

Image processing with MATLAB

@INAF

Giuseppe Ridinò - gridino@mathworks.com
Senior Application Engineer

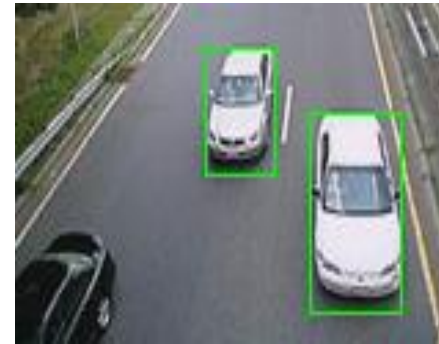
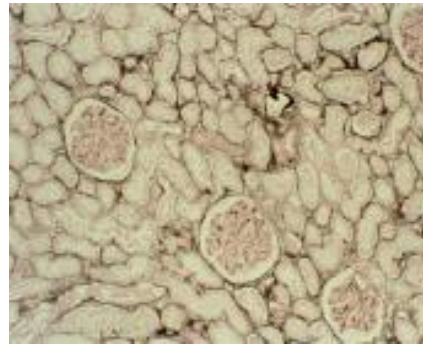
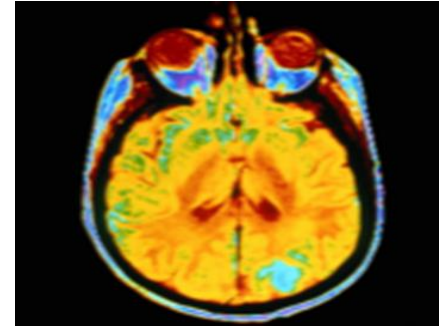
22 Maggio 2019

Agenda

- Introduction
- Quick intro to MATLAB
- Image Processing with MATLAB
- Managing large image sets
- What's New
- Wrap-up

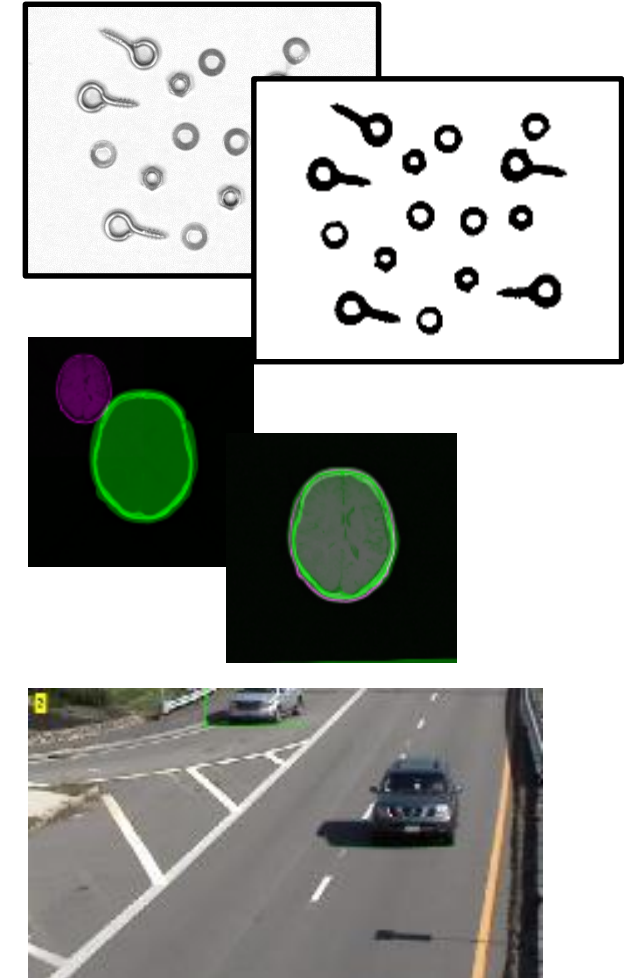
Applications: Image and Video Processing

- Medical imaging
- Surveillance
- Robotics
- Automotive safety
- Consumer electronics
- Geospatial computing
- Machine vision
- Science research
- and more...



Challenges with Imaging and Vision Systems

- Reading and writing to various file formats
- Create and test algorithms with what-if scenarios
- Identifying causes of algorithm failure
- Visualizing images and intermediate results
- Processing large images with limited memory
- Executing algorithms faster



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» 7 Reasons to Use MATLAB

Research Highlights

Images of remotely sensed subsurface 8:51

MATLAB Analysis of Prestack Seismic: Using MATLAB Beyond the Geophysicist's Sandbox (Highlights)

The Robot Made Me Do It: How Robots are Changing the Lives of Children with Disabilities

Read story

MIT researchers magnify nature

Read story

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Neuroscience

Overview Use Cases Resources Latest Features

Use Cases

Explore how MATLAB is used for neuroscience applications

Human Brain Mapping

Use cases illustrating analysis of macroscopic data modalities,

Interictal (normal) data

Preictal (pre-seizure) data

Channel

Time, s (log)

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Earth, Ocean, and Atmospheric Sciences

Overview Working with Geoscience Data Teaching Geoscience with MATLAB Seismology

Seismology: An Active MATLAB Community

Seismologists around the world use MATLAB to study seismic events, from early analysis of data from sensor sites.

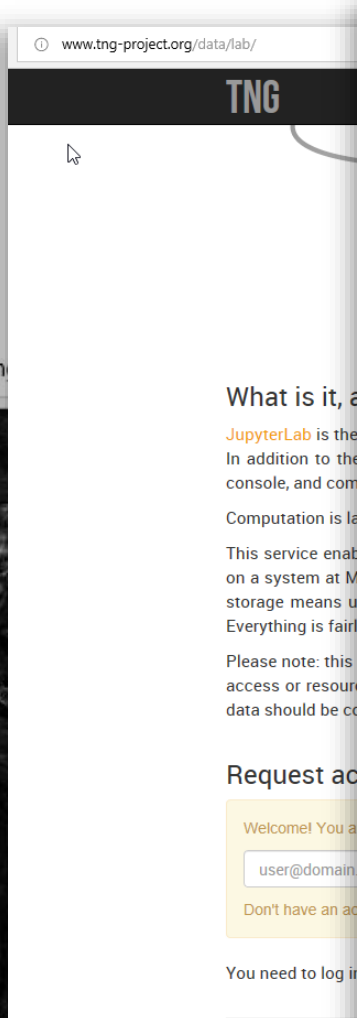
Explore how scientists use MATLAB in seismology, download the code, and learn more.

GISMO: MATLAB Toolbox for Scientific Research in Seismology and Infrasound (File Exchange)

MATLAB for Analyzing and Visualizing Geospatial Data (Video)

BRTT Technologies Antelope Software (Toolbox)

TNG Data Project and Jupyterlab Interface



Public Data Access **Overview** / Example Scripts

We provide example scripts for reading the data files of the Illustris[TNG] simulations. They are available in the **Public Data Access** section of the website. This includes:

- (i) reading a given particle type and/or data field from the snapshot files,
- (ii) reading only the particle subset from the snapshot corresponding to a halo or subhalo,
- (iii) extracting the full subtree or main progenitor branch from either SubLink or LHaloTree for a given subhalo,
- (iv) walking a tree to count the number of mergers,
- (v) reading the entire group catalog at one snapshot,
- (vi) reading specific fields from the group catalog, or the entries for a single halo or subhalo.

We expect they will provide a useful starting point for writing any analysis task, and intend them as a reference that they can be quickly understood and extended.

Currently available are: **Python** (3.6+ recommended), **IDL** (8.0+ required), and **Matlab** (R2013a+ required). We provide example scripts for each language. For that language.

[Python](#) [IDL](#) [Matlab](#)

In all cases, these scripts assume that you have downloaded local copies of the relevant files. Paths are provided in to all read functions. The locations of group catalog files, snapshot files, and merger trees files are provided in `snapPath()`, and `treePath()`. These can be modified as necessary to point to your local files, but it is recommended to use the default paths.

- **TNG100-1/**
- **TNG100-1/output/**
 - group catalogs: `TNG100-1/output/groups_099/fof_subhalo_tab_099.*.hdf5`
 - snapshots: `TNG100-1/output/snapdir_099/snap_099.*.hdf5`
- **TNG100-1/postprocessing/**
 - offsets: `TNG100-1/postprocessing/offsets/offsets_*.hdf5`
 - SubLink mergertree: `TNG100-1/postprocessing/trees/SubLink/tree_extended.*.hdf5`
 - other catalogs: `TNG100-1/postprocessing/catalog_name/files*.hdf5`

Project: <http://www.tng-project.org/>
Jupyterlab: <http://www.tng-project.org/data/lab/>
Scripts: <http://www.tng-project.org/data/docs/scripts/>



7

LIGO: Spot 1st-Ever Gravitational Waves with MATLAB


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Confirming the First-Ever Detection of Gravitational Waves by Analyzing Laser Interferometer Data


By Matthew Evans, MIT

At about 7 a.m. on September 14, 2015, I received an email from my colleagues in Europe notifying me of an extraordinary event: Two detectors in the Laser Interferometer Gravitational-Wave Observatory (LIGO) had simultaneously identified what appeared to be a transient gravitational-wave signal—a “ripple” in space-time.

As a member of the team that developed the LIGO instrumentation, I was excited but also slightly apprehensive. I was excited because if the signal was authentic, it would mark the first time that a gravitational wave had ever been directly observed, confirming Albert Einstein’s prediction of their existence, made a century ago. It would also mark the first observation of a pair of black holes merging to form a single black hole. My colleagues and I were apprehensive, however, because we did not yet know whether the signal came from a genuine gravitational wave or was merely the result of some error in the LIGO control system and instrumentation.


I immediately downloaded the LIGO data onto my laptop, opened MATLAB®, and began analyzing the recorded signals and visualizing the data. In the months that followed, my LIGO colleagues and I confirmed that we had, in fact, detected a gravitational wave, and identified its source: the cataclysmic collision of two black holes with a combined mass 60 times greater than our sun in a galaxy more than one billion light years away (Figure 1).




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4 MAR Amaze, A Maze Generator

18 FEB Experiments with Variable Format Half Precision

18 JAN Floating Point Arithmetic Before IEEE 754

[Categories](#)

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Dark Energy Gravitational Waves

Posted by [Cleve Moler](#), April 1, 2016

Recent theoretical, observational and computational results establish the dawn of the universe affect the clock rate of silicon digital process

[Contents](#)

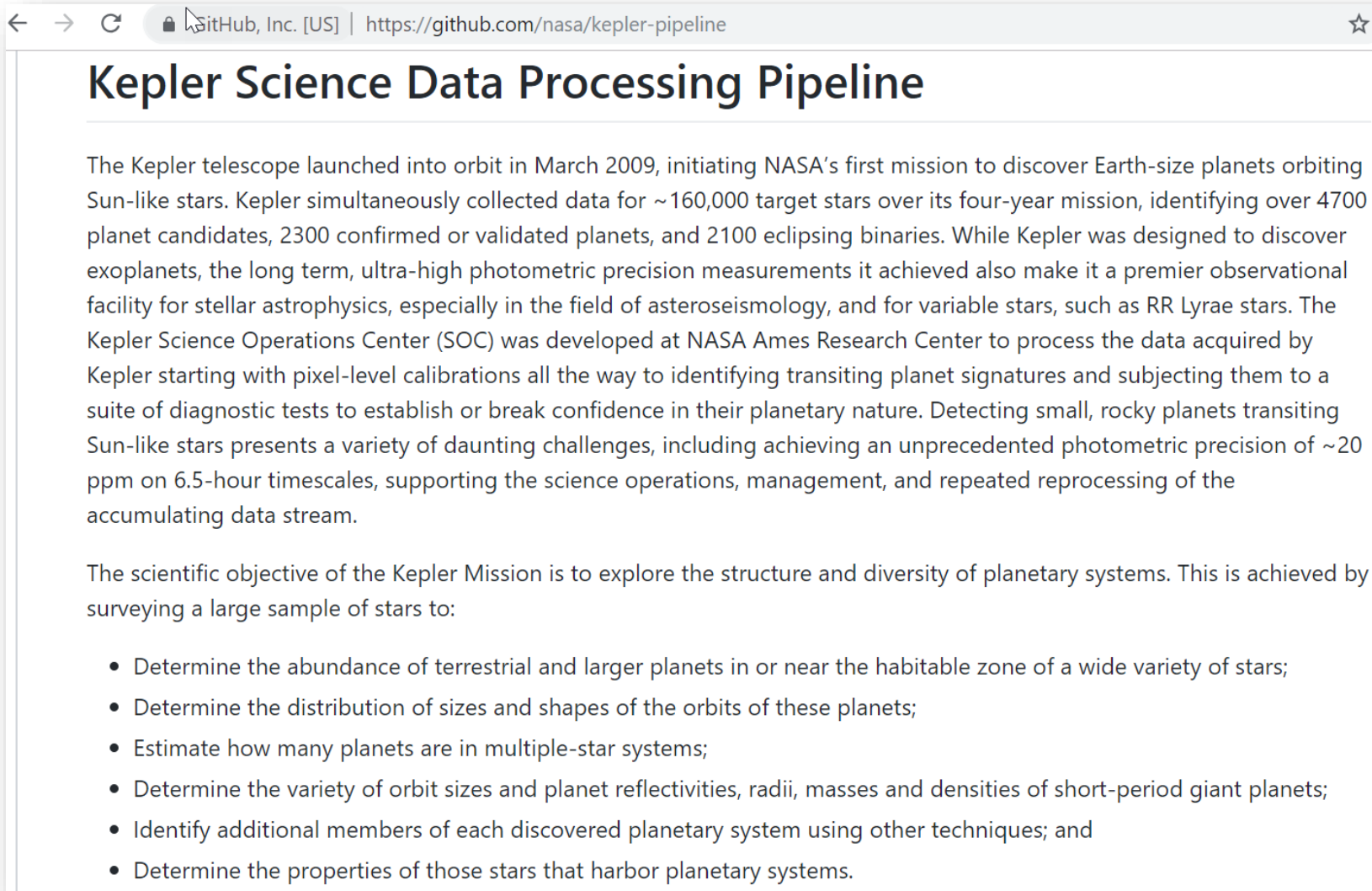
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- [LIGO Gravitational Waves](#)
- [Dark Energy Gravitational Waves](#)
- [The signal](#)
- [The sound](#)
- [The spectrogram](#)
- [Expectations](#)

[Ed Plum](#)

[Article](#)
[Blog post](#)

NASA Build Kepler Pipeline tools with MATLAB

download: github.com/nasa/kepler-pipeline



The screenshot shows a web browser window with the address bar displaying "GitHub, Inc. [US] | https://github.com/nasa/kepler-pipeline". The main heading of the page is "Kepler Science Data Processing Pipeline". Below the heading, there is a paragraph of text describing the Kepler telescope mission and the Science Operations Center (SOC). At the bottom of the page, there is a bulleted list of scientific objectives.

Kepler Science Data Processing Pipeline

The Kepler telescope launched into orbit in March 2009, initiating NASA's first mission to discover Earth-size planets orbiting Sun-like stars. Kepler simultaneously collected data for ~160,000 target stars over its four-year mission, identifying over 4700 planet candidates, 2300 confirmed or validated planets, and 2100 eclipsing binaries. While Kepler was designed to discover exoplanets, the long term, ultra-high photometric precision measurements it achieved also make it a premier observational facility for stellar astrophysics, especially in the field of asteroseismology, and for variable stars, such as RR Lyrae stars. The Kepler Science Operations Center (SOC) was developed at NASA Ames Research Center to process the data acquired by Kepler starting with pixel-level calibrations all the way to identifying transiting planet signatures and subjecting them to a suite of diagnostic tests to establish or break confidence in their planetary nature. Detecting small, rocky planets transiting Sun-like stars presents a variety of daunting challenges, including achieving an unprecedented photometric precision of ~20 ppm on 6.5-hour timescales, supporting the science operations, management, and repeated reprocessing of the accumulating data stream.

