컴퓨터비전의 최신기술
: Deep Learning, 3D Vision and Embedded Vision

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Application Engineer
Three Main Topics

New capabilities for computer vision system design:

- Deep Learning
- 3-D Vision and Image Processing
- Embedded Vision
New MATLAB framework makes deep learning easy and accessible

and

MATLAB can be used by experts for real deep learning(computer vision) problems
What is Deep Learning?

Deep learning is a type of machine learning that performs end-to-end learning by learning tasks directly from images, text, and sound.
Two Approaches for Deep Learning

1. **Train a Deep Neural Network from Scratch**

   ![Diagram of a convolutional neural network (CNN) with learned features and classification results for Car, Truck, Bicycle, Dog, and Cat.]

2. **Fine-tune a pre-trained model (transfer learning)**

   ![Diagram of fine-tuning a pre-trained CNN with new data for a new task (e.g., Cat).]
Example: Classify Vehicles With Transfer Learning

AlexNet Pretrained Model

1000 classes
Trained on millions of images

Transfer learning – use AlexNet as starting point

Vehicle Classifier (5 Class)

Car
SUV
Van
Truck
Large Truck

New Data
Transfer Learning to Classify New Objects
MATLAB makes Deep Learning Easy and Accessible

Learn about new MATLAB capabilities to

- Handle and label large sets of images
- Accelerate deep learning with GPU’s
- Visualize and debug deep neural networks
- Access and use models from experts
3D Image Processing
3-D Image Processing

Over 40 functions support 3-D volumetric image processing

Capabilities includes:
- Image arithmetic
- Morphology
- Segmentation
- Geometric transforms
- Enhancement

Volume Viewer App for exploration
3-D Image Processing
3D Vision – LiDAR Processing
What are Point Clouds?

- Point clouds represent a set of data points in a 3-D coordinate system
- Typically used to measure physical world surfaces
- Used for navigation and perception in robotics and Advanced Driver Assistance Systems (ADAS)
Common Sources of Point Cloud Data

- LIDAR
- Laser Scanner
- Depth Camera
- Stereo Camera
3-D Vision: Design LiDAR Processing
3-D Vision: Design LiDAR Processing

```matlab
clear;
close all;
load singlePtCloud.mat;

%% Display Image
figure;
subplot(1,2,1);imshow(videoFrame);
title('Input Video Frame');
subplot(1,2,2);
pcshow(lidarPtCloud);
title('Lidar Point Cloud');

%% Find ground plane
[mdl,inlierIndices,outlierIndices] = ...
```
Embedded Vision System Development using Automatic Code Generation
Typical Workflow for Embedded Vision System Development

Development of the algorithm and implementation are often done by different groups

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
MATLAB Coder app with Integrated Editor and Simplified Workflow

New user interface simplifies code generation workflow
Embedded Coder for Optimized Code

Embedded Coder extends MATLAB Coder with:

- Processor-specific code generation
  - Built-in support for select processors
  - Open APIs for use with any processor
- Speed, memory, and code appearance advanced features
MATLAB Language Support for Code Generation

- Java
- nested functions
- graphics
- sparse
- visualization
- variable-sized data
- struct
- global
- complex
- classes
- System objects
- fixed-point
- numeric
- functions
- malloc
- persistent
- arrays
- complex
- numeric
- fixed-point
- numeric
- functions
- malloc
- persistent
- arrays
**Supported MATLAB Language Features and Functions**

Broad set of language features and functions/system objects supported for code generation

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Supported algorithms
- More than 1300 MATLAB operators, functions, and System objects for:
  - Communications
  - Computer vision
  - Image processing
  - Neural networks
  - Phased Array signal processing
  - Robotics
  - Signal processing
  - Statistics and machine learning
Algorithm Design and Code Generation in MATLAB

With MATLAB Coder, design engineers can:

- Maintain one design in MATLAB
- Design faster and get to C quickly
- Test more systematically and frequently
- Spend more time improving algorithms in MATLAB
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
Pixel Based Video Image Algorithms

- **Analysis & Enhancement**
  - Edge Detection, Median Filter

- **Conversions**
  - Chroma Resampling, Color-Space Converter
  - Demosaic Interpolator, Gamma Corrector, Look-up Table

- **Filters**
  - Image Filter, Median Filter

- **Morphological Operations**
  - Dilation, Erosion,
  - Opening, Closing

- **Statistics**
  - Histogram
  - Image Statistics

- **I/O Interfaces**
  - Frame to Pixels, Pixels to Frame, FIL versions

- **Utilities**
  - Pixel Control Bus Creator
  - Pixel Control Bus Selector
Frame To Pixels and Pixels To Frame
A Complete Solution for Embedded Vision

Concept Development

Algorithm Development

Prototyping

Architecture design

Prototyping

Chip design

Frame based

Pixel based

Computer Vision System Toolbox

Image Processing Toolbox

Vision HDL Toolbox

MATLAB Coder

Fixed Point Designer

HDL Coder

HDL Verifier

MATLAB / Simulink
Challenge
Accelerate the implementation of advanced thermal imaging filters and algorithms on FPGA hardware

Solution
Use MATLAB to develop, simulate, and evaluate algorithms, and use HDL Coder to implement the best algorithms on FPGAs

Results
- Time from concept to field-testable prototype reduced by 60%
- Enhancements completed in hours, not weeks
- Code reuse increased from zero to 30%

“With MATLAB and HDL Coder we are much more responsive to marketplace needs. We now embrace change, because we can take a new idea to a real-time-capable hardware prototype in just a few weeks. There is more joy in engineering, so we’ve increased job satisfaction as well as customer satisfaction.”

Nicholas Hogasten
FLIR Systems

Link to user story