Computer Vision with MATLAB

Master Class

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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
…

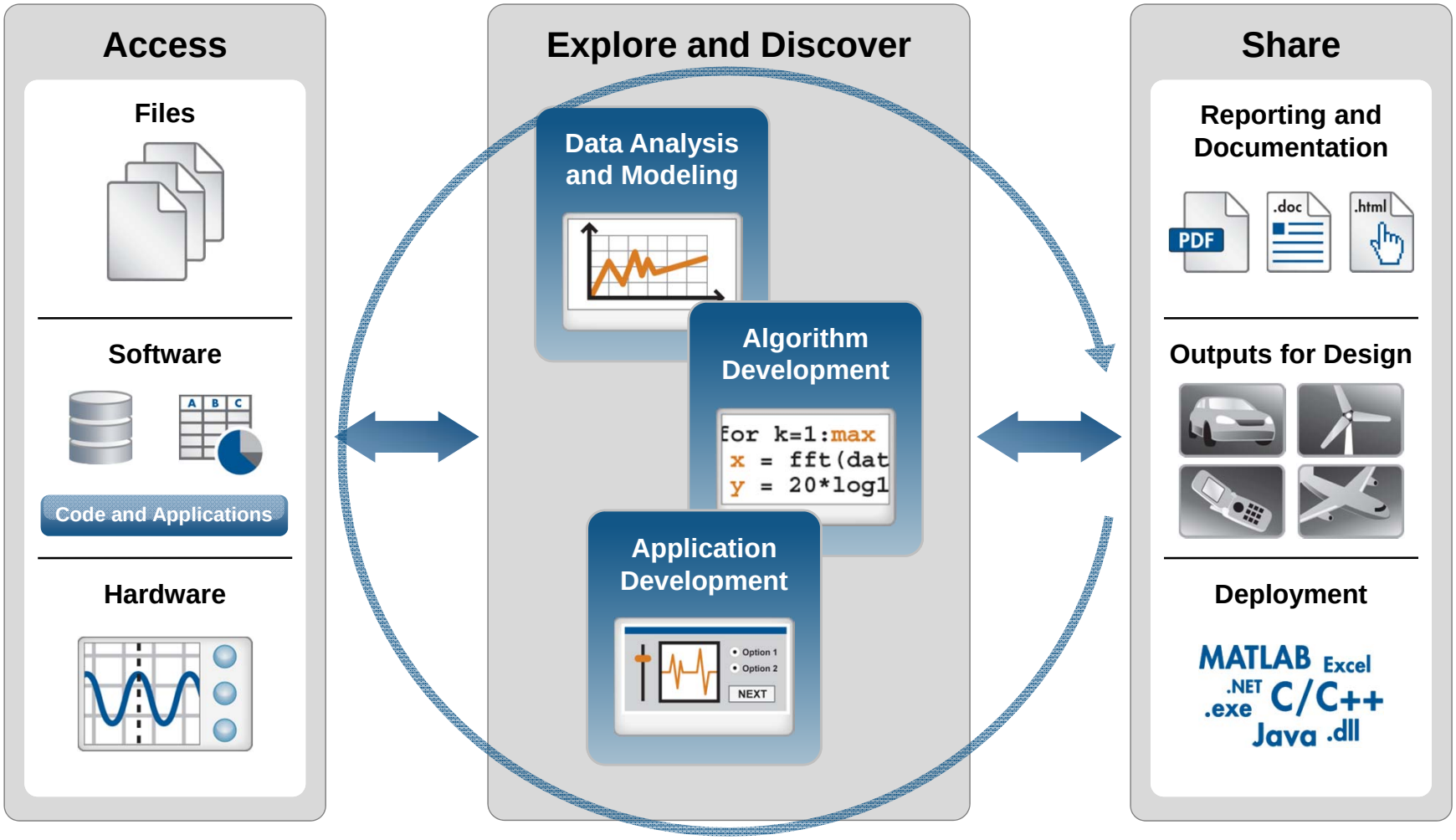
Interpretation

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



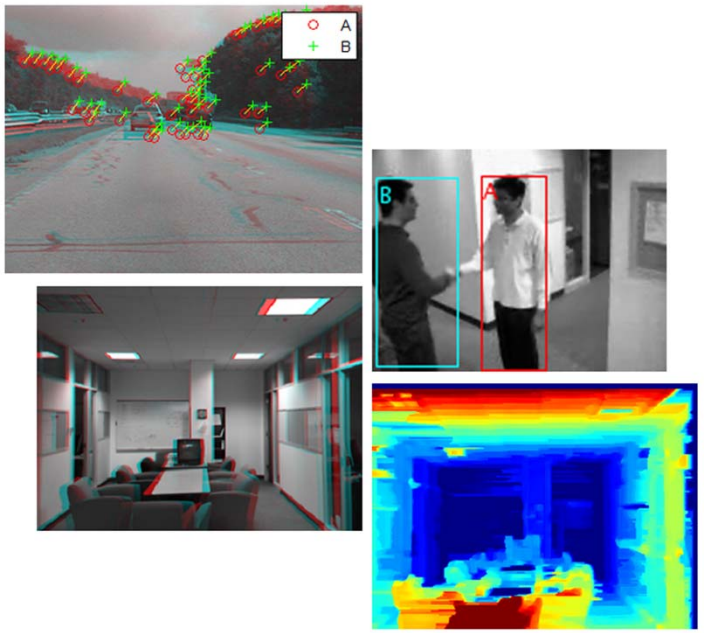
Key Products for Computer Vision

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

