What's New in MATLAB for Finance Professionals

R2020**a**

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Agenda

Develop as Fast as you Think

Make Sense of your Data

Speak Finance

Think in Models

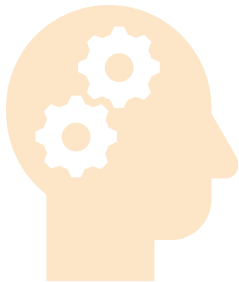Engineer Robust Models

Collaborate and Share

Agenda

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"How can I get from idea to prototype with as little friction as possible?"

The Advantage of Live Editor

- Live scripts are living whitepapers

- Use contextual hints when calling functions

- Automatically generate code when interacting with plots and tables in the output

- Add Live Tasks to interactively explore parameters and options
  - Tasks are lightweight apps that can be included in scripts

Automating Even More of Your Tasks

- New tasks available in R2020a
  - **MATLAB** – for interactively manipulating tables and timetables

  - **Symbolic Math Toolbox** – for solving symbolic equations and simplifying symbolic expressions

  - **Audio Toolbox** – for extracting audio features

With Apps, Think About Your Work Instead of Your Code

- Apps let you use your domain knowledge without getting tripped up by code

- Fully interactive workflows
  - Do your work interactively
  - Generate code as you work
  - Integrate code into production systems

- Apps available for:
  - Machine Learning
  - Econometric Modeling
  - Database Access
  - Many, many more
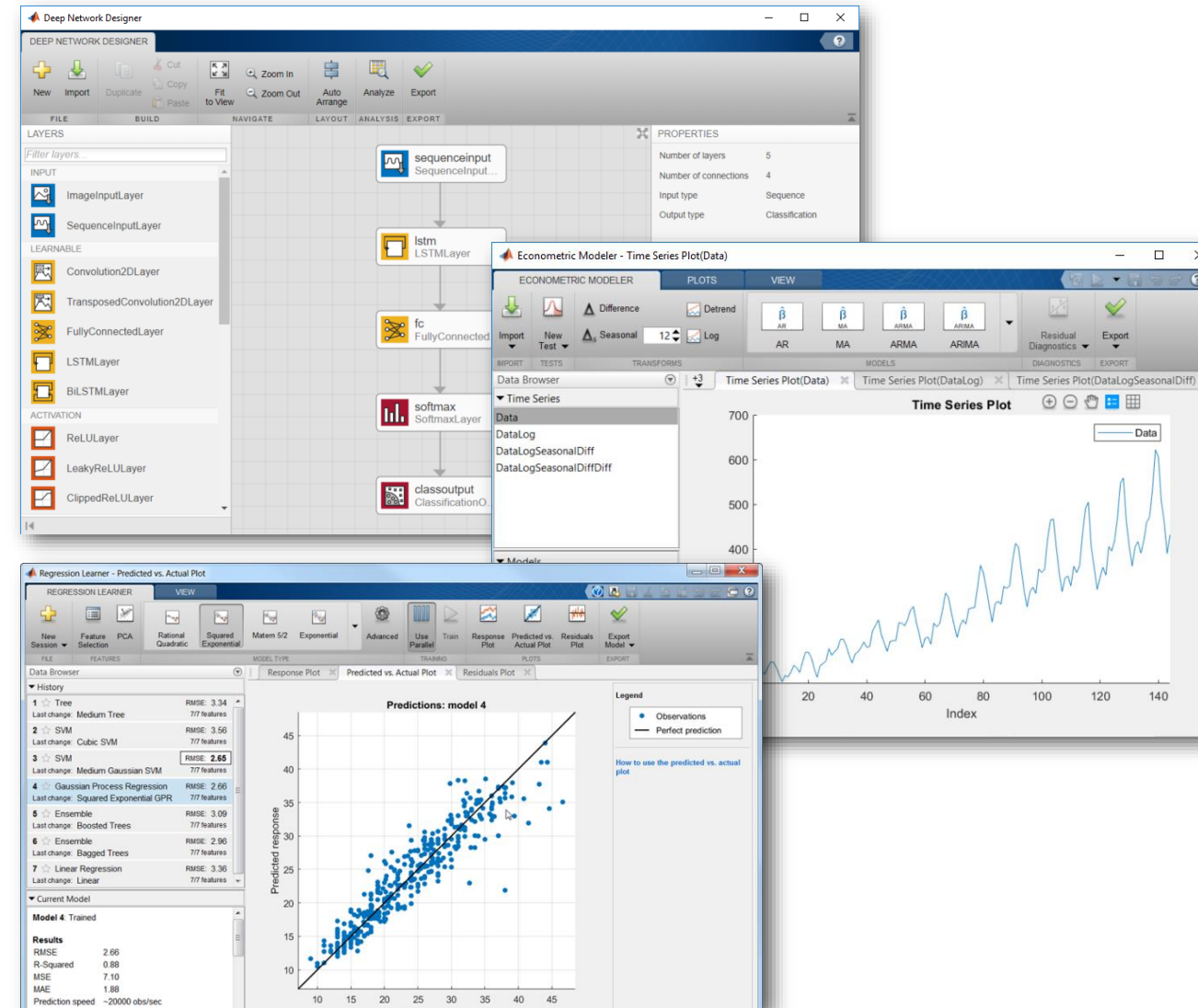
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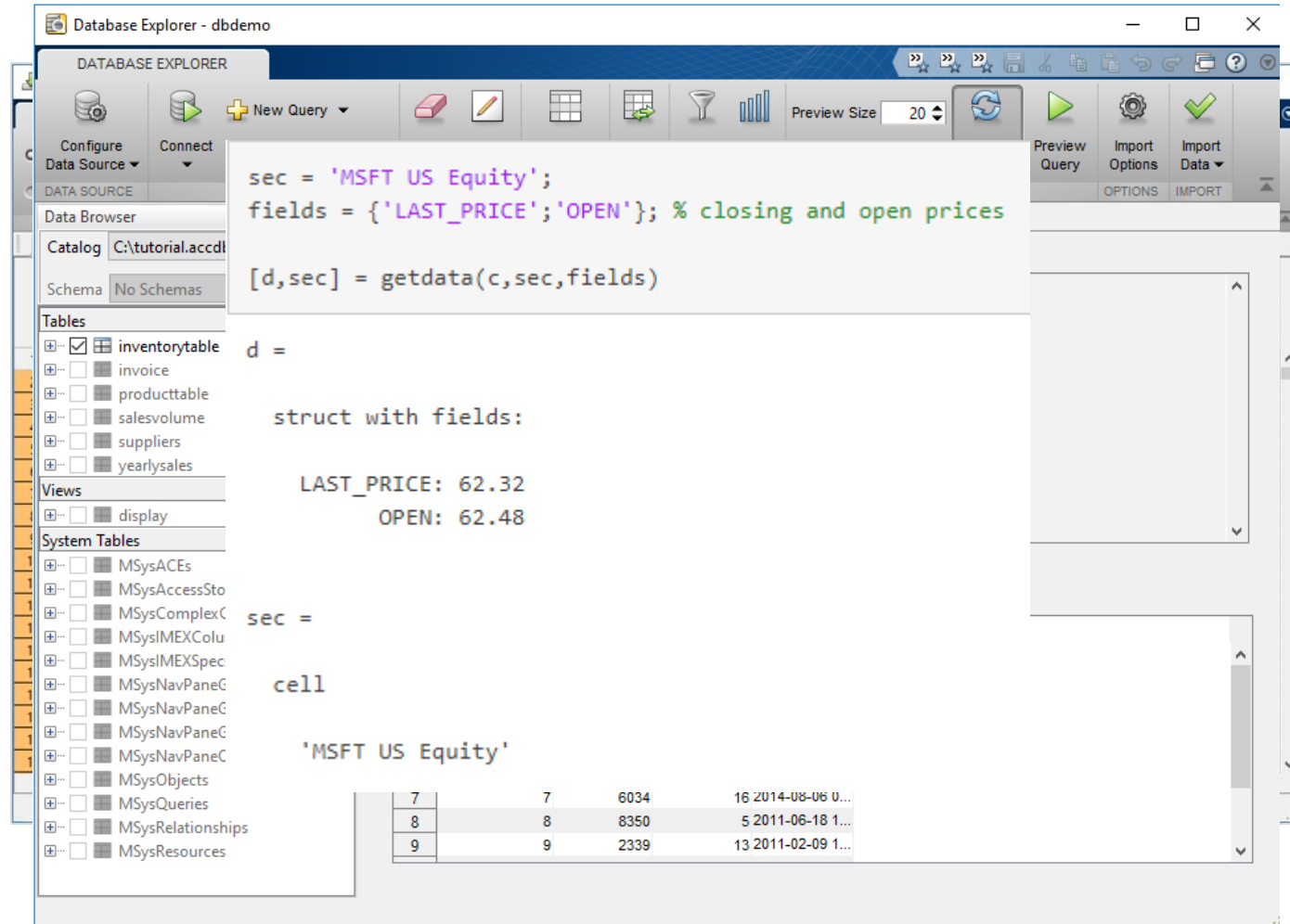
Engineer Robust Models

Collaborate and Share

"How can I spend more time adding value and less time juggling data?"