The scientific objective of the Kepler Mission is to explore the structure and diversity of planetary systems. This is achieved by surveying a large sample of stars to:

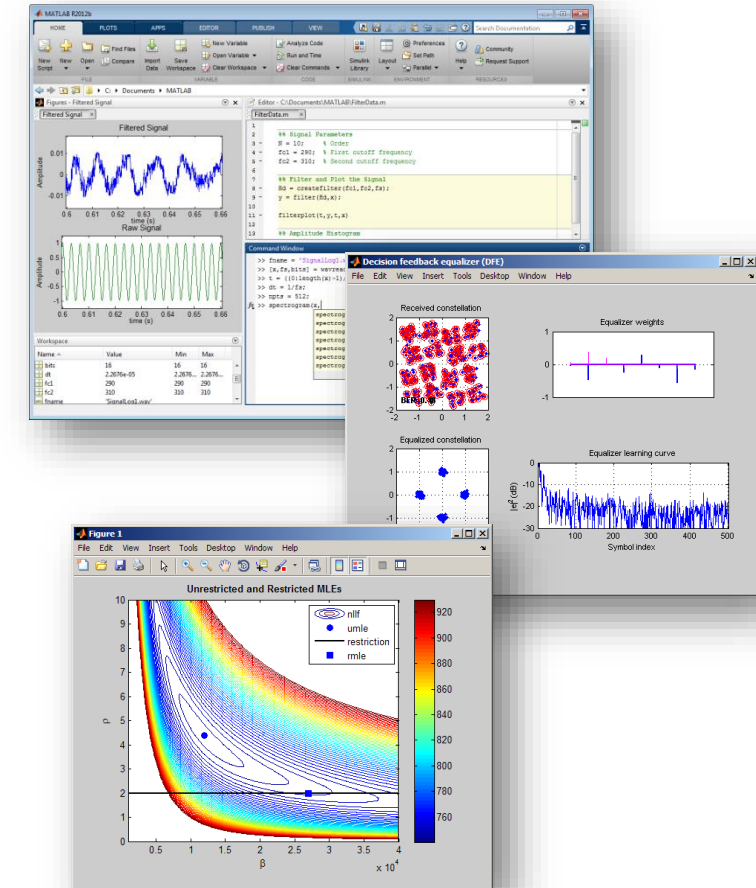
- Determine the abundance of terrestrial and larger planets in or near the habitable zone of a wide variety of stars;
- Determine the distribution of sizes and shapes of the orbits of these planets;
- Estimate how many planets are in multiple-star systems;
- Determine the variety of orbit sizes and planet reflectivities, radii, masses and densities of short-period giant planets;
- Identify additional members of each discovered planetary system using other techniques; and
- Determine the properties of those stars that harbor planetary systems.

Agenda

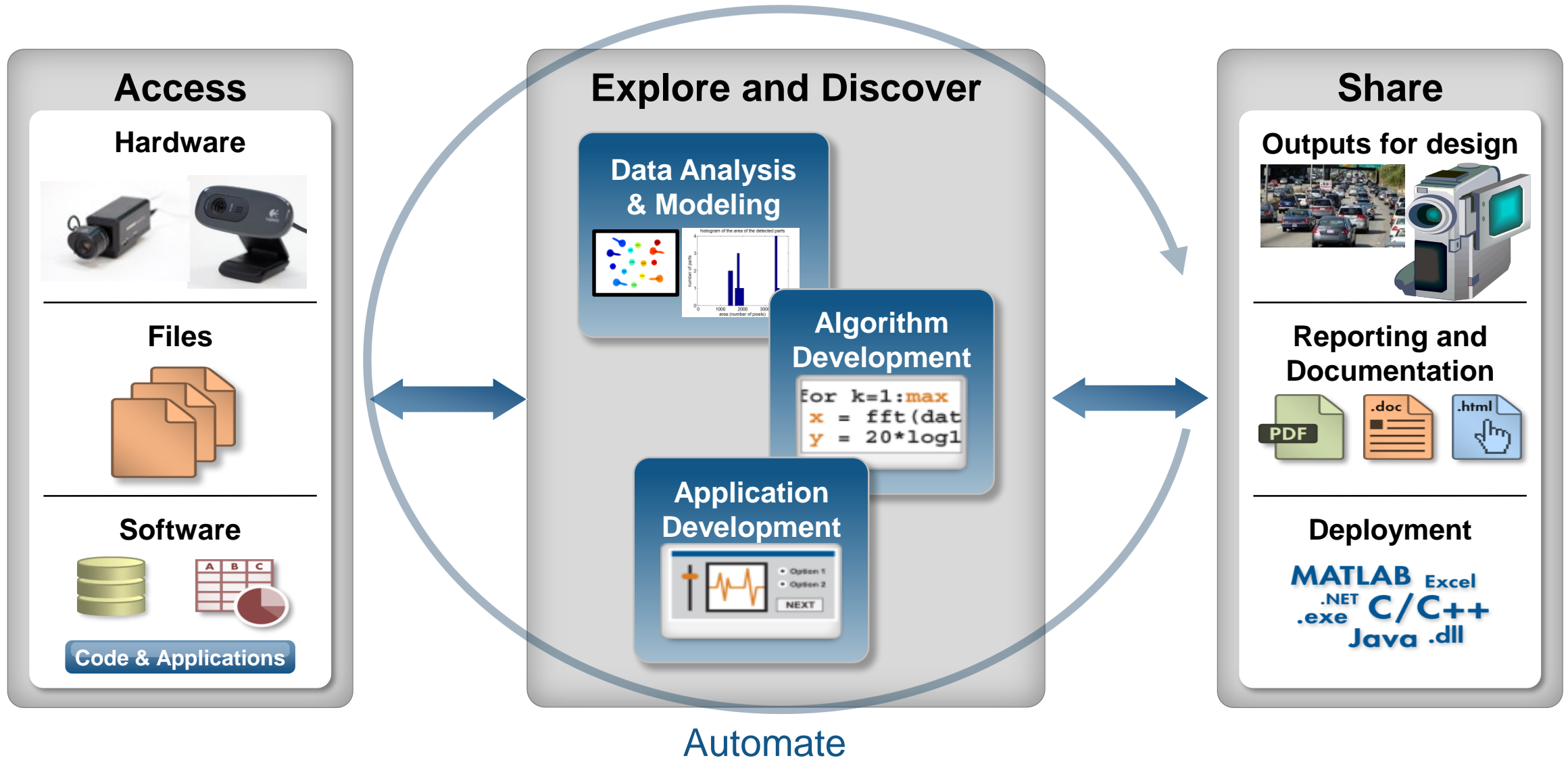
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What is MATLAB?

- High-level language
- Interactive development environment
- Used for:
 - Numerical computation
 - Data analysis and visualization
 - Algorithm development and programming
 - Application development and deployment



Workflow: Image and Video Processing



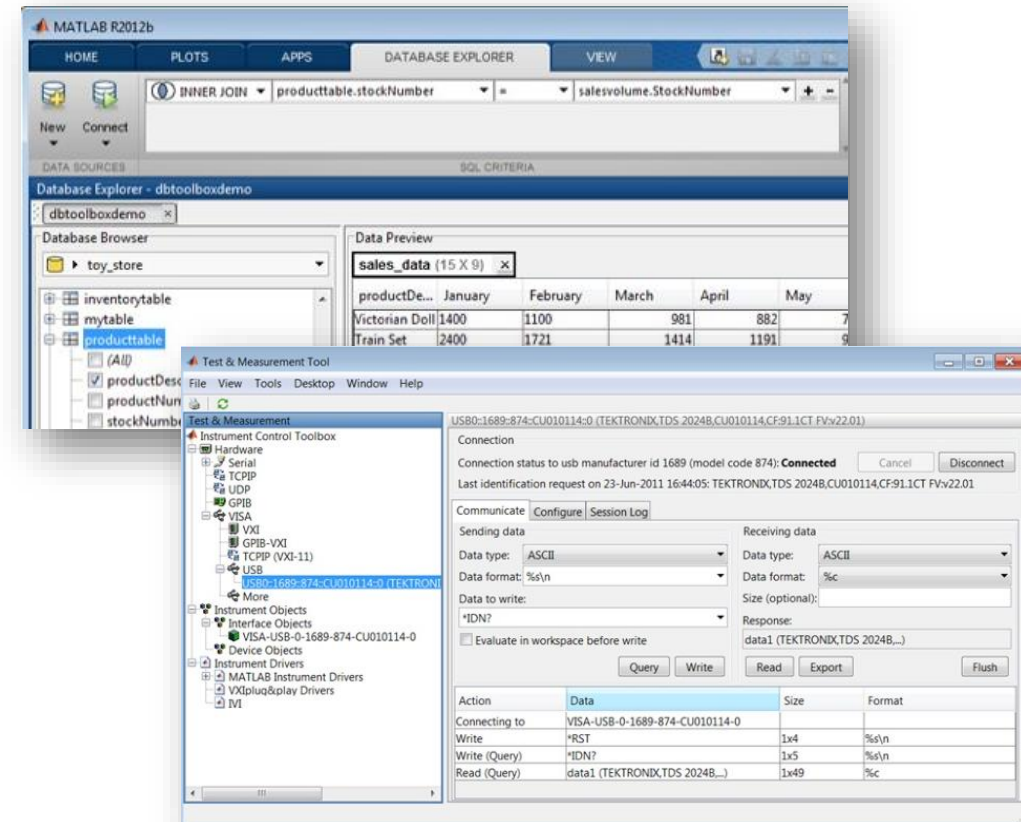
Accessing Data from MATLAB

Access

Explore & Discover

Share

- Files
 - Excel, text, or binary
 - Audio and video, image
 - Scientific formats and XML
- Applications and languages
 - C/C++, Java, FORTRAN, Python
 - COM, .NET, shared libraries
 - Databases (*Database Toolbox*)
- Measurement hardware
 - Data acquisition hardware (*Data Acquisition Toolbox*)
 - Stand-alone instruments and devices (*Instrument Control Toolbox*)



What do data look like?

Access

The screenshot displays two overlapping windows from a Windows operating system. The background window is Microsoft Excel, titled '2008Jan.csv - Excel'. It shows a spreadsheet with the following data:

| Year | Month | DayofMonth | DayOfWeek | DepTime | CRC |
|------|-------|------------|-----------|---------|-----|
| 2008 | 1 | 3 | 4 | 2003 | |
| 2008 | 1 | 3 | 4 | 754 | |
| 2008 | 1 | 3 | 4 | 628 | |
| 2008 | 1 | 3 | 4 | 926 | |
| 2008 | 1 | 3 | 4 | 1829 | |
| 2008 | 1 | 3 | 4 | 1940 | |
| 2008 | 1 | 3 | 4 | 1937 | |
| 2008 | 1 | 3 | 4 | 1039 | |
| 2008 | 1 | 3 | 4 | 617 | |
| 2008 | 1 | 3 | 4 | 1620 | |
| 2008 | 1 | 3 | 4 | 706 | |
| 2008 | 1 | 3 | 4 | 1644 | |
| 2008 | 1 | 3 | 4 | 1426 | |

The foreground window is Microsoft Access, titled 'HistoricalCreditRatings : Database - C:\myFold...'. It shows the 'Ratings' table in the 'All Tables' pane. The table structure is as follows:

| ID | WC_TA | RE_TA | EB |
|-------|--------|--------|----|
| 32529 | 0.017 | 0.124 | |
| 32542 | -0.029 | -0.462 | |
| 32543 | 0.358 | 0.484 | |
| 32544 | 0.254 | 0.385 | |

>HXBGP Human gene for bone gla protein (BGP)

GGCAGATTCCCCCTAGACCCGCCCGCCACCTGTTGACGGCATGCCCTCTCTCATCGCTGGGCACAGCCCGAGAGGTT
ATAAACAGTCTGGAGGCTGGCGGGCGAGCCAGCTGAGTCTTGACAGCCAGCCAGCGCAGCCAGCGACACCC
ATGAGAGCCCTCACACTCTCTGCCCTATTGGCCCTTGGCCGCACTTTGCATCGTGGCCAGGCAGGCTGAGTGGCCCC
CACCTCCCCCTCAGGCGCGATTGCAGTGGGGGCTGAGAGAGGAGAACACCATGGCCACCTCTCTCACCCCTTTTG
CTGGCAGTCCCTTTGCAGTCTAACCACTGTTTGCAGGCTCAATCCATTTGCCCCAGCTCTGCCCTTTGCAGAGG
GAGAGGAGGGAAGAGCAAGTCTGCCGACGCCAGCGGGAAGAGAGTGAAGGCGCTGGGATGAGCTGGGGTGAAC
CAGAGCTCCCTTTCTTCTTGAGGTGCGAAGCCAGCGGTGACAGGTCCAGGAAGGTGCAAGTATGAGTATGAGGATGCAC
TGATGGGTTCTCTGGACCTCCGCTCTCACCTTGGTCCCTCAGTCTCATTCCCCCACTCTCTGCCACCTCTGTCTG
GCCATCAGGAAGGCCAGCTCTCTCCCCACTGATCTCTCCAAACCCAGAGCCAGCTGATGCTCTGCCCTCTGCTC
CACAGCCTTTTGTGTCCAAGCAGGAGGGCAGCAGGTAGTGAAGAGACCCAGGCGCTACTGTATCAATGGCTGGG
GTGAGAGAAAAGGCAGAGCTGGGCCAAGGCCCTGCCTCTCCGGGATGCTCTGTGGGGAGCTGCAGACAGGGAGTG
GCCTCTCTGGGTTTGGTGGGGGTCACAGCGAGCTGCCCTGGTGGGCACCTGGAGGCCCATGTGTGTAGGGAGAGG
AGGATGGGCATTTTGCAGCGGGGCTGATGCCACCAGCTCGGGTGTCTCAGAGCCCCAGTCCCCATCCCGGATCC
CCTGGAGCCCAGGAGAGGCTGTTGTGAGCTCAATCCGACTGTGACGAGTTGGCTGACCACTAGGGCTTTCAGGA
GGCTATCGGCGCTTACGTGGCCGGTCTAGGGTGTGCTCTGCTGGCTGCCCGGCAACCCCACTTCTGCTCCT
CTCCAGACCCCTTTCTTCTCTCTCCCTTGGCCCTTGGCCTGACCTCCAGCCCTATGAGTATGGGGTCCCCATC
ATCCCAAGCTGCTCCCAAATAAACTCCAGAAG

>HSLTH1 Human theta 1-globin gene

CCACTGCACTCACCGCACCCGGCCAAATTTTGTGTTTTAGTAGAGACTAAATACCATATAGTGAACACCTAAGA
CGGGGGCGCTTTGATACGGCGGATTCAGAGGGCCCGGGTGGAGGTGTGCGGAGATTGAGCGCGCGGGTCCCGG
GATCTCCGACAGCCCTTGACCCCGGGCGGGAAGCTGCGCGCGCGCGCTCTGAGAGCGCGGGGACCCCTG
GCCGCTCCGCGCAGCGCAGCGGGGTGCGAGGGCGCGCGGGTTCCAGCGCGGGATGCGCTGTCTCGCGGAGGA
CTCGGCGAGCTGGTGCGCGCTTGGAAGAAAGCTGGGCGACCAACCTCGCGCTCTACACGACAGAGGCTCTGGAAG
GCGGGCAGCTGGGCGCGCCCGCGCCAGCGGGCCCTCTCCCAAGCCCCCGGCGAGCGCTCACCCAGCTTC
CTCTCGAGGACCTTCTCTGGCTTTCCCGGCCAGGAAGCACTACTTCTCCCACTGGACCTGAGCGCGGCTCTC
ACAAGTCAGAGCCACCGCCAGAAGGTGGCGGACGCGCTGAGCCTCGCGCTGGAGCGCTGGACGACCTACCCCA
CGCGCTGTCCGCGCTGAGCCACTGCACGCGTGCCAGCTGCGAGTGGACCGCGCGAGCTTCCAGTGAAGCGGCTG
CCGTGTCGGGCCCTGTCTCCCGGGAGGCGCCCGCGGGGTGGGTGCGGGGGCGCTGCGGGCGGGTGCAGGCGAG
TGAGCCTTGAGCGCTGCGCGAGCTCTGGGCACTGCTGTGTTAGTCTGCTCCGCCACTACCCCGAGACT
TCAGCCCCCGCTGTCAGGCGTGTGCTGGACAAGTTCTTGAGCCAGCTTCTCGGCGCTGGTTTCCAGTACCCT
GAATCTGGTGGTGGTGGCGCGGATCCACCGGACGACTTCCCCGTGTTTGAAGAACCTCTCCAGGAGCAGC
CTTTCTGCCGTGCTCTCTCGAGTCTCAGGACGCGAGGAGGAAGCGCG

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"20130630";"1";2,93;"6 ";-3,49
"20130630";"1";0,72;"5+";-4,91
"20130630";"1";4,84;"6-";-2,97
"20130630";"1";0,17;"4 ";-6,33
"20130630";"1";1,34;"5-";-4,29
"20130630";"1";0,81;"5 ";-4,80
"20130630";"1";12,25;"7 ";-1,96
"20130630";"1";1,60;"6+";-4,11
"20130630";"1";0,61;"5+";-5,07
"20130630";"1";0,33;"4-";-5,68
"20130630";"1";0,23;"4 ";-6,05
"20130630";"1";13,07;"7 ";-1,89
"20130630";"1";16,44;"7 ";-1,62
"20130630";"1";3,29;"6-";-3,38
"20130630";"1";5,53;"7 ";-2,83
"20130630";"1";25,68;"8 ";-1,06
"20130630";"1";0,63;"5+";-5,05
"20130630";"1";5,80;"7 ";-2,78
"20130630";"1";0,55;"5+";-5,19
"20130630";"1";0,68;"5+";-4,9
"20130630";"1";0,50;"5+";-5,2
"20130630";"1";0,97;"5 ";-4,6



Ukraine Election Signals Market Triumph for Bonds: Russia Credit

Pope i Invites Meet c

Violence fe
as Egyptian
head to the
polls

Live: All set for Modi's swearing-in ceremony, Nawaz flies in with 'message of ...

