

Computer Vision with MATLAB

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Agenda

- Introduction
- Feature-based registration
 - Automatic image registration
 - Rotation correction with SURF
 - Stereo image rectification
- Video processing with System objects
 - Tracking cars with optical flow
- Classification
 - Texture classification
 - Face detection
- Summary

Examples of Computer Vision with MATLAB



Computer Vision

Using images and video to detect, classify, and track objects or events in order to “understand” a real-world scene



Image Processing

Remove noise
Adjust contrast
Measure
...



Computer Vision

Detect
Identify
Classify
Recognize
Track
...



Interpretation

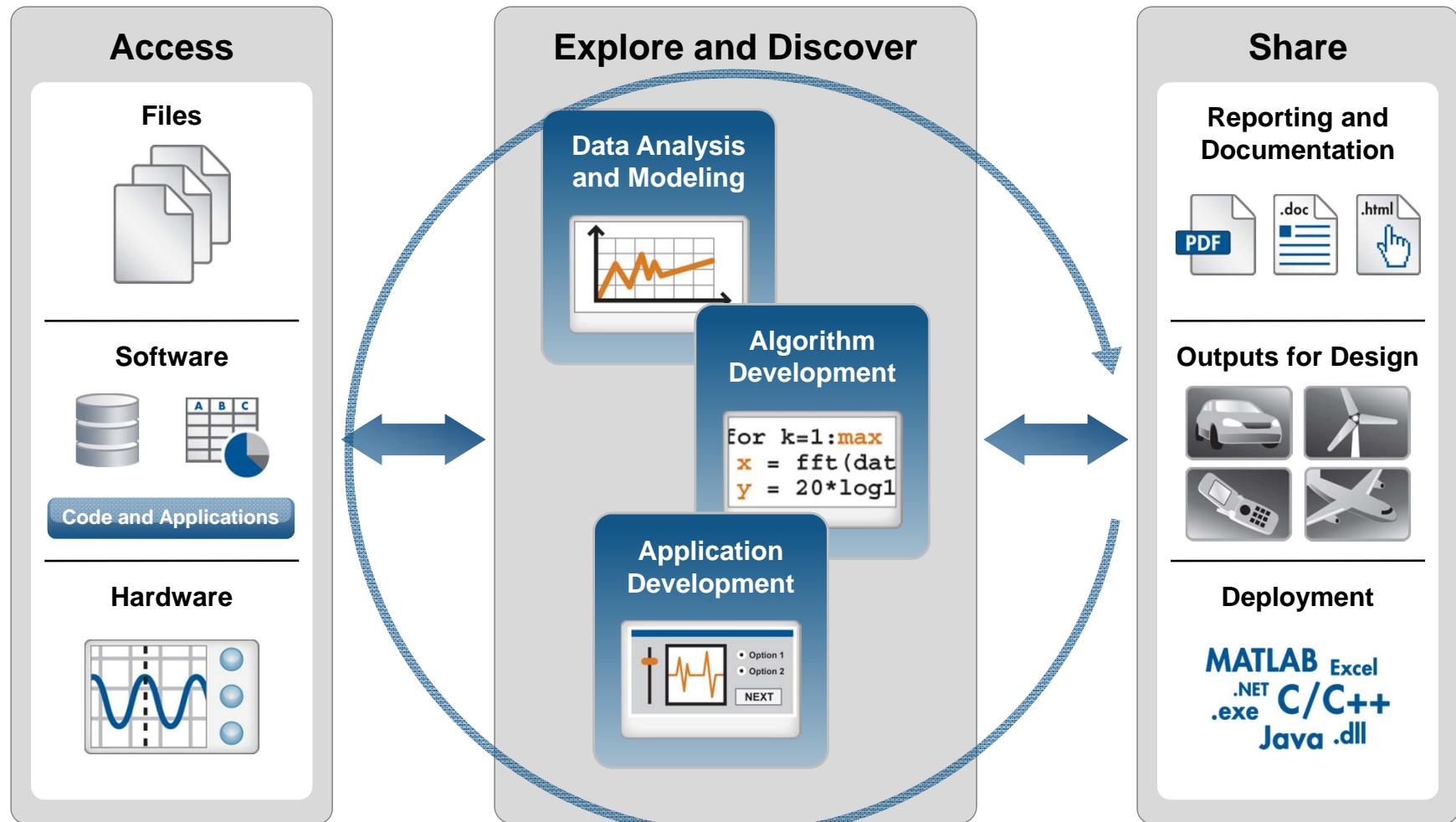
Pedestrian
Bicyclist
Truck
Car
Traffic violation
Accident
...

