산업용 어플리케이션을 위한 딥러닝 기반 머신비전 솔루션

송완빈, MathWorks
What is Automated Optical Inspection?

“Automated optical inspection is the image-based or visual inspection of manufacturing parts where a camera scans the device under test for both failures and quality defects.”

Automated Defect Detection

Machine Vision  Visual Inspection  Automated Inspection
Customer References

Automatic Defect Detection

Defect Detection in Railway Components

Visual Inspection of Automotive Parts

Assess Pipe Weld Damage at Power Plants
Can you find the defective hex nut?
Finding Defective Hex Nuts

Good

Defective
Detecting Parts
Defect Detection Workflow

**DATA PREPARATION**
- Data access and preprocessing
- Simulation-based data generation
- Ground truth labeling

**AI MODELING**
- Model design and tuning
- Hardware-accelerated training
- Model exchange across frameworks

**DEPLOYMENT**
- Embedded Devices
- Enterprise Systems
- Edge, cloud, desktop

**Iteration and Refinement**
Defect Detection Workflow

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Iteration and Refinement
Data Access and Preprocessing – Common Challenges

How do I access large data that might not fit in memory?

How do I preprocess data and get the right features?

How do I label my data faster?

What if I have an imbalanced dataset or don’t have enough data?
How do I access large data that might not fit in memory?
How do I load and access large amounts of data?

**Datastores**

Loads image/signal data into memory as and when needed

```matlab
>> imageDatastore
>> audioDatastore
>> fileDatastore
```

Custom Datastores also available

**Tall Arrays**

Work with out-of-memory numeric data
- Train deep neural networks for numeric arrays

**BigImage**

Work with very large, tiled and multi-resolution images

Each red box is a 1024-by-1024 tile in the file.
L1’s dimensions = 29,600 x 46,000
L2’s dimensions = 14,800 x 23,000
L3’s dimensions = 7,500 x 12,000
Rows = 29600
Columns = 46000
TileSizeIntrinsic = [1024 1024]
ResolutionLevelSizes = [29600 46000 14800 23000 7500]
12000]
CoarsestLevel = 3
FinestLevel = 1
Pixel1Spacings = [1 1; 2 2; 3.947 3.833]
How do I preprocess data and get the right features?
Pre-processing Data – Registration Estimator App
Pre-processing Data – Image Segmenter App
Preprocessing Data - Apps

Color Thresholder

Image Region Analyzer
Pre-processing Data – Built-in Algorithms

imadjust  imgaborfilt  fibermetric

And Many More!
Defect detection using AlexNet: Results with preprocessing

**Without Preprocessing**

**With Preprocessing**
How do I label my data faster?
Data Preprocessing - Labeling

MATLAB R2020a

HOME  PLOTS  APPS

Design App  Get More Apps  Install App  Package App

FILE

Current Folder

- Name
- R2019a
- R2019b
- R2020a

AUTOMOTIVE

- Ground Truth Labeler

SIGNAL PROCESSING AND COMMUNICATIONS

- Audio Labeler
- Signal Labeler

IMAGE PROCESSING AND COMPUTER VISION

- Image Labeler
- Video Labeler
Image Labeler

Image Labeler

Video Labeler

Big-Image Labeler
Video Labeler

Image Labeler

Video Labeler

Big-Image Labeler
Big Image Labeler

Image Labeler

Video Labeler

Big-Image Labeler
Data Access and Preprocessing – Common Challenges

What if I have an imbalanced dataset or don’t have enough data?
Data Augmentation by Transformation

- Rotation
- Reflection
- Warping
- Contrast Jitter on Grayscale
- Hue Jitter

Original Dataset

Augmented Dataset
N times as much data
Data Augmentation: Generative Adversarial Networks (GANs)

Generative Adversarial Networks
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Iteration and Refinement
Deep Learning for Defect Detection

Deep learning for Classification

Deep Learning for Object Detection
Deep Learning for Defect Detection – Multiple techniques

Deep learning for Classification
Two Approaches for Deep Learning

1. Train a deep neural network from scratch

2. Fine-tune a pre-trained model (transfer learning)
Train a Deep Neural Network from Scratch
Two approaches for Deep learning

Approach 2. Fine-tune a pre-trained model (Transfer learning)
Fine-tune a Pre-trained Model (Transfer Learning)
Classification with Trained MobileNetV2

Why the defect nuts are classified as ‘Bad’?
Challenges with Deep Learning Models

- Deep Learning model is a black box model

  - Is it possible to classify an unknown image correctly?
  - Why the model misclassify for certain images?

  **Explainable AI is required**
  - Class Activation Mapping (CAM)
  - Grad-CAM
Class Activation Mapping to Investigate Network Predictions

Attribution Reveals the Why Behind Deep Learning Decisions

Full code available

Classified as “keyboard” due to the presence of the mouse

Incorrectly classified “coffee mug” as “buckle” due to the watch
Visualization of Features with CAM

Captured Image

Classification and CAM

The network judges the unit as Bad by seeing the scratched area.
Deep Learning for Defect Detection

Deep Learning for Object Detection
Object Detection in Image/Vision System

- **Object detection**
  - Computer technology related to computer vision and image processing that deals with **detecting instances of semantic objects** of a certain class (such as humans, buildings, or cars) in digital images and videos.
Increase productivity using built-in functions for design and analysis

Use MATLAB high-level API for changing network type, backbone network for better performance easily.

Choose Network to Train

Model design and tuning
Hardware accelerated training
Interoperability
Practical Object Detection Examples using Deep Learning

Repository Link

MATLAB Deep Learning
mathworks.github.io
https://www.mathworks.com/solutions/deep-learning

Repository Link
Defect Detection Workflow

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Iteration and Refinement
Deploy to Any Processor with Best-in-class Performance

Code Generation

CPU

GPU

FPGA

MATLAB EXPO
Deploy defect detection algorithms from MATLAB to ZCU102 board from Xilinx

Deploy defect detection algorithms from MATLAB to Jetson AGX Xavier
Deploy to Hardware

Additional Resources

- Deploying Deep Neural Networks to GPUs and CPUs Using MATLAB Coder and GPU Coder
- Using GPU Coder to Prototype and Deploy on NVIDIA Drive, Jetson
- Real-Time Object Detection with YOLO v2 Using GPU Coder
- Image Classification on ARM CPU: SqueezeNet on Raspberry Pi
- Deep Learning on an Intel Processor with MKL-DNN

Defect detection deployed on ARM Cortex-A microprocessor
Defect Detection Workflow

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Iteration and Refinement
Key Takeaways

- Interactive and easy to use apps help explore, iterate and automate workflows
- Flexibility and options to choose networks and optimizations based on data and requirements
- MATLAB provides an easy and extensible framework for defect detection from data access to deployment
Thank You