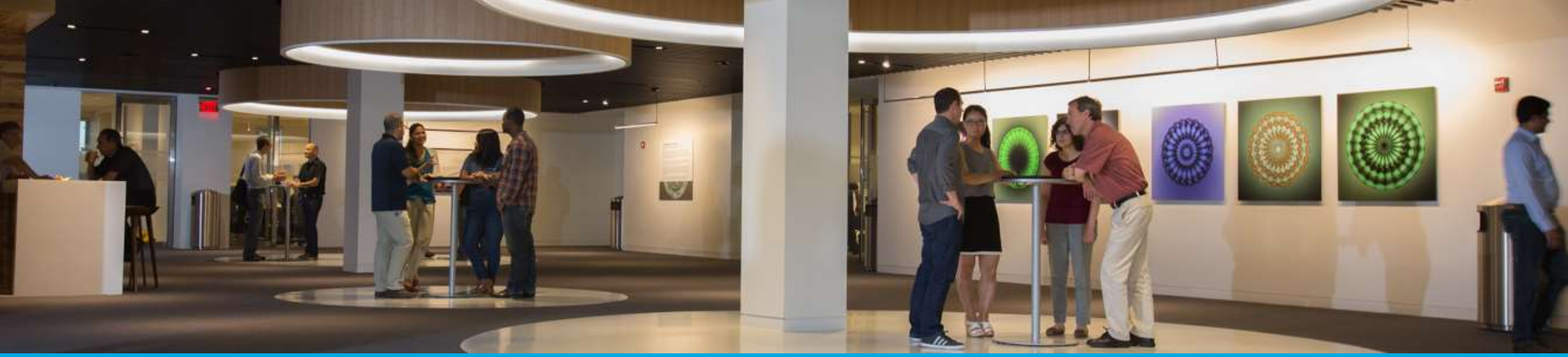


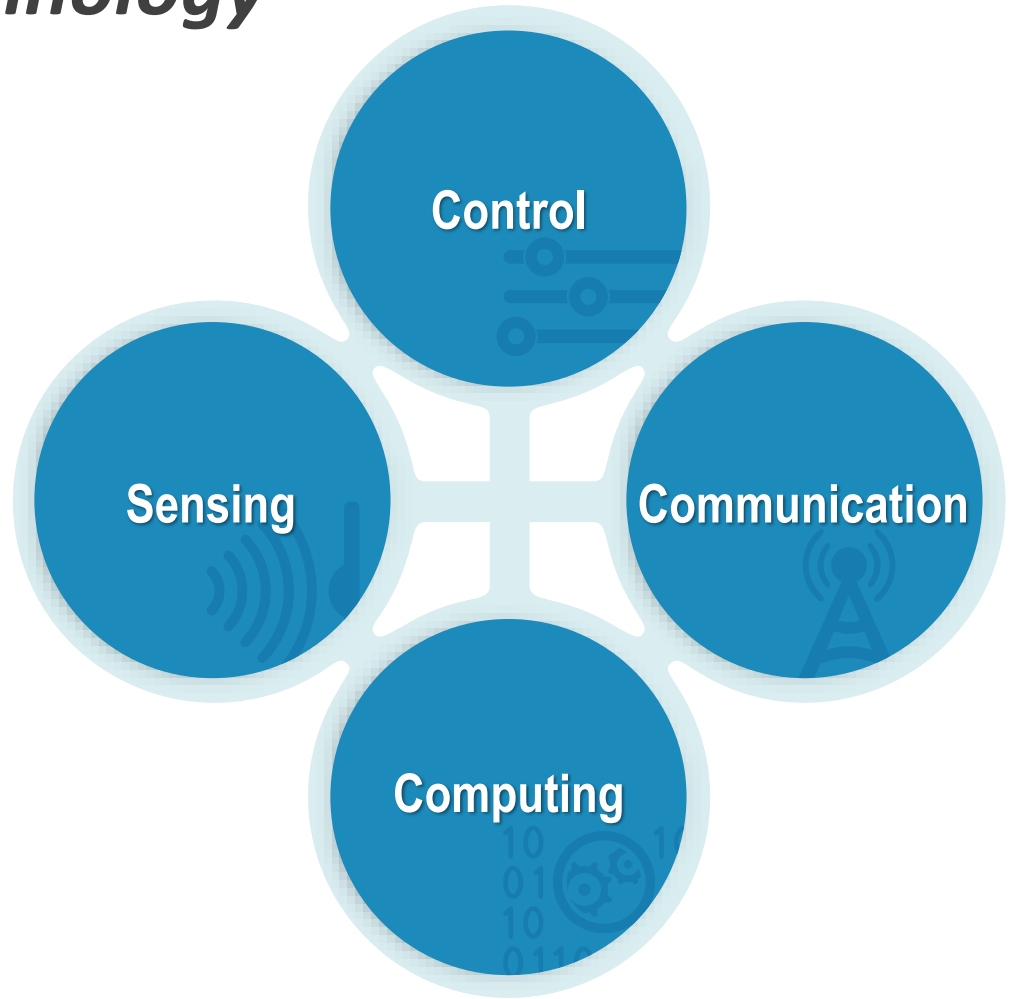
MathWorks 인공지능 솔루션을 활용한 전반적인 응용사례 소개

김 영우 전무 (Technical Manager)

MathWorks®

Accelerating the pace of engineering and science

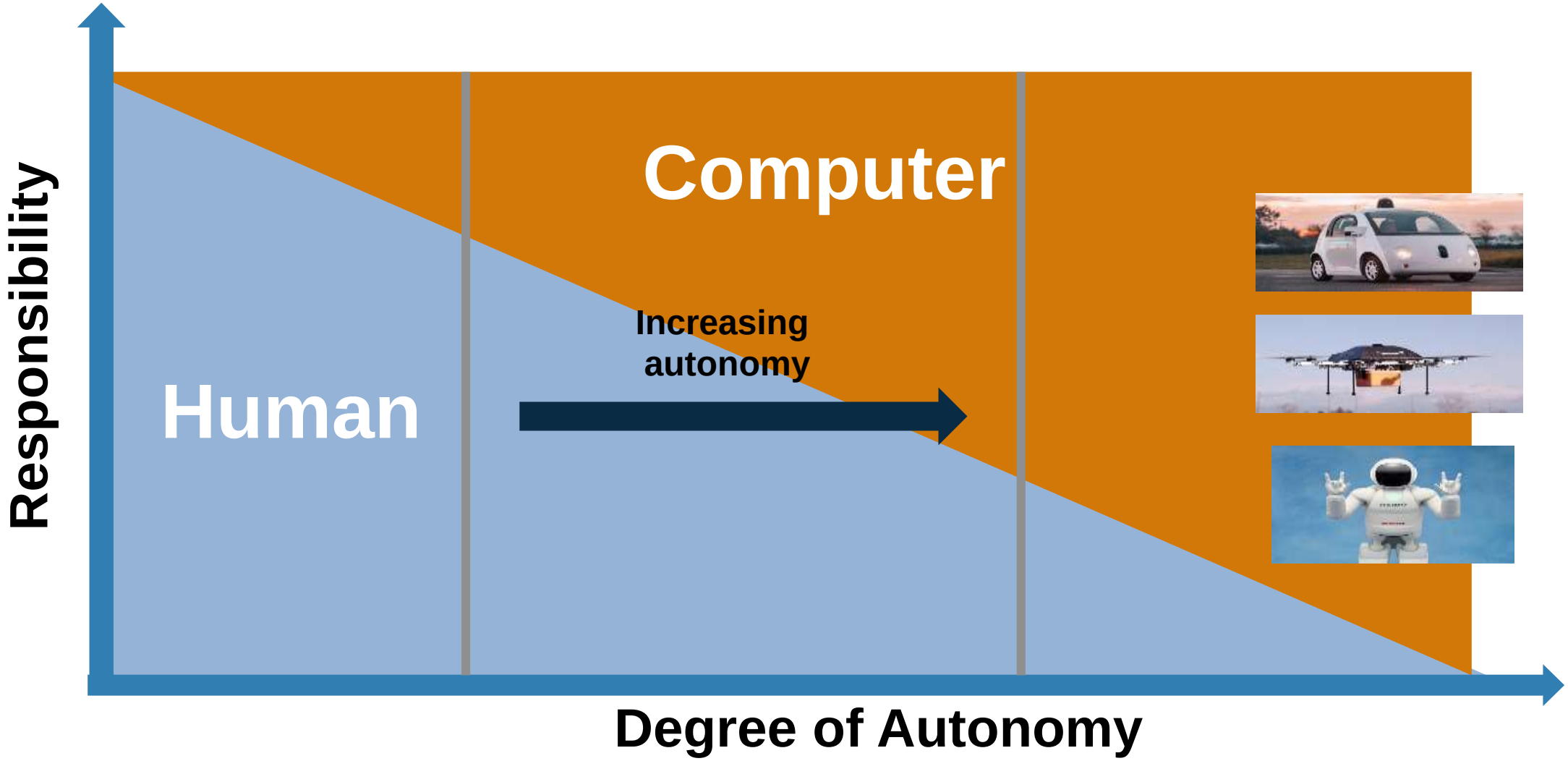
Fusion Technology



Autonomous Technology

Provides the ability of a system to act independently of direct human control under unrehearsed conditions

Autonomous Technology Transfers Responsibility to Computers



Oil and gas extraction from Baker Hughes.

Autonomous Service for Predictive Maintenance

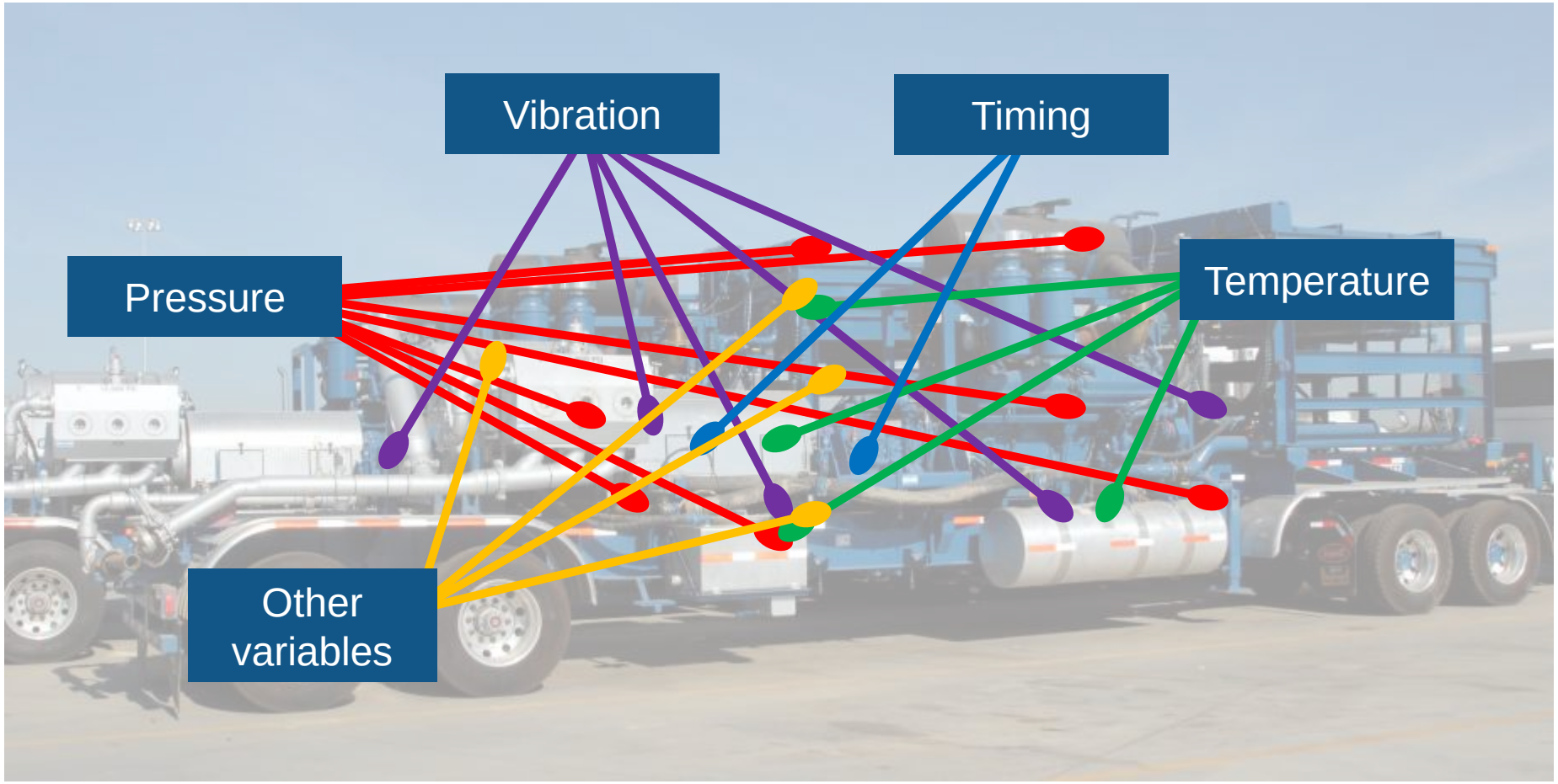
Sense

Perceive

Decide & Plan

Act

Which sensor values should they use?



Autonomous Service for Predictive Maintenance

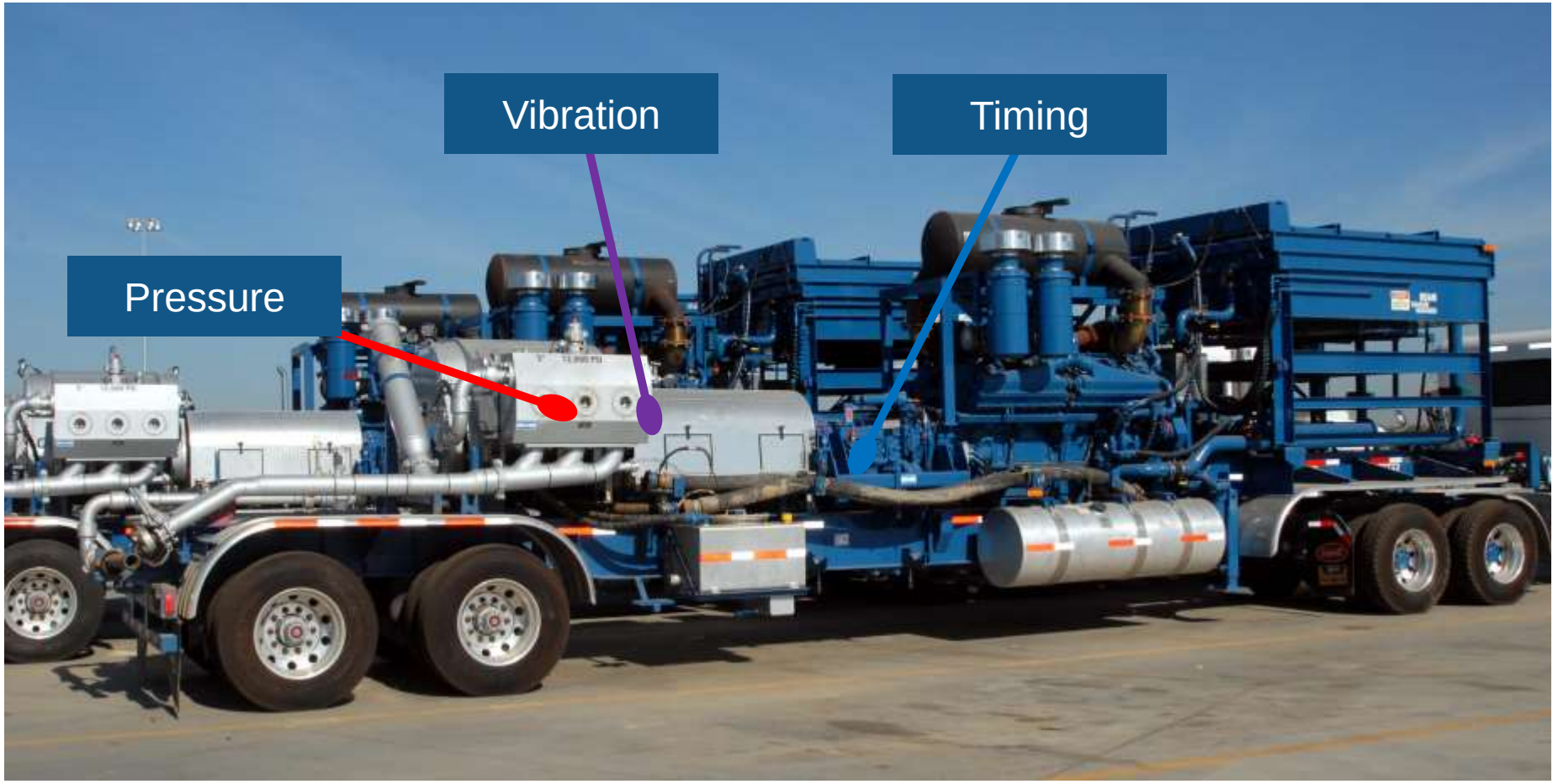
Sense

Perceive

Decide & Plan

Act

Which sensor values should they use?



Those provided characteristic information that enabled them to make a decision.

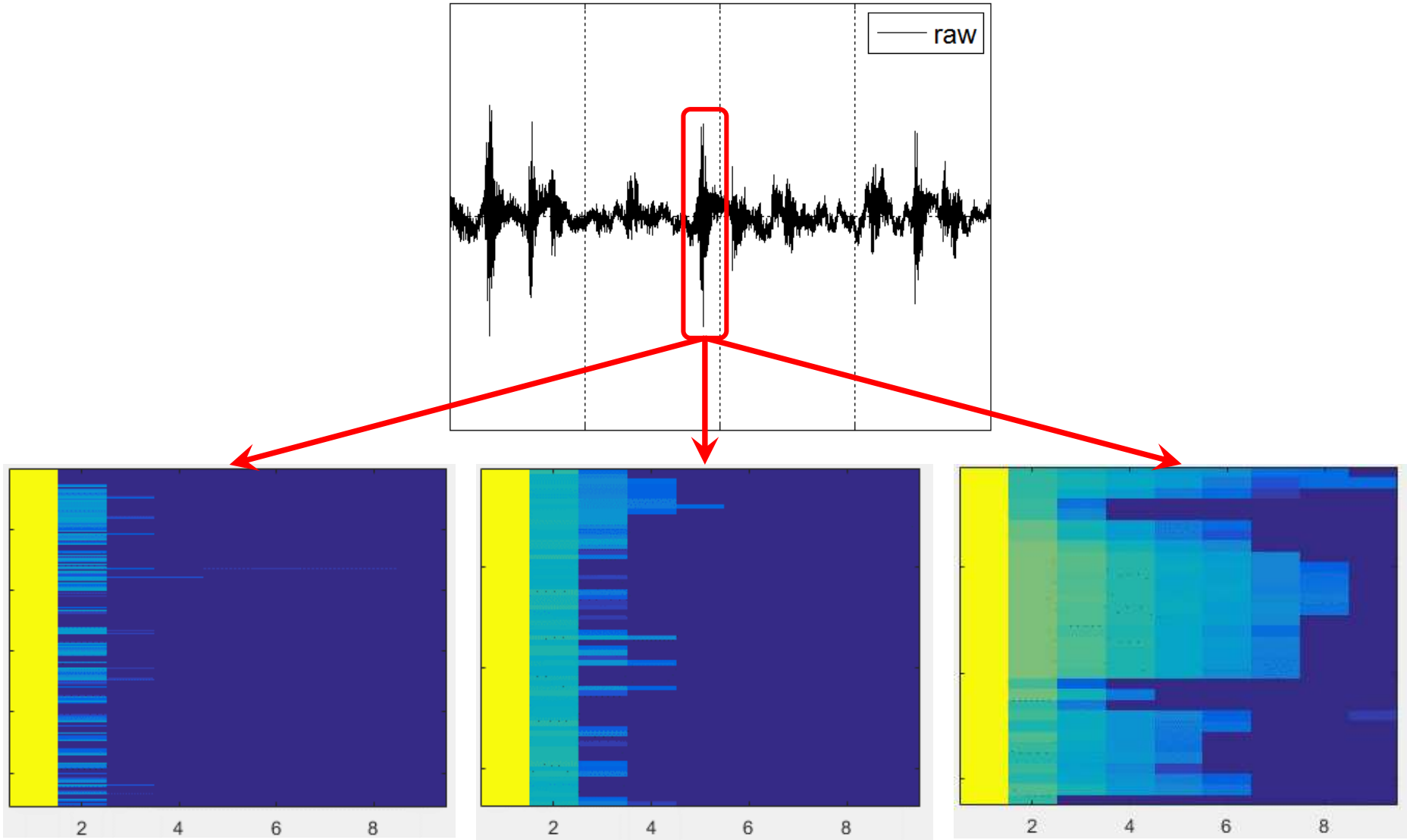
Autonomous Service for Predictive Maintenance

Sense

Perceive

Decide & Plan

Act



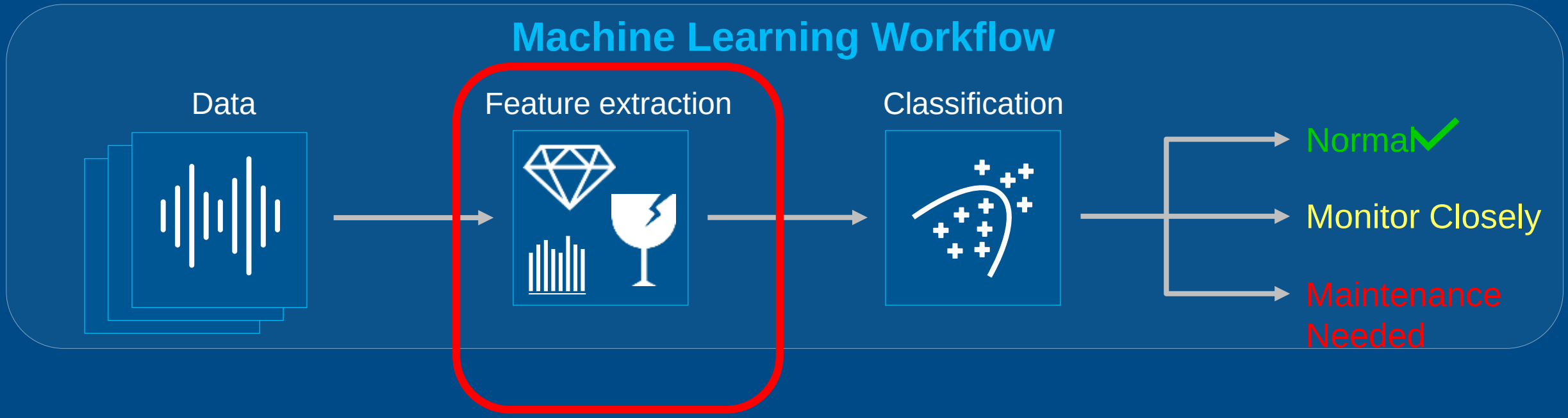
Normal Operation

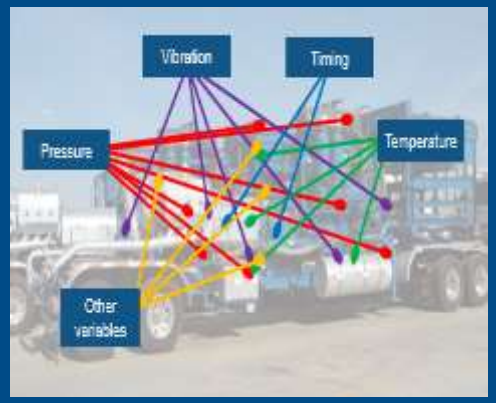
Monitor Closely

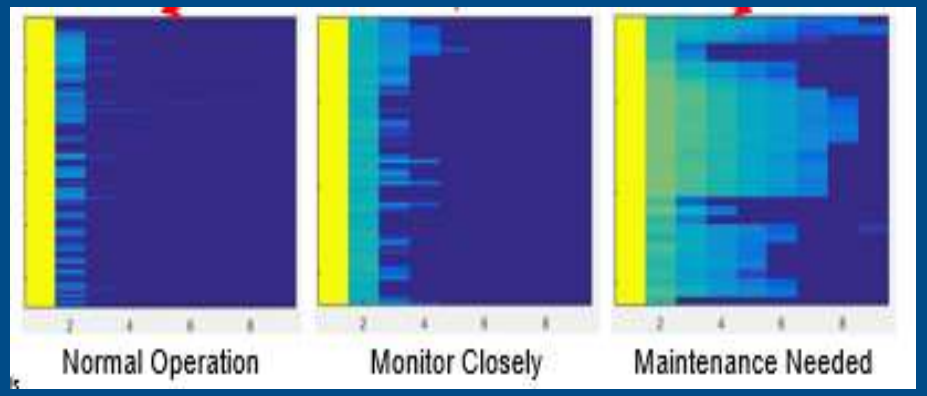
Maintenance Needed

Statistical and Frequency domain analysis ..

Machine learning Workflow



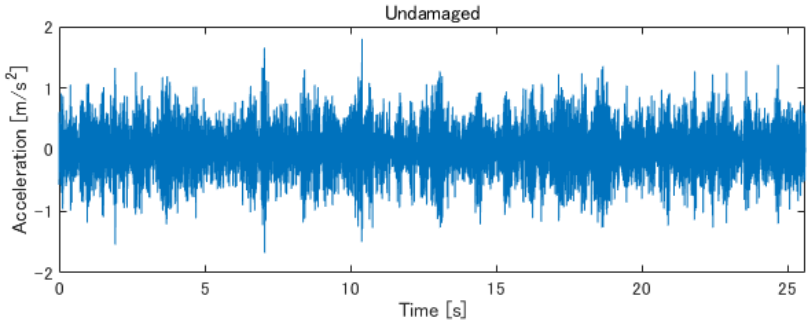


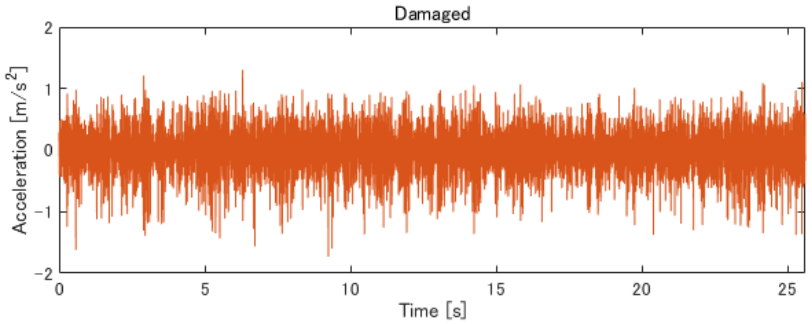


Feature Extraction

Biggest Challenge is to Find the **Right** Feature

Acceleration data

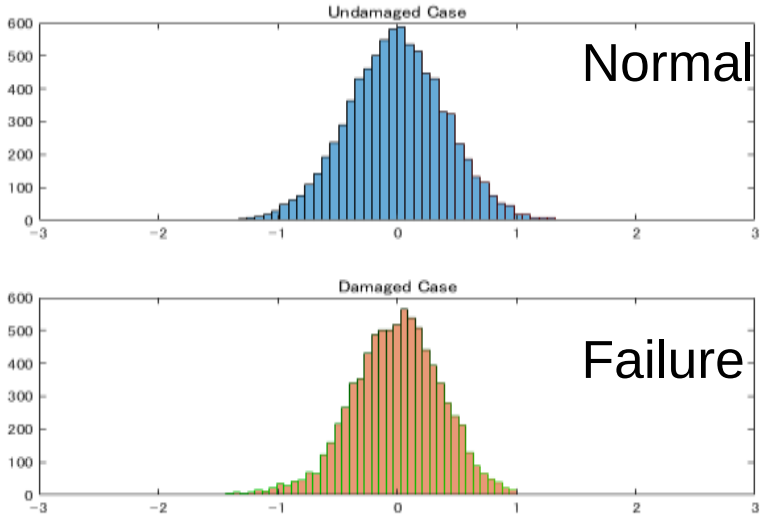




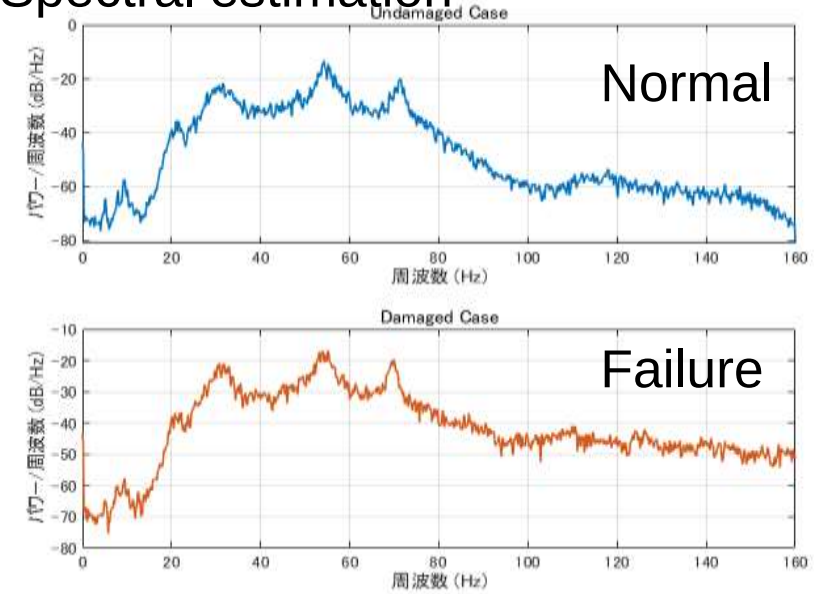
Normal

Failure

Histogram



Spectral estimation



Diagnostic Feature Explorer - Signal Trace: vibration/Var1

FEATURE EXPLORER | SIGNAL TRACE | 보기

Clean Up

Open Session | Save Session | Import Data | Signal Trace | Computation Options | Filtering & Averaging | Residue Generation | Spectral Estimation | Time-Domain Features | Spectral Features | Rank Features | Export

FILE | PLOT | COMPUTATION | DATA PROCESSING | FEATURE GENERATION | RANKING | EXPORT

데이터 브라우저

Signals & Spectra

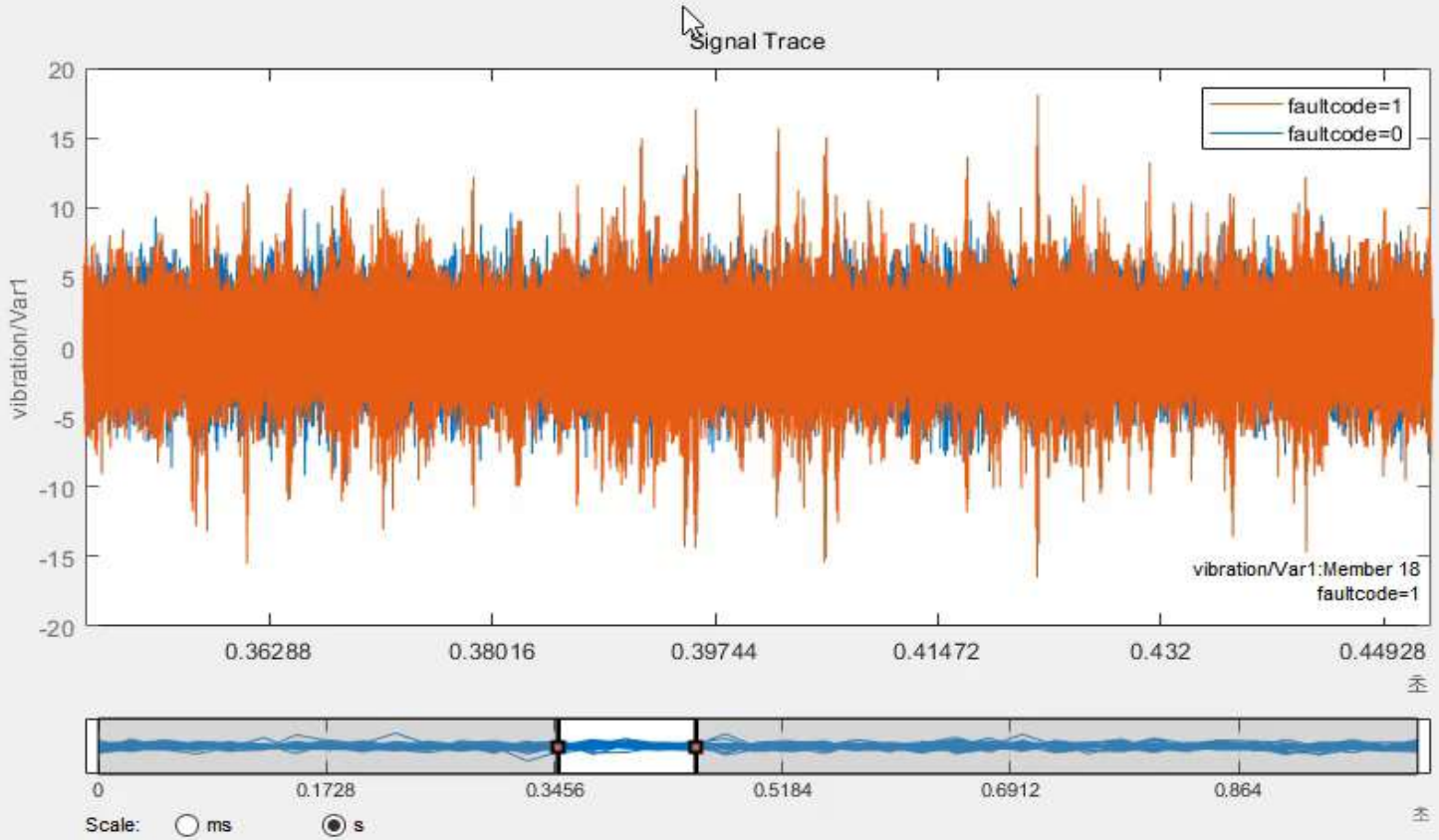
vibration/Var1

Feature Tables

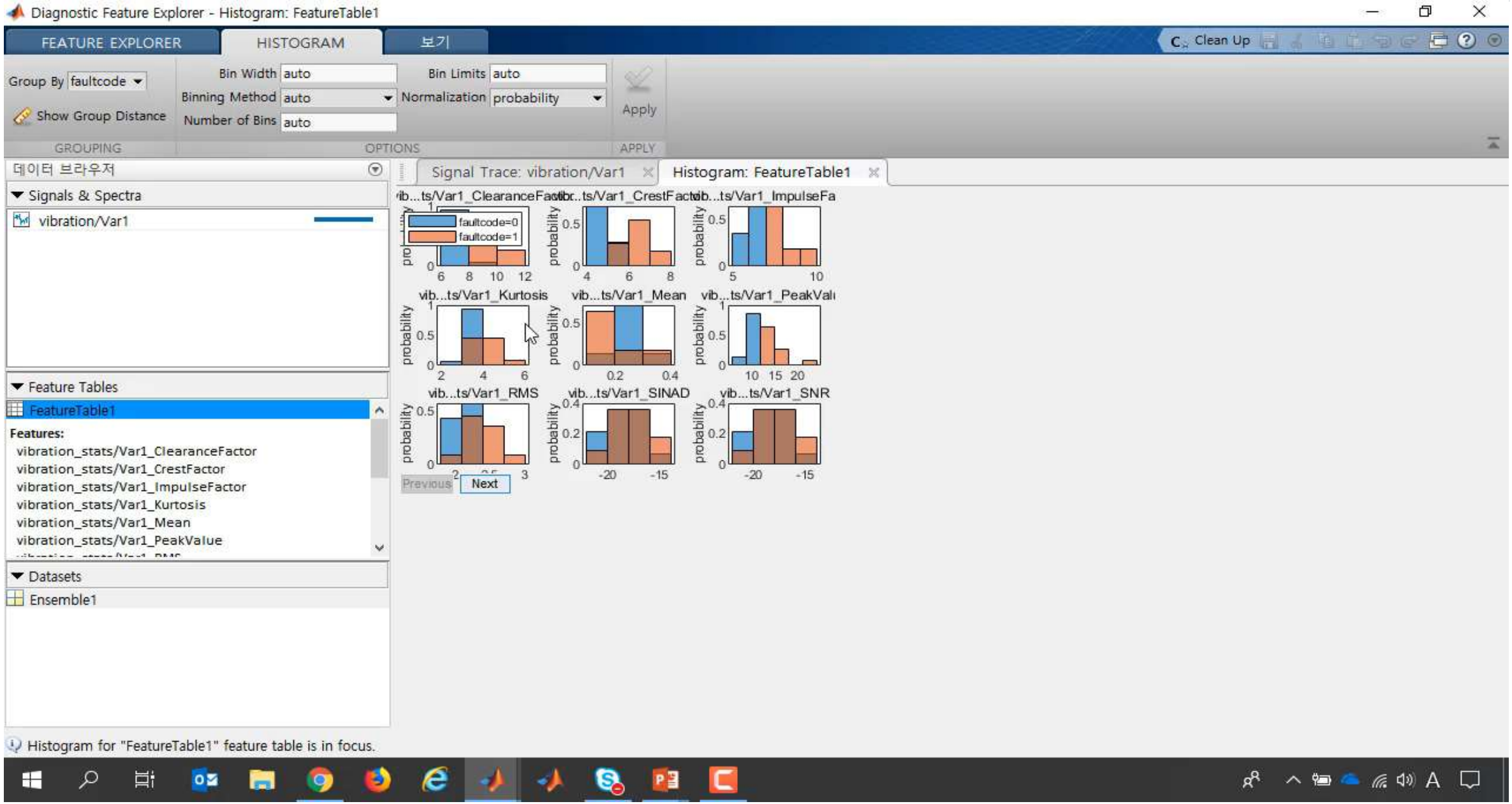
Datasets

Ensemble1

Signal Trace: vibration/Var1



Opening Signal Features dialog...


Diagnostic Feature Explorer - Histogram: FeatureTable1
FEATURE EXPLORER
HISTOGRAM
보기
Clean Up
Group By faultcode
Show Group Distance
Bin Width auto
Binning Method auto
Number of Bins auto
Bin Limits auto
Normalization probability
Apply
GROUPING
OPTIONS
APPLY
데이터 브라우저
Signals & Spectra
vibration/Var1
Feature Tables
FeatureTable1
Features:
vibration_stats/Var1_ClearanceFactor
vibration_stats/Var1_CrestFactor
vibration_stats/Var1_ImpulseFactor
vibration_stats/Var1_Kurtosis
vibration_stats/Var1_Mean
vibration_stats/Var1_PeakValue
Datasets
Ensemble1
Signal Trace: vibration/Var1
Histogram: FeatureTable1
faultcode=0
faultcode=1
probability
vib...ts/Var1_ImpulseFa
vib...ts/Var1_Kurtosis
vib...ts/Var1_Mean
vib...ts/Var1_PeakVali
vib...ts/Var1_RMS
vib...ts/Var1_SINAD
vib...ts/Var1_SNR
Previous
Next
Histogram for "FeatureTable1" feature table is in focus.