Typical Computer Vision Challenges

- Variable lighting conditions
- Unknown scene depth or perspective
- Background clutter
- Partially hidden objects (occlusion)
- Differences in scale, location, and orientation



Technical Computing with MATLAB



Key Products for Computer Vision

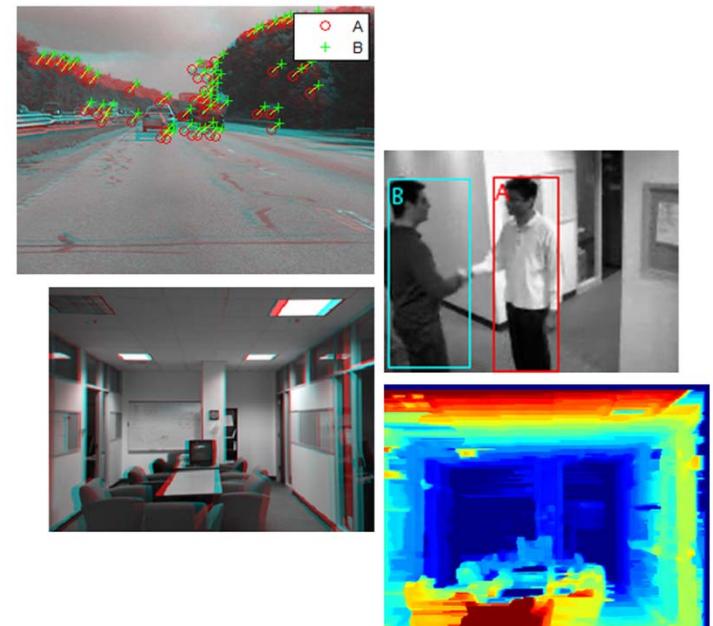
- Computer Vision System Toolbox - **NEW**
- Image Processing Toolbox
- MATLAB
- Statistics Toolbox

- Additionally...
 - Image Acquisition Toolbox
 - MATLAB Coder
 - Parallel Computing Toolbox

Computer Vision System Toolbox

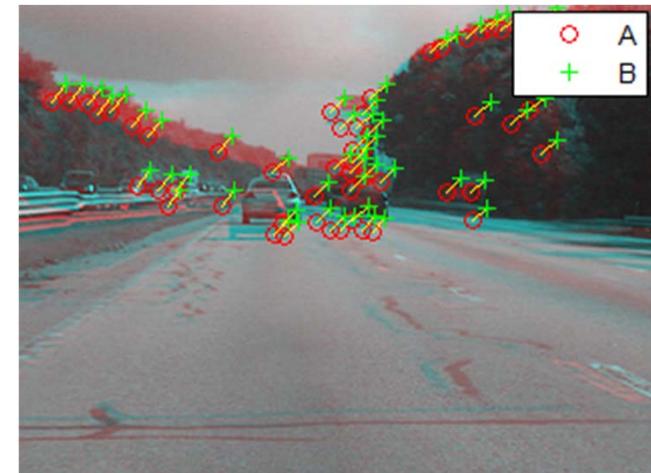
Design and simulate computer vision
and video processing systems

- Feature detection
- Feature extraction and matching
- Feature-based registration
- Motion estimation and tracking
- Stereo vision
- Video processing
- Video file I/O, display, and graphics



Demo: Feature-Based Registration

- Workflow
 - Feature detection
 - Feature extraction
 - Feature matching
 - Geometric transformation estimation with RANSAC