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

Computer Vision System Toolbox

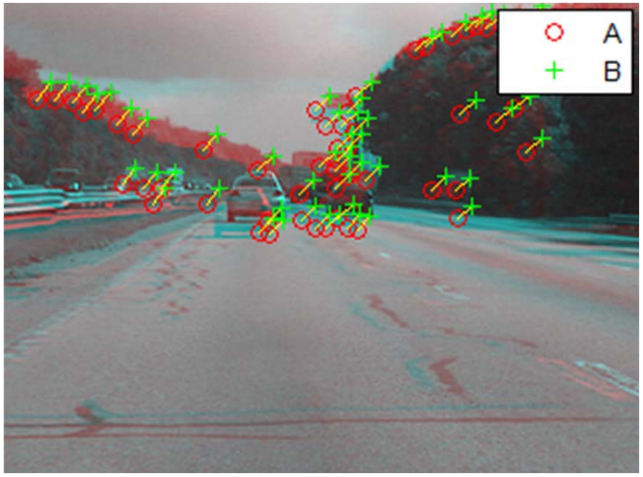
Design and simulate computer vision and video processing systems



- 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

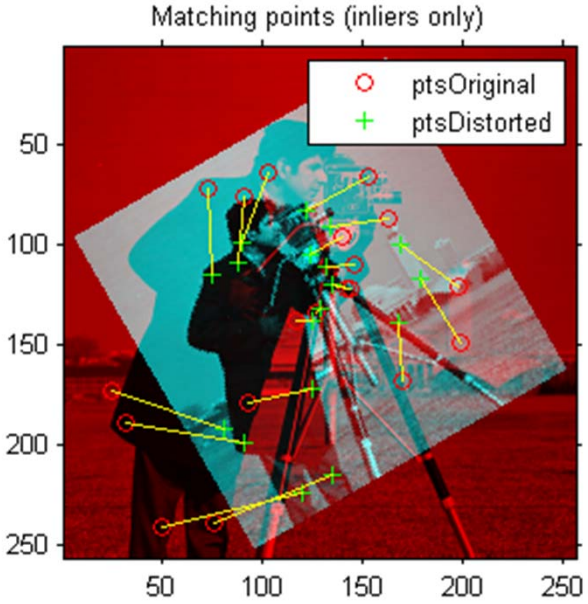
- Workflow
  - Feature detection
  - Feature extraction
  - Feature matching
  - Geometric transformation estimation with RANSAC