Getting Your Data into MATLAB

- ## I have data in a file
  - Use the import tool to import data
  - Generate code for similar files

- ## I have a database
  - Use Database Explorer app for SQL to view and query*
  - Or connect and query via code*

- ## I need live data
  - MATLAB can connect to a host of live datafeeds**

* Requires Database Toolbox
** Requires Datafeed Toolbox

MATLAB

Representing Financial Data in MATLAB

- **Tables**
  - Good for mixed-type tabular data
  - Gives flexibility for indexing and organization

- **Datetimes**
  - Allow for expression and arithmetic with dates and durations
  - Accounts for time zones, daylight savings and more

- **Timetables**
  - The best of both above – easily work with, format, and organize time-stamped data

```
data(timerange("01-Jan-2017","17-Mar-2017"),:)
```

ans = 161×4 timetable

	begin_timestamp	state	event_type	event_narrative	damage_total
1	21-Jan-2017 13:02:00	GEORGIA	Thunderstorm...	"a tree was blown d...	0
2	21-Jan-2017 05:14:00	ALABAMA	Tornado	"the tornado first tou...	750
3	05-Jan-2017 04:00:00	OHIO	Winter Weather	"the county garage ...	0
4	05-Mar-2017 18:00:00	OREGON	Snow	"there were reports ...	0
5	04-Feb-2017 12:15:00	WYOMING	Wind	"the wydot sensor a...	0
6	08-Feb-2017 08:00:00	INDIANA	Winter Weather	"the observers locat...	0
7	18-Jan-2017 18:00:00	CALIFORNIA	Winter Weather	"a spotter in moonri...	0
8	07-Feb-2017 07:00:00	CALIFORNIA	Flood	"major flooding from...	0
9	13-Jan-2017 15:00:00	KANSAS	Ice Storm	"ice accretion was 3...	0
10	23-Jan-2017 09:00:00	NEW YORK	Wind	"a mesonet station...	50

Big Data Analysis Without Big Changes

One file

Access Data

```
measured = readtable('PumpData.csv');
measured = table2timetable(measured);
```

Preprocess Data

Select data of interest

```
measured = measured(timerange(seconds(1),seconds(2)),'Speed')
```

Work with missing data

```
measured = fillmissing(measured,'linear');
```

Calculate statistics

```
m = mean(measured.Speed);
s = std(measured.Speed);
```

One hundred files

Access Data

```
measured = datastore('PumpData*.csv');
measured = tall(measured);
measured = table2timetable(measured);
```