Diagnostic Feature Explorer - Feature Ranking: FeatureTable1

FEATURE EXPLORER | FEATURE RANKING | 보기

Clean Up

Ranking Techniques | Rank By: faultcode | Sort By: T-Test | Delete Scores | Export

TWO-CLASS RANKING METHODS

T-Test
Absolute value two-sample T-test with pooled variance estimate

Entropy
Rank features using an independent evaluation criterion by relative entropy

Bhattacharyya
Rank features by minimum attainable classification error or Chernoff bound

ROC
Rank features by area between the empirical receiver operating characteristic (ROC) curve and the random classifier slope

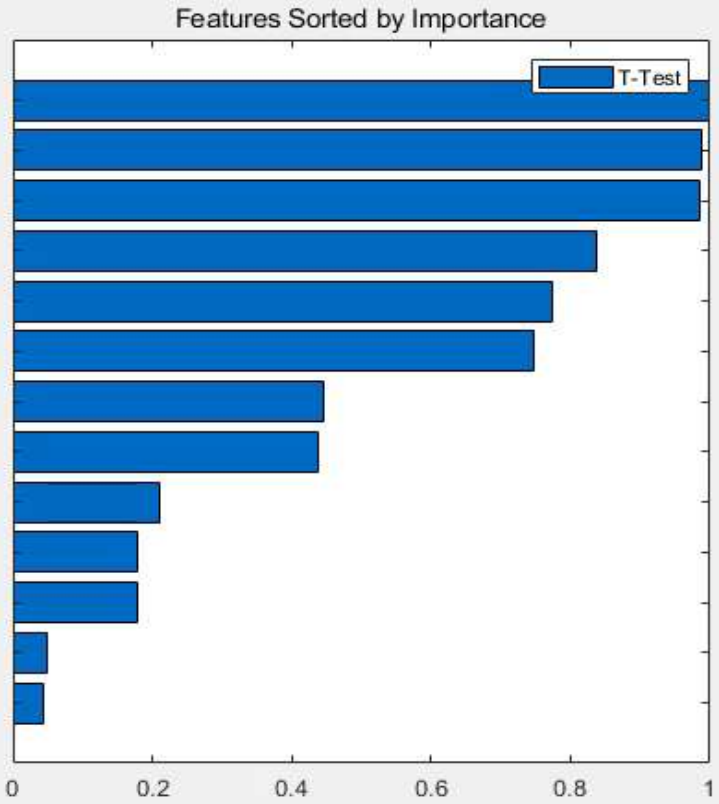
Wilcoxon
Rank features by absolute value of the standardized U-statistic of a two-sample unpaired Wilcoxon test

MULTI-CLASS RANKING METHODS

One-way ANOVA
Rank features by one-way analysis of variance

Kruskal-Wallis
Rank features by chi-square statistic of a Kruskal-Wallis test

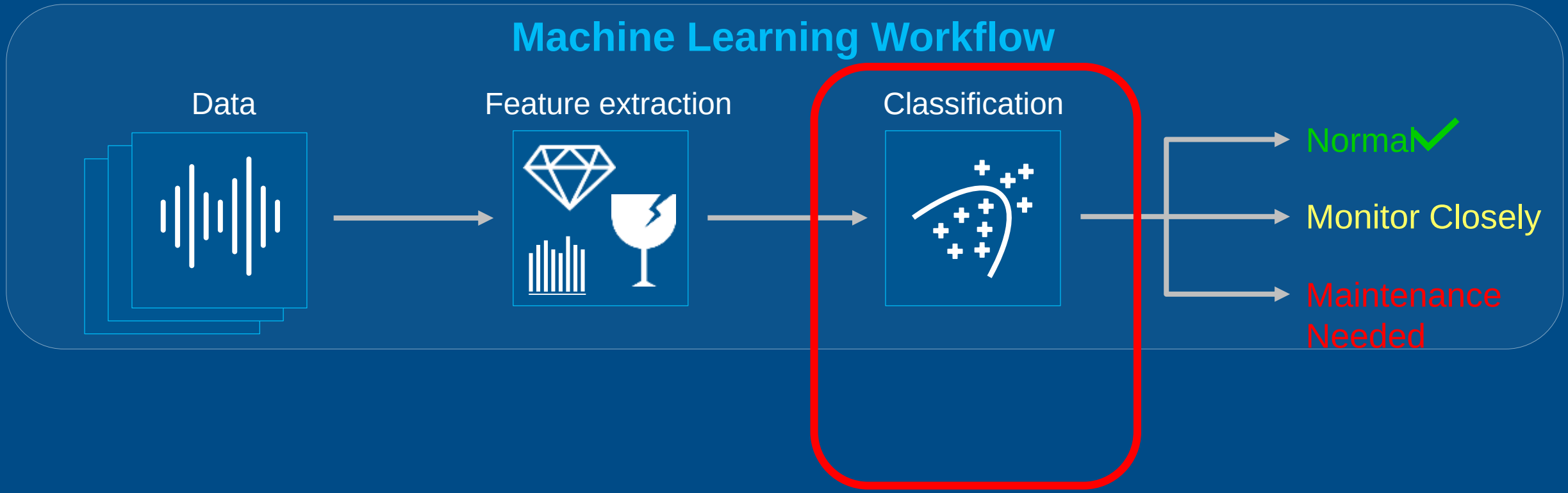
Trace: vibration/Var1 | Histogram: FeatureTable1 | Feature Ranking: FeatureTable1



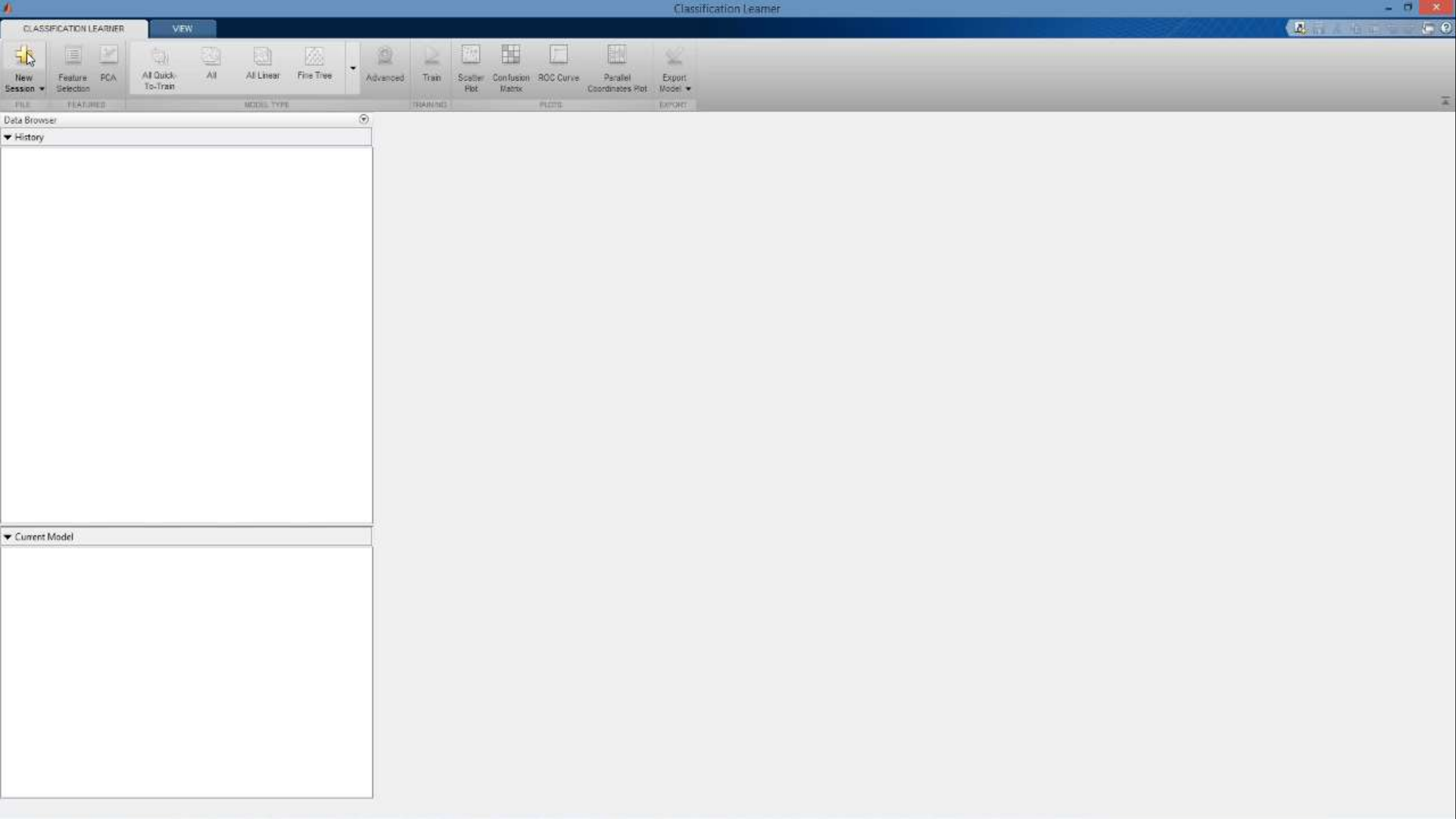
Feature	T-Test
vib...ts/Var1_CrestFactor	7.6576
vib...ts/Var1_ImpulseFactor	7.5706
vib...ts/Var1_ClearanceFactor	7.5478
vib...ts/Var1_ShapeFactor	6.4083
vib...ts/Var1_PeakValue	5.9344
vib...ts/Var1_Kurtosis	5.7292
vib...ts/Var1_Std	3.4040
vib...ts/Var1_RMS	3.3512
vib...ts/Var1_Mean	1.6029
vib...ts/Var1_SNR	1.3618
vib...ts/Var1_SINAD	1.3580
vib...ts/Var1_THD	0.3765
vib...ts/Var1_Skewness	0.3308

Feature ranking plot for "FeatureTable1" is in focus.

Machine learning Workflow



다음? → 나무


Classification Learner
CLASSIFICATION LEARNER
VIEW
New Session
Feature Selection
PCA
All Quick-To-Train
All
All Linear
Fine Tree
Advanced
Train
Scatter Plot
Confusion Matrix
ROC Curve
Parallel Coordinates Plot
Export Model
FILE
FEATURES
MODEL TYPE
TRAINING
PLOTS
EXPORT
Data Browser
History
Current Model

Machine learning Workflow

Machine Learning Workflow

Data

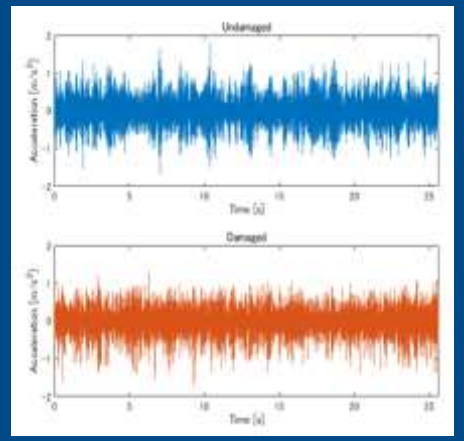
Feature extraction

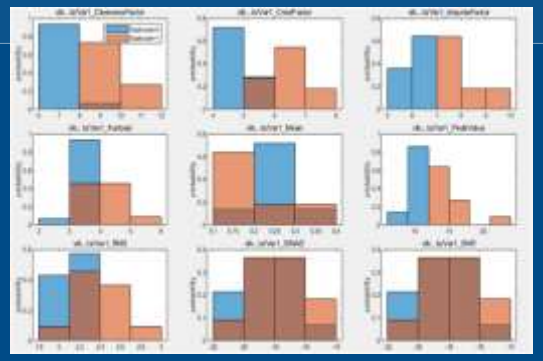
Classification

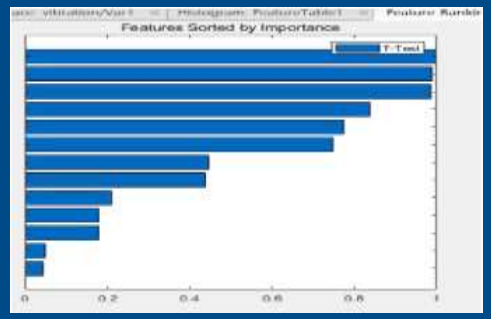
Normal

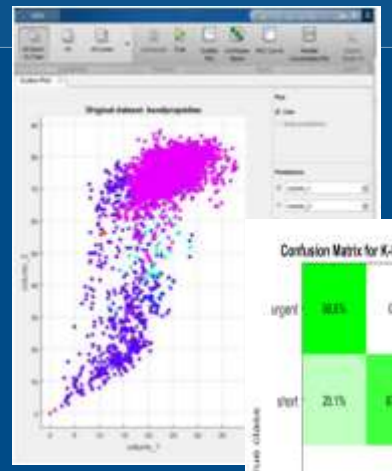
Monitor Closely

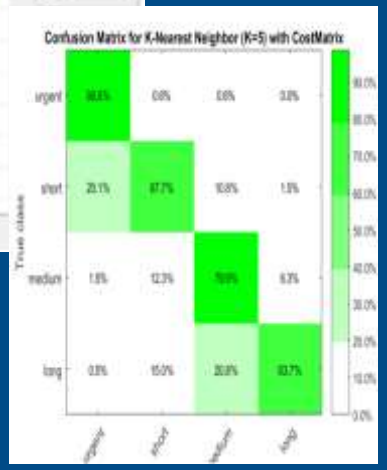
Maintenance Needed





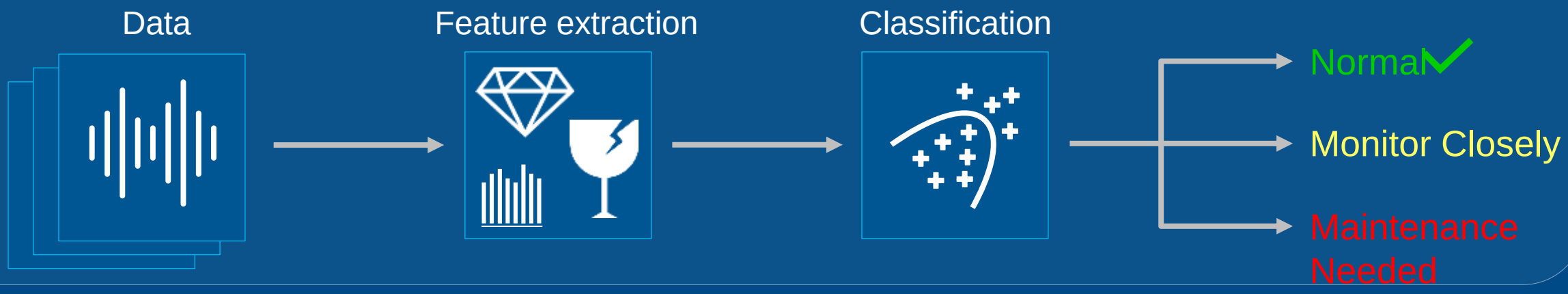




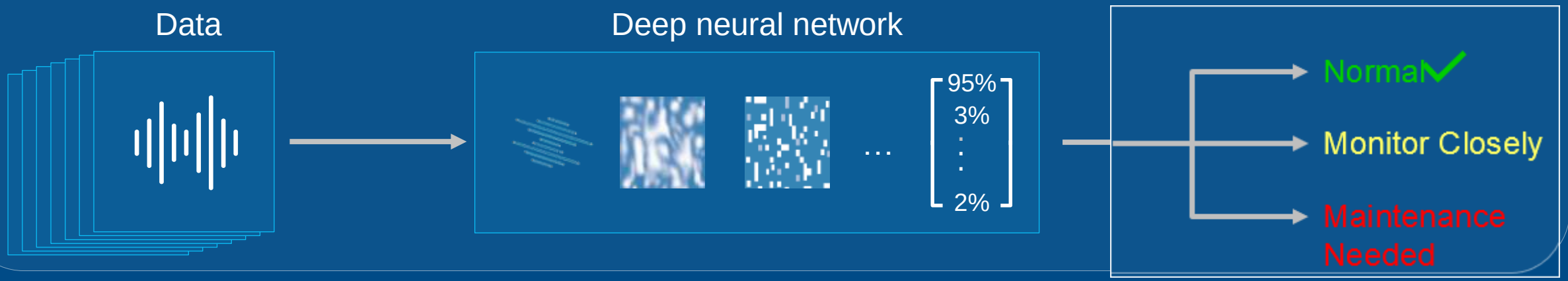


Use deep learning to identify features automatically

Machine Learning Workflow



Deep Learning Workflow



Object Recognition using Deep Learning

Object recognition (whole image)

CNN (Convolutional Neural Network)

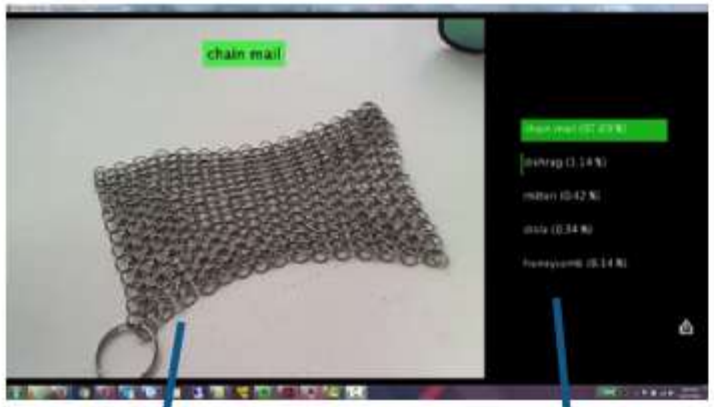
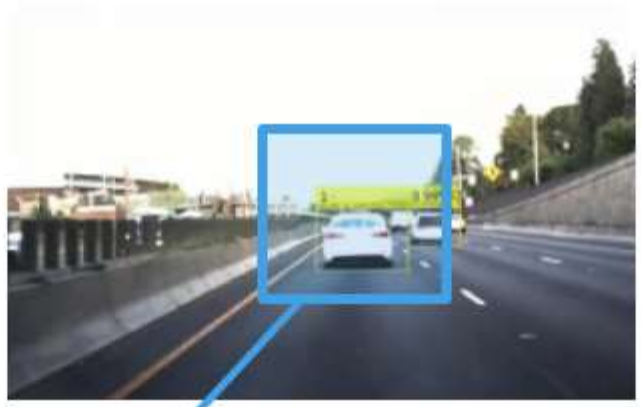


Image (Input)

Probability

Object detection and recognition

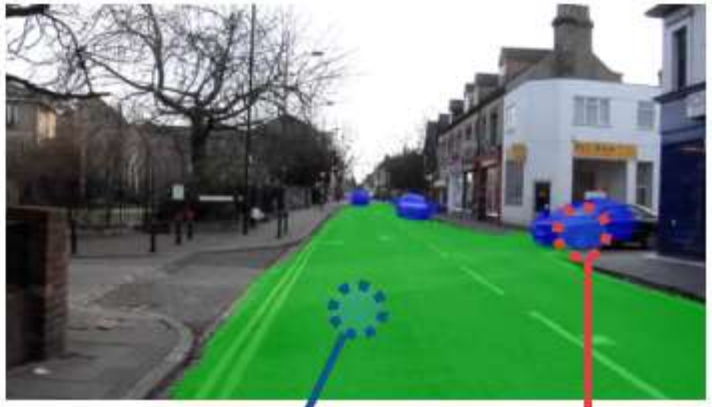
R-CNN / Fast R-CNN / Faster R-CNN



Front of Car

Object recognition (in pixels)

SegNet / FCN

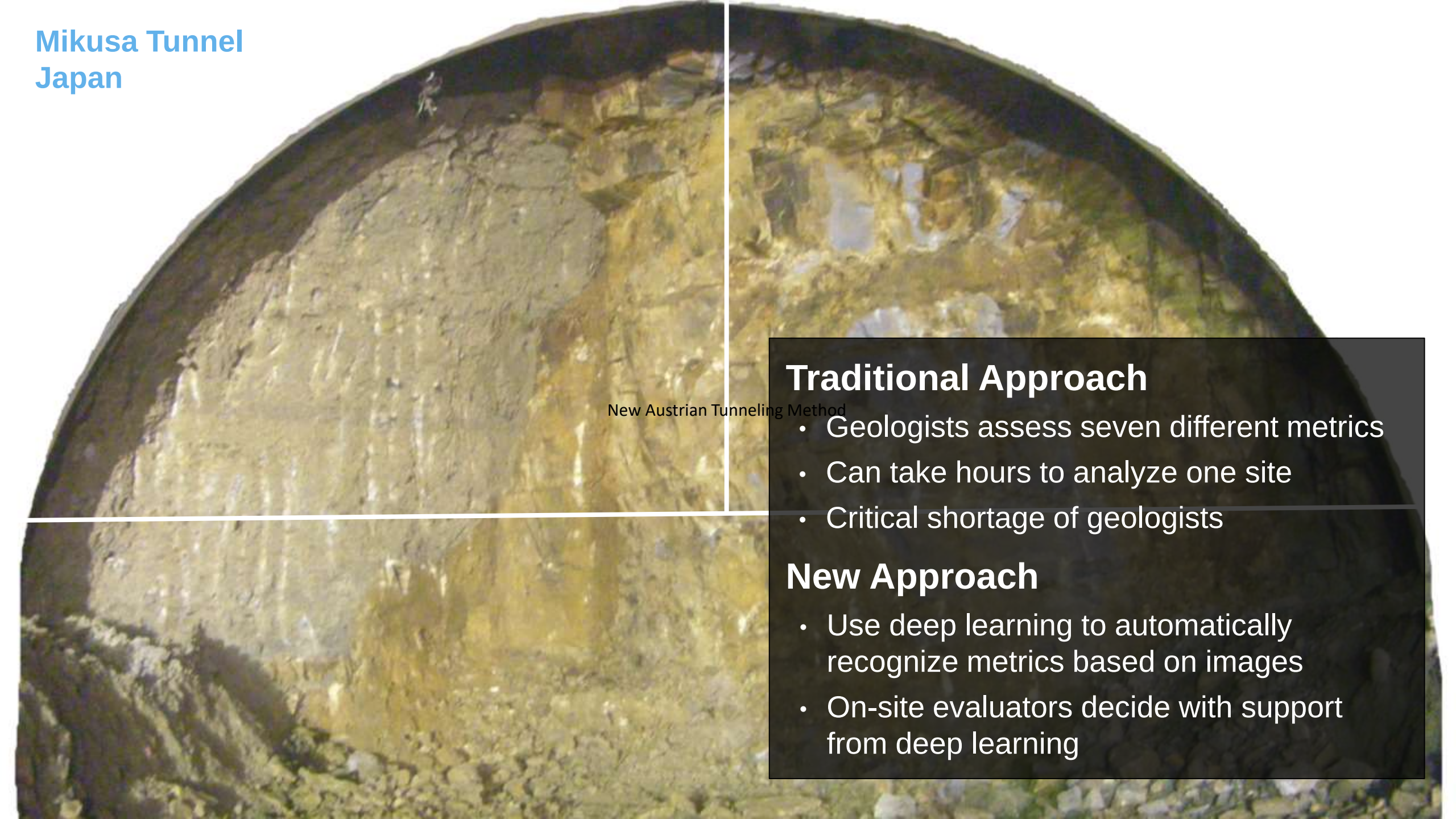


Road

Vehicle

Efficient tunnel drilling with deep learning (Obayashi Corporation)


45



Traditional Approach

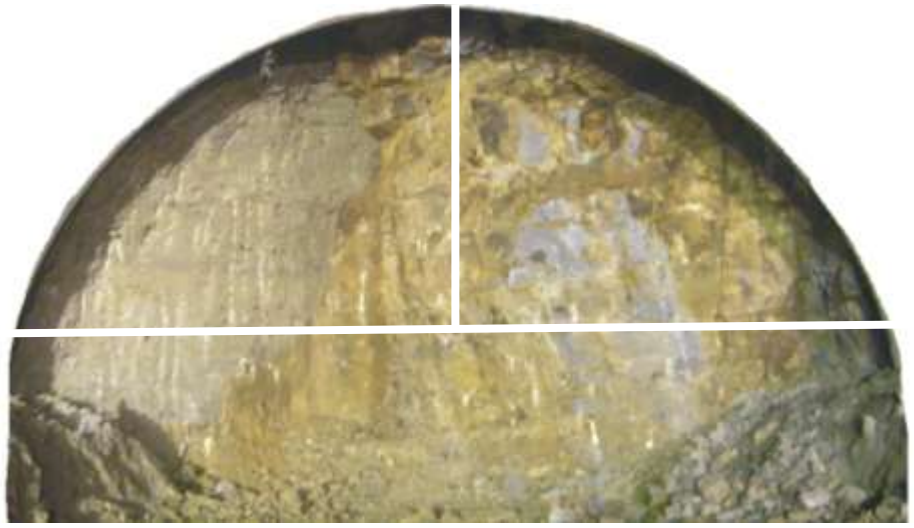
- Geologists assess seven different metrics
- Can take hours to analyze one site
- Critical shortage of geologists

New Approach

- Use deep learning to automatically recognize metrics based on images
- On-site evaluators decide with support from deep learning

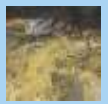
Efficient tunnel drilling with deep learning

Obayashi Corporation



Split into sub-images

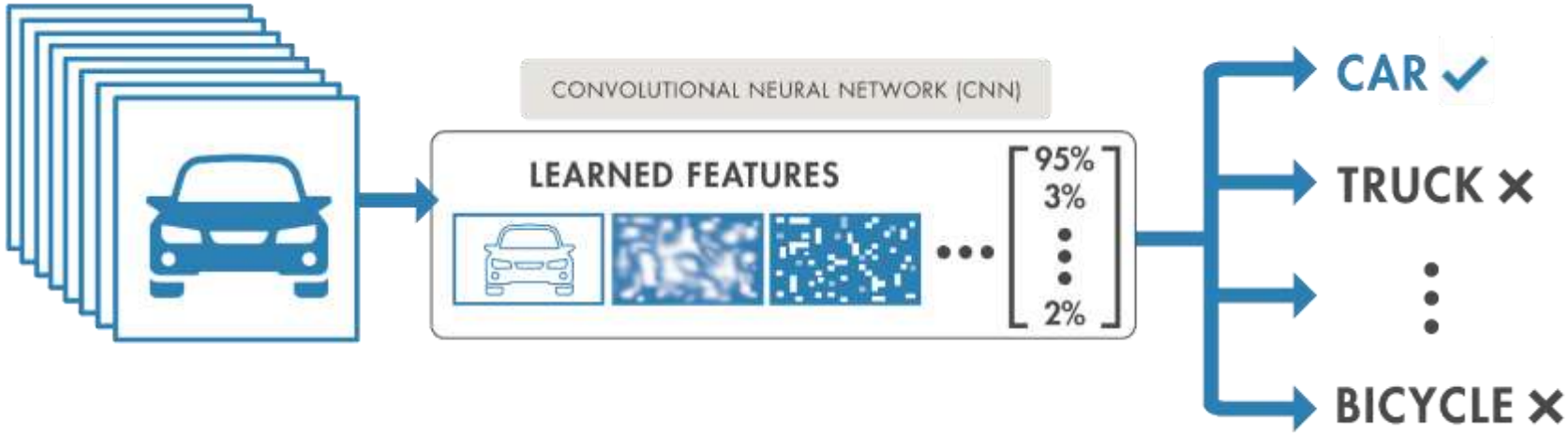
Label each sub-image

Image	Weathering Alteration (1-4)	Fracture Spacing (1-5)	Fracture State (1-5)
	3	3	2
	4	1	1
	2	3	2
	3	3	2
⋮	⋮	⋮	⋮

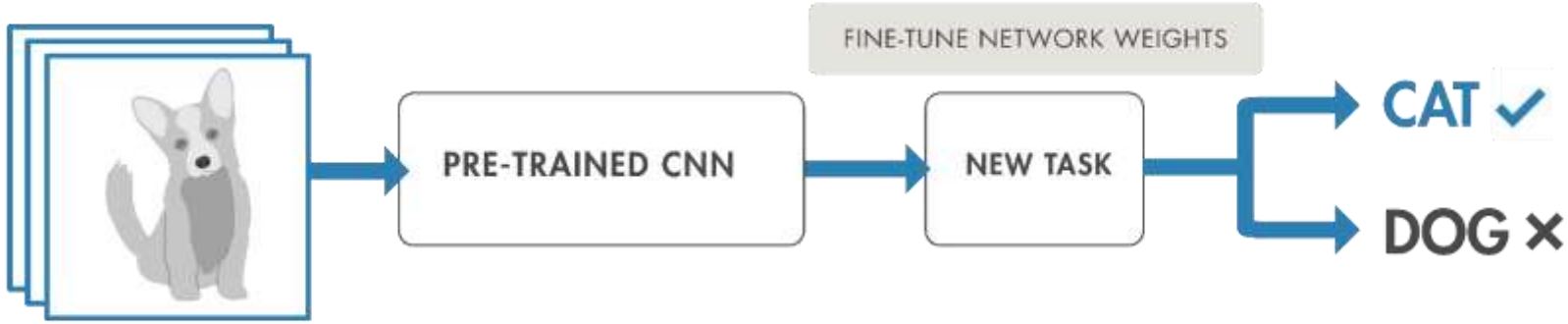
풍화작용. 균열 간격, 균영 상태

Two Approaches for Deep Learning

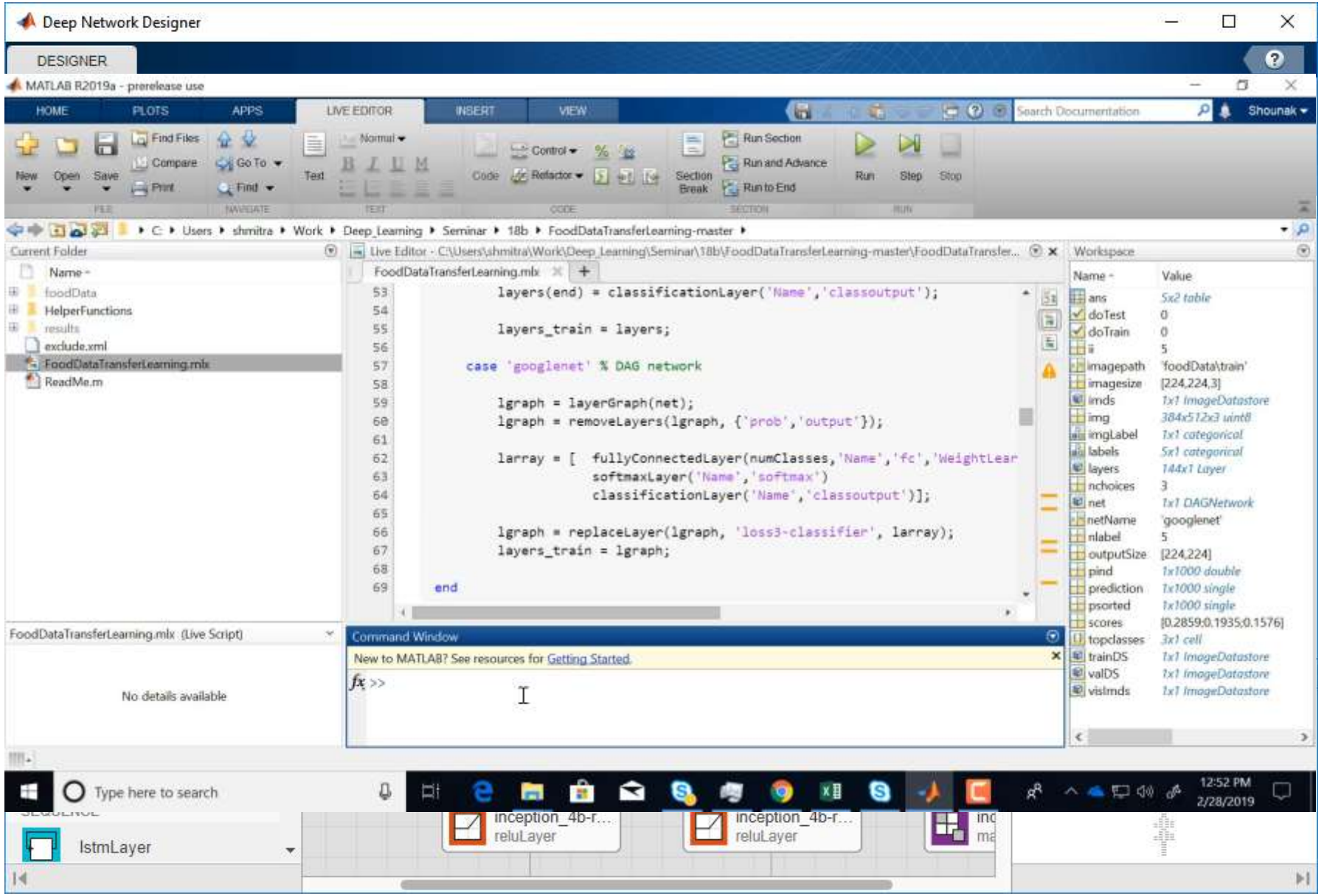
1. Train a Deep Neural Network from Scratch



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



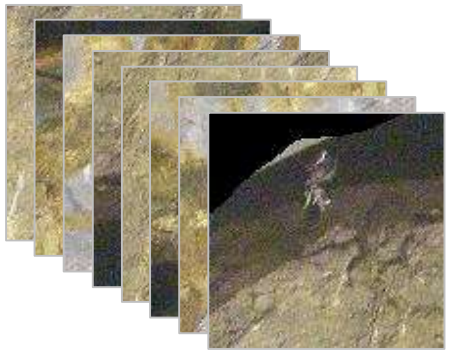
Develop Predictive Models – Deep Learning



R2018b

Efficient tunnel drilling with deep learning

Obayashi Corporation



Transfer learning

AlexNet

PRETRAINED MODEL

Ice cream

Teapot

Goose

Custom Network

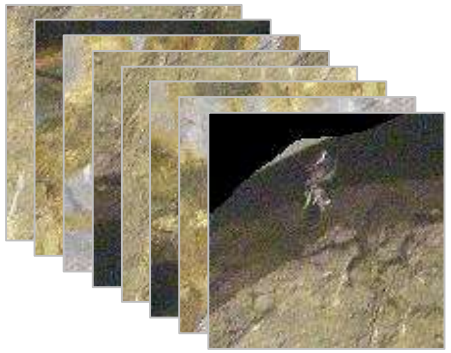
Weathering alteration: 4

Fracture spacing: 3

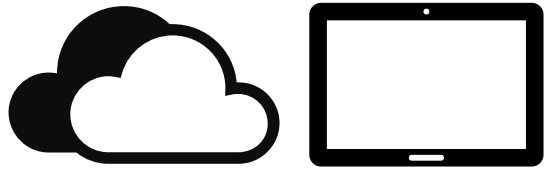
Fracture state: 2

Efficient tunnel drilling with deep learning

Obayashi Corporation



Transfer learning



MATLAB Production Server

AlexNet

PRETRAINED MODEL

Ice cream

Teapot

Goose

Custom Network

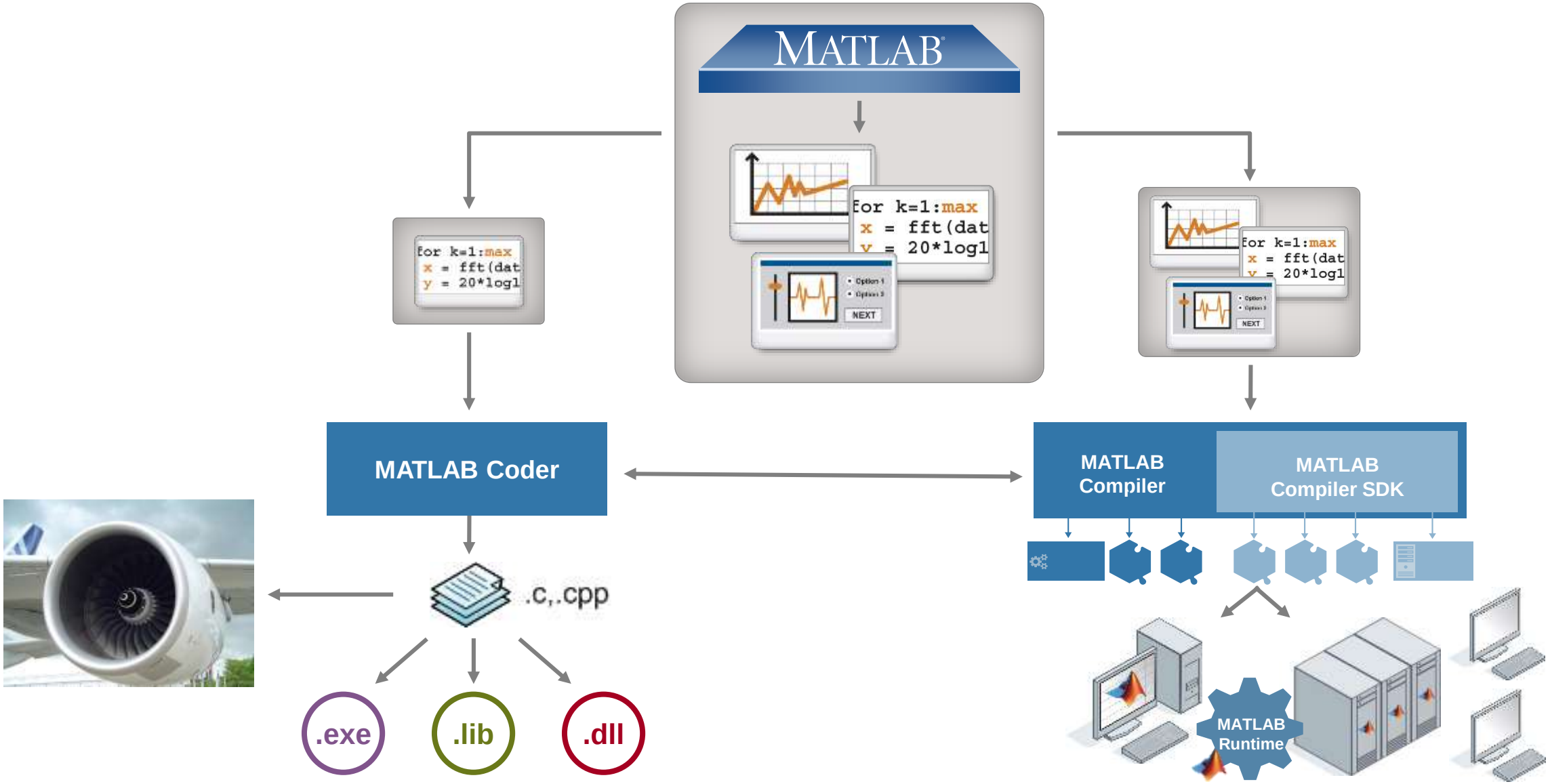
Weathering alteration: 4

Fracture spacing: 3

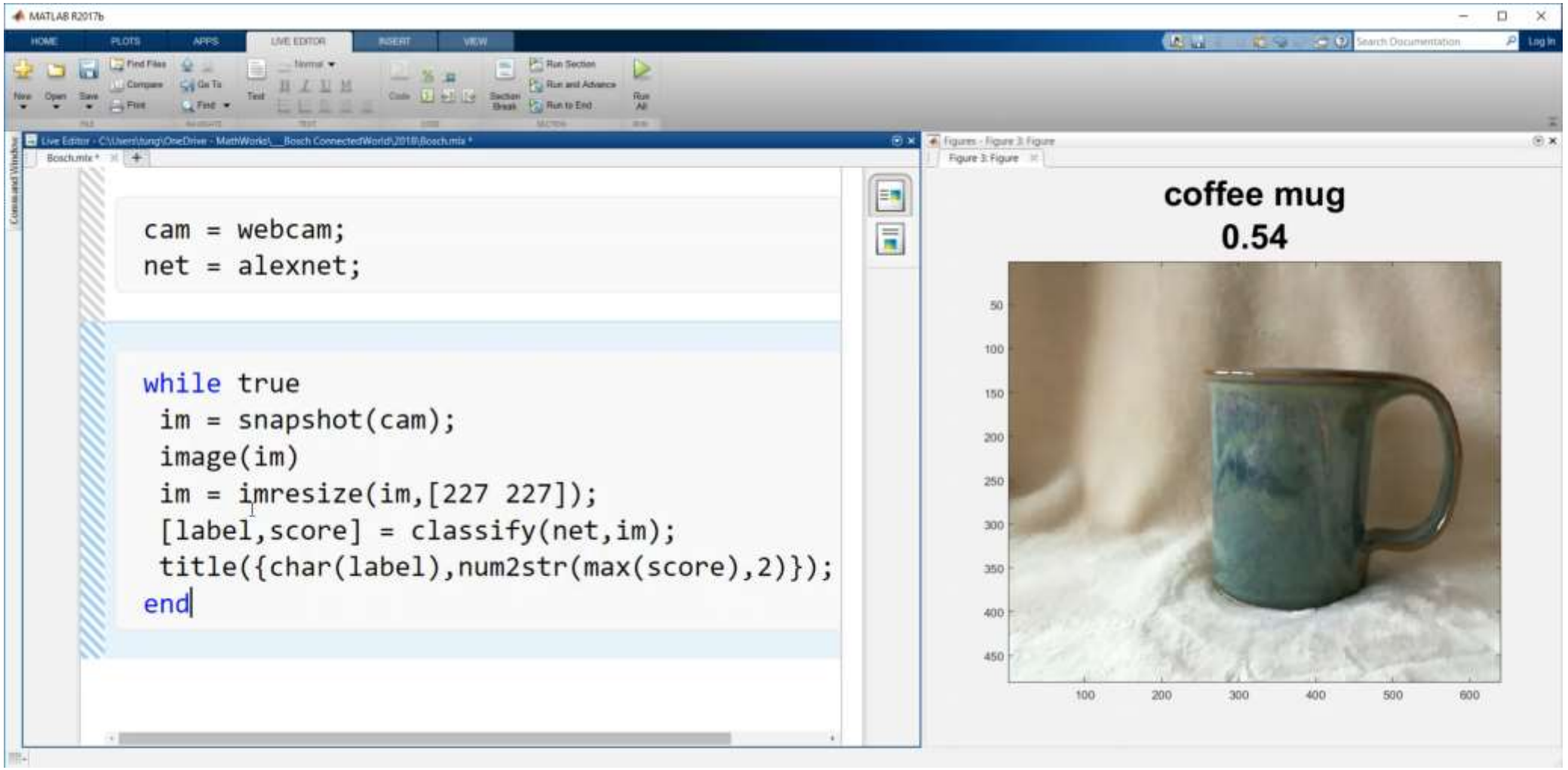
Fracture state: 2

Integrate analytics with your enterprise systems

MATLAB Compiler and MATLAB Coder

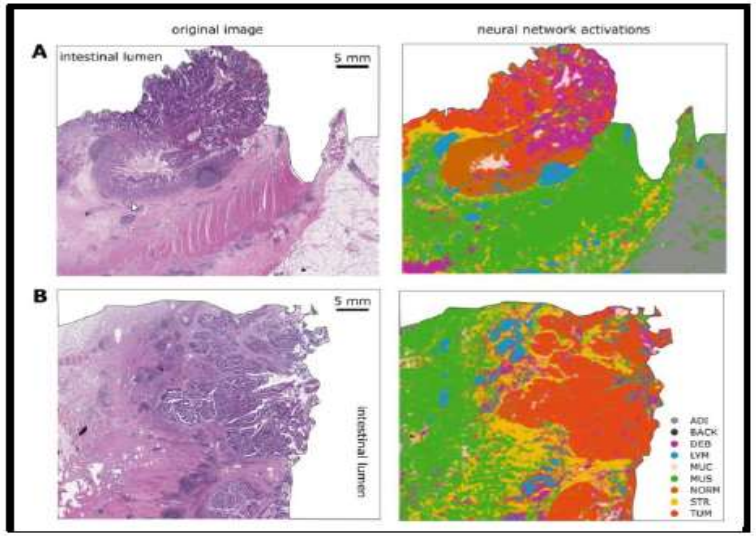


Industry Software- Deep Learning in Five Lines of Code



University Hospital Heidelberg

Predicting survival from colorectal cancer histology slides using deep learning



Semantic segmentation of histopathological whole-slide images

MATLAB use in project:

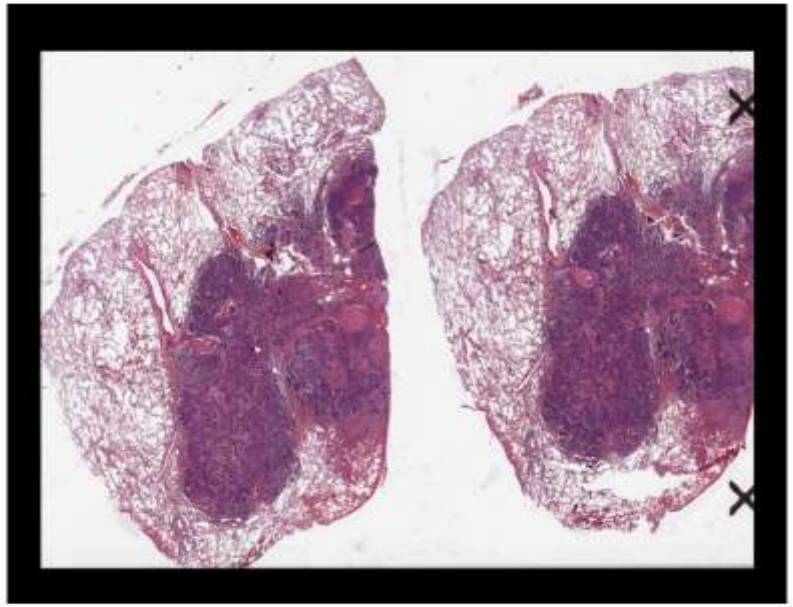
- Semantic segmentation using deep learning
- CNN trained using two Nvidia Quadro P6000 GPUs and a Nvidia Titan Xp GPU

Citation:Kather JN, Krisam J, Charoentong P, Luedde T, Herpel E, Weis C-A, et al. (2019) Predictingsurvival from colorectal cancer histology slides using deep learning:A retrospective multicenter study. PLoS Med 16(1): e1002730. https://doi.org/10.1371/journal.pmed.1002730

https://blogs.mathworks.com/deep-learning/2019/07/24/deep-learning-for-medical-imaging/?s_tid=srchtitle

Meta data (SVS file) handling with MATLAB command *(blockproc.. Imfinfo..)*

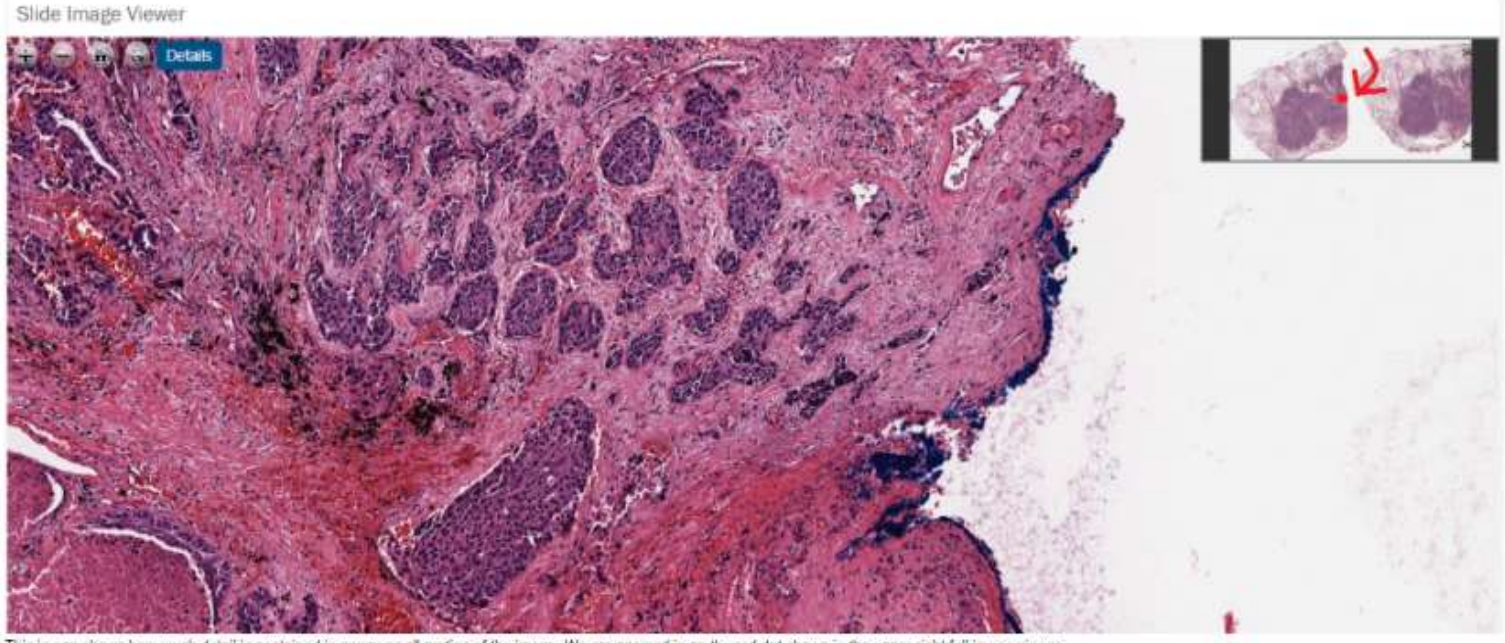
Thousands of such images are freely available in public repositories. Some of these repositories are available at the National Institutes of Health (NIH) data portal. From https://portal.gdc.cancer.gov we can download tumor images such as this (in this case, a lung cancer):



These images are in SVS format, which is essentially a multi-layer TIFF image.

This may look like an ordinary image, but SVS images are huge: the files are often larger than 1 GB and the images have up to a billion pixels. A zoomed in version of one section of this image shows how large this image is:

This may look like an ordinary image, but SVS images are huge: the files are often larger than 1 GB and the images have up to a billion pixels. A zoomed in version of one section of this image shows how large this image is:



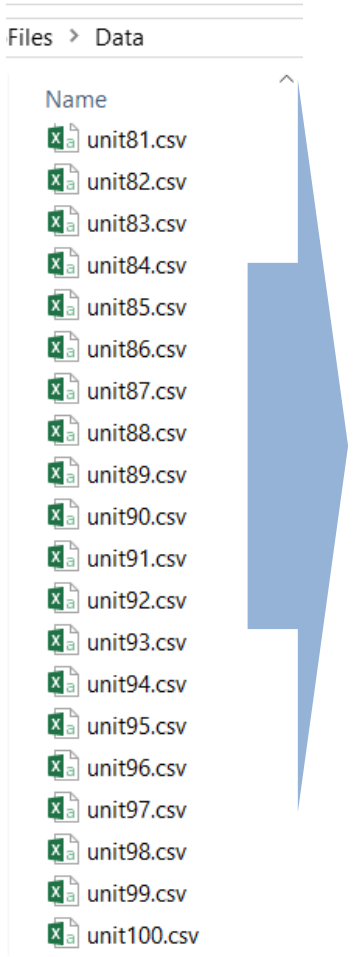
This image shows how much detail is contained in a very small portion of the image. We are zoomed in on the red dot shown in the upper right full image viewer.

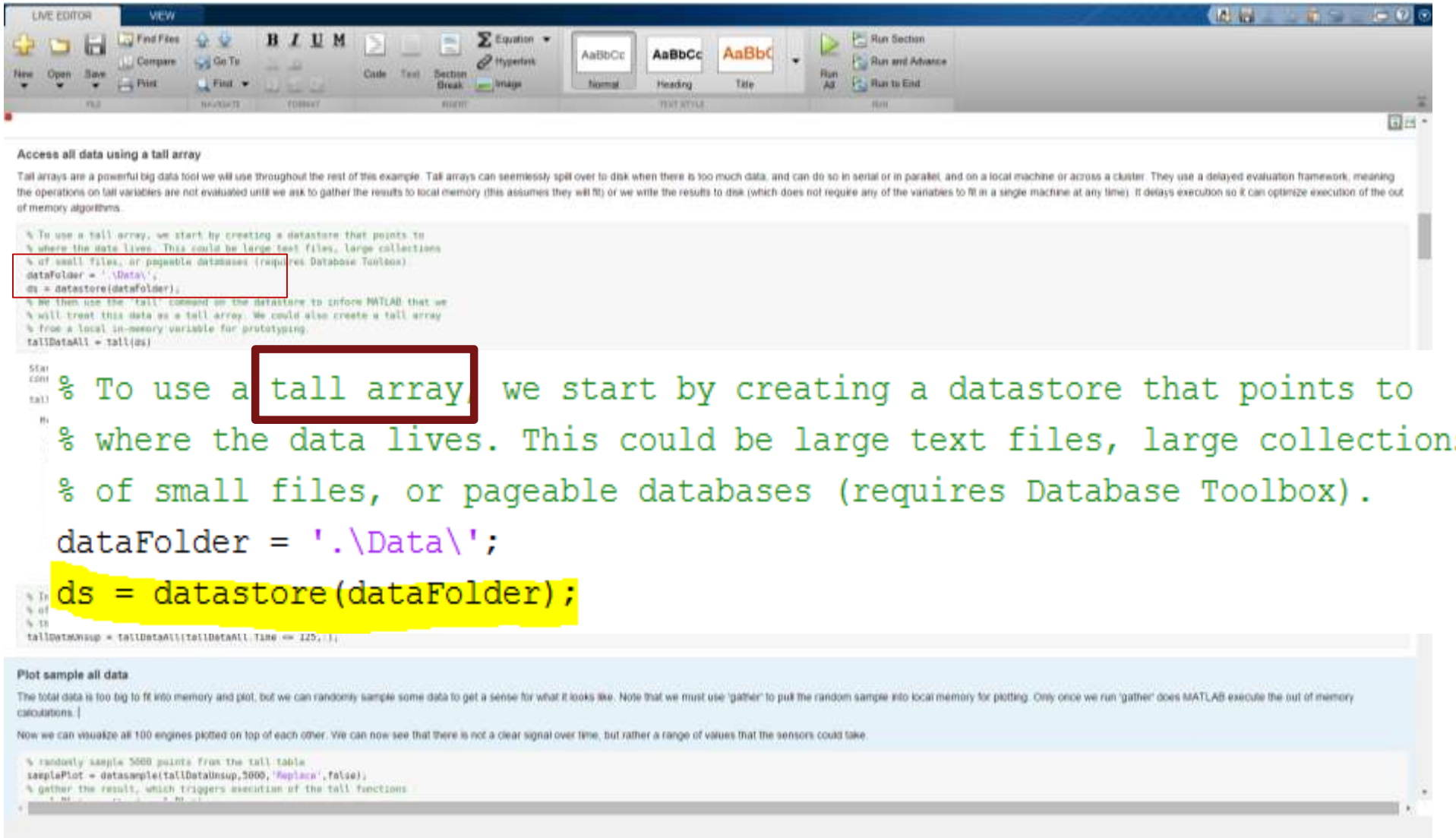
Images courtesy of National Cancer Institute.

Many people struggle to even load these images, but MATLAB has some nice functions to deal with this huge amount of data. In particular, we will be using the functions imfinfo (to extract metadata), imread (to read the thumbnail) and blockproc (to read the actual image data without loading the full image into RAM).

So, let's use MATLAB to look at these images. We start by downloading an example image from the TCGA database. The image in this post can be found here: https://portal.gdc.cancer.gov/files/0afb5489-719c-4e4d-bb8a-e0e146f0adb2

Access Data


Files > Data
Name
unit81.csv
unit82.csv
unit83.csv
unit84.csv
unit85.csv
unit86.csv
unit87.csv
unit88.csv
unit89.csv
unit90.csv
unit91.csv
unit92.csv
unit93.csv
unit94.csv
unit95.csv
unit96.csv
unit97.csv
unit98.csv
unit99.csv
unit100.csv

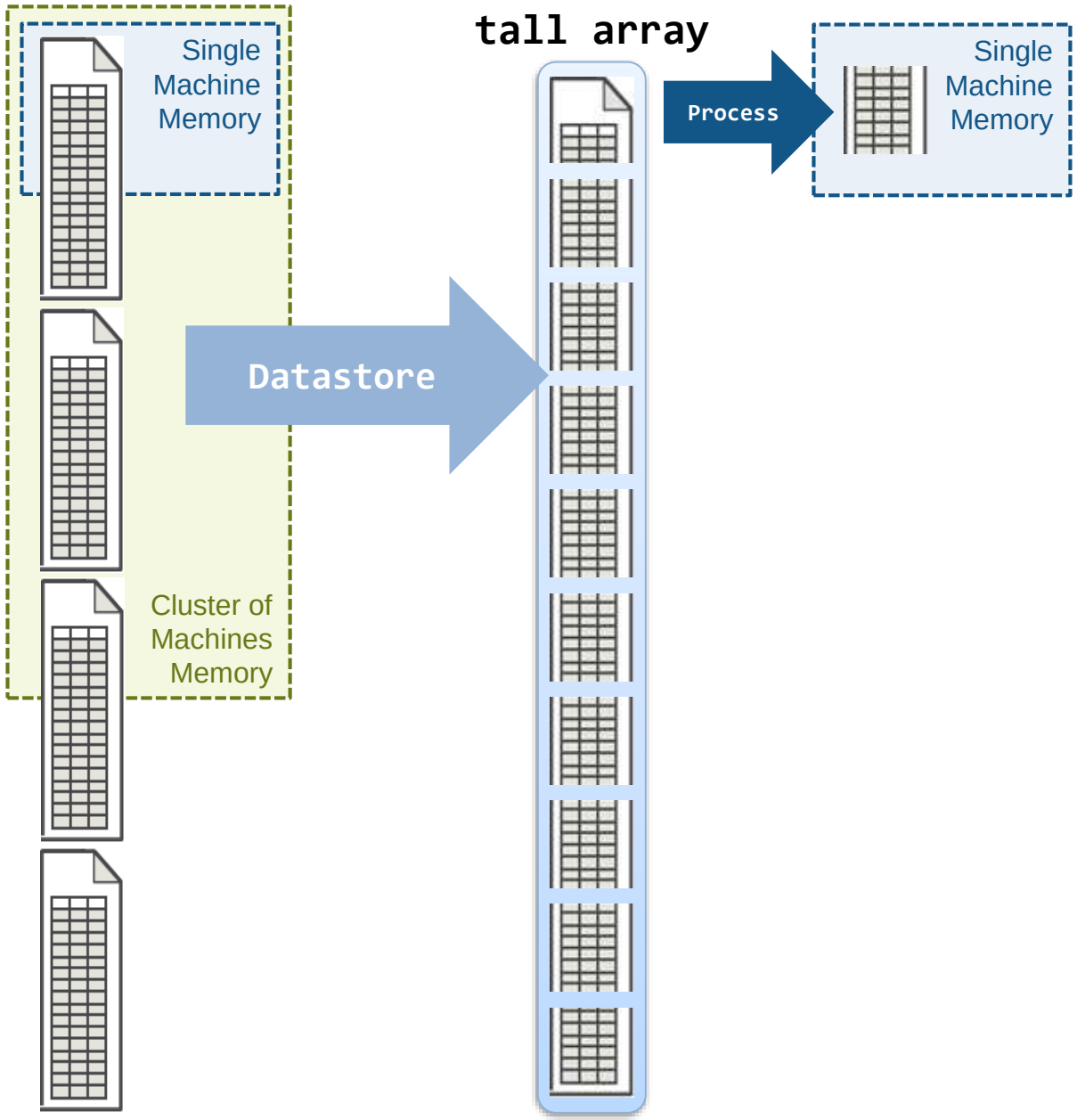

LIVE EDITOR
VIEW
Access all data using a tall array
% To use a tall array, we start by creating a datastore that points to
% where the data lives. This could be large text files, large collections
% of small files, or pageable databases (requires Database Toolbox).
dataFolder = '.\Data\';
ds = datastore(dataFolder);
Plot sample all data

Tall Arrays

- Data is in one or more files
- Typically tabular data
- Files stacked vertically
- Data doesn't fit into memory
  (even cluster memory)

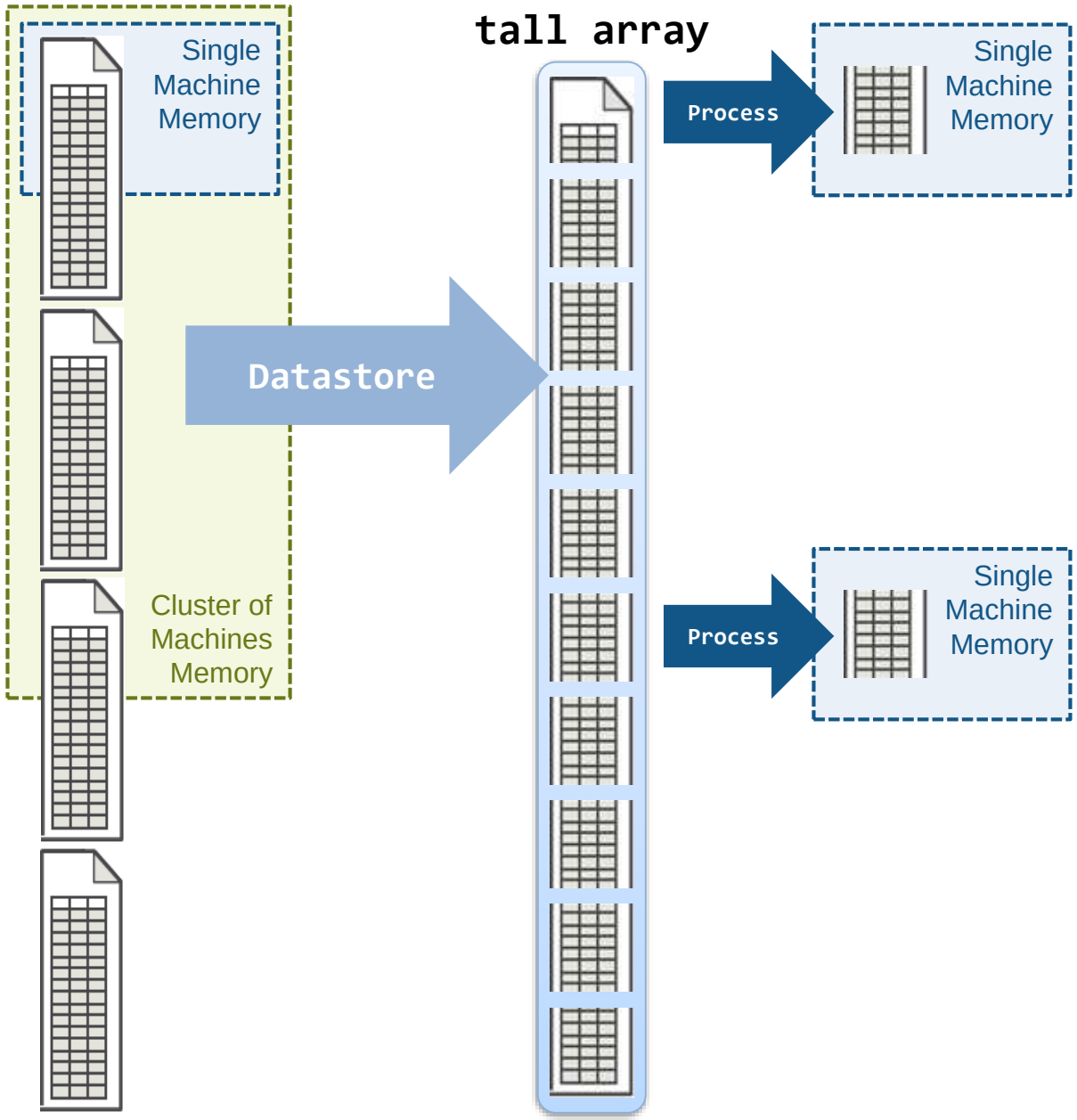
- Create tall table from datastore

```
ds = datastore('*.csv')
tt = tall(ds)
```



Tall Arrays

- With Parallel Computing Toolbox, process several pieces at once

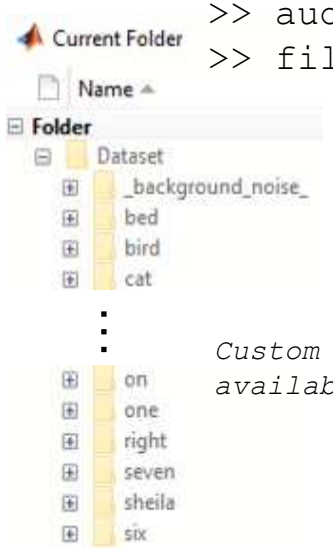


How do I load and access large amounts of data?

Datastores

Loads image/signal data into memory as and when needed

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



Custom Datastores also available

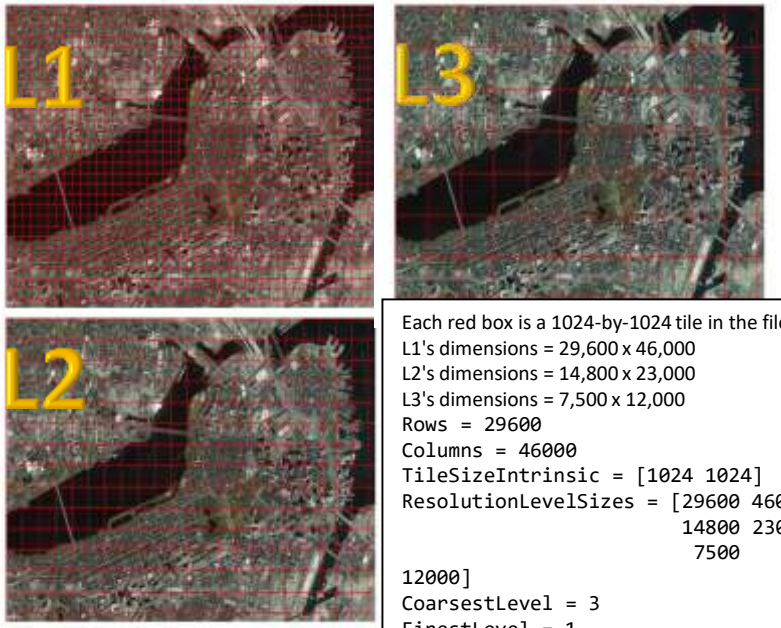
Tall Arrays

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

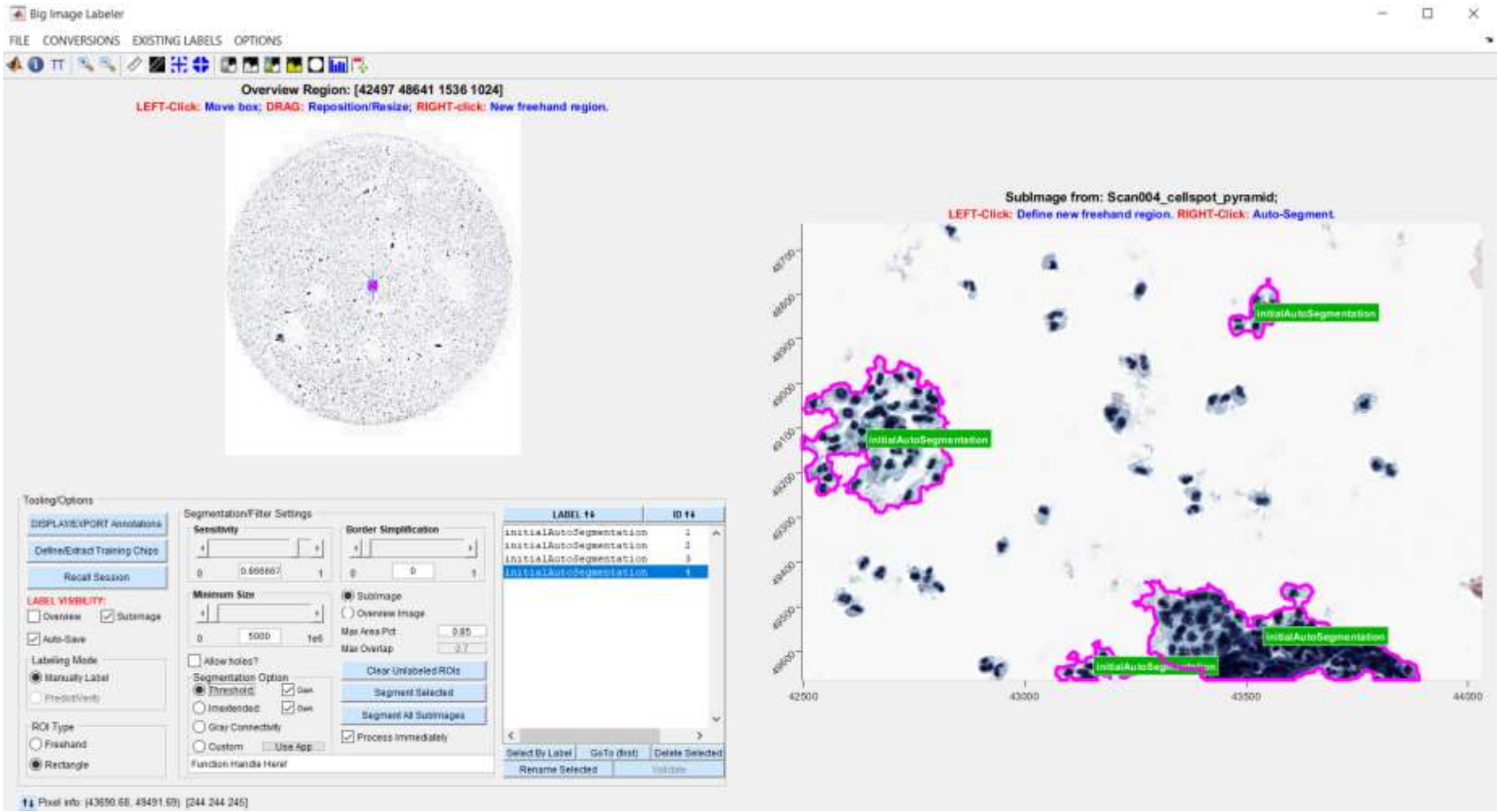
```
Rows = 29600
Columns = 46000
TileSizeIntrinsic = [1024 1024]
ResolutionLevelSizes = [29600 46000
                        14800 23000
                         7500
12000]
CoarsestLevel = 3
FinestLevel = 1
PixelSpacings = [1 1; 2 2; 3.947
3.833]
```


35

Big Image Labeler

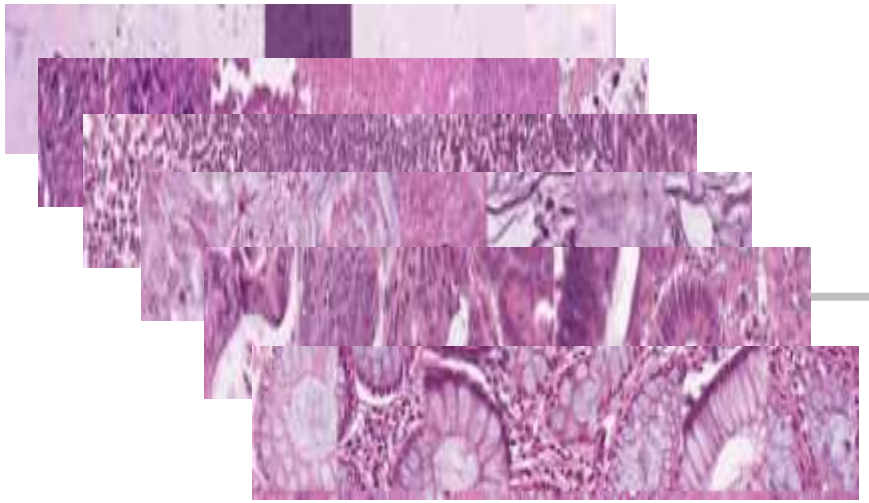
Image Labeler
+ Video labeler

Big-Image
Labeler



36

Colorectal Cancer Histology using Deep learning



Transfer learning

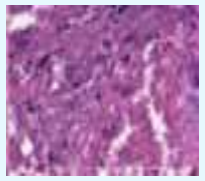
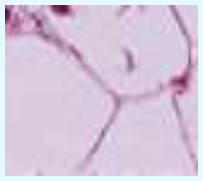
AlexNet
PRETRAINED MODEL


Ice cream


Teapot


Goose

Custom Network


약어	
ADI	지방조직
BACK	배경
DEB	조직 파편
LYM	림프구
MUC	점액
MUS	근육
NORM	정상점막
STR	기공
TUM	종양상피

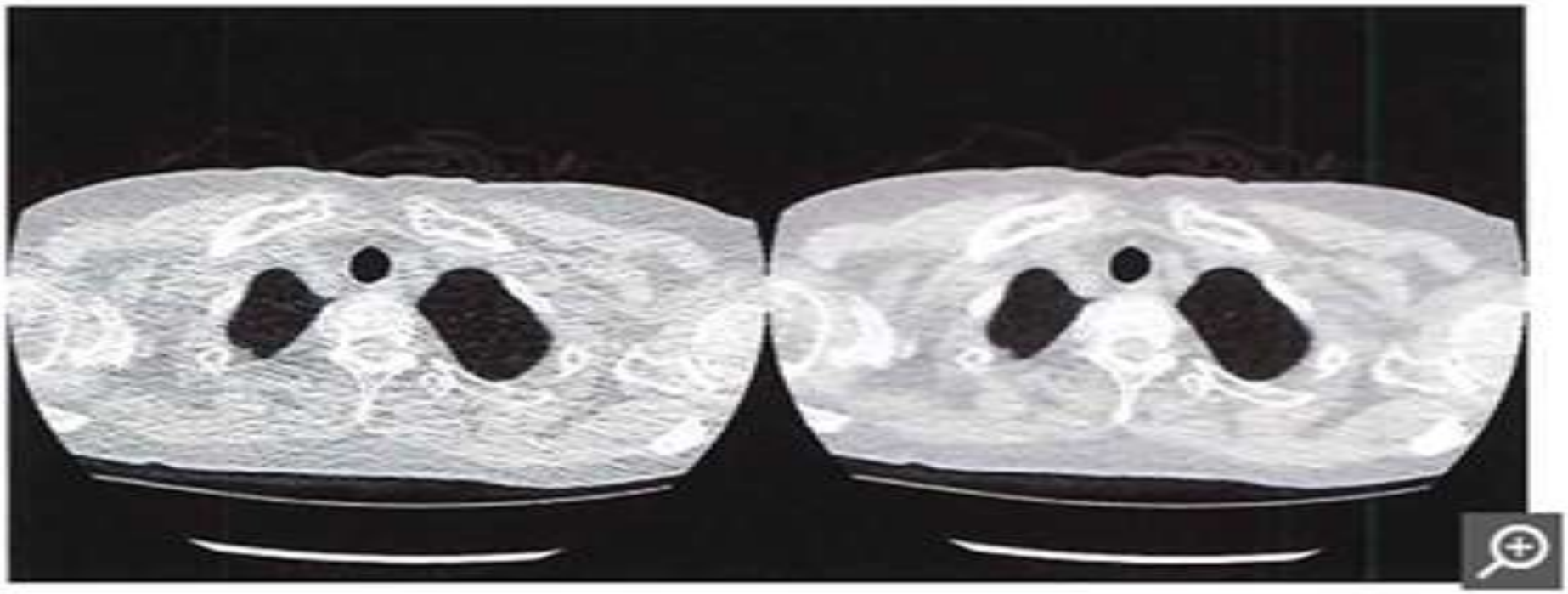
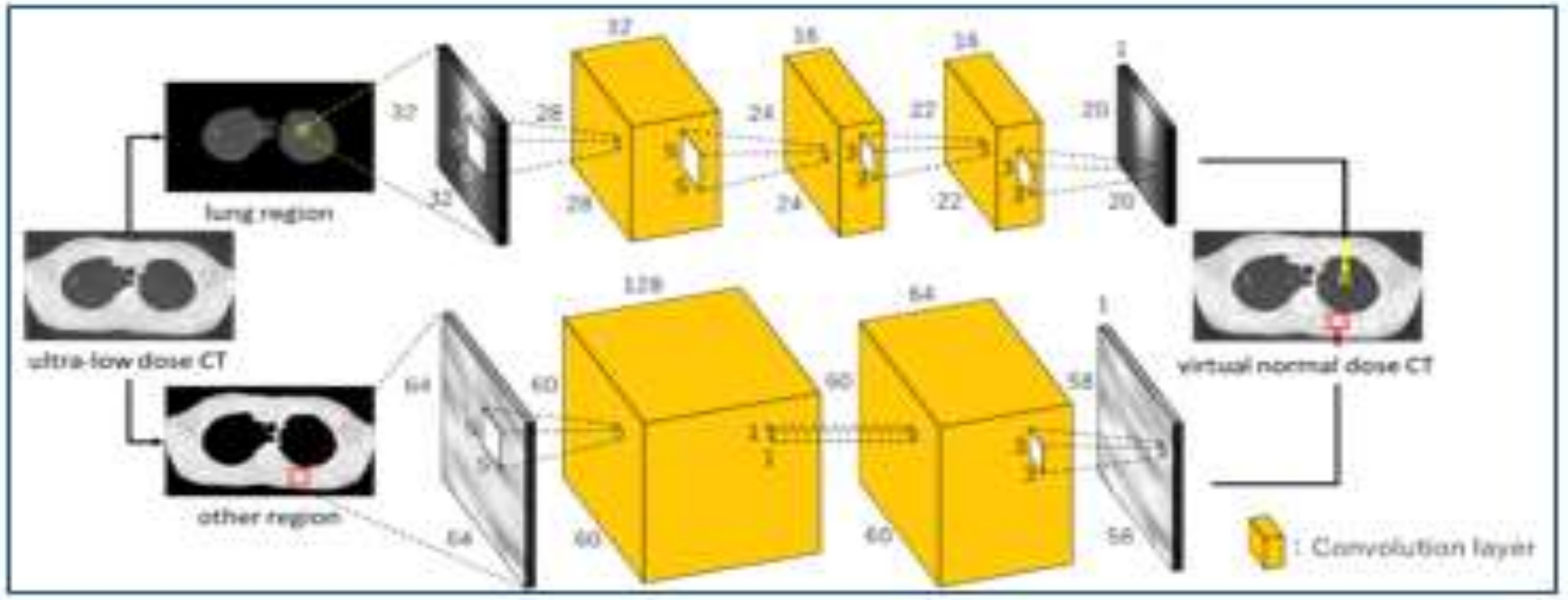


Figure 1. Comparing the image quality of ultra-low-dose CT (left) with a traditional CT (right).

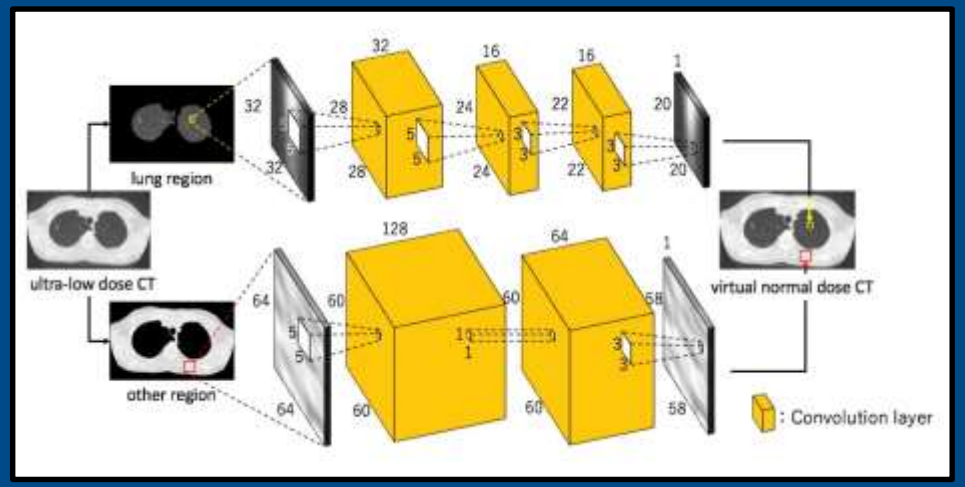
Ritsumeikan Researchers Use Deep Learning to Reduce Radiation Exposure Risk in CT Imaging



Convolutional neural networks (CNNs) trained on lung and non-lung areas of an ultra-low dose CT scan.

