

Image Processing and Computer Vision with MATLAB

Agenda

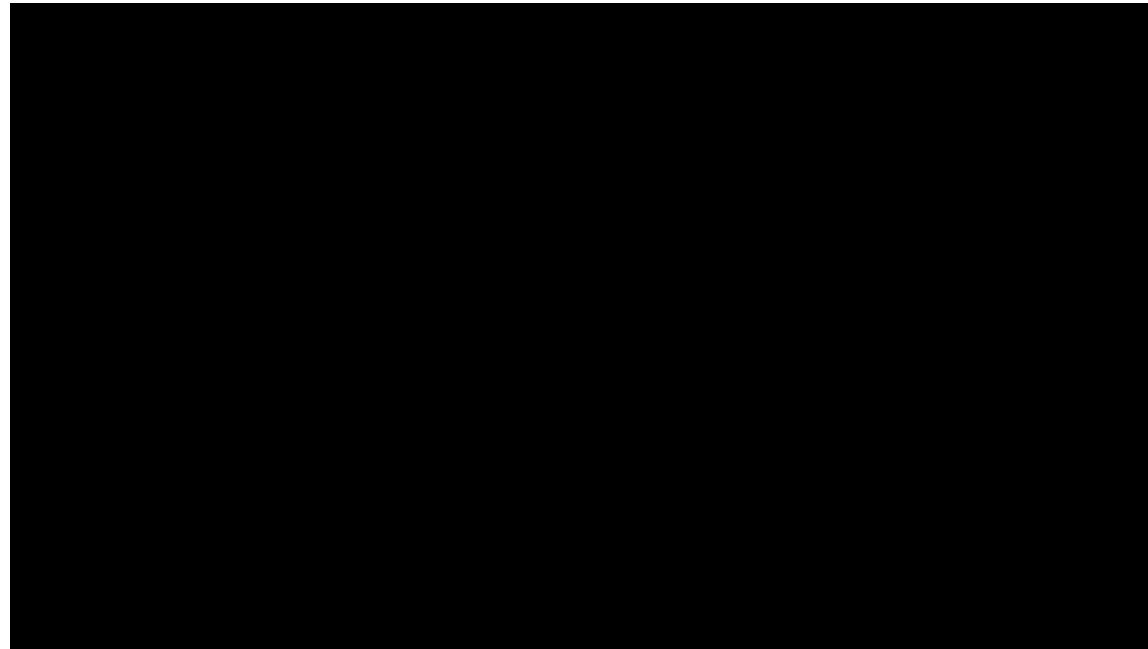
- Application areas
 - Deep learning
 - 3-D image processing
 - LiDAR and 3-D point cloud processing
 - Automated driving
- MATLAB Apps
- Performance improvements
- Code generation and embedded vision

