Deep Learning Networks
Using Transfer Learning with Pre-trained Models

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

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

MATLAB

Keras-Tensorflow

Caffe

PyTorch

ONNX

Caffe2

MXNet

Core ML

(...)

Deep Learning Toolbox
Deploying Deep Learning Applications

- Pre-processing
- Post-processing
- Coder Products
- Deep Learning Application
- MATLAB Coder
- GPU Coder
- Intel MKL-DNN Library
- NVIDIA TensorRT & cuDNN Libraries
- ARM Compute Library
Using MATLAB and Simulink for Reinforcement Learning

Inputs -> Data

Machine Learning

Deep Learning

Design

Model

Outputs

Reinforcement Learning Toolbox
Using MATLAB and Simulink for Reinforcement Learning
Find out more:

2:30 PM: Deep Learning and Reinforcement Learning Workflows in A.I.

3:30 PM: AI Techniques in MATLAB for Signal, Time-Series, and Text Data

4:30 PM: Deploying Deep Neural Networks to Embedded GPUs and CPUs
Using MATLAB & Simulink to Build Algorithms in Everything
Working with Data

Business and Transactional Data

Repositories
- Databases (SQL/NoSQL)
- Hadoop

File I/O
- Text
- Spreadsheet

Web Sources
- RESTful/SOAP
- JSON
- HTML/XML
- Mapping
- Financial datafeeds
- FTP

Recent Additions

File I/O
- PDF
- Microsoft Word
- Parquet
- Vector BLF
- STL (Stereolithography)

Web Sources
- Amazon Web Services
- Azure Blob Storage
- Internet of Things (IOT)
  - ThingSpeak

Engineering, Scientific and Field Data

File I/O
- CDF/HDF
- Audio/Image/Video
- Geospatial
- Microarrays
- CAD Models
- MDF

Communication Protocols
- CAN (Controller Area Network)
- DDS (Data Distribution Service)
- OPC (OLE for Process Control) (e.g. PI)
- XCP (eXplicit Control Protocol)
- TCP/IP
- Serial/Bluetooth/USB

Real-Time Sources
- Sensors/Instrumentation/Cameras
- GPS
- Communication systems
- Machines (embedded systems)
- Robot Operating System (ROS)

The above list is not all-inclusive, but is intended for guidance only.
Live Editor Tasks

Data Analytics - Load Forecasting Case Study

Load messy data

```
load LE1data.mat
head(ny1so)
```

Missing Data

```
ans = timetable
          Date    CAPITAL   CNT
     05/01/2007    881.0600    1.571
     05/01/2007    891.5600    1.556
     05/01/2007    850.1000    1.564
     05/01/2007    808.9000    1.569
     05/01/2007    868.5000    1.555
     05/01/2007    848.0000    1.554
     05/01/2007    941.0000    1.036
     05/01/2007    838.4000    1.557
```
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
```
Using Stateflow in MATLAB

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

% Code that executes after component creation
function startFcn(app)
    app.lanternlogic = Blink.lantern_logic('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
end
Editing at the Speed of Thought
Editing at the Speed of Thought

- Automatic Port Creation
- Edit on Block Icon
- Block Parameter Autocomplete
- Predictive Quick Insert
Controlling the Execution of Model Components

Schedulable Rate-Based Model

Export Function Model
Controlling the Execution of Model Components
More Ways to Componentize Your Design
Simplifying Blockset Creation and Sharing

- Ideas
- Code Templates
  - Design
  - Build
  - Test
- Simulink Blocks
- Packaged Toolbox
- Organization

Development → Build → Test → Documentation → Publish
Viewing Generated Code Alongside the Model
Sharing Live Scripts

![Live Editor with Compressibility Factor example](image)

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

Carbon dioxide @ 350 Kelvin

Compressibility Factor, Z
Deploying Web Apps

MATLAB Web Apps

Transient Conduction

Initial and Boundary Conditions
- Initial T (C): 10
- Top T (C): 0
- Bottom T (C): 58
- Left T (C): 25
- Right T (C): 26

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 (m^2/s): 1e-4

Material
- Copper, Water

Start
Stop

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

Time vs. Temperature

Time - 35 s

MATLAB Compiler
Using MATLAB & Simulink to Build Algorithms in Everything

Inputs → Design → Outputs
Evaluating Architectures
Designing System and Software Architectures
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

- Inputs
- Architecture
- Design
- Outputs

- Test & Verification
- Collaboration
- Scaling

MATLAB & SIMULINK®
Integrating with Third-party Requirements Tools

External Requirements

- .doc
- .xls
- Database

Requirements Management Tools

Simulink Requirements

- External Requirements
- Authored Requirements

Import
Edit
Export

ReqIF

R2019a

Test & Verification
Include Custom Code in Test & Verification

Simulink to C/C++ to Simulink Design Verifier

Stateflow to C/C++ to Simulink Design Verifier

Test & Verification
Validating Function Arguments

```matlab
% Error check required input arguments
if nargin < 1
    error("rectangle requires width and height values");
elseif ~isnumeric(width) || ~isscalar(width)
    error("width must be a scalar numeric value");
elseif ~isnumeric(height) || ~isscalar(height)
    error("height must be a scalar numeric value");
end