Ritsumeikan University

Using Deep Learning to Reduce Radiation Exposure Risk in CT Imaging



CNNs trained on lung and non-lung areas of ultra-low dose CT

Generate high-resolution computed tomography scans from ultra-low dose CT

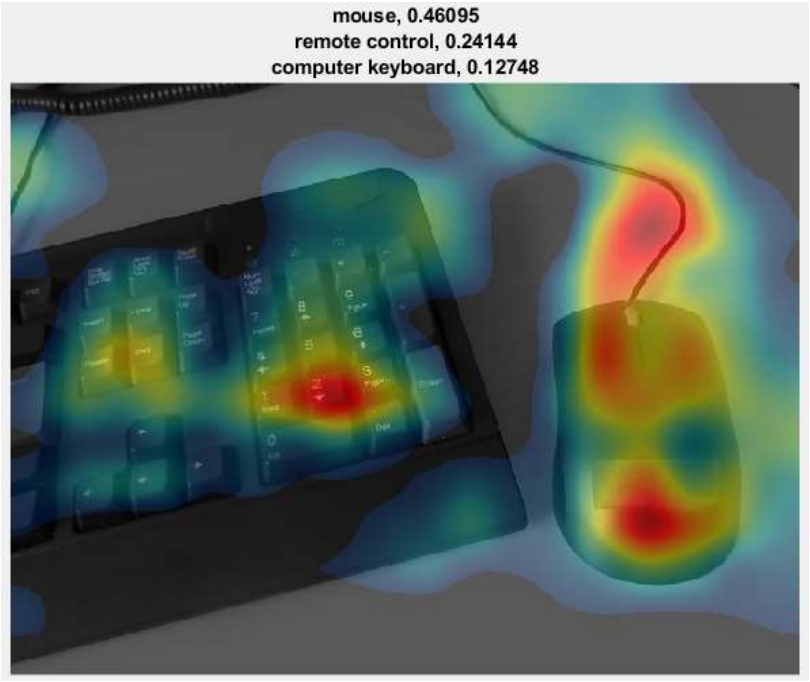
- Better diagnostic accuracy while reducing radiation exposure

- **MATLAB use in project:**
  - Train CNNs for lung and non-lung images
  - GPU acceleration if training process using multiple GPU

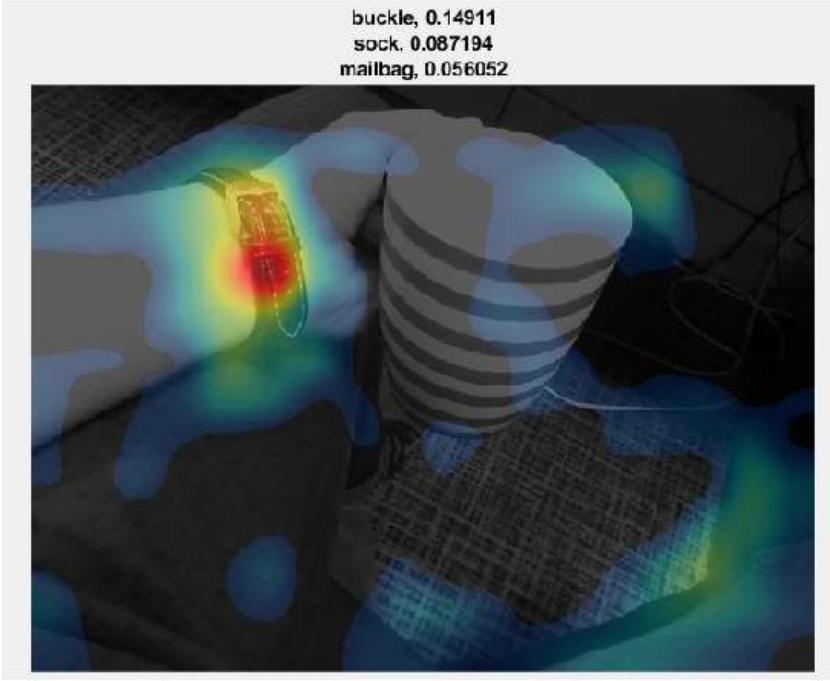
Plans in place to deploy system to clinical setting

Link to article

Class Activation Mapping to Investigate Network Predictions



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

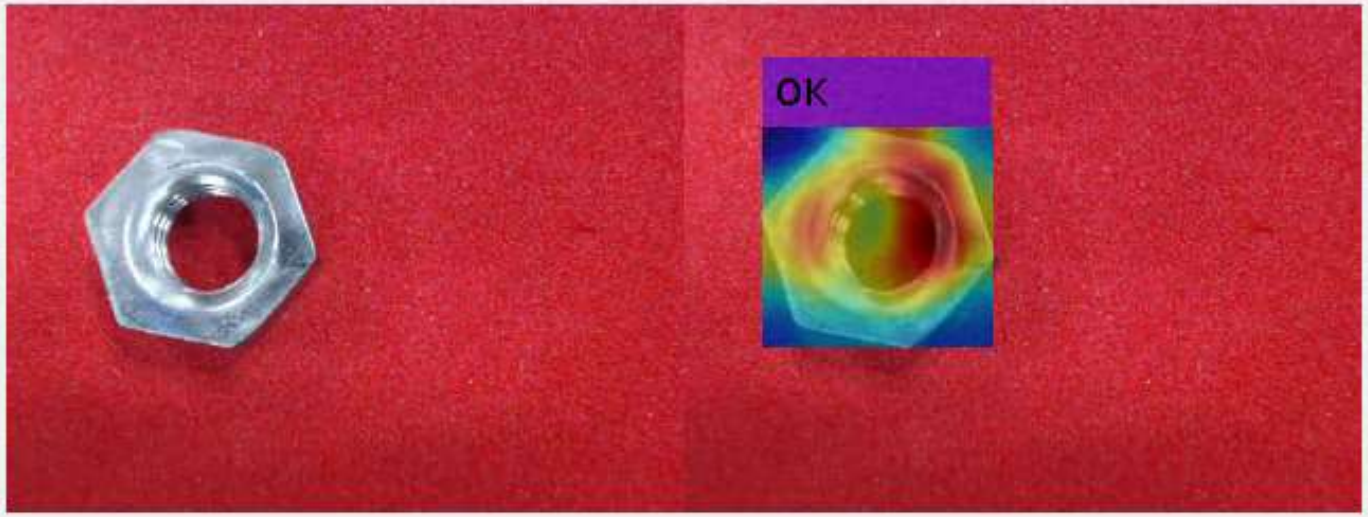


Incorrectly classified “coffee mug” as “buckle” due to the watch

41

Apply the CAM technique to industrial shipping inspection

Video Classification and CAM



OK→ watch a whole nut
NG→ watch at broken point

This network should makes a correct decision

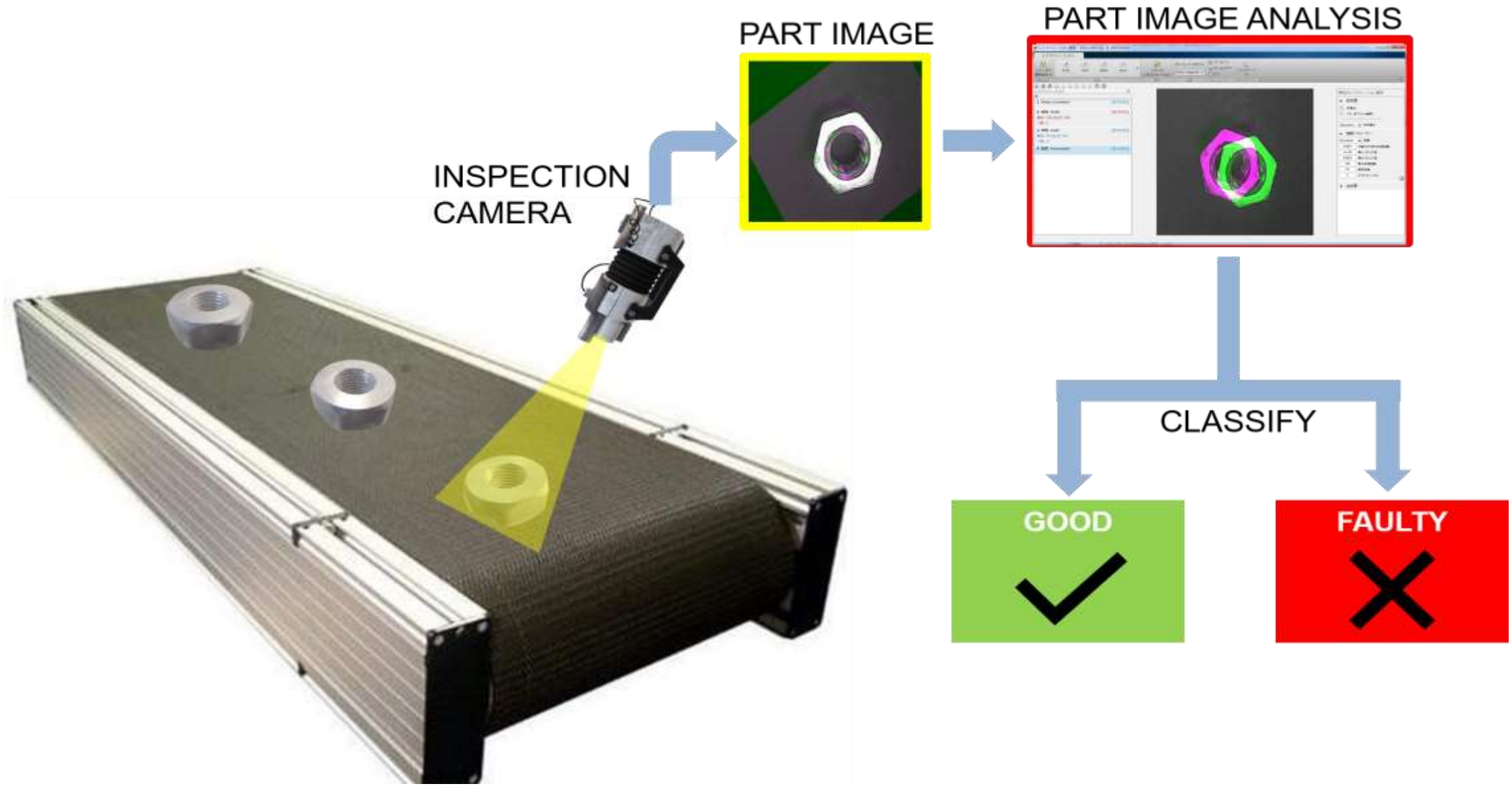
Musashi Seimitsu Industry Co.,Ltd.

Detect Abnormalities in Automotive Parts

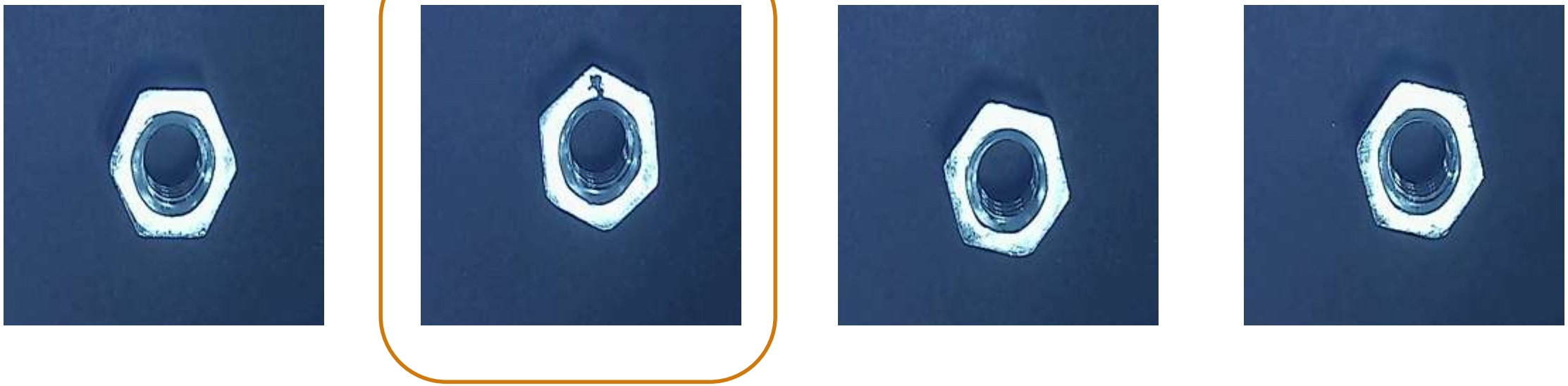
Automated visual inspection of 1.3 million bevel gear per month

MATLAB use in project:

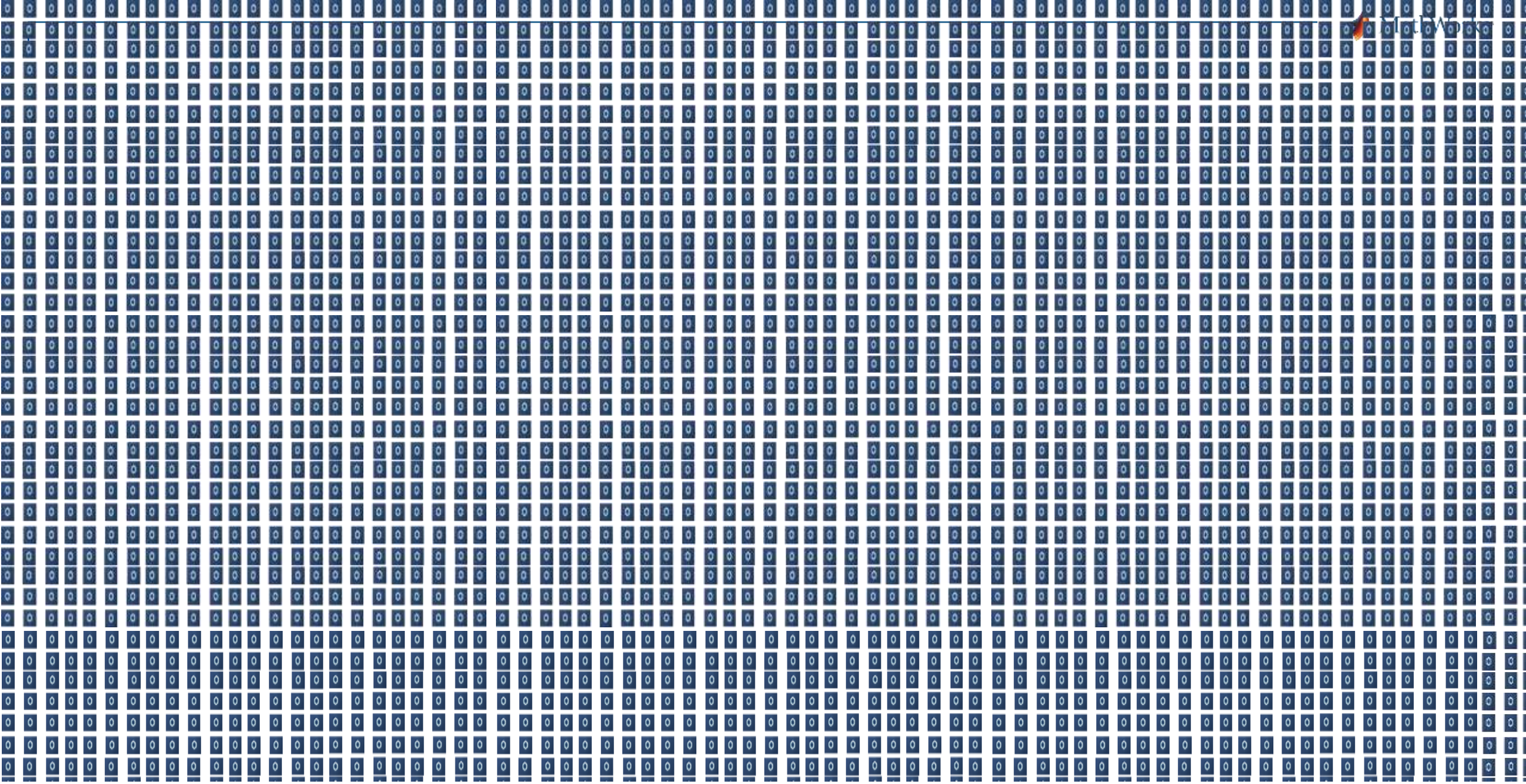
- Preprocessing of captured images
- Image annotation for training
- Deep learning based analysis
  - Various transfer learning methods (Combinations of CNN models, Classifiers)
  - Estimation of defect area using Class Activation Map (CAM)
  - Abnormality/defect classification
- Deployment to NVIDIA Jetson using GPU Coder


PART IMAGE
PART IMAGE ANALYSIS
INSPECTION
CAMERA
CLASSIFY
GOOD
FAULTY

Can you find the defective hex nut?

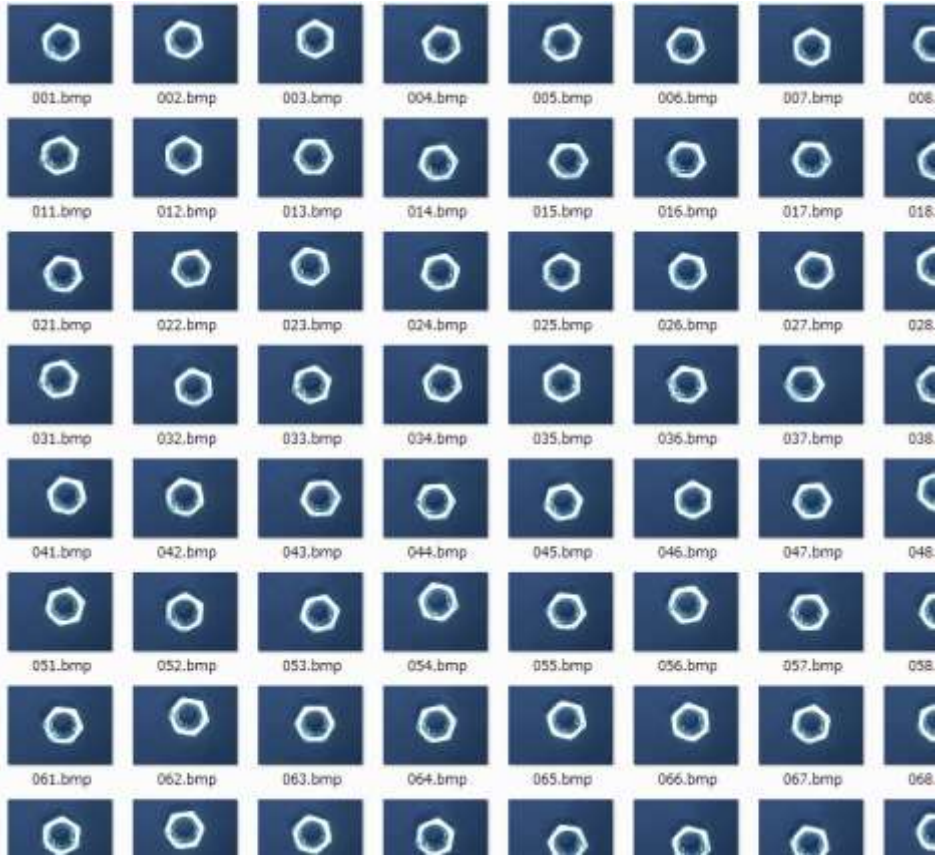


45

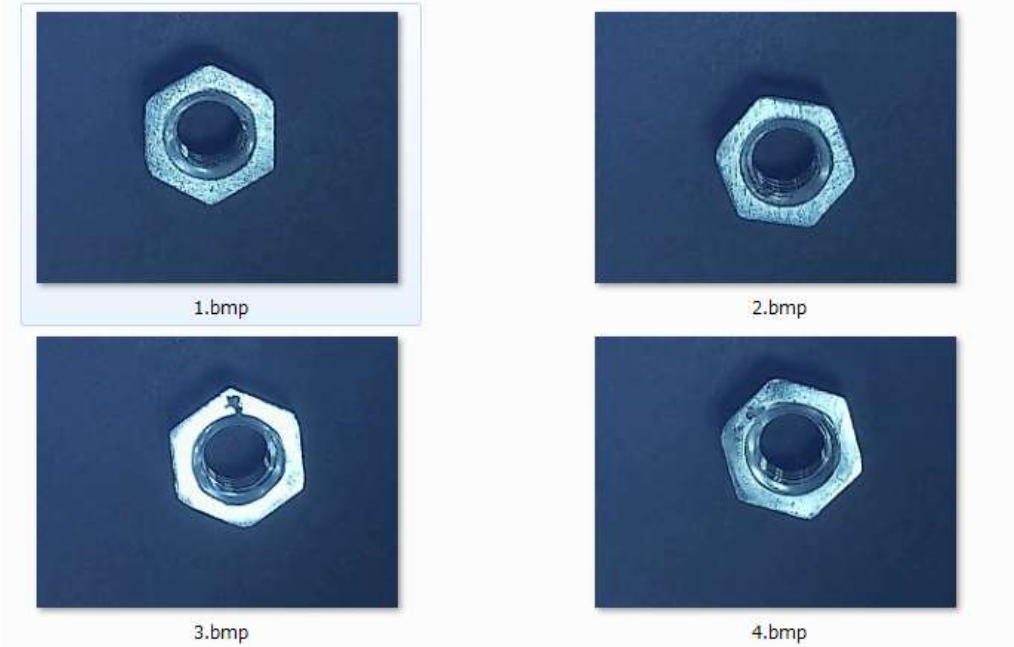


Finding Defective Hex Nuts

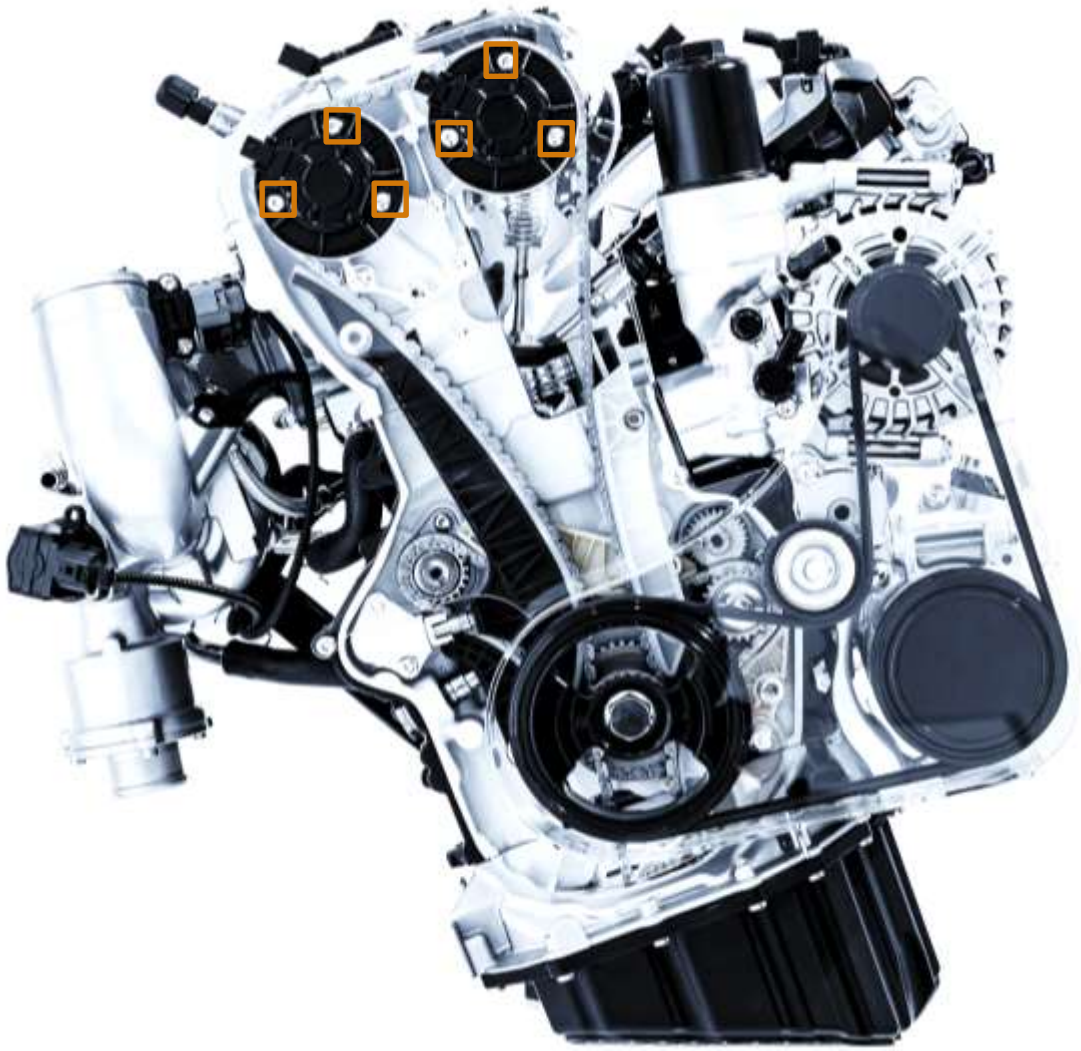
Good



Defective

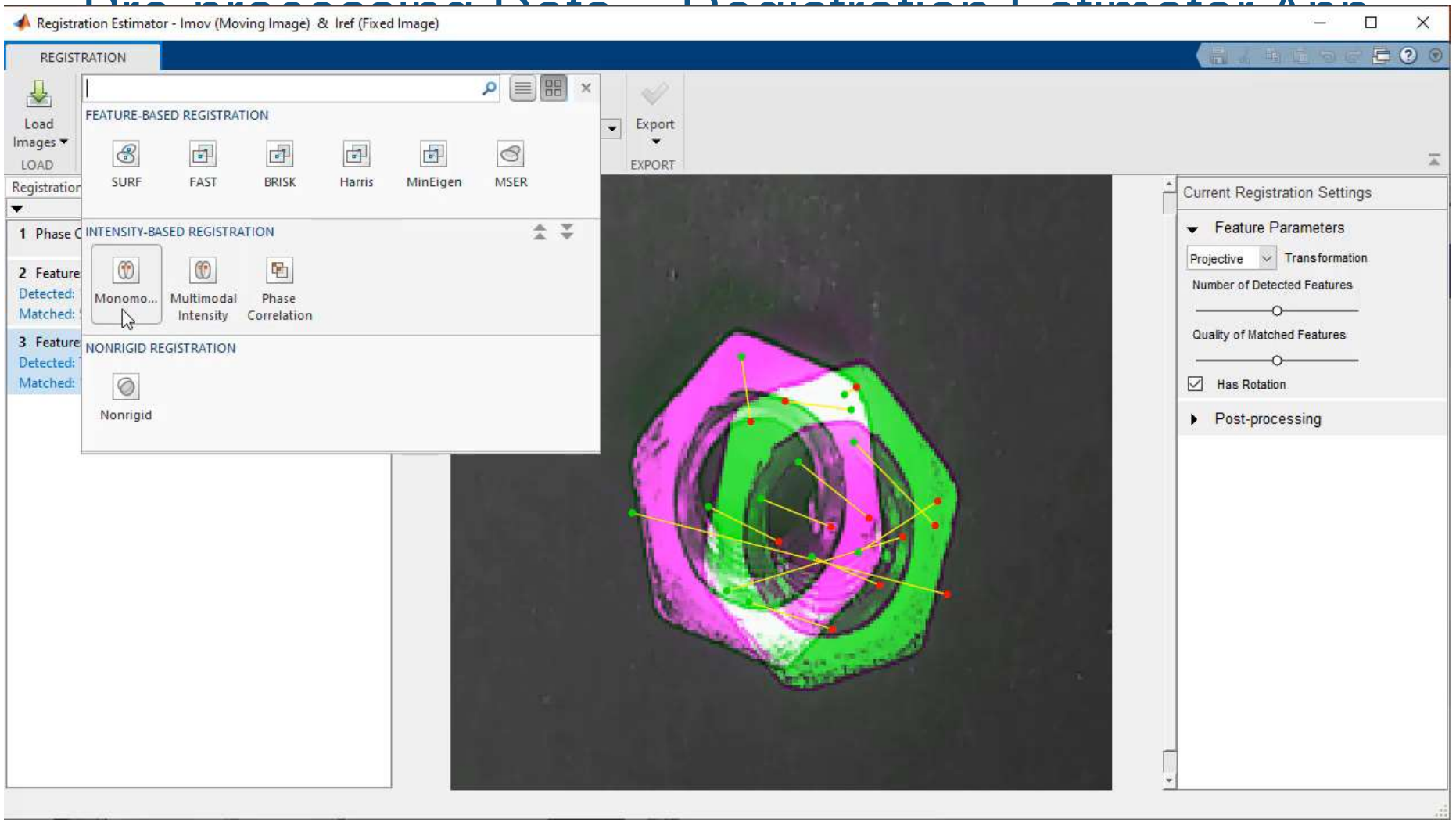


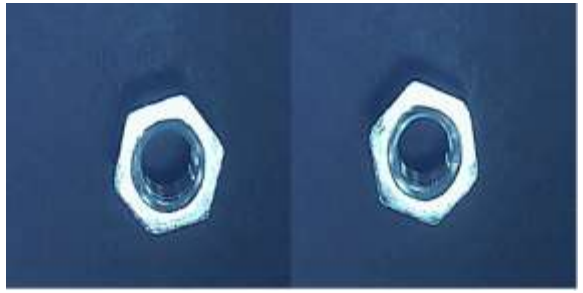
Detecting Parts

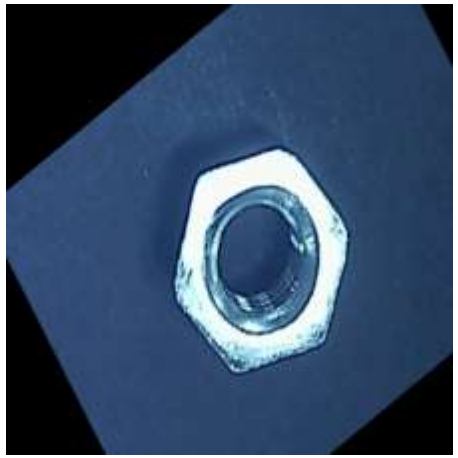


48

Pre-processing Data – Registration Estimator App

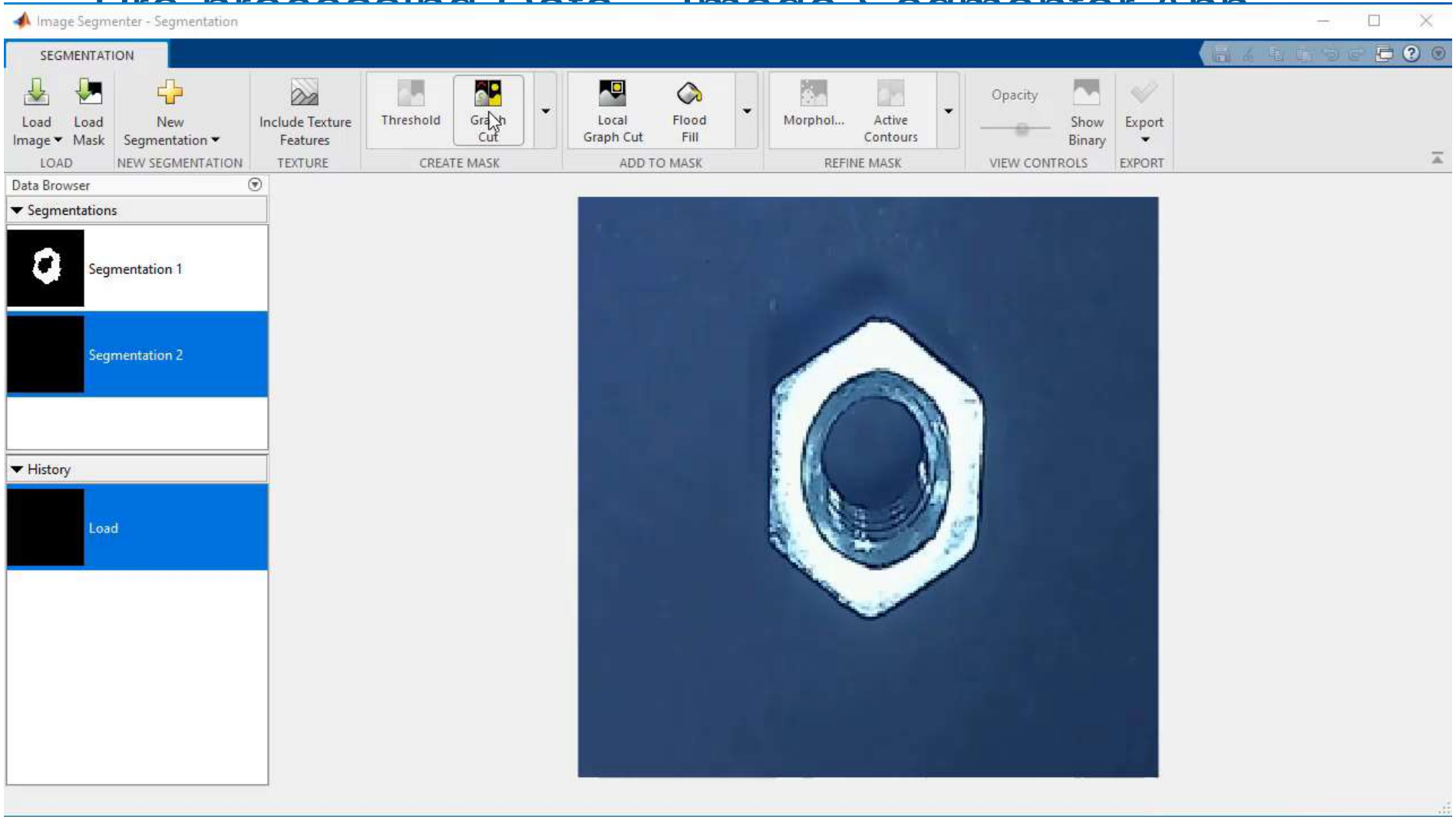




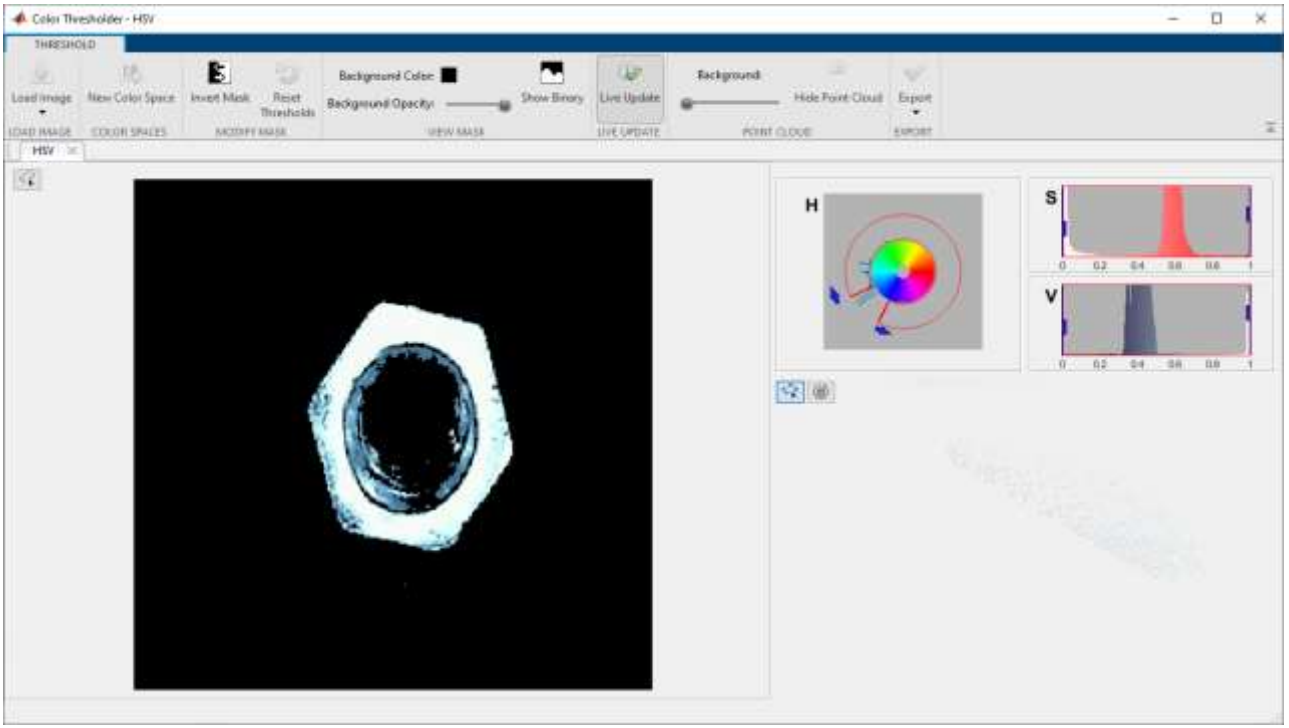


49

Pre-processing Data – Image Segmenter App



Preprocessing Data - Apps



Color Thresholder

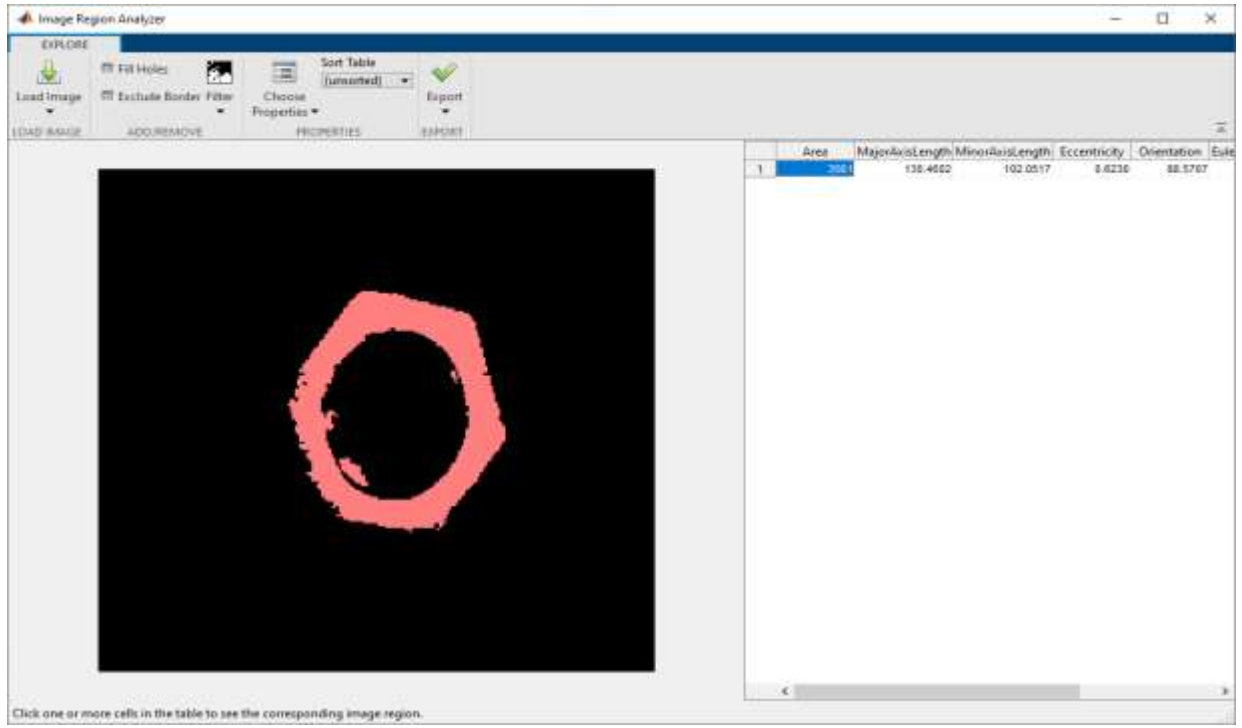
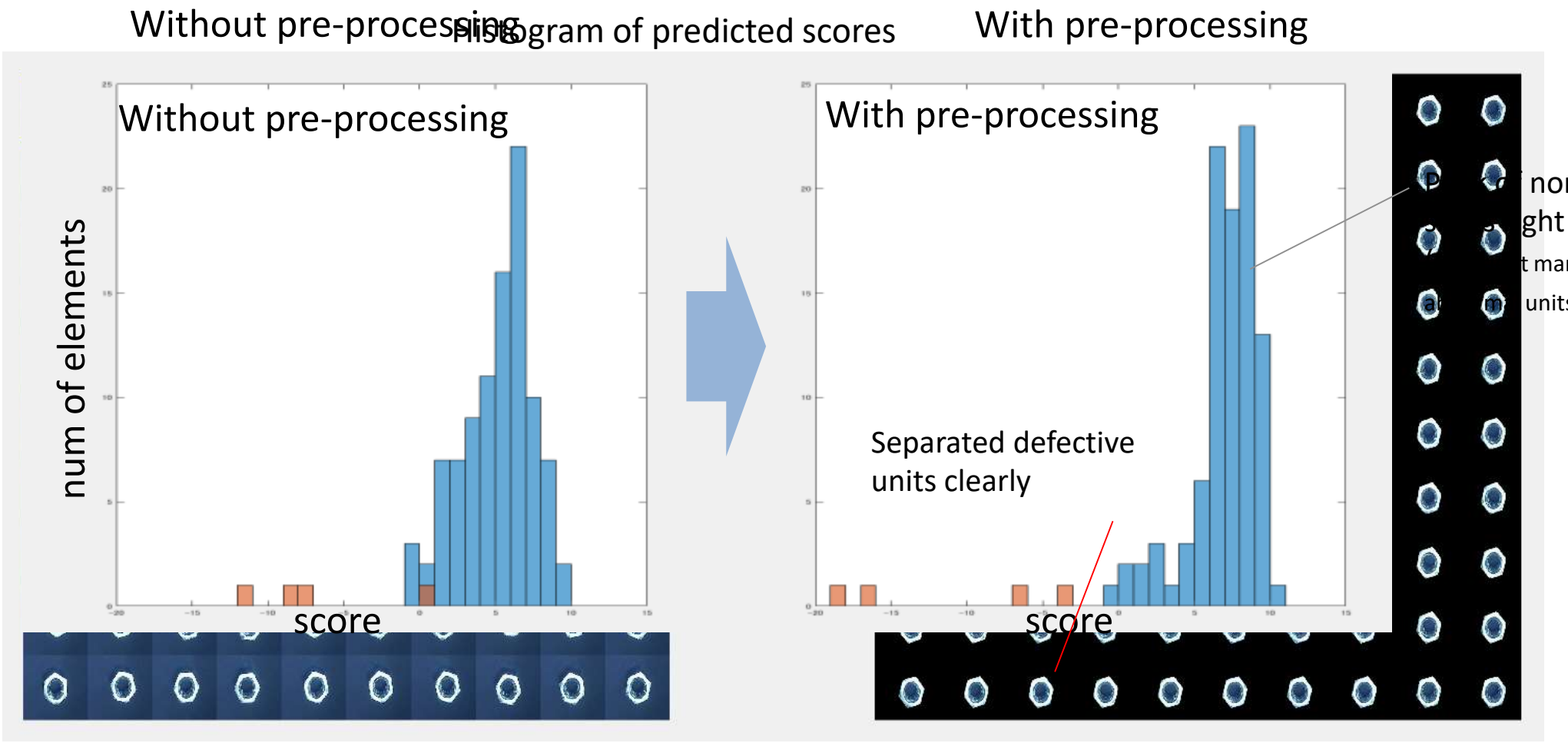


