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WHAT'S NEW IN ENVI DEEP LEARNING 1.2

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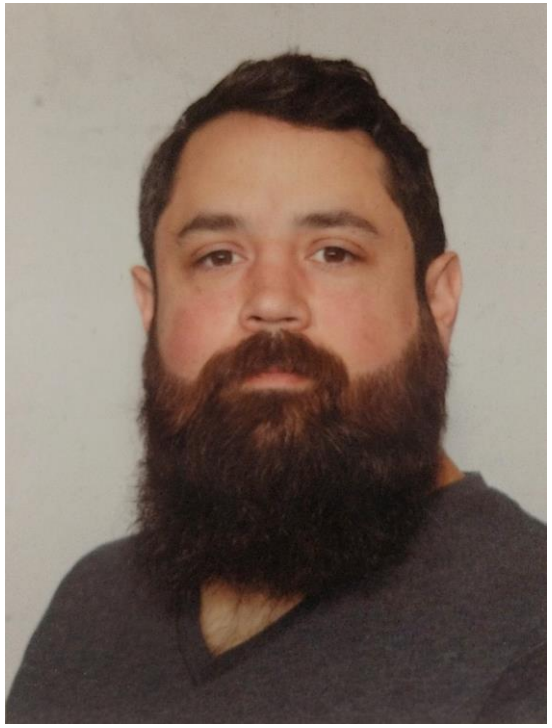
Contact Information and Introductions



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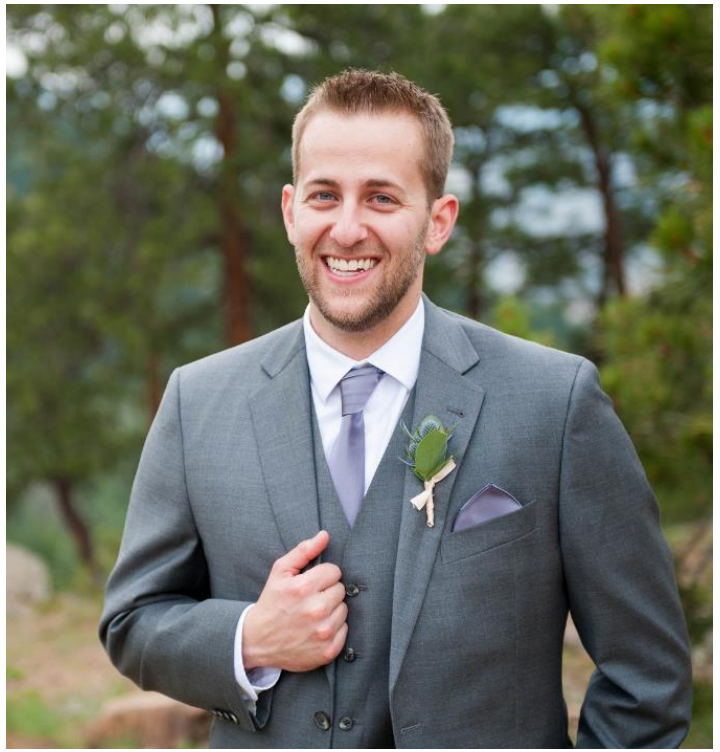

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Agenda

ENVI Deep Learning Overview

What is Object Detection?

ENVI Deep Learning: Object Detection Workflow

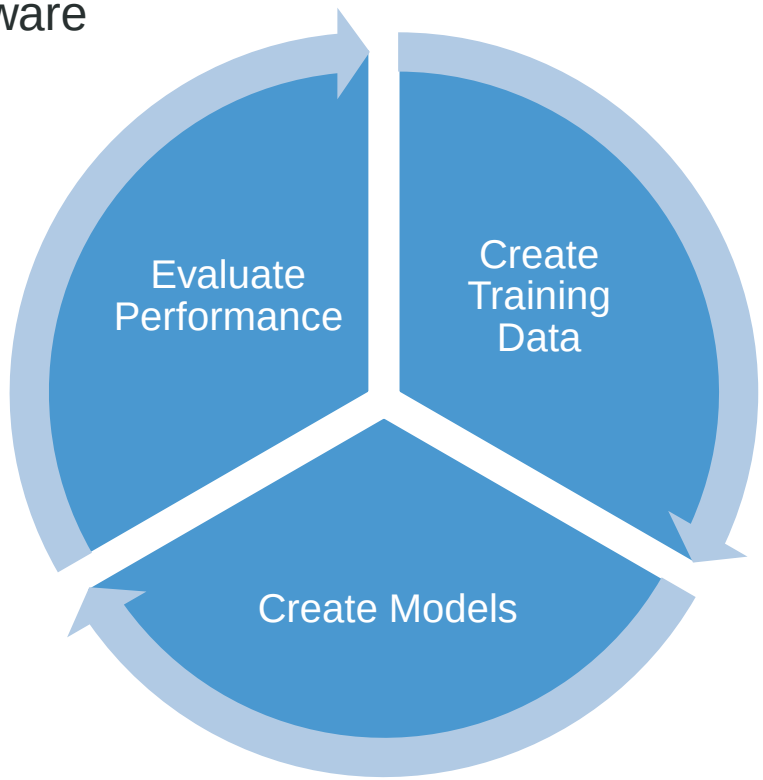
Examples and Use Cases

Object Detection vs. Pixel Classification

Questions and Discussion

ENVI Deep Learning Recap

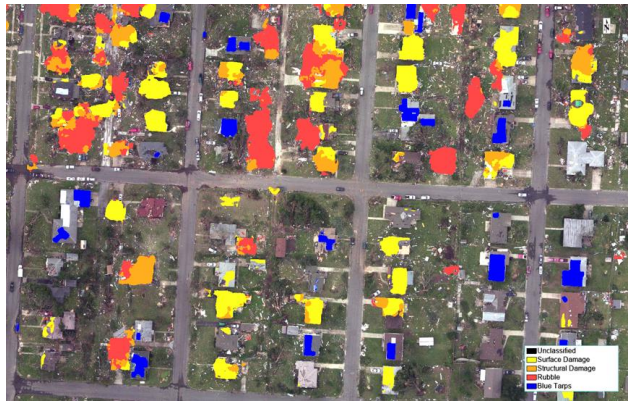
Applied deep learning for geospatial imagery in ENVI, the leading remote sensing and image analysis software



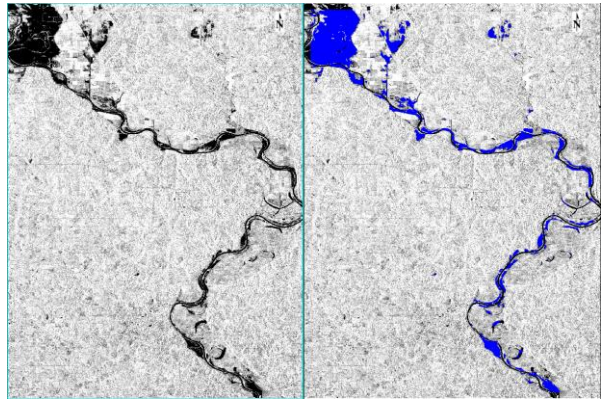
Deep learning workflow in ENVI, built on TensorFlow and Keras

<u>Without</u> needing to program, the capabilities include:

- Segmentation (i.e. cloud masking)
- Linear feature extraction (i.e. roads)
- Support for nearly any image format and data modality



