

MATLAB EXPO

November 13–14, 2024 | Online

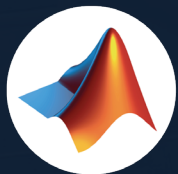
Open Source Software and MATLAB: Principles, Practices, and Python

Heather Gorr, PhD



Mike Croucher, PhD





MathWorks ✓

@MathWorks

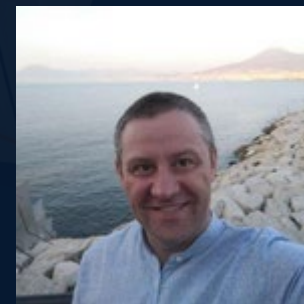
Share the EXPO experience

#MATLABEXPO

Mike Croucher, PhD



Mike Croucher
Principal Customer Success Engineer



Heather Gorr, PhD



@heather.codes



heather-gorr-phd



MATLAB



MATLAB



MATLAB



MATLAB



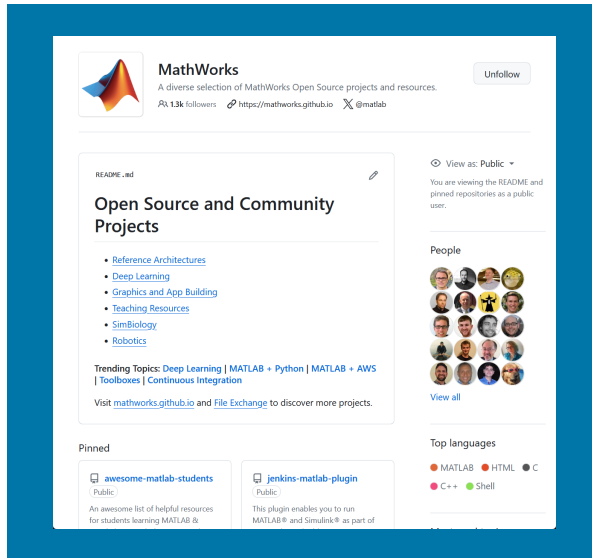
MATLAB

What does Open Source Software mean to you?

What does Open Source Software mean to us?

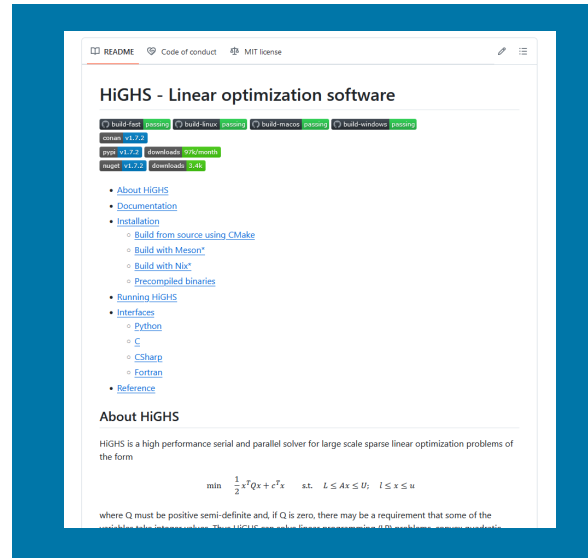
MathWorks and OSS work together in three ways

Open Source (On Top Of)



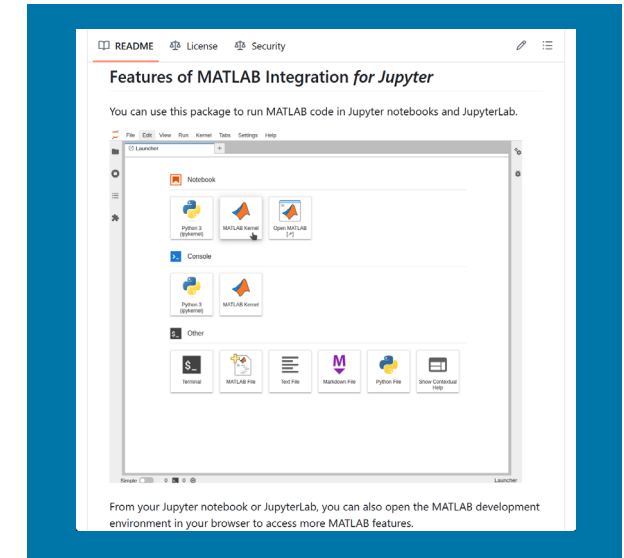
Community OSS software built on top of MATLAB and Simulink

Open Source (Within)



OSS used to build MathWorks software

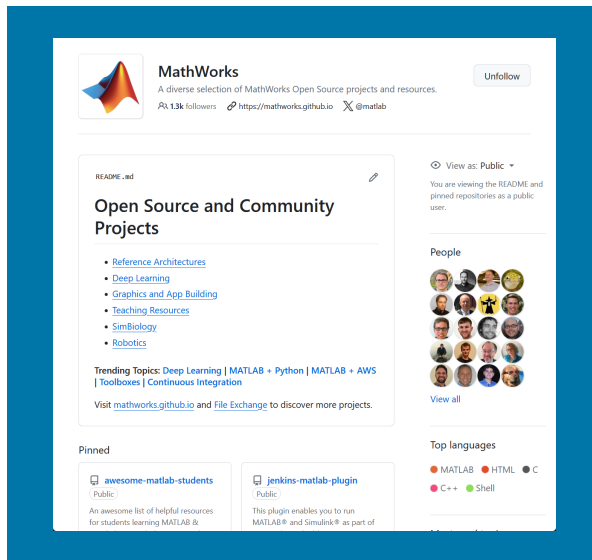
Open Source (Alongside)



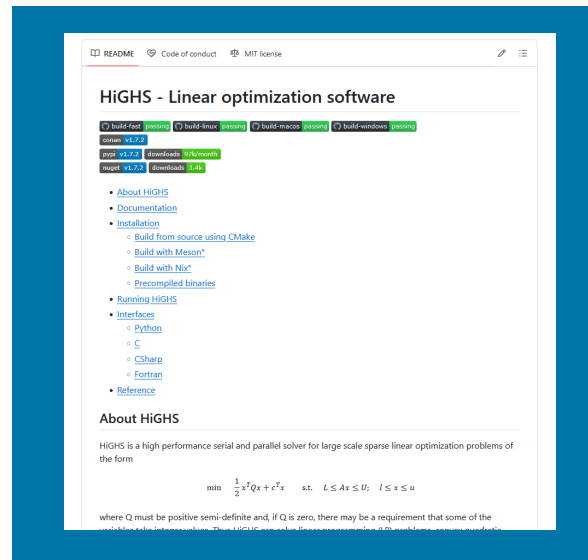
OSS that interoperates with MATLAB and Simulink

MathWorks and OSS work together in three ways

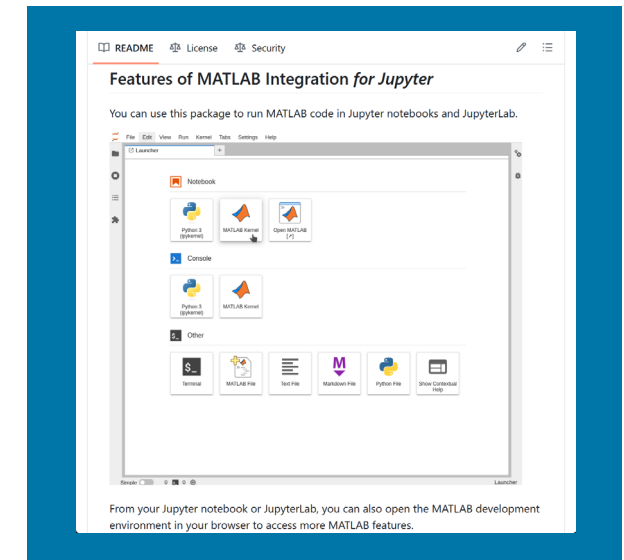
Open Source (On Top Of)



Open Source (Within)



Open Source (Alongside)