% Process optional inputs xStart and yStart
xStart = 0;
if nargin > 2 && isnumeric(varargin{1}) && isscalar(varargin{1})
    xStart = varargin{1};
end
yStart = 0;
if nargin > 3 && isnumeric(varargin{2}) && isscalar(varargin{2})
    yStart = varargin{2};
end
```

Arguments:
- `width` (1,1) double `{mustBeNumeric}`
- `height` (1,1) double `{mustBeNumeric}`
- `xStart` (1,1) double `{mustBeNumeric} = 0;` % optional
- `yStart` (1,1) double `{mustBeNumeric} = 0;` % optional
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 Projects in MATLAB

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<th>Git</th>
<th>Classification</th>
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Parallel Simulations in Simulink

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

MATLAB & SIMULINK

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Specialized Tools for Building Algorithms in Everything

Physical Interconnects

Find out more:

2:30 PM: Wired Communications Systems Modeling and Analysis.

3:30 PM: Top-Down Modeling and Analysis of Analog Mixed-Signal Systems

4:30 PM: Understanding and Modeling the 5G NR Physical Layer
Developing Autonomous Systems

Perception

Planning

Control
Developing Autonomous Systems

Find out more:

12:00 PM: Design and Test of Automated Driving Algorithms

4:00 PM: Sensor Fusion and Tracking for Autonomous Systems
Using MATLAB & Simulink to Build Algorithms in Everything

Inputs → Architecture → Design → Outputs

- Test & Verification
- Collaboration
- Scaling
### Attend Sessions this Afternoon

<table>
<thead>
<tr>
<th>Time</th>
<th>Track 1: Siskiyou/Donner</th>
<th>Track 2: Sierra</th>
<th>Track 3: San Jose/Santa Clara</th>
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</thead>
<tbody>
<tr>
<td>11:00 a.m.</td>
<td>On the New Generation of Bio-Inspired Robots</td>
<td>Exploring Microsoft Machine Teaching Online Service for Building Autonomous Systems Using Simulink Models</td>
<td>Leveraging MATLAB and Simulink in Building Battery SOH</td>
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<tr>
<td></td>
<td>All Maryamnejad, University of Southern California</td>
<td>Cyril Gluckner, Microsoft Corporation</td>
<td>Matthew Dagle, NIO</td>
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<tr>
<td>11:30 a.m.</td>
<td>Model-Based Hyper Scalable Assessment of Automated Vehicle Functions</td>
<td>Design for AMI - A New Integrated Workflow for Modeling High-Speed PAM4 SetDes Systems</td>
<td>Full Vehicle Simulation for Electrified Powertrain Selector</td>
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<td>Stefano Marzani, Samsung</td>
<td>Jongsik Kim, Intel</td>
<td>Kevin Oshiro, MathWorks</td>
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<tr>
<td>12:00 p.m.</td>
<td>CAEMI Research in Hardware Design and Optimization Using Machine Learning</td>
<td>Verify 5G System Performance Using Xilinx RFSoC and Avnet RFSoC Development Kit</td>
<td>Design and Test of Automated Driving Algorithms</td>
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<td>Chris Cheng, HP Enterprise</td>
<td>Matt Brown, Avnet</td>
<td>Shusen Zhang, MathWorks</td>
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<td>12:30 p.m.</td>
<td>Lunch and Technology Showcase: Bayshore Foyer and Cascade</td>
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<td></td>
<td>Women in Tech Ignite Lunch and Networking: Carmel/Monterrey</td>
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<td>1:30 p.m.</td>
<td>Insights into MATLAB — Memory Handling and Datatypes</td>
<td>RF Design and Test Using MATLAB and NI Tools</td>
<td>Adopting Model-Based Design for FPGA, ASIC, and SoC</td>
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<td>Loren Shure, MathWorks</td>
<td>Tim Reeves, MathWorks and Chen Chang, National Instruments</td>
<td>Robert Anderson, MathWorks</td>
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<td>2:00 p.m.</td>
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<tr>
<td>2:30 p.m.</td>
<td>Deep Learning and Reinforcement Learning Workflows in AI</td>
<td>Wired Communications Systems Modeling and Analysis</td>
<td>Planning Simulink Model Architecture and Modeling Patterns for ISO 26262 Compliance</td>
</tr>
<tr>
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<td>Abhijit Bhattacharjee, MathWorks</td>
<td>Barry Katz, MathWorks</td>
<td>David Hoadley, MathWorks</td>
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<tr>
<td>3:00 p.m.</td>
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<tr>
<td>3:30 p.m.</td>
<td>AI Techniques in MATLAB for Signal, Time-Series, and Test Data</td>
<td>Top-Down Modeling and Analysis of Analog Mixed-Signal Systems</td>
<td>Toolchain Definition and Integration for ISO 26262-Compliant Development</td>
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<td>Bryan Perfetti, MathWorks</td>
<td>Rajesh Berigei, MathWorks</td>
<td>David Hoadley, MathWorks</td>
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<tr>
<td>4:00 p.m.</td>
<td>Sensor Fusion and Tracking for Autonomous Systems</td>
<td>Understanding and Modeling the 5G NR Physical Layer</td>
<td>Developing Battery Management Systems Using Simulink</td>
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<td>Rick Gentle, MathWorks</td>
<td>Marc Barbeins, MathWorks</td>
<td>Chiag Patel, MathWorks</td>
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<tr>
<td>4:30 p.m.</td>
<td>Deploying Deep Neural Networks to Embedded GPUs and CPUs</td>
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<td>Abhijit Bhattacharjee, MathWorks</td>
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<td>5:00 p.m.</td>
<td>Digital Twins for Smart Manufacturing</td>
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</table>
Read the Release Notes

R2019a at a Glance

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

Download release now

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.

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

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

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 simulate Simulink models.

**Stateflow Onramp**
Learn to create, edit, and simulate state machines.

**Deep Learning Onramp**
Learn to use deep learning techniques in MATLAB.
MATLAB EXPO 2019