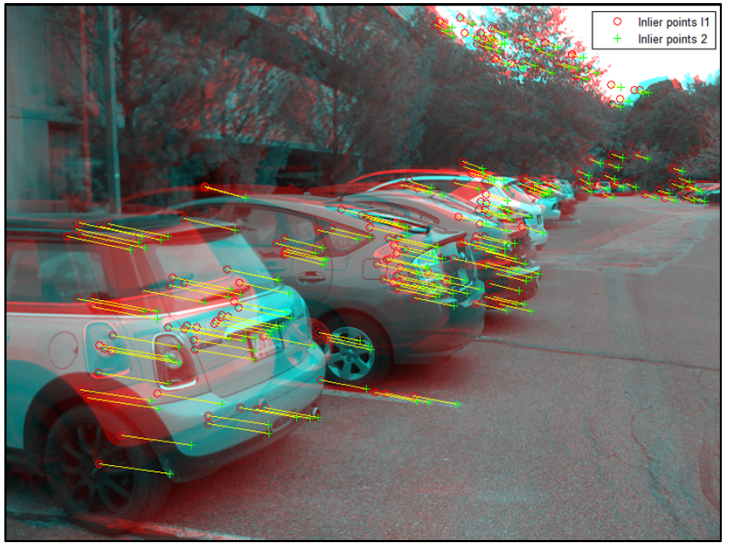
Demo: Rotation Correction with SURF

- Workflow
  - Feature detection
  - Feature extraction
  - Feature matching

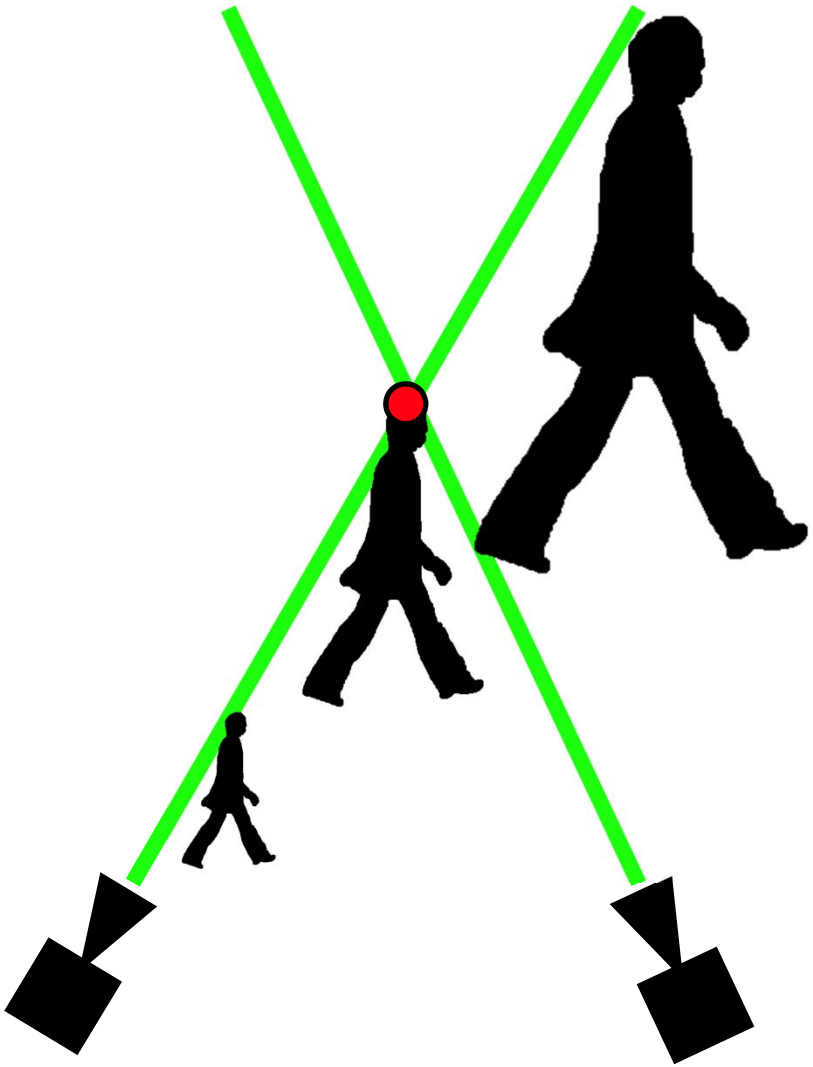
Image courtesy of Massachusetts Institute of Technology