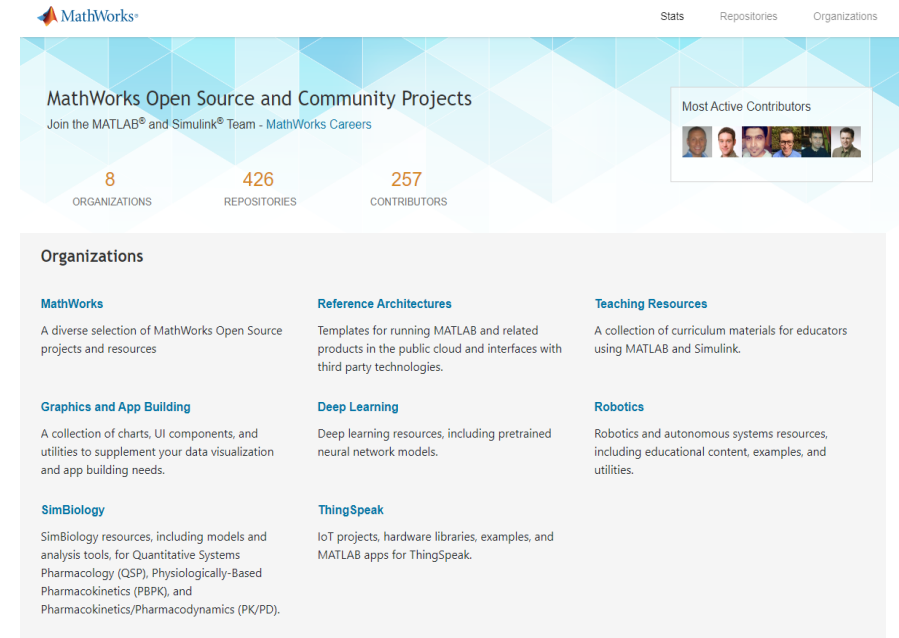
The OSS community have been active and important for many years

```
Command Prompt - ftp.mathworks.com
230- Hong Kong      ftp://ftp.cse.cuhk.edu.hk/pub/matlab
230-
230- If you would like to be a mirror site for this ftp library
230- send e-mail to ftpadmin@mathworks.com.
230-
230- Send questions/comments/suggestions to ftpadmin@mathworks.com
230-
230- Hello!
230-
230 Logged in anonymously.
ftp> cd pub
250 "/pub/" is new cwd.
250-
250-To see descriptions of the contents of each directory get the
250-file named INDEX.
250-
ftp> dir
200 PORT command successful.
150 Opening ASCII mode data connection for /bin/ls.
-rw-r--r--  1 ftpuser  ftpusers      1504  Nov  1  1995  INDEX
-rw-r--r--  1 ftpuser  ftpusers     16349  Sep 18  1995  MEMFILES
drwxr-xr-x  3 ftpuser  ftpusers       512  Oct  9  17:29  admin
drwxr-xr-x 16 ftpuser  ftpusers     5632  Sep 28  11:20  beta
-rw-r--r--  1 ftpuser  ftpusers     5784  Sep  5  1995  bin
drwxr-xr-x 82 ftpuser  ftpusers     5120  Oct  2  15:48  books
drwxr-xr-x  2 ftpuser  ftpusers     512  Oct 30  2000  compiler
drwxr-xr-x  6 ftpuser  ftpusers     512  Dec 13  1995  conference
drwxr-xr-x  4 ftpuser  ftpusers     512  May 23  1998  connections
drwxr-xr-x  5 ftpuser  ftpusers     512  Nov 15  2000  contrib
drwxr-xr-x 11 ftpuser  ftpusers     512  Sep 16  1999  digest
drwxr-xr-x  9 ftpuser  ftpusers     512  Nov  1  16:18  doc
-rw-r--r--  1 ftpuser  ftpusers     2134  Oct 20  1995  ftphelp
-rw-r--r--  1 ftpuser  ftpusers    3817278  Nov  2  00:06  ls-1R
drwxr-xr-x  8 ftpuser  ftpusers     512  Feb 19  1998  mathworks
-rw-r--r--  1 ftpuser  ftpusers    296113  Dec 18  1995  natueb.exe
drwxr-xr-x  2 ftpuser  ftpusers     512  Jan 31  2000  ops
drwxr-xr-x  4 ftpuser  ftpusers     512  May 25  12:02  outgoing
drwxr-xr-x  1 ftpuser  ftpusers     512  Nov  4  2000  patch -> mathworks
drwxr-xr-x  2 ftpuser  ftpusers    1024  Jan 17  1996  pentium
drwxr-xr-x  2 ftpuser  ftpusers    1536  Dec 16  1998  pressroom
drwxr-xr-x 66 ftpuser  ftpusers    1536  Nov 30  1995  proceedings
drwxr-xr-x  3 ftpuser  ftpusers    1024  Dec  4  1997  product-info
drwxr-xr-x 66 ftpuser  ftpusers    2048  Nov 11 17:53  tech-support
drwxr-xr-x  2 ftpuser  ftpusers     512  Oct 30  2000  temp
drwxr-xr-x  6 ftpuser  ftpusers     512  Jan 22  2001  utilities
226 Listing completed.
ftp> 1707 bytes received in 0.18Seconds 9.48Kbytes/sec.
ftp>
```

1993



2001



2024

File Exchange: The home of OSS built on top of MATLAB

The screenshot displays the MATLAB File Exchange interface. At the top, the MathWorks logo and navigation menu (Products, Solutions, Academia, Support, Community, Events) are visible. The main navigation bar includes links for MATLAB Answers, File Exchange, Cody, AI Chat Playground, Discussions, Contests, Blogs, and More. A search bar and a 'MATLAB' button are on the right. Below the navigation, a 'FILTER' sidebar on the left allows users to filter by source (Community: 49,409) and category (Using MATLAB: 11,678; Using Simulink: 832). The main content area is divided into 'Community Toolboxes' and 'Community Apps'. Each item features a thumbnail image, a title, a brief description, a download count, and a star rating. The 'Community Toolboxes' section includes:

- PIVlab**: Particle image velocimetry (PIV) tool with GUI. 100.9K downloads, 4.90/5 rating.
- FSDA - Flexible Statistics Data Analysis toolbox**: Flexible Statistics Data Analysis Toolbox. 15.8K downloads, 5.00/5 rating.
- CFDTool - MATLAB OpenFOAM and CFD Fluid Dynamics Toolbox**: An Easy to Use Computational Fluid Dynamics (CFD) Toolbox. 19.4K downloads, 4.60/5 rating.
- Quanser Interactive Labs for MATLAB**: High-fidelity digital twins of Quanser's world renowned controls, mechatronics, and robotics hardware. 5K downloads, 5.00/5 rating.
- Control 101 toolbox**: MATLAB toolbox for control 101 course. 4.6K downloads, 5.00/5 rating.
- GUI Layout Toolbox**: Layout manager for MATLAB graphical user interfaces. 99.7K downloads, 4.90/5 rating.
- Simulink Onramp**: Learn the basics of how to create, edit, and simulate Simulink models through an interactive tutorial. 64.7K downloads, 4.30/5 rating.
- FOMCON Toolbox for MATLAB**: FOMCON toolbox for MATLAB is dedicated to fractional-order modeling and control of dynamic. 16.6K downloads, 4.60/5 rating.
- FEATool Multiphysics - MATLAB FEA and CFD Toolbox**: FEATool Multiphysics - Physics Simulation Made Easy. 27.1K downloads, 4.50/5 rating.

 The 'Community Apps' section includes:

- PID Controller Simulator**: PID controller simulator on an LTI system w/ or w/o input delays. 34.4K downloads, 4.90/5 rating.
- Aircraft Intuitive Design (AID)**: An academic tool intended to assist in developing an intuitive understanding of aircraft design. 22.3K downloads, 4.40/5 rating.
- Frequency Response Analyzer**: Perform frequency analysis of your Simulink model without linearization. 5.6K downloads, 5.00/5 rating.
- Phase Portrait Plotter**: Plot the phase portrait for the entered system of differential equations. 6.2K downloads, 5.00/5 rating.
- Transfer Learning**: Transfer Learning of Pre-trained Neural Network or Imported ONNX Classification Model in GUI. 15.4K downloads, 5.00/5 rating.
- VEXCompanionApp**: Add-on to enhance user experience of the VEX EDR hardware support packages. 32.7K downloads, 4.80/5 rating.
- V-n Diagram**: V-n Diagram for Fixed wing Aircraft. 3.2K downloads, 4.60/5 rating.
- Metabolite Profiling Toolbox**: Metabolite Profiling Toolbox. Cplex and python are also necessary. 733 downloads, 5.00/5 rating.
- Raspberry Pi Hardware Resource Manager**: Monitor the status of different hardware resources on the raspberry pi. 5.6K downloads, 5.00/5 rating.

Users are sharing frequently and making it easy to access their work

MathWorks® Products Solutions Academia Support Community Events

File Exchange

FILTER Close MATLAB Central Files Authors My File Exchange

Filter by Source

Community	48,380
MathWorks	337

Get and Share Code

Share free, open-source MATLAB and Simulink code. Publish your code to help others.