Team Modi to be

Emma Watson Graduates from Brown University

The British actress best known as Hermione Granger in the Harry Potter movies was among 2,000 graduates receiving degrees Sunday from Brown University. She tweeted a photo of herself in cap and gown. Watson graduated with a bachelor's degree in

Wade looking like the Wade of old in East finals

Kurt Busch's double bid beat the number

S Ibaka, Thursday
by top Spurs 1
S 97, cut lead
2-1

The British actress, who played Hermione Granger in the Harry Potter movies, is receiving a degree from the University of Cambridge. She tweeted a photo of her diploma, which says she graduated with a

ss best known as Her
movies was among 2,0
s Sunday from Brown
of herself in cap and ge
bachelor's degree in

Union Granger in
100 graduates
University. She
own. Watson

NASCAR Sprint Cup: Coca-Cola 600 Race Rewind

French Open: Federer celebrates Mother's Day with victory in

| | |
|--|--|
| <p> Federal cruises as Serena, Venus eye Paris showdown </p> | <p> Daring Pass Produces Narrow </p> |
|--|--|

May 26 06

NBA Notes: Dave Joerges spurs Timberwolves

Sweden tops Czech Republic, takes bronze at Olympic world

6:00 | **133 related articles**

| | |
|---|---|
| <p>Norm Scott Wins Pulitzer Prize for Fiction</p> | <p>Turkish drama <i>Winter Sleep</i> wins the Palme d'Or, top prize at Cannes</p> |
| <p>Police say Wile Khalifa took plea</p> | |

Emma Watson
Graduates
from Brown
University

| | | | |
|----------------------------------|---------------|--------------|-------------------------|
| Diagh Convenes | West Asian | Gener al | Can on ary Cry |
| Berlin Volers | Kokao | Chin | Hea r |
| Super Vior and Deme offers | Brans Zap | Room bell | How |

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☒ SPORTS

ENTERTAINMENT

LESS THAN 10 MIN. AGO

Example: FITS files

The screenshot shows a web browser window with the MathWorks documentation page for FITS Files. The browser's address bar shows the URL `https://it.mathworks.com/help/matlab/flexible-image-transport-system.html`. The page header includes the MathWorks logo and navigation links: [Prodotti](#), [Soluzioni](#), [Università](#), [Assistenza](#), [Community](#), and [Eventi](#). Below the header is a blue navigation bar with the word **Documentation** and tabs for [All](#), [Examples](#), and [Functions](#). A search bar is present with the text "Search R2019a Documentation".

The main content area is titled **FITS Files** with a sub-header **Flexible Image Transport System**. It includes a paragraph: "High-level access functions make it easy to read data from a FITS file or write data from the MATLAB workspace to a FITS file. Low-level functions provide direct access to more than 50 functions in the CFITSIO library." Below this, there are two sections: **High-Level Functions** with the text "Easily view, read, and write FITS files", and **Low-Level Functions** with the text "Interact directly with CFITSIO library functions".

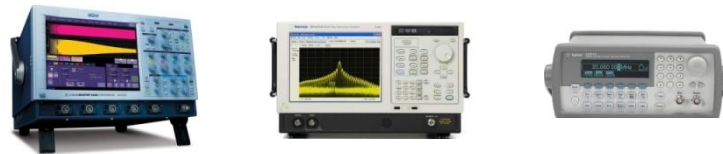
On the left side, there is a **CONTENTS** sidebar with a list of links: « Documentation Home, « MATLAB, « Data Import and Analysis, « Data Import and Export, « Standard File Formats, « Scientific Data, NetCDF Files, HDF5 Files, HDF4 Files, **FITS Files**, High-Level Functions, Low-Level Functions, Band-Interleaved Files, and Common Data Format.

MATLAB connects to your hardware



Data Acquisition Toolbox

Plug in data acquisition boards and modules



Instrument Control Toolbox

Instruments and RS-232 devices

Image Acquisition Toolbox™

Image capture devices



Vehicle Network Toolbox

CAN bus interface devices



MATLAB

Interfaces for communicating with everything



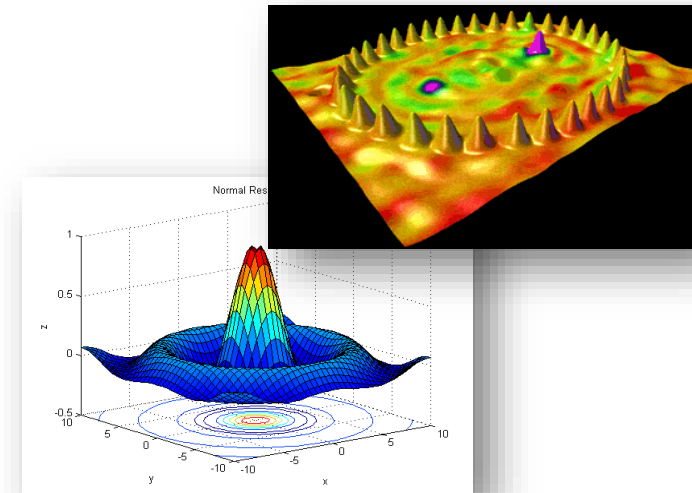
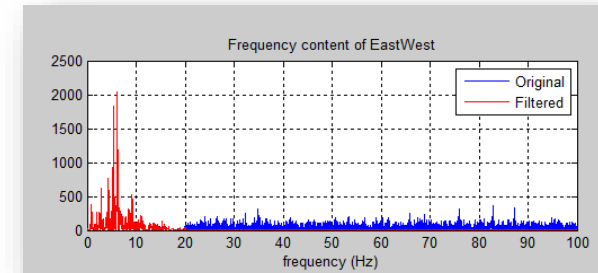
Data Analysis and Visualization in MATLAB

Access

Explore & Discover

Share

- Built-in engineering and mathematical functions
 - Interpolation, filtering, smoothing, Fourier analysis
- Extensive plotting capabilities
 - 2-D, 3-D, and volume visualization
 - Tools for creating custom plots



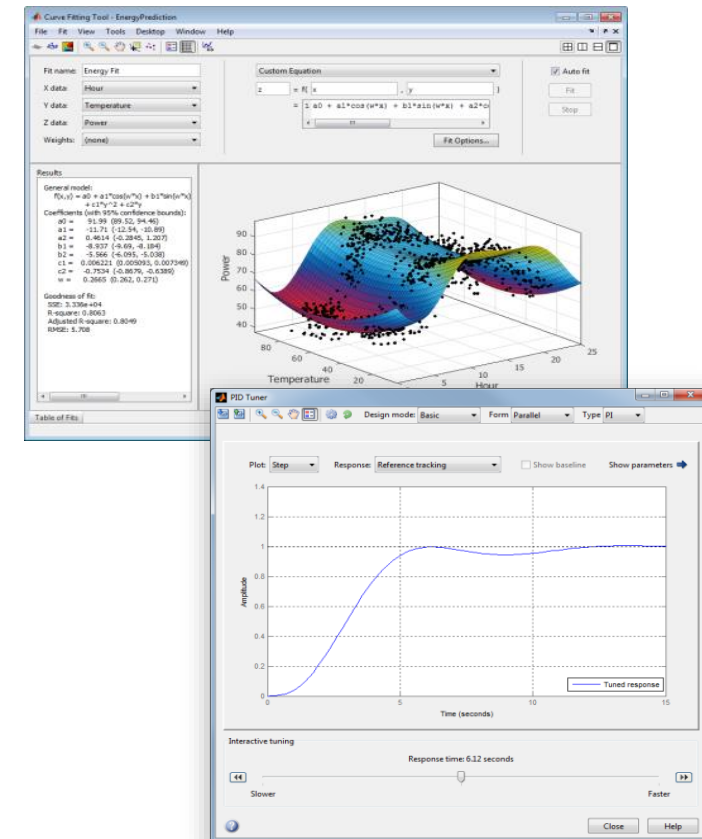
Expanding the Capabilities of MATLAB

Access

Explore & Discover

Share

- MathWorks add-on tools for:
 - Math, statistics, and optimization
 - Control system design and analysis
 - Signal processing and communications
 - Image processing and computer vision
 - Parallel computing and more...
- Partner products provide:
 - Additional interfaces
 - Domain-specific analysis
 - Support for niche applications



Sharing Results from MATLAB

Access

Explore & Discover

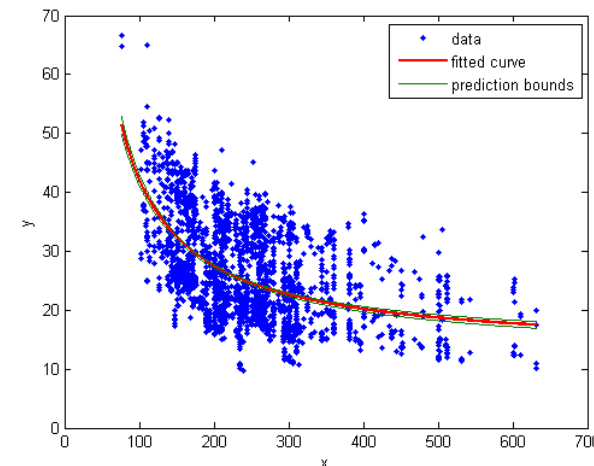
Share

- Automatically generate reports
 - Publish MATLAB files
 - Customize reports
(MATLAB Report Generator)
- Live scripts export
- Deploy applications to other environments

Plot Data and Model

The result from the Curve Fitting Toolbox has a `plot` method for displaying the result graphically. We can choose to display the prediction bounds for the fit.

```
figure;  
hh = plot(cf, 'r', carDataDS.RatedHP, carDataDS.MPG, 'predfunc', 0.95);  
set(hh(2), 'LineWidth', 2);  
set(hh(3:4), 'LineStyle', '-', 'Color', [0 .5 0]);
```