Image Region Analyzer

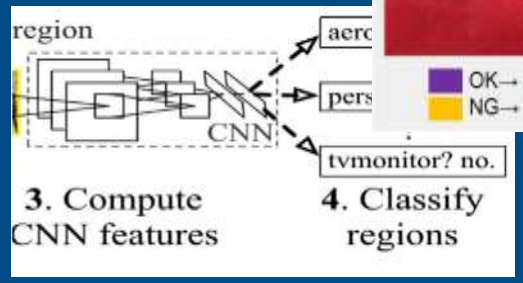
51

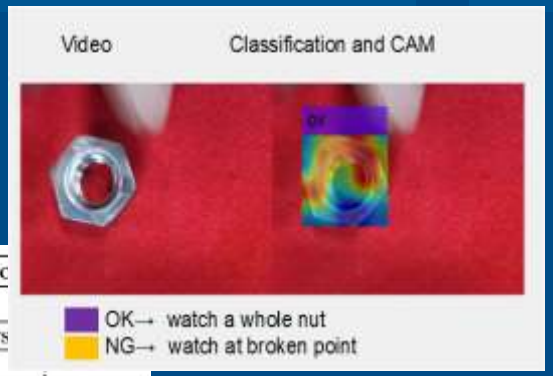
Defect detection using AlexNet: Results with preprocessing



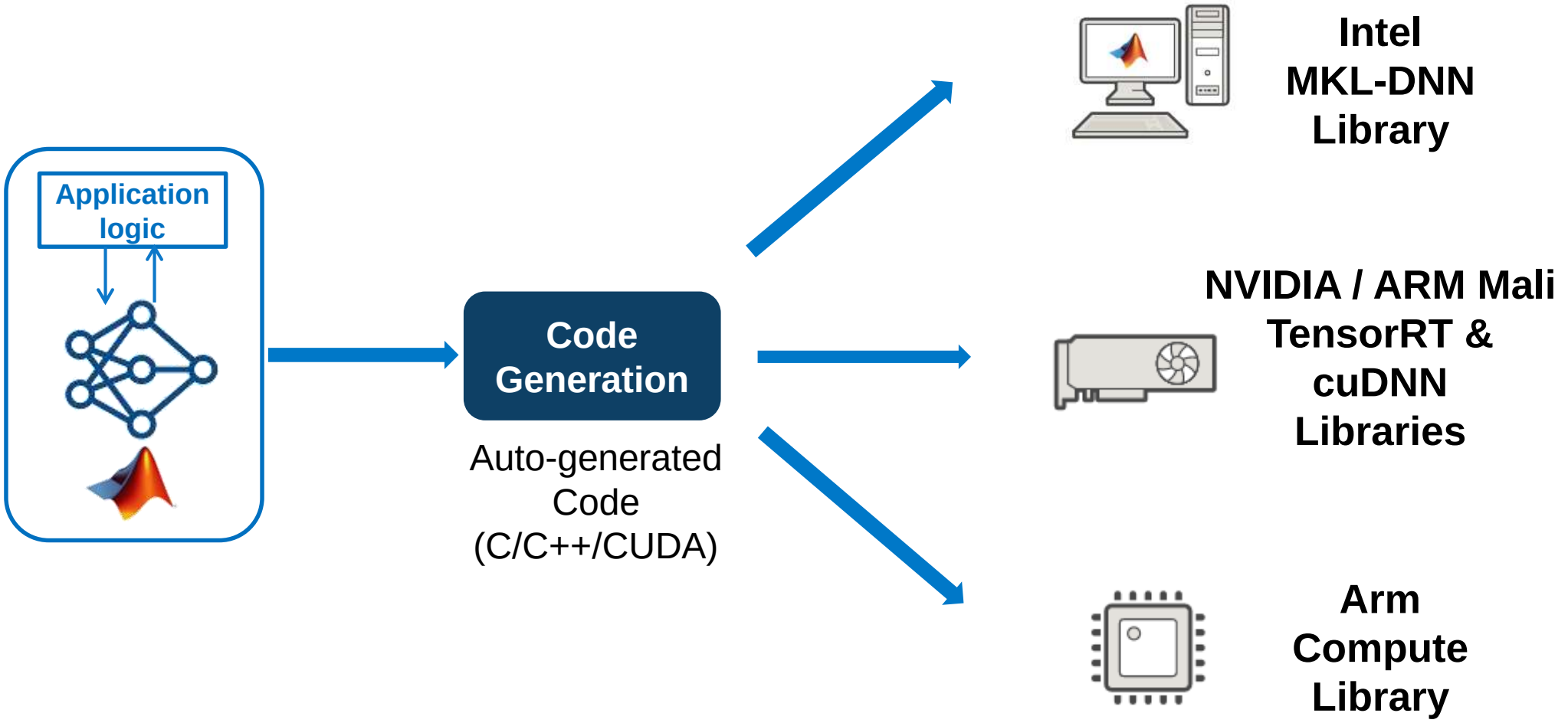
End to end AI workflow

Access Data	Analyze Data	Develop	Deploy
Sensors	Data exploration	AI model	Desktop apps
Files	Preprocessing	Algorithm development	Enterprise systems
Databases	Domain-specific algorithms	Modeling & simulation	Embedded devices





Deploy your deep learning application on multiple hardware platforms



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Musashi Seimitsu Industry Co.,Ltd.

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  - Estimation of defect area using Class Activation Map (CAM)
  - Abnormality/defect classification
- Deployment to NVIDIA Jetson using GPU Coder

Kansai Electric Power Uses Deep Learning to Assess Pipe Weld Damage

Kenichi Kizu, The Kansai Electric Power Co. Inc.

Kansai Electric Power applied deep learning to assess creep damage on high chromium steel pipe welds. Evaluating damage to internal pipe is difficult using conventional nondestructive inspection of the outer surface, so Kansai engineers attempted to use images from strain distribution measurement on the outer surface.

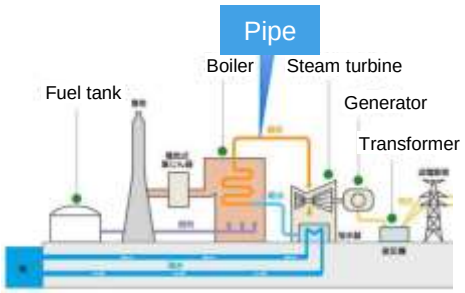
In the research, they used the strain distribution images of the test body and extracted features using MATLAB® and AlexNet, a deep learning network. This approach confirmed that the images can be classified into small damage and large damage using a support vector machine. In addition, they created a regression model to estimate the damage rate using the same network, and confirmed that the larger the damage rate, the better the accuracy.

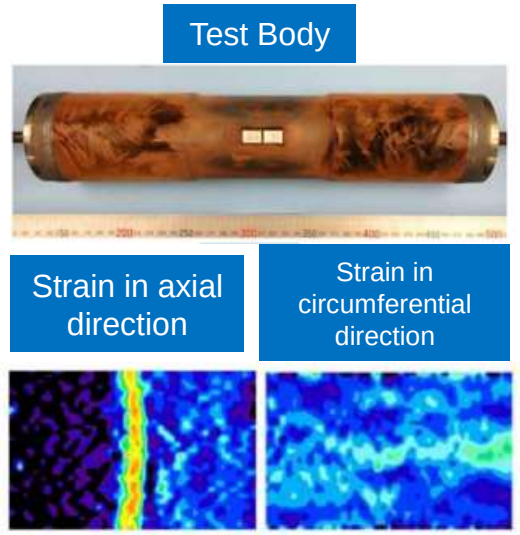
Kansai Electric Power intends to confirm the applicability of this method to actual machines and apply it to pipes made of various materials.

Advantages of using MATLAB

- Availability of sample code that enabled immediate use of transfer learning
- Easy-to-use pretrained networks
- Ability to combine with other machine learning methods by using toolboxes
- Availability of seminars, rich documentation, and other learning resources

> “Deep learning development was easy using MATLAB. Even though I was not an expert, I could learn enough from **seminars** and **rich documentation**.”

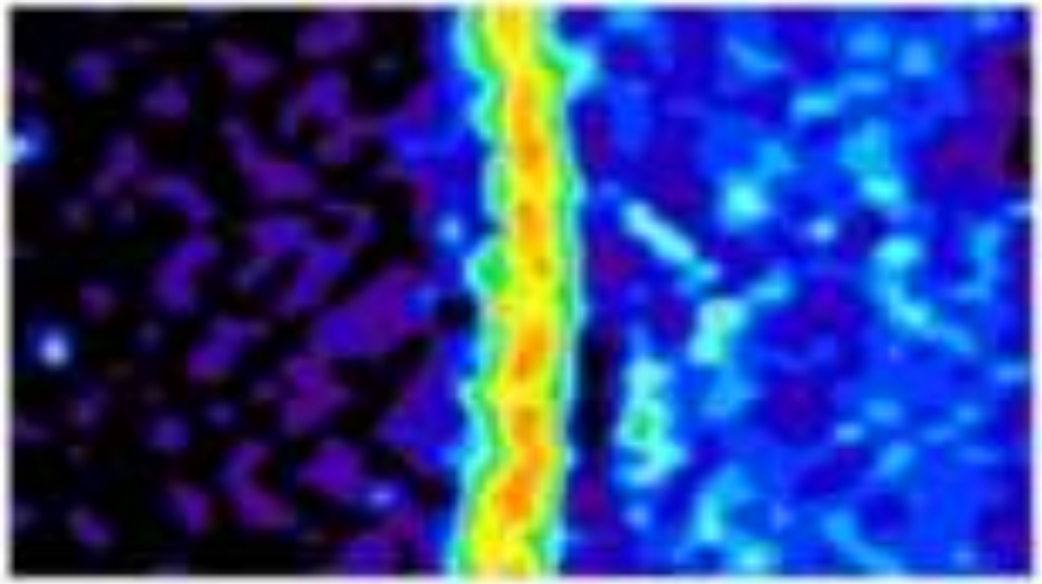




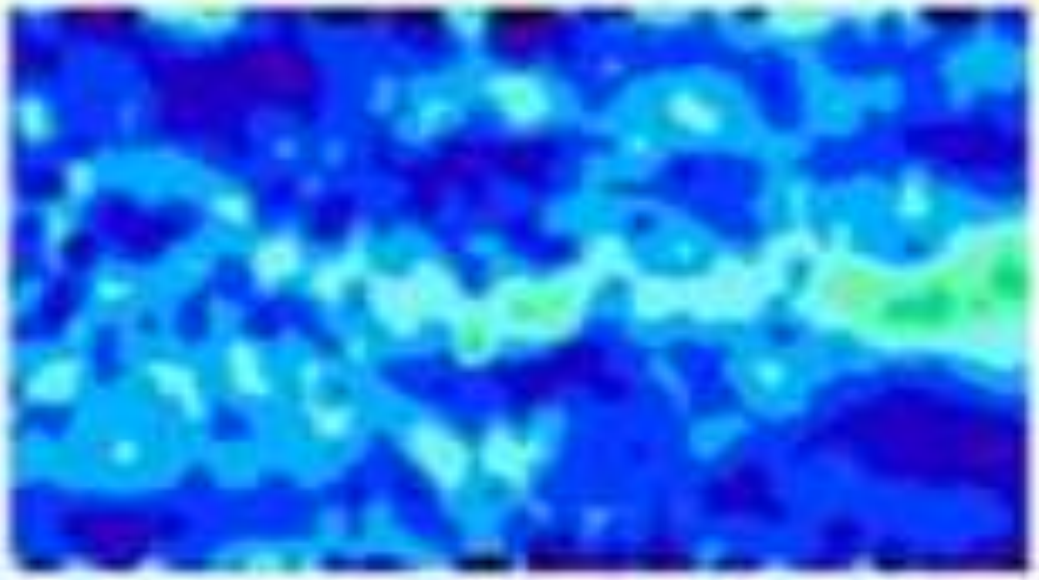
Learn how to extract image features using pretrained network

Test Body

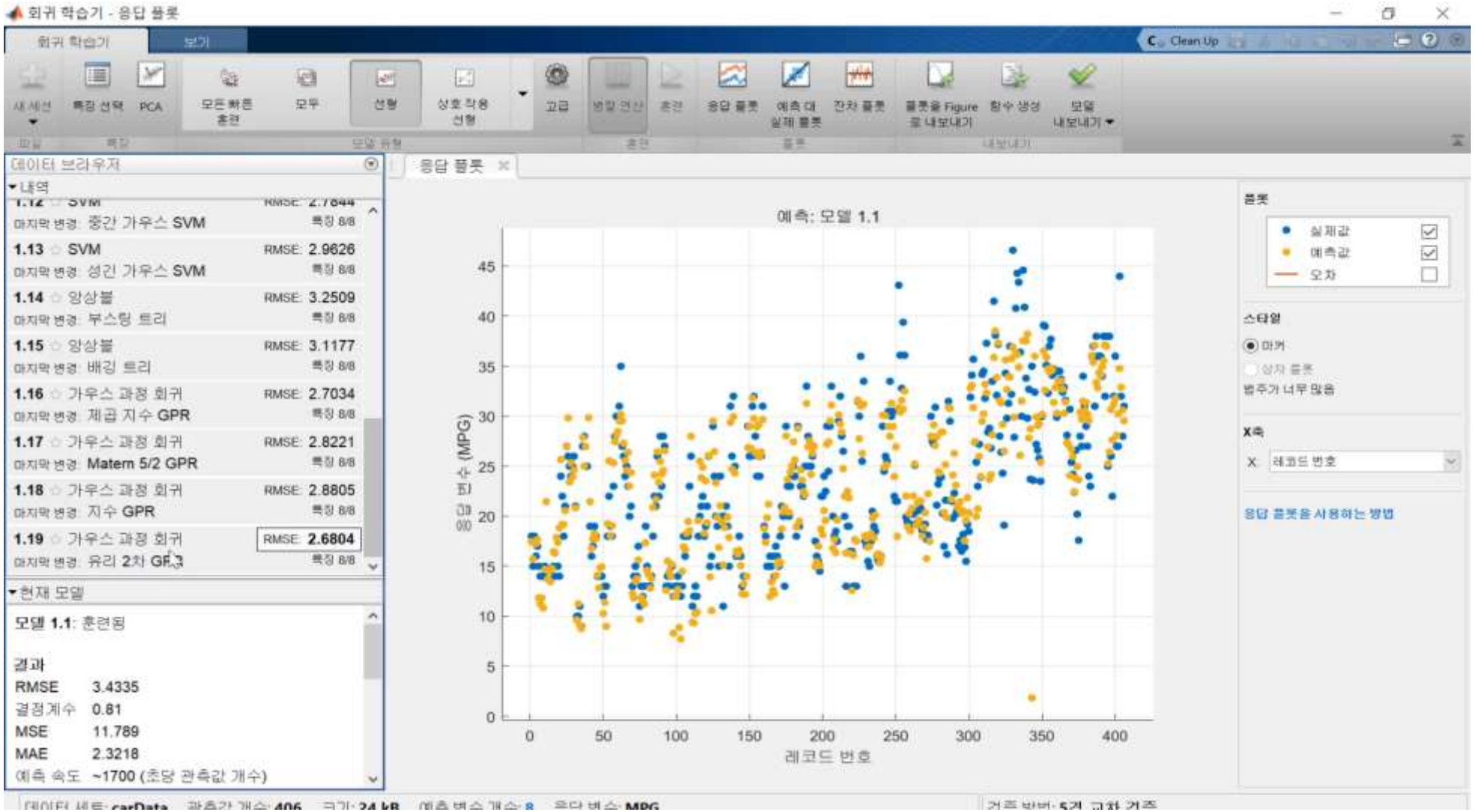
Strain in axial direction



Strain in circumferential direction



Quick Demo: Regression Learner App



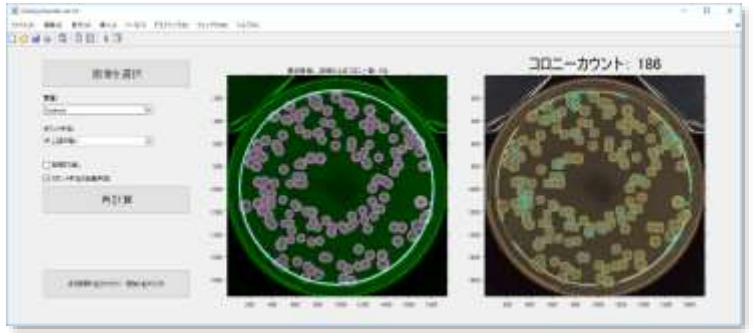
Deep Learning to Accelerate Microbial Testing in Cosmetic Product Development

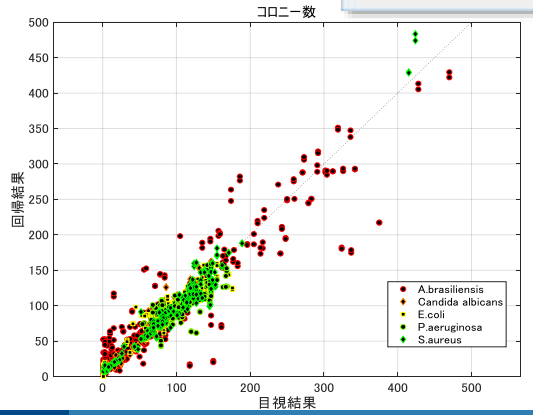
Koki Yoshida, Ki Sai, and Yoshimasa Nakatani, Shiseido Global Innovation Center

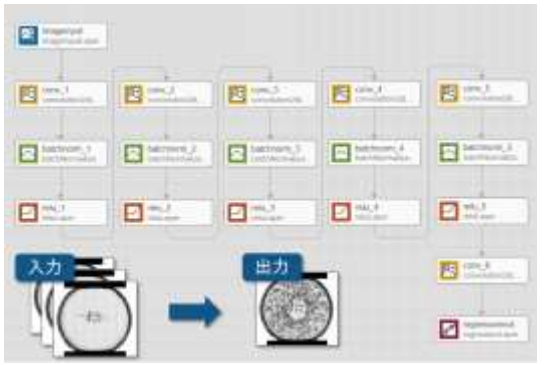
> “Using MATLAB in the microbial evaluation required for cosmetic development, we obtained good results that led to faster testing.”

To ensure cosmetic products are safe and secure, they must contain the optimum amount of preservatives to prevent both skin irritation and microbial contamination. A challenge test (preservation efficacy test) is performed to evaluate effectiveness of preservatives. Many types of bacteria, yeast, and mold are cultivated over a long period of time during the test.

Shiseido conducted research to speed up the test while maintaining accuracy by using AI to identify, count, and predict growth of microbes and to predict whether tests could be omitted. They used MATLAB® to predict whether the challenge test could be omitted by creating a machine learning model that predicts the decay curve of the fungus from the ingredients and the ratio to be blended, then used deep learning to predict the growth of the fungus. To improve the efficiency of the experiment, they created a custom user interface in MATLAB to ease the processes of identifying the bacterial species and counting the number of bacteria.



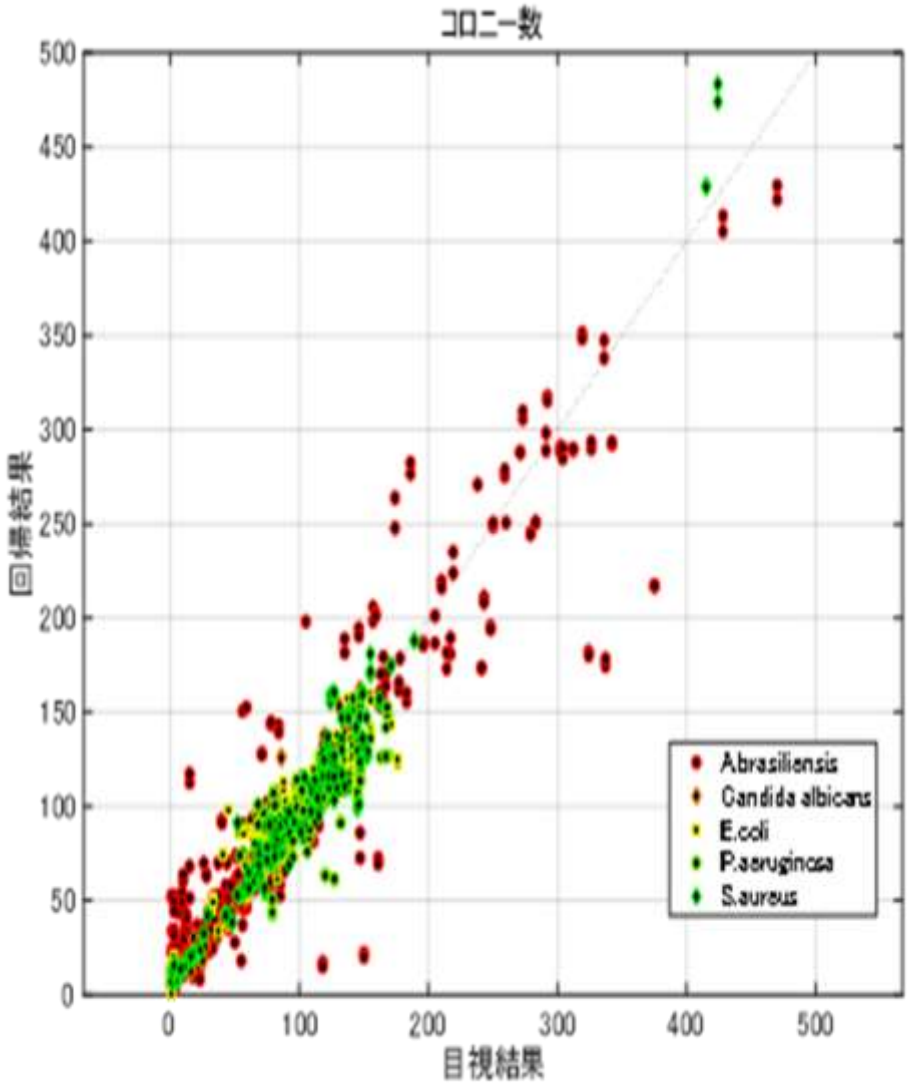


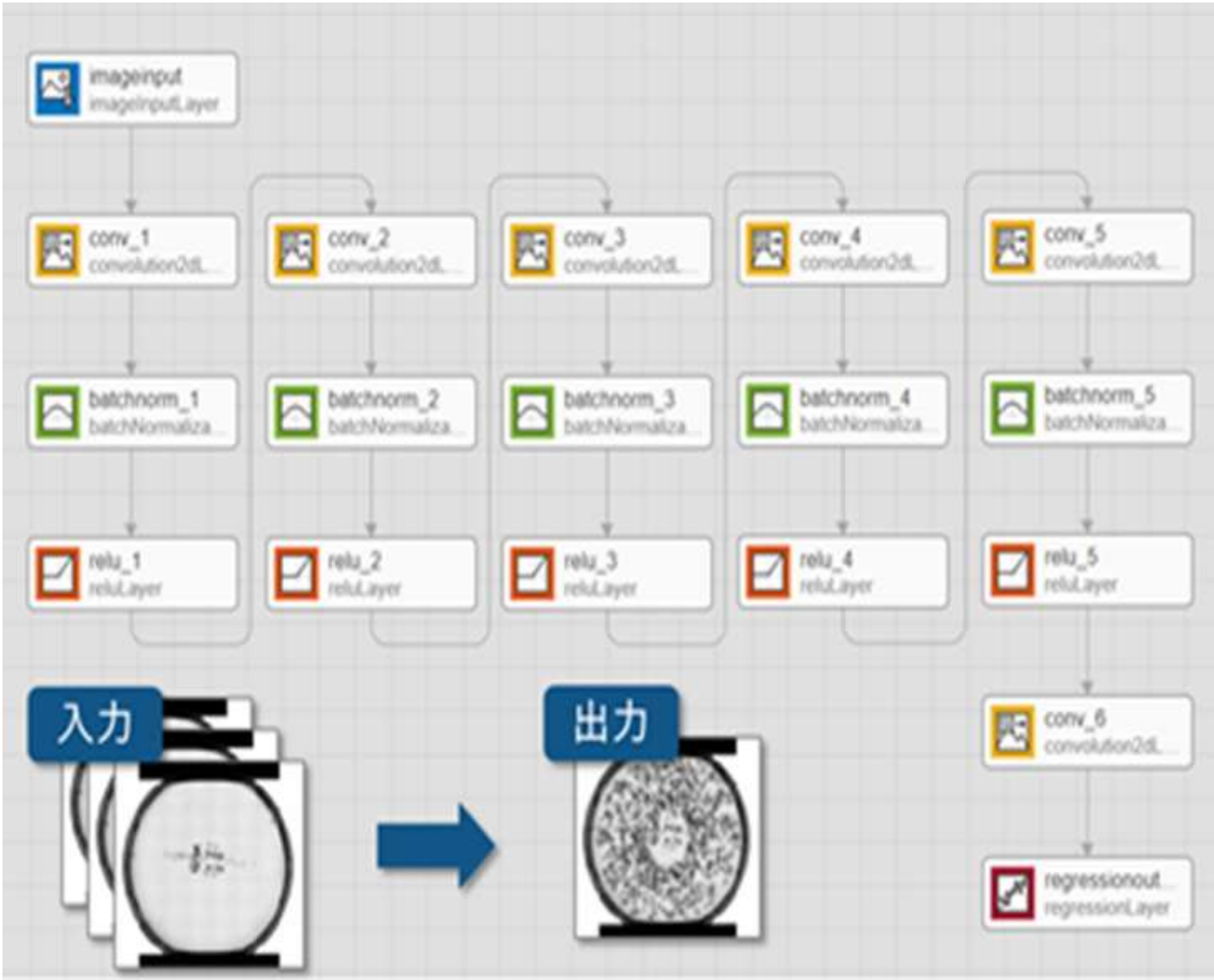


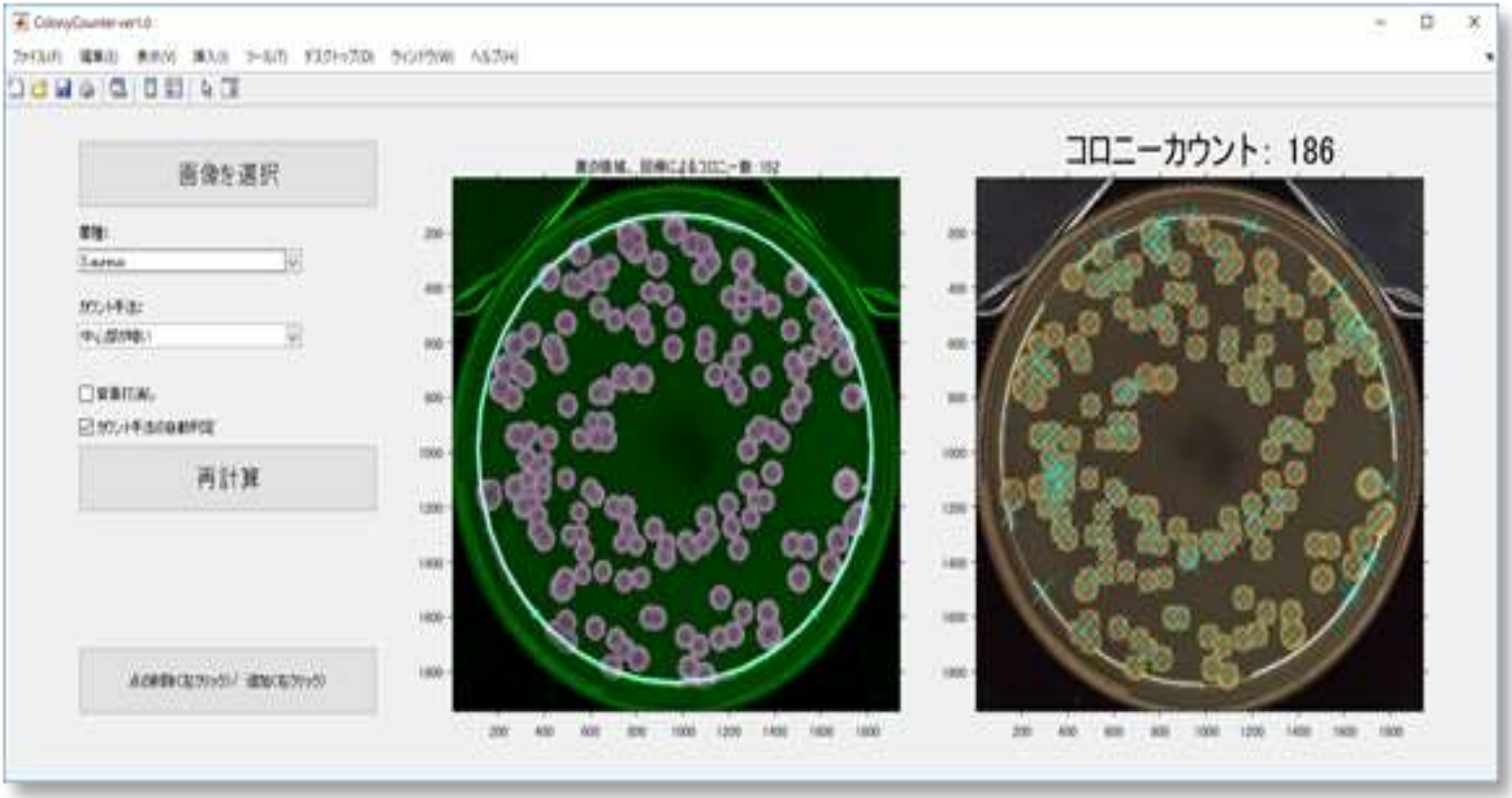
Advantages of using MATLAB:

- Custom network construction using Deep Network Designer
- Ease of performing “trial and error” during machine learning algorithm development
- Development of custom user interfaces using App Designer

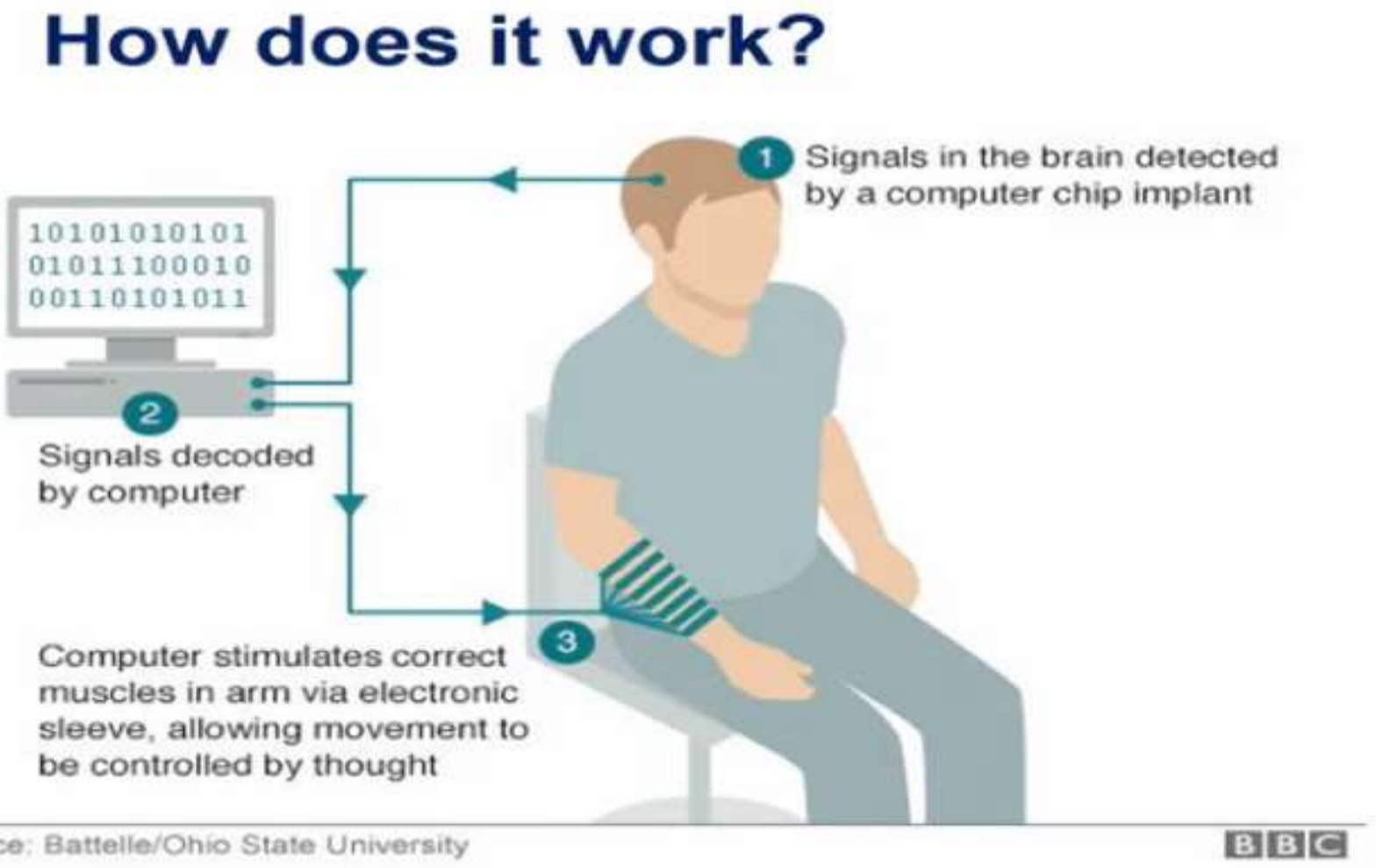
Explore MATLAB for deep learning

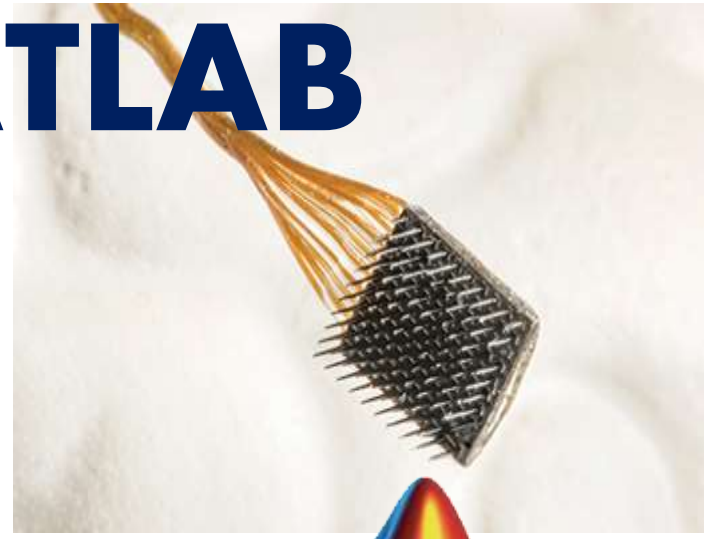

コロニー数
回帰結果
目視結果
0
50
100
150
200
250
300
350
400
450
500
0
100
200
300
400
500
Abrasiliensis
Candida albicans
E.coli
P.aeruginosa
S.aureus