Assess building damage after hurricanes and tornadoes



Automated flood detection using SAR

Hardware and Software Requirements

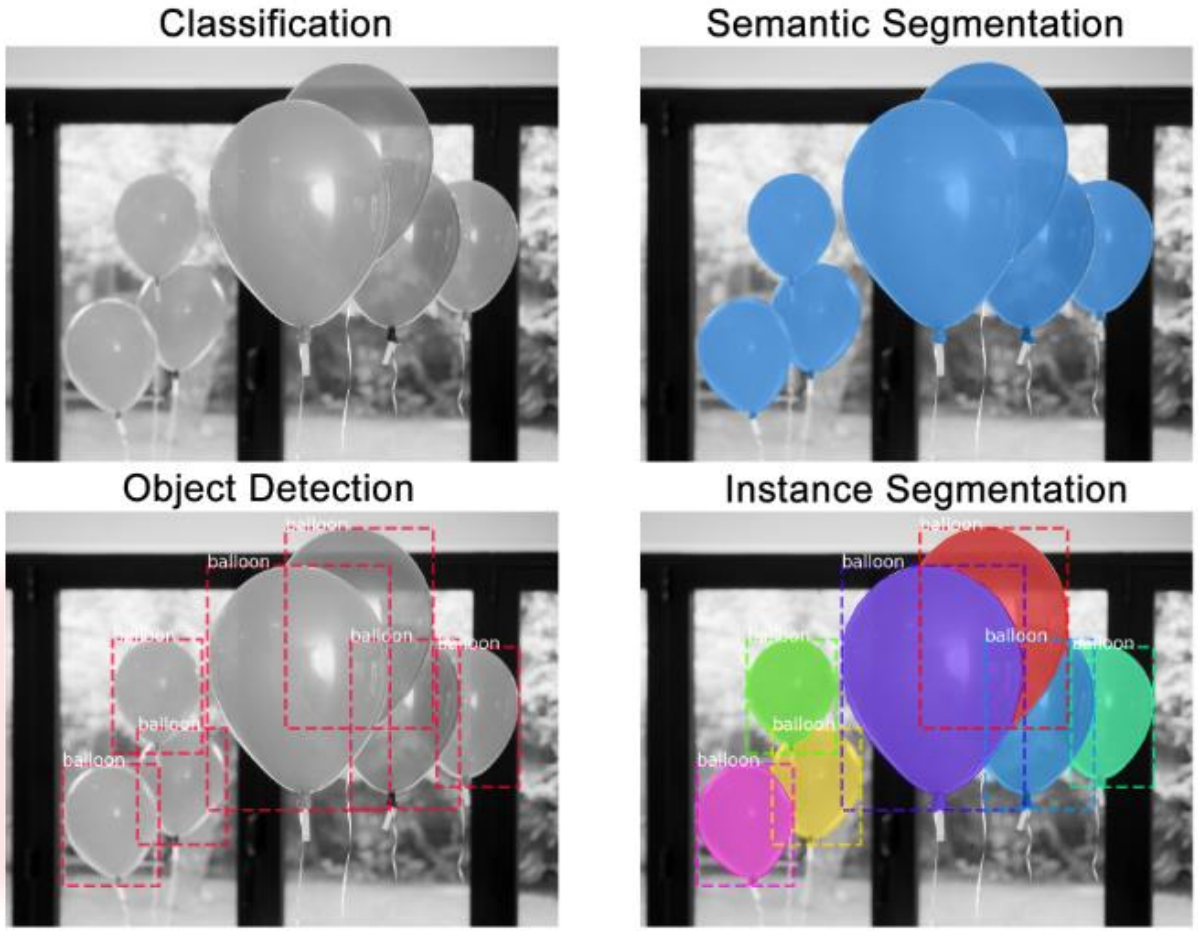
ENVI 5.6.1 is needed for DL 1.2

NVIDIA GPU card with CUDA® Compute Capability 3.5 or higher
https://developer.nvidia.com/cuda-gpus

CUDA 11 is required for the latest version of ENVI Deep Learning

Minimum 8GB of GPU RAM recommended

What is Object Detection?



ENVI Deep Learning 1.2
Returns geometry (bounding box) for features and detections are allowed to overlap

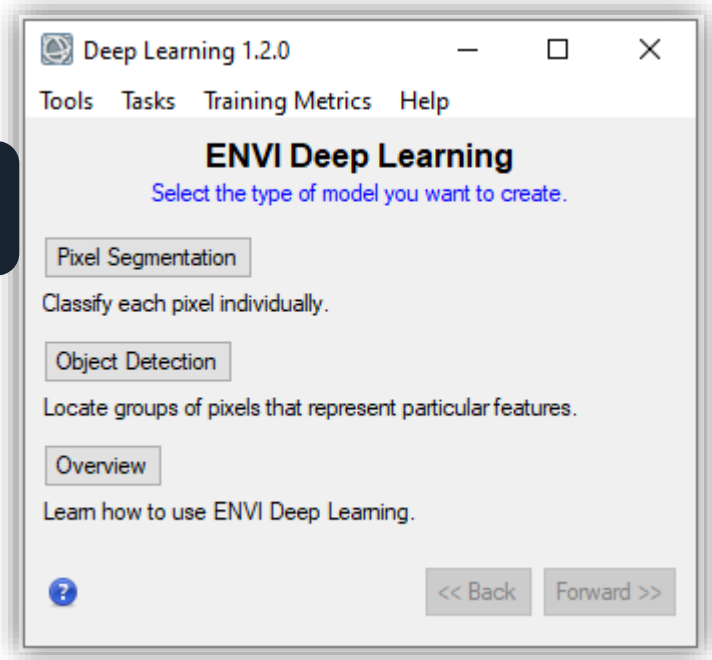
ENVI Deep Learning
Pixels are classified, post processing can extract features if they don't touch

Not in ENVI Deep Learning
Returns geometry (polygon) for features and detections are allowed to overlap

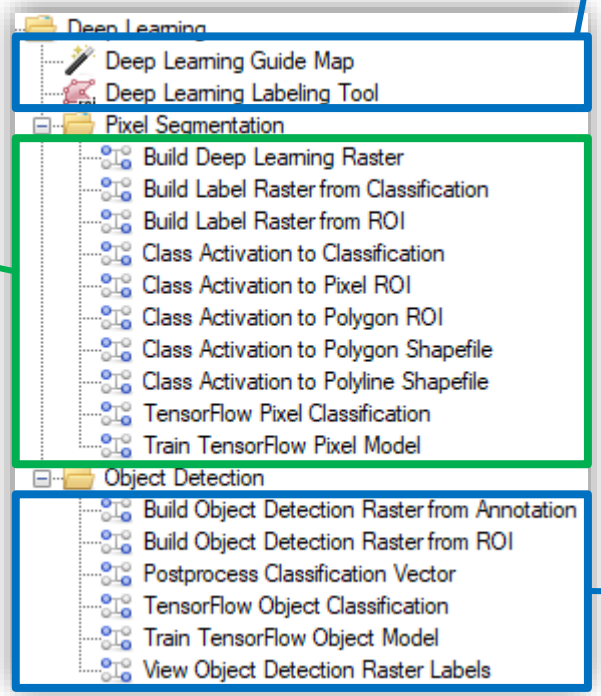
Image source: https://medium.com/onepanel/instance-segmentation-with-mask-r-cnn-and-tensorflow-on-onepanel-6a072a4273dd