Brain Observatory Toolbox

README BSD-2-Clause license

Open in MATLAB Online File Exchange

Unfollow

View as: Public

Viewing the README and repositories as a public

Recent

- MATLAB 11,693
- Using Simulink 845
- Simulink 845
- Physical Modeling 2,211
- Event-Based Modeling 66
- Real-Time Simulation and Testing 33
- Workflows
- Parallel Computing 188
- Reporting and Database Access 202
- Systems Engineering 25
- Code Generation 329
- Application Deployment 121
- Verification, Validation, and Test 161
- Cloud Capabilities 70
- Teaching and Learning 3
- Applications
- AI, Data Science, and Statistics 3,090
- Mathematics and Optimization 2,468
- Signal Processing 2,752
- Image Processing and Computer Vision 3,810
- Control Systems 1,414
- Test and Measurement 957
- RF and Mixed Signal 244
- Wireless Communications 1,090
- Radar 610
- Robotics and Autonomous Systems 412
- FPGA, ASIC, and SoC Development 311
- Computational Finance 755

Thin wall sections Class 1, 2, 3 and 4

3 Downloads

Beam column

13 Downloads

Community Toolboxes

PIVlab

PIVlab - particle image velocimetry (PIV) tool with GUI

Easy to use, GUI based tool to capture, analyze, validate, postprocess, visualize and simulate

GUI Layout T

Layout manager graphical user int

A MATLAB toolbox for accessing and using the neural recording public datasets from the [Allen Brain Observatory](#).

Get oriented and get started with 3 lines of code. You can:

- Open in MATLAB Online
- Enter `>>bot.README` on your own local/cloud [installation](#)

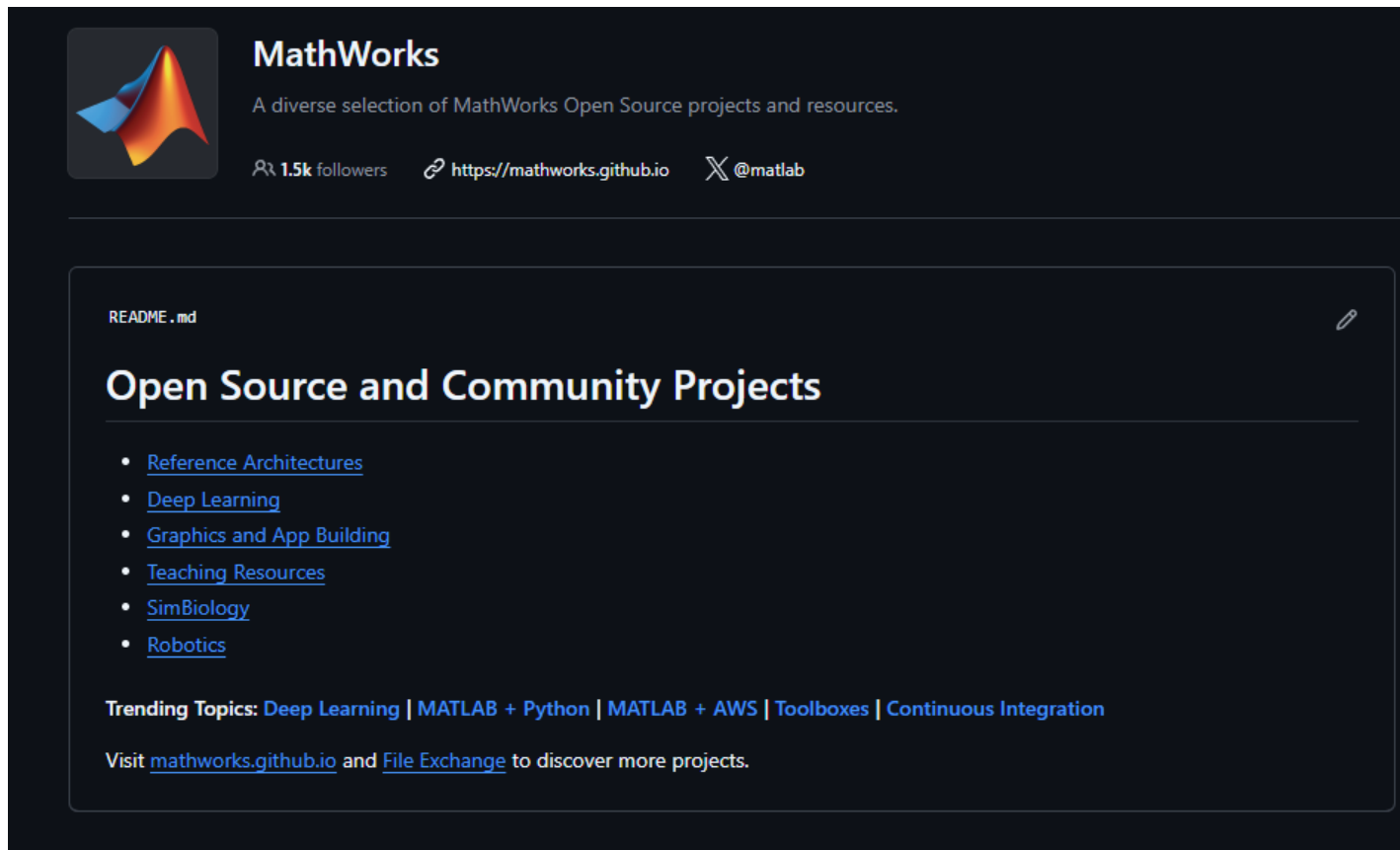
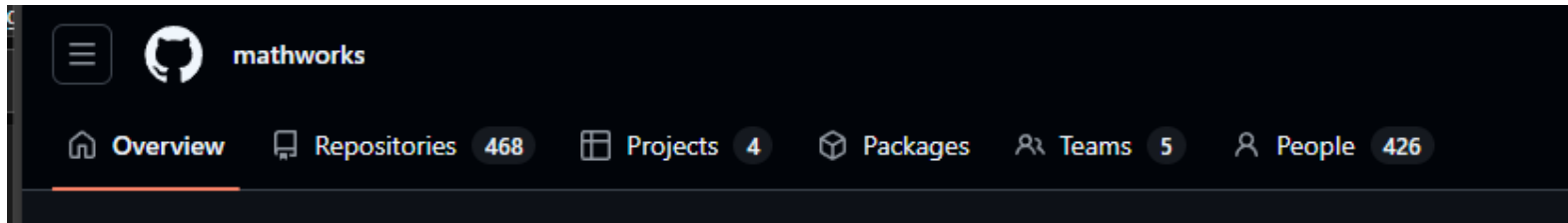
Either will orient you to several **live script examples** available to guide new users, including **demos** of neural data analysis & **tutorials** covering Brain Observatory Toolbox concepts & operations.

You can also individually view (👁) or run (▶) these examples on MATLAB Online:

Languages

LAB HTML C Shell

MathWorks on GitHub



Open in MATLAB Online from GitHub

mulusoy Update README.md d8b37d0 · last year 🕒 24 Commits

File/Folder	Commit Message	Time
animations	update copyright	3 years ago
helperfunctions	Copyright update	3 years ago
models	Copyright update	3 years ago
resources/project	Add resources	3 years ago
Kalman_Filter_Virtual_Lab.mlx	Update lab mlx	3 years ago
LICENSE.md	Copyright update	3 years ago
README.md	Update README.md	last year
SECURITY.md	add files	3 years ago
myMeasurementFcn.m	Copyright update	3 years ago
myStateTransitionFcn.m	Copyright update	3 years ago
pend.png	Create repo	3 years ago
project.prj	Create repo	3 years ago

[README](#) [License](#) [Security](#)