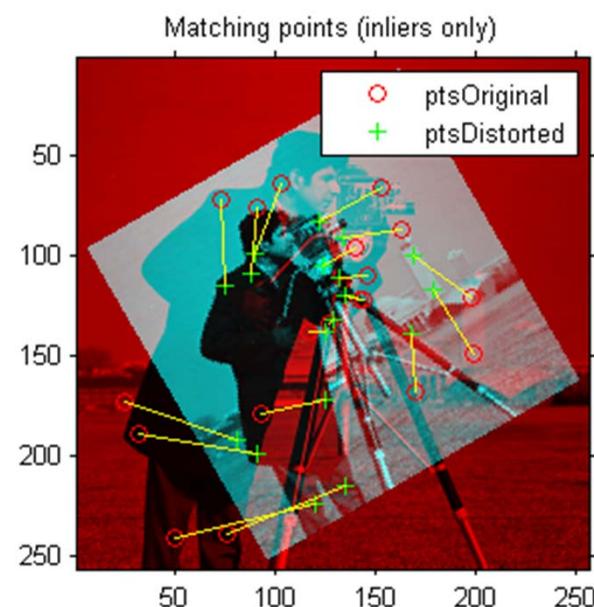


Demo: Rotation Correction with SURF

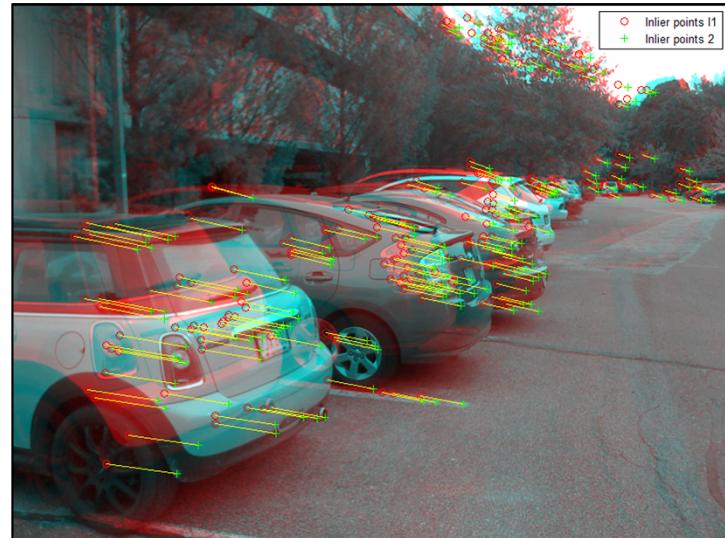
- Workflow
 - Feature detection
 - Feature extraction
 - Feature matching



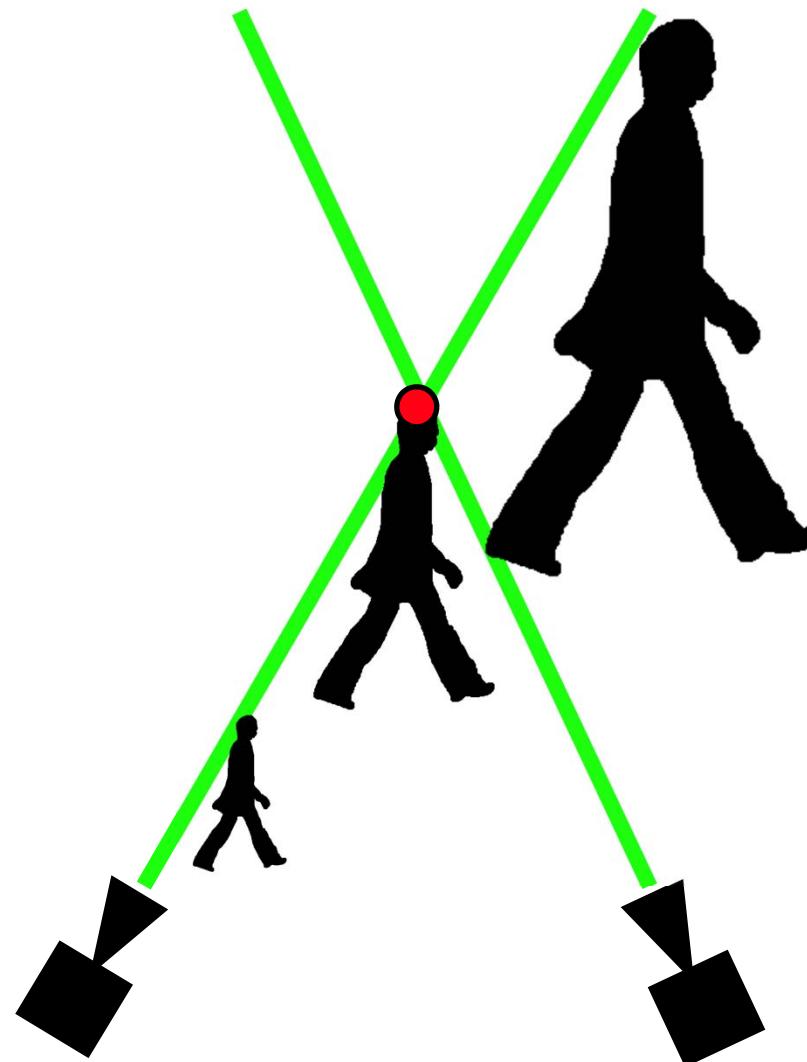
Image courtesy of Massachusetts Institute of Technology