ENVI Deep Learning 1.2 Toolbox

Several tools updated for object detection

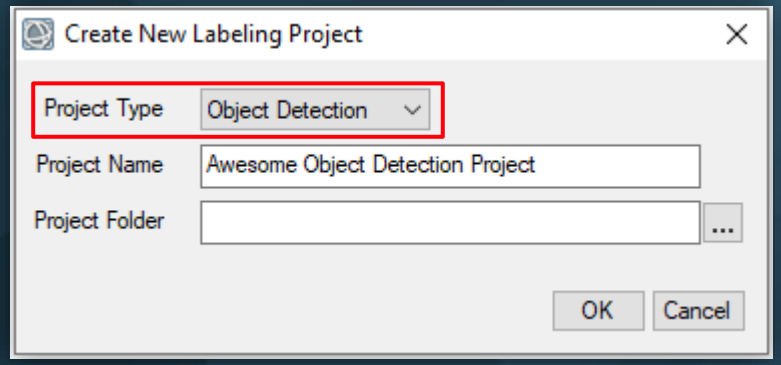


Existing capabilities have been moved under “Pixel Segmentation”



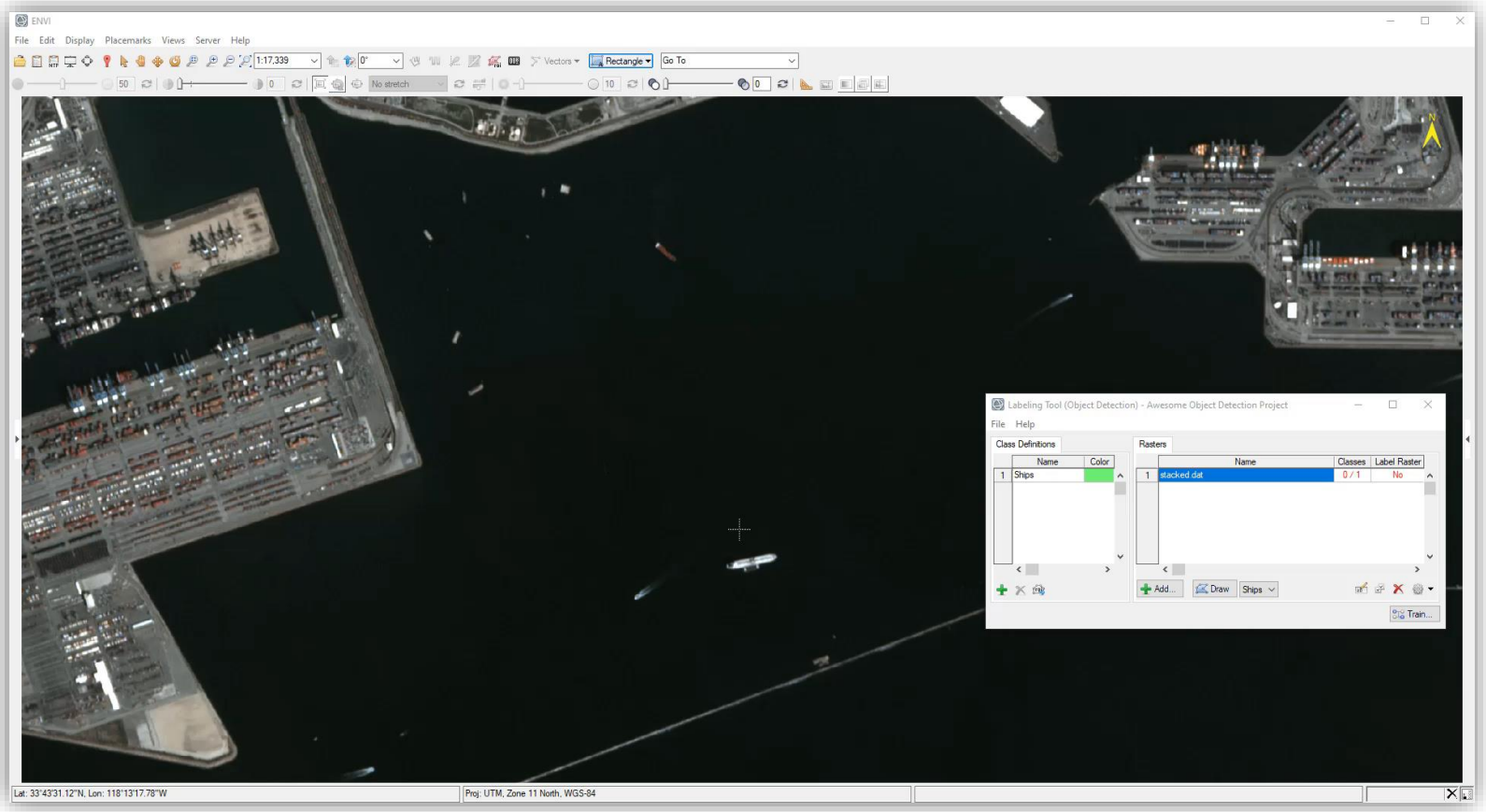
New tools for object detection

Labeling Tool



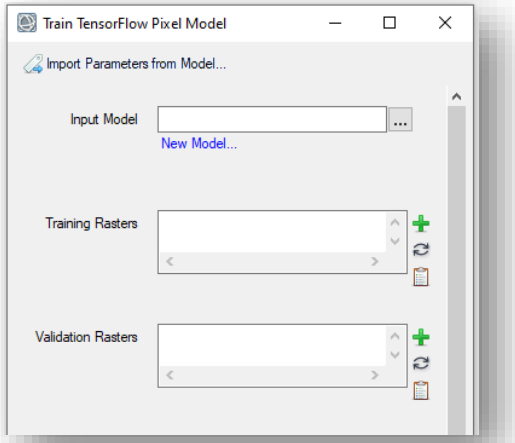
When you create a new project using the Deep Learning Labeling Tool, there is a new setting to indicate whether you are labeling data for “Pixel Classification” or “Object Detection”

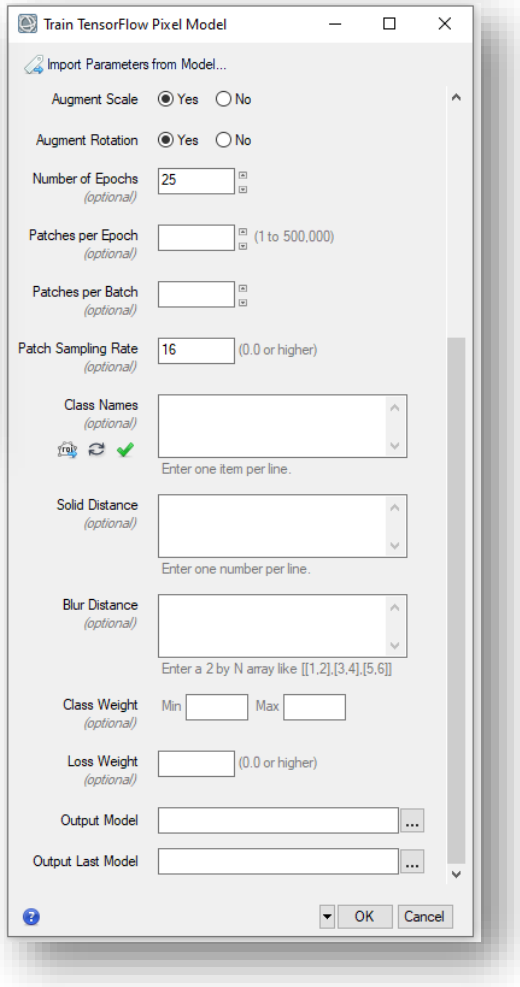
A short video showing the Labeling Tool being used to identify ships for an object detection model