Kalman Filter Virtual Lab

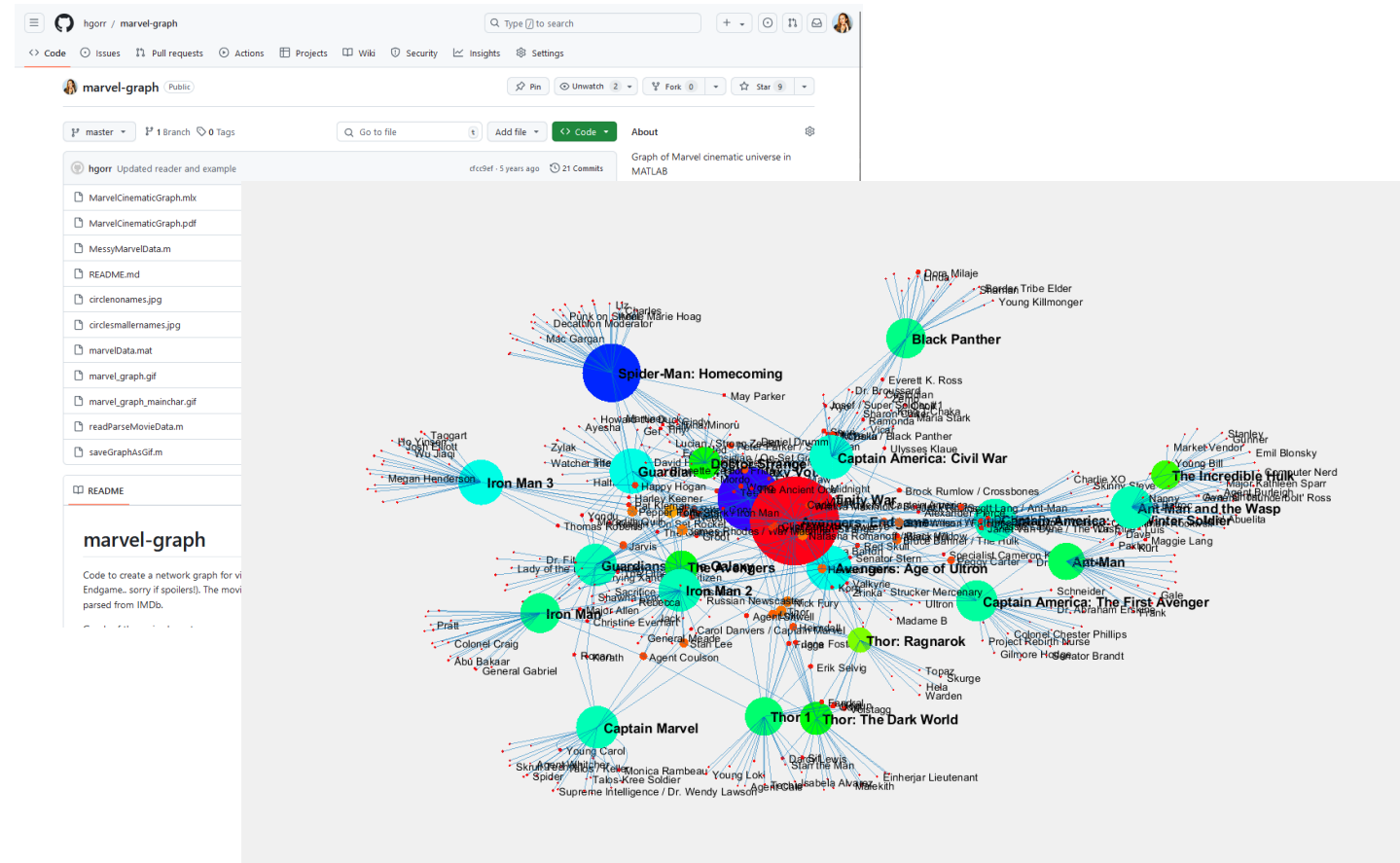
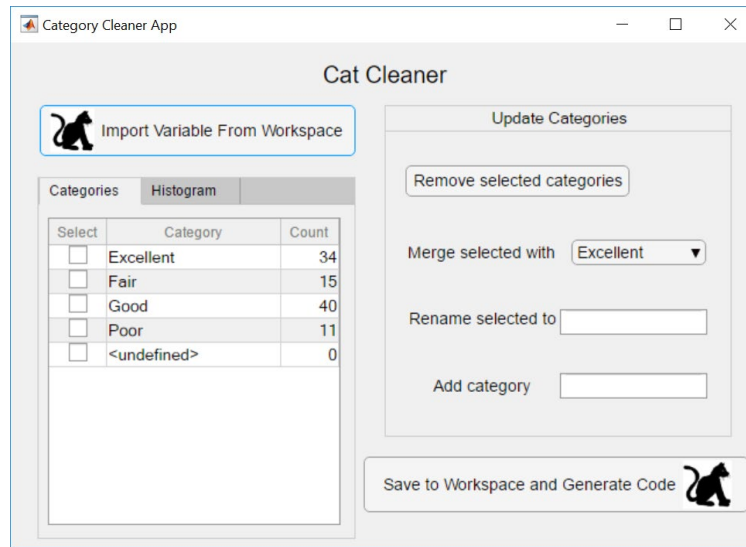
[File Exchange](#)

[Open in MATLAB Online](#)

The Kalman Filter virtual laboratory contains interactive exercises that let you study linear and extended Kalman filter

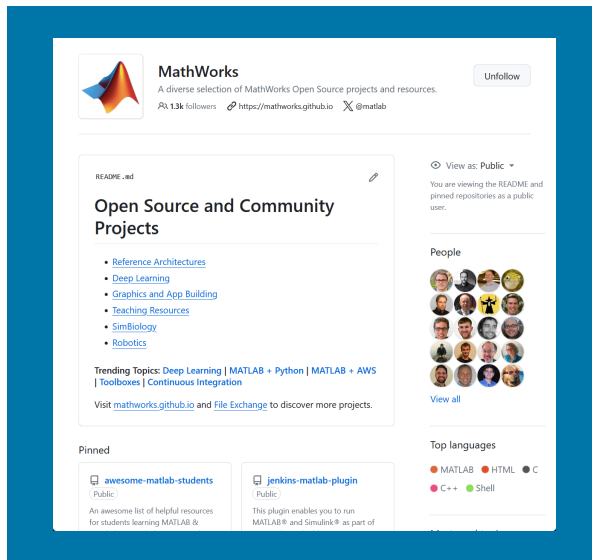
Have you shared MATLAB and Simulink work through
FileExchange / GitHub?

Have you shared MATLAB and Simulink work through FileExchange / GitHub?

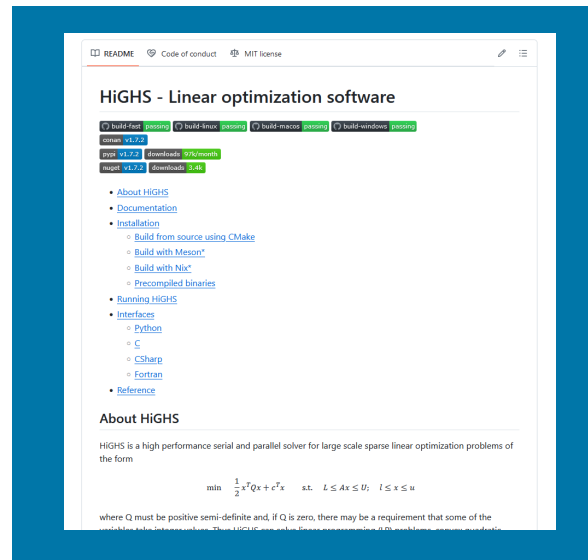


MathWorks and OSS work together in three ways

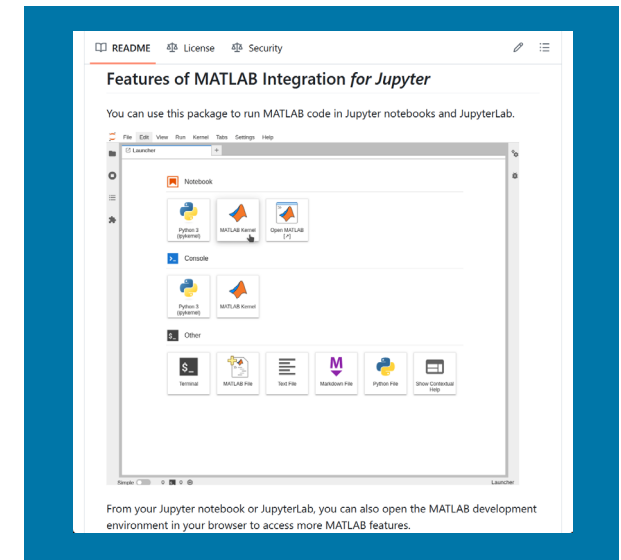
Open Source (On Top Of)



Open Source (Within)



Open Source (Alongside)



MathWorks has been a contributor to LAPACK for many years

$$\begin{bmatrix} \mathbf{L} & \mathbf{A} & \mathbf{P} & \mathbf{A} & \mathbf{C} & \mathbf{K} \\ \mathbf{L} & \mathbf{-A} & \mathbf{P} & \mathbf{-A} & \mathbf{C} & \mathbf{-K} \\ \mathbf{L} & \mathbf{A} & \mathbf{P} & \mathbf{A} & \mathbf{-C} & \mathbf{-K} \\ \mathbf{L} & \mathbf{-A} & \mathbf{P} & \mathbf{-A} & \mathbf{-C} & \mathbf{K} \\ \mathbf{L} & \mathbf{A} & \mathbf{-P} & \mathbf{-A} & \mathbf{C} & \mathbf{K} \\ \mathbf{L} & \mathbf{-A} & \mathbf{-P} & \mathbf{A} & \mathbf{C} & \mathbf{-K} \end{bmatrix}$$

The LAPACK project is also sponsored in part by [MathWorks](#) and [Intel](#) since many years.

