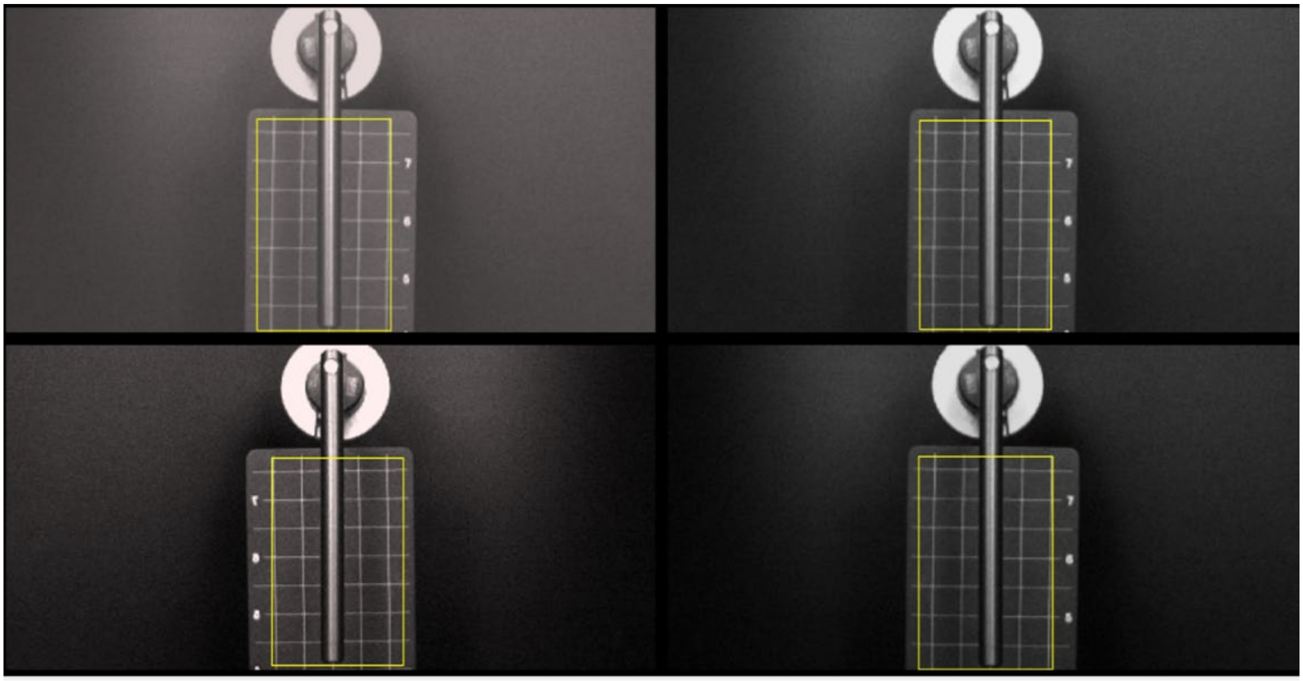
Labeling and gTruth for SSD and YOLO Convolutional State Recognition

- First attempt – recognizing just the ZERO state
- Second attempt – add 3 classes: left, ZERO, right and have it learn basic location of pendulum
- Third attempt – N classes with ZERO, left X degrees, right X degrees
- Best comparison is SSDV1, for cars – included with updates in https://github.com/sbsiewertcsu/ERP/tree/master/MATLAB
- Best MATLAB references:
  - https://www.mathworks.com/help/vision/ug/get-started-with-the-image-labeler.html
  - https://www.mathworks.com/help/vision/ref/imagelabeler-app.html