Deep Learning

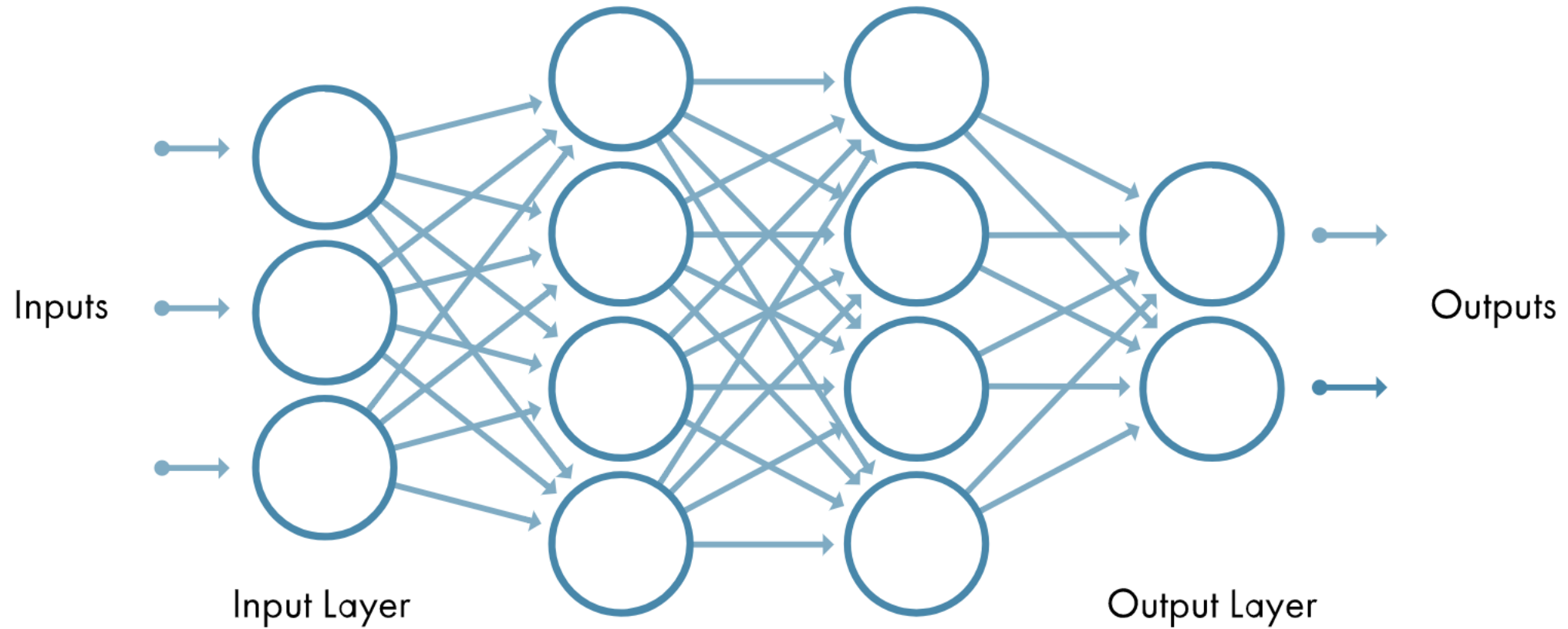
R2016b

R2017a

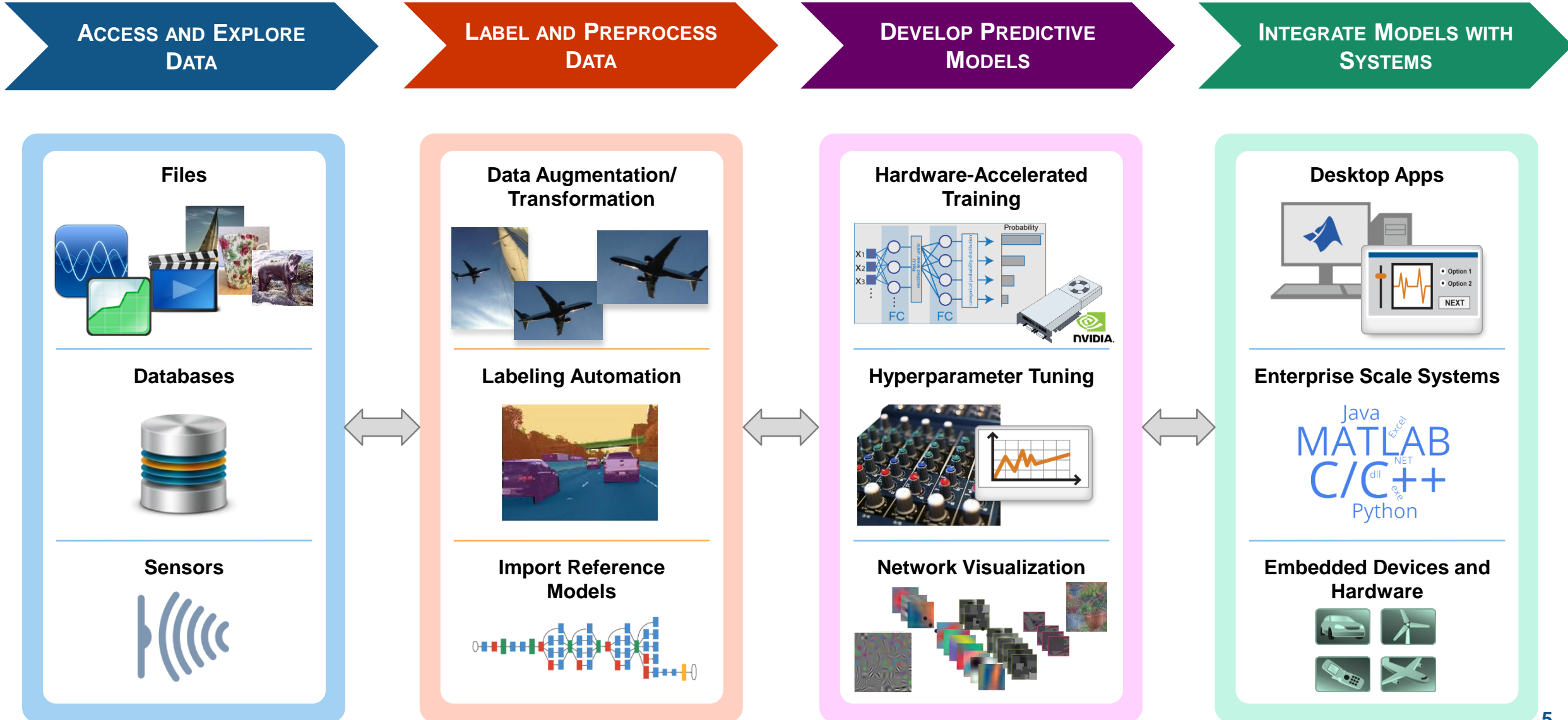
R2017b



Deep Learning



Deep Learning Workflow



Deep Learning Features

Object Detection Frameworks

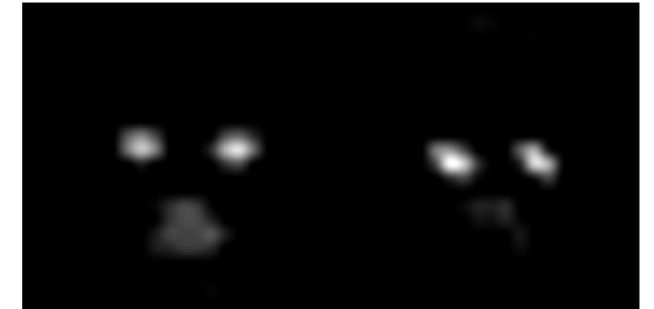
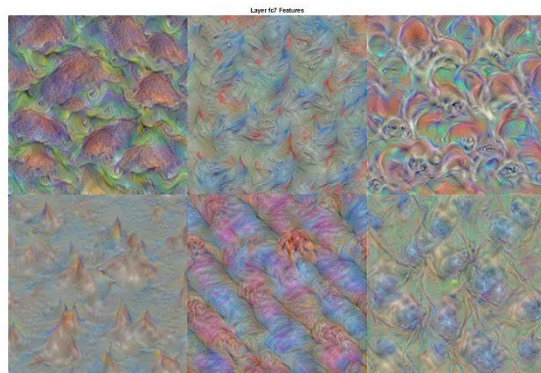
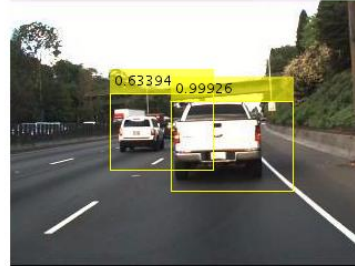
- R-CNN, Fast R-CNN & Faster R-CNN

Regression with Deep Learning

Deep Learning Visualization

Activations of Networks

Handling Large Sets of Images Easily

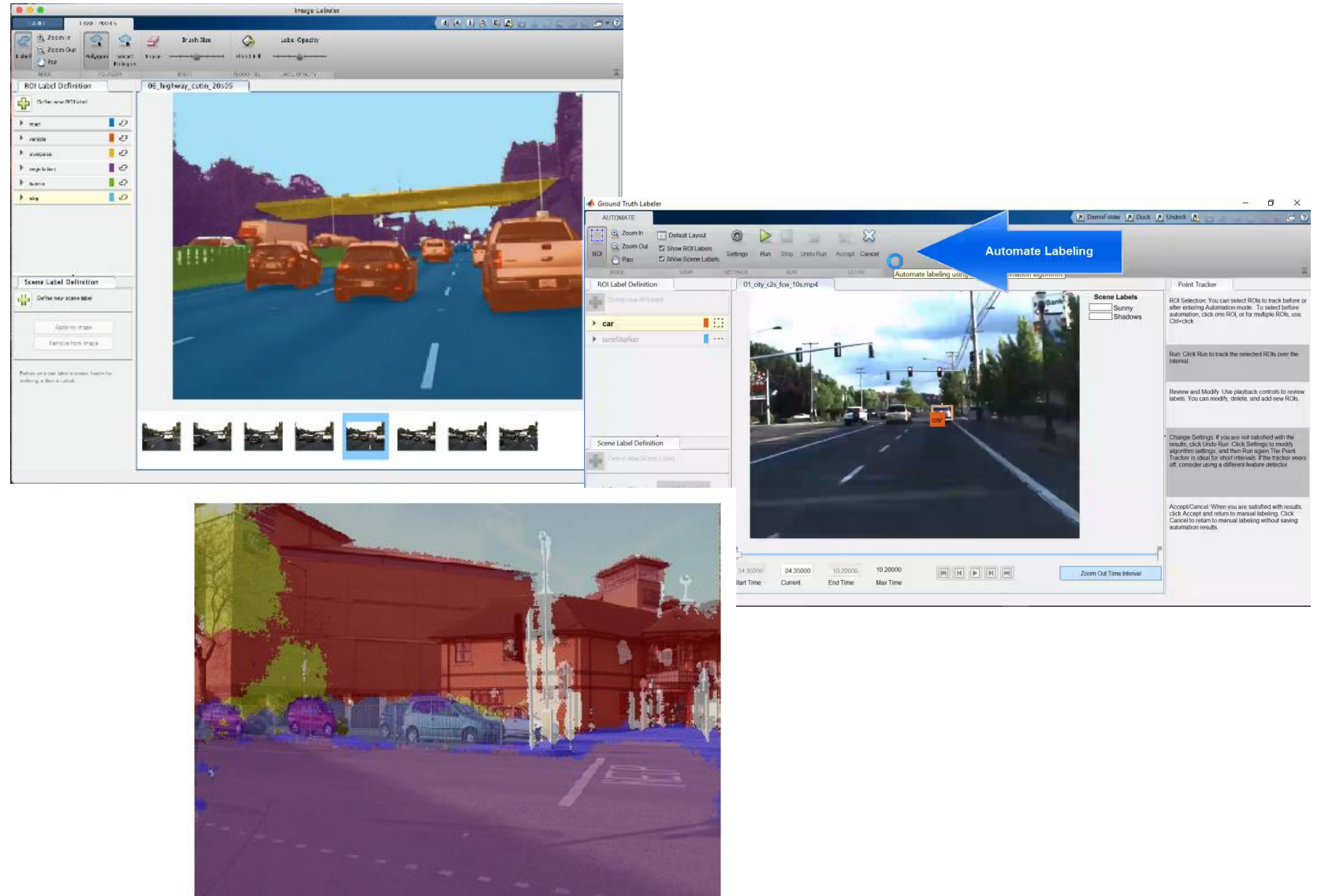


Deep Learning with MATLAB

“How do I *label* my data?”

New App for Ground Truth Labeling

Label pixels and regions for semantic segmentation



Deep Learning with MATLAB

“How do I access the latest models?”