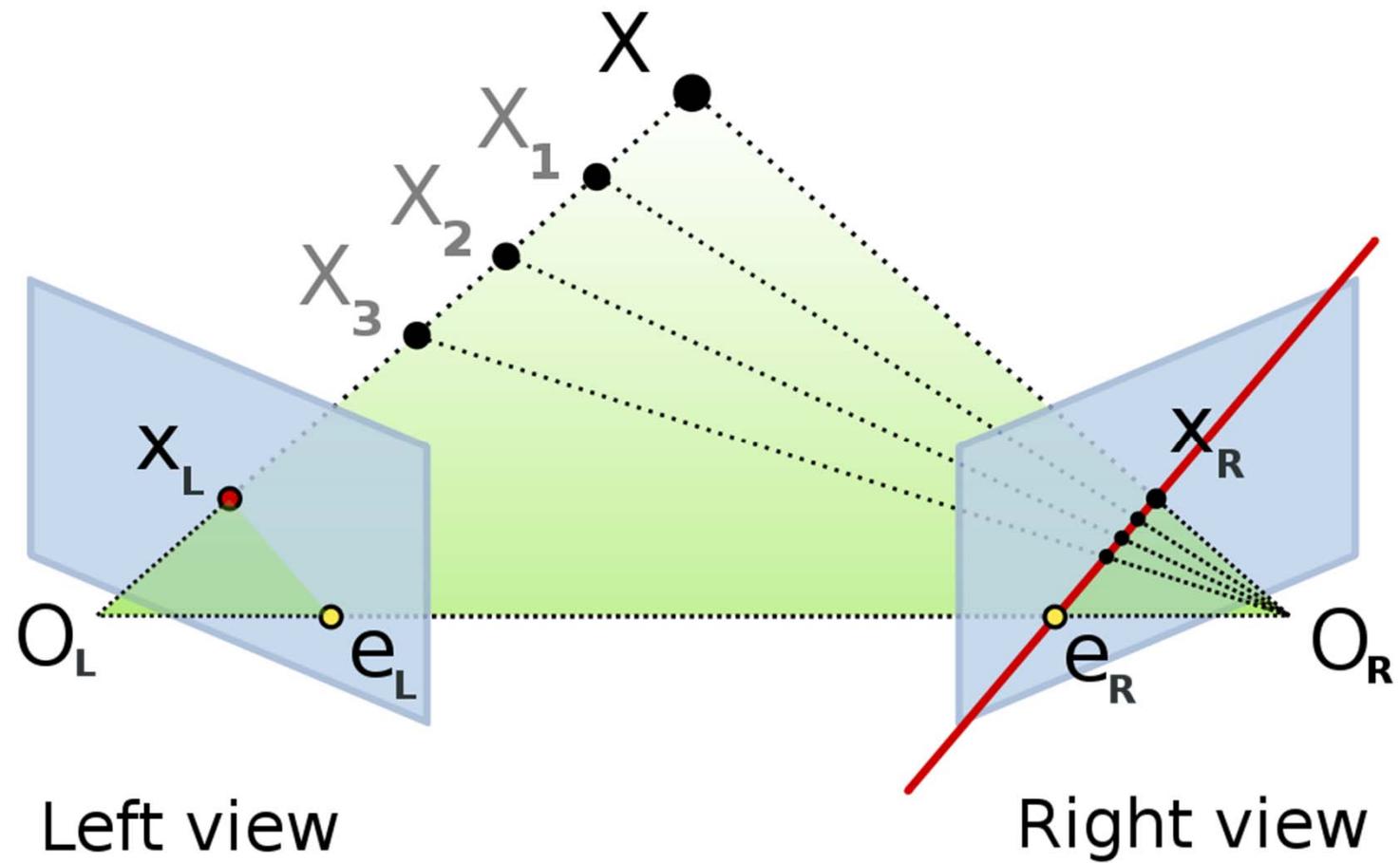
Demo: Stereo Image Rectification



Recovering Scene Depth with Stereo Cameras

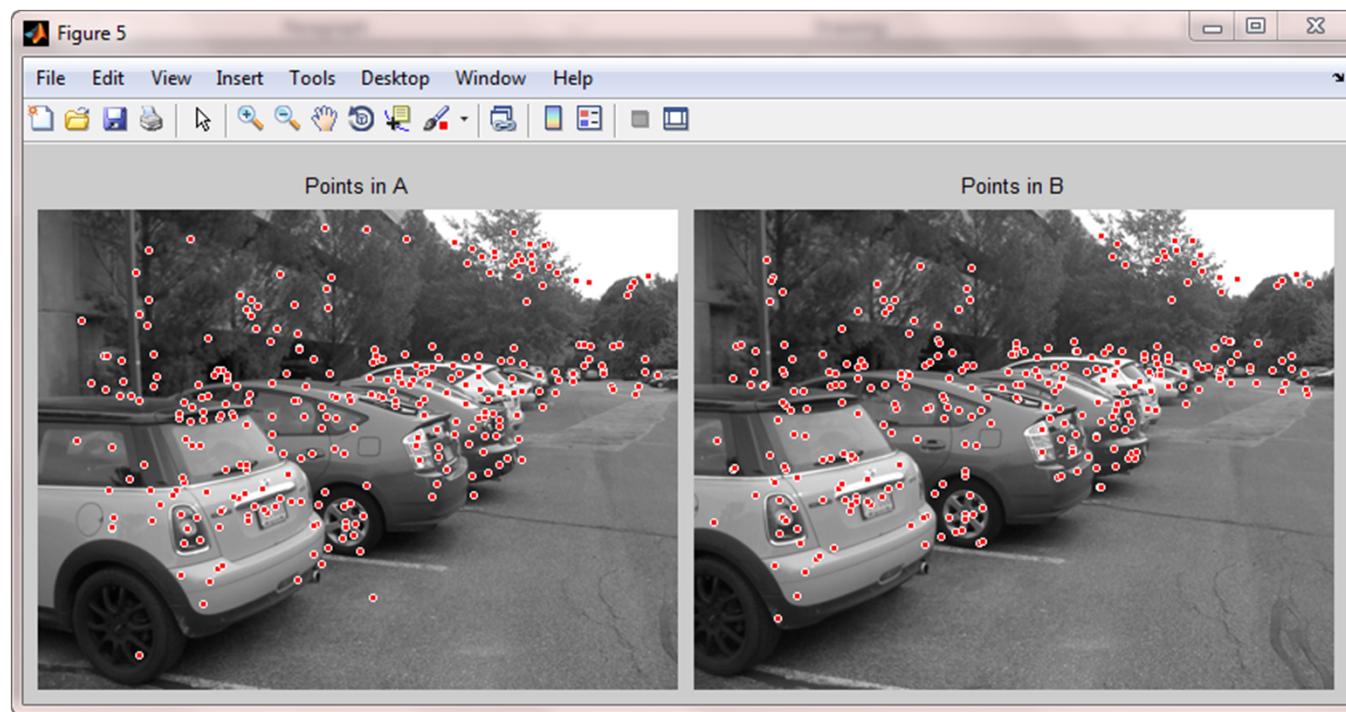


Epipolar Geometry



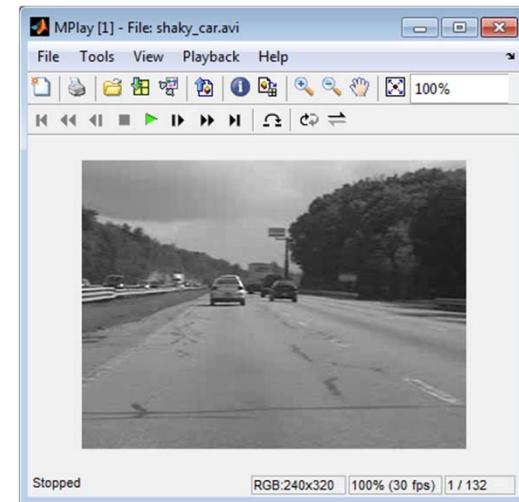
Fundamental Matrix

$$X_L^T F X_R = 0$$



Video Processing

- Video file I/O and display
- Video pre-processing
- Motion estimation and analysis



Motion Estimation and Analysis

- Techniques
 - Block matching
 - Optical flow
 - Template matching
 - Background estimation using Gaussian mixture models



- Applications
 - Object tracking
 - Interpolation
 - Compression



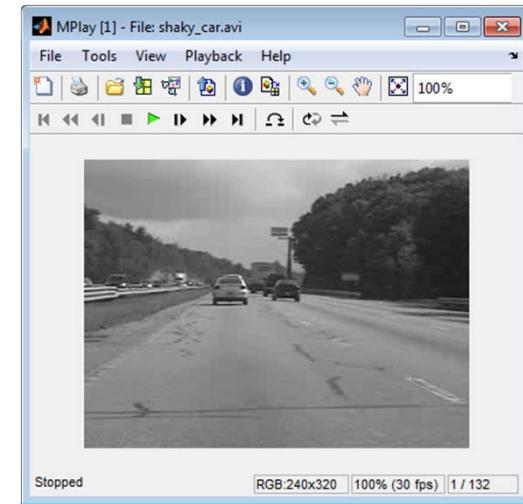
Demo: Using Optical Flow to Track Cars

- Video file I/O and display