Preprocess Data

Select data of interest

```
measured = measured(timerange(seconds(1),seconds(2)),'Speed')
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Work with missing data

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measured = fillmissing(measured,'linear');
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m = mean(measured.Speed);
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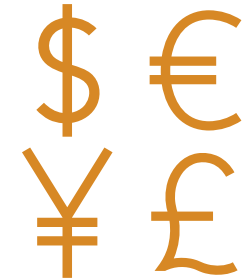
```
[m,s] = gather(m,s);
```
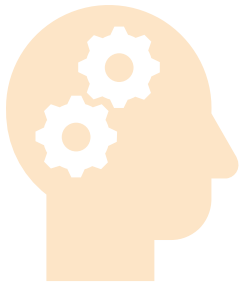
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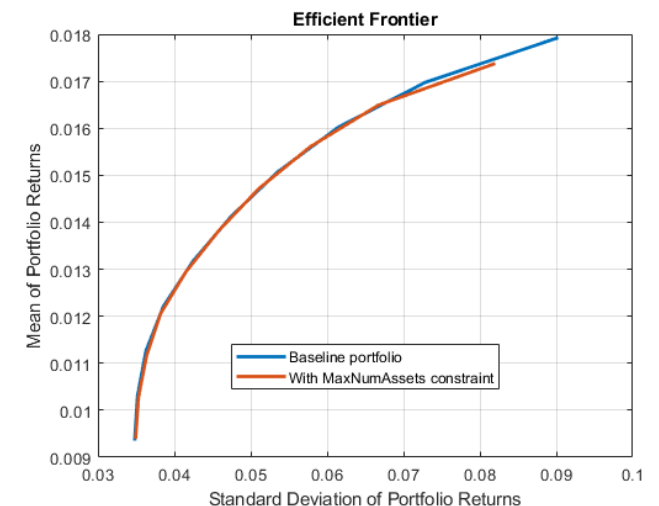Think in Models

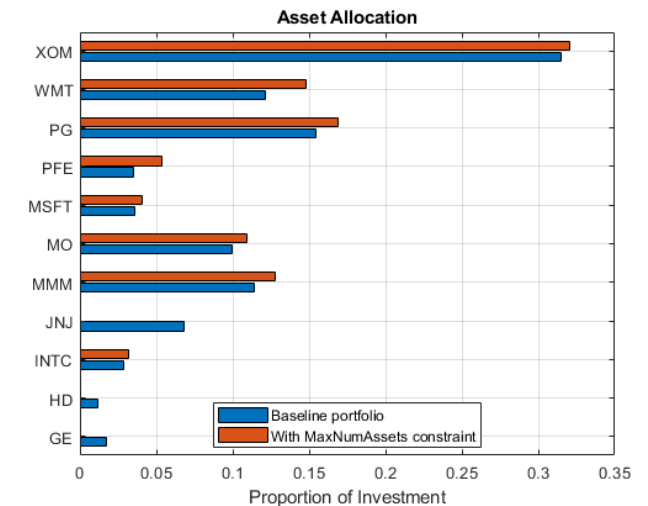Engineer Robust Models

Collaborate and Share

"How can I perform and automate the financial tasks I do every day?"

Analyze Financial Data and Develop Financial Models

- **Portfolio integrality constraints**
  - Set the minimum and maximum number of assets
  - Supported for Mean-Variance, MAD, and CVaR Portfolio Optimization

- **Improved performance of implied volatility functionality**

- **New simulation methods**
  - Monte Carlo: CIR, Bates and Merton jump diffusion
  - Quadratic-exponential discretization scheme: Heston, CIR, and Bates

- **Default Probability Modeling with the Jarrow-Turnbull model**

New MATLAB Examples
- Black-Litterman Portfolio Optimization
- Hierarchical Risk Parity
- Portfolio Optimization Using Factor Models
- Machine Learning Examples for Statistical Arbitrage

Asset Allocation

Baseline portfolio
With MaxNumAssets constraint

Proportion of Investment

Efficient Frontier

Baseline portfolio
With MaxNumAssets constraint

Mean of Portfolio Returns

Standard Deviation of Portfolio Returns

Design, Price, and Hedge Complex Financial Instruments

- **Object-based framework for pricing financial instruments**

- One-touch and double one-touch options

- Double Barrier options with Closed Form and Finite Differences

- FFT option pricing methods for Heston, Bates, Merton models

- Cox-Ingersoll-Ross Trees

- Closed form solution for discretely monitored Asian options
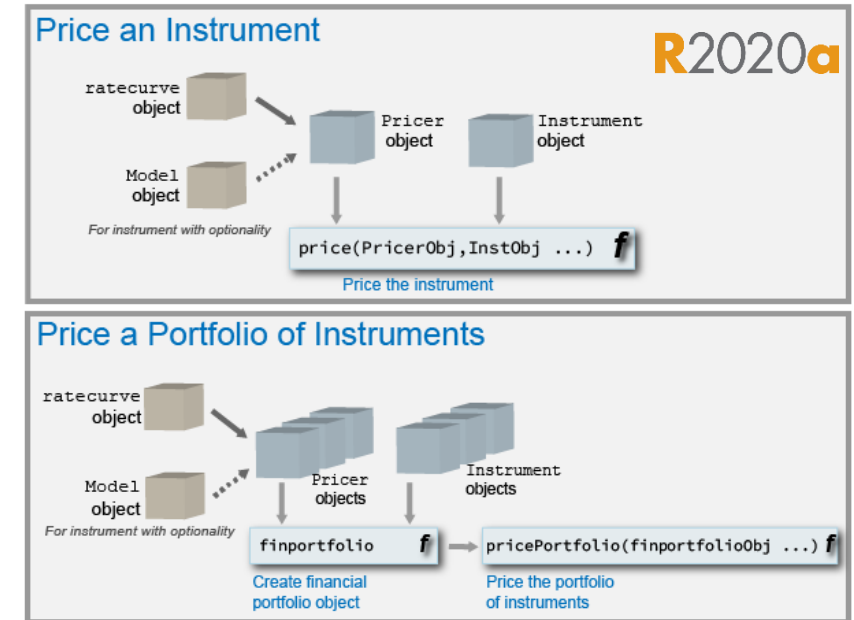