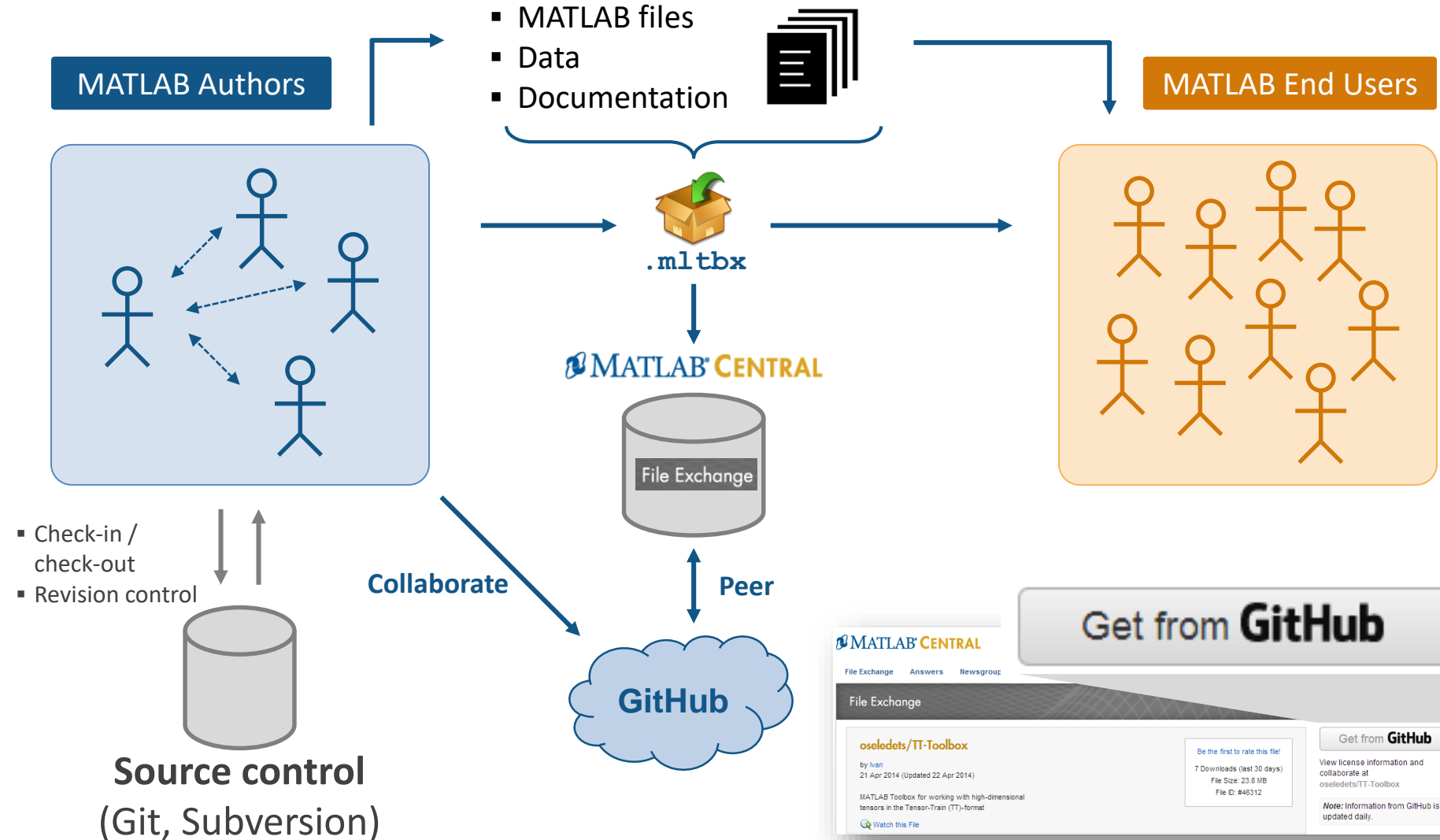


Share MATLAB Code as Toolboxes or Apps

Access

Explore & Discover

Share

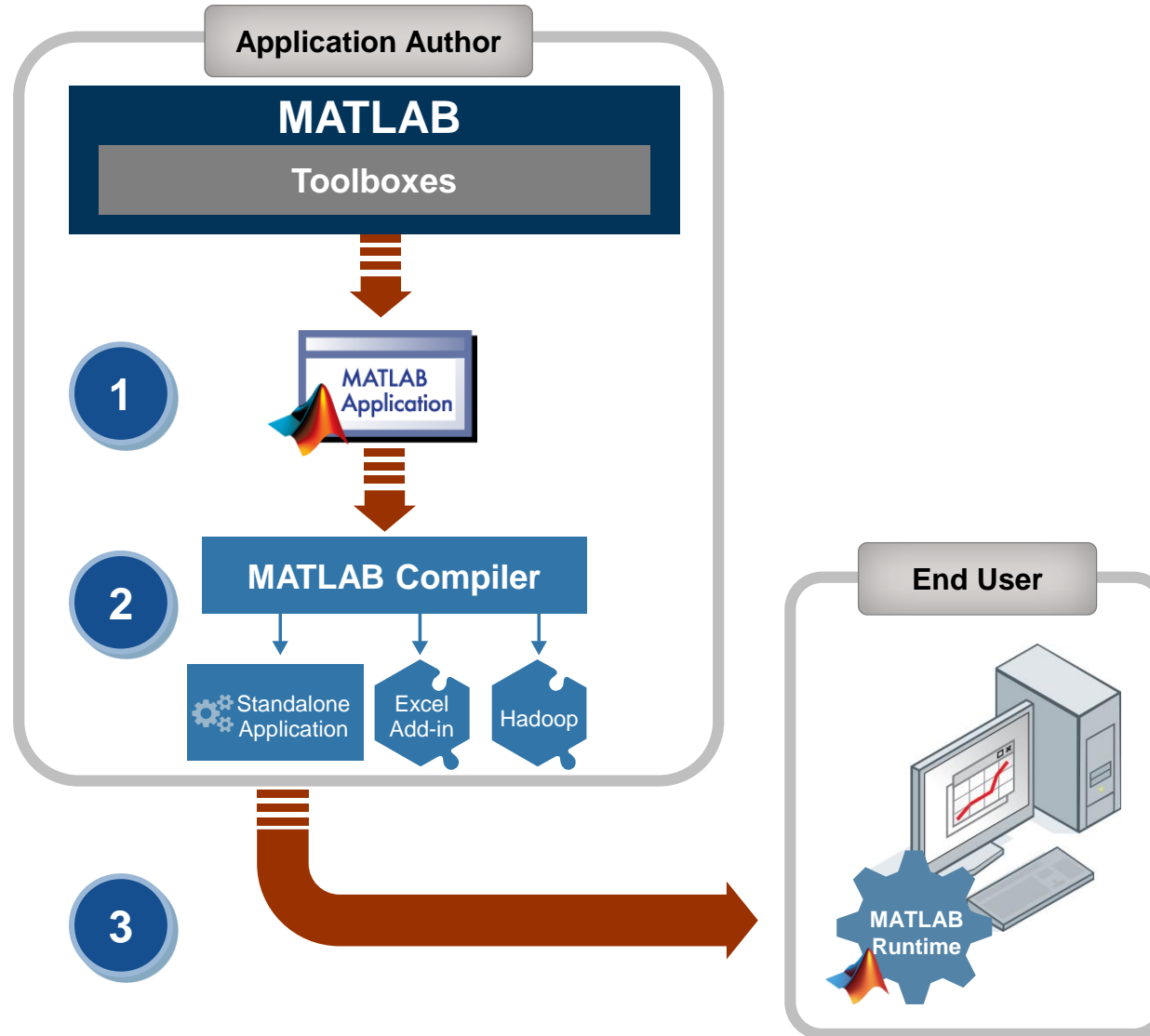


Sharing Standalone Applications

Access

Explore & Discover

Share



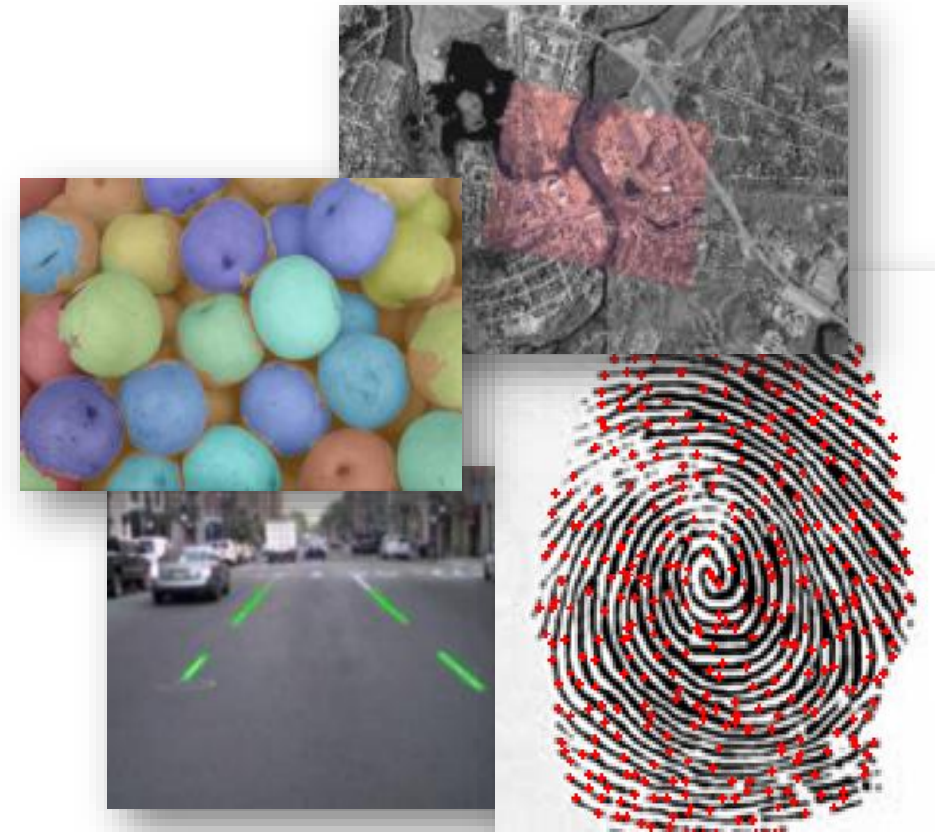
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Image Processing Toolbox

Perform image processing, analysis, visualization, and algorithm development

- Image display and exploration
- Image enhancement
- Image analysis
- Morphological operations
- Image registration
- Geometric transformation
- ROI-based processing

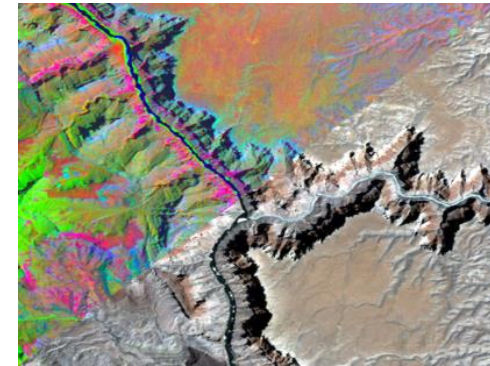


What is image enhancement?

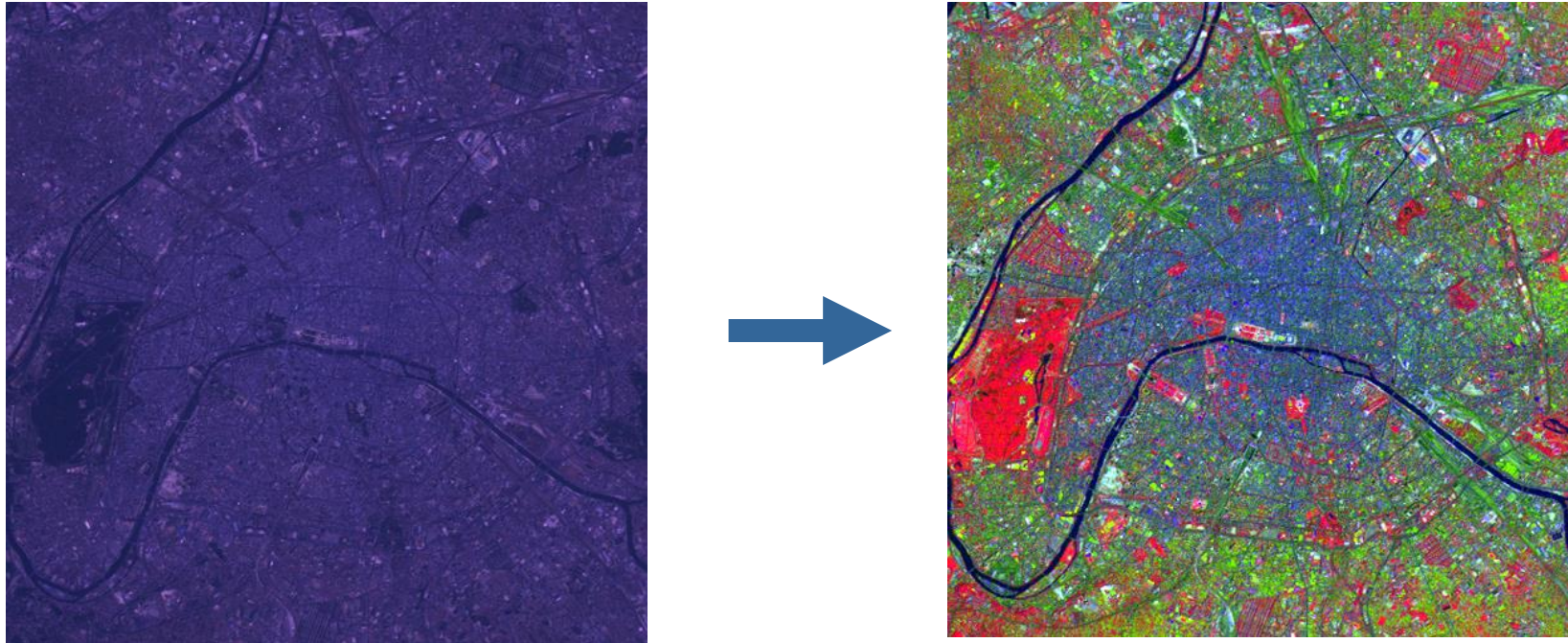
Pre- and Post-Processing

Image enhancement is the process of adjusting digital images so that the results are more suitable for display or further processing.

- Noise removal
- Deblurring
- Filtering



Demo: Image Enhancement



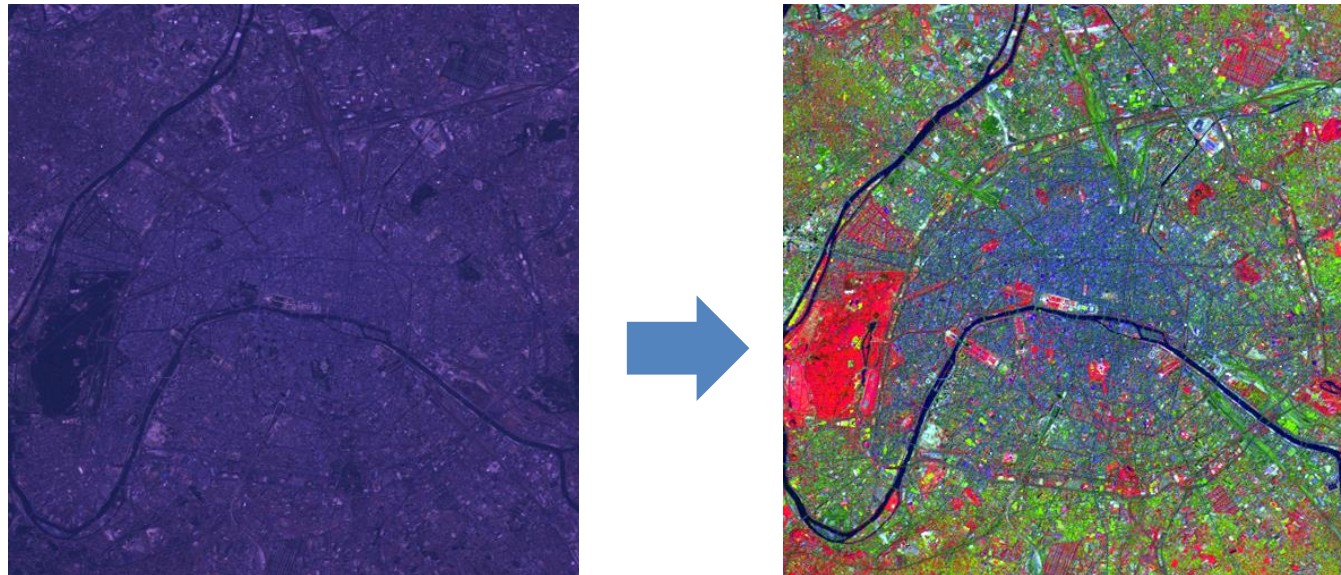
- Import and visualize map of Paris
- Correct for poor contrast and unbalanced colors

```
>> Histogram_Stretch
```

Demo: Image Enhancement

Summary

- Visualize images
- Visualize histogram and scatter plot
- Perform contrast and decorrelation stretch

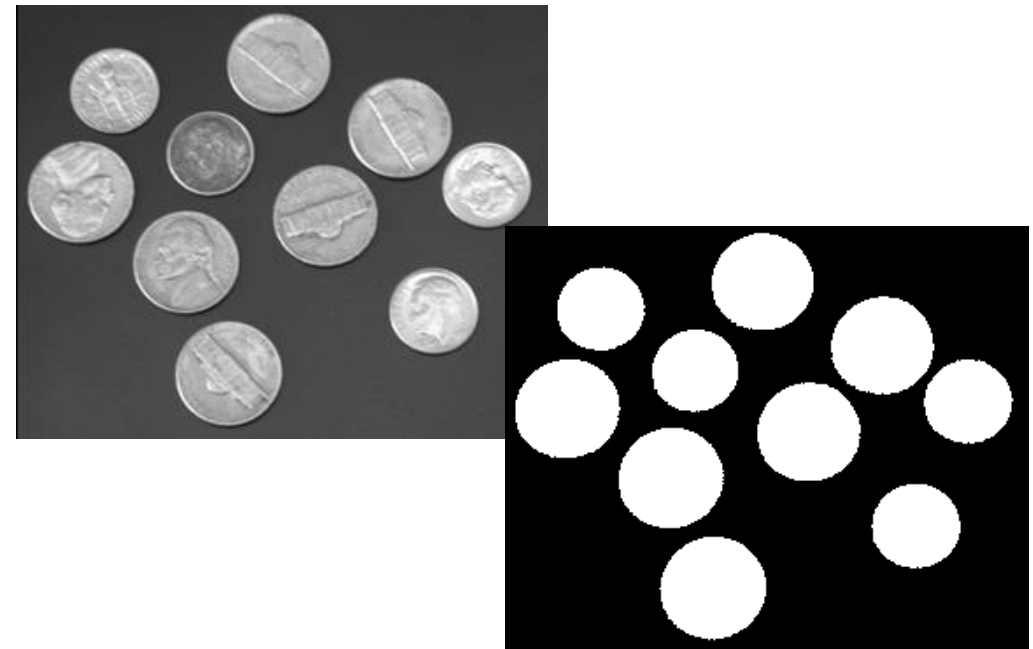
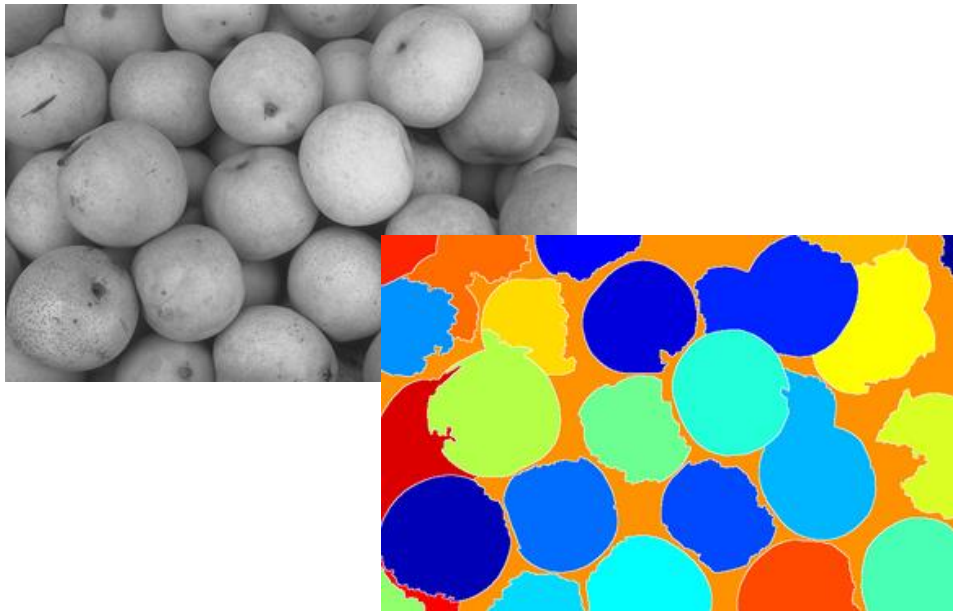


What is image segmentation?

Image processing for detection

- Image segmentation is the process of dividing an image into multiple parts.

This is typically used to identify objects and other relevant information within an image.