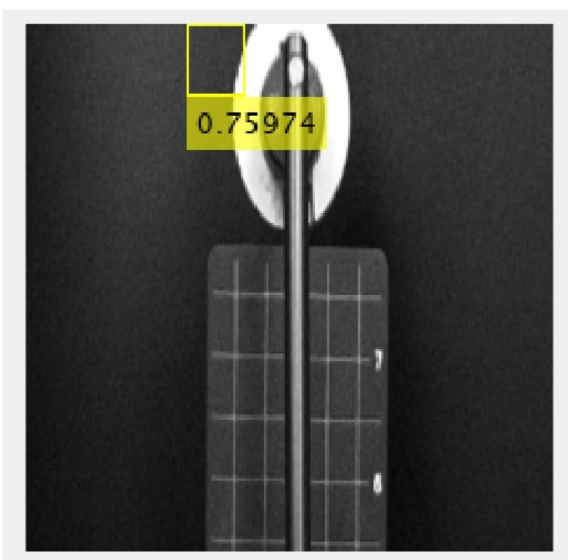
1) Run "imageLabeler" in MATLAB and import PPM 24-bit images, label each state (I just did "zero") and save the session file. Note that you must export a "table" to MATLAB and then save that to a file as "groundTruth" or similar name. The table should look like this:

```
>> SSDV1pend

ans =

  4×2 table

                                  imageFilename                                           zero
    ____________________________________________________________________________    ____________

    {'C:\Users\sbsiewert\Documents\MATLAB\pendTruth\temp-10282022162323-282.ppm'}    {1×4 double}
    {'C:\Users\sbsiewert\Documents\MATLAB\pendTruth\temp-10282022162325-473.ppm'}    {1×4 double}
    {'C:\Users\sbsiewert\Documents\MATLAB\pendTruth\temp-10282022162327-663.ppm'}    {1×4 double}
    {'C:\Users\sbsiewert\Documents\MATLAB\pendTruth\temp-10282022162329-853.ppm'}    {1×4 double}

*************************************************************************
Training an SSD Object Detector for the following object classes:

* zero

Training on single GPU.
Initializing input data normalization.
|=======================================================================================================|
|  Epoch  |  Iteration  |  Time Elapsed  |  Mini-batch  |  Mini-batch  |  Mini-batch  |  Base Learning  |
|         |             |   (hh:mm:ss)   |     Loss     |   Accuracy   |     RMSE     |      Rate       |
|=======================================================================================================|
|       1 |           1 |       00:00:07 |       1.2463 |       57.40% |         1.95 |          0.0010 |
|      17 |          50 |       00:01:53 |       0.0637 |       96.94% |         0.34 |          0.0010 |
|      34 |         100 |       00:03:40 |       0.0417 |       98.13% |         0.28 |          0.0008 |
|      50 |         150 |       00:05:22 |       0.0324 |       98.57% |         0.24 |          0.0008 |
|      67 |         200 |       00:07:21 |       0.0255 |       98.81% |         0.22 |          0.0006 |
|      84 |         250 |       00:09:07 |       0.0265 |       98.93% |         0.22 |          0.0006 |
|     100 |         300 |       00:10:50 |       0.0213 |       99.05% |         0.20 |          0.0005 |
|     117 |         350 |       00:12:36 |       0.0194 |       99.09% |         0.19 |          0.0005 |
|     134 |         400 |       00:14:22 |       0.0194 |       99.16% |         0.19 |          0.0004 |
|     150 |         450 |       00:16:05 |       0.0170 |       99.18% |         0.18 |          0.0004 |
|     167 |         500 |       00:17:54 |       0.0221 |       99.23% |         0.20 |          0.0003 |
|     184 |         550 |       00:19:43 |       0.0184 |       99.24% |         0.18 |          0.0003 |
|     200 |         600 |       00:21:26 |       0.0143 |       99.26% |         0.16 |          0.0003 |
|     217 |         650 |       00:23:13 |       0.0167 |       99.27% |         0.17 |          0.0002 |
|     234 |         700 |       00:25:01 |       0.0166 |       99.30% |         0.17 |          0.0002 |
|     250 |         750 |       00:26:43 |       0.0187 |       99.31% |         0.19 |          0.0002 |
|     267 |         800 |       00:28:29 |       0.0125 |       99.33% |         0.15 |          0.0002 |
|     284 |         850 |       00:30:19 |       0.0140 |       99.34% |         0.16 |          0.0001 |
|     300 |         900 |       00:32:01 |       0.0142 |       99.36% |         0.16 |          0.0001 |
|=======================================================================================================|
Detector training complete.
*************************************************************************

>>
```

The input was this (lighting adjusted to make it generalize to different conditions):



The test image claims 75.974% confidence, but boxes an odd location?



2) Download MATAB and run on your machine to get familiar with code – the path problem we saw is the gTruth data paths, which are generated by imageLabler – I would load the "*session.mat" files and Export gTruth as a "table" in your environment
    a. Perhaps there is a better solution to the gTruth pathing issue, but I do not know how to change – this work-around has worked for the group so far
    b. Otherwise, the data can just be unzipped in place as long as the paths in gTruth match where the files are

3) Had to recall how we made the cow gTruth – we really somehow made “cowDatasetGroundTruth.mat”, which can be imported by just double clicking and becomes “gTruth” as a MATLAB variable.
    a. We repeated this for eleDatasetGroundTruth.mat and it works the same.
    b.
    c. This was based on vehicleDatasetGroundTruth.mat, the starting example.
4) gTruth table should be loaded