Thanks to all our contributors!

- Special Thanks to the Mathworks team: Penny Anderson, Mary Ann Freeman, Bobby Cheng, Pat Quillen, Christine Tobler, Heiko Weichelt.
- Special Thanks to the AIMdyn Inc. team Igor Mezic and Maria Fonoberova.

HiGHS is another great example of OSS (within) MATLAB

HiGHS - High Performance Optimization Software

Warning
This HiGHS documentation is a work in progress.

HiGHS is software for the definition, modification and solution of large scale sparse linear optimization models. HiGHS is freely available from [GitHub](#) under the MIT licence and has no third-party dependencies.

Specification

HiGHS can solve linear programming (LP) models of the form:

$$\begin{aligned} \min \quad & c^T x \\ \text{subject to} \quad & L \leq Ax \leq U \\ & l \leq x \leq u, \end{aligned}$$

as well as mixed integer linear programming (MILP) models of the same form, for which some of the variables must take integer values.

HiGHS also solves quadratic programming (QP) models, which contain an additional objective term $\frac{1}{2}x^T Q x$, where the Hessian matrix Q is positive semi-definite. HiGHS cannot solve QP models where some of the variables must take integer values.

Read the [Terminology](#) section for more details.

Using HiGHS

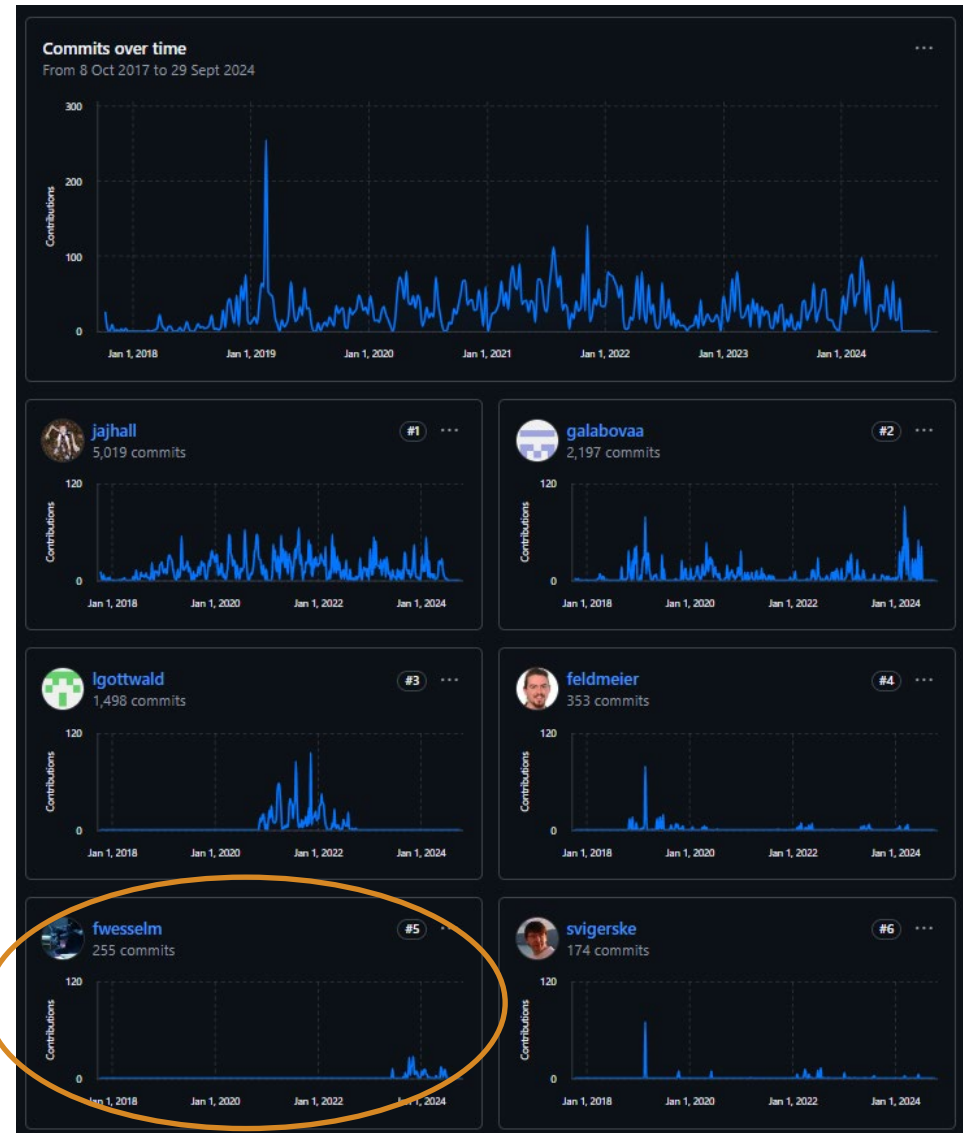
HiGHS can be used as a standalone executable on Windows, Linux and MacOS. There is also a C++11 library that can be used within a C++ project or, via its C, C#, FORTRAN, Julia, and Python interfaces.

Get started by following [Install HiGHS](#).

Overview

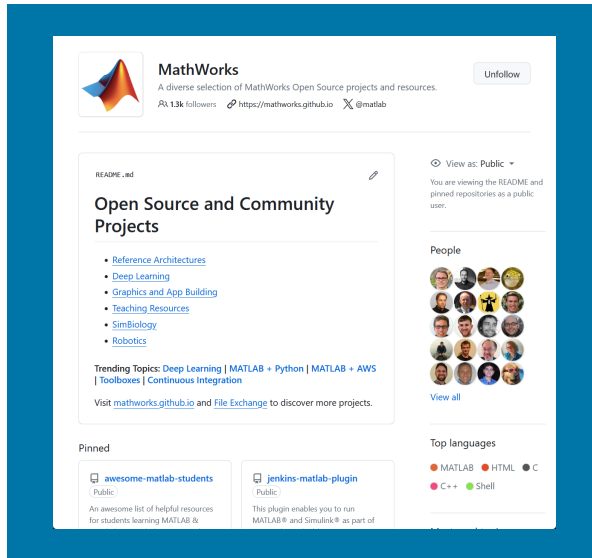
The standalone **executable** allows models to be solved from **MPS** or **(CPLEX) LP** files, with full control of the HiGHS run-time options, and the solution can be written to files in human and computer-readable formats.

The HiGHS shared library allows models to be loaded, built and modified. It can also be used to extract solution data and perform other operations relating to the incumbent model. The basic functionality is introduced via a [Guide](#), with links to examples of its use in the Python interface [highspy](#). This makes use of the C++ structures and enums, and is as close as possible to the native C++ library calls. These can be studied via the [C++ header file](#).