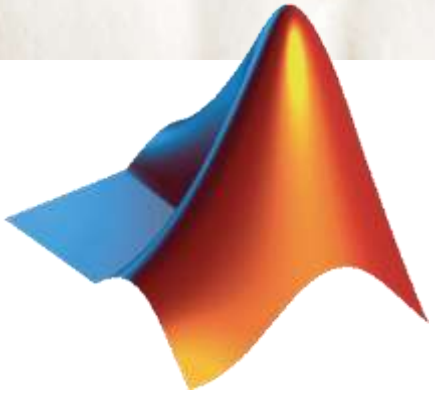

imageinput
imageInputLayer
conv_1
convolution2dL...
conv_2
convolution2dL...
conv_3
convolution2dL...
conv_4
convolution2dL...
conv_5
convolution2dL...
batchnorm_1
batchNormaliza...
batchnorm_2
batchNormaliza...
batchnorm_3
batchNormaliza...
batchnorm_4
batchNormaliza...
batchnorm_5
batchNormaliza...
relu_1
reluLayer
relu_2
reluLayer
relu_3
reluLayer
relu_4
reluLayer
relu_5
reluLayer
conv_6
convolution2dL...
regressionout...
regressionLayer
入力
出力


画像を選択
再計算
コロニーカウント: 186

Machine Learning with MATLAB

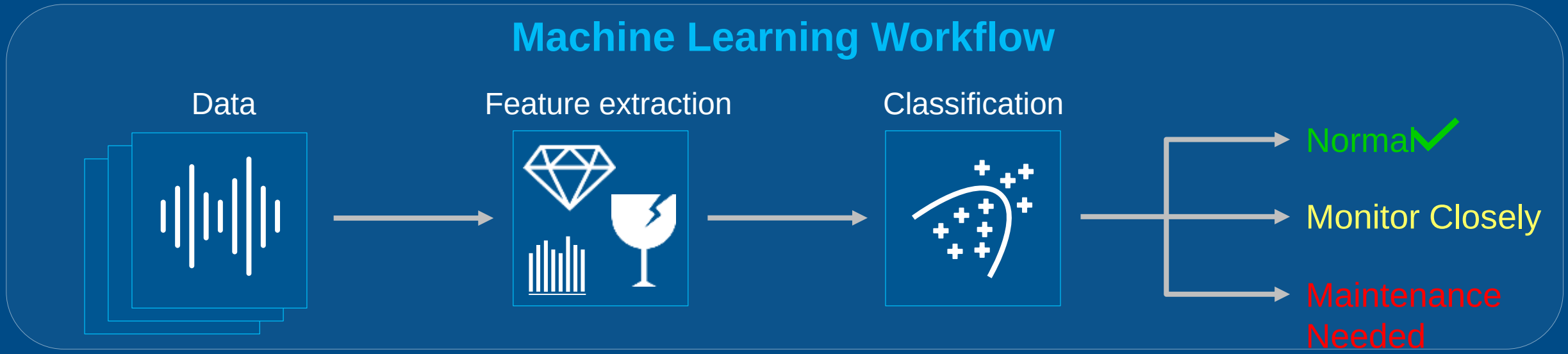


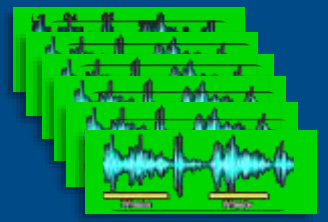


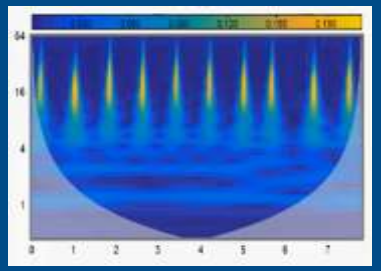


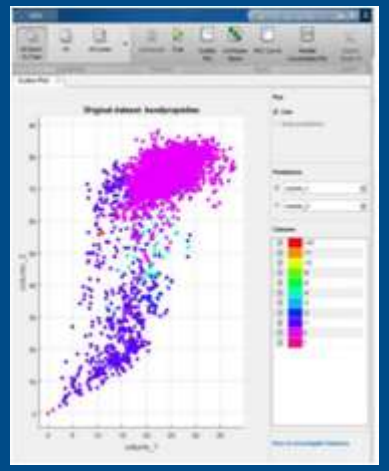
- MATLAB running in real-time at 10 Hz
- Wavelets for data reduction
- Machine learning for neural decoders and wrist control encoders

Machine learning Workflow

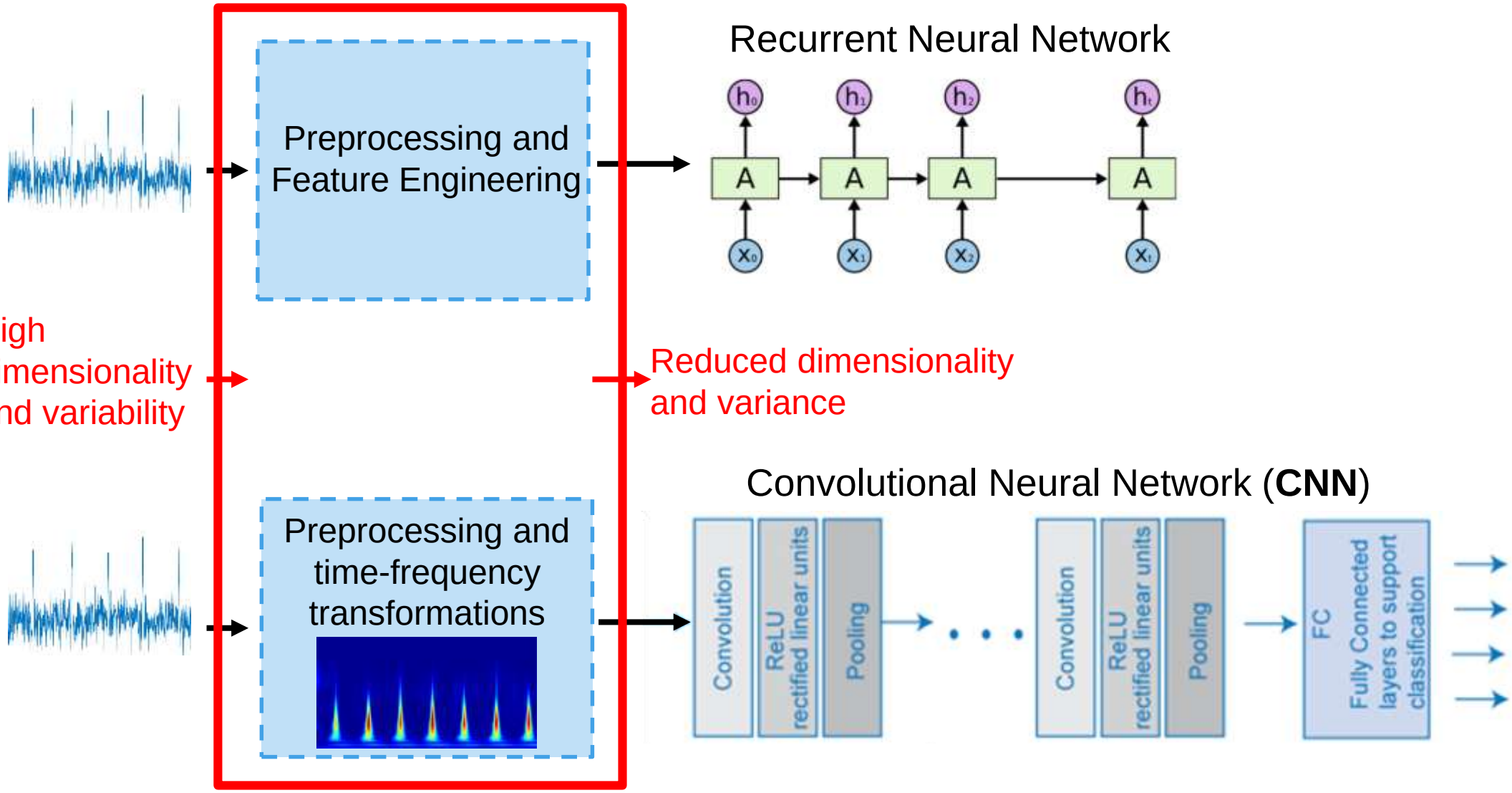




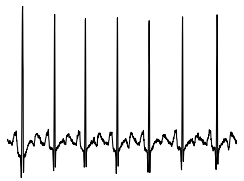




Your Model Is Only As Good As The Input Data

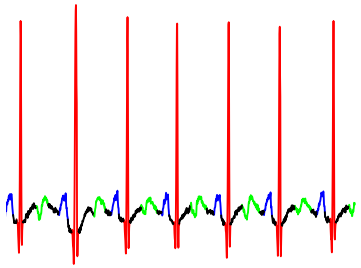


Signal Segmentation Using LSTM networks



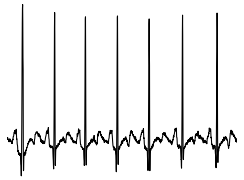
ECG

LSTM

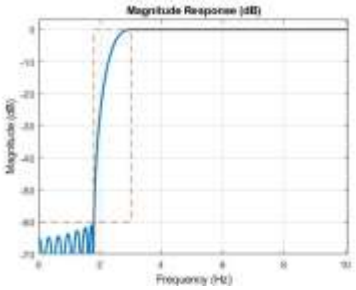


Labeled ECG

Accuracy

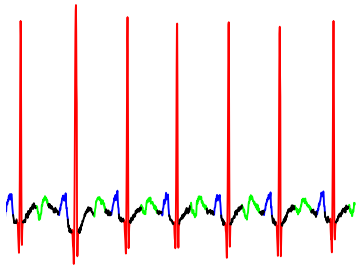


ECG

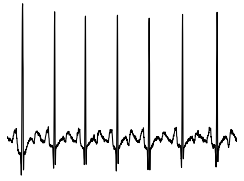


Filtering

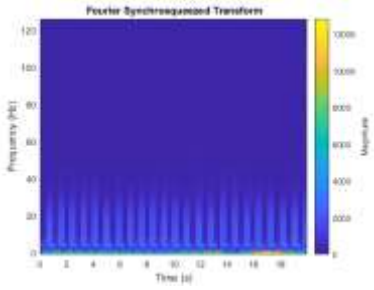
LSTM



Labeled ECG

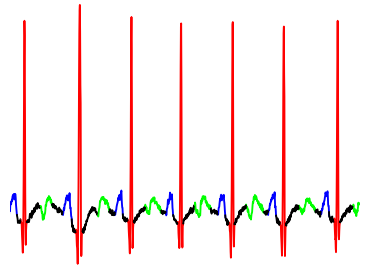


ECG



Fourier Synchrosqueezed Transform

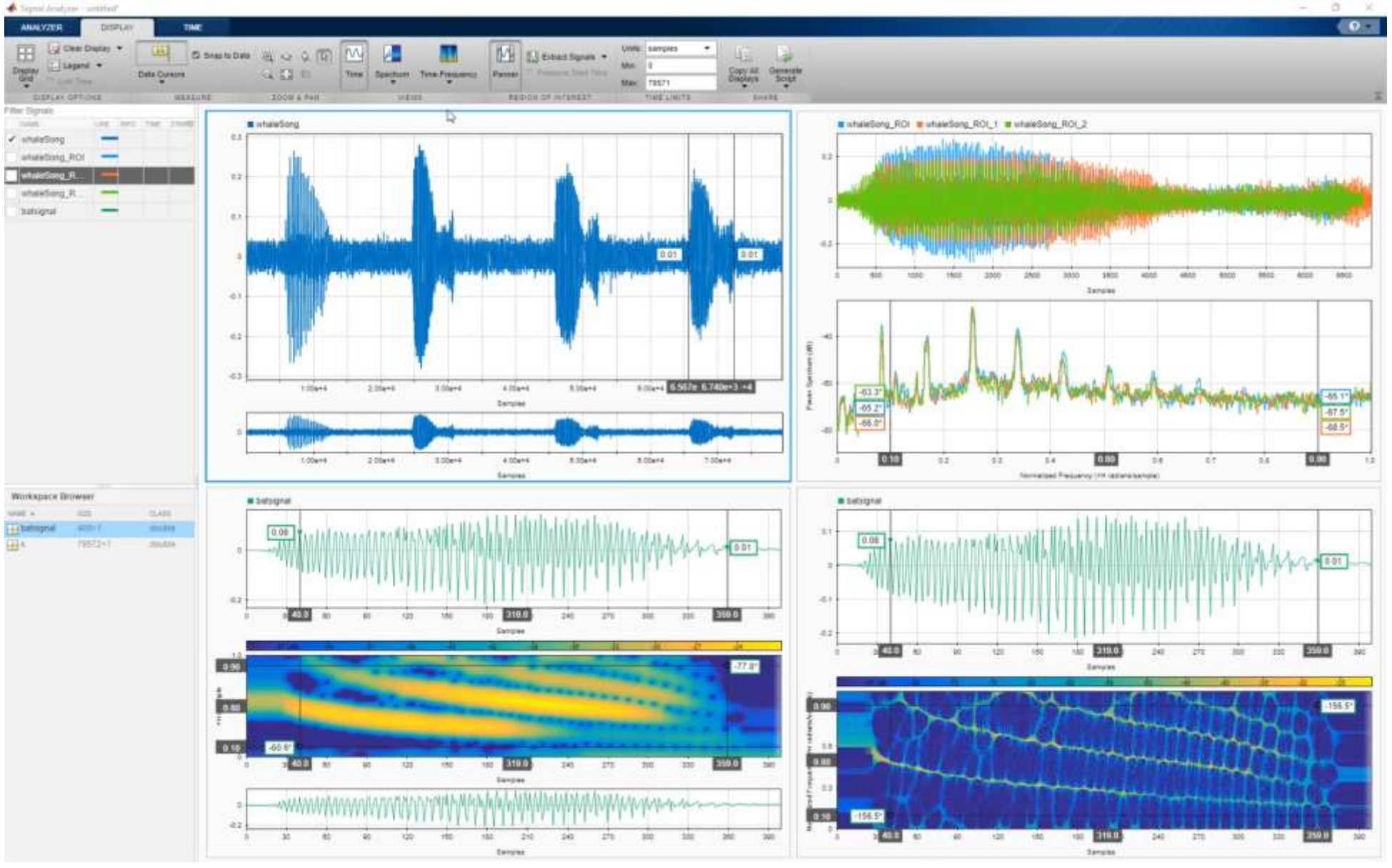
LSTM



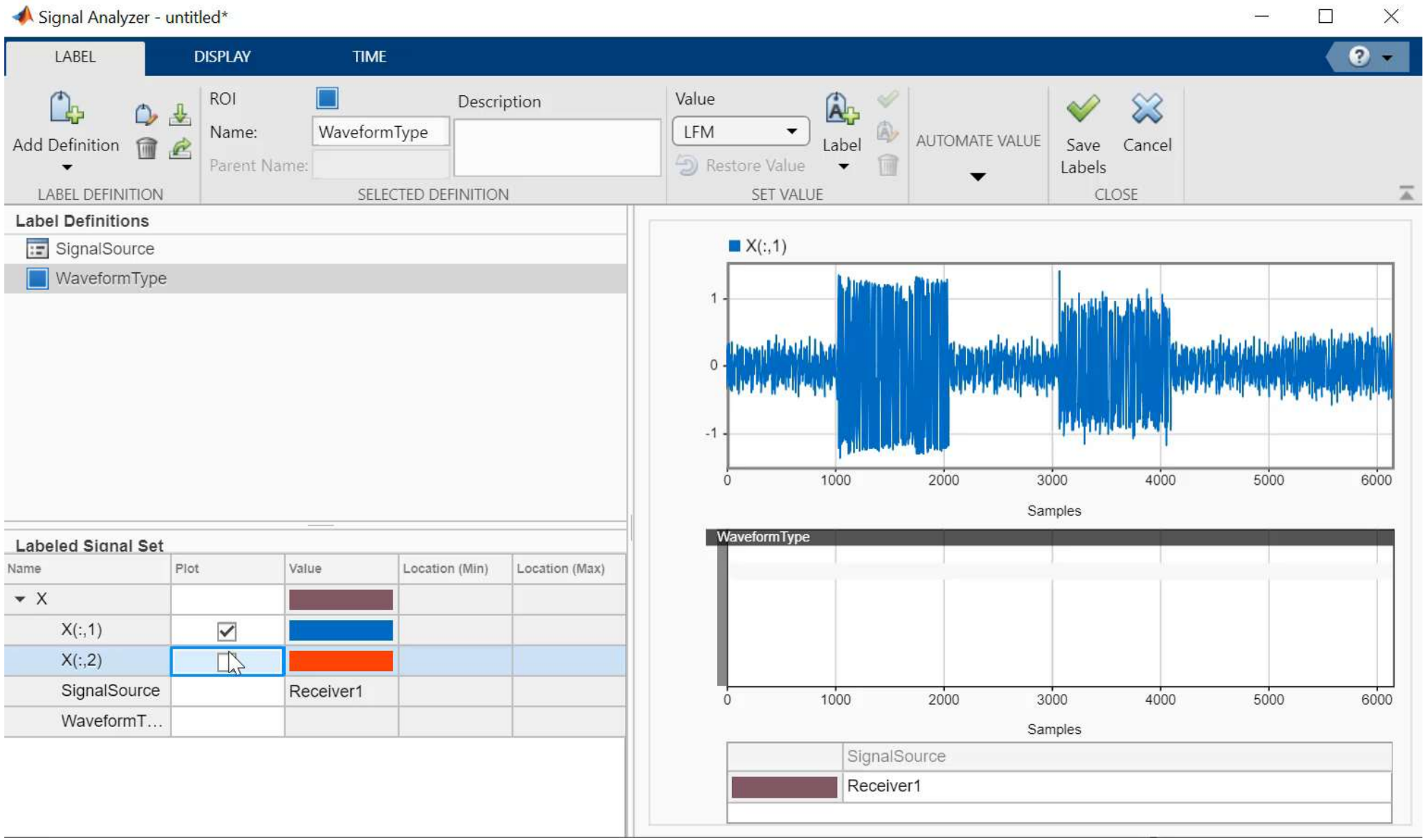
Labeled ECG

https://www.mathworks.com/help/releases/R2020a/signal/examples/waveform-segmentation-using-deep-learning.html

Signal Analyzer App

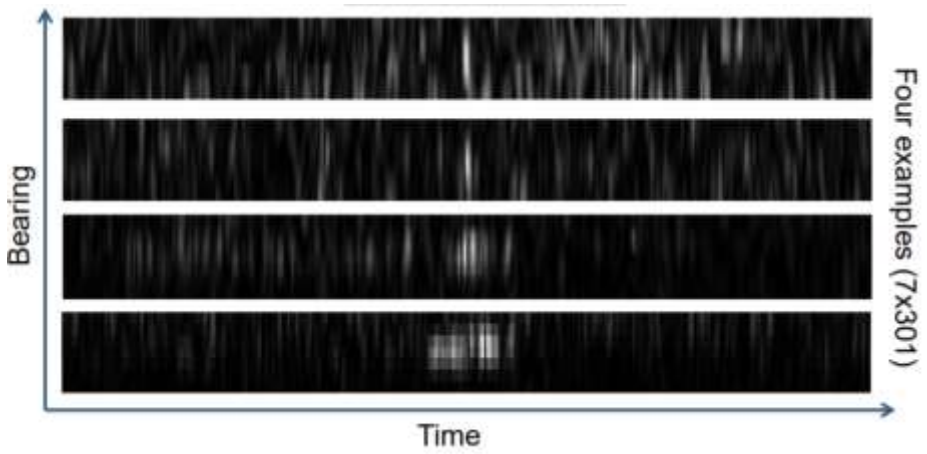


Signal Labeler App



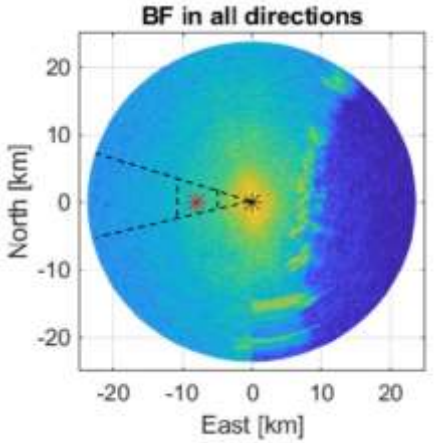
Norwegian Defense Research Department/FFI

Deep Learning for Sonar Applications



MATLAB use in project:

- Signal preprocessing and analysis
- Data synthesis for neural network training
- Deep neural network training and analysis



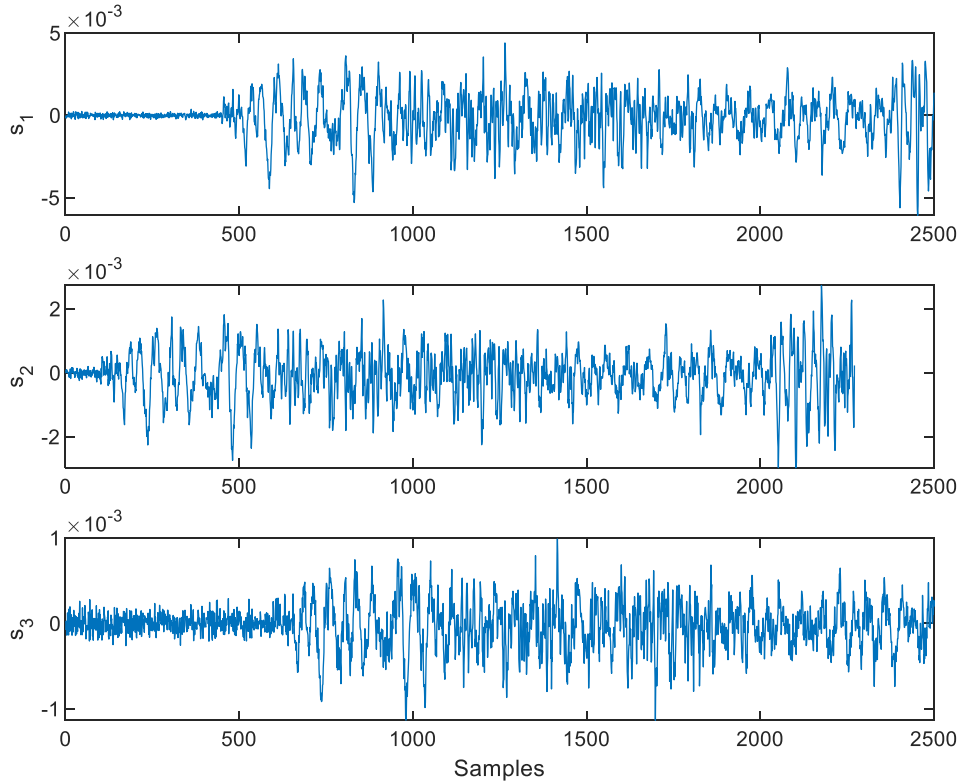
Classification of anti-submarine warfare sonar targets using a deep neural network

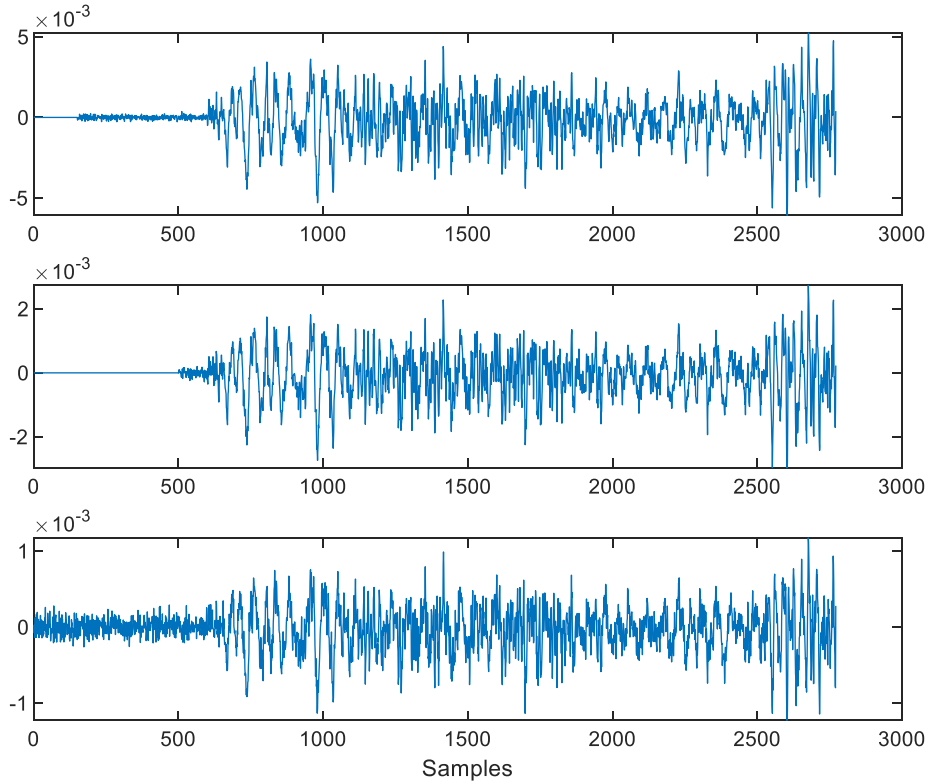
[Classification of anti-submarine warfare sonar targets using a deep neural network;]

Karl Thomas Hjelmervik Henrik Berg; MATLAB Expo 2019

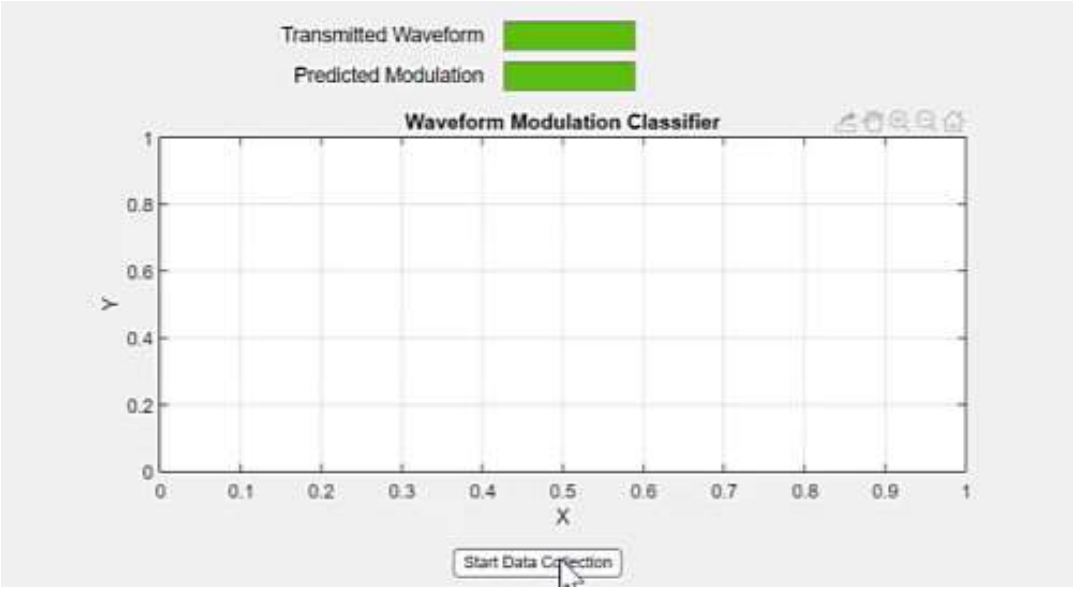
Example: Align Signals with Different Start Times

```
t21 = finddelay(s2,s1)
t31 = finddelay(s3,s1)
t32 = finddelay(s2,s3)
```



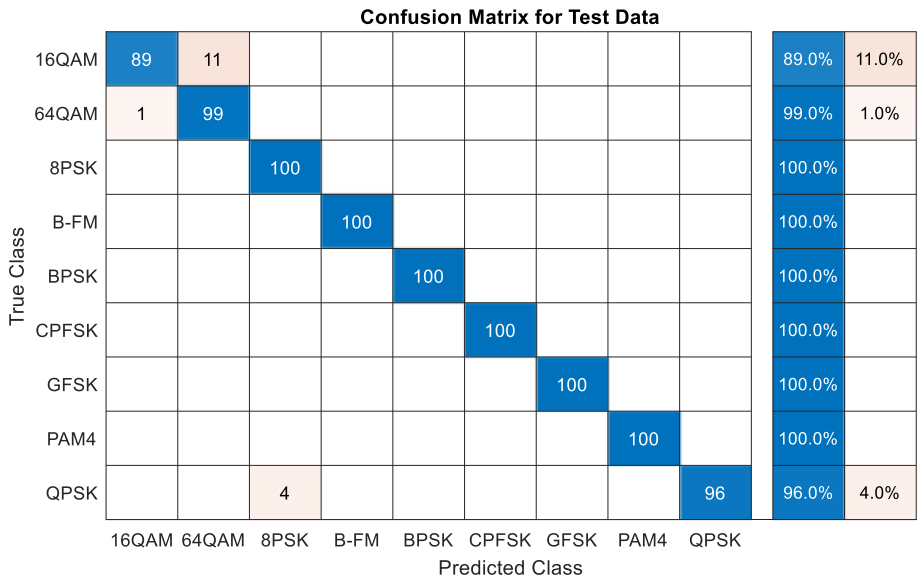


Example: Radar/Comm Modulation Classification

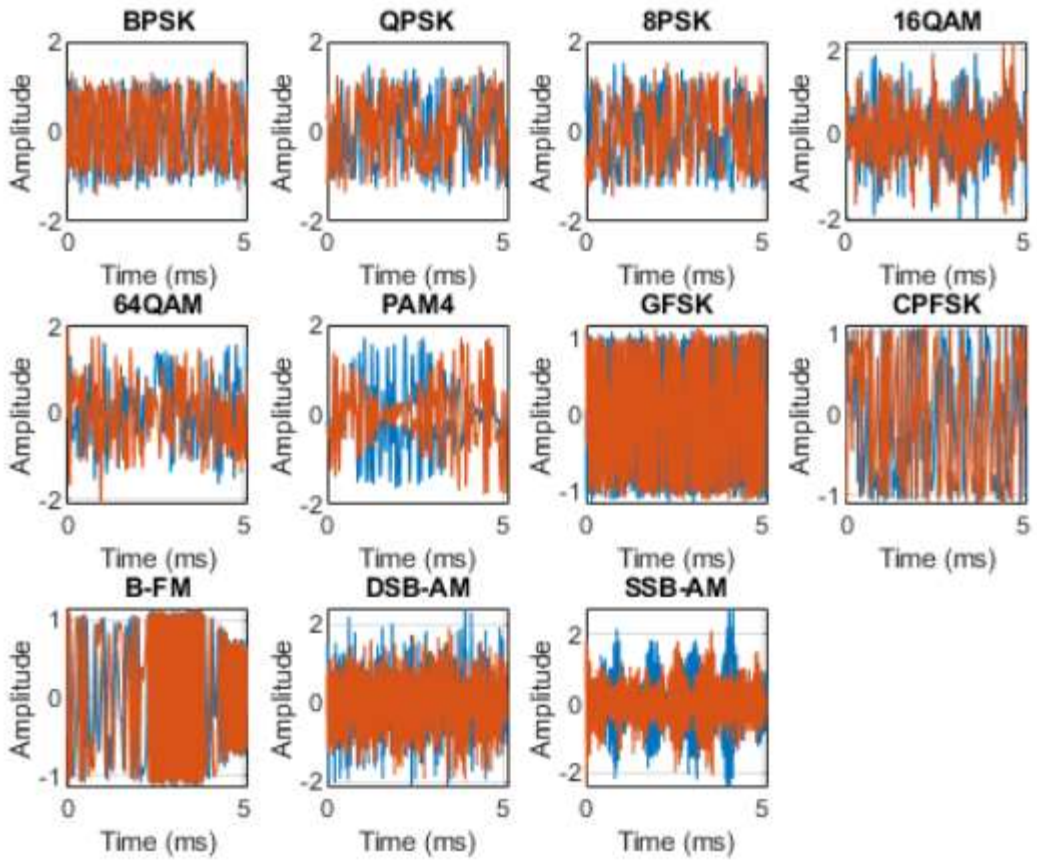


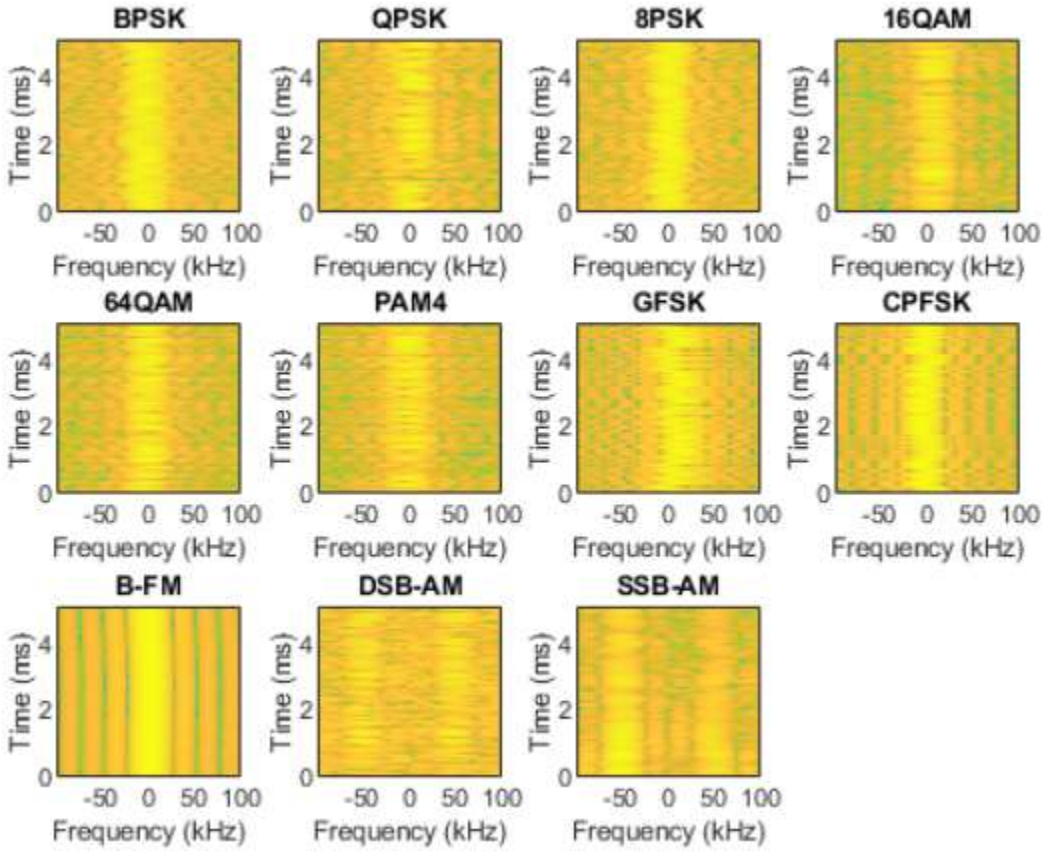
Modulation Classification

http://www.mathworks.com/help/comm/examples/modulation-classification-with-deep-learning.html

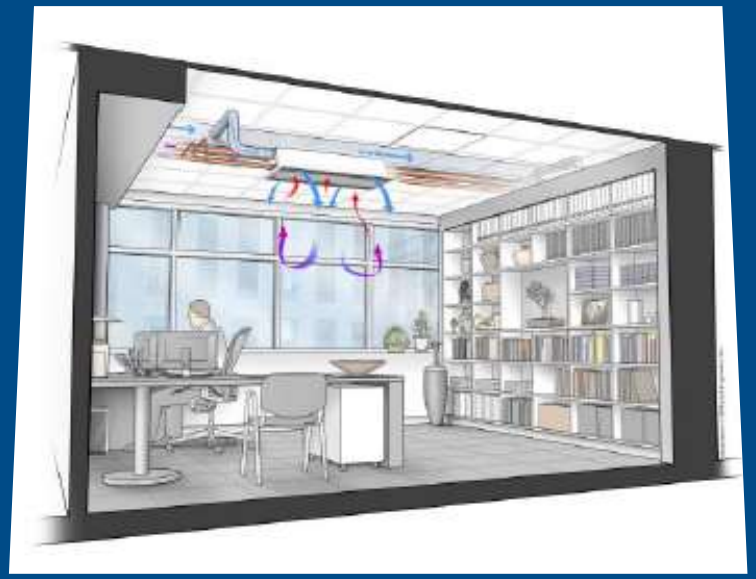


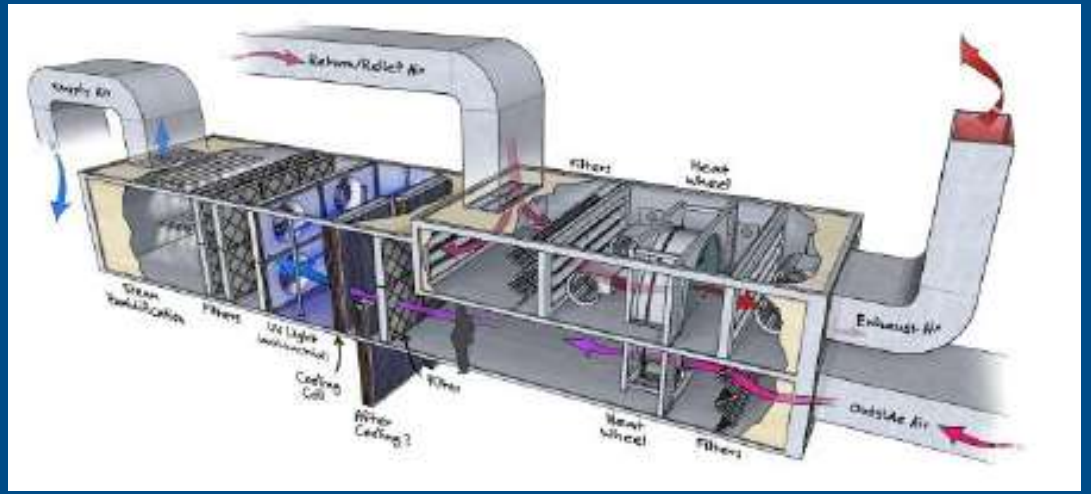
Example: Radar/Comm Modulation Classification





Predictive energy optimization using Big Data Analytics





10-25% savings on total energy cost.

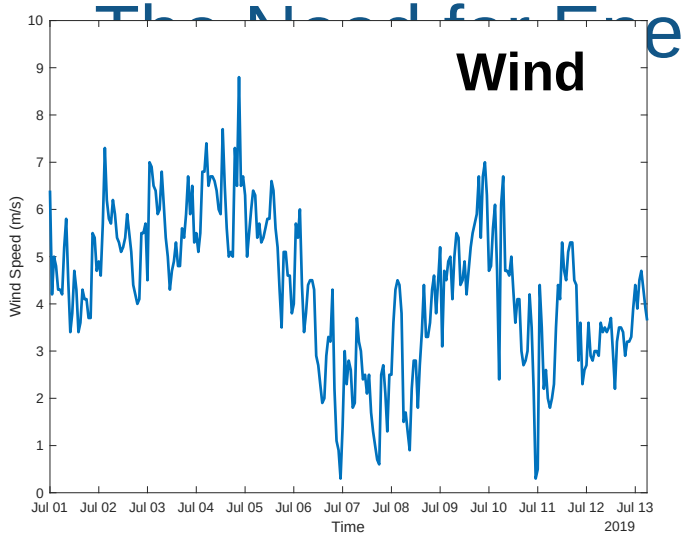
HVAC consumption is generally approx.