Demo: Image Segmentation

- Objects detection



There are 4 objects in the image!

```
>> cardetection
```

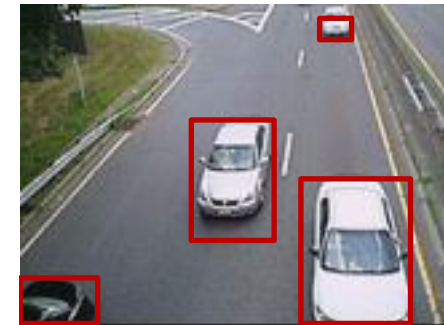

Demo: Image Segmentation

Summary

1. Detection concept: Image difference
2. Preprocessing: Enhancements
3. Segmentation: Threshold, Fill in, Morph. Opening
4. Region Properties



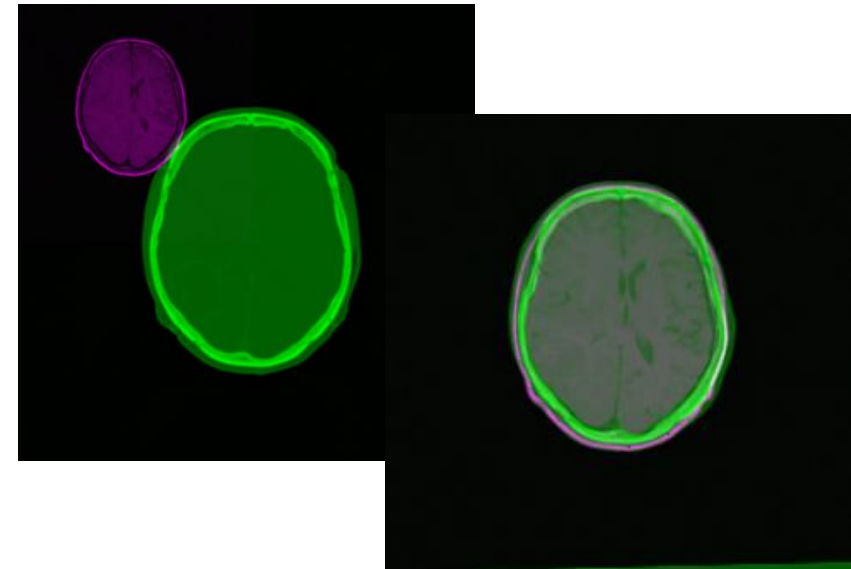
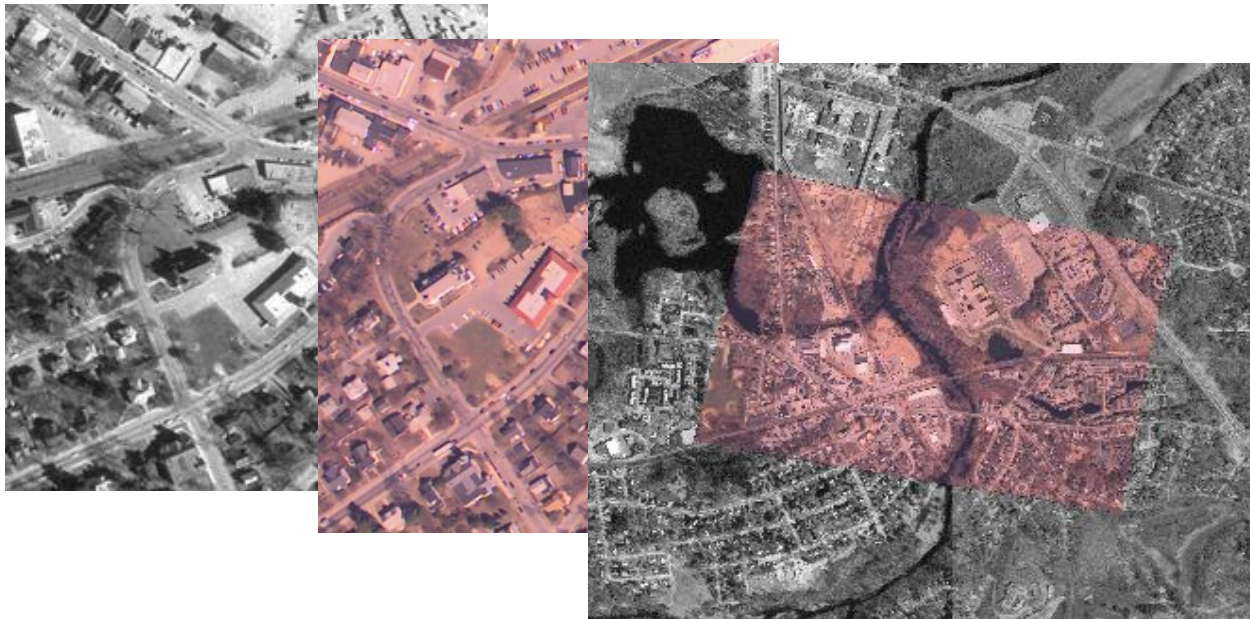
There are 4 objects in the image!



What is image registration?

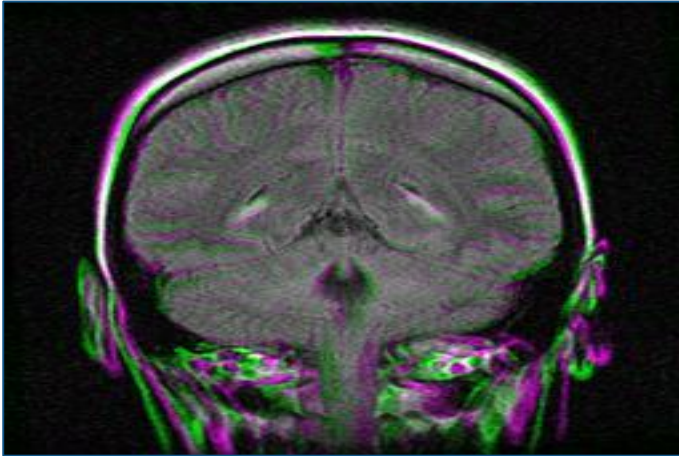
Image alignment

- Process of aligning images from different data sets for visual or computational analysis.
 - Enables quantitative comparison
 - Removes changes due to camera motion

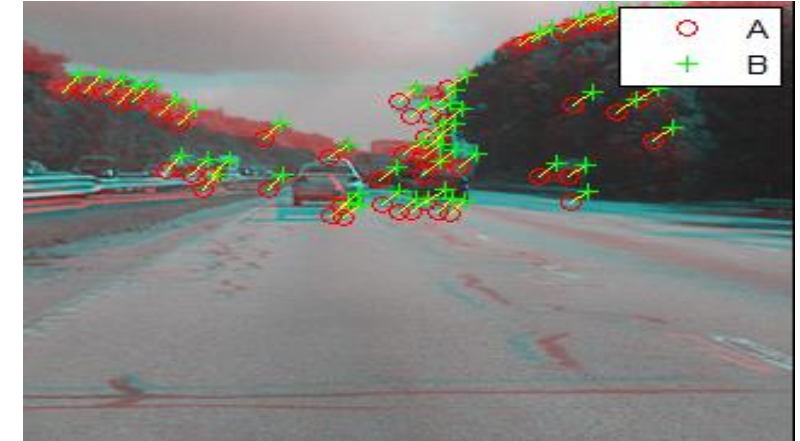


Automatic Image Registration

Intensity-based



Feature-based



- Two registration types supported:
 - Intensity-based (Image Processing Toolbox)
 - Feature-based (Computer Vision Toolbox)

Demo: Image Registration

- Goal: Register the image pair to detect the eyes and measure body temperature

Webcam image



Thermal IR image



```
>> ThermalScreening
```


Demo: Image Registration

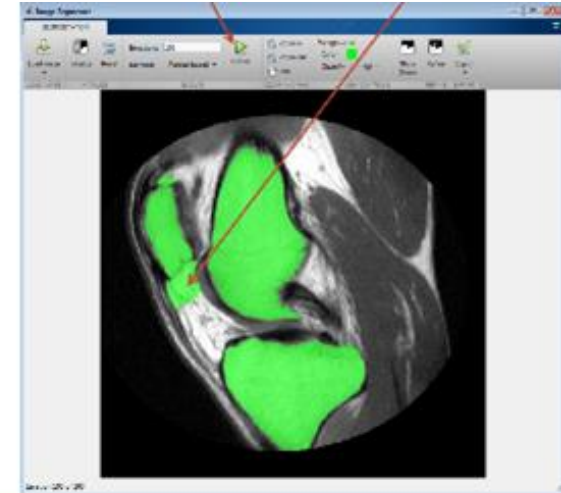
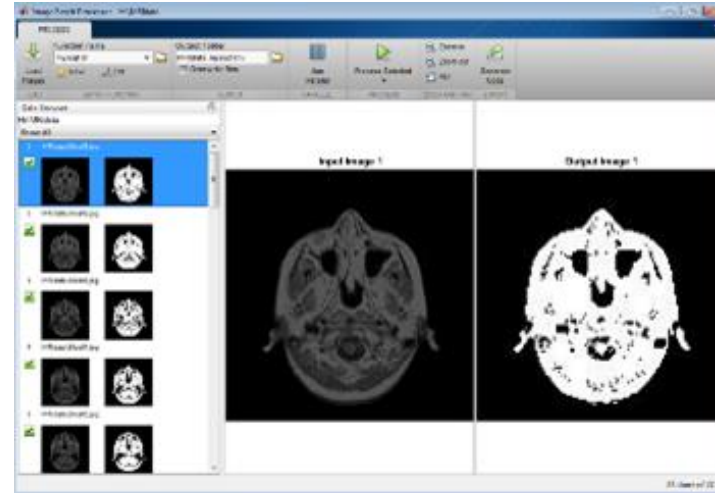
Summary

- Acquire images into MATLAB
- Visualize images
- Automatic image registration
- Feature detection (where are eyes?)
- Text annotation on the image



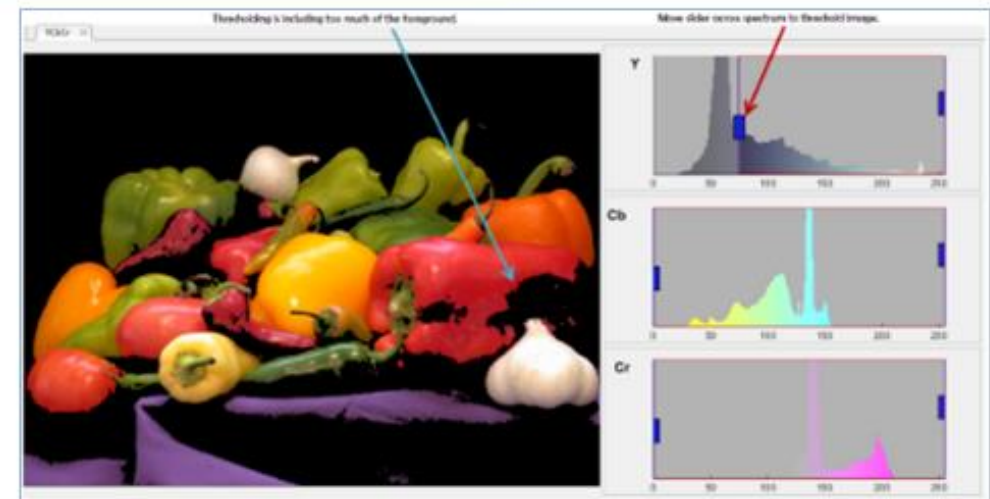
Use Apps to Quickly Explore Ideas or Find Solutions

1. Image Batch Processor App
2. Image Segmenter App
3. Region Analyzer App
4. Color Thresholder App



From the Community:

- Image Morphology App
- Image Registration App



File Exchange: <http://www.mathworks.com/matlabcentral/fileexchange/>

Agenda

- Introduction
- Quick intro to MATLAB
- Image Processing with MATLAB
- Managing large image sets
- What's New
- Wrap-up

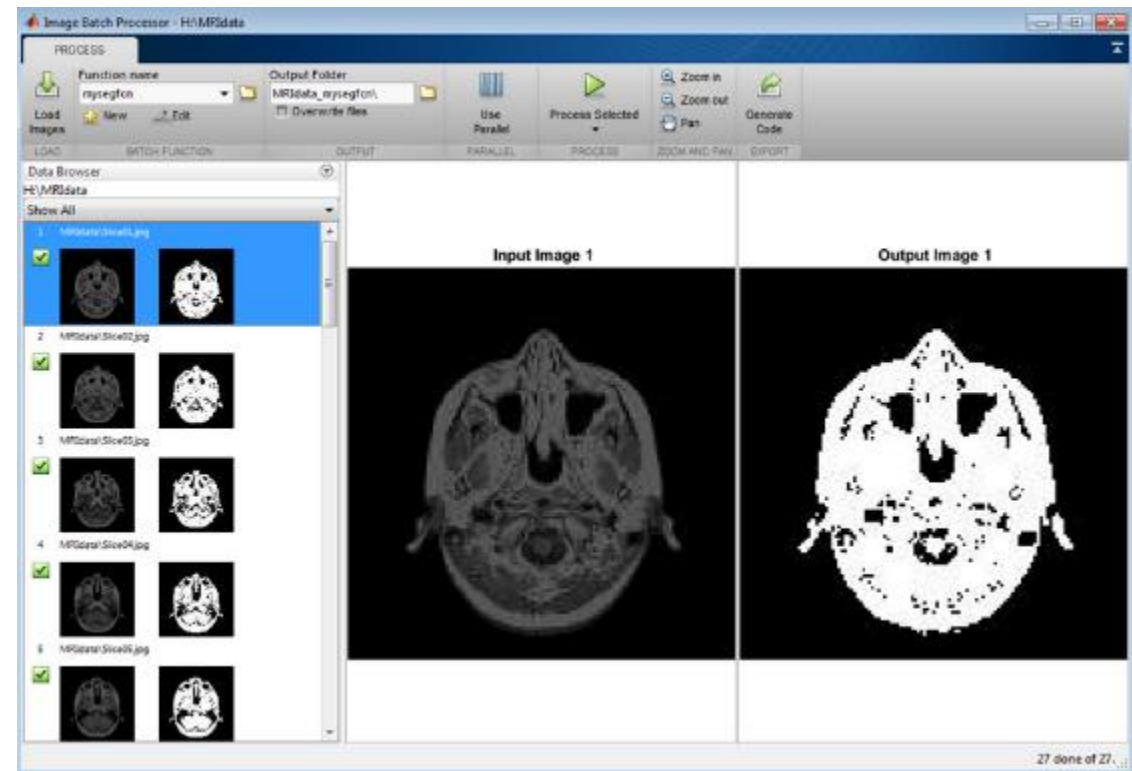
Images & Video Applications Have Massive Data Challenges

- 20+ Mega Pixel cameras
- 4K or 8K video
- Thousands to millions of images or videos to process

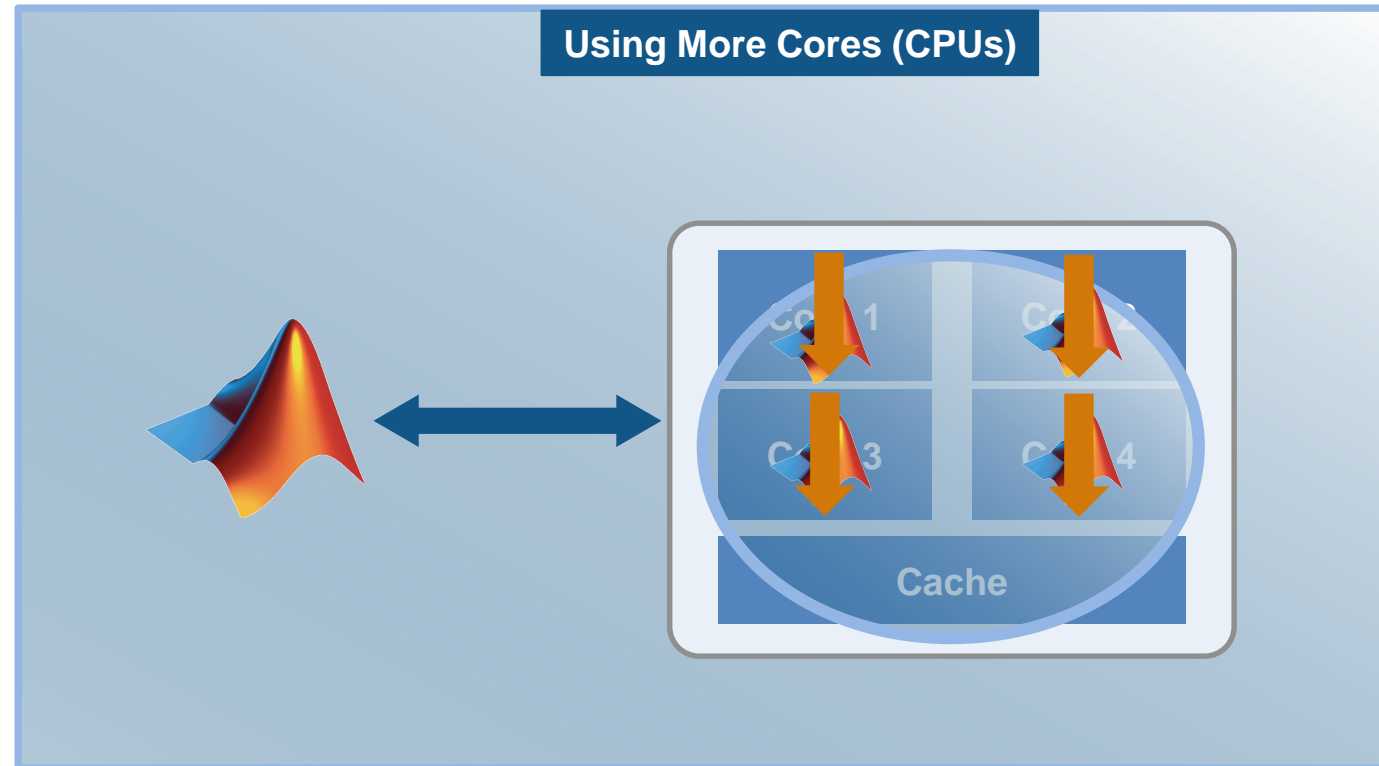


Working with Large Images Sets

- Processing large data sets with `datastore` and `imageSet`
 - Navigate data too large for memory.
 - Process multiple files as a single entity.
 - Works with `mapreduce`
- Image Batch Processor App
 - Apply algorithms to sets of images
 - Interactive interface
 - Support for parallel processing

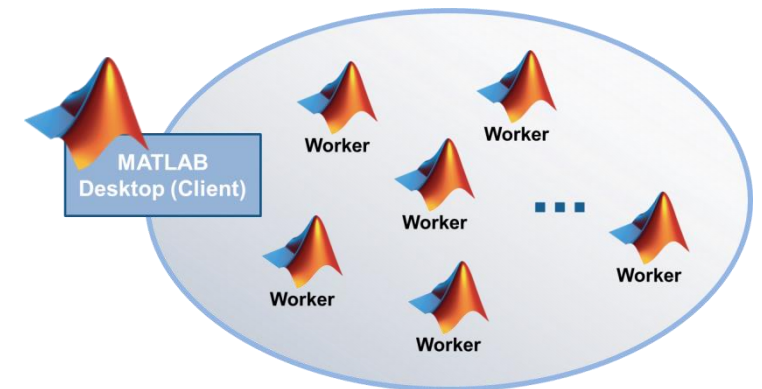


Parallel computing



Parallel computing support for image processing applications

- Option in Batch Image Processor to improve performance with parallel processing.
- Option in `blockproc` function to improve performance of block processing tasks.