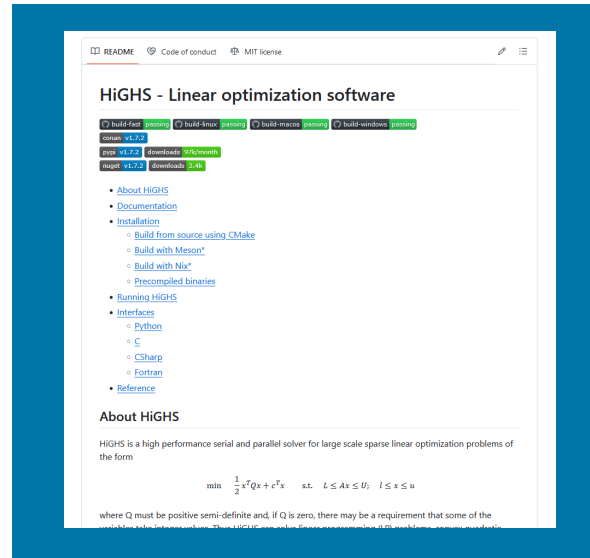


MathWorks and OSS work together in three ways

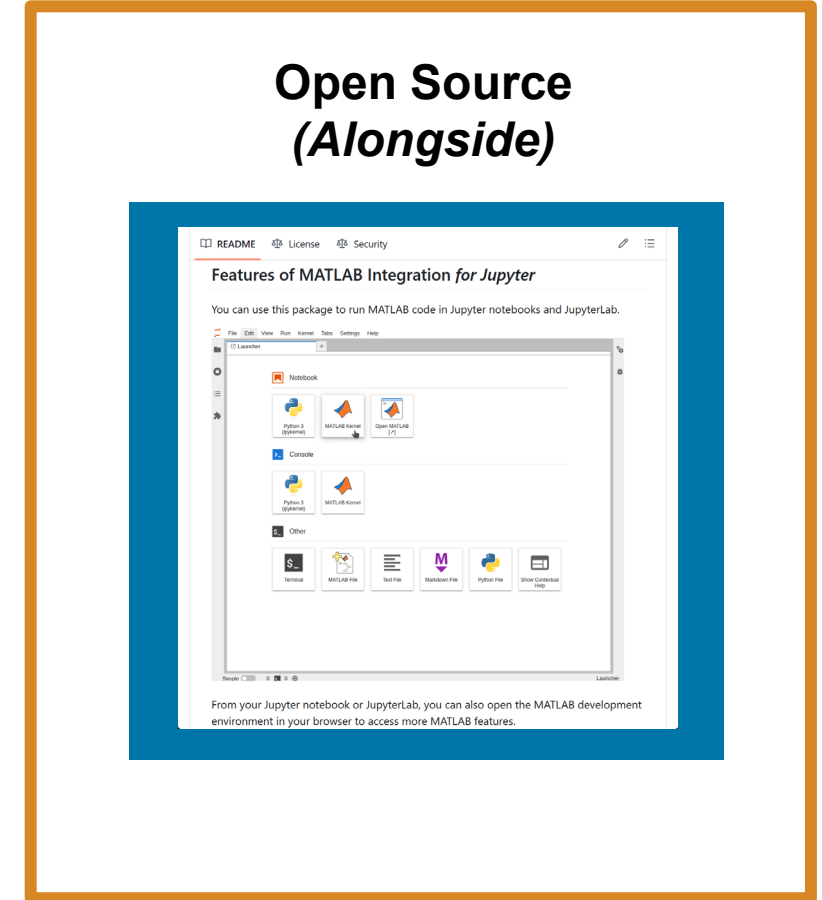
Open Source (On Top Of)



Open Source (Within)



Open Source (Alongside)



MathWorks maintains APIs for Python, C++, TensorFlow, PyTorch, and many more

Predicting True Air Speed from Other Sensors

This example shows how to use historical data to train a regression model that is capable of predicting the True Air Speed (TAS) of a flight from the measurements of other sensors. Such models can be useful in controls applications where it may be desirable to use a regression model as a nonlinear state estimator for a non-observable or costly-to-observe state. These types of models can also be used as surrogate models in simulations and trade-studies, in cases where a physics-based model is too complex to create or takes too long to simulate.

Import data from Excel

Start by reading in the data with code generated by the Import Live Task. Also remove data recorded when the aircraft was stationary on the ground as that will not be useful for predicting airspeed.

```
1 FlightData = readinetable("FlightData.xlsx");
2 % perform simple clean up of stationary ground data
3 FlightData = FlightData(FlightData.TrueAirSpeed >= 10 , :);
4 head(FlightData)
```

Time	Altitude	LatitudePosition	LongitudePosition	OilPressure	OilTemperature	TrueAirSpeed
02-Jun-2001 05:50:05	203	44.891	-63.508	90.354	58.595	100.19
02-Jun-2001 05:50:06	201	44.891	-63.509	90.354	58.595	102.81
02-Jun-2001 05:50:07	197	44.891	-63.509	90.354	58.595	107.75
02-Jun-2001 05:50:08	194	44.892	-63.511	92.780	58.595	120.81
02-Jun-2001 05:50:09	191	44.892	-63.511	90.354	58.595	134.19
02-Jun-2001 05:50:10	187	44.892	-63.511	90.354	58.595	118.25
02-Jun-2001 05:50:11	182	44.893	-63.512	90.354	59.938	121.56
02-Jun-2001 05:50:12	177	44.893	-63.512	90.354	59.938	124.31

Visualize data

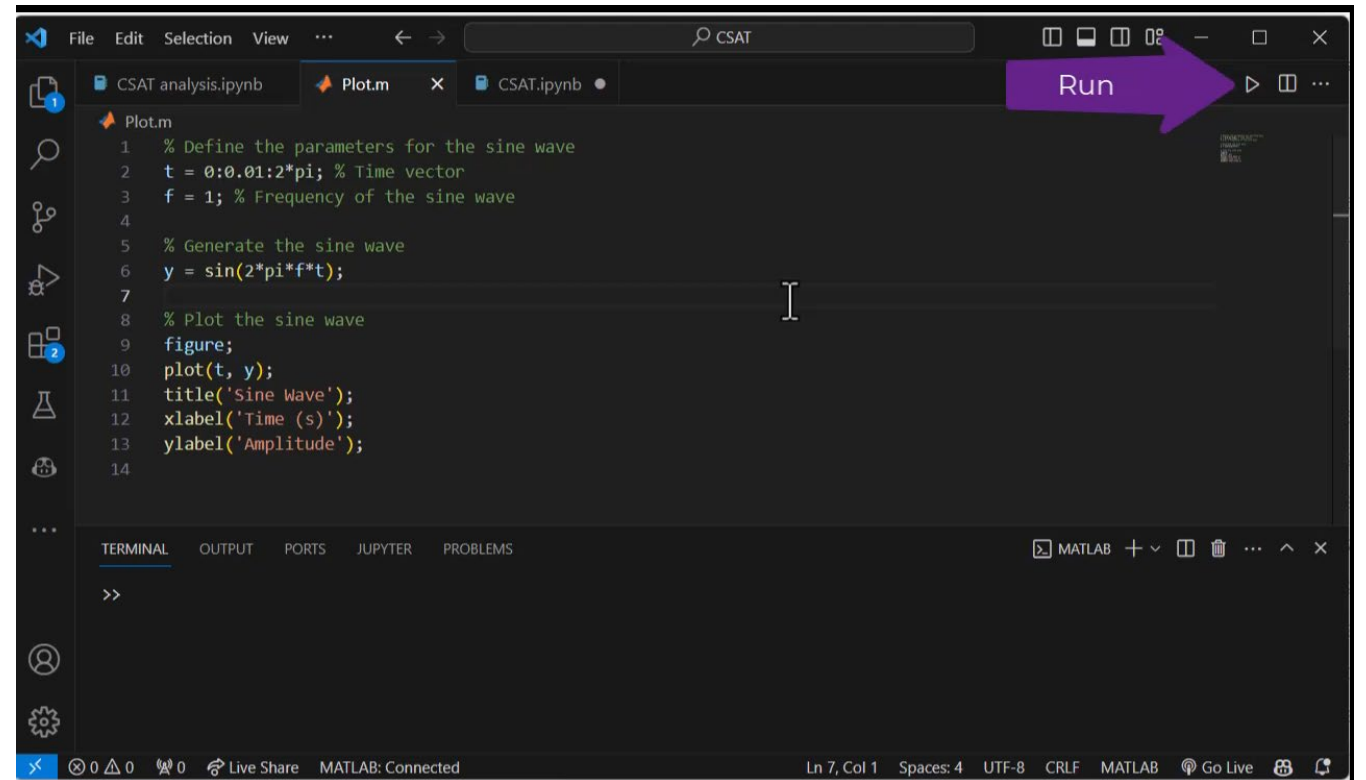
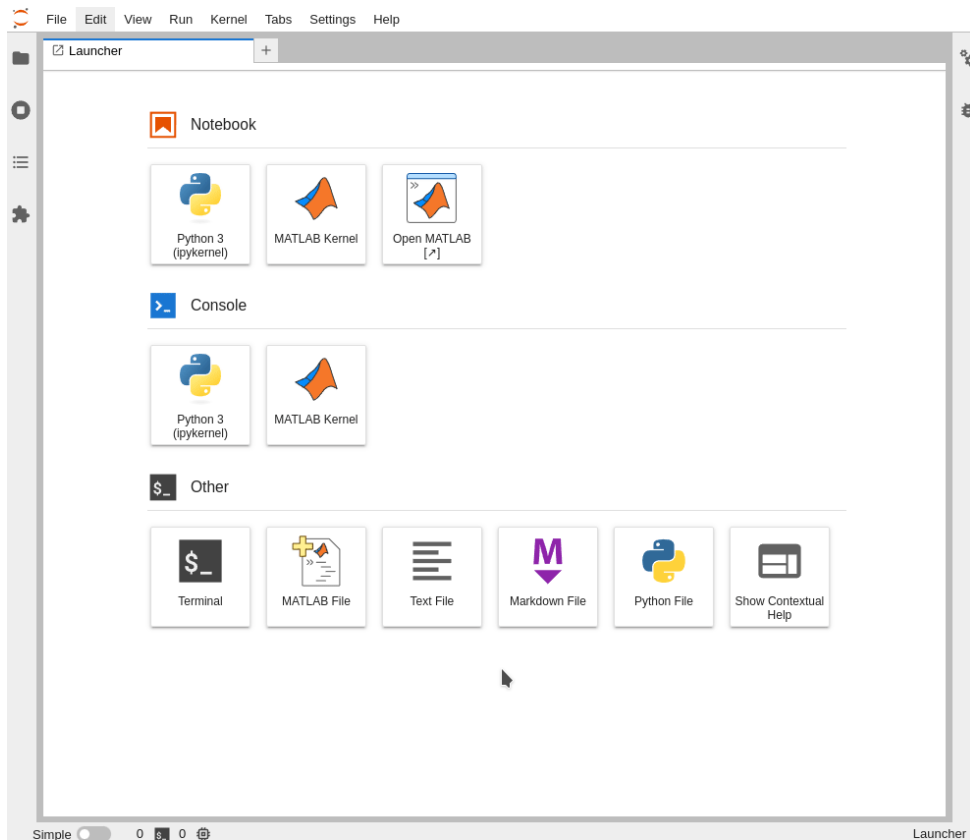
We can see the flight path by viewing a geoplot of latitude and longitude.

```
5 % Create geoplot of FlightData.LatitudePosition and FlightData.LongitudePosition
6 h = geoplot(FlightData.LatitudePosition,FlightData.LongitudePosition,"LineWidth",2,"Color","red");
7
8 % Add title
9 title("LatitudePosition vs. LongitudePosition")
10
11 geobasemap colorterrain
```