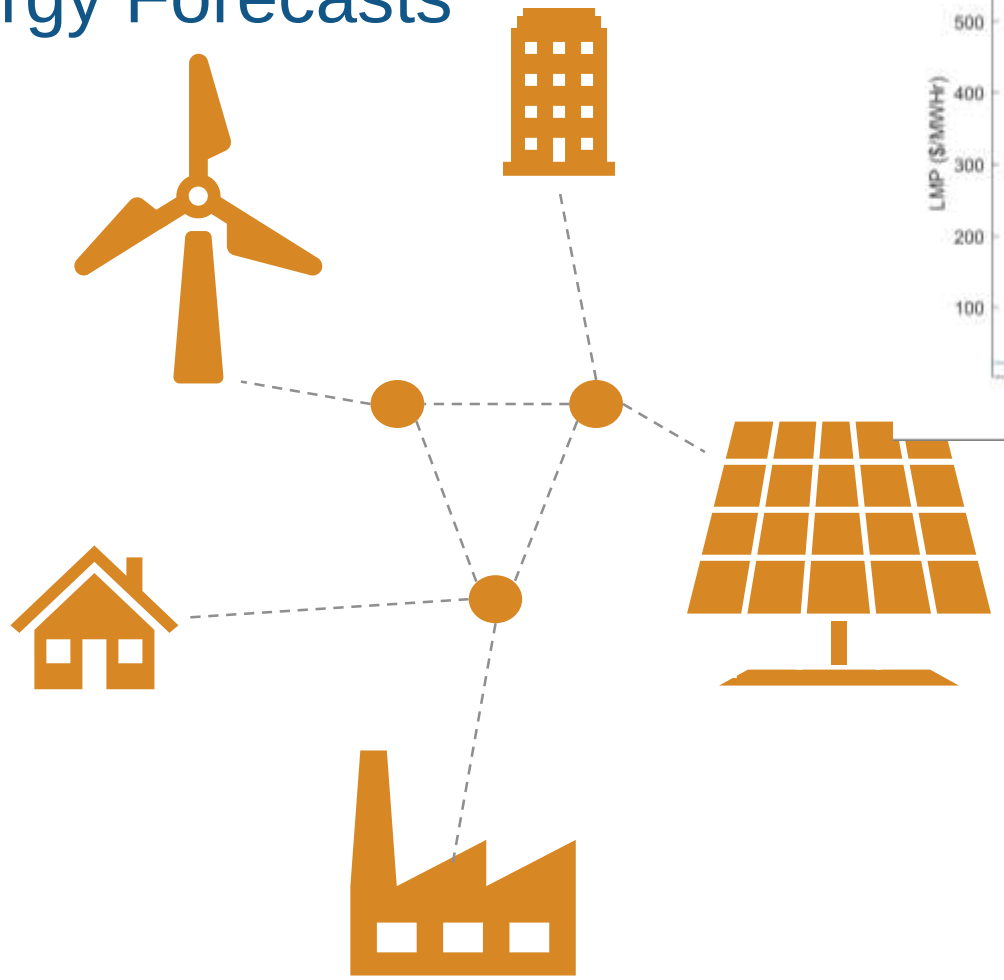
40% of total energy cost, so we can reduce

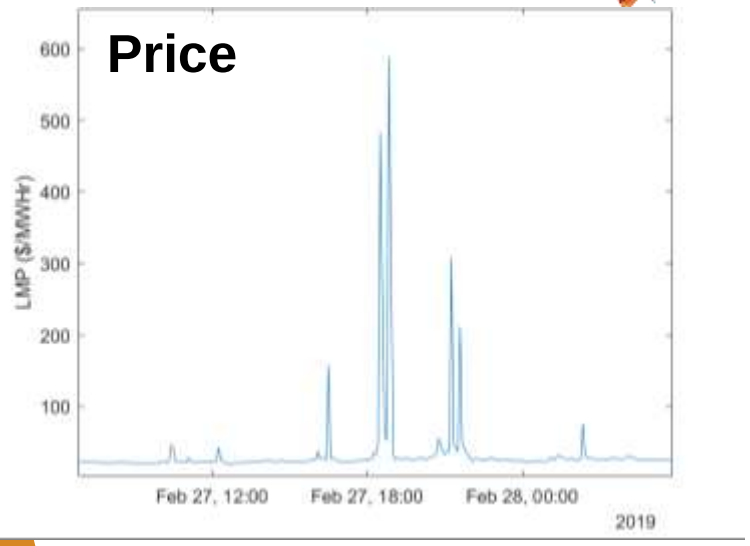
HVAC energy consumption by half!

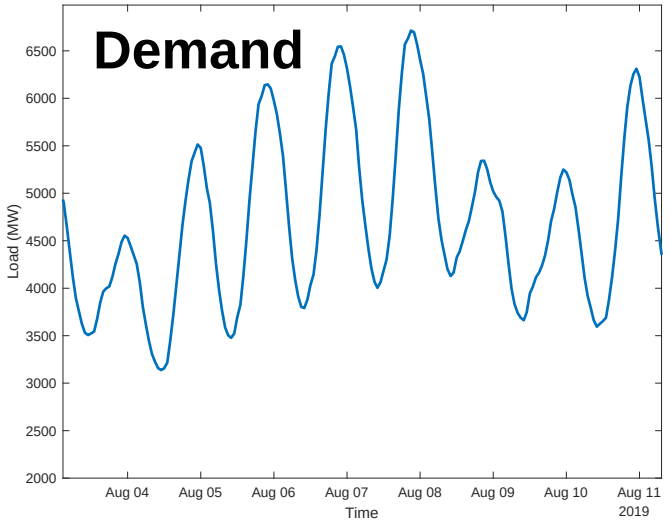
스마트 빌딩

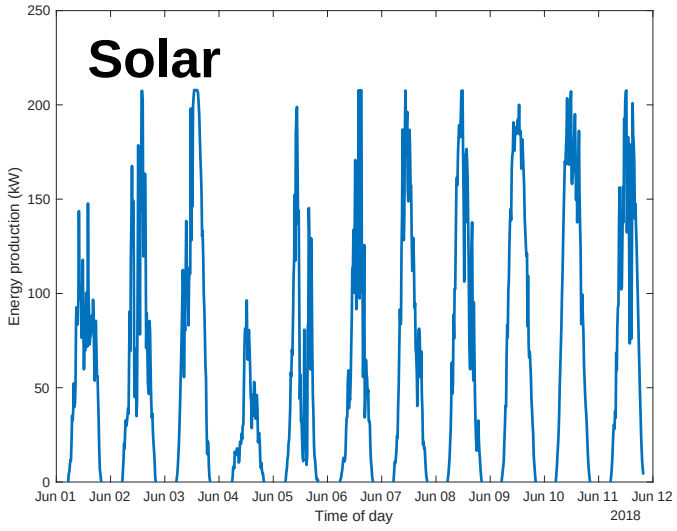
The Need for Energy Forecasts











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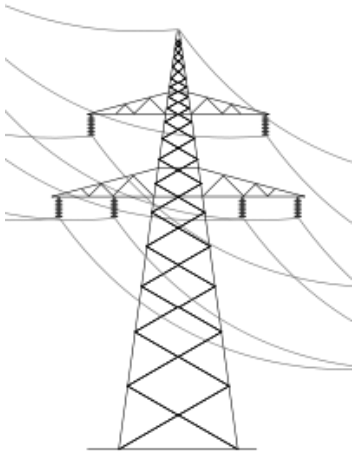
Community EMS

CEMS – ***community with variable loads***

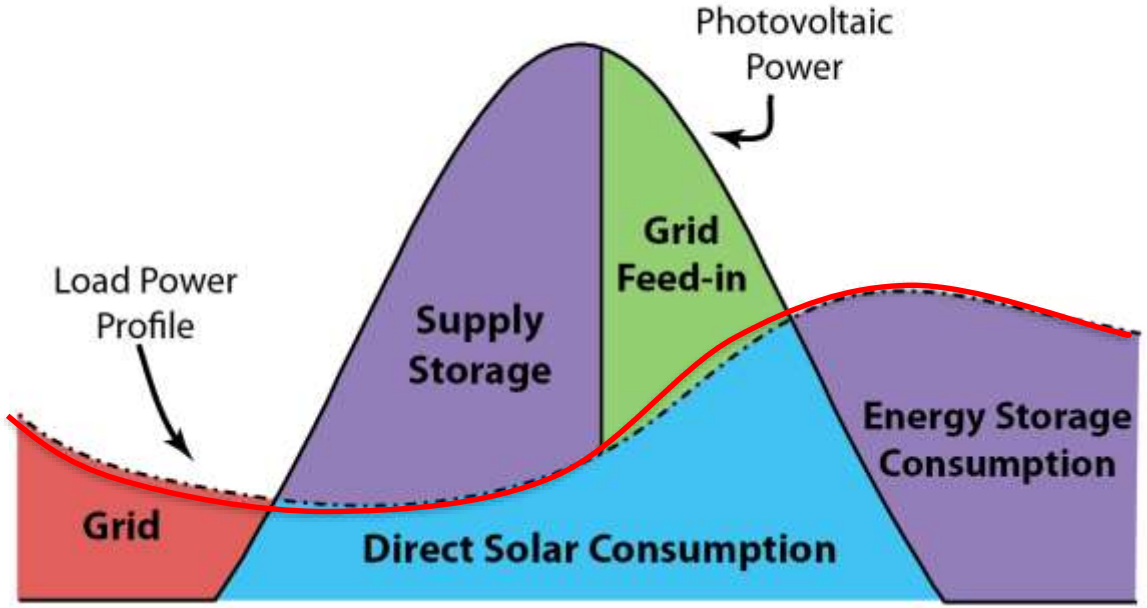
PV Panels:
- MPPT Control
- Power electronics



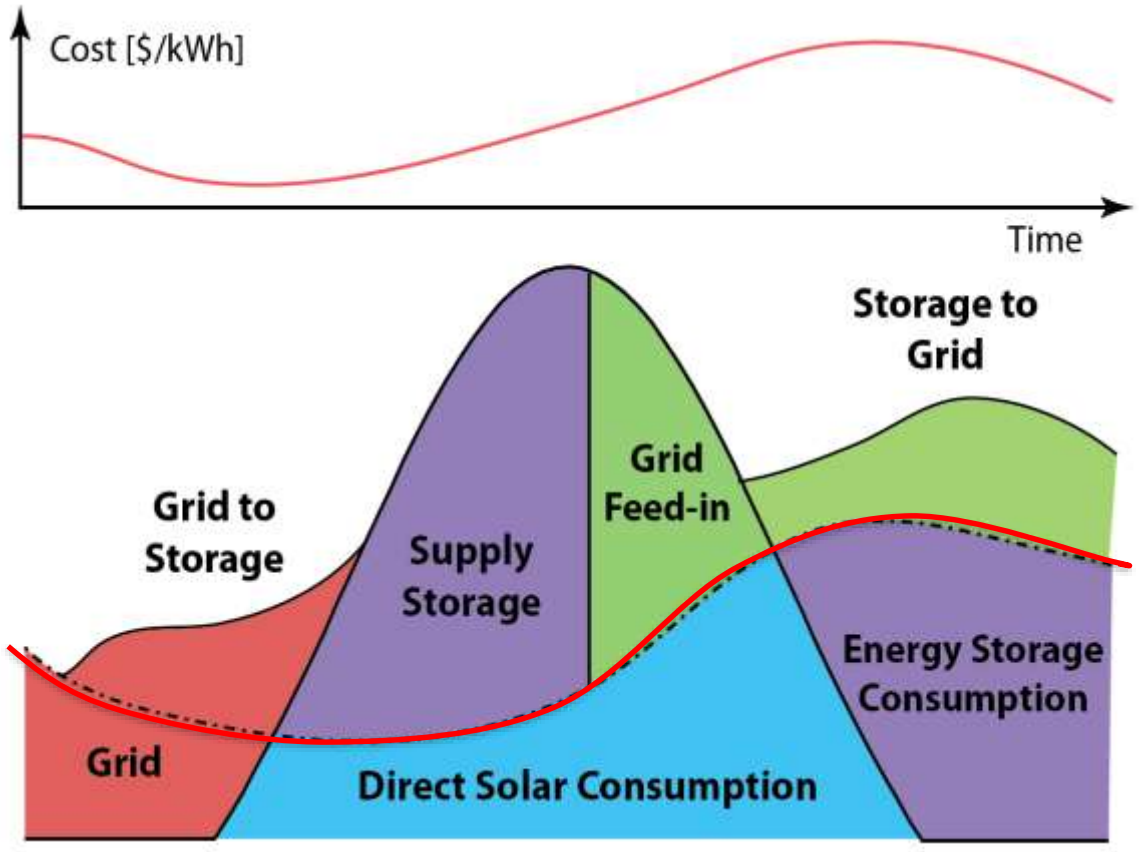
Decision Logic:
- Store/draw power
- Use external grid
- Optimize energy

Battery System:
- Charge controls
- Discharge controls
- Power electronics

EMS Logic



Heuristic EMS

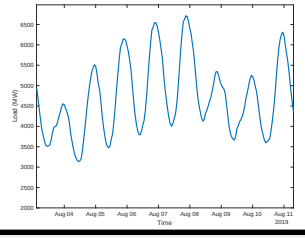


Smart EMS

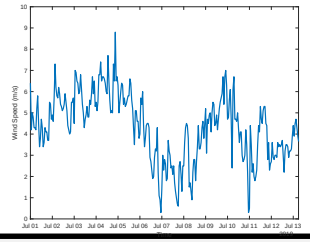
How Energy Forecasting Works

Historical Data

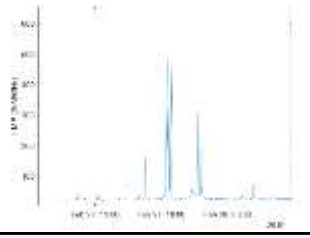
Electricity Demand



Weather

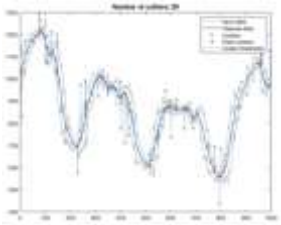


Electricity Prices



Combine

Preprocess



Features

load *wind*

temp *24hr*

day *1week*

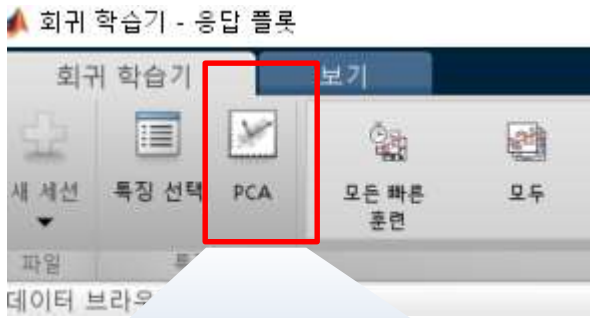
month

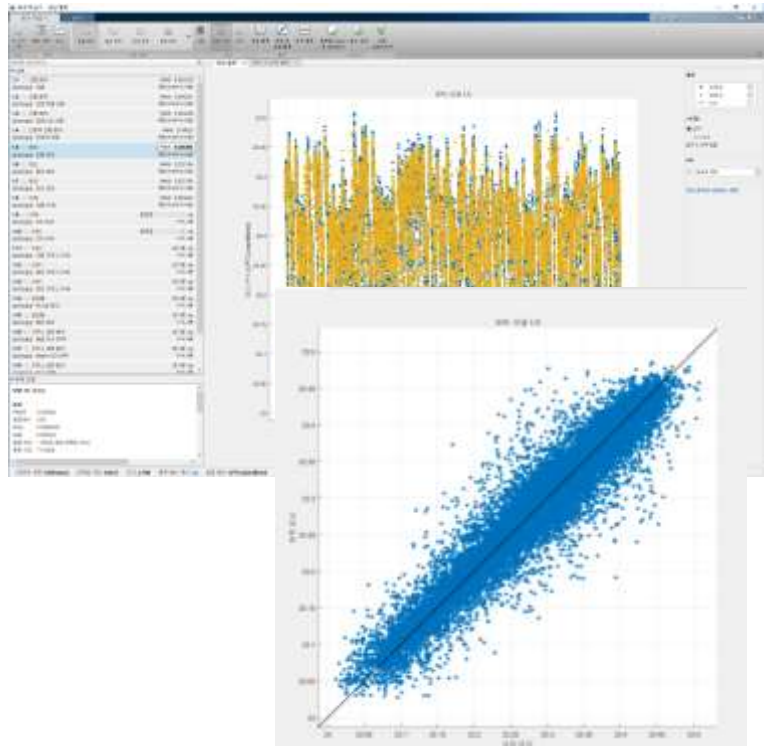
Machine Learning

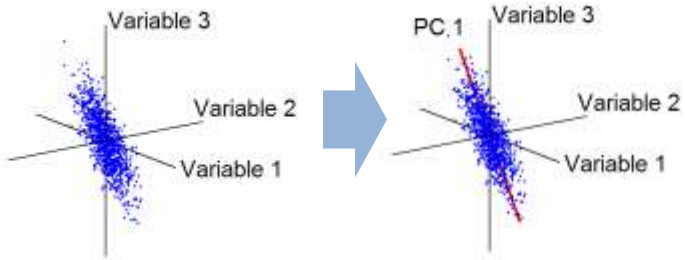
Prediction Example: Energy Demand

- Make prediction model using the pattern of energy demand with the data of the grid → Regression
- Find the important variables for the prediction of energy demand

- Important variables:
  - Customer behavior
  - Temperature
  - Price
  - Illumination
  - Hour, holiday, month
  - …







Evaluate all Regression Models

Finding the best predition model

- Train all models using training data and compare accuracy of each one
  - Trainings can run in parallel
- Multiple methods to assess accuracy

Regression Models

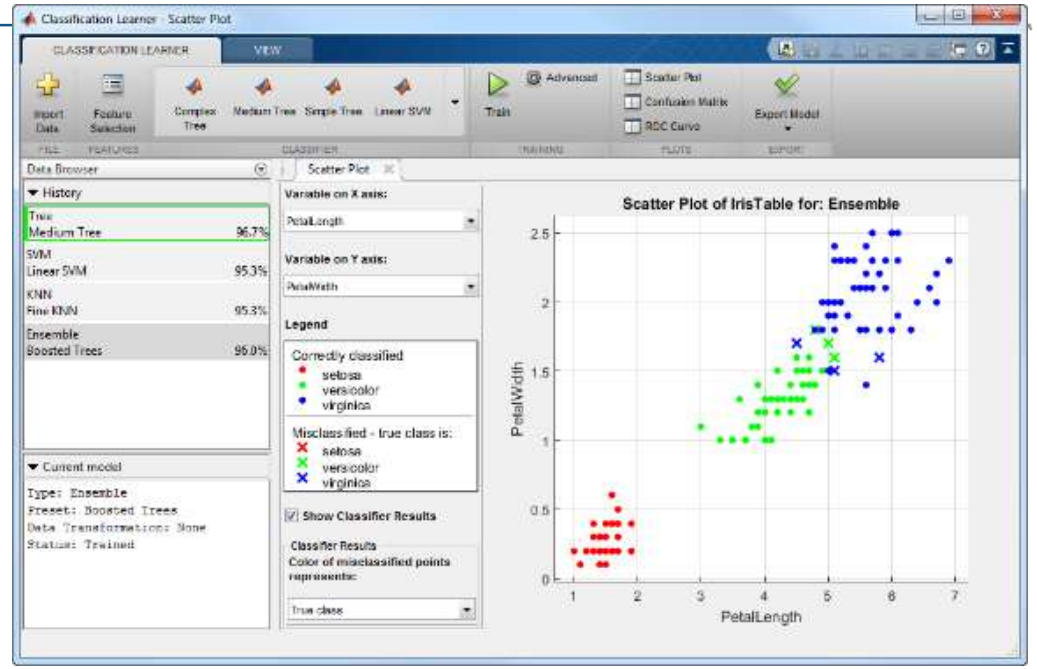
데이터 브라우저

내역

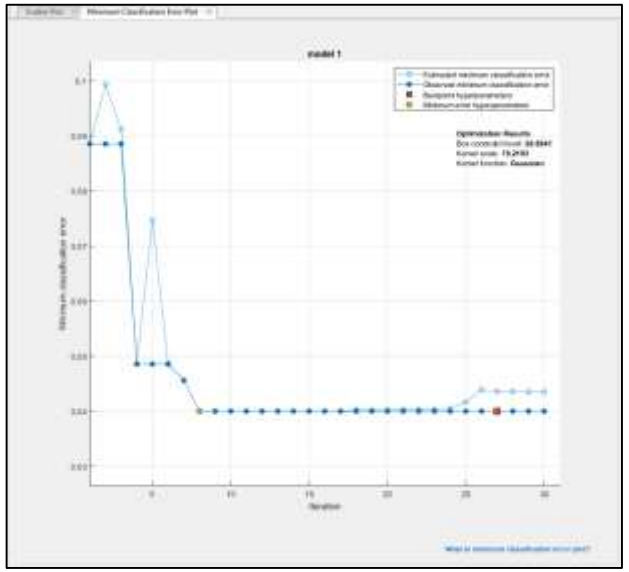
1.1 선형 회귀 마지막 변경: 선형	RMSE: 0.054229 특징 4/16(PCA 사용)
1.2 선형 회귀 마지막 변경: 상호 작용 선형	RMSE: 0.046231 특징 4/16(PCA 사용)
1.3 선형 회귀 마지막 변경: 로버스트 선형	RMSE: 0.054239 특징 4/16(PCA 사용)
1.4 단계적 선형 회귀 마지막 변경: 단계적 선형	RMSE: 0.04623 특징 4/16(PCA 사용)
1.5 트리 마지막 변경: 조밀 트리	RMSE: 0.028364 특징 4/16(PCA 사용)
1.6 트리 마지막 변경: 중간 트리	RMSE: 0.032164 특징 4/16(PCA 사용)
1.7 트리 마지막 변경: 성긴 트리	RMSE: 0.037195 특징 4/16(PCA 사용)
1.8 SVM 마지막 변경: 선형 SVM	RMSE: 0.054343 특징 4/16(PCA 사용)
1.9 SVM 마지막 변경: 2차 SVM	RMSE: 0.046012 특징 4/16(PCA 사용)
1.10 SVM 마지막 변경: 3차 SVM	RMSE: 0.047342 특징 4/16(PCA 사용)
1.11 SVM 마지막 변경: 조밀 가우스 SVM	RMSE: 0.042549 특징 4/16(PCA 사용)
1.12 SVM 마지막 변경: 중간 가우스 SVM	RMSE: 0.045173 특징 4/16(PCA 사용)
1.13 SVM 마지막 변경: 성긴 가우스 SVM	RMSE: 0.049373 특징 4/16(PCA 사용)
1.14 앙상블 마지막 변경: 부스팅 트리	RMSE: 0.98836 특징 4/16(PCA 사용)
1.15 앙상블 마지막 변경: 배깅 트리	RMSE: **0.027709** 특징 4/16(PCA 사용)

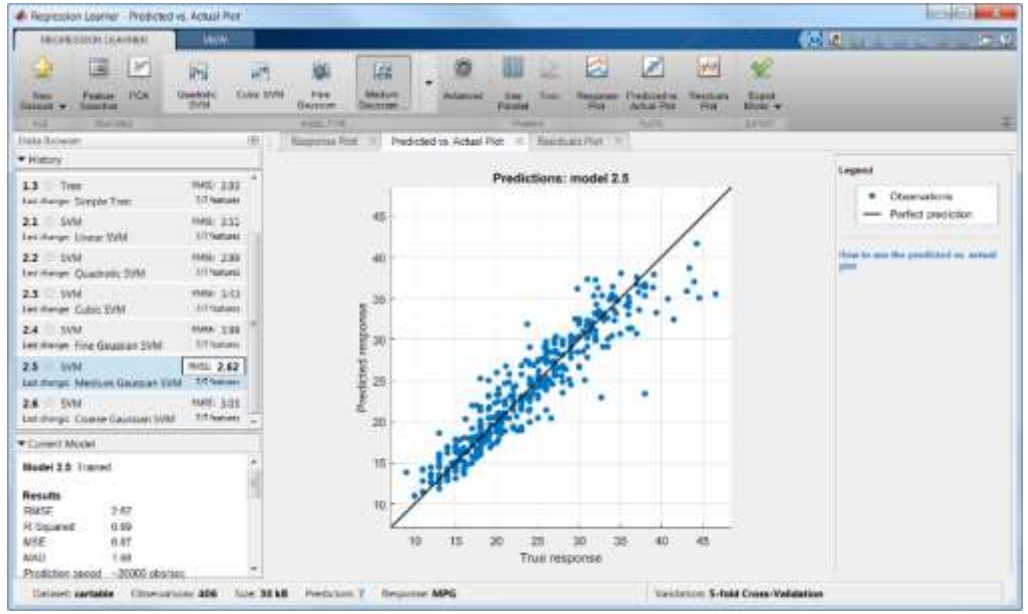
Machine Learning apps

- Try out many models
- Compare Results
- Get to a reasonable model wi thout worrying about the deta ils



Perform Hyperparameter Optimization in apps





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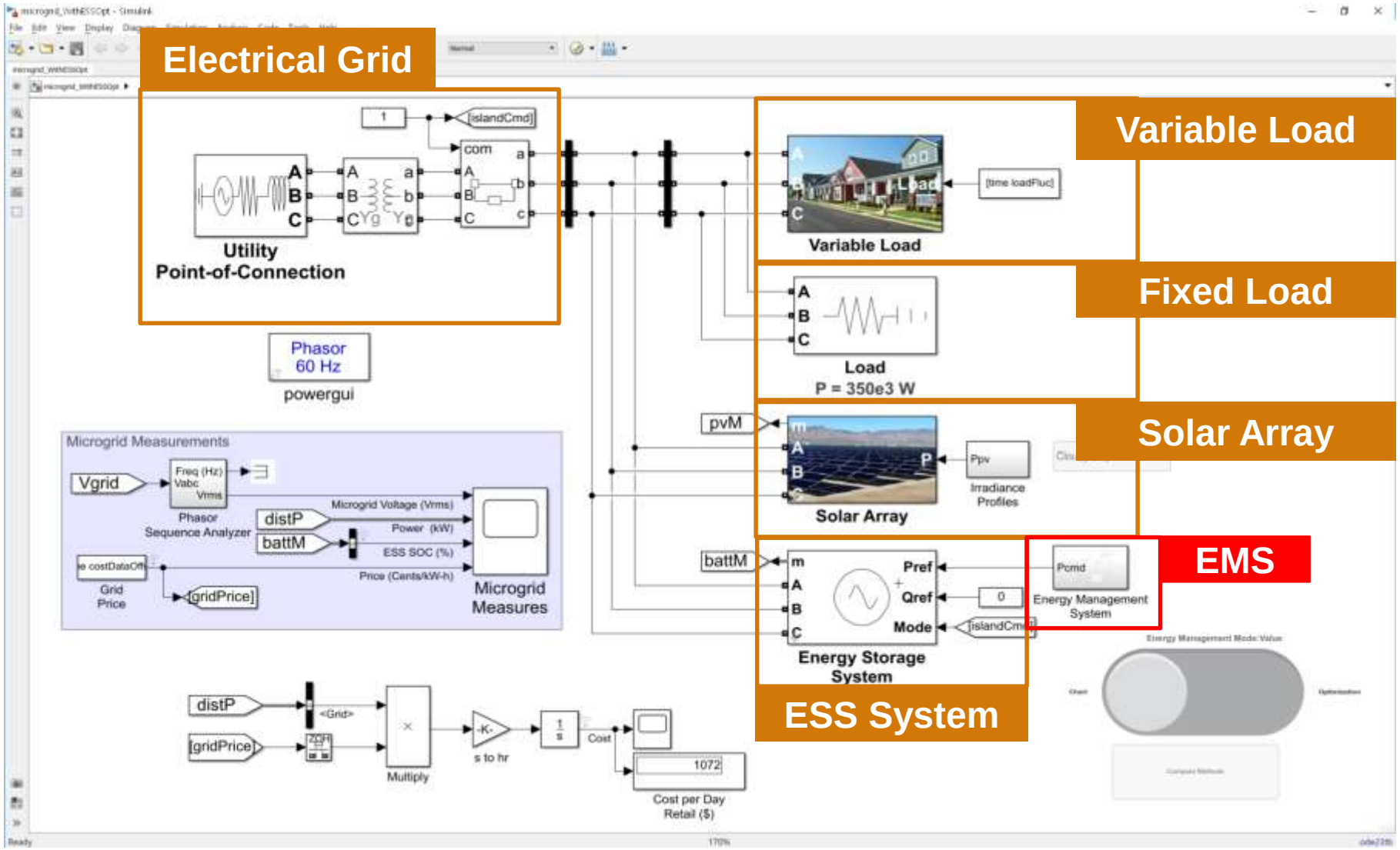
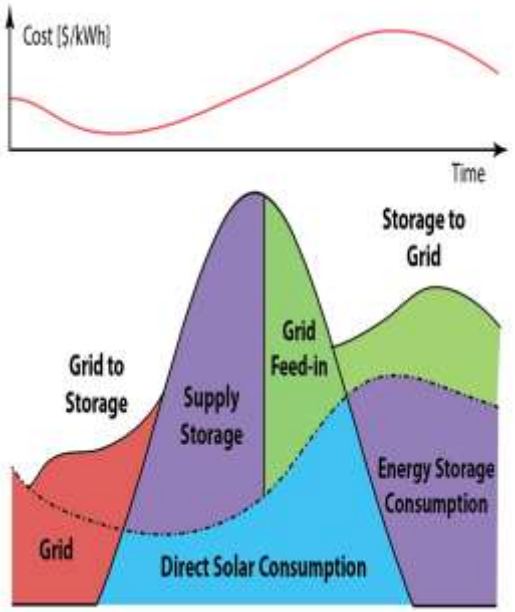
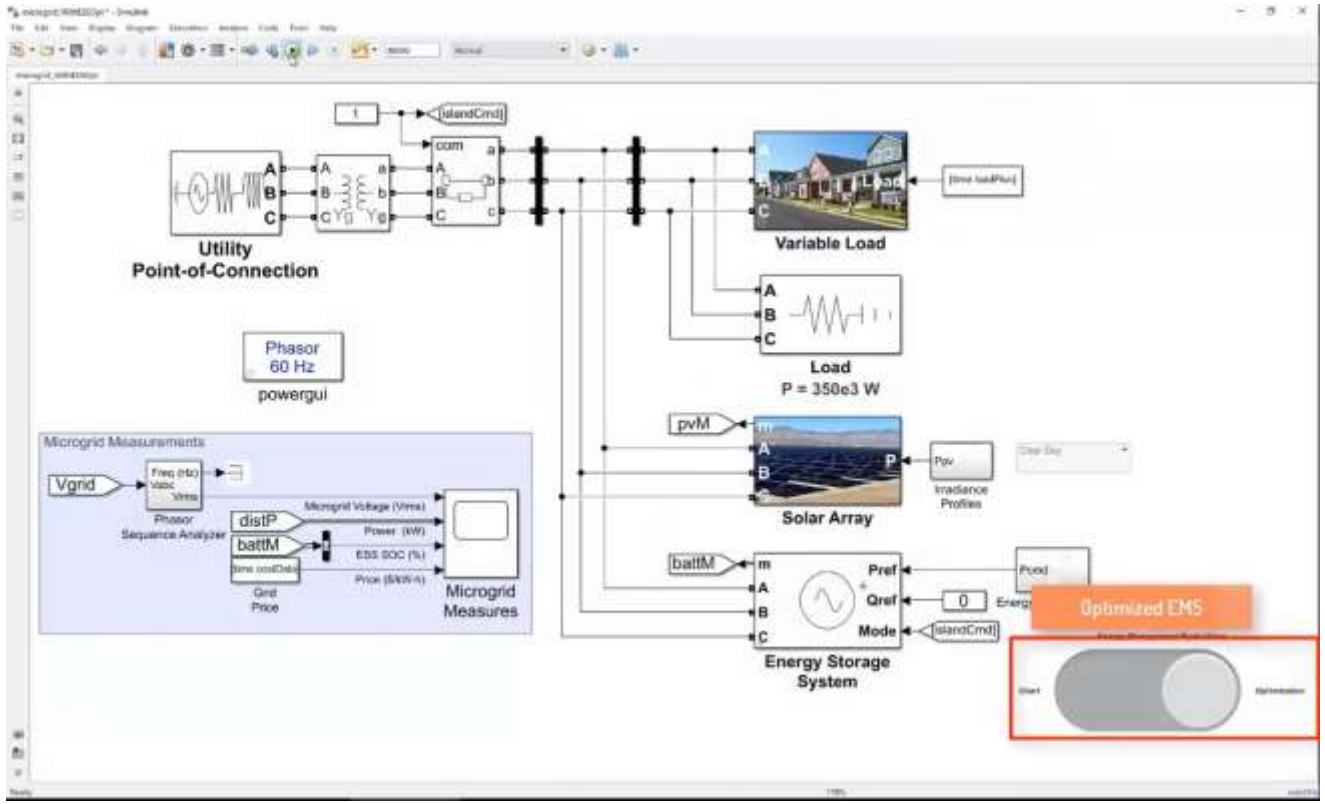
Community EMS

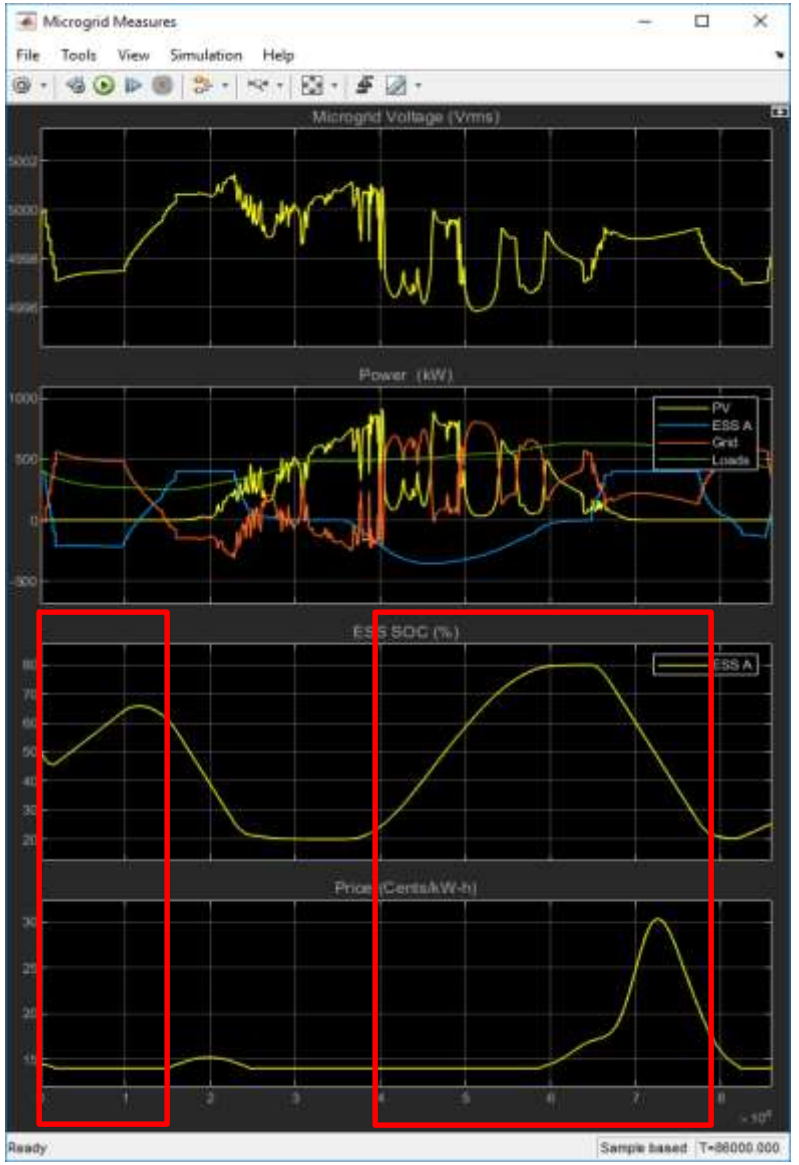




Simulation Results

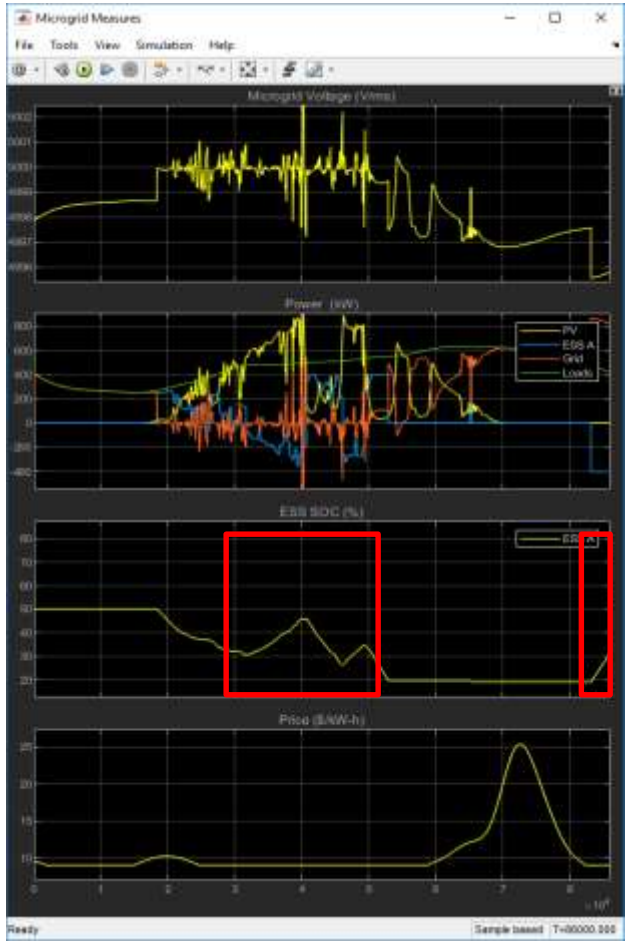
Smart EMS



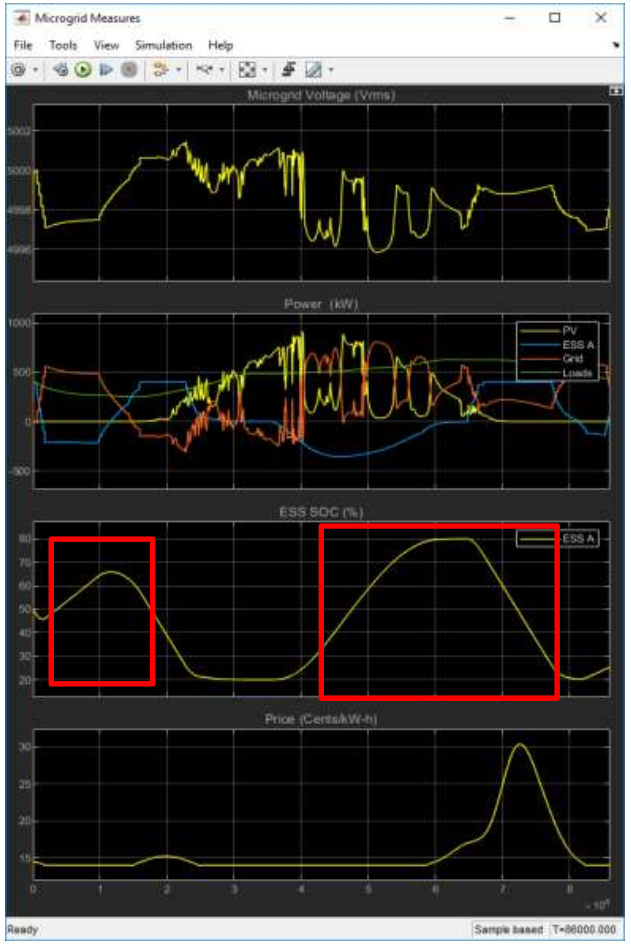


Policy Comparison - Cloudy Day

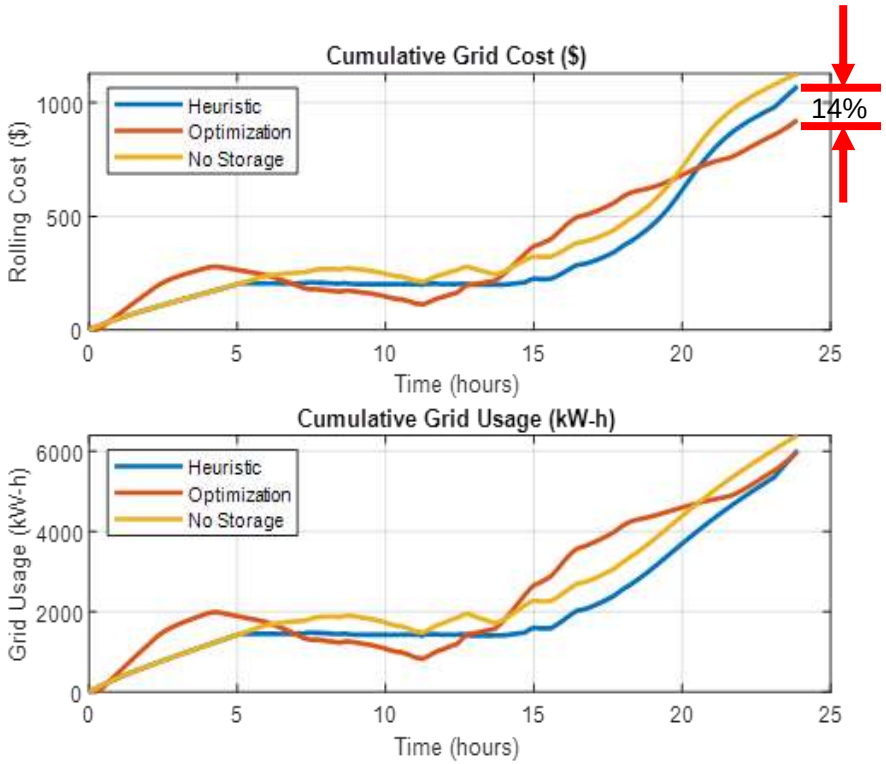
Heuristic



Optimized



Comparison



14% lower cost with optimization

BuildingIQ Develops Proactive Algorithms for HVAC Energy O ptimization in Large-Scale Buildings

Challenge

Develop a real-time system to minimize HVAC energy costs in large-scale commercial buildings via proactive, predictive optimization

Solution

Use MATLAB to analyze and visualize big data sets, implement advanced optimization algorithms, and run the algorithms in a production cloud environment

Results

- Gigabytes of data analyzed and visualized
- Algorithm development speed increased tenfold
- Best algorithmic approaches quickly identified

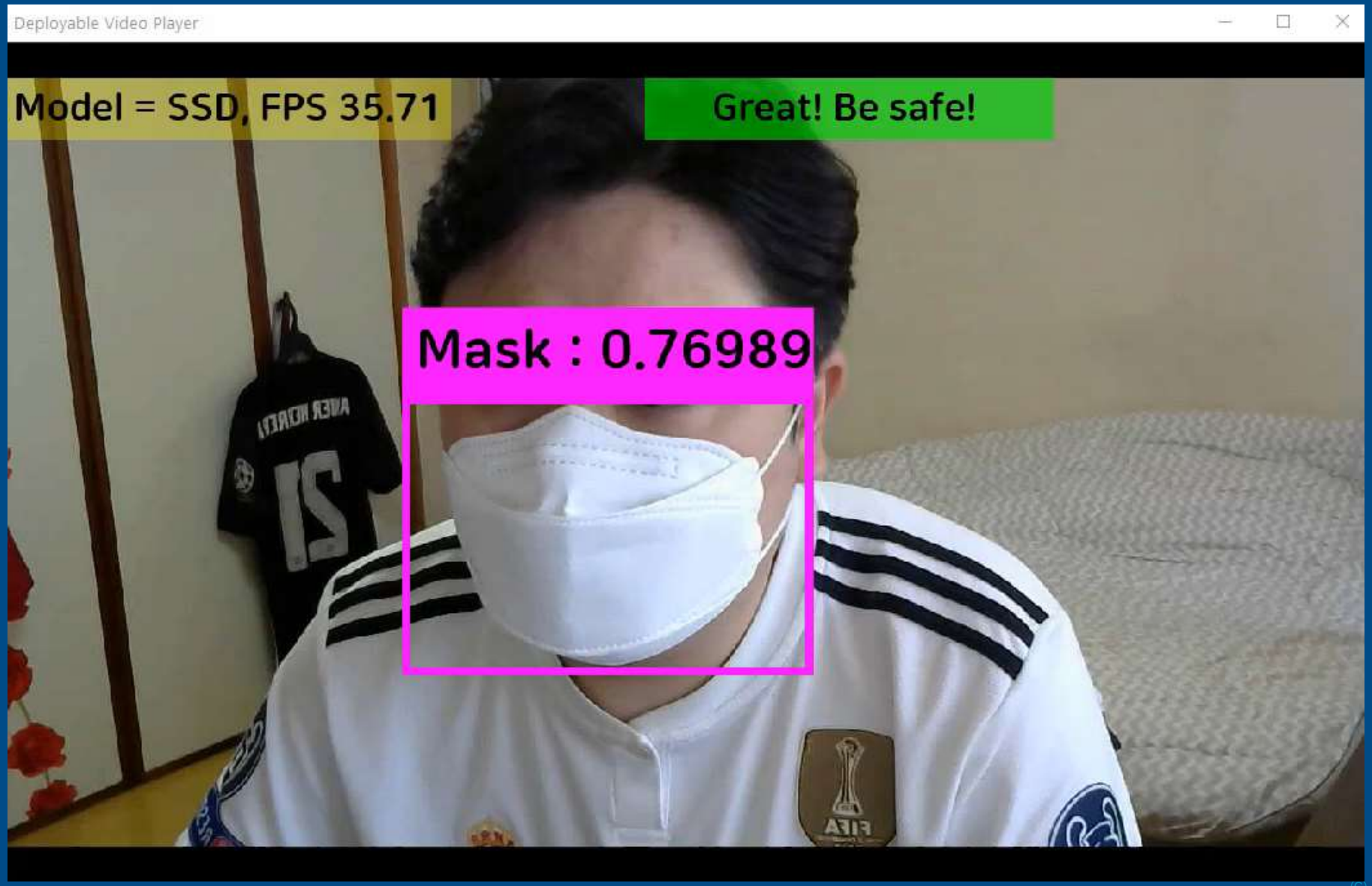
Large-scale commercial buildings can reduce energy costs by 10–25% with BuildingIQ's energy optimization system.

"MATLAB has helped accelerate our R&D and deployment with its robust numerical algorithms, extensive visualization and analytics tools, reliable optimization routines, support for object-oriented programming, and ability to run in the cloud with our production Java applications."

- Borislav Savkovic, Building IQ


Model = YOLOv2, FPS 6.15
Great! Be safe!
Mask : 0.88868
Model = YOLOv2, FPS 45.03
Great! Be safe!
Mask : 0.9016

Application Examples Using MATLAB – SSD



Object Recognition using Deep Learning

Object recognition (whole image)

CNN (Convolutional Neural Network)

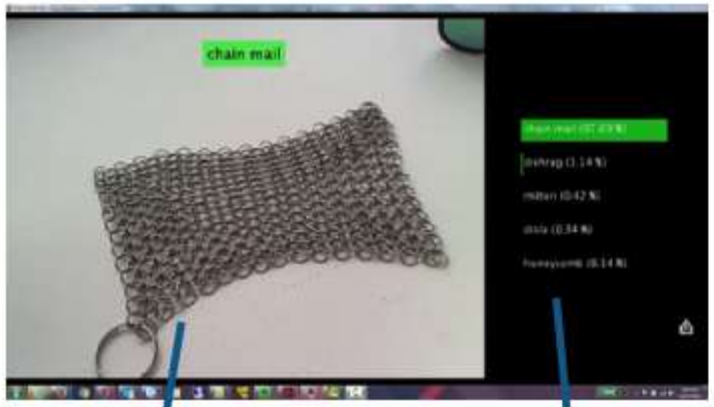
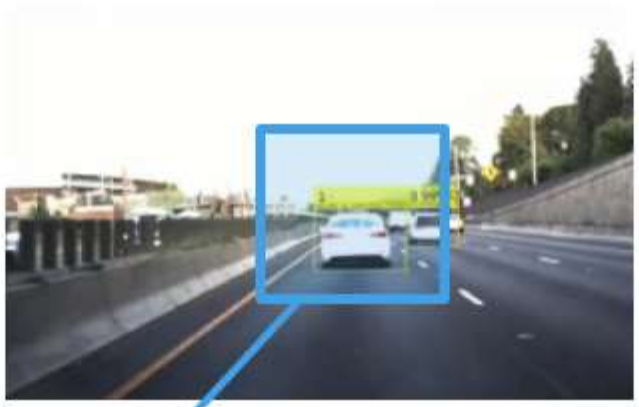


Image (Input)

Probability

Object detection and recognition

R-CNN / Fast R-CNN / Faster R-CNN



Front of Car

Object recognition (in pixels)

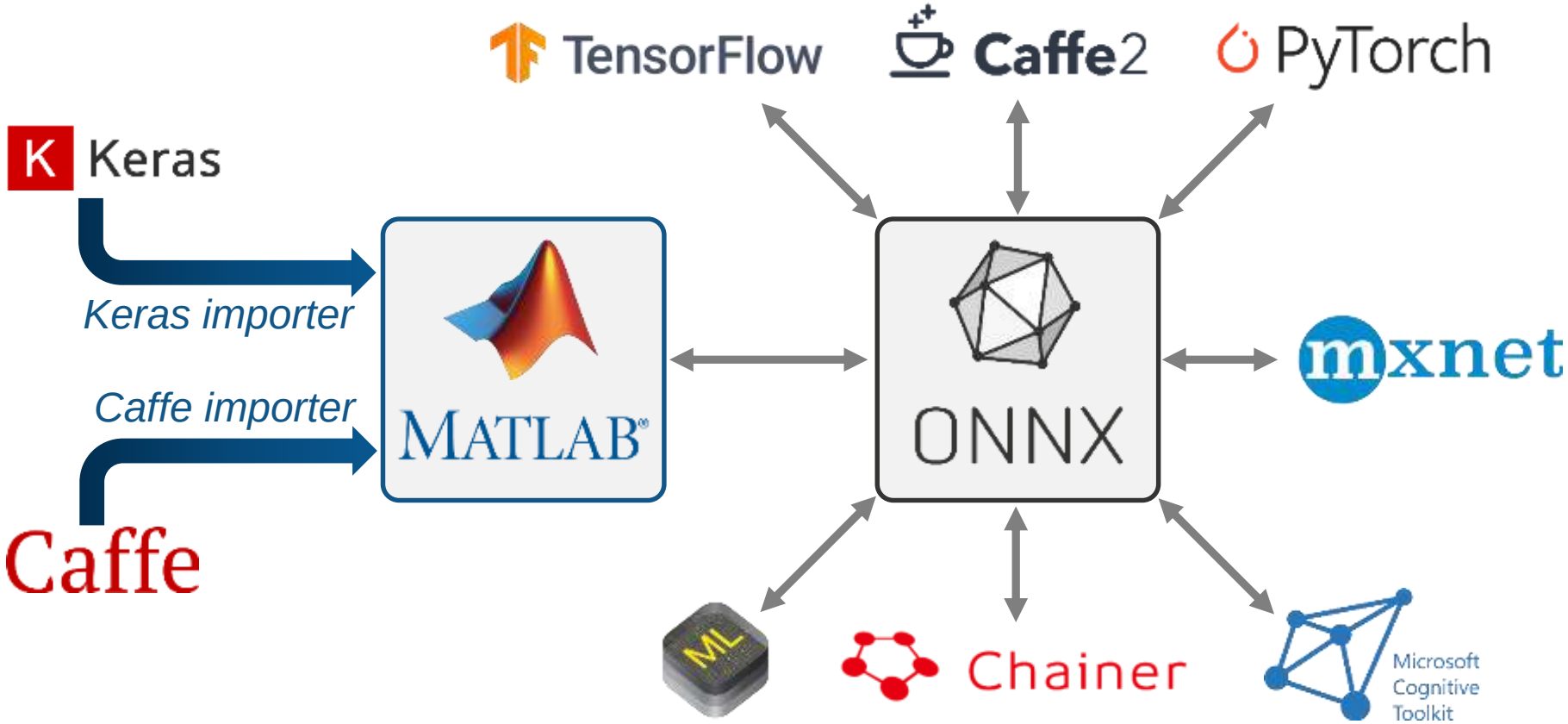
SegNet / FCN

Road

Vehicle

MATLAB interoperates with other frameworks

Supports ONNX and can exchange models with PyTorch, TensorFlow, and other frameworks.



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Face detection using Deep Learning

- Import each pretrained caffemodel and running on MATLAB
- Use as if MATLAB trained model, after first import.

Import Caffe Network models to MATLAB using Caffe model Importer

Deep Learning Toolbox Importer for Caffe Models

by MathWorks Deep Learning Toolbox Team STAFF

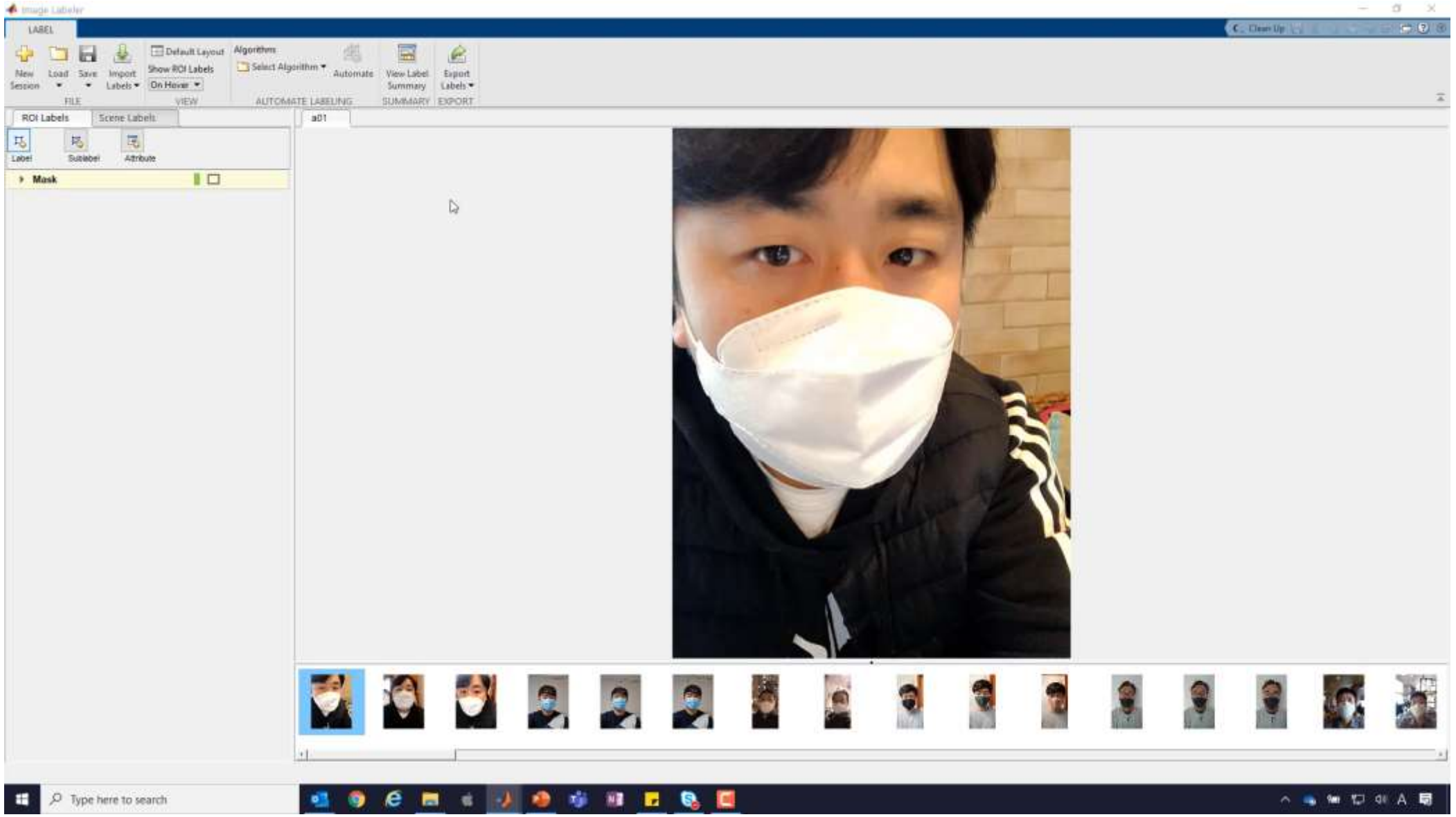
Software support package for importing pretrained Caffe Models

Prepare face detection network in MATLAB format

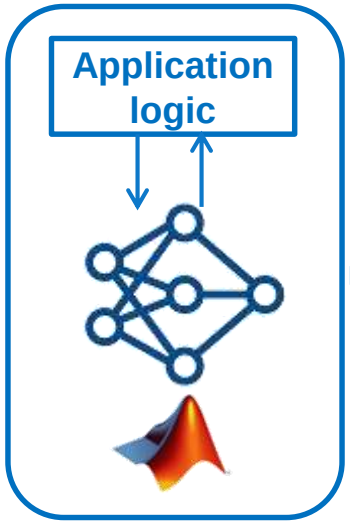
```
doImport = true;
if doImport
    faceYoloNet = importCaffeNetwork('models\net_face_yolo_deploy.prototxt','models\net_face_yolo.caffemodel','OutputLayerType','regression');
    save net_face_yolo.mat faceYoloNet
end
```

https://kr.mathworks.com/matlabcentral/fileexchange/71819-face-age-and-emotion-detection

Automate Ground Truth Labeling – Custom automation



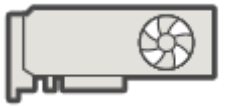
Deploy your deep learning application on multiple hardware platforms



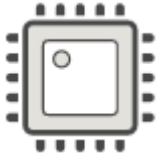
Code Generation

Auto-generated Code (C/C++/CUDA)

Intel MKL-DNN Library

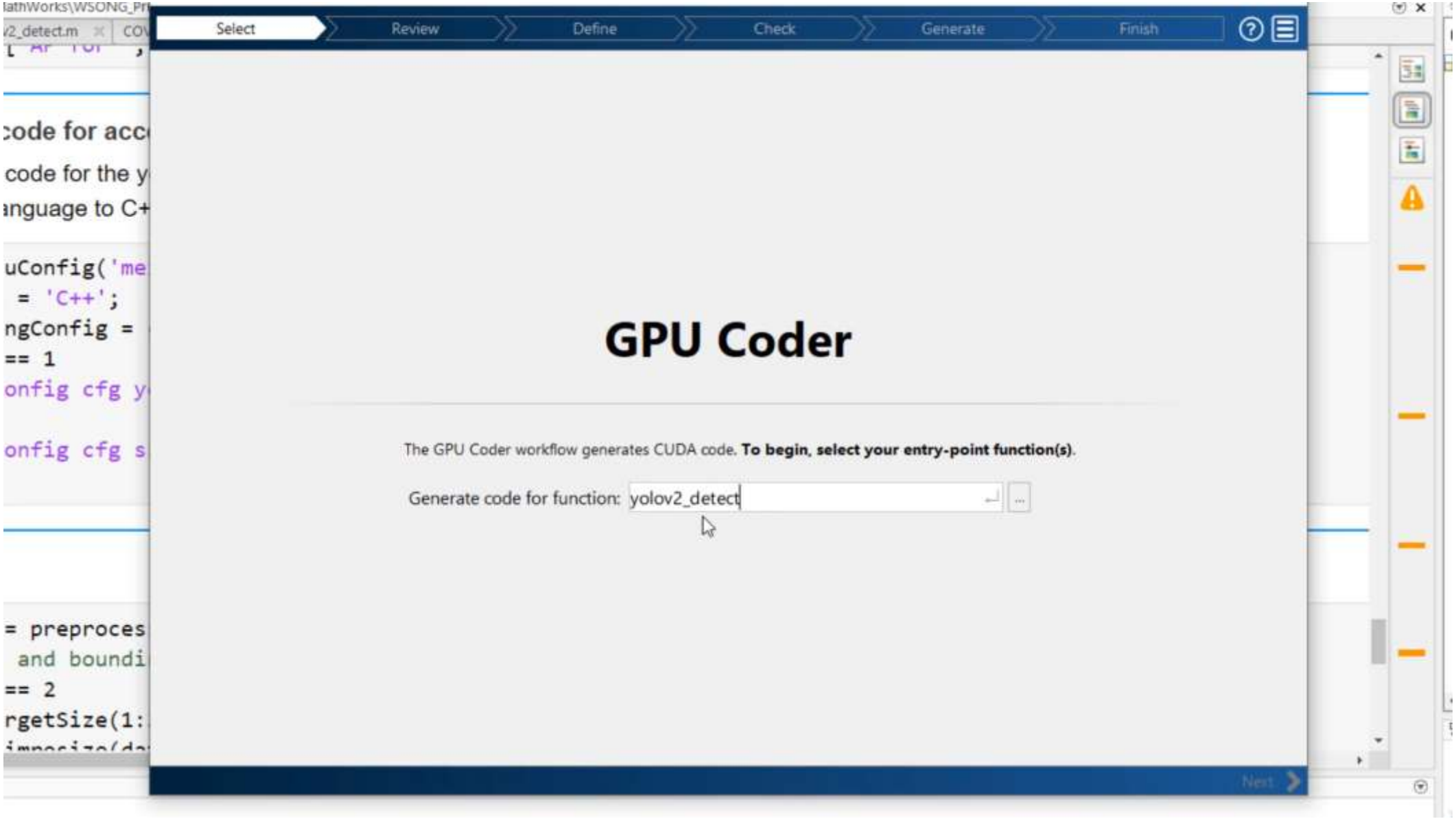


NVIDIA / ARM Mali TensorRT & cuDNN Libraries



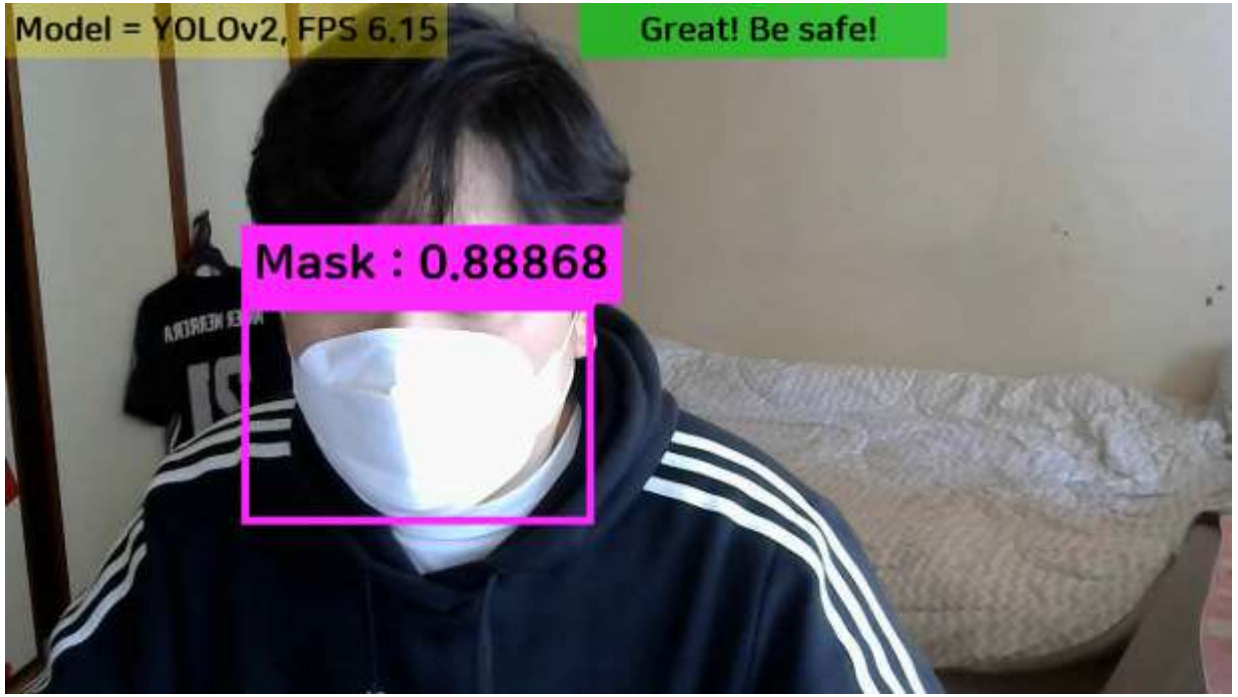
Arm Compute Library

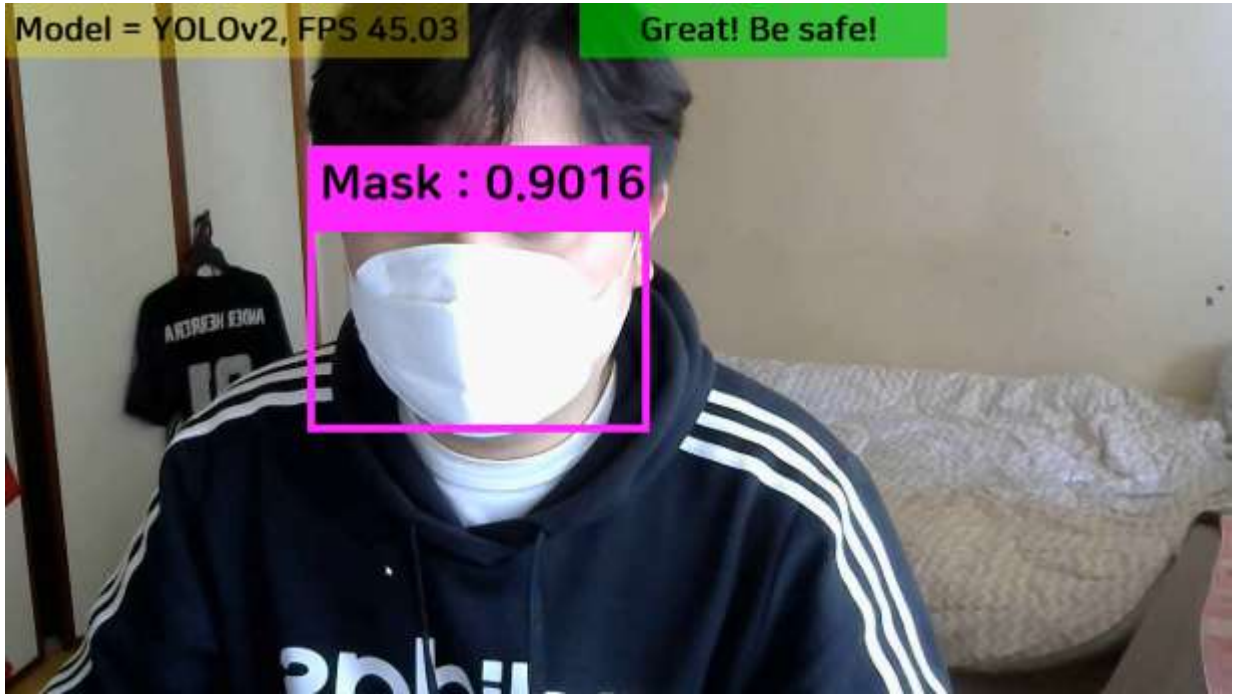
Generate C/C++ CUDA code for acceleration



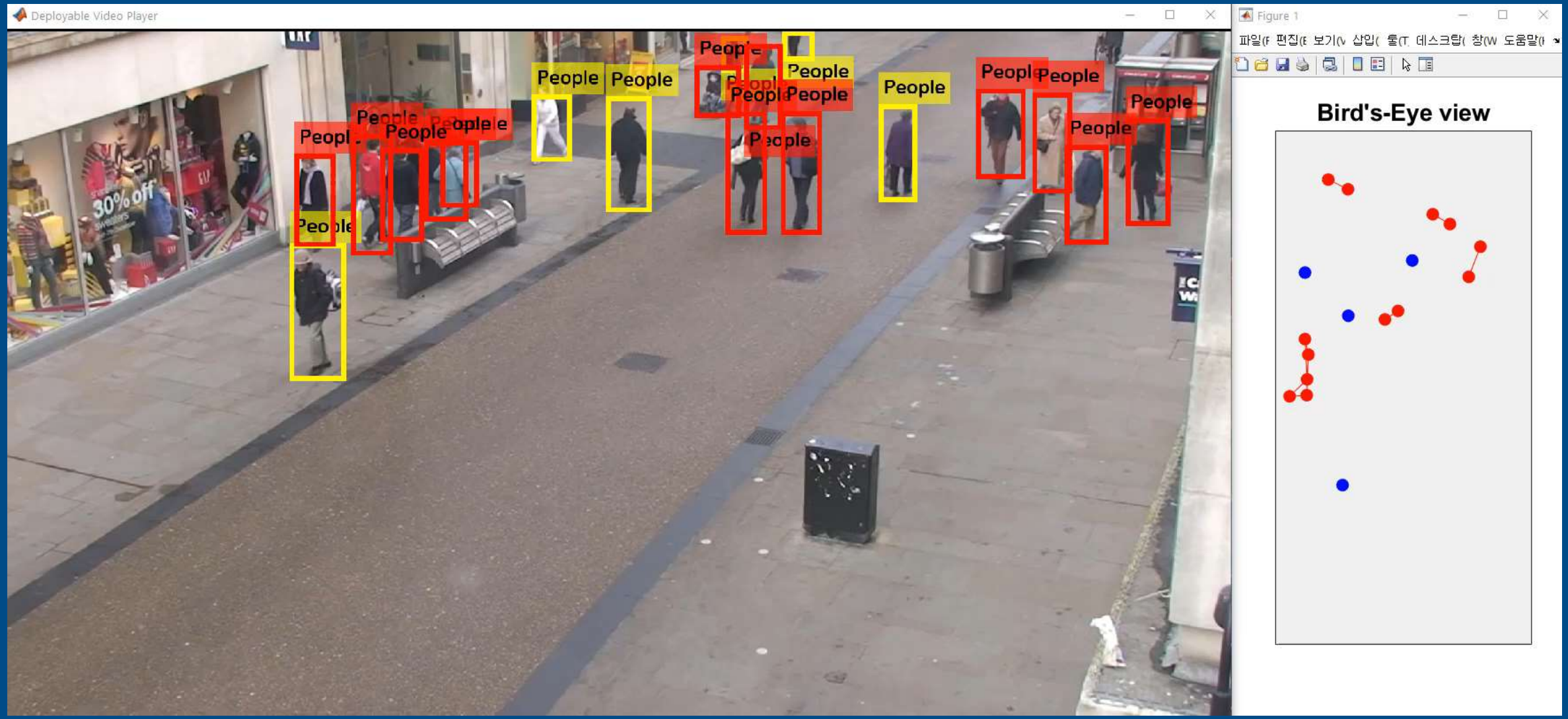
Inference speed comparison

- For Intel i7 CPU, Titan XP external GPU
  - CUDA Mex performs, specifically in this task
    - Approx. 8x Faster than CPU running in MATLAB
    - Approx. 2x Faster than GPU running in MATLAB

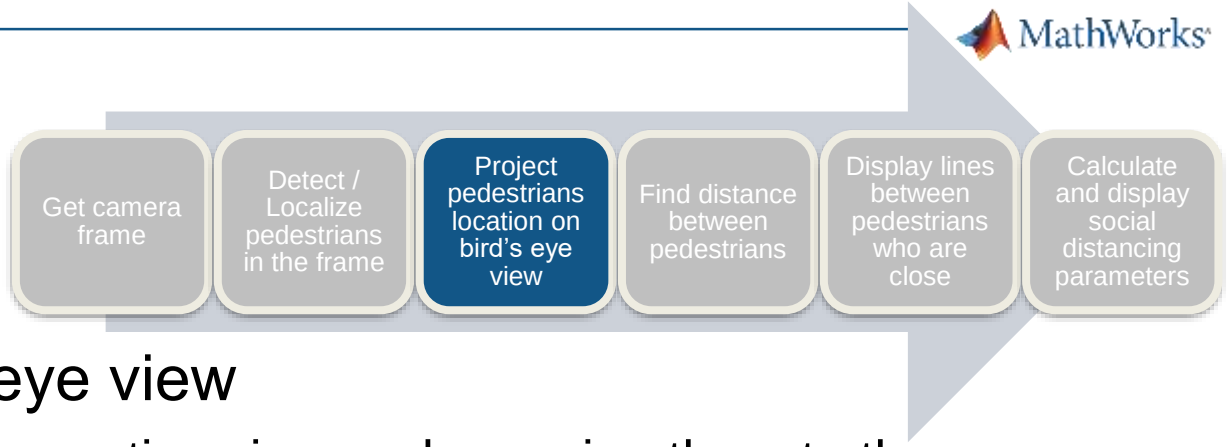




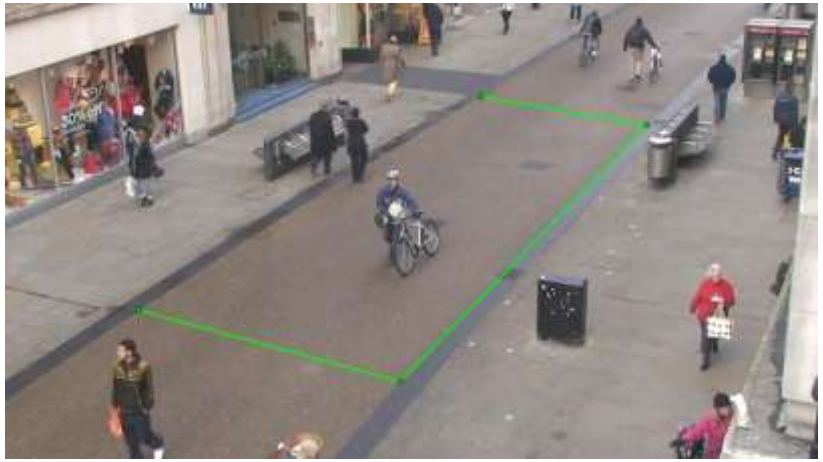
Social distancing detector App



Social Distancing Application



- Project pedestrians location on birds' eye view
  - Calibration, Selecting four points in the perspective view and mapping them to the corners of a rectangle in the bird's-eye view.
  - This assumes that every person is standing on the same flat *ground plane*.

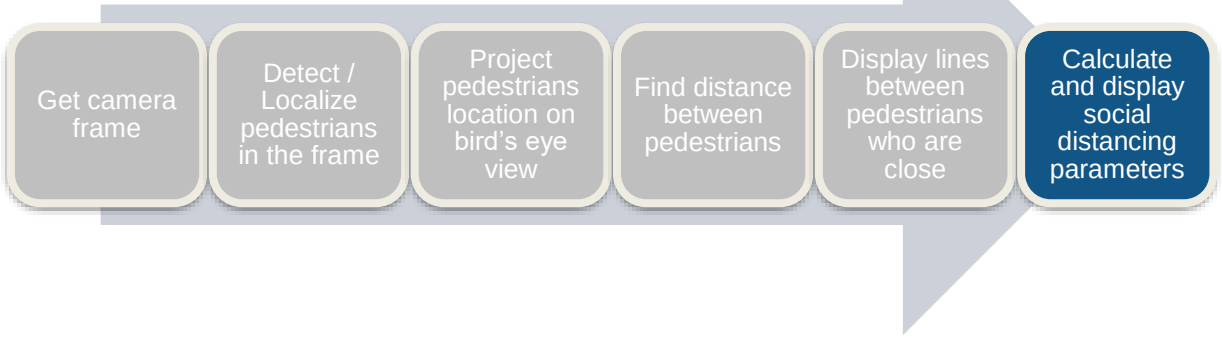


Social distancing detector App

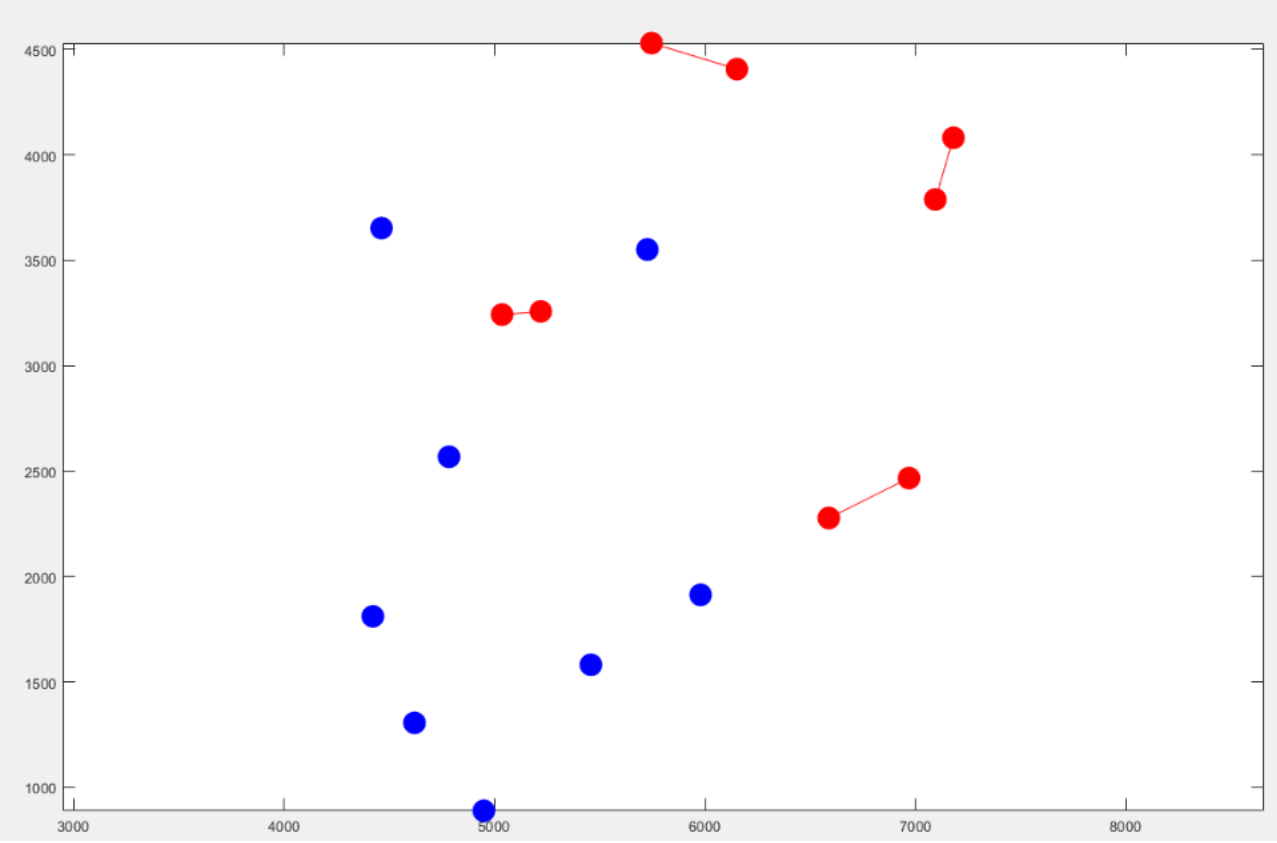
Social Distancing Application

- Detect/Localize pedestrians in the frame
  - Bottom-center point of each person's bounding box

Social Distancing Application



- Display social distancing map
  - Fine tune the threshold of the minimal distance



감사합니다