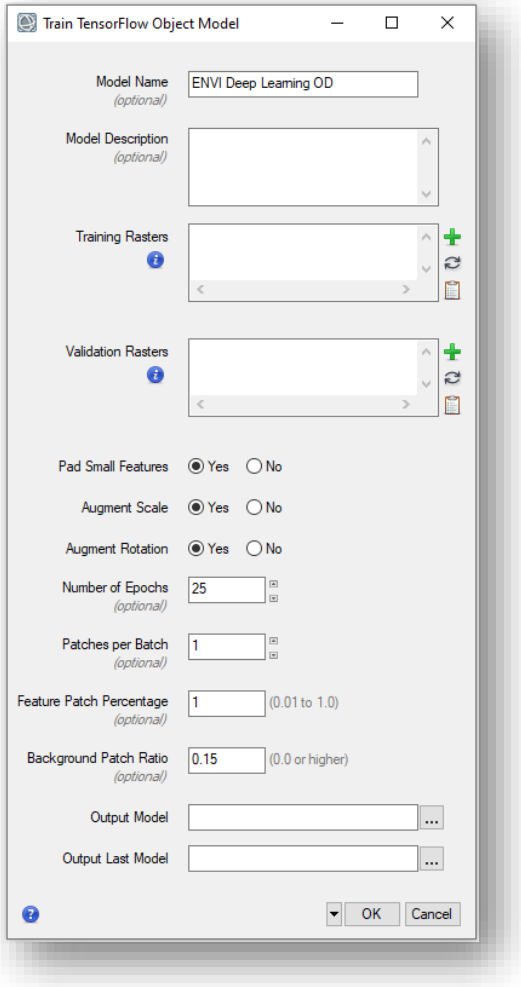
Training: Pixel Classification vs Object Detection

Pixel Classification (UNet)





Object Detection



Object Detection Training Parameters

Model creation is a part of the training process and no longer requires an extra step.

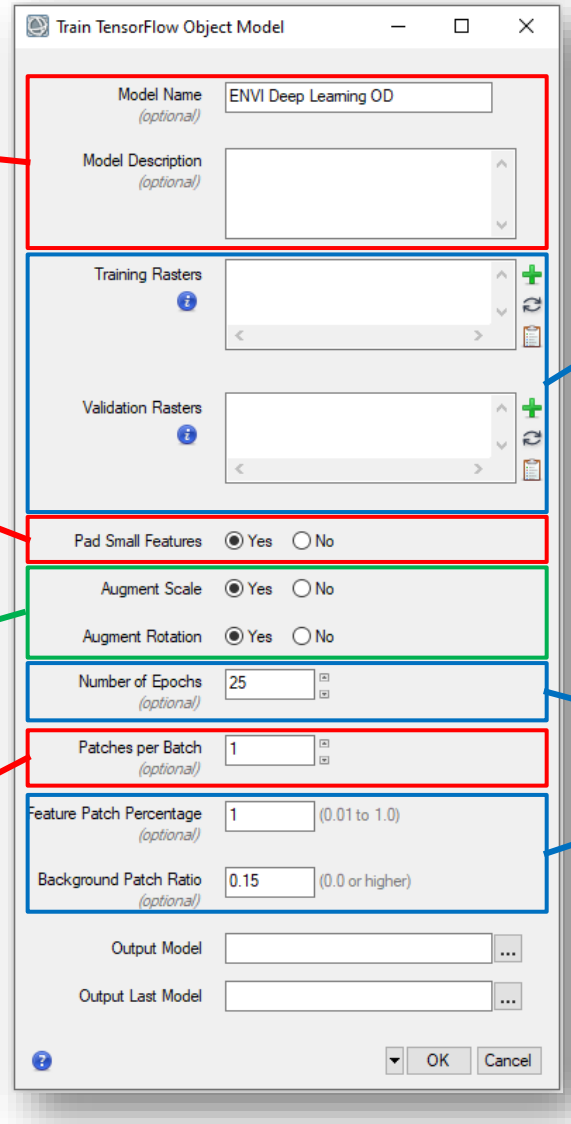
Pre-trained weights are used for all models

For features/labels less than 25 pixels in size, increase size to 25 pixels

Augmentation during training is the same as before

Patches per batch is *not* auto-calculated as before.

You can use 4-5 for a GPU with 8 GB or RAM



Training and validation data is the same as before

Parameters to control training.

For object detection, you don't specify the number of training steps as this is done for you based on your training data.