Caffe model importer

LSTM
(time series, text)

DAG Networks

Models

Pretrained Models from Deep Learning Frameworks

AlexNet
PRETRAINED MODEL

VGG-16
PRETRAINED MODEL

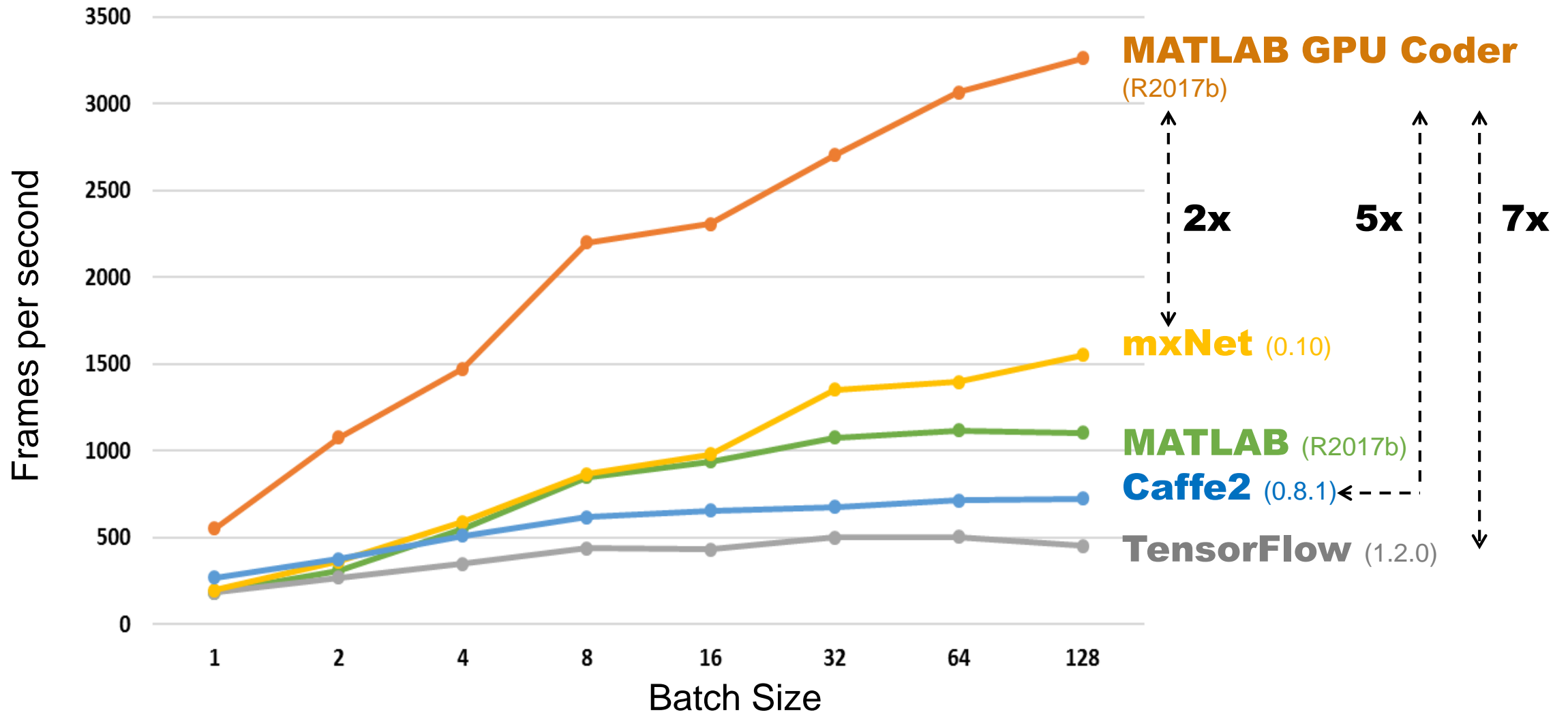
VGG-19
PRETRAINED MODEL

Caffe
Caffe Model Zoo

Available Models:

- AlexNet
- VGG-16
- VGG-19
- GoogLeNet
- Many More with Caffe Model Importer

Alexnet Inference on NVIDIA Titan XP



CPU	Intel(R) Xeon(R) CPU E5-1650 v3 @ 3.50GHz
GPU	Pascal Titan Xp
cuDNN	v5

Testing platform

3-D Image Processing

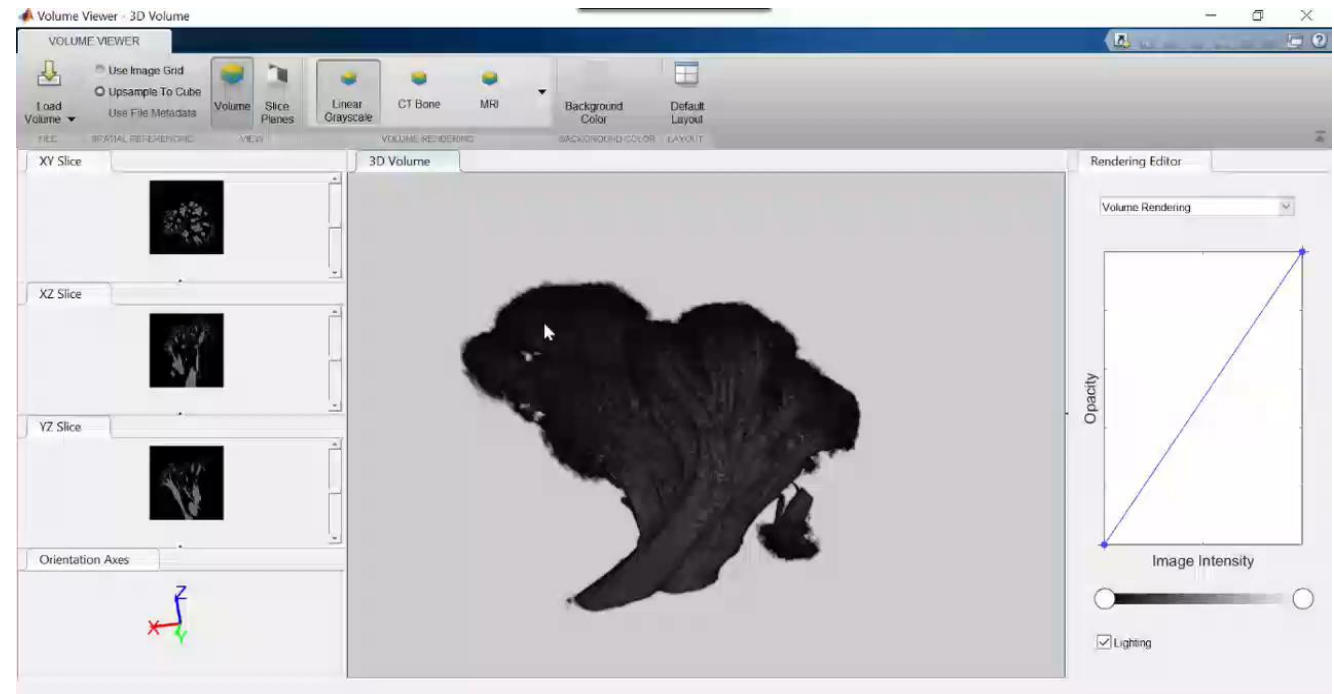
R2016b R2017a

Over 40 functions support 3-D volumetric image processing

Capabilities Includes:

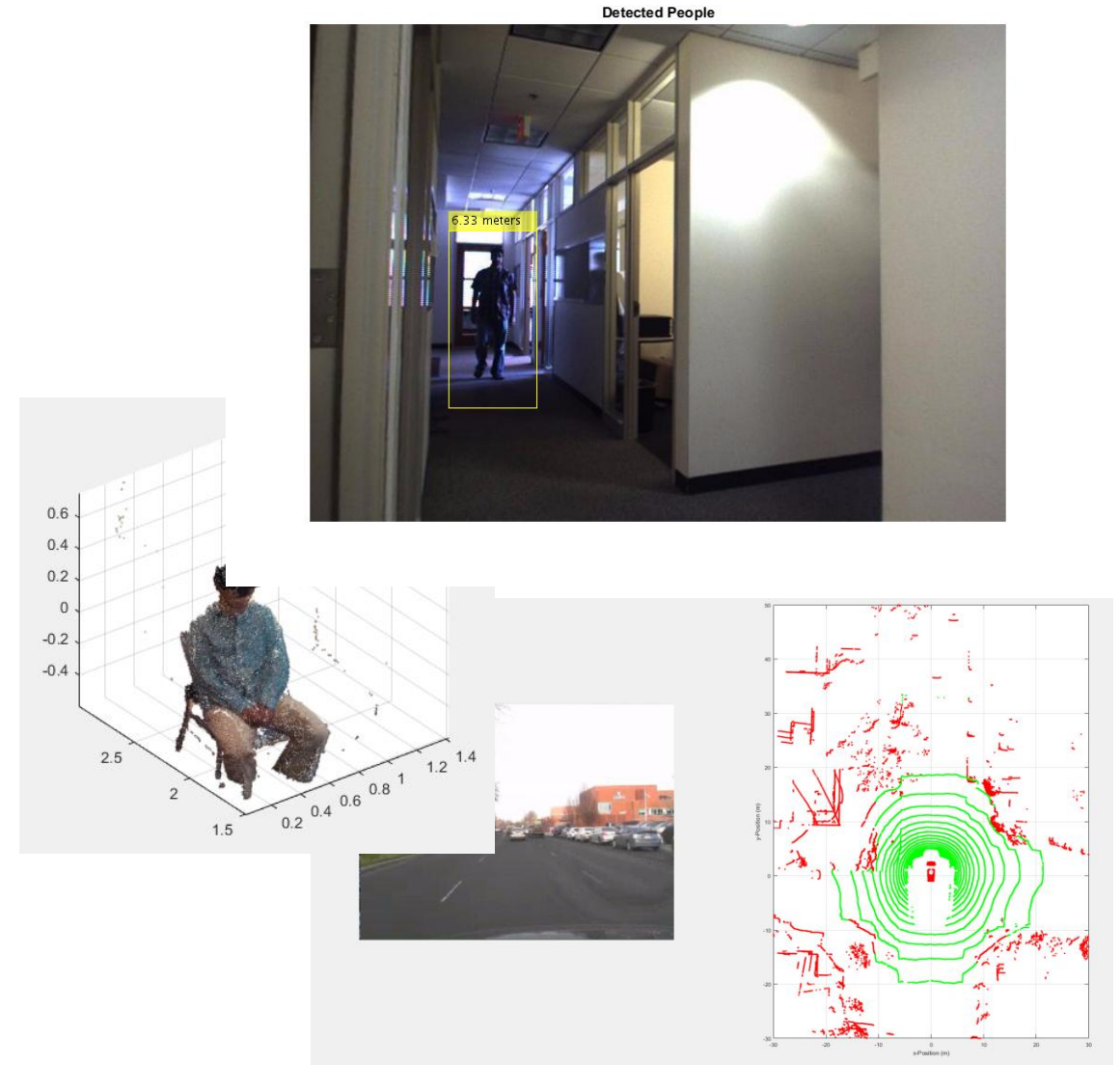
- Image arithmetic
- Morphology
- Segmentation
- Geometric transforms
- Enhancement

Volume Viewer App for exploration

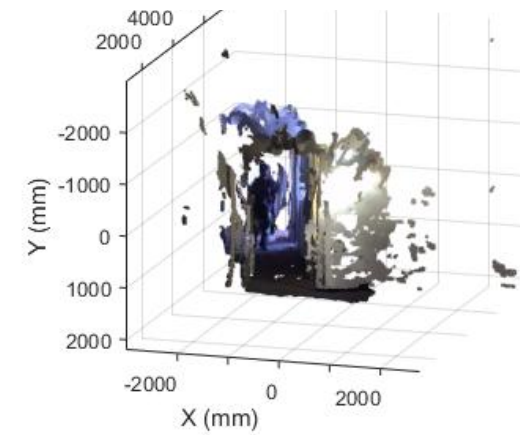
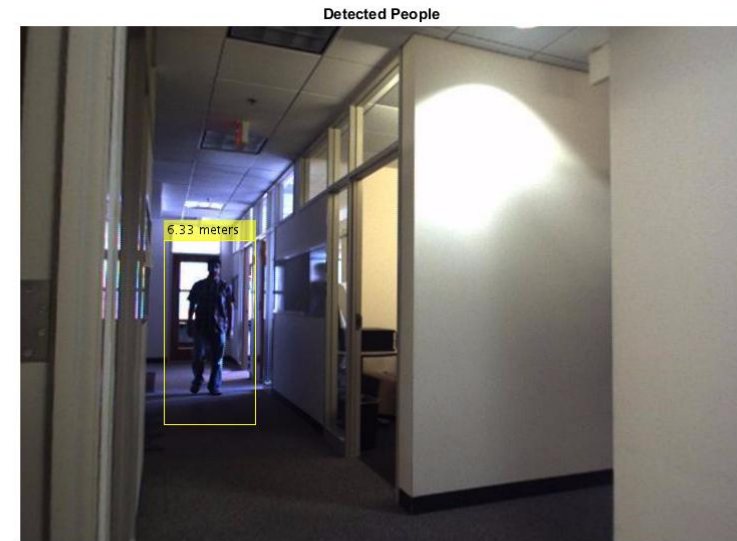


3D Point Cloud Processing

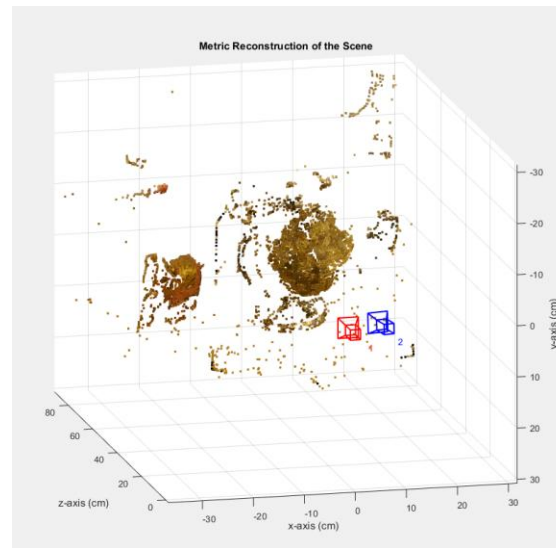
- **Multiple View Geometry**
 - 3-D Reconstruction with stereo vision
 - *Structure from Motion**
- **3-D Point Cloud Processing**
 - Point Cloud Registration
 - Geometric Shape Fitting