- Video preprocessing
- Motion estimation
- Segmentation and analysis



Useful System Objects for Video File I/O, Display, and Graphics

- File I/O
 - VideoFileReader
 - VideoFileWriter
- Display
 - VideoPlayer
 - DeployableVideoPlayer
- Graphics
 - AlphaBlender
 - MarkerInserter
 - ShapeInserter
 - TextInserter



Useful System Objects for Video Preprocessing and Statistics

- Preprocessing
 - ChromaResampler
 - Deinterlacer
 - DemosaicInterpolator
- Statistics (running across video frames)
 - Histogram
 - Maximum
 - Mean
 - Median
 - Minimum
 - StandardDeviation
 - Variance

Different Interfaces, Different Benefits in Computer Vision System Toolbox

Audience	Functions	System Objects	Simulink Blocks
Algorithm developers	<ul style="list-style-type: none">Application-specific algorithms and tools	<ul style="list-style-type: none">Algorithms that maintain stateEfficient video stream processing	
System designers		<ul style="list-style-type: none">Fixed-point modelingC-code generation	<ul style="list-style-type: none">Multidomain modelingReal-time system design
Implementers			<ul style="list-style-type: none">Target-specific embedded hardwareHIL, PIL

Typical Parts of a Computer Vision Algorithm

1. Image/video acquisition
2. Image/video pre-processing
3. Feature detection
4. Feature extraction
5. Feature matching
6. Using features
 - Stabilization, mosaicking
 - Stereo image rectification
7. Feature classification