MATLAB supports GPU Acceleration with NVIDIA



- Over 300 MATLAB functions supporting NVIDIA GPUs
- 50 of the most popular Image Processing functions
- Support for functions in bag-of-words workflow
- Constantly adding more GPU functionality

```
bagOfFeatures  
bagOfFeatures.encode  
trainImageCategoryClassifier  
imageCategoryClassifier  
imageCategoryClassifier.predict
```



```
bwmorph  
bwlookup  
corr2  
edge  
histeq  
imadjust  
imbothat  
imclose  
imdilate  
imerode  
imfill  
imfilter  
imgradient  
imhist  
imnoise  
imopen  
imresize  
imreconstruct  
imrotate  
imshow  
imtophat  
imwarp  
mean2  
medfilt2  
padarray  
rgb2gray
```

GPU Example - Required Code Changes

```
function vv = waveEqn(N,Nsteps)
% Initialization / Setup
vv = exp(-40*((xx-.4).^2 + yy.^2));

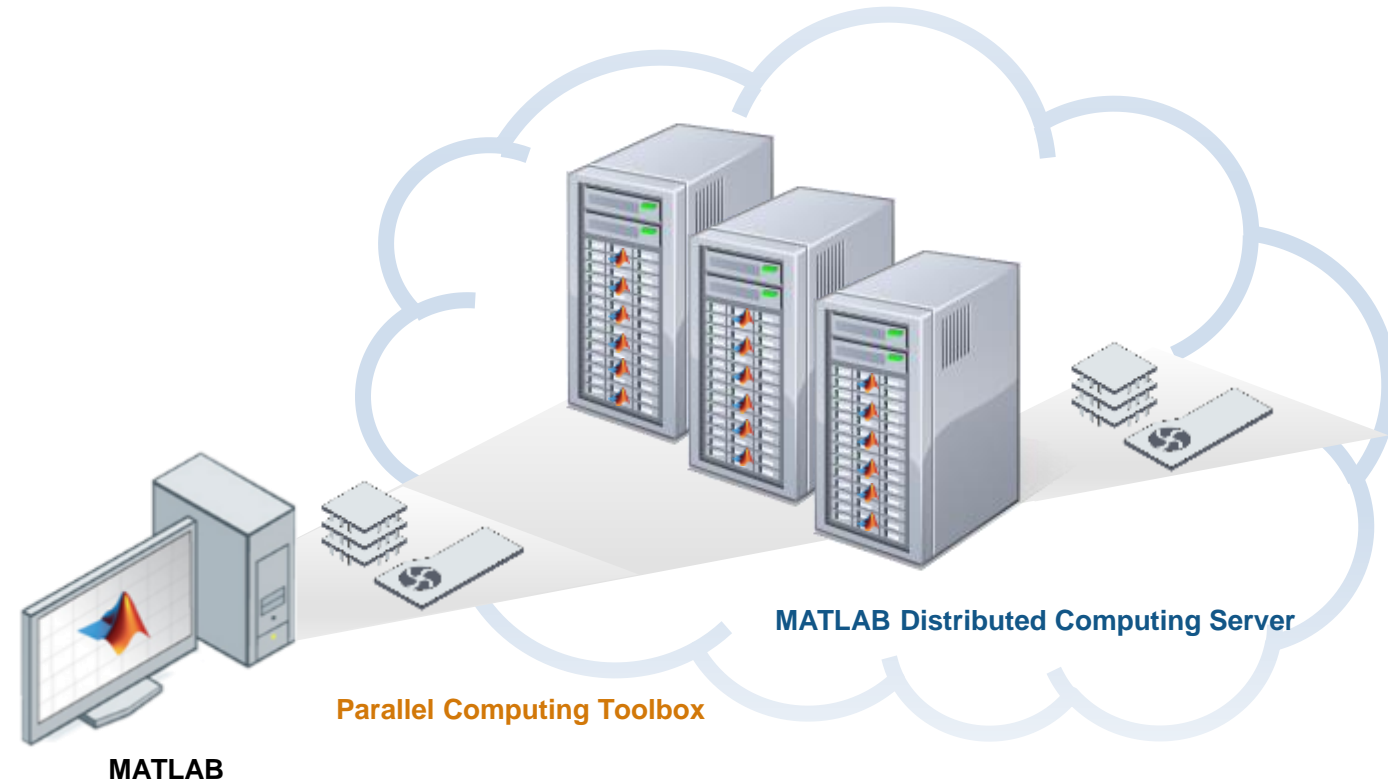
% Send data to GPU
dt = gpuArray(dt);
vv = gpuArray(vv);
index1 = gpuArray(index1);

% Processing
n=0;
while n < Nsteps
    V = [vv(ii,:) vv(ii,N:-1:2)];
    U = real(fft(V.')).';
    W1test = (U.*W1T).';
    W1 = (real(ifft(W1test))).';

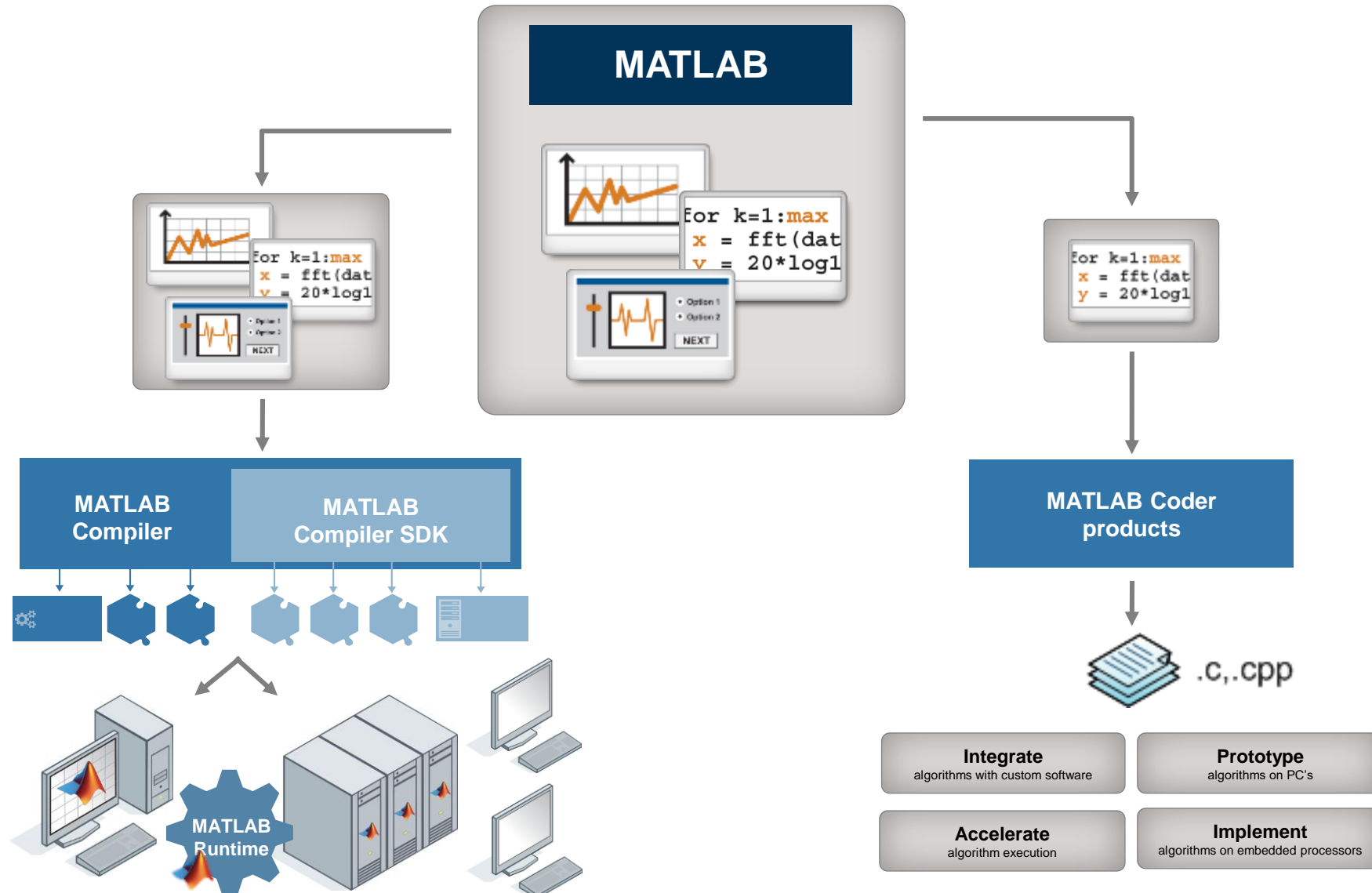
% Gather vvg back from GPU memory when done
vvg = gather(vv);
```


Scale to Clusters and Clouds

- Offload computation:
 - Free up desktop
 - Access better computers
- Scale speed-up:
 - Use more cores
 - Go from hours to minutes
- Scale memory:
 - Utilize distributed arrays
 - Solve larger problems without re-coding algorithms

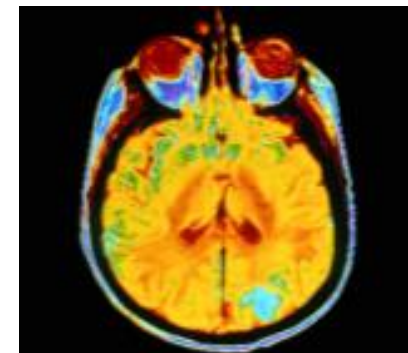
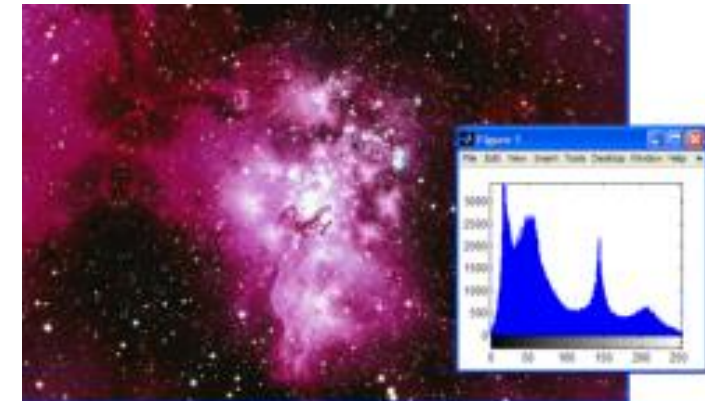


Advising on Deployment or Code Generation



Code Generation for Image Processing Functions

- regionprops
- watershed
- bweuler
- bwlabel
- bwperim
- multithresh
- padarray
- bwmorph
- bwlookup
- Conndef
- fspecial
- bwtraceboundary
- imadjust
- imclearborder
- medfilt2
- imfill
- imhmax
- imhmin
- imreconstruct
- imregionalmax
- iptcheckconn
- ...



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Sustainable Research Software Engineering with MATLAB

- MATLAB Live Script**

Create computational code stories with Live Editor for papers and teaching

- Source Control**

Use git and SVN from MATLAB



- MATLAB Projects (R2019a)**

Organize, manage, and share your work



- Test Frameworks**

Unit Test, Performance Test, App Test, and Mocking Framework tests

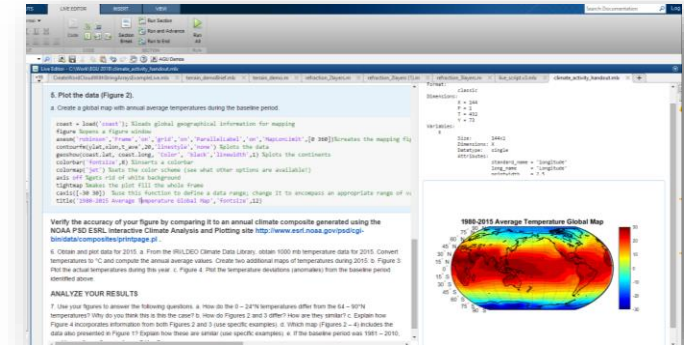


- Object Oriented Programming**

Validate object properties by their type, size, shape, or other attributes (R2017a)

- Continuous Integration**

Use MATLAB with Jenkins



MATLAB Projects: Organize, manage, and share your code

- Configure your environment
- Analyze dependencies
- Track and control changes
- Package and share projects

Search

Custom Tasks

Run Checks

References

Details

Project Path

Startup Shutdown

Git Details

Refresh

Commit

Fetch

Push

Pull

Remote

Branches

TOOLS

ENVIRONMENT

SOURCE CONTROL

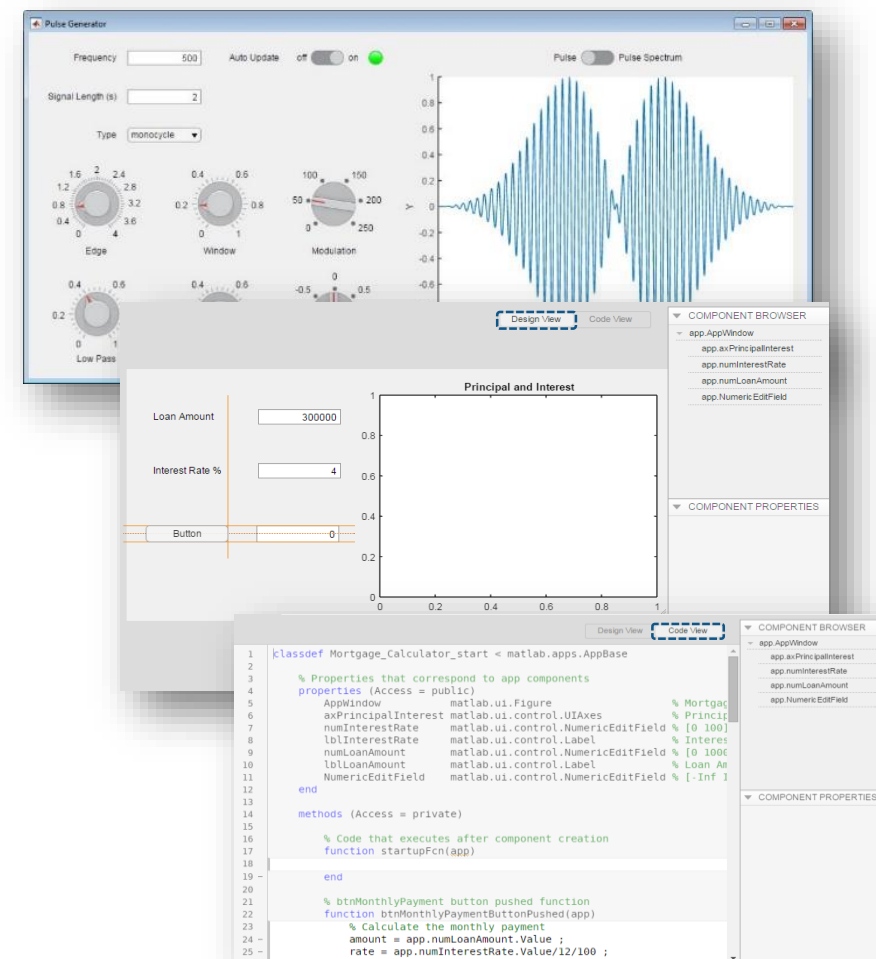
All | Project (226) | Modified (344)

| Name | Status | Git | Classification |
|---|--------|-----|----------------|
| +Test | ✓ | ■ | Test |
| ACI | ✓ | · | |
| Dashboard | ✓ | · | |
| Documents | ✓ | · | |
| Elasticsearch | ✓ | · | |
| MachineLearning | ✓ | ■ | |
| MATLAB_Kafka_Producer_Java | ✓ | · | |
| mps_stream | ✓ | ■ | |
| SimExecutable | ✓ | · | |
| Simulation | ✓ | · | |
| DocExample_MultiClassFaultDetectionUsi... | ✓ | ● | Design |
| genPumpData.m | ✓ | ● | Design |
| javasetup.m | ✓ | + | Design |
| Main_ExampleWorkflow.mlx | ✓ | ● | Design |
| MLModels.mat | ✓ | ● | Design |
| rawdata.mat | ✓ | ● | Design |
| README.md | ✓ | ● | |