Pricing Interest-rate options with negative

| Normal Volatility Model (Bachelier Model)	Shifted Black Model	Shifted SABR Model
European swaption (swaptionbynormal)	European swaption (swaptionbyblk)	Implied Black volatility (blackvolbysabr)
Cap (capbynormal)	Cap (capbyblk)	Option sensitivity (optsensbysabr)
Floor (floorbynormal)	Floor (floorbyblk)	
Caplet volatilities (capvolstrip)		
Floorlet volatilities (floorvolstrip)		

Model and Analyze Econometric Systems

- Bayesian vector autoregression models

- Markov-switching autoregression models

- Granger Causality Test

- Impulse response (IRF) and forecast error decomposition (FEVD) functions for VAR and VEC models

- Bayesian Model Variable and Feature Selection


Forecast and 95% Forecast Interval
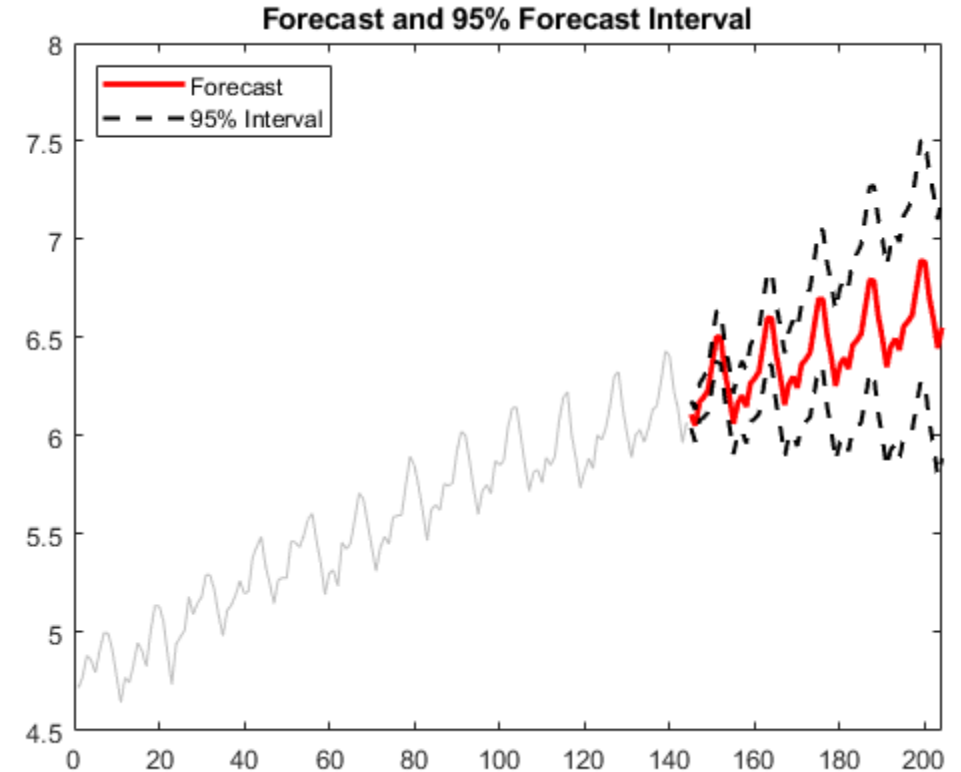
Interactive Econometric Modeling and Reporting

- **Econometric Modeler app**

- Popular econometric models, tests, and visualizations available as interactive workflow

- Document your entire model development workflow with one click
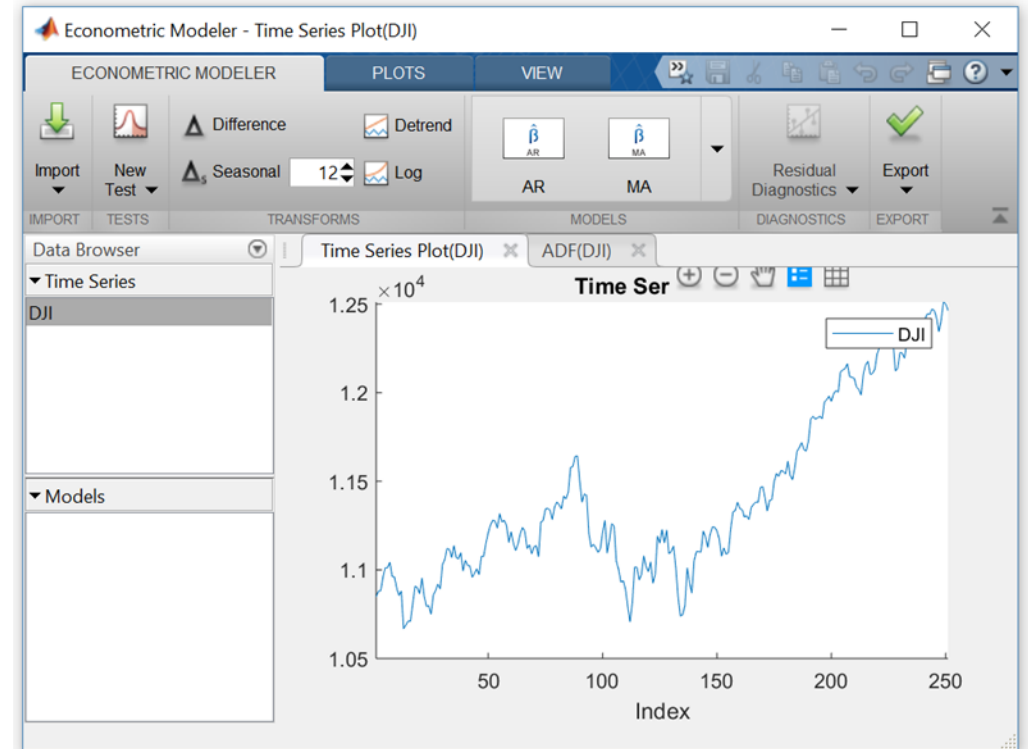
Develop Models for Risk and Run Simulations

- Functions for mathematical modeling and simulation of credit and market risk

- Model probabilities of default

- Create credit scorecards

- Perform credit portfolio analysis

- Backtest VaR and ES models

  - Acerbi and Szekely ES tests

  - Du and Escanciano ES tests

- Assess corporate and consumer credit risk, as well as market risk
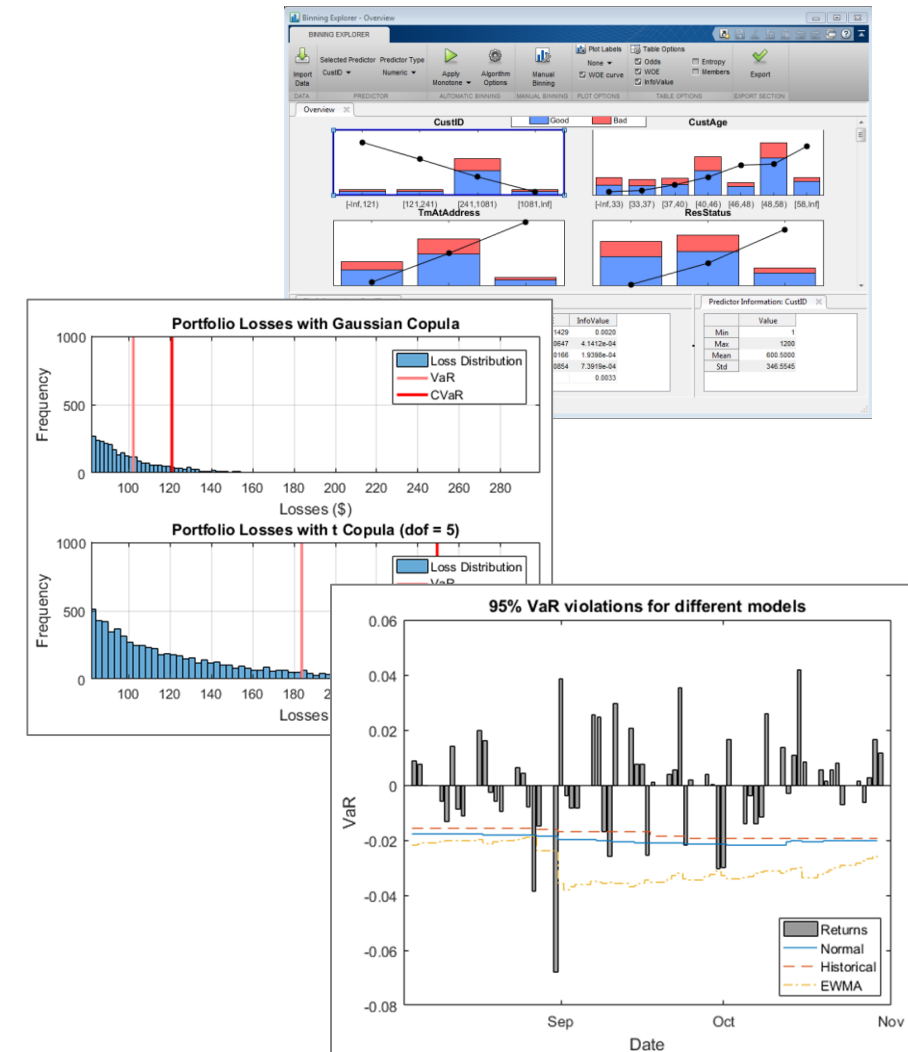
Develop and Execute Trading Strategies

- **Transaction Cost Analysis**
  - Estimate transaction costs associated with market impact, timing, liquidity, and price appreciation

- **Analyze and estimate transaction costs before placing an order**

- **Attribute costs for post-trade analysis**

- **Determine optimal volume for trading execution to minimize transaction costs or market impacts**

- **Wind Data Feed Services support**
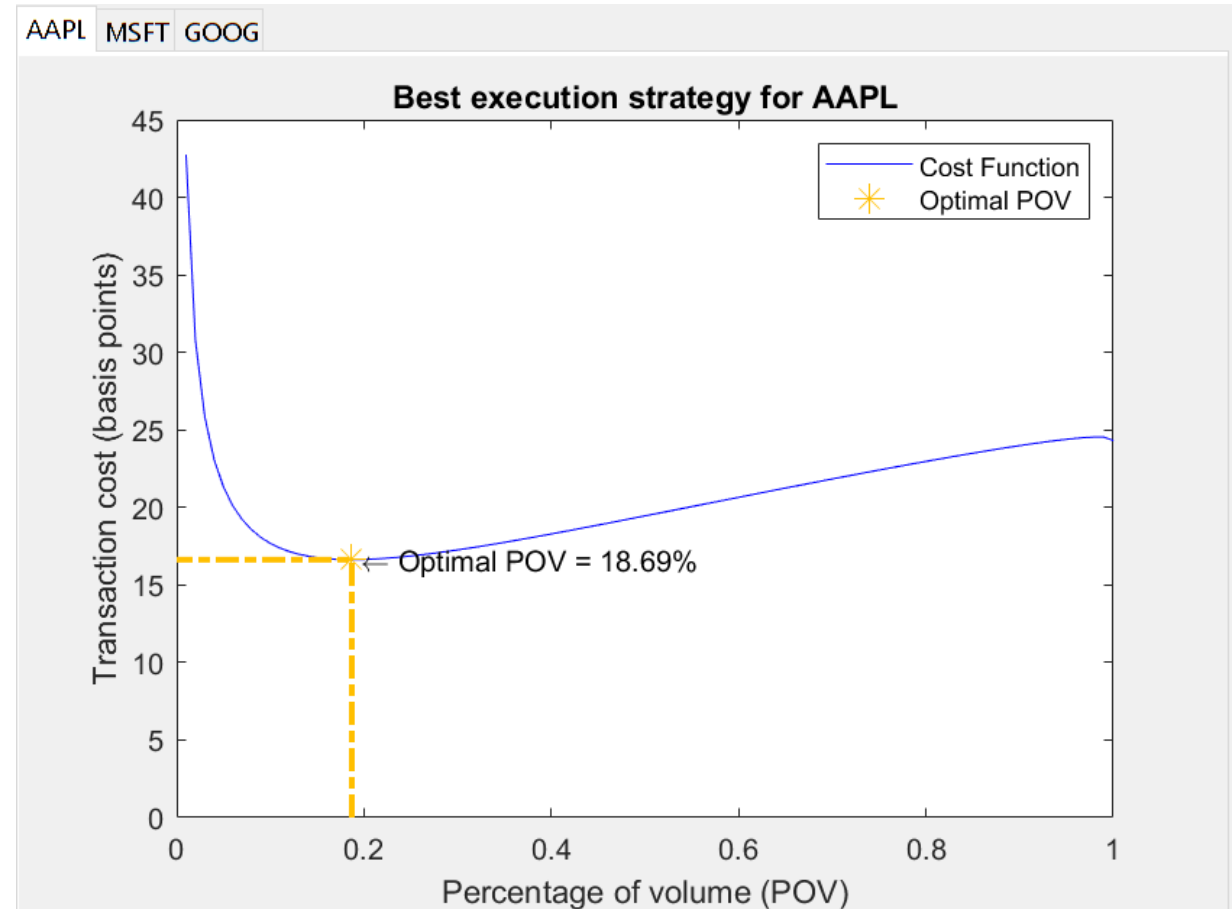
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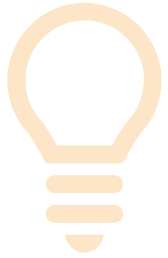
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"How can I jump into advanced analytics if I'm new to MATLAB?"