This means object detectors train using *all* of your labels

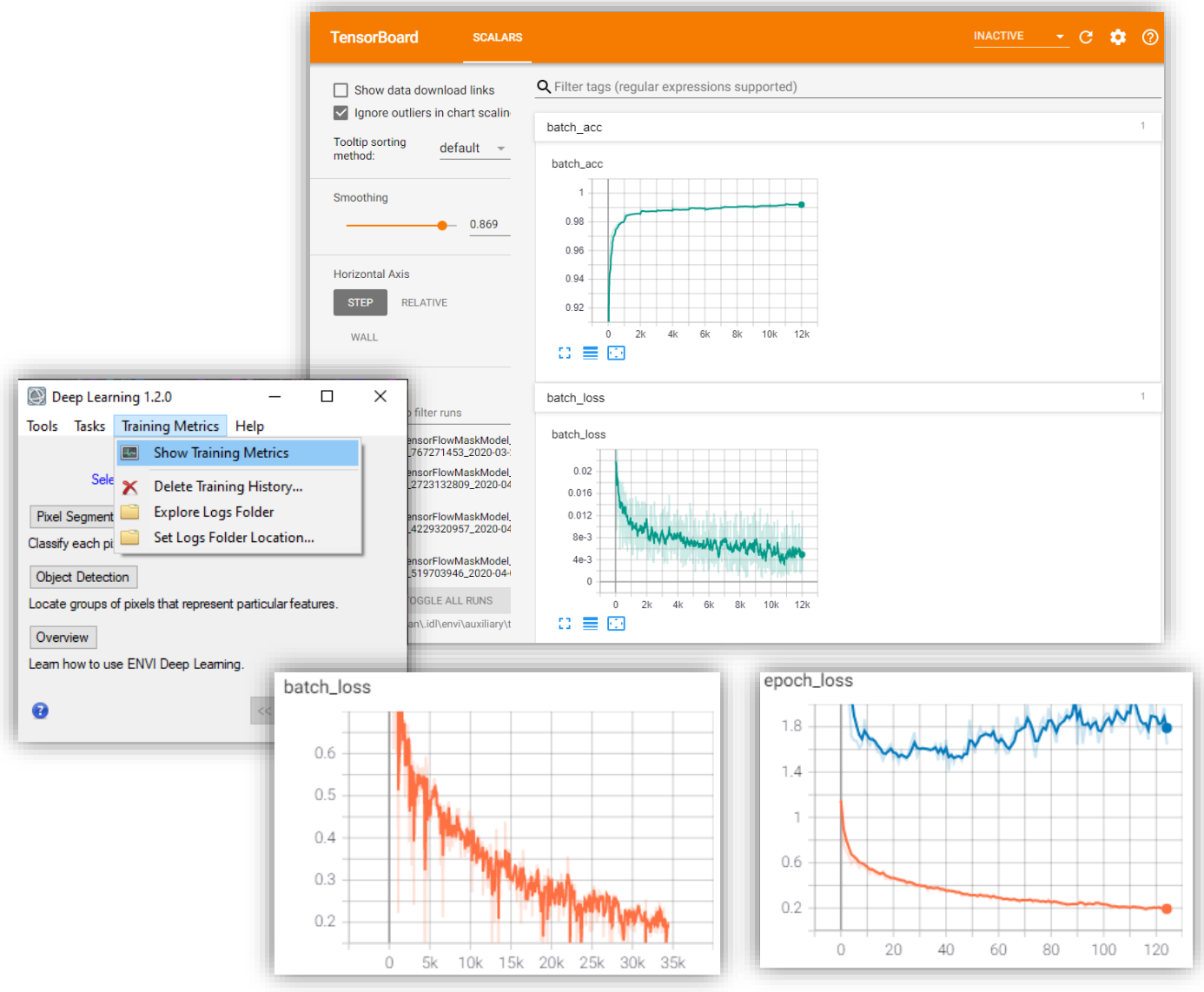
TensorBoard Integration

TensorBoard is a tool for visualizing the performance of your neural networks during and after training

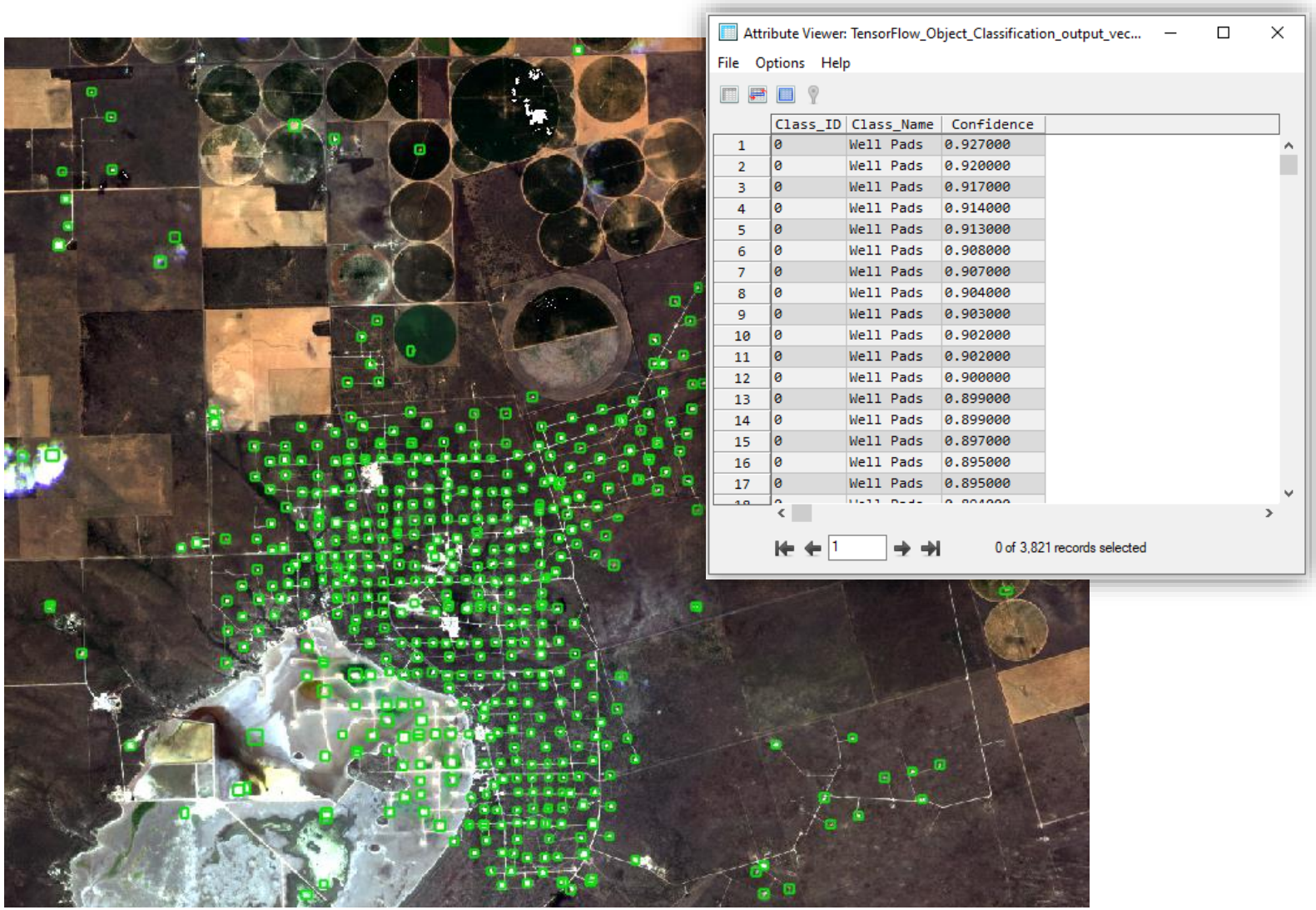
Logs for object detection are reset each training session

Only loss is reported for object detection

Loss around 0.2 indicates a model is converging well



Object Detection: Results and Attributes



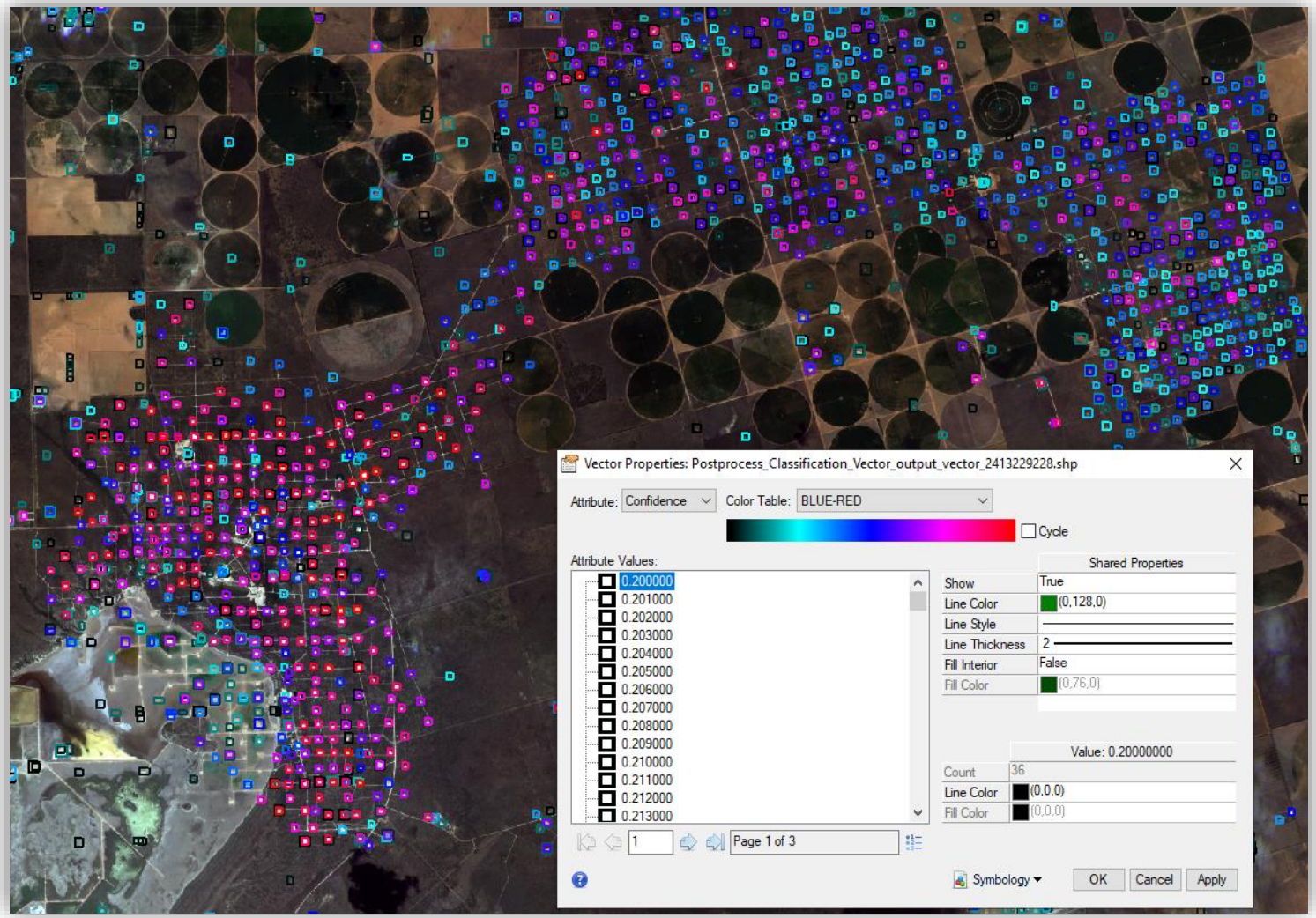
Classification results:

- Provided as a vector (shapefile) with class information and confidence (probability)
- When displayed in ENVI, features will have their class color applied
- Shapefiles are used for all outputs, even when images are not georeferenced

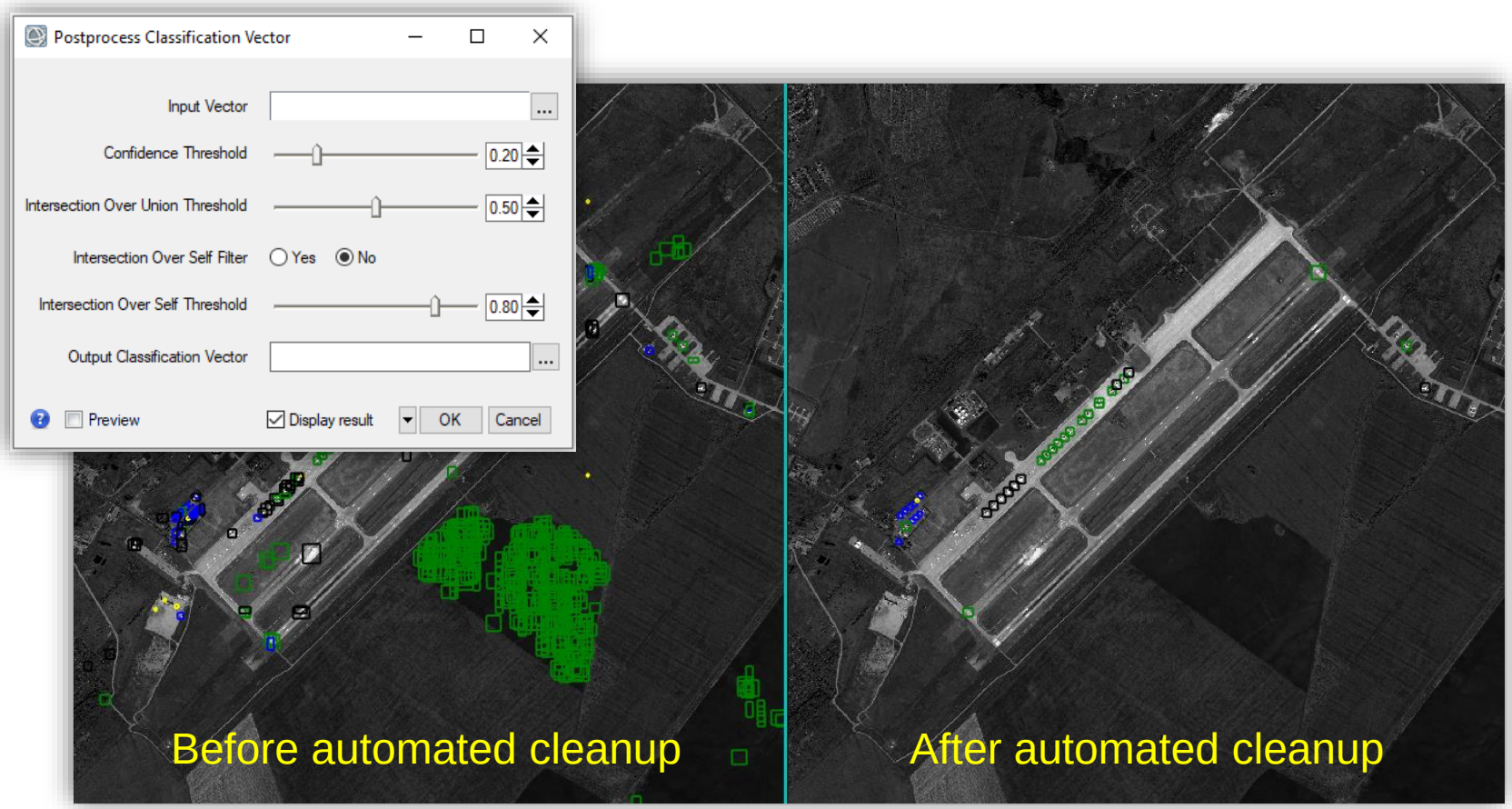
Examining Detections

Fun fact: when you are viewing the outputs of object detection in ENVI, you can colorize the vector data by the confidence of detects.

This is a great tool to quickly gauge the performance of models and see where low-probability detects are found.



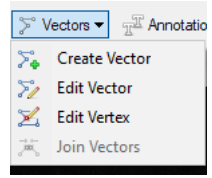
Cleaning Up Results



Before and after results using the new “Postprocess Classification Vector” task

Once you have classified an image, there are two options to cleanup results:

1. Use the “Postprocess Classification Vector” to filter detections based on confidence, IoU, and optionally intersection
2. Within ENVI, you can use the vector editing tool to add or remove features



Easy-to-use ENVI API

Custom Data Preprocessing

```
;process and generate labels
foreach file, process, fIdx do begin
  print, fIdx
  ;build the output filename
  outRaster = file.replace('_metadata.xml', '_labels.dat')
  if file_test(outRaster) then begin
    labelRasters.add, e.openRaster(outRaster)
    continue
  endif

  ;get the ROI file
  roiFile = labels[fIdx]

  ;open everything
  roi = e.openROI(roiFile)
  rasters = e.openRaster(file)

  ;normalize
  norm = ENVILinearRangeStretchRaster(rasters[1], MIN=0, MAX=10000)

  ;build the label raster
  task = ENVITask('BuildLabelRasterFromROI')
  task.INPUT_RASTER = norm
  task.INPUT_ROI = roi
  task.OUTPUT_RASTER_URI = outRaster
  task.execute

  ;clean up and save
  norm.close
  foreach r, rasters do r.close
  foreach r, roi do r.close
  labelRasters.add, e.openRaster(outRaster)
endforeach
```

