Simplifying Computer Vision Application Development

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Agenda

- Tracking Objects of Interest
- Stereo Vision
- Using OpenCV with MATLAB
- Generating C-code from MATLAB
- Summary, Next Steps
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Computer Vision – What is it?

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

<table>
<thead>
<tr>
<th>Step</th>
<th>Task</th>
<th>Related Toolboxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Image/video acquisition</td>
<td>Image Acquisition Toolbox, Image Processing Toolbox</td>
</tr>
<tr>
<td>2.</td>
<td>Image pre-processing</td>
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<tr>
<td>3.</td>
<td>Feature detection</td>
<td></td>
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<td>4.</td>
<td>Feature extraction</td>
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<td>5.</td>
<td>Feature matching</td>
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<td>6.</td>
<td>Using features</td>
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<tr>
<td></td>
<td>– Stabilization, mosaicking</td>
<td></td>
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<tr>
<td></td>
<td>– Targeting, tracking</td>
<td></td>
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<tr>
<td>7.</td>
<td>Feature classification</td>
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</tbody>
</table>

- Statistics & Machine Learning Toolbox
- Computer Vision System Toolbox
Detecting and Tracking a Single Face
Workflow: Detecting and Tracking a Single Face

- First detect person/object

- Use point tracking algorithm to track persons movements from frame-frame
Face Detection, Tracking and Feature Extraction

- Many algorithms available
  - vision.CascadeObjectDetector (Viola-Jones)
  - vision.HistogramBasedTracker (CAMShift)
  - Vision.ForegroundDetector (GMM)
  - Fast Retina Keypoint (FREAK) algorithm for feature extraction
  - Cascade object detector training using Haar, Histogram of Oriented Gradients (HOG), and Local Binary Pattern (LBP) features
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Workflow: Depth Estimation from Stereo Camera

Given pair of stereo images. Measure the distances from the camera to the three faces in the scene.
Stereo Vision Workflow

1. Stereo Calibration
   - Lens distortion correction
   - Rectification

2. Depth estimation

3. 3D Scene reconstruction
Result
Agenda

- Tracking Objects of Interest
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- **Using OpenCV with MATLAB**
- Generating C-code from MATLAB
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OpenCV Interface: What's in the package?

- Based on MEX Interface
- Provides “custom MEX” command to bring OpenCV based code into MATLAB
- Provides extensive set of data type conversions between OpenCV and MATLAB
- Examples and documentation to help users get started
Why use this OpenCV Interface?

- Extensive support for data type conversions
  - Differences in data storage paradigms accounted for
    - Row-major (OpenCV) and column-major (MATLAB)
    - 0-based indexing (OpenCV) and 1-based indexing (MATLAB)

- Ability to bring full OpenCV-based projects not just single functions
  - More efficient

- Pre-built OpenCV binaries provided with interfaces
Why use OpenCV with MATLAB?

- MATLAB advantages for OpenCV users
  - MATLAB environment for algorithm development and exploration
  - Visualizations and plots
  - Simpler interfaces

- OpenCV advantages for MATLAB users
  - Explore new algorithms submitted by researchers
  - Explore additional methods for common algorithms (e.g. optical flow and background subtraction)

- Collaborate with colleagues using OpenCV or MATLAB
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Typical Development Workflow

- Many iterations

**Concept Development**
- Algorithm Development
- Prototyping
- Architecture
- Prototyping
- Detailed Design

**Algorithm Development**
- Is my idea new? What is required?
- Is it robust to all kinds of conditions? (lighting noise, etc.)

**Implementation**
- Consideration of HW platform
  - FPGA? CPU? DSP? GPU?
- Speed and resource requirement
  - Resolution, Frame-rate constraint
  - Memory constraint

Development of the algorithm and implementation are often done by different groups.
Why Engineers translate MATLAB to C today?

<table>
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<tr>
<th>File Extension</th>
<th>Description</th>
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<tbody>
<tr>
<td>.exe</td>
<td>Deploy MATLAB algorithms on Windows/Linux desktop PC</td>
</tr>
<tr>
<td>.lib</td>
<td>Integrate MATLAB algorithms w/ existing C environment</td>
</tr>
<tr>
<td>.dll</td>
<td>Hand-off code to software engineers for embedded processor implementation</td>
</tr>
<tr>
<td>.c, .cpp</td>
<td>Accelerate MATLAB algorithms</td>
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</tbody>
</table>
Improved MATLAB Coder app with Integrated Editor and Simplified Workflow

New user interface simplifies code generation workflow
Vision HDL Toolbox

*Design and prototype video image processing systems*

- Modeling hardware behavior of the algorithms
  - Pixel-based functions and blocks
  - Conversion between frames and pixels
  - Standard and custom frame sizes

- Prototyping algorithms on hardware
  - *(With HDL Coder)* Efficient and readable HDL code
  - *(With HDL Verifier)* FPGA-in-the-loop testing and acceleration
Summary: Why Use MATLAB for Computer Vision

- **Save time**
  - Simpler interfaces
  - Pre-trained models for detection and recognition
  - Apps to simplify time consuming workflows

- **Extensive algorithm coverage**
  - Object detection, recognition and tracking, 3D vision, point cloud processing
  - Feature detection, extraction and matching

- Use documentation to learn computer vision
- Use OpenCV with MATLAB
For More Information

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<td>MATLAB Fundamentals</td>
<td>8th – 10th June</td>
<td>Chennai</td>
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<tr>
<td>Simulink for System and Algorithm Modeling</td>
<td>11th – 12th June</td>
<td>Chennai</td>
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<tr>
<td>Signal Processing with MATLAB</td>
<td>16th – 17th June</td>
<td>Bangalore</td>
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<tr>
<td>Image Processing with MATLAB</td>
<td>18th – 19th June</td>
<td>Bangalore</td>
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<tr>
<td>MATLAB Fundamentals</td>
<td>29th Jun – 01st July</td>
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<td>Simulink for System and Algorithm Modeling</td>
<td>2nd – 3rd July</td>
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<td>Statistical Methods in MATLAB</td>
<td>20th – 21st July</td>
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<td>MATLAB based Optimization Techniques</td>
<td>22nd Jul</td>
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<td>Building Interactive Applications with MATLAB</td>
<td>23rd July</td>
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<td>MATLAB to C with MATLAB Coder</td>
<td>3rd – 4th Aug</td>
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<td>Embedded Coder for Production Code Generation</td>
<td>5th – 7th Aug</td>
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<td>Generating HDL Code from Simulink</td>
<td>7th – 8th Sep</td>
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<tr>
<td>Programming Xilinx Zynq SoCs with MATLAB and Simulink</td>
<td>10th – 11th Sep</td>
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Training Certification

- Accelerate professional growth
- Validate proficiency with MATLAB
- Increase productivity and project success

MathWorks Certified MATLAB Associate Examination

Bangalore
29th July & 25th Nov

Pune
3rd June

Recommended Courses
MATLAB Fundamentals (MLBE)

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