MATLAB as a Platform for Advanced Analytics

- MATLAB can support traditional modeling as well as your advanced analytics work

- Consolidated platform for:
  - Optimization
  - Regression
  - Time Series Modeling
  - Machine Learning
  - Deep Learning
  - Natural Language Processing
  - Reinforcement Learning

Math, Statistics, and Optimization

Curve Fitting Toolbox
Deep Learning Toolbox
Global Optimization Toolbox
Optimization Toolbox
Partial Differential Equation Toolbox
Statistics and Machine Learning Toolbox
Symbolic Math Toolbox
Text Analytics Toolbox

Data Science and Deep Learning

Deep Learning Toolbox
Predictive Maintenance Toolbox
Reinforcement Learning Toolbox
Statistics and Machine Learning Toolbox
Text Analytics Toolbox

Computational Finance

Database Toolbox
Datafeed Toolbox
Econometrics Toolbox
Financial Instruments Toolbox
Financial Toolbox
Risk Management Toolbox
Spreadsheet Link
Trading Toolbox

Train, Compare, and Optimize Machine Learning Models

- Use apps to interactively train and compare regression and classification models
  - Use Bayesian optimization in the apps to tune hyperparameters

- Automatically pick the best model using AutoML functionality

- Generate fixed-point C/C++ code* for decision trees and its ensembles
 - Provides options for power and memory constrained deployment
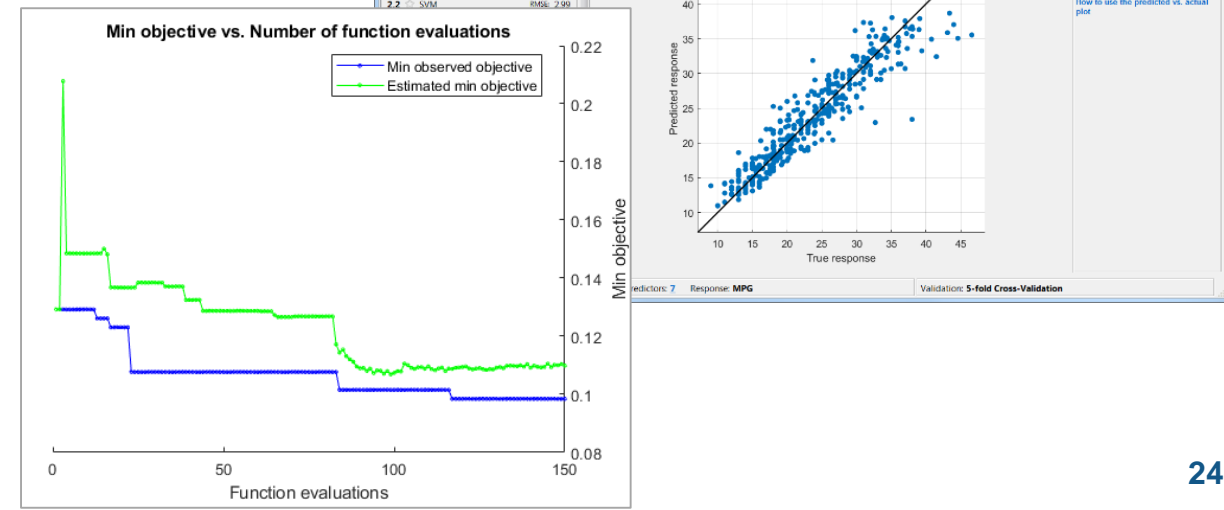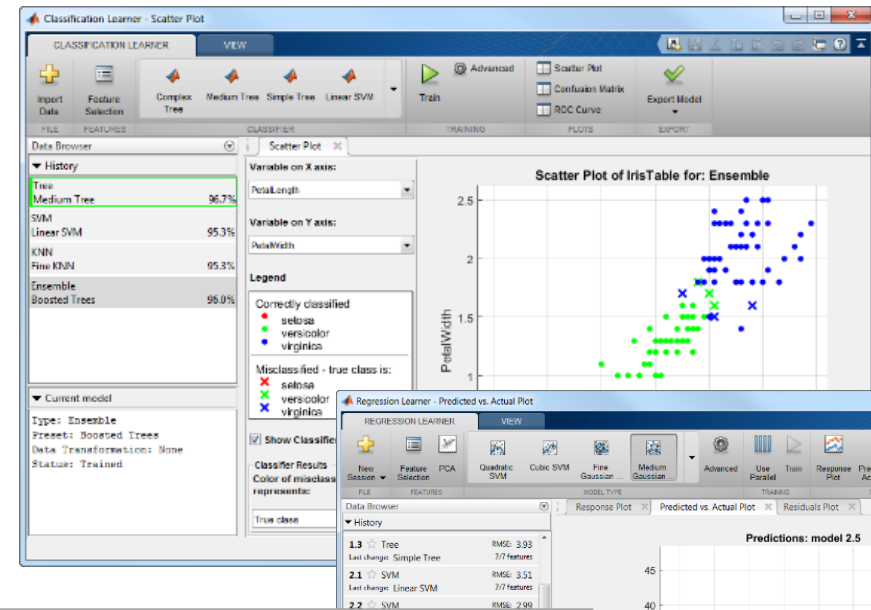
* Requires Fixed-Point Designer
* Requires MATLAB Coder
**Statistics and Machine Learning Toolbox**

Efficiently Design Deep Networks

- Deep Network Designer
  - Easily visualize and design a network
  - Start from scratch or with a pretrained model for transfer learning

- Experiment Manager
  - Conduct experiments with varying network architecture/parameters
  - One location to manage all of your network test data
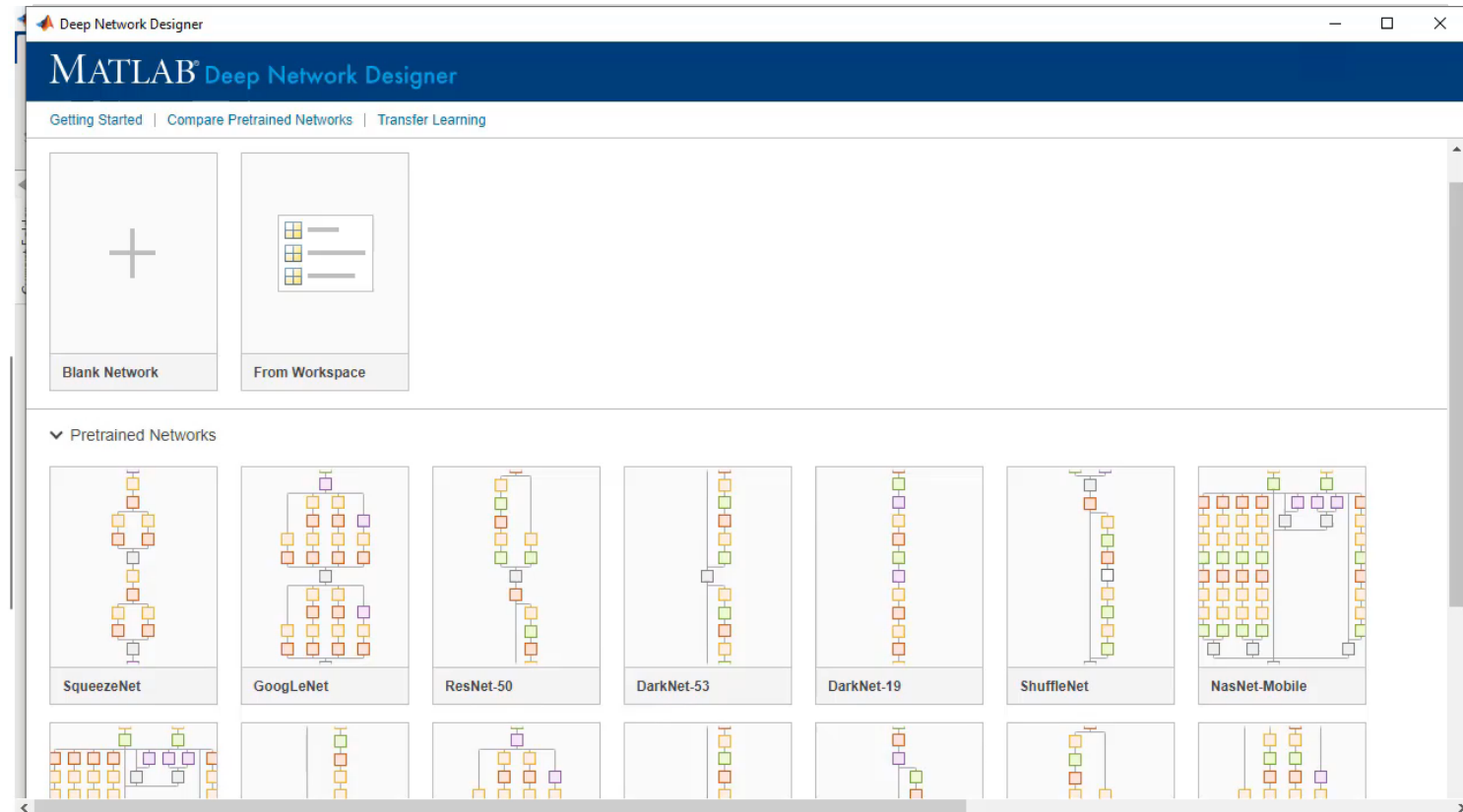
An Ecosystem for Deep Learning

- Powerful tools to perform and automate ground-truth labeling for signal data

- Import/export networks from frameworks like Tensorflow and PyTorch