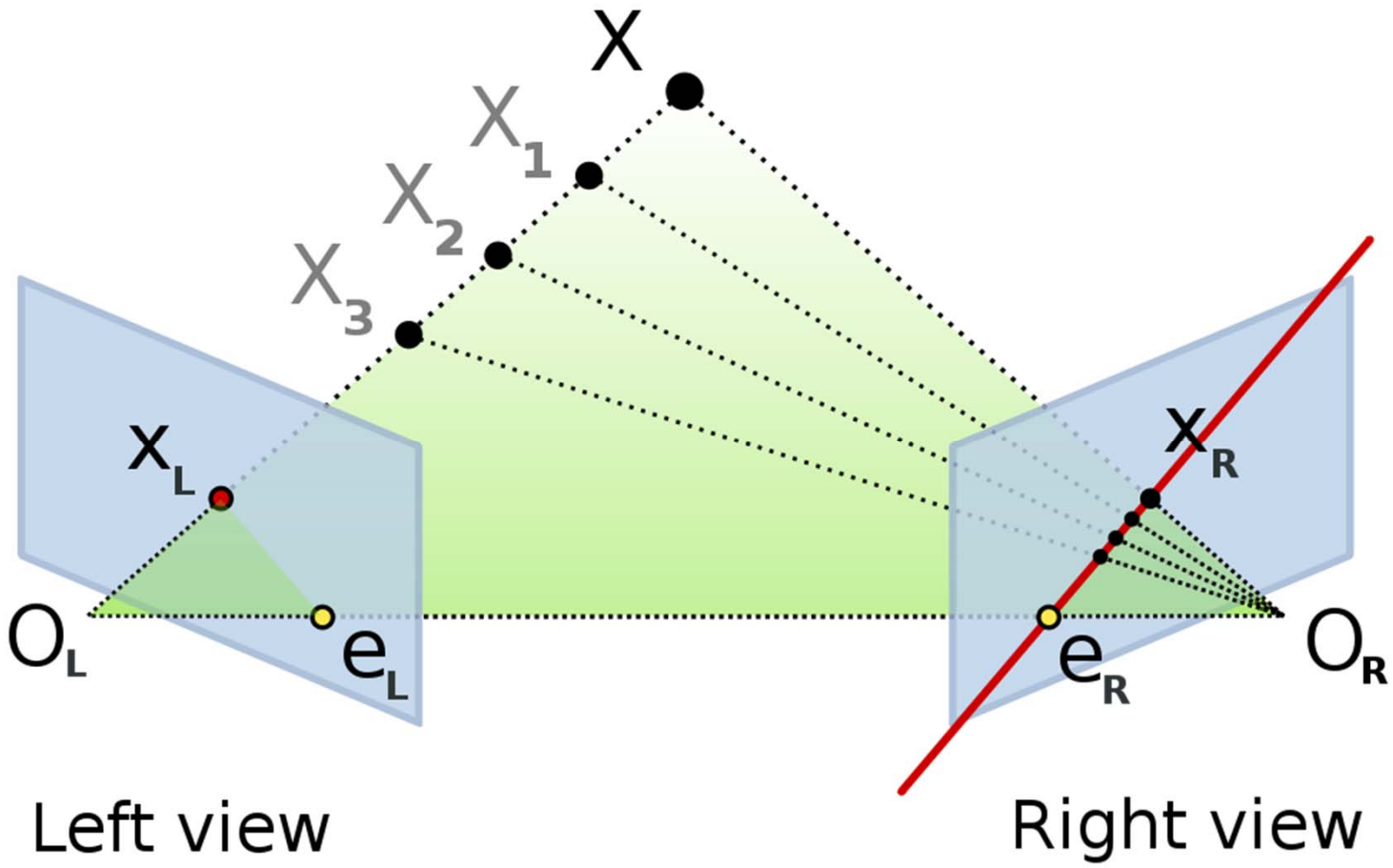
Demo: Stereo Image Rectification



Recovering Scene Depth with Stereo Cameras

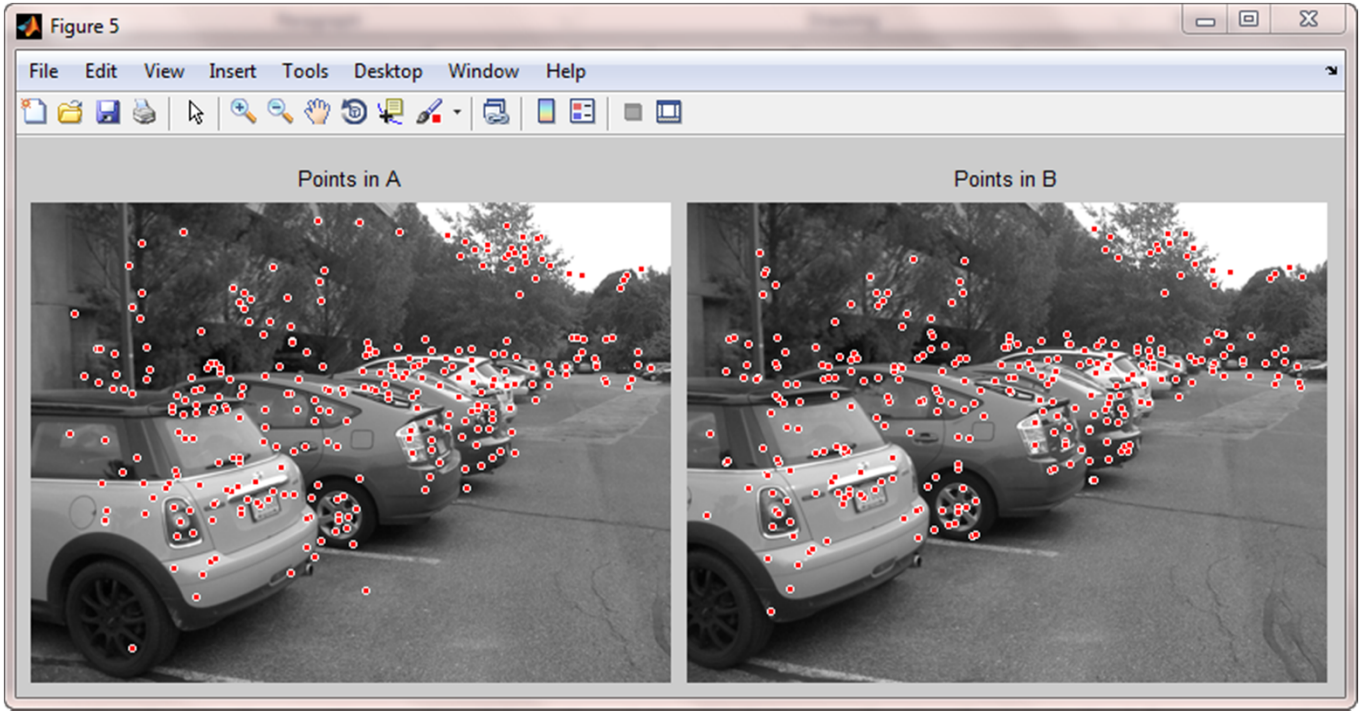


Epipolar Geometry



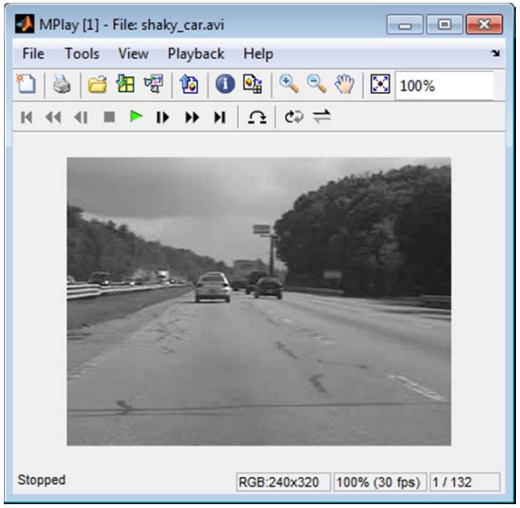
Fundamental Matrix

$$X_L^T F X_R = 0$$



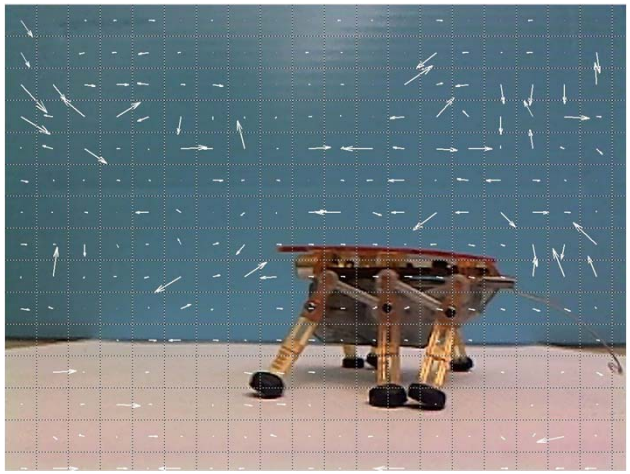
Video Processing

- 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



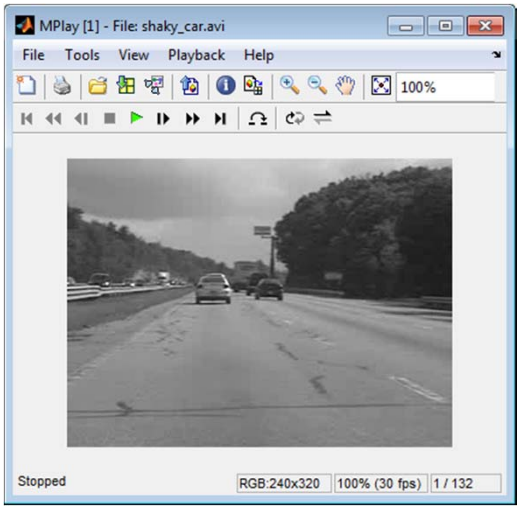
- Applications
  - Object tracking
  - Interpolation
  - Compression