Classifier Generation

```
; create our task
task = ENVITask('TrainTensorflowObjectModel')

; specify training time
task.EPOCHS = epochs
task.FEATURE_PATCH_PERCENTAGE = dataPerEpoch
task.BACKGROUND_PATCH_RATIO = bpr

; set some properties for our project
task.MODEL_NAME = 'Crosswalks'
task.MODEL_DESCRIPTION = 'Crosswalks from aerial data'

; set our rasters
task.TRAINING_RASTERS = training
task.VALIDATION_RASTERS = validation
task.PATCHES_PER_BATCH = patchesPerBatch

; set our outputs
task.OUTPUT_MODEL_URI = bestUri
task.OUTPUT_LAST_MODEL_URI = lastUri

; execute
task.execute
```

Creating Custom Training Data

```
; create our ROI, let ENVI handle colors
roi = ENVIROI(NAME = "Airplane")

; buffer around points, pixels
buffer = 20

; add all of our features to the ROI
foreach point, points do begin
  ; make a polygon bounding box from our points
  roi.AddGeometry, [ $
    [point[0]-buffer, point[1]-buffer],$
    [point[0]-buffer, point[1]+buffer],$
    [point[0]+buffer, point[1]+buffer],$
    [point[0]+buffer, point[1]-buffer],$
    [point[0]-buffer, point[1]-buffer]],$
    /POLYGON
endforeach

; get our task to make an object detection raster
Task = ENVITask('BuildObjectDetectionRasterFromROI')

; specify our inputs
Task.INPUT_RASTER = e.openRaster("C:\some\file.dat")
Task.INPUT_ROI = [roi]

; run
Task.Execute
```

Recommended

When the out-of-the-box tools for data preparation are not enough, you have several options via the ENVI API to choose from to get your data in the right format.

Out-of-the-box tools allow you to create training data from ROIs, annotations, and vectors (after conversion to ROIs)

Advanced usage

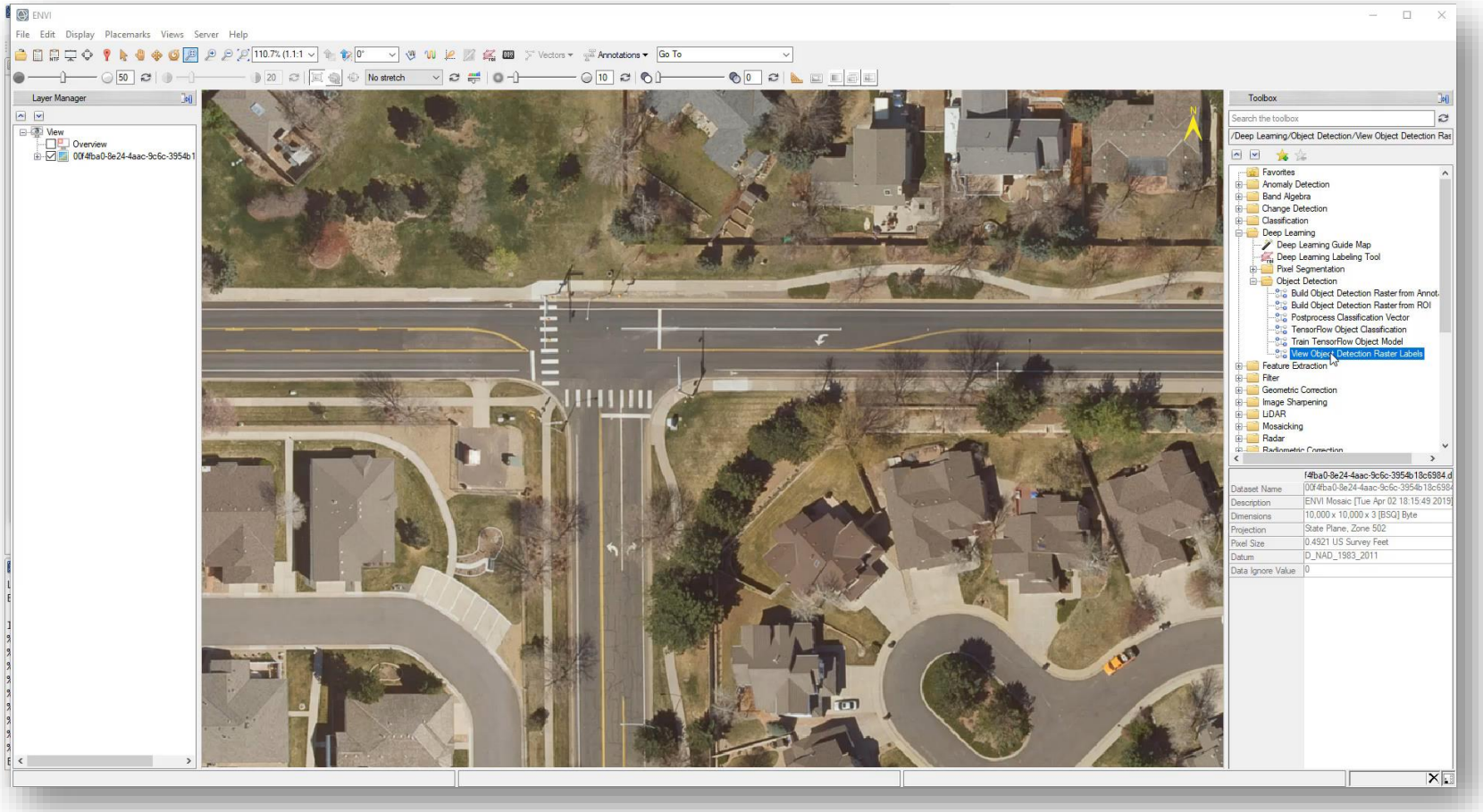
```
; specify class information
names = list("Airplane", "Helicopter", "Fighter Jet")
colors = list([255, 0, 0], [0, 255, 0], [0, 0, 255])

; specify some training data
boxes = ... ; [nBoxes, 4] array of [xmin, ymin, xmax, ymax] pixel coordinates
classes = ... ; [nBoxes] array of classes, zero-based

; make bounding box set
objBox = ENVIBoundingBoxSet()

; add our classes to the bounding box set
foreach name, names, idx do $
    objBox.AddClass, CLASS=idx, LABEL=name, COLOR=colors[idx]

; process each bounding box
foreach class, classes, idx do begin
    ; unpack the bbox
    bbox = boxes[*,idx] ; [xmin, ymin, xmax, ymax]

    ; convert extent to [2,5] bbox:
    ;   [[Upper Left XY],
    ;    [Upper Right XY],
    ;    [Lower Right XY],
    ;    [Lower Left XY],
    ;    [Upper Left XY]]
    bbox = reform([bbox[[0,1]], bbox[[0,3]], $
        bbox[[2,3]], bbox[[2,1]], bbox[[0,1]]], [2,5])

    ; add to our training data
    objBox.AddBoundingBox, CLASS=0, BOUNDING_BOX=bbox
endforeach

; make GeoJSON
geoJSON = objBox.GetGeoJSON()

; update and add metadata fields
meta = myRaster.METADATA
meta['dlobjectbounds'] = ENVIDeepLearningObjectDetectionRaster.Encode(geoJSON)
meta['dlclassnames'] = names.toArray() ; 1D array
meta['dlclasscolors'] = colors.toArray() ; 1D*3 array
myRaster.WriteMetadata
```

Verifying Custom Training Data

Use the "**View Object Detection Raster Labels**" tool to verify your bounding boxes are correct before training

Important note!