- Accelerate training with multi-GPU support

- Generate high-performance C/C++ or CUDA code for inference*
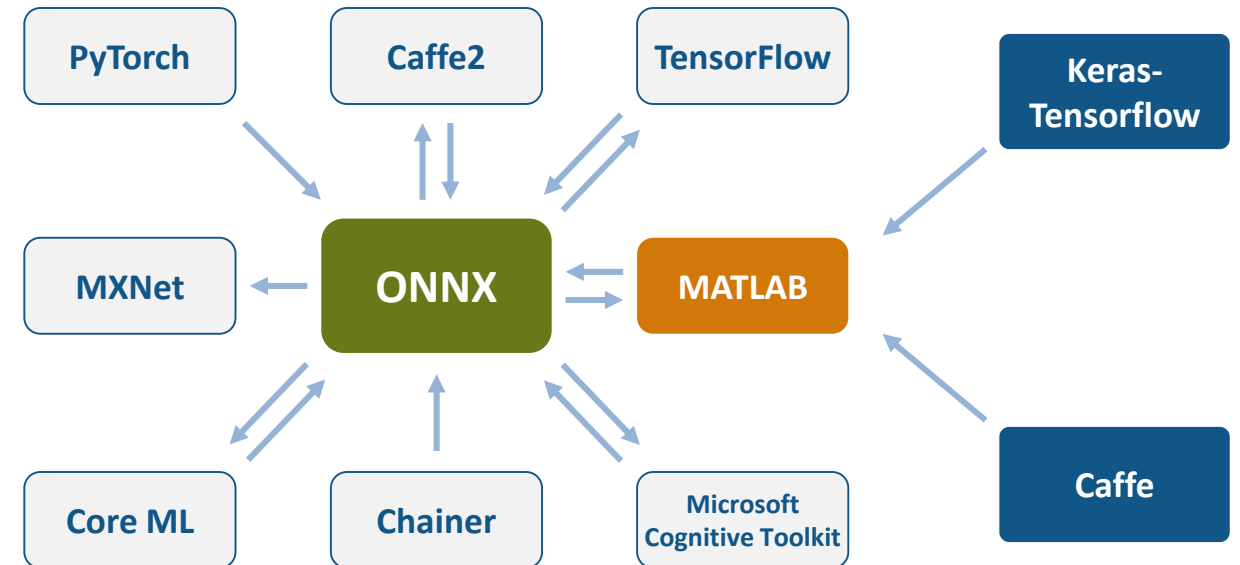
* Requires GPU Coder
* Requires MATLAB Coder
Deep Learning Toolbox

Get the Most out of Your Hardware with Parallel Computing

Ease of Use

Greater Control

Parallel-enabled toolboxes
(`'UseParallel'`, `true`)

Parallel Programming Made Easy
(`parfor, batch`)

Advanced Parallel Programming
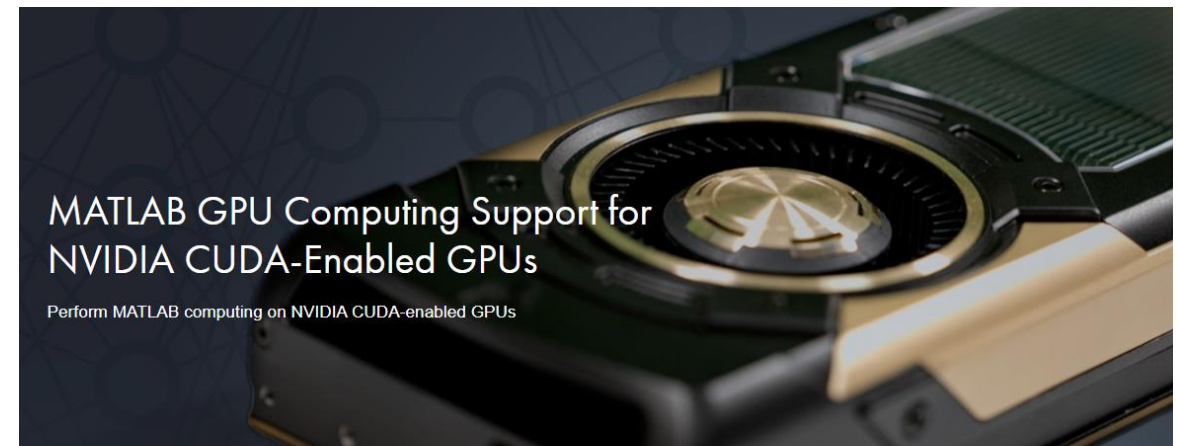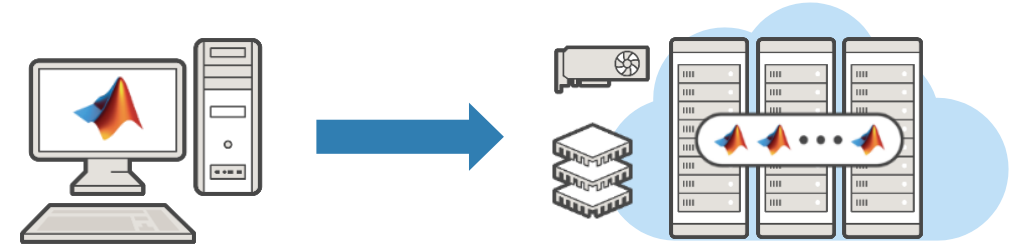(`spmd, createJob, parfeval,..`)

Get the Most out of Your Hardware with Parallel Computing

- New pool type: Thread-based parallel pool
  - In process (explicit workers without extra MATLAB processes)
  - Optimized for reduced memory usage, faster scheduling, and less data transfer

- Scaling to clusters*
  - License updates provide increased scaling at same price
  - Cloud Support
    - AWS, Azure, NVIDIA GPU Cloud, Containers

- **Support for GPU Computing**
  - Matrix math computed on GPUs
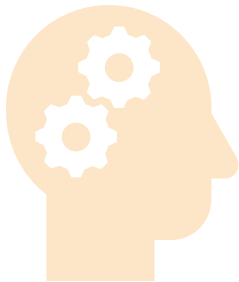 - Train Deep Networks on GPUs

MATLAB GPU Computing Support for
NVIDIA CUDA-Enabled GPUs

Perform MATLAB computing on NVIDIA CUDA-enabled GPUs

* Requires MATLAB Parallel Server
Parallel Computing Toolbox

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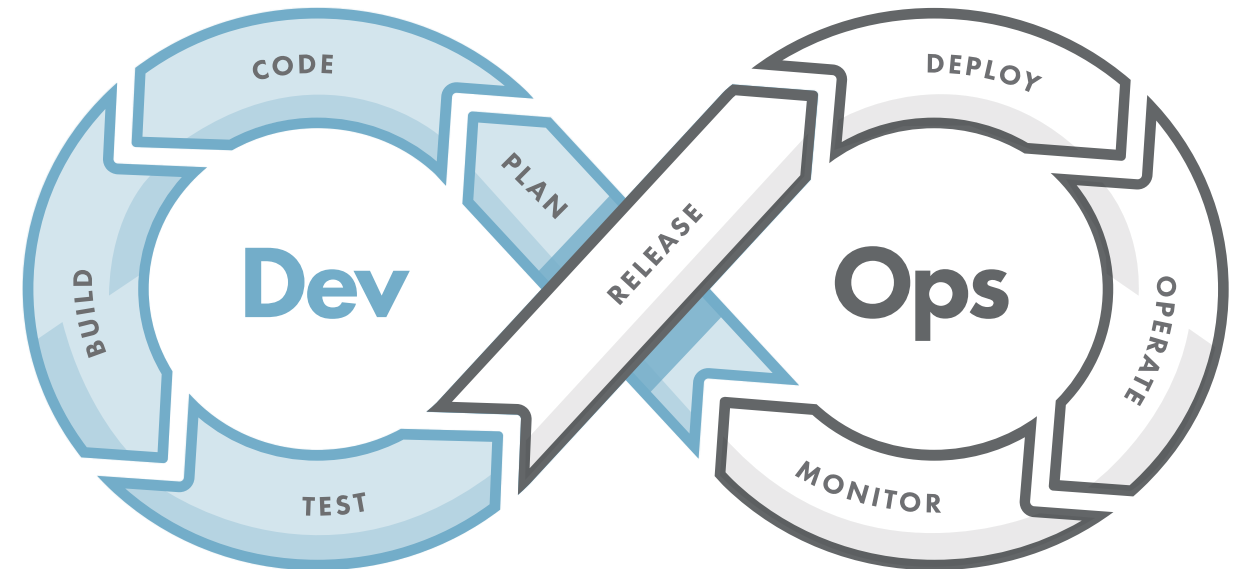
Think in Models

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"How can I write clean, robust code?"

A Fully-Featured Software Engineering Environment

- **Familiar Software Engineering Features**
  - Class structures
  - Unit testing framework

- **Support for Dev Ops Tasks**
  - CI/CD Workflows
  - Seamless source control integration

Framework for Creating, Running, and Reporting on Tests

- MATLAB Unit Testing Framework
  - Includes script-, function-, and class-based testing
  - Works with continuous integration servers

- Performance Testing Framework
  - Time MATLAB code automatically
  - Track performance over time

- App Testing Framework
  - Author automated test for App Designer apps

- New Jenkins plugin for your CI/CD Workflows

Run the tests and examine results.