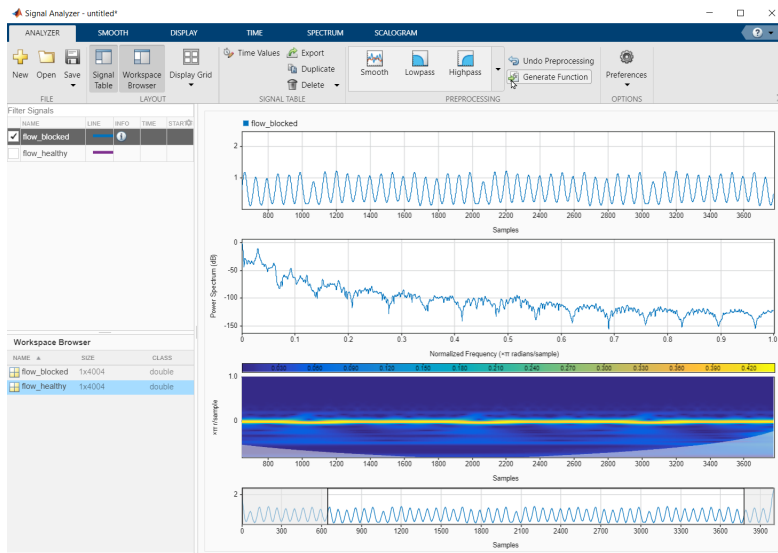
```
1 from IPython.core.magic import (Magic, magic_class, line_magic,
2 cell_magic, line_cell_magic)
3 from IPython.core.magic_arguments import (argument, # type: ignore
4 argument_group,
5 magic_arguments,
6 parse_argstring)
7 import matlab.engine
8 import io
9 import numpy as np
10
11 @magic_class
12 class MATLABMagic(Magics):
13
14     def __init__(self, shell):
15         # You must call the parent constructor
16         super(MATLABMagic, self).__init__(shell)
17         self.eng = matlab.engine.start_matlab()
18         self.evalnum = 0;
19
20     def convert(self, var):
21         """Autoconversion rules from MATLAB -> Python
22
23         """
24         if isinstance(var, matlab.double):
25             return(np.array(var))
26
27     @magic_arguments()
28     @argument('-o', '--output', action='append')
29     @argument('-i', '--input', action='append')
30     @argument('-q', '--quiet', action='store_true')
31     @argument('-n', '--noconvert', action='store_true')
32     @line_cell_magic
33     def MATLAB(self, line, cell=None):
34         args = parse_argstring(self.MATLAB, line)
35         if cell is None: # This is a line magic
36             self.evalnum = self.evalnum+1;
37             return self.eng.eval(line)
38         else: # This is a cell magic
39             # Increment evaluation number
40             self.evalnum = self.evalnum + 1;
41
42         # Set up I/O
43         out = io.StringIO()
44         err = io.StringIO()
45
46         # Push requested variables from Python to MATLAB
47         if args.input:
48             for var in ','.join(args.input).split(',');
```

Users are thrilled about the integration with Jupyter and VSCode



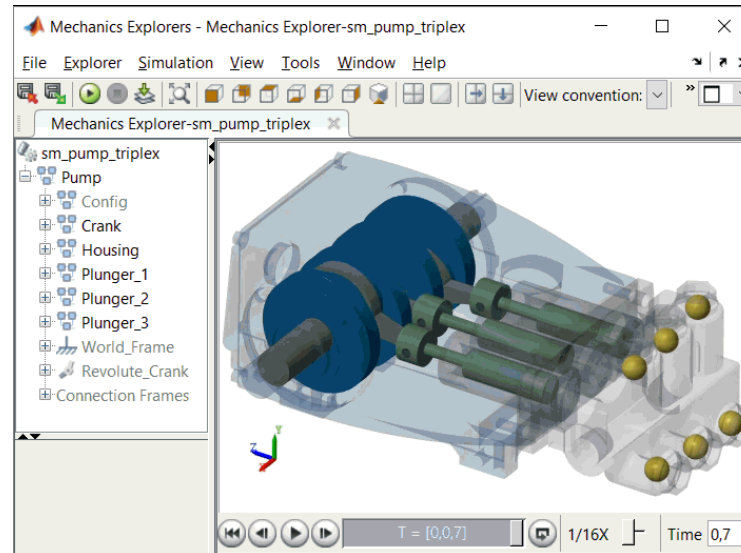
Top ways users are combining MATLAB and Python

Use Best in Class Tools



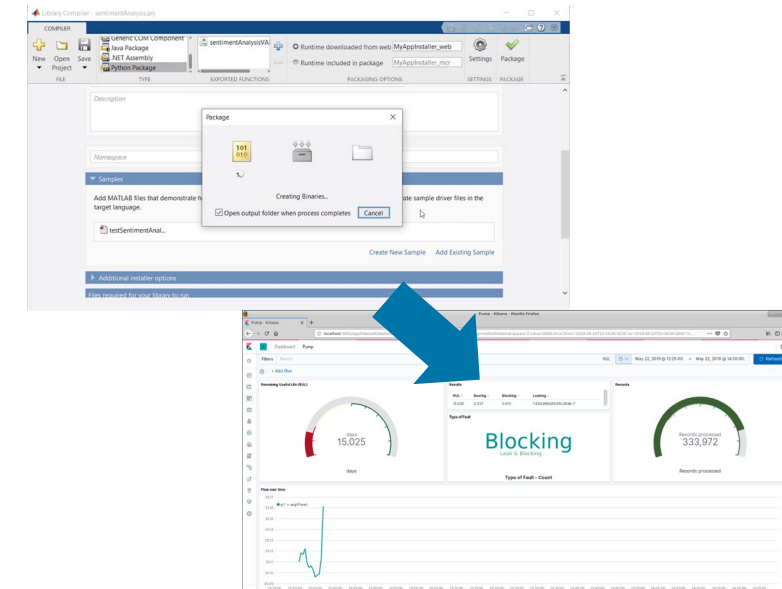
Use MATLAB apps, generate code, and combine with Python (and vice versa)

Collaborate Across Teams



Engineers, data scientists, and IT teams can collaborate with their preferred tools

Deploy Easily



Simplify deployment of applications built in MATLAB, Python, or both

Example: Using MATLAB and Python Together

Session Information

Presenter Profile

x

Algorithm Development and Data Analysis

The CLASSIX Story: Developing the Same Algorithm in MATLAB and Python Simultaneously

Stefan Güttel, University of Manchester

Dr. Mike Croucher, MathWorks

Thursday, November 14, 2024 | 1:00 PM - 1:25
PM EST

[Register/Log in](#) to save session

CLASSIX is a fast and explainable machine learning algorithm developed by researchers at The University of Manchester. In this presentation, hear about how it was originally written in Python and then ported to MATLAB® for fun by Mike Croucher of MathWorks following an interoperability demo. Since MATLAB's profiler is more informative than anything in the Python world, this allowed the original researchers to further refine the algorithm and improve the original Python package, speeding it up by a factor of 50. Lessons from the Python package were then brought back to the MATLAB version for an additional 10x increase in speed. The work also identified a performance bottleneck in MATLAB that didn't exist in Python and provided a benchmark that allowed it to be resolved in the latest version of MATLAB. Developing the same algorithm in two environments simultaneously provided useful insights and resulted in better native Python and MATLAB packages. The MATLAB version is currently the faster of the two.