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	• Application-specific algorithms and tools	• Algorithms that maintain state • Efficient video stream processing	
System designers		• Fixed-point modeling • C-code generation	• Multidomain modeling • Real-time system design
Implementers			• Target-specific embedded hardware • HIL, PIL

Typical Parts of a Computer Vision Algorithm

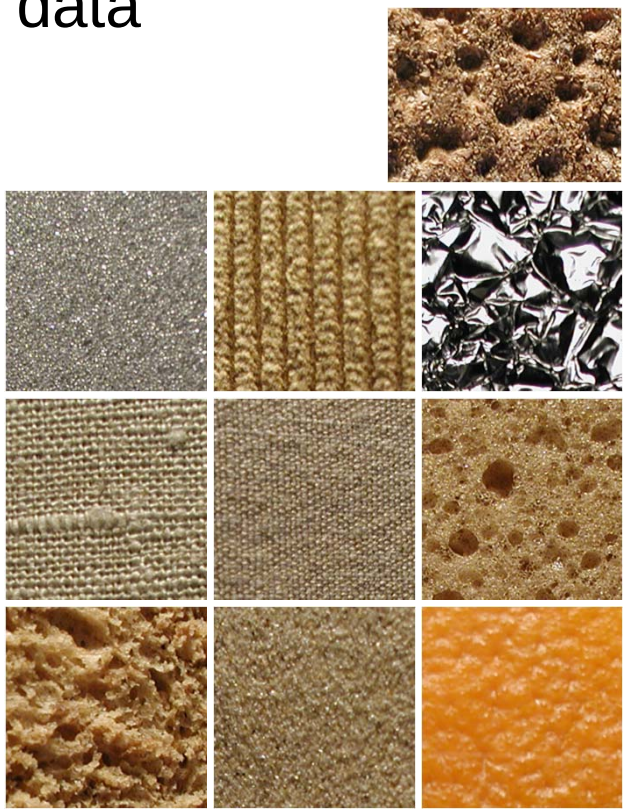
1. Image/video acquisition — Image Acquisition Toolbox
2. Image/video pre-processing — Image Processing Toolbox
3. Feature detection
4. Feature extraction
5. Feature matching