App Designer

Create professional Apps for no professional software developer

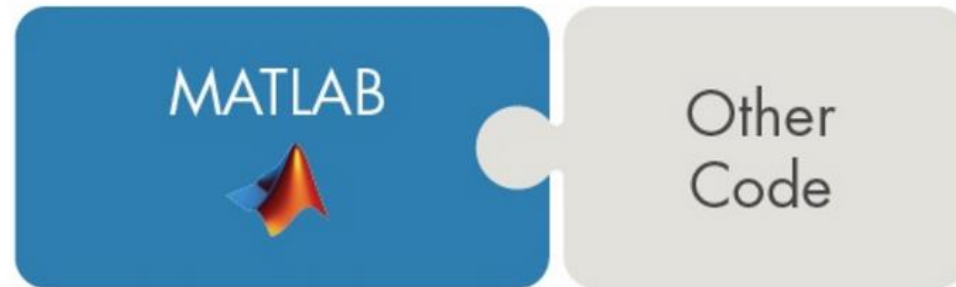
- Enhanced design environment
- New UI components: gauges, dials, tabbed interfaces, and more...
- Improved object-based code and coding tools
- Deploy apps to the web



Working with Other Languages

Interoperate with Python, C, and more from MATLAB

Call Other-Language Libraries from MATLAB



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

Call C++ libraries directly from MATLAB **R2019a**

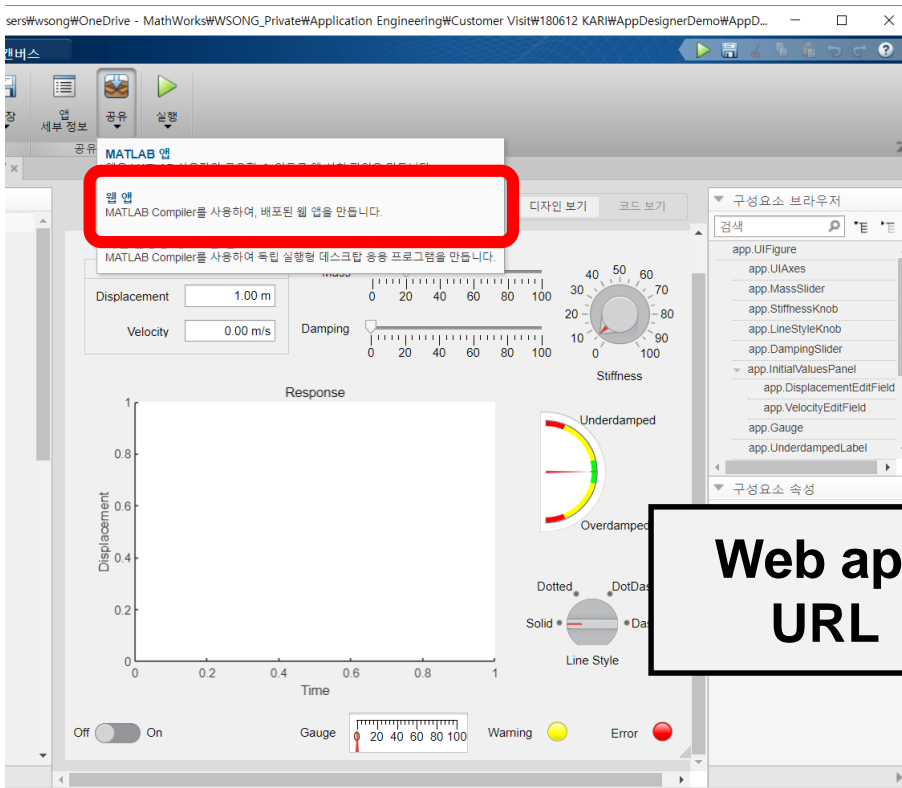
Call MATLAB from Another Language



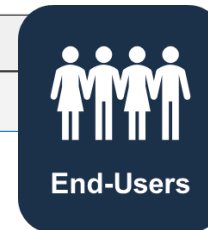
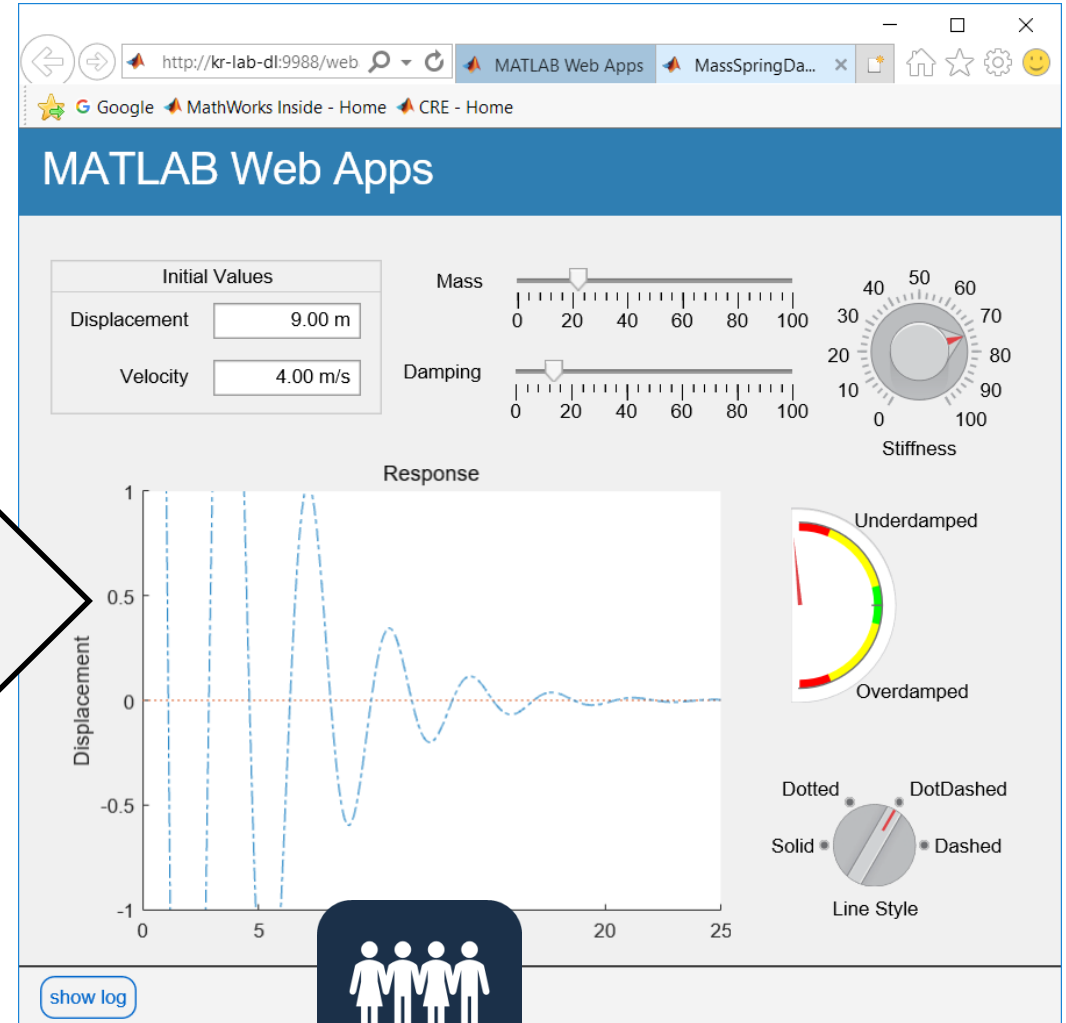
- Java
- Python
- C/C++
 - Updated C++ API
- Fortran
- COM Automation server

MATLAB Programs Can be Shared With Anyone

Standalone desktop app & Web Deploy



Web app
URL



Deep Learning Toolbox

Create, analyze, and train deep learning networks

Interoperability with other
deep learning frameworks



Deep Network Designer
app



Improved inference
performance



Domain-specific workflow
support

- Ground truth labeling apps for audio and video
- Application-specific datastores

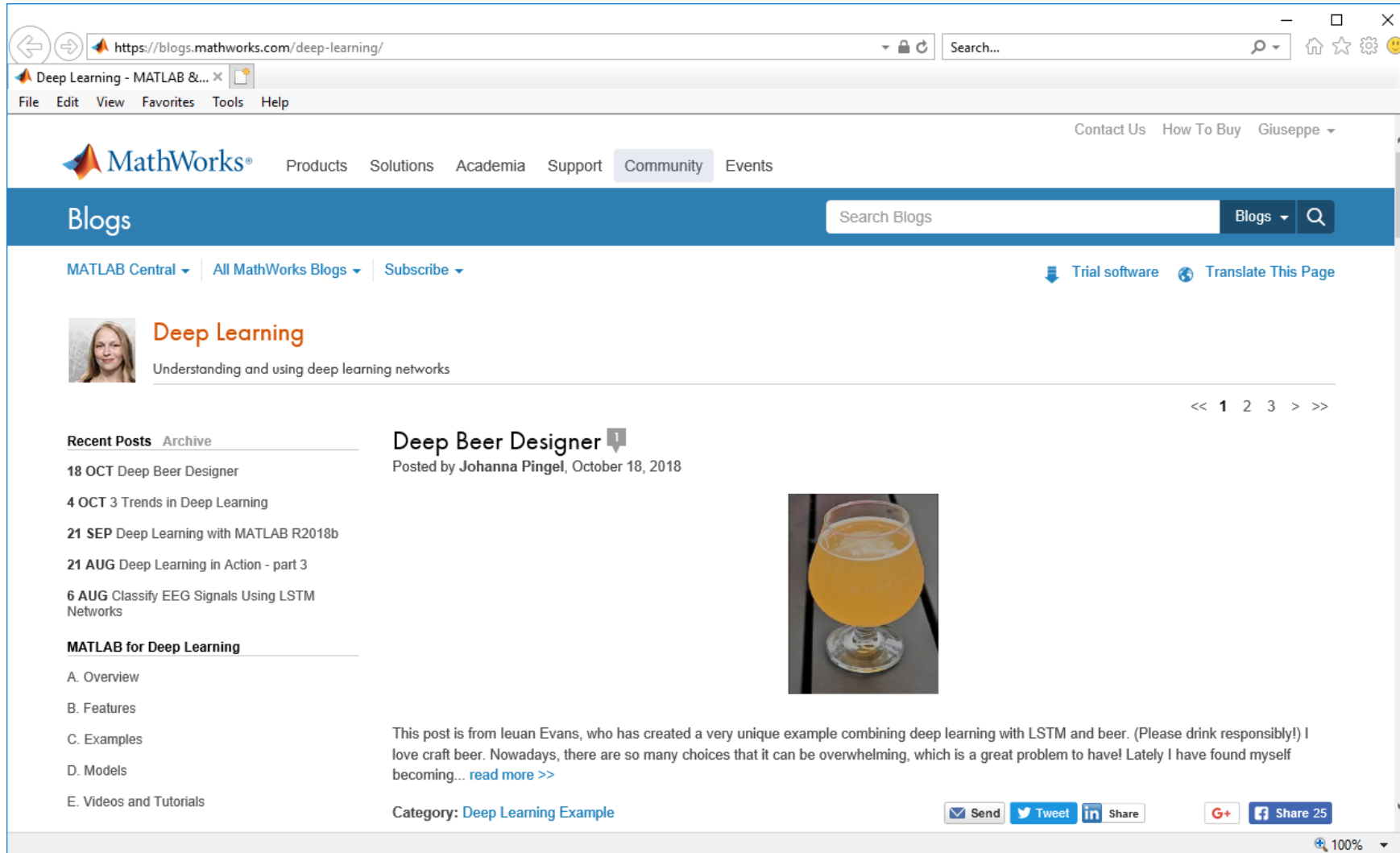
Network training
performance



Expanded deployment
support



Blog: Deep Learning




The screenshot shows a web browser window displaying the MathWorks Deep Learning blog. The browser's address bar shows the URL <https://blogs.mathworks.com/deep-learning/>. The MathWorks logo is in the top right corner. The page has a blue header with the word "Blogs" and a search bar. Below the header, there are navigation links for "MATLAB Central", "All MathWorks Blogs", and "Subscribe". The main content area features a post titled "Deep Learning" by a user with a profile picture. Below this, there is a section for "Recent Posts" with a list of articles including "18 OCT Deep Beer Designer", "4 OCT 3 Trends in Deep Learning", "21 SEP Deep Learning with MATLAB R2018b", "21 AUG Deep Learning in Action - part 3", and "6 AUG Classify EEG Signals Using LSTM Networks". The "Deep Beer Designer" post is highlighted, showing its title, author (Johanna Pingel), date (October 18, 2018), and a thumbnail image of a glass of beer. The post text discusses combining deep learning with LSTM and beer, and includes a "read more" link. At the bottom of the post, there are social media sharing buttons for Send, Tweet, Share, G+, and Facebook (Share 25).

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Blogs Search Blogs

MATLAB Central All MathWorks Blogs Subscribe

Trial software Translate This Page

 **Deep Learning**
Understanding and using deep learning networks

<< 1 2 3 > >>


Recent Posts Archive

- 18 OCT Deep Beer Designer
- 4 OCT 3 Trends in Deep Learning
- 21 SEP Deep Learning with MATLAB R2018b
- 21 AUG Deep Learning in Action - part 3
- 6 AUG Classify EEG Signals Using LSTM Networks

MATLAB for Deep Learning

- A. Overview
- B. Features
- C. Examples
- D. Models
- E. Videos and Tutorials

Deep Beer Designer
Posted by Johanna Pingel, October 18, 2018



This post is from Ieuan Evans, who has created a very unique example combining deep learning with LSTM and beer. (Please drink responsibly!) I love craft beer. Nowadays, there are so many choices that it can be overwhelming, which is a great problem to have! Lately I have found myself becoming... [read more >>](#)

Category: **Deep Learning Example**

Send Tweet Share G+ Share 25

<http://blogs.mathworks.com/deep-learning/>

Agenda

- Introduction
- Quick intro to MATLAB
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Why use MATLAB for Image Processing?

Key takeaways

- Complete environment
- Verified and trusted algorithms
- Faster than hand-coding algorithms in C/C++
- Open and flexible architecture enables a customized workflow



Download Image Processing Tips, Techniques, and Code

Author and developer Steve Eddins shares excerpts from his blog, featuring the most popular tips and techniques for image processing and image segmentation with MATLAB®.

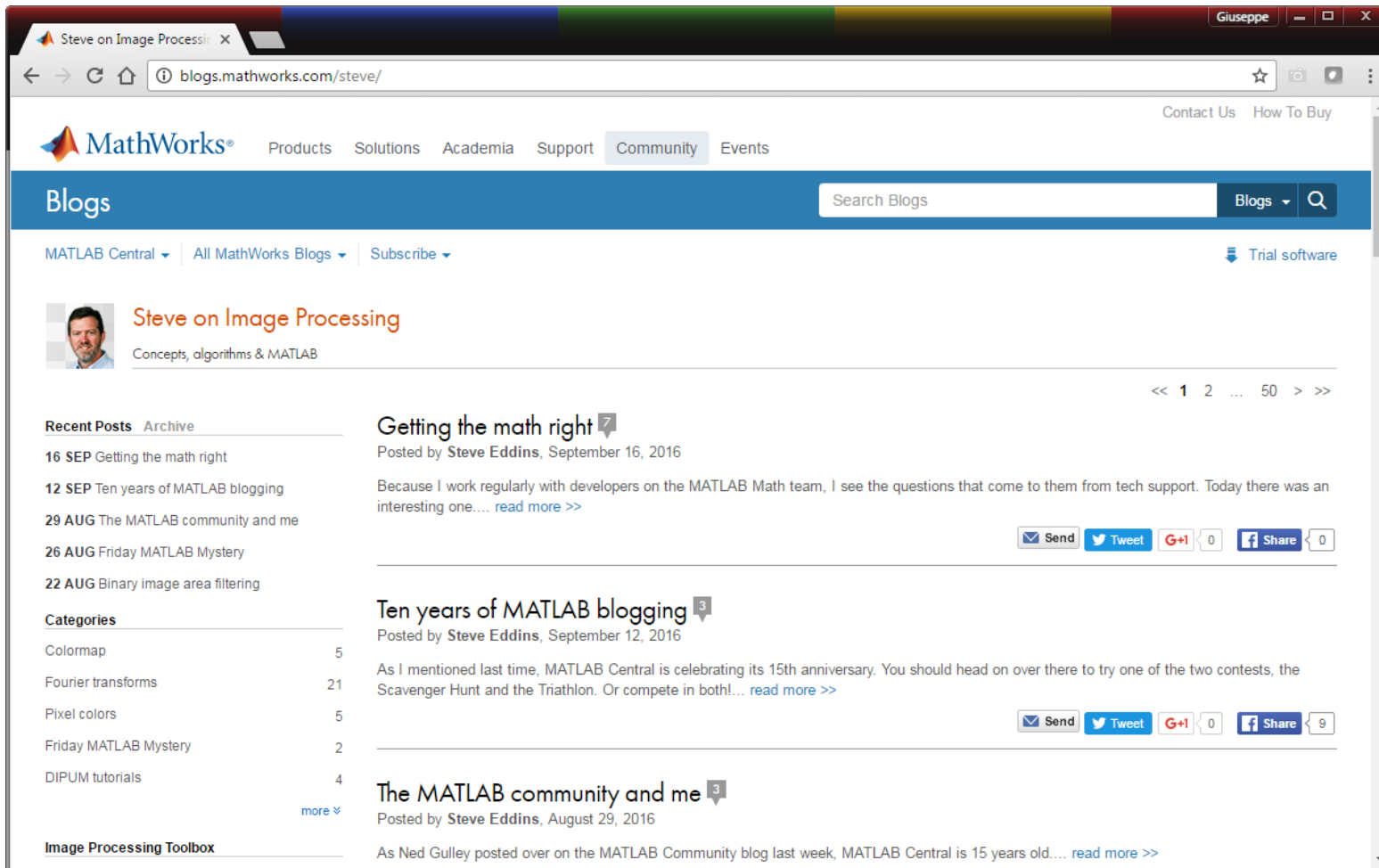


Download the Image Processing Tips and Techniques Kit to get code and step-by-step instructions for implementing these tasks easily in MATLAB:

- ✓ Color Segmentation
- ✓ Image Region Analysis
- ✓ Watershed Segmentation

The kit also includes several bonus techniques that MATLAB users have found helpful.