Thurs November 14, 2024
1 – 1:25PM EST

Organizations need to integrate with DevOps/IT/OT Platforms

The screenshot shows the GitHub profile for 'MathWorks Reference Architectures'. The profile includes a repository named 'MathWorks Reference Architectures' with a README file. The README content is as follows:

```
README .md

MathWorks Reference Architectures

View by platform or cloud technology:

• AWS
• Azure
• GCP
• Jupyter
• Docker
• Kubernetes

Visit MATLAB and Simulink in the Cloud to learn more.
```

The repository page also features a 'Pinned' section with two repositories:

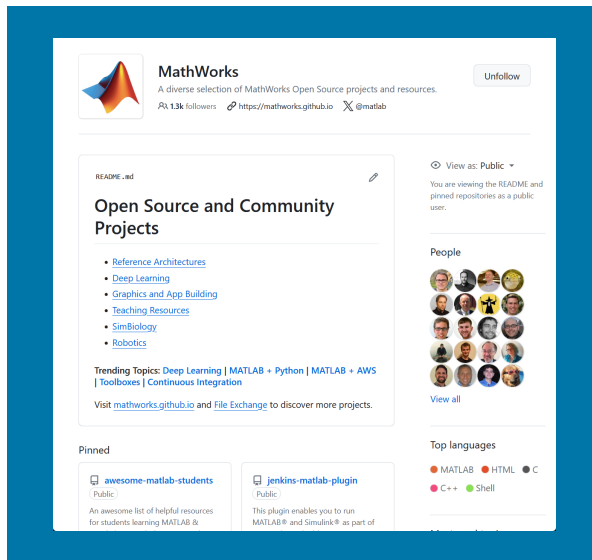
- matlab-dockerfile** (Public): Create a docker container that contains a MATLAB install. Languages: Python. Stars: 335, Forks: 96.
- matlab-on-aws** (Public): Stand up a MATLAB desktop with Remote Desktop access using AWS CloudFormation. Languages: HCL. Stars: 107, Forks: 44.

Additional features on the profile page include a 'People' section with 47 members, a 'Top languages' section showing MATLAB, Python, Shell, PowerShell, and Dockerfile, and a 'Most used topics' section with tags for matlab-aws, matlab, matlab-azure, aws, and azure.

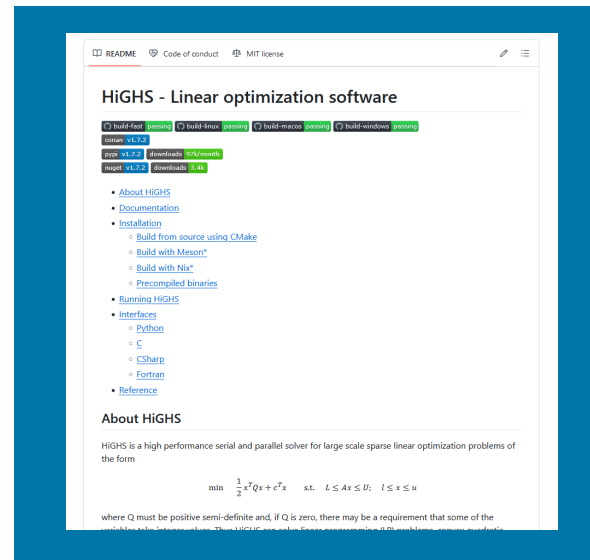
What's next for MathWorks and OSS?

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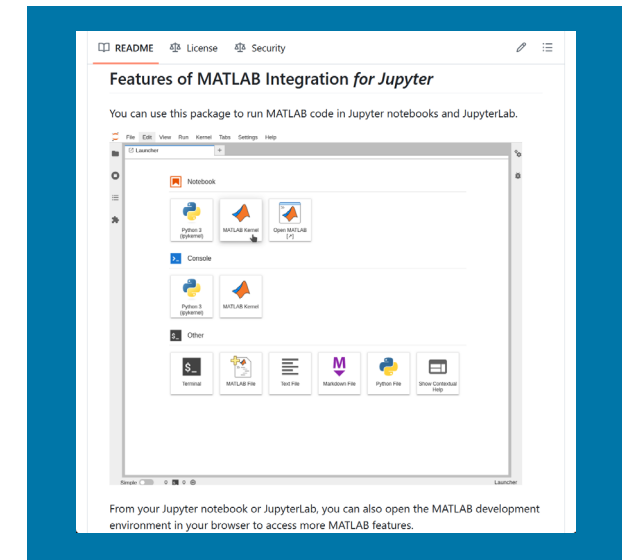
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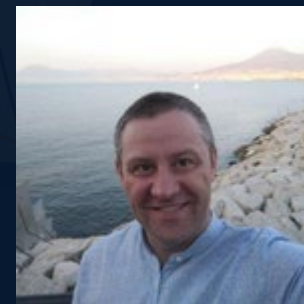
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Mike Croucher, PhD



Mike Croucher
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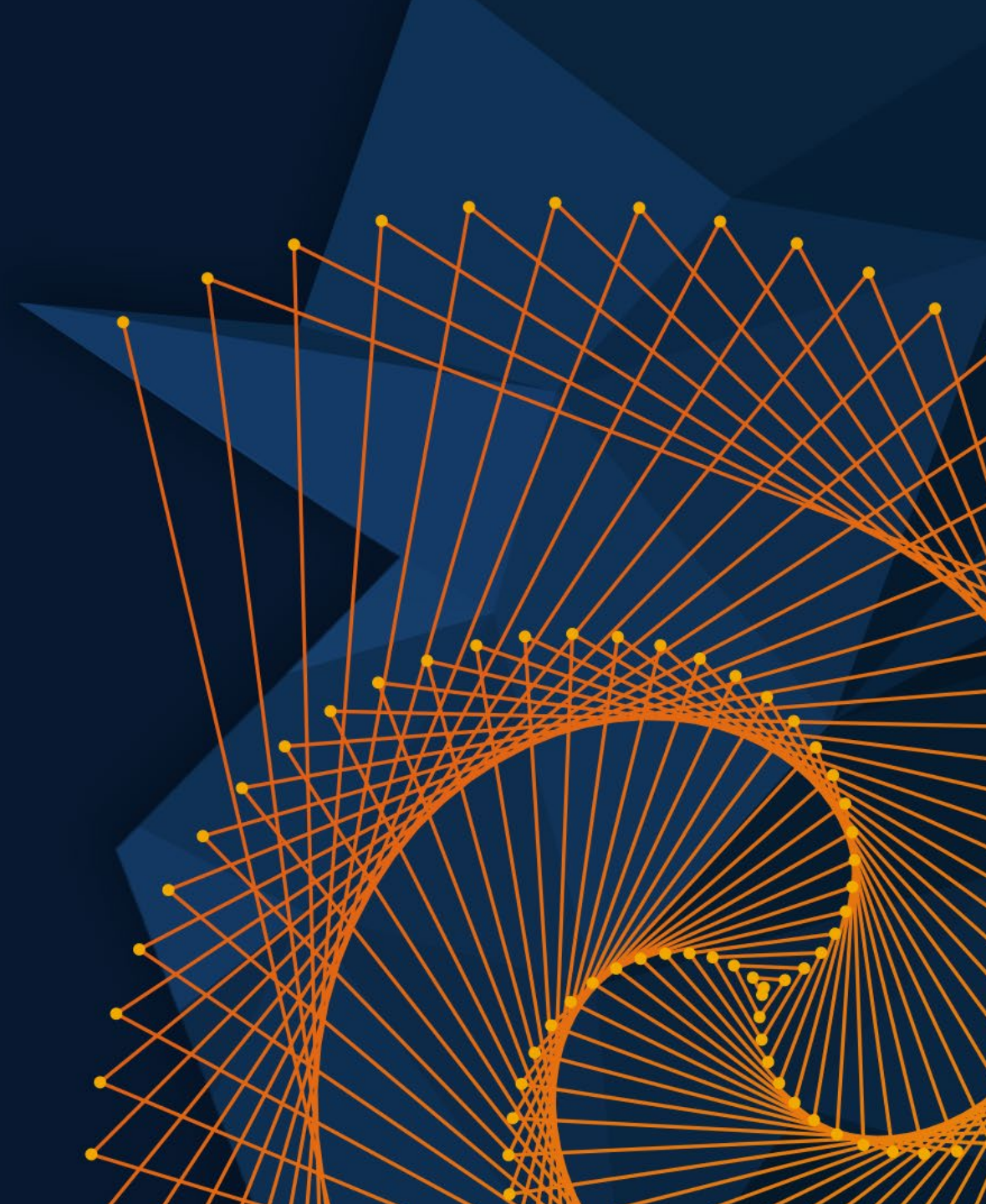
MATLAB

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Questions?



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