SSD Network Configuration:
https://www.mathworks.com/help/vision/ref/ssdlayers.html

Best references on network configuration:
- https://www.mathworks.com/help/vision/ug/getting-started-with-ssd.html
- https://www.mathworks.com/help/deeplearning/ref/vgg16.html - much simpler than resnet50
- https://www.mathworks.com/help/deeplearning/ug/train-deep-learning-network-to-classify-new-images.html
- https://www.mathworks.com/help/deeplearning/ug/train-residual-network-for-image-classification.html

Training:
https://www.mathworks.com/help/vision/ref/trainssdobjectdetector.html

Most likely want multi-class detector with classes that include zero offset left and right be specific angles.

MATLAB Deep Learning Examples (Original)

1. SSD - https://www.mathworks.com/help/vision/ug/object-detection-using-single-shot-detector.html

```
openExample('deeplearning_shared/ObjectDetectionUsingSSDDeepLearningExample')
```

2. RCNN - https://www.mathworks.com/help/vision/ug/object-detection-using-faster-r-cnn-deep-learning.html

```
openExample('deeplearning_shared/DeepLearningFasterRCNNObjectDetectionExample'
)
```

3. YOLO V2 - https://www.mathworks.com/help/vision/ug/train-yolo-v2-network-for-vehicle-detection.html

```
openExample('vision/TrainYOLOV2NetworkForVehicleDetectionExample')
```

4. YOLO V3 - https://www.mathworks.com/help/vision/ug/object-detection-using-yolo-v3-deep-learning.html

```
openExample('deeplearning_shared/ObjectDetectionUsingYOLOV3DeepLearningExample
')
```

```
doTraining = true;
```

```
C:\Program Files\MATLAB\R2020a\examples\deeplearning_shared\data
```

vehicleDatasetGroundTruth.mat	1/7/2019 10:38 AM	Microsoft Access ...	5 KB
vehicleDatasetImages.zip	1/7/2019 10:38 AM	Compressed (zipp...	3,577 KB

We need new GroundTruth and new DatasetImages for our objects of interest.

https://www.mathworks.com/help/deeplearning/ug/data-sets-for-deep-learning.html

Vehicle

The Vehicle data set consists of 295 images containing one or two labeled instances of a vehicle. This small data set is useful for exploring the YOLO-v2 training procedure, but in practice, more labeled images are needed to train a robust detector.

The images are of size 720-by-960-by-3.

Extract the Vehicle data set. Set `dataFolder` to the location of the data.

```
filename =
'vehicleDatasetImages.zip';

dataFolder =
fullfile(tempdir,'vehicleImages');
if ~exist(dataFolder,'dir')
    unzip(filename,tempdir);
end
```

Load the data set as a table of file names and bounding boxes from the extracted MAT file and convert the file names to absolute file paths.

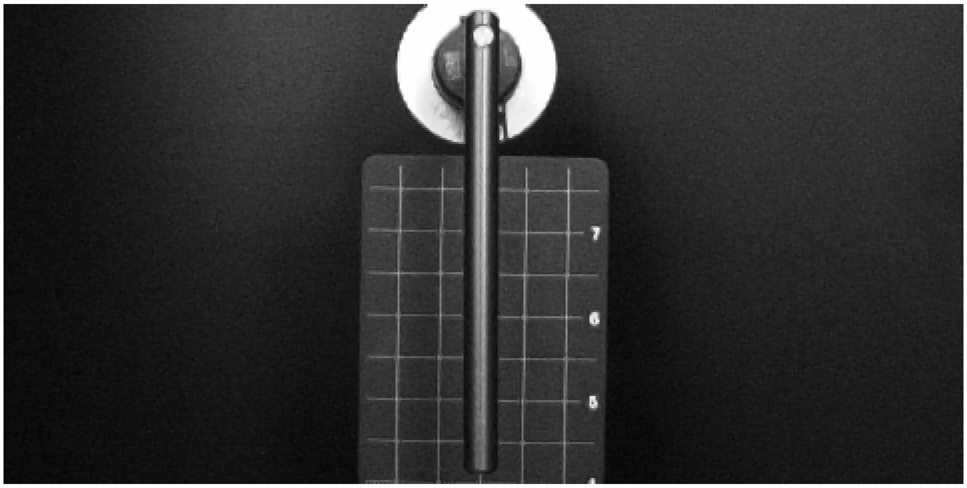
```
data =
load('vehicleDatasetGroundTruth.mat
');
vehicleDataset =
data.vehicleDataset;

vehicleDataset.imageFilename =
fullfile(tempdir,vehicleDataset.ima
geFilename);
```