Blog: Steve on Image Processing




The screenshot shows a web browser window displaying the MathWorks blog page for Steve Eddins. The browser's address bar shows the URL `blogs.mathworks.com/steve/`. The page features the MathWorks logo and navigation links for Products, Solutions, Academia, Support, Community, and Events. A search bar is located in the top right. Below the navigation, there's a section for "Blogs" with a search bar and a dropdown menu. The main content area displays the blog profile for Steve Eddins, with a profile picture and the title "Steve on Image Processing". Below the profile, there's a list of recent posts and a table of categories. The posts listed are "Getting the math right", "Ten years of MATLAB blogging", and "The MATLAB community and me". The categories listed are Colormap, Fourier transforms, Pixel colors, Friday MATLAB Mystery, and DIPUM tutorials. The page also includes social media sharing buttons for Send, Tweet, G+, and Share.

MathWorks® Products Solutions Academia Support Community Events

Blogs Search Blogs Blogs Q

MATLAB Central All MathWorks Blogs Subscribe Trial software

 **Steve on Image Processing**
Concepts, algorithms & MATLAB

<< 1 2 ... 50 >>

Recent Posts Archive

- 16 SEP Getting the math right
- 12 SEP Ten years of MATLAB blogging
- 29 AUG The MATLAB community and me
- 26 AUG Friday MATLAB Mystery
- 22 AUG Binary image area filtering

Categories

| | |
|-----------------------|----|
| Colormap | 5 |
| Fourier transforms | 21 |
| Pixel colors | 5 |
| Friday MATLAB Mystery | 2 |
| DIPUM tutorials | 4 |

[more](#)

Image Processing Toolbox

Getting the math right 7
Posted by Steve Eddins, September 16, 2016
Because I work regularly with developers on the MATLAB Math team, I see the questions that come to them from tech support. Today there was an interesting one.... [read more >>](#)

Send Tweet G+ 0 Share 0

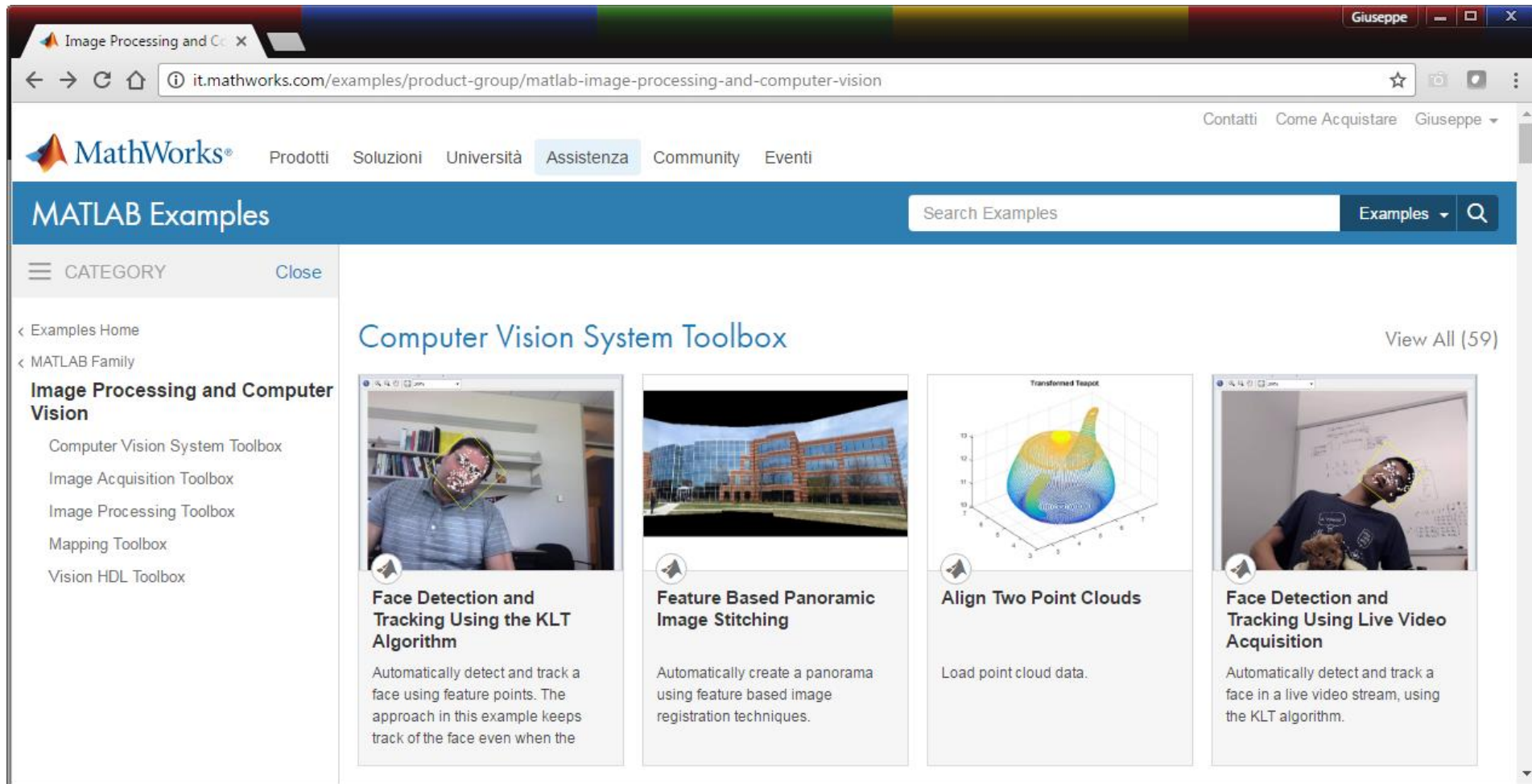
Ten years of MATLAB blogging 3
Posted by Steve Eddins, September 12, 2016
As I mentioned last time, MATLAB Central is celebrating its 15th anniversary. You should head on over there to try one of the two contests, the Scavenger Hunt and the Triathlon. Or compete in both!... [read more >>](#)

Send Tweet G+ 0 Share 9

The MATLAB community and me 3
Posted by Steve Eddins, August 29, 2016
As Ned Gulley posted over on the MATLAB Community blog last week, MATLAB Central is 15 years old.... [read more >>](#)

<http://blogs.mathworks.com/steve/>

MATLAB Examples



The screenshot shows the MATLAB Examples website interface. The browser address bar displays `it.mathworks.com/examples/product-group/matlab-image-processing-and-computer-vision`. The page header includes the MathWorks logo and navigation links: **Prodotti**, **Soluzioni**, **Università**, **Assistenza**, **Community**, and **Eventi**. A search bar labeled "Search Examples" is present, along with a dropdown menu for "Examples".

The main content area is titled "MATLAB Examples" and features a sidebar on the left with a "CATEGORY" filter. The sidebar lists the following categories under "Image Processing and Computer Vision":

- Computer Vision System Toolbox
- Image Acquisition Toolbox
- Image Processing Toolbox
- Mapping Toolbox
- Vision HDL Toolbox

The main content area displays the "Computer Vision System Toolbox" section, which includes a "View All (59)" link. Four example cards are visible:

- Face Detection and Tracking Using the KLT Algorithm**: Automatically detect and track a face using feature points. The approach in this example keeps track of the face even when the
- Feature Based Panoramic Image Stitching**: Automatically create a panorama using feature based image registration techniques.
- Align Two Point Clouds**: Load point cloud data.
- Face Detection and Tracking Using Live Video Acquisition**: Automatically detect and track a face in a live video stream, using the KLT algorithm.

<http://it.mathworks.com/examples/product-group/matlab-image-processing-and-computer-vision>

Hardware Support in MATLAB

- Validate algorithms with live data
- Integrate with webcams and IP cameras
- Access images and video from network cameras
- Webcam and IP Camera support in base MATLAB



Support for Industrial and Scientific Cameras

- Acquire images & video from industry-standard hardware:

- Camera Link
- DCAM compatible FireWire (IIDC 1394)
- GigE Vision
- GenICam Interface

- Manufacturers include:

- Allied Vision Technologies
- Basler
- Baumer
- FLIR
- Hamamatsu
- Point Grey
- Teledyne DALSA



HAMAMATSU

- See Hardware Catalog for more details: www.mathworks.com/hardware

Getting Started Resources

Web Resource Portal

- [MATLAB and C/C++ Resources](http://it.mathworks.com/matlab-c-resources)
 - Videos
 - Examples
 - Documentation

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MATLAB and C/C++ Resources

Search MathWorks.com

Learn about working with MATLAB® and C/C++ to verify designs, leverage existing code, and target embedded processors.

Simulation (MATLAB) ↔ **Development** (Visual Studio, Eclipse) ↔ **Existing Code** (C/C++) → **Deployment** (\$)

Get Started Converting MATLAB to C/C++

- MATLAB to C Made Easy 57:22
 - View Related Presentation
- MATLAB Coder Getting Started Guides
- Integrate Code into Visual Studio 4:17
- Deciding between MATLAB Coder and Compiler
- Building DLLs for C/C++ Applications 5:08
- MATLAB for Product Development 40:52

Incorporate C/C++ Code in MATLAB

- Calling C libraries from MATLAB
- Call C/C++ Code from MATLAB with MEX

Debug, Test, and Verify C/C++ Code

- Visualizing C/C++ Data with MATLAB
 - View Related Visual Studio Project
- MATLAB Unit Testing Framework 8:38
- Write and Run Tests Using Unit Testing Framework
- Finding and Fixing C/C++ Bugs 1:15

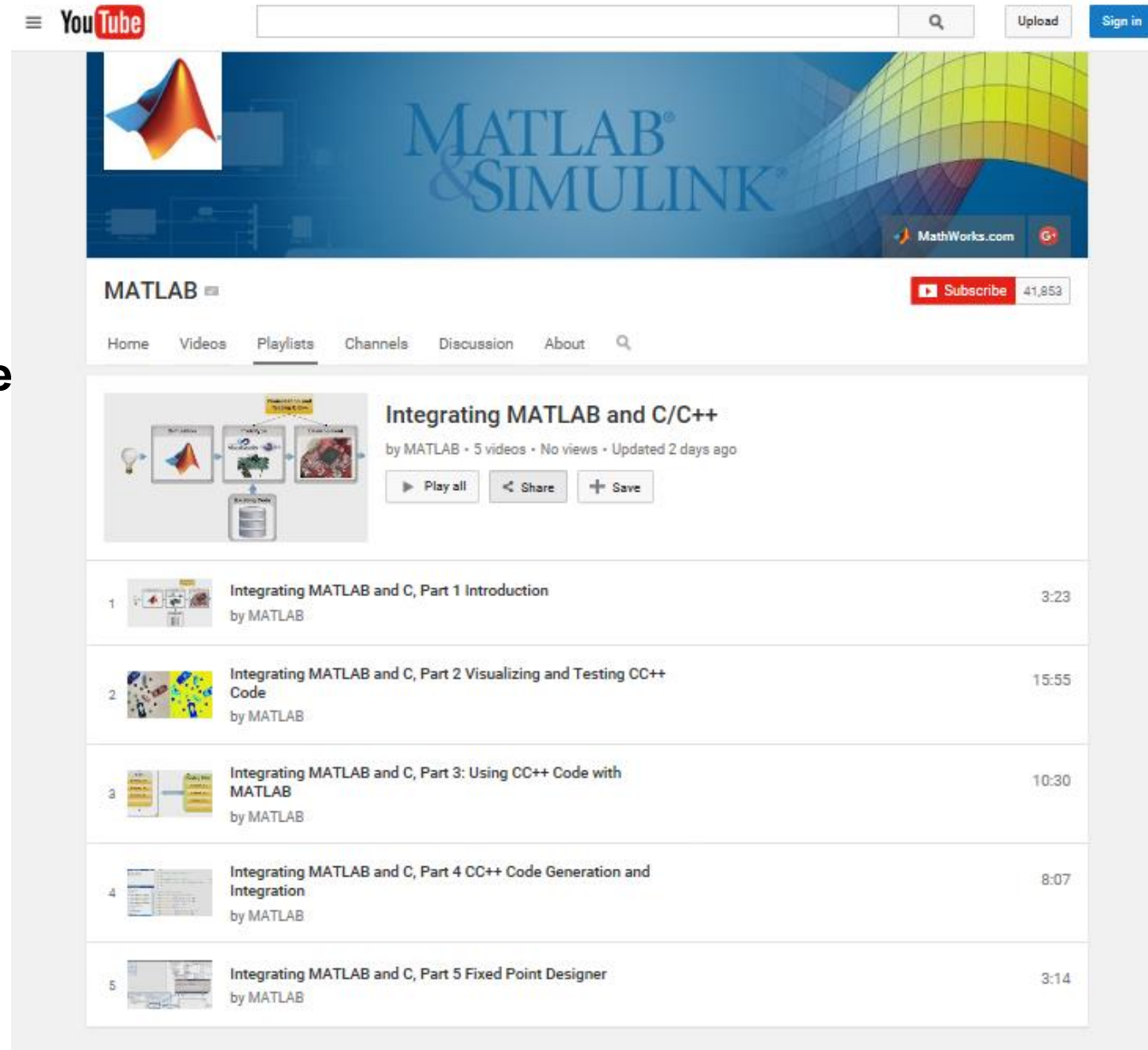
Explore Support for Application Domains

- Tips and Tricks for Vision Applications
- Image Processing Functions
- Signal Processing Functions
- Communications Functions
- Statistics Functions
- Request More Function Support

Getting Started Video Series

YouTube:

- [Integrating MATLAB and C/C++](#)
 - Visualizing and Testing C/C++ Code
 - Using C/C++ Code with MATLAB
 - Fixed Point Conversion Overview
 - ...

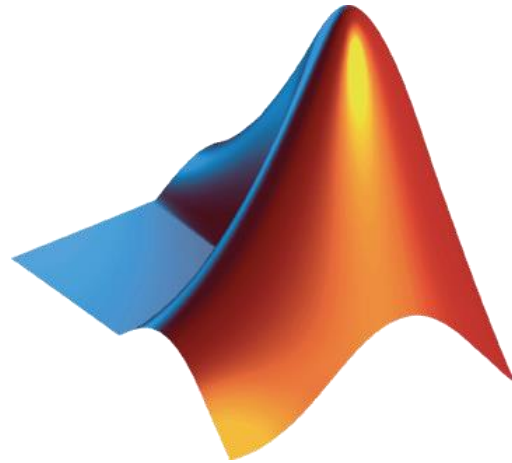


The screenshot shows the MATLAB YouTube channel page. At the top, there's a banner with the MATLAB & SIMULINK logo and a MathWorks.com link. Below the banner, the channel name 'MATLAB' is displayed with a 'Subscribe' button showing 41,853 subscribers. The navigation menu includes Home, Videos, Playlists, Channels, Discussion, and About. The 'Integrating MATLAB and C/C++' playlist is featured, showing a thumbnail with a flowchart of the integration process. Below the playlist title, it says 'by MATLAB • 5 videos • No views • Updated 2 days ago'. There are buttons for 'Play all', 'Share', and 'Save'. The playlist contains five videos:

| Video Number | Video Title | Duration |
|--------------|---|----------|
| 1 | Integrating MATLAB and C, Part 1 Introduction | 3:23 |
| 2 | Integrating MATLAB and C, Part 2 Visualizing and Testing CC++ Code | 15:55 |
| 3 | Integrating MATLAB and C, Part 3: Using CC++ Code with MATLAB | 10:30 |
| 4 | Integrating MATLAB and C, Part 4 CC++ Code Generation and Integration | 8:07 |
| 5 | Integrating MATLAB and C, Part 5 Fixed Point Designer | 3:14 |

Thank you for your attention!

Questions?



Accelerating the pace of engineering and science