There is an ENVI bug you may encounter while using this tool. It will be fixed in the next release of ENVI (likely Q1 2022)



Object Detection Examples

Aircraft Detection

Data Source: WorldView panchromatic

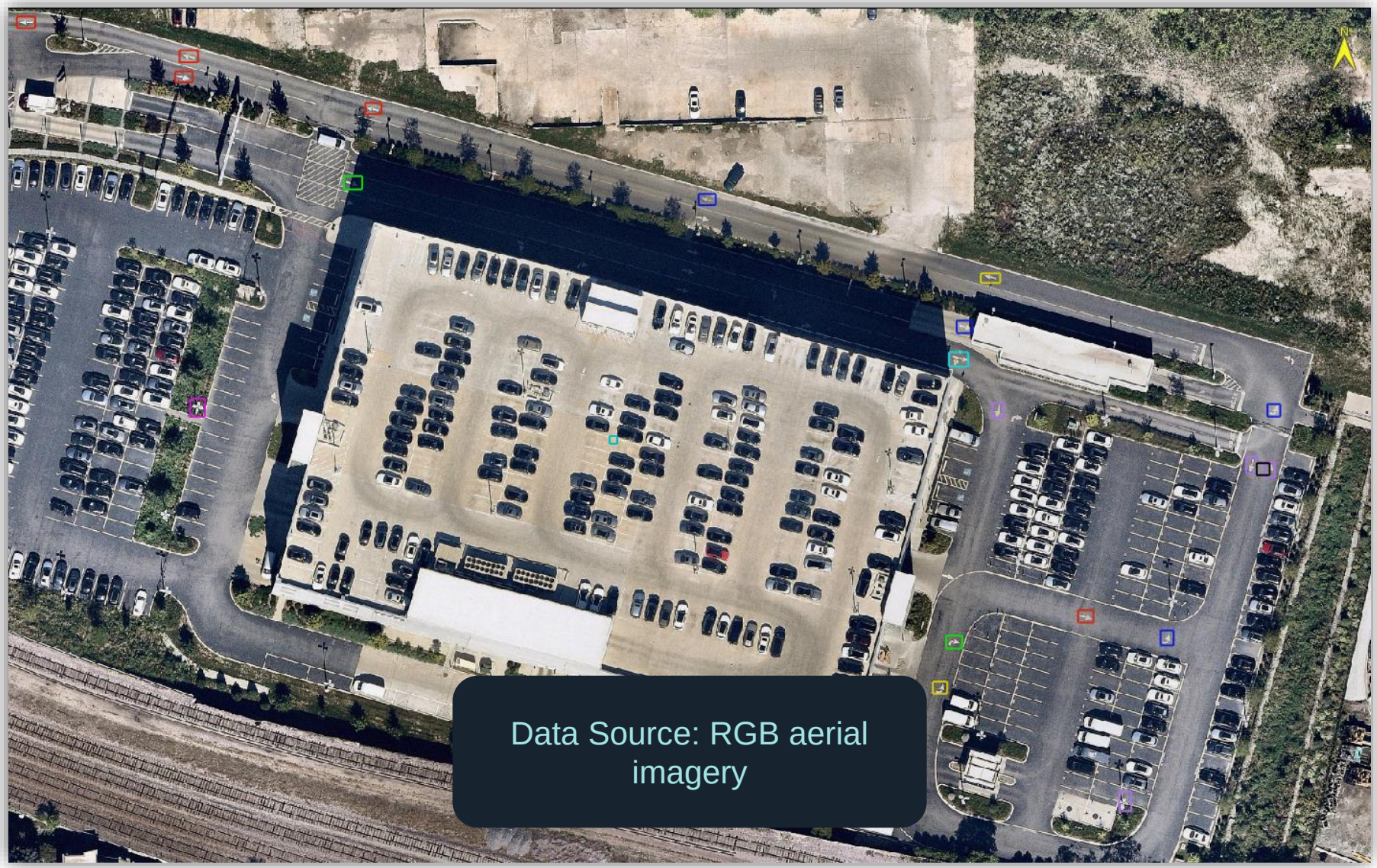
Ship Detection: Optical

Data Source: PlanetScope VNIR, surface reflectance

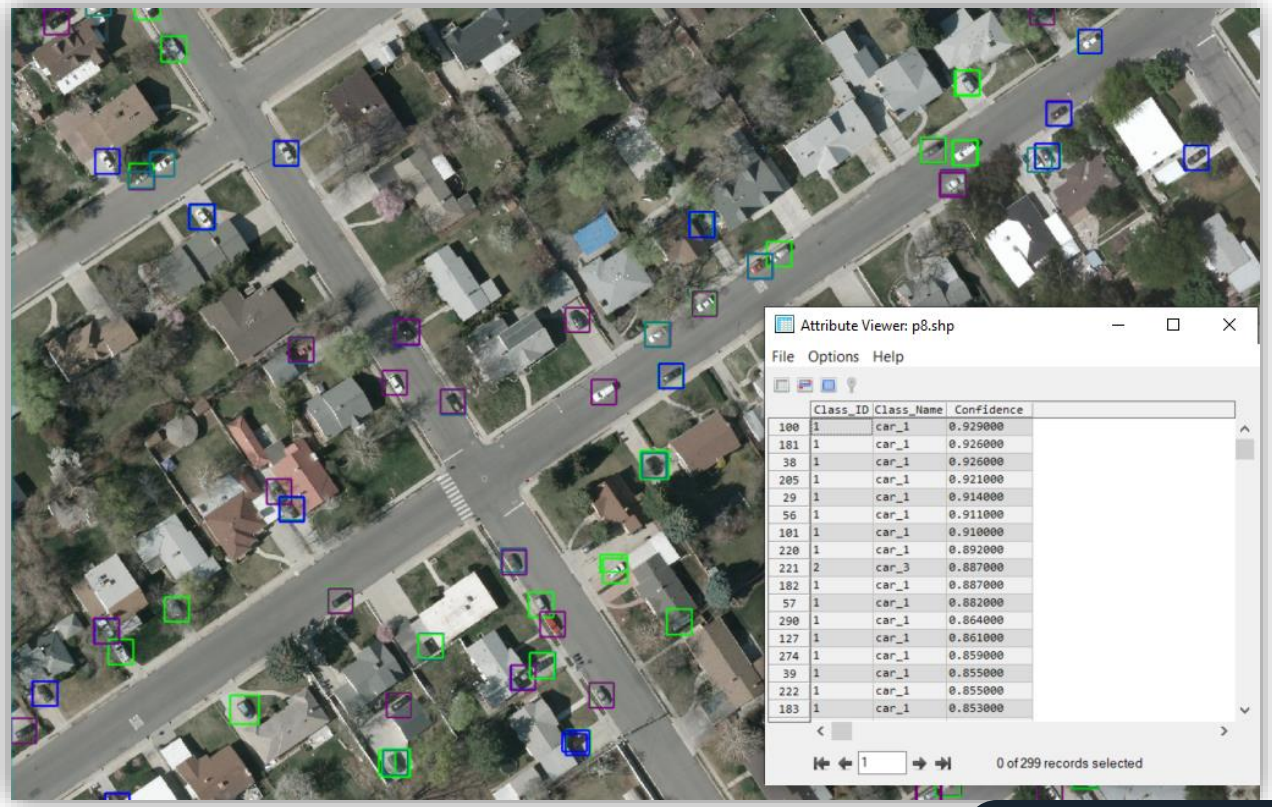
Ship Detection: SAR