```
result = runtests('test_Predictions.mlx')

Running test_Predictions
..
Done test_Predictions
_____

result =
   1×2 TestResult array with properties:

     Name
     Passed
     Failed
     Incomplete
     Duration
     Details

Totals:
   2 Passed, 0 Failed, 0 Incomplete.
   0.41712 seconds testing time.
```

Use MATLAB Projects to Collaborate with Other MATLAB Developers

- Configure your environment

- Analyze dependencies

- Track and control changes

- Package and share projects

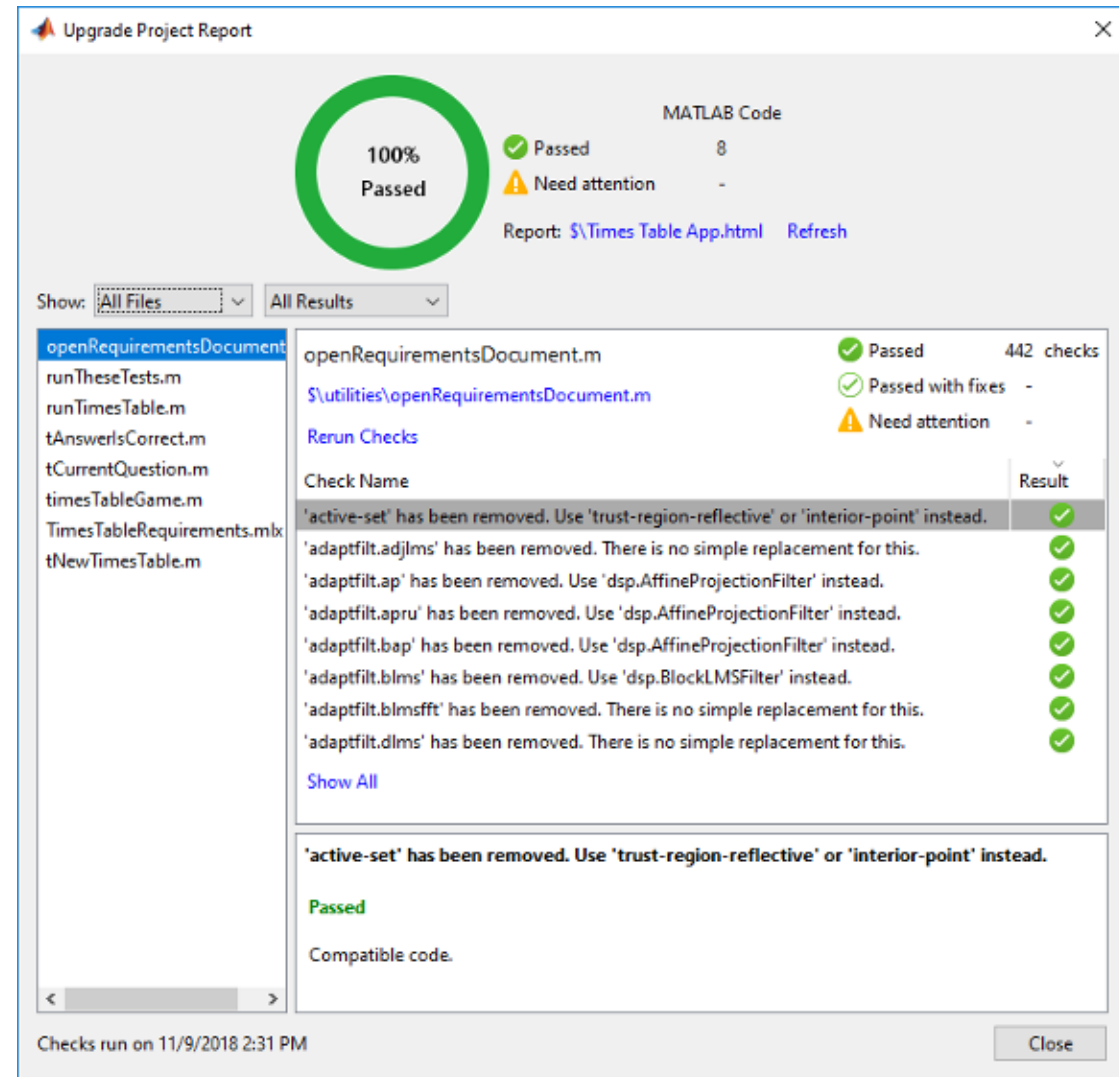- Full integration with source control
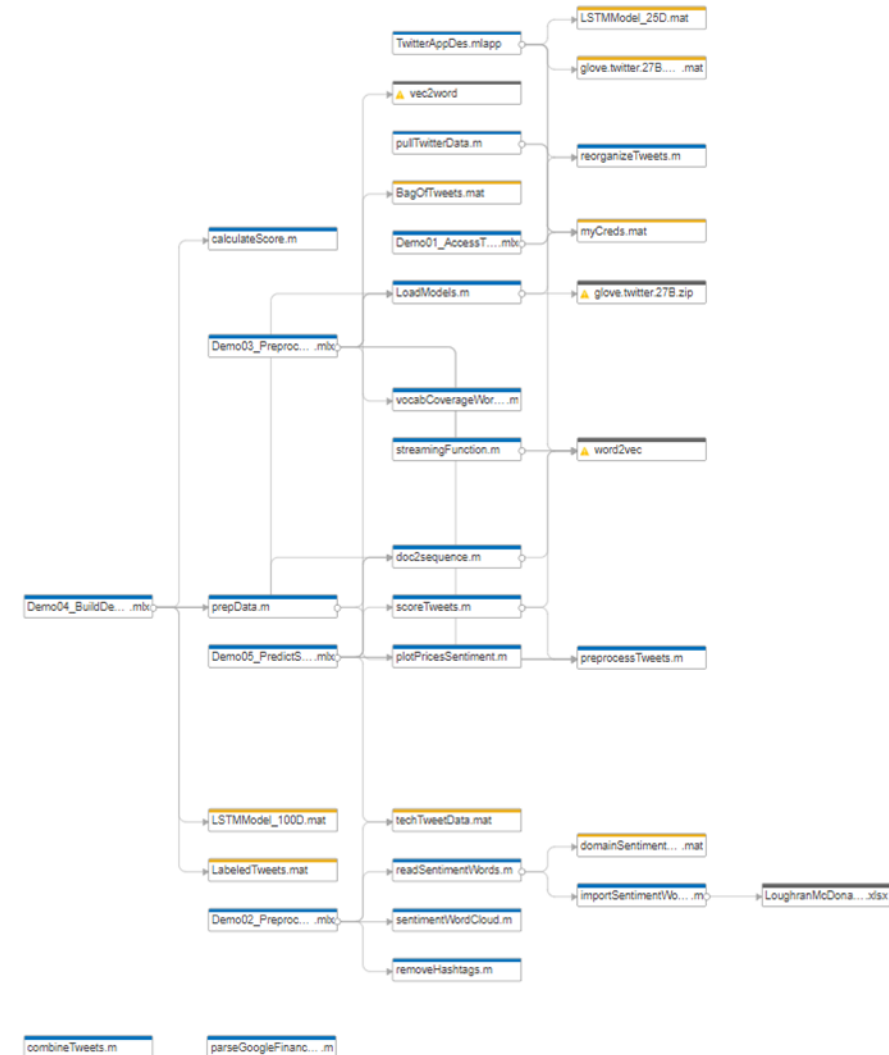
Source Control Integration

- **Manage your code from within the MATLAB Desktop**

- **Leverage modern source control capabilities**
  - Git and Subversion integration in Current Folder browser

- **Use Comparison Tool to view and merge changes between revisions**
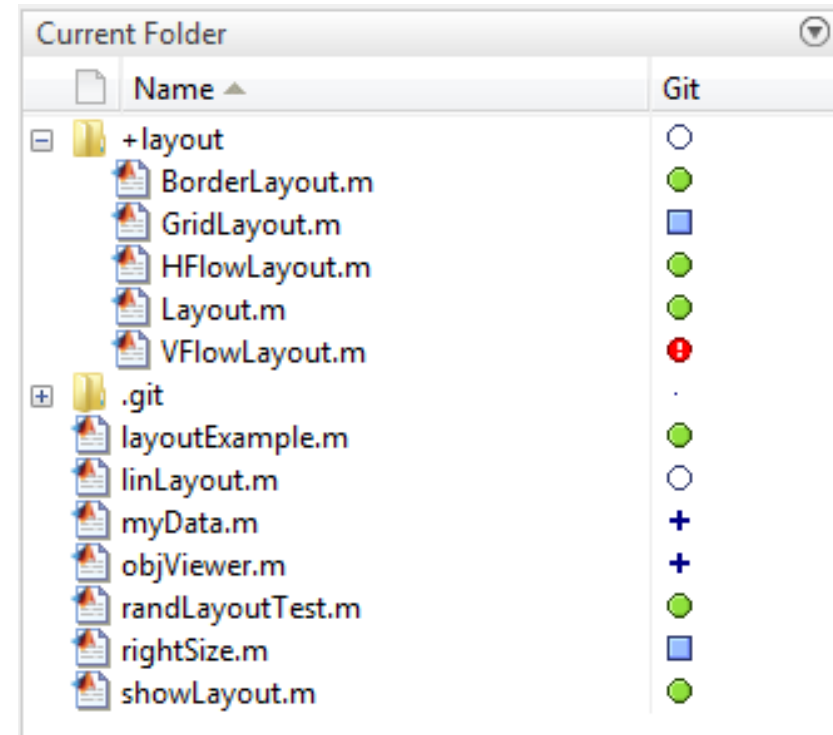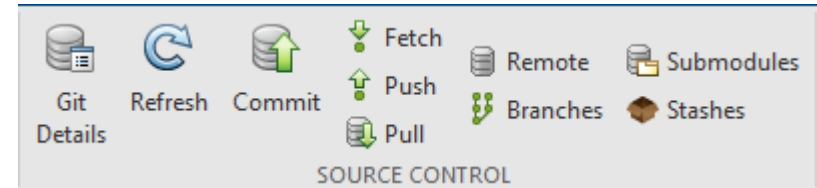
Upgrading to the latest MATLAB – Upgrade Projects

- Tool to help upgrade code to latest and greatest MATLAB

- Hundreds of checks for incompatibilities, errors, and warnings
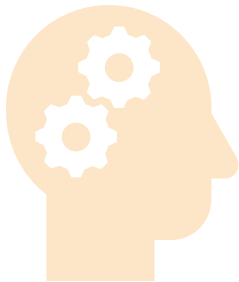
- Applies fixes automatically

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*"What's the best way for my colleagues to access my models?"*

Create and Share Apps as a Vehicle for Your Models

- **App Designer can be used to design GUIs for your models**
  - No need to learn another language to make your models interactive

- **These apps can be shared to end users who don't have a MATLAB License**
  - Can be shared as an executable
 - Can be shared as an in-browser web application
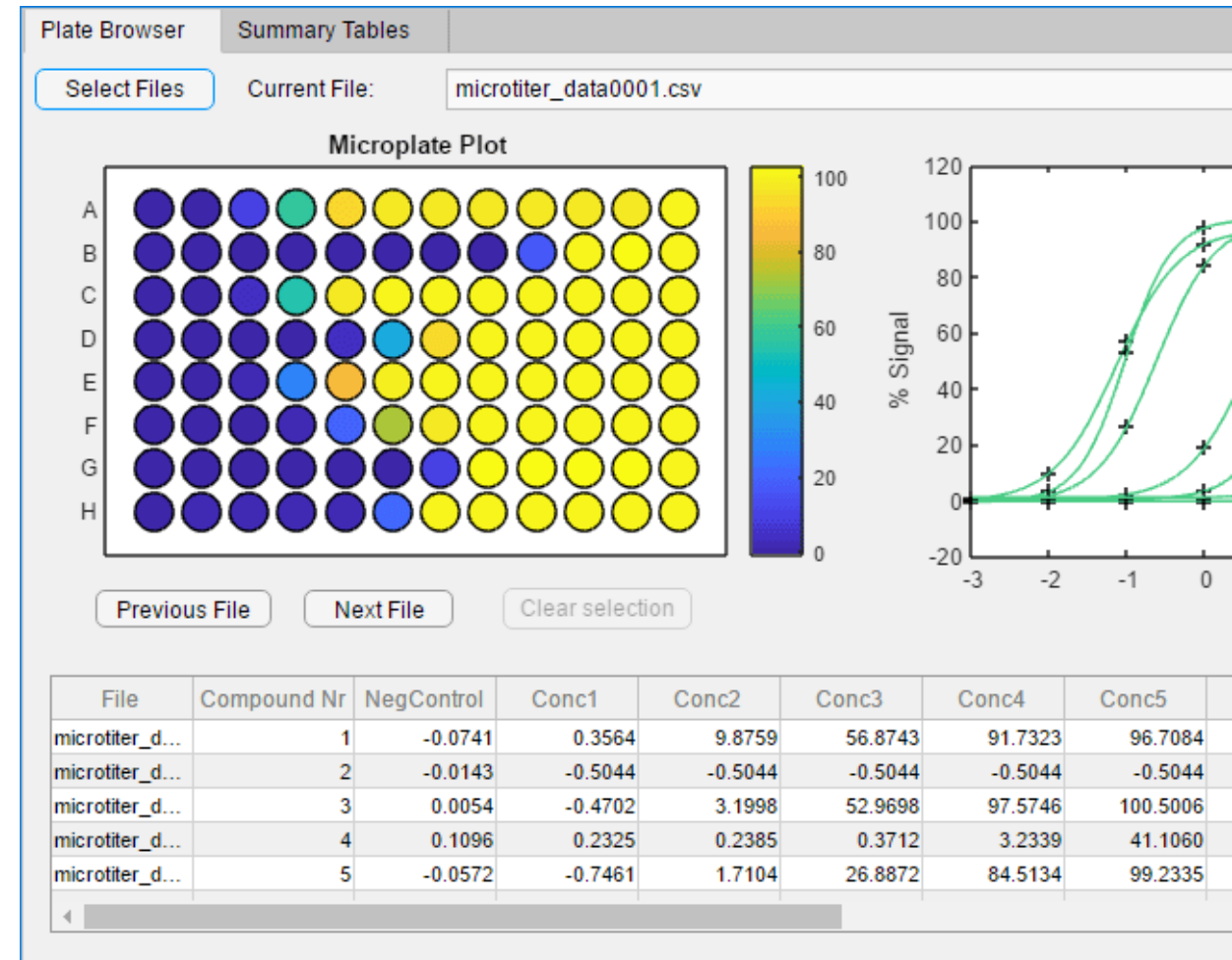
Share MATLAB Apps as Browser-Based Web Apps

- ## MATLAB Web App Server **NEW PRODUCT**

- ## Provides
  - Authentication using OpenID Connect and LDAP
  - Support for apps developed in different releases of MATLAB or Simulink

https://www.mathworks.com/products/matlab-web-app-server.html
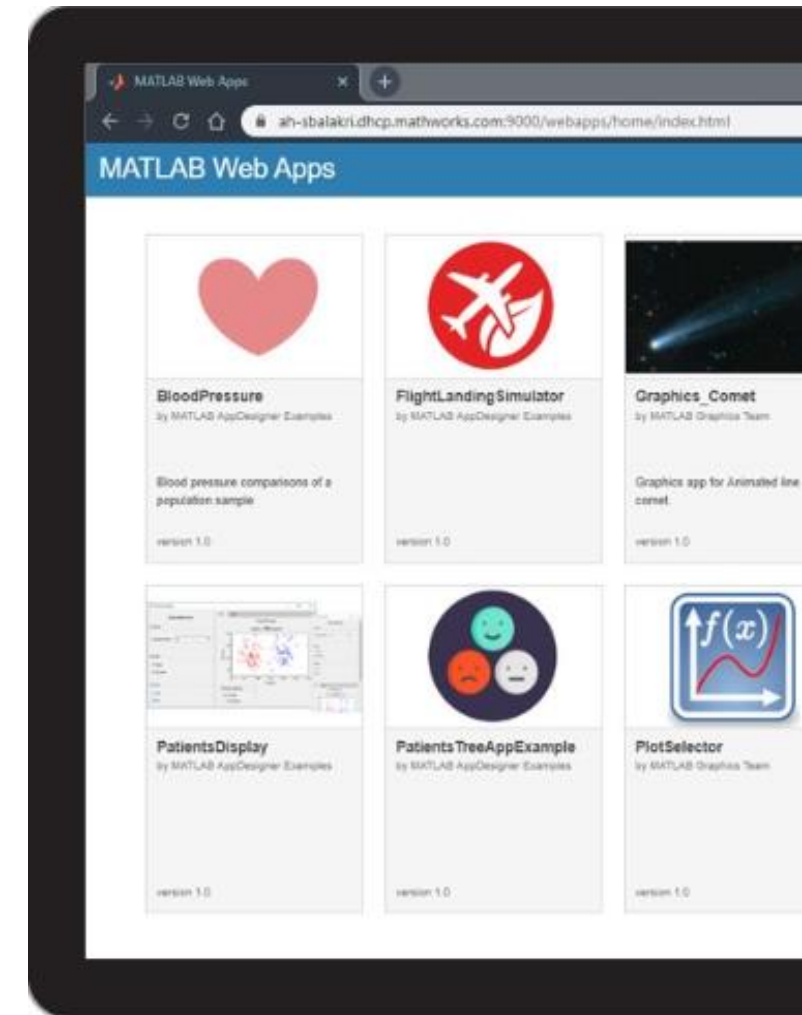
Deployment to Other Languages and Systems

- **Share your models with colleagues who use other tools**
  - Create libraries for Python, Java, C/C++, and .NET*
  - Create Excel Add-ins

- **Create MapReduce applications that run against Hadoop**

- **Create MATLAB applications that run against an Apache Spark enabled cluster**
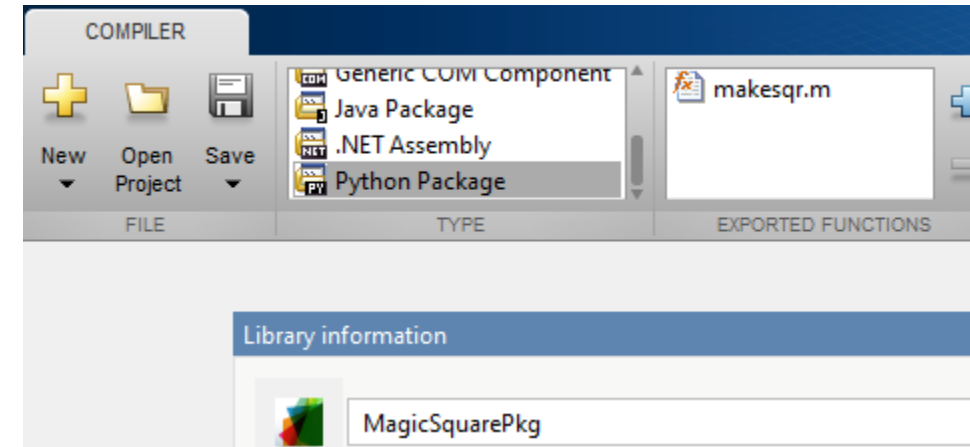