6. Using features — Computer Vision System Toolbox
   - Stabilization, mosaicking
   - Stereo image rectification
7. Feature classification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

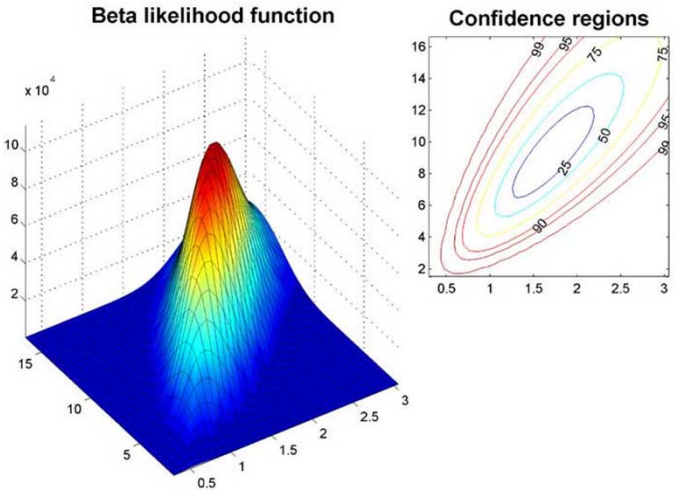
"Classifying materials in the real world," B. Caputo, E. Hayman, M. J. Fritz, J.-O. Eklundh, Image and Vision Computing, 28 (2010), 150- 163.

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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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