Create an image datastore containing the images and a box label datastore containing the bounding boxes using the `imageDatastore` and `boxLabelDatastore` functions, respectively. Combine the resulting datastores using the `combine` function.

```
filenamesImages =
vehicleDataset.imageFilename;
tblBoxes =
vehicleDataset(:,'vehicle');

imds =
imageDatastore(filenamesImages);
blds = boxLabelDatastore(tblBoxes);

cds = combine(imds,blds);
```

For an example showing how to process this data for deep learning, see [Object Detection Using YOLO v2 Deep Learning].

For the Pendulum (Synchronome) the images were capture with the FLIR high speed camera in PGM format and look like this:



For the resnet50 Deep Learning architecture, they must be converted into 24-bit PPM grayscale done with:

```
images = 'C:\Users\siewerts\Documents\MATLAB\pendTruth\PGM';
pgmfiles=dir(fullfile(images, '\*.pgm*'));
cd C:\Users\siewerts\Documents\MATLAB\pendTruth\PGM

fullFileName = fullfile(theFiles(k).folder, baseFileName);

for i=1:length(pgmfiles)
imshow(pgmfiles(i).name)
end

% this is a 256x256x1 grayscale image
gimage = imread(pgmfiles(i).name);

% this is a 256x256x3 grayscale image
cimage = repmat(gimage,[1 1 3]);


for i=1:length(pgmfiles)
pgmfullfile=fullfile(pgmfiles(i).folder, pgmfiles(i).name);
gimage = imread(pgmfullfile);
cimage = repmat(gimage,[1 1 3]);
imshow(cimage)
end

ppmfiles=pgmfiles;

for i=1:length(pgmfiles)
pgmfiles(i).name
end

for i=1:length(pgmfiles)
```

```
ppmfiles(i).name(length(pgmfiles(i).name)-1)='p';
%length(pgmfiles(i).name)
end


for i=1:length(ppmfiles)
ppmfiles(i).name
length(pgmfiles(i).name)
end

for i=1:length(pgmfiles)
pgmfullfile=fullfile(pgmfiles(i).folder, pgmfiles(i).name);
gimage = imread(pgmfullfile);
cimage = repmat(gimage,[1 1 3]);
cimagefullfile=fullfile('C:\Users\siewerts\Documents\MATLAB\pendTruth\PGM24',
ppmfiles(i).name);
imshow(cimage)
imwrite(cimage, cimagefullfile);
end
```

MATLAB version and toolboxes used

```
>> ver

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MATLAB Version: 9.8.0.1451342 (R2020a) Update 5

MATLAB License Number: 40937346

Operating System: Microsoft Windows 10 Pro Version 10.0 (Build 18362)

Java Version: Java 1.8.0_202-b08 with Oracle Corporation Java HotSpot(TM) 64-Bit Server VM mixed mode

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MATLAB                                                Version 9.8         (R2020a)

Simulink                                              Version 10.1        (R2020a)

Aerospace Blockset                                    Version 4.3         (R2020a)

Aerospace Toolbox                                     Version 3.3         (R2020a)

Automated Driving Toolbox                             Version 3.1         (R2020a)

Computer Vision Toolbox                               Version 9.2         (R2020a)

Control System Toolbox                                Version 10.8        (R2020a)

DSP System Toolbox                                    Version 9.10        (R2020a)

Deep Learning Toolbox                                 Version 14.0        (R2020a)

Embedded Coder                                        Version 7.4         (R2020a)

GPU Coder                                             Version 1.5         (R2020a)

Image Acquisition Toolbox                             Version 6.2         (R2020a)

Image Processing Toolbox                              Version 11.1        (R2020a)

MATLAB Coder                                          Version 5.0         (R2020a)

Parallel Computing Toolbox                            Version 7.2         (R2020a)

Partial Differential Equation Toolbox                 Version 3.4         (R2020a)
```

```
ROS Toolbox                                          Version 1.1         (R2020a)

Robotics System Toolbox                              Version 3.1         (R2020a)

Sensor Fusion and Tracking Toolbox                   Version 1.3         (R2020a)

Signal Processing Toolbox                            Version 8.4         (R2020a)

Statistics and Machine Learning Toolbox              Version 11.7        (R2020a)

Symbolic Math Toolbox                                Version 8.5         (R2020a)

Vehicle Dynamics Blockset                            Version 1.4         (R2020a)

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```