Image Acquisition Toolbox
Image Processing Toolbox

Computer Vision
System Toolbox

Statistics Toolbox

Challenge: Accurate Classification is Hard



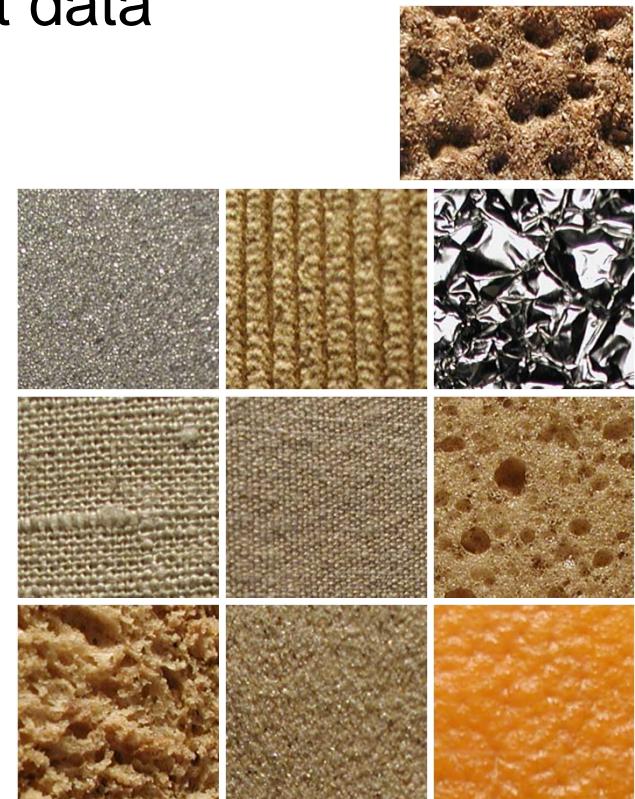
How can a computer tell that these are all chairs?

Demo: Texture Classification

- Identify features appropriate for classification
 - Extract features for training and test data
 - Train classifier with features
 - Test classifier and analyze results
-
- Using KTH-TIPS database
<http://www.nada.kth.se/cvap/databases/kth-tips/>

“On the significance of real-world conditions for material classification,”
E. Hayman, B. Caputo, M. J. Fritz, J-O. Eklund, Proc ECCV 2004

“Classifying materials in the real world,” B. Caputo, E. Hayman, M. J.
Fritz, J.-O. Eklundh, Image and Vision Computing, 28 (2010), 150- 163.



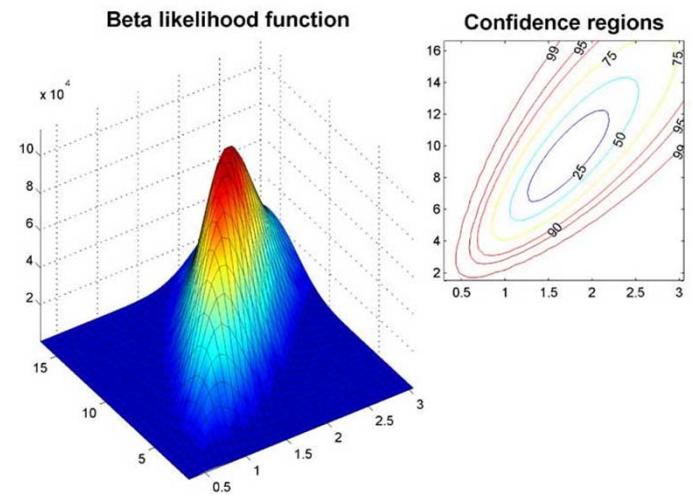
Demo: Face Detection



Statistics Toolbox

Perform statistical analysis, modeling, and algorithm development

- Clustering
 - Principle components analysis
 - K-means
 - Gaussian mixture models
- Classification
 - Naïve Bayes
 - K-nearest neighbor search
 - Boosted decision trees
 - AdaBoost, GentleBoost, LogitBoost, ...



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- MATLAB
- Statistics Toolbox

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Why Use MATLAB for Computer Vision?

- Comprehensive environment
 - Analysis, algorithm development, visualization, etc.
- Broad library of algorithms
 - Computer vision
 - Image processing
 - Classification and clustering
- Documentation, examples, and technical support
- Increased productivity over C/C++ programming

For More Information

- mathworks.com/products/computer-vision
- Relevant demos:
 - Barcode Recognition
 - Image Rectification
 - Traffic Warning Sign Recognition
 - People Tracking
 - Video Mosaicking
- Documentation
- Contact your sales representative

Questions and Answers