Demo: Depth Estimation and 3-D Reconstruction using Stereo Vision



3-D Point Cloud Processing: Structure from Motion



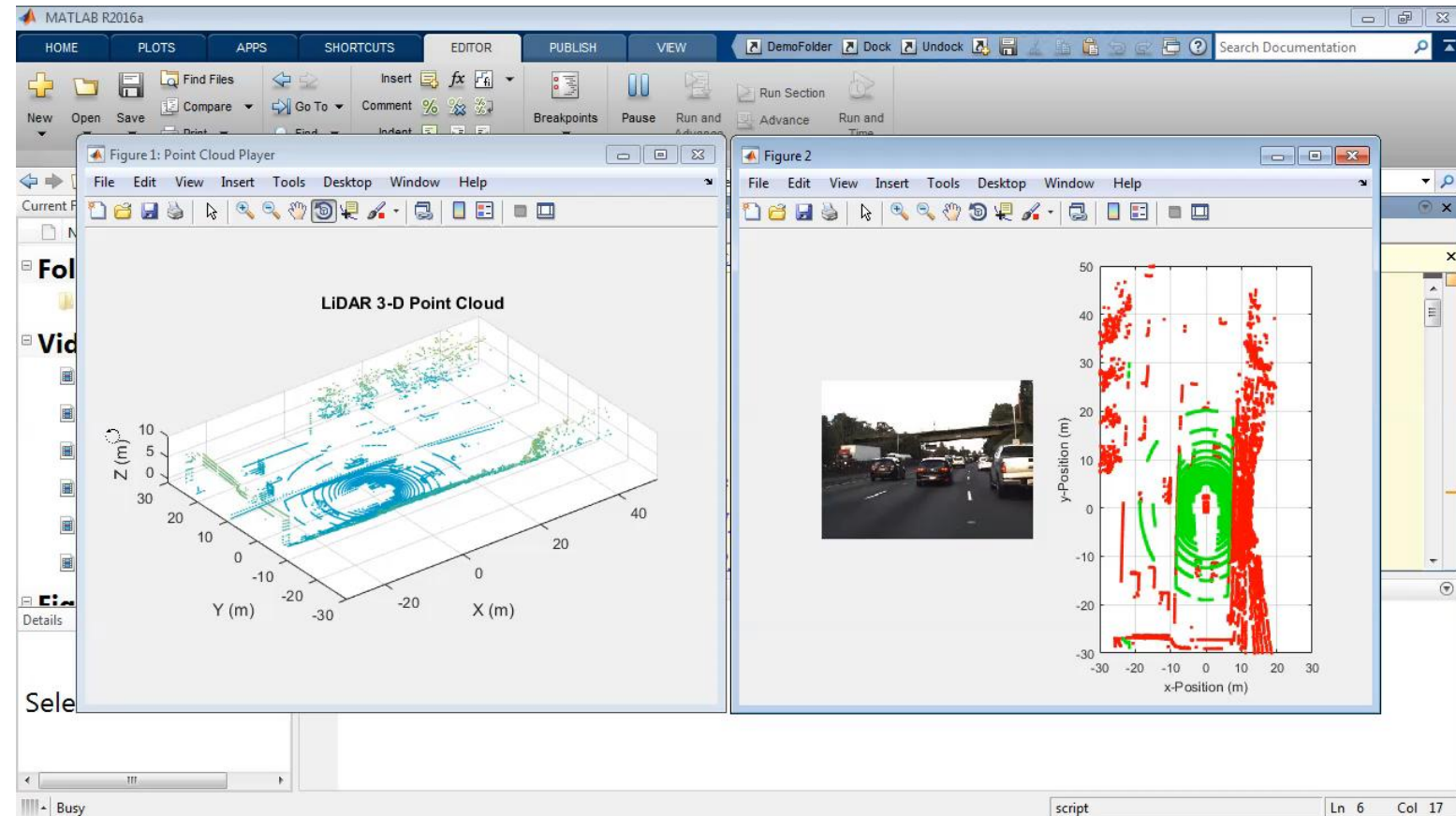
LiDAR/3-D Point Cloud Processing

3-D point cloud processing for LiDAR, stereo cameras, RGB-D sensors

Capabilities Includes:

- Point cloud file I/O
- Viewers
- Registration and stitching
- Shape fitting
- Easy data handling

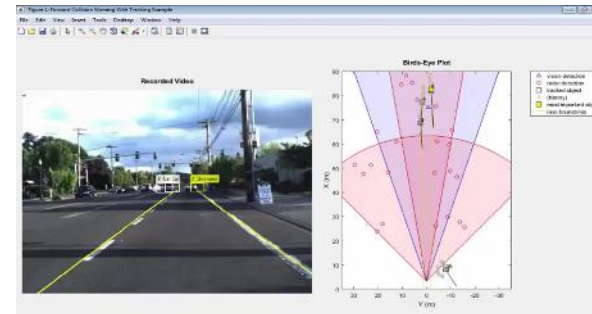
Designed to run real-time on a PC



Automated Driving System Toolbox

1. Algorithm Development

- Sensor fusion
- Computer vision
- Deep learning



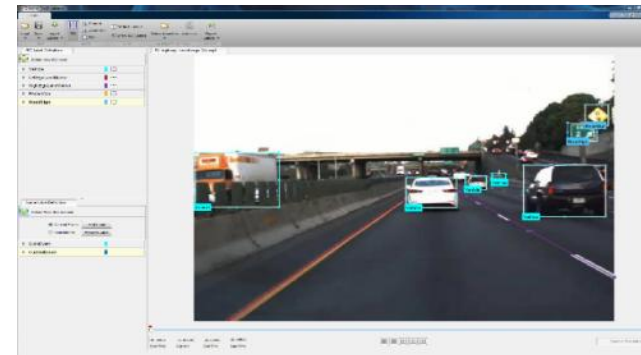
Sensor Fusion



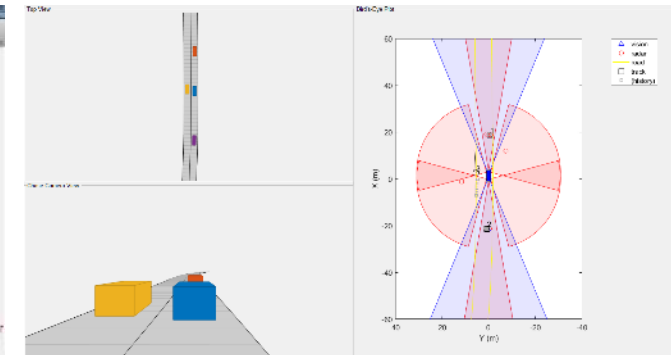
Computer Vision & Deep Learning

2. Testing and Verification

- Ground-truth labeling
- Traffic scenario generation



Ground truth-labeling



Scenario Generation

3. Visualization Tools

Automated Driving System Toolbox

Computer Vision System Design

Vision system design for ADAS and autonomous driving

Capabilities Include:

- Lane boundary fitting and classification
- Vehicle detection
- Image - world co-ordinate transforms
- Distance estimation with mono-camera



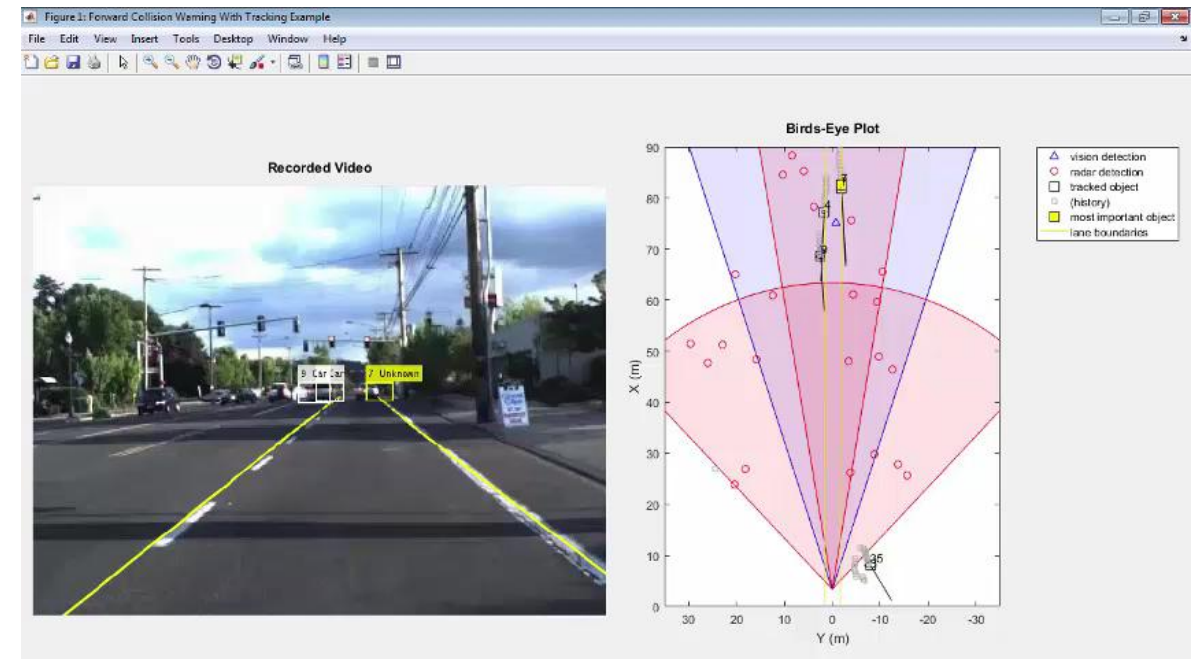
Vehicle and Lane Detection

Automated Driving System Toolbox

Sensor Fusion and Tracking

Capabilities Include:

- Multi-Sensor Fusion and Tracking Framework
 - Track creation, removal, deaths etc.
- Tracking filters and motion models
 - Linear, extended & unscented Kalman filters
 - Constant velocity, acceleration and turn rate
- Visualizations
 - 2-D birds eye view
 - Overlay camera and radar sensors
- Supports code generation



Automated Driving System Toolbox

Scenario Generation and Sensor Models

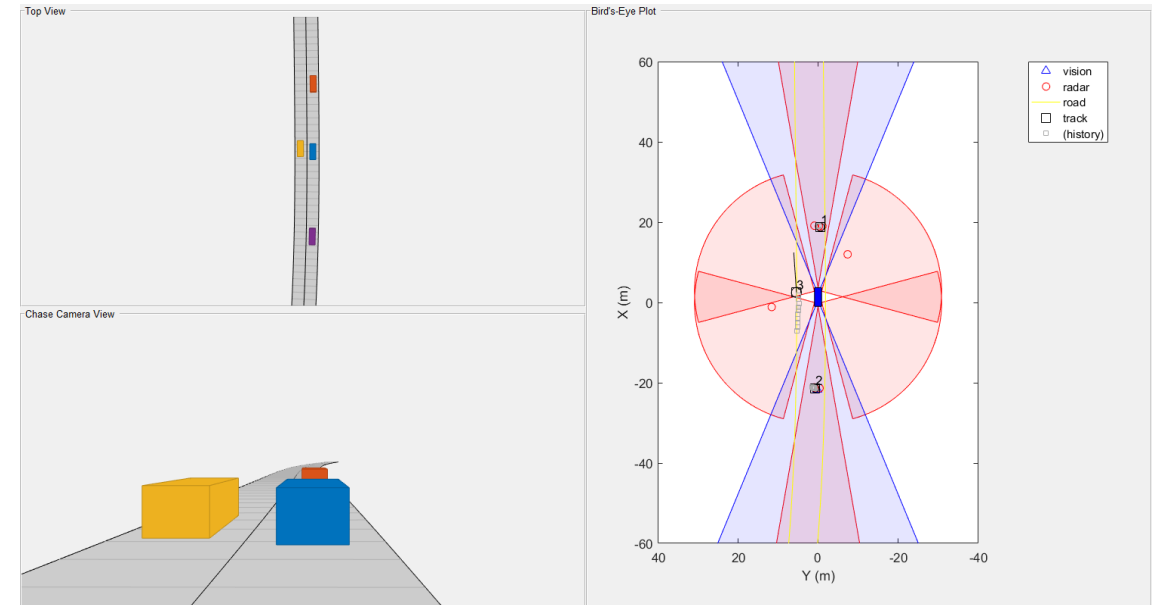
Camera and radar sensor simulation from synthetically generated driving scenarios

Capabilities Include:

- Scenario Generation
 - Actor and road segments definition
- Sensor Models
 - Camera and radar sensor models

Use Cases:

- Recorded data doesn't exist
- Testing dangerous scenarios (E.g. illegal U-turn)
- Different sensor configurations
- What-if analysis of failure cases



Automated Driving System Toolbox

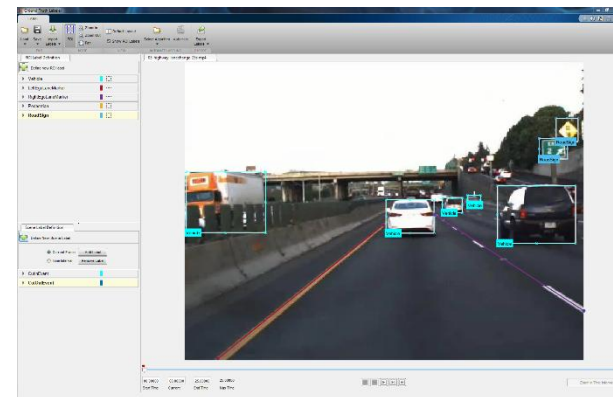
Ground Truth Labeling

R2017a

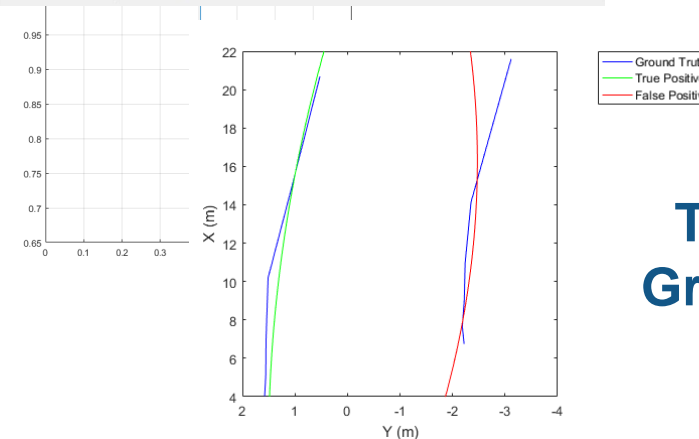
Automate labeling of ground truth data in video

Capabilities Include:

- App for labeling and inspection of ground-truth
- Algorithms for automation
 - Vehicle detection (deep learning, ACF)
 - Object tracking
 - ROI interpolation
 - Add custom algorithms with open API
- Tools to test algorithms vs. ground truth
- Use labeled data to train deep learning and machine learning algorithms