```
python makesqrSample1.py

[[8.0,1.0,6.0],
 [3.0,5.0,7.0],
 [4.0,9.0,2.0]]
```

* Requires MATLAB Compiler SDK
MATLAB Compiler

Integrate MATLAB Analytics into Enterprise Applications

Deploy MATLAB algorithms without recoding or creating custom infrastructure

- Develop clients for MATLAB Production Server in any programming language that supports HTTP using RESTful API and JSON

- Configure and manage multiple server instances using a web-based interface

- Discover the list of APIs provided by installed applications through a RESTful interface
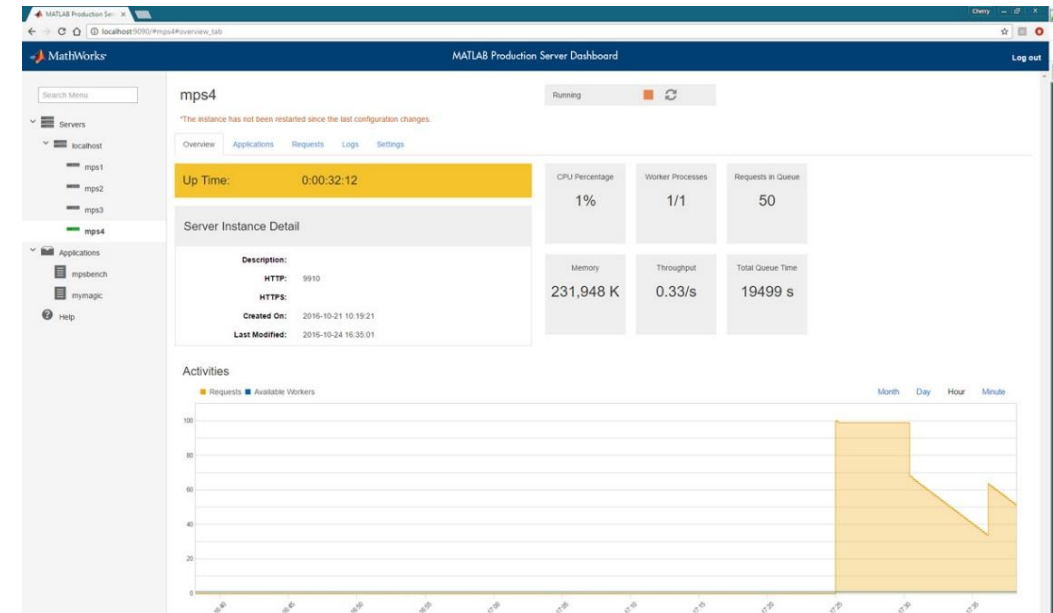
Using MATLAB with Other Languages

Calling Libraries Written in Another Language From MATLAB

- Java
- Python
- C
- C++
- Fortran
- COM components and ActiveX® controls
- RESTful, HTTP, and WSDL web services

Execute Python functions out of process **R**2019**b**

Call C++ libraries directly from MATLAB **R**2019**a**

Calling MATLAB from Another Language

- Java
- Python
- C/C++
- Fortran
- COM Automation server

MathWorks Services

Training Services

- Targeted courses for computational finance skills
  - Courses can be customized

- Deliver both on-site and virtual trainings for MATLAB users

- Offer self-paced training programs

Consulting Services

- Allows for completion of complex projects by expert MATLAB engineers
  - Example: LIBOR-SOFR Transition

- Train your engineers on how the solution works to eliminate black-box effect

Questions? Contact Us!

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