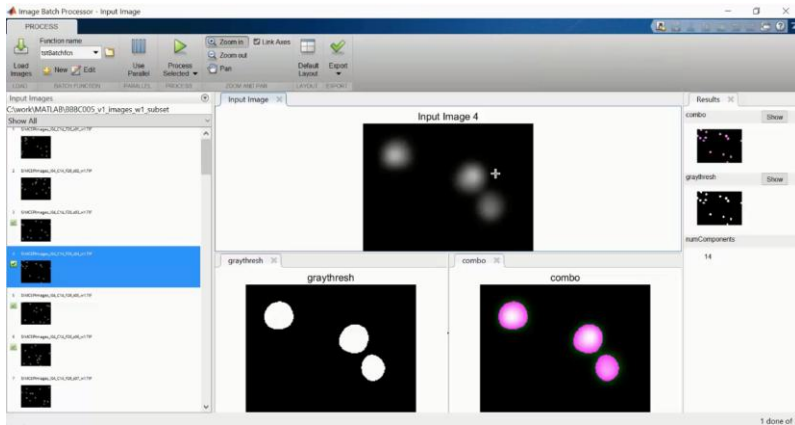


Ground Truth Labeling

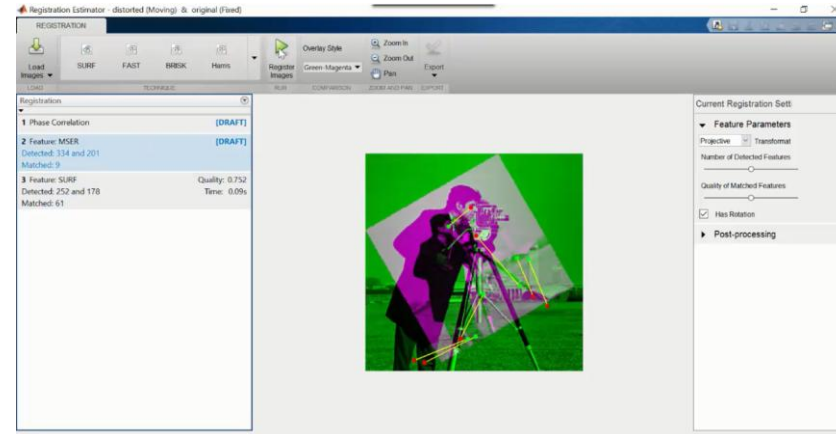


Testing vs. Ground Truth

Image Processing Apps



Batch Processing



Registration Estimation

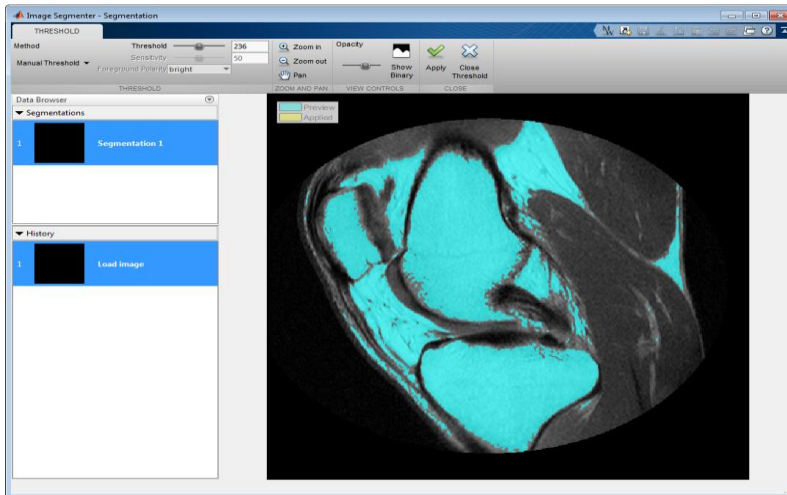
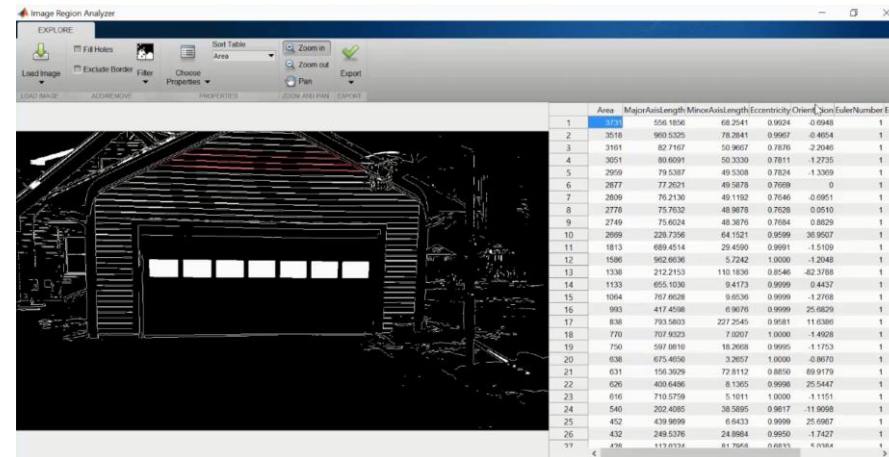
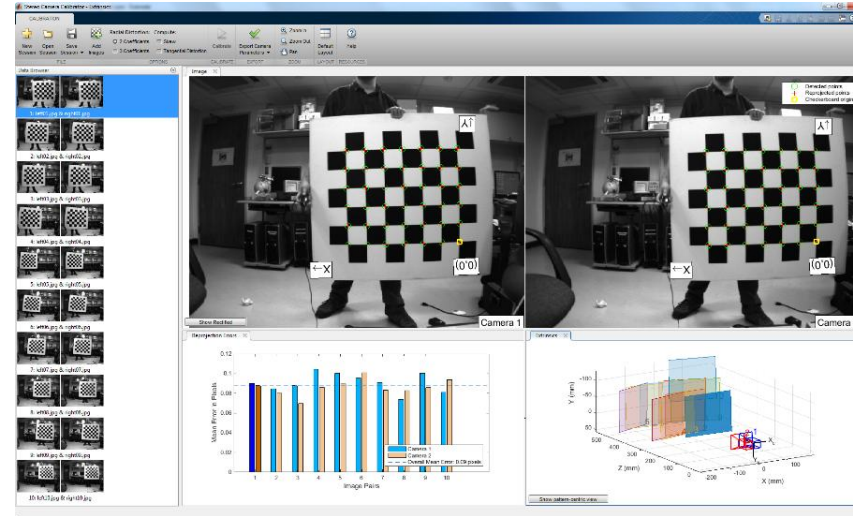
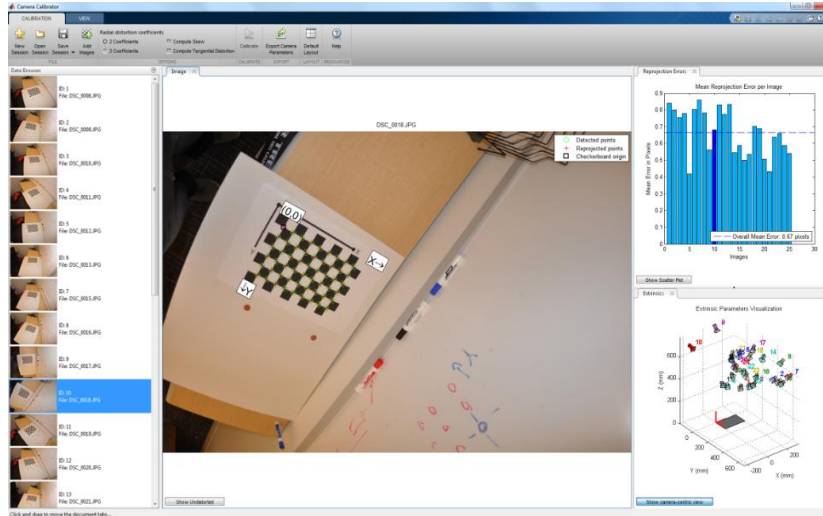


Image Segmentation



Region Analysis

Computer Vision Apps



Single and Stereo Camera Calibration

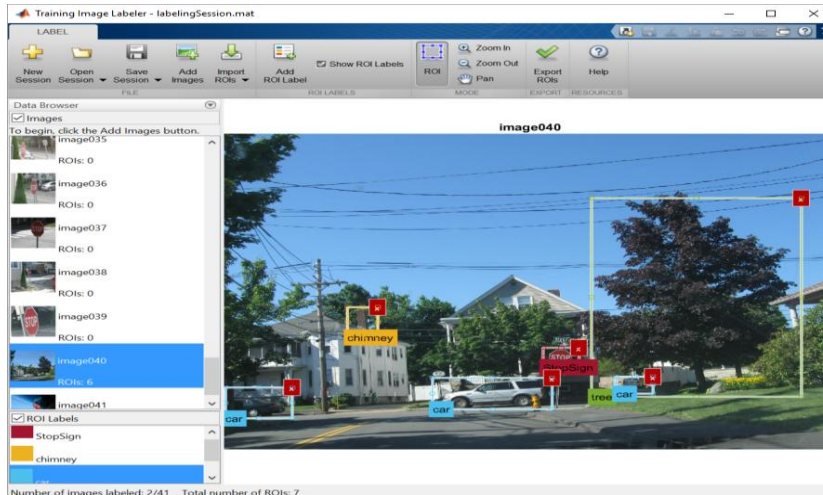
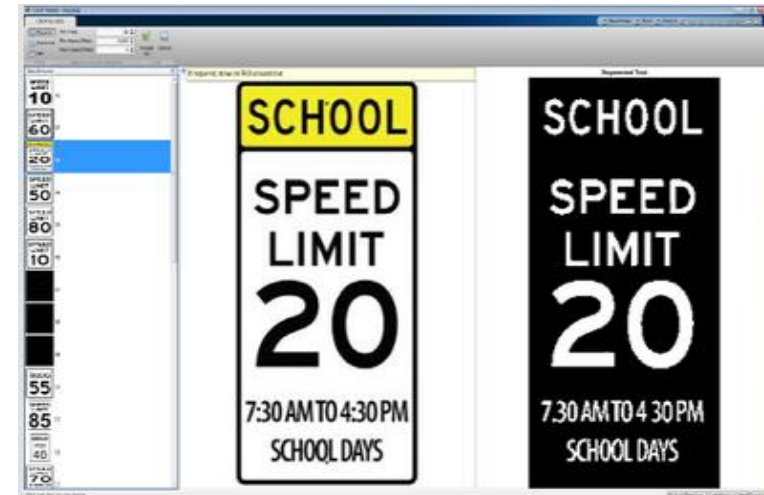


Image Labeler



OCR Training

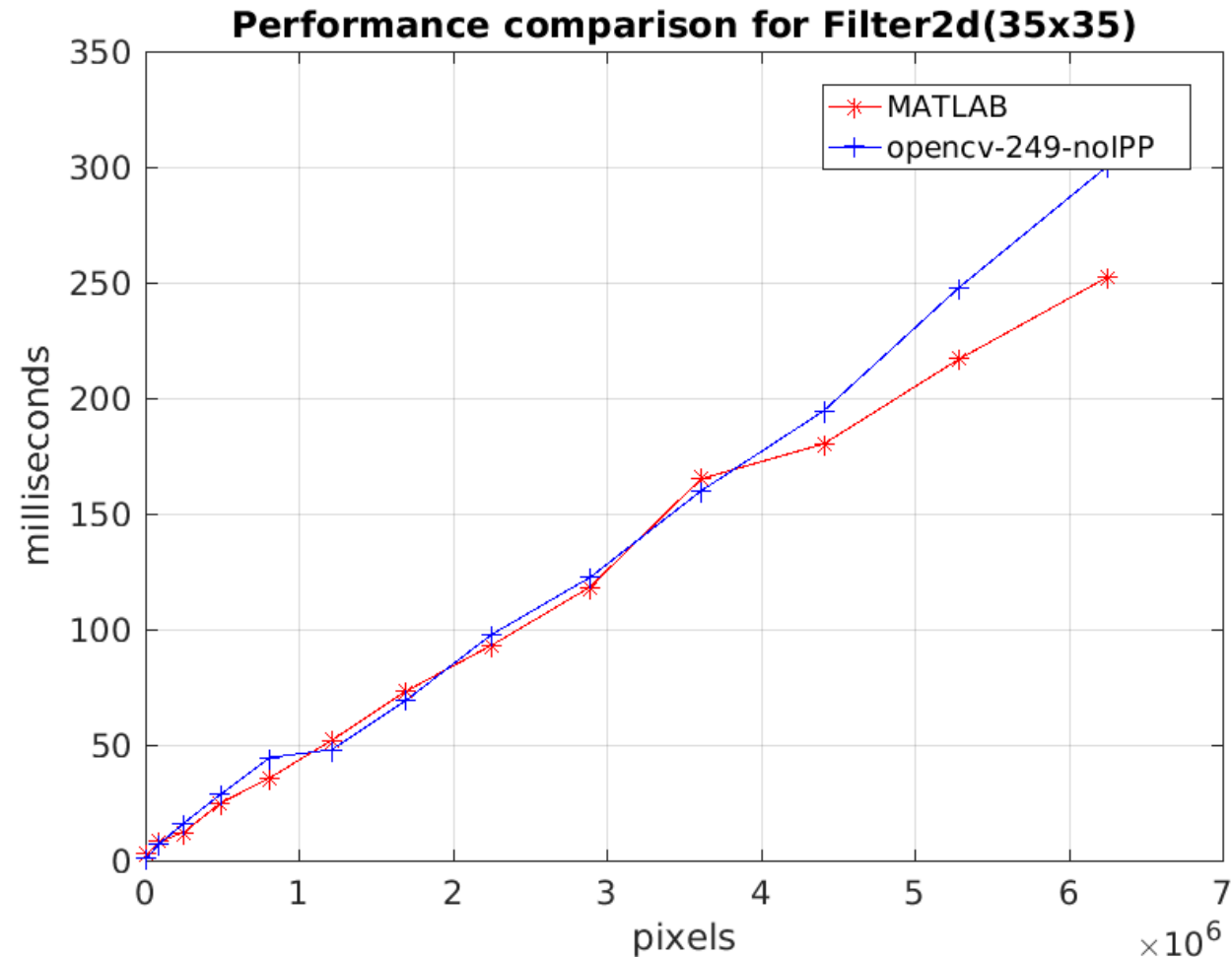
Performance Improvements

Optimizations for commonly used image processing and computer vision functions

Optimizations Include:

- Use of **IPP**
- **SSE** optimization
- **Multi-threading**

Performance parity with OpenCV

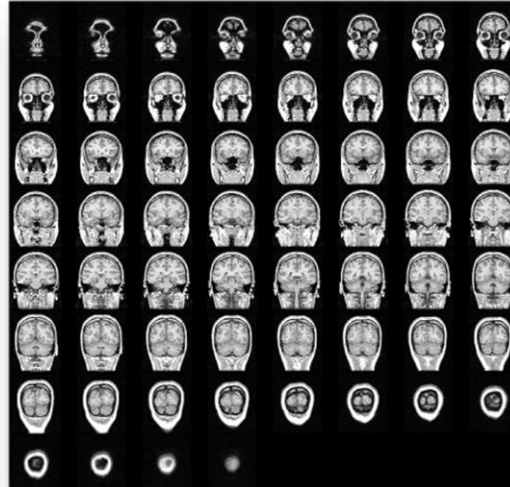
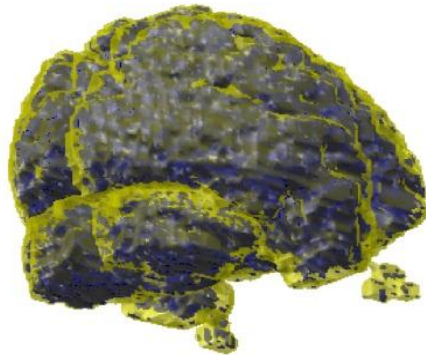


GPU Acceleration for 43 functions



Use NVIDIA GPUs to accelerate 43 of the most popular Image Processing Toolbox functions


- Accelerate complex algorithms with large data
- Integrate CUDA code for prototyping and testing



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

OpenCV Interface

- Bring OpenCV C/C++ code into MATLAB using MEX
- Ships with OpenCV-binaries
- Large library of data type conversions
- Several examples to help get started

Search Documentation 

Computer Vision System Toolbox > Code Generation and Third-Party Support > Third-Party Support Packages

OpenCV Interface

Install OpenCV Interface Files

The OpenCV Support package helps you integrate your OpenCV C++ code into MATLAB®. It lets you build MEX files that calls OpenCV functions. Use the [visionSupportPackages](#) function to launch the Support Package Installer. Follow the steps in the [Install Computer Vision System Toolbox Support Packages](#) directions.

Support Package Contents

The Computer Vision System Toolbox™ OpenCV Interface support package installs all the files you need in the `visionopencv` folder. To find the path to this folder, type the following command:

```
which mexOpenCV.m
```

The `visionopencv` folder contains:

example folder: Template Matching, Foreground Detector, and Oriented FAST and Rotated BRIEF (ORB) examples. Each subfolder contains a README.txt file with step-by-step instructions.
opencv folder: OpenCV header files, library files (for Windows® only), and OpenCV license file.
registry folder: Registration files.
mexOpenCV.m file: Function to build MEX files.
README.txt file: Help file.

C Code Generation

ANSI-C Code Generation for:

- Most computer vision functions
- Over 100 image processing functions
- Run generated code on generic-ARM target
 - Face detection and tracking on R-Pi 2 featured example



CVST Support Package for Xilinx Zynq-Based Hardware

- Workflow to target algorithms designed with Vision HDL Toolbox on FPGA portion of Zynq
- Zynq Development Boards (ZedBoard, ZC702, ZC706)
- FMC HDMI CAM Card (and discontinued FMC IMAGEON)
- HDMI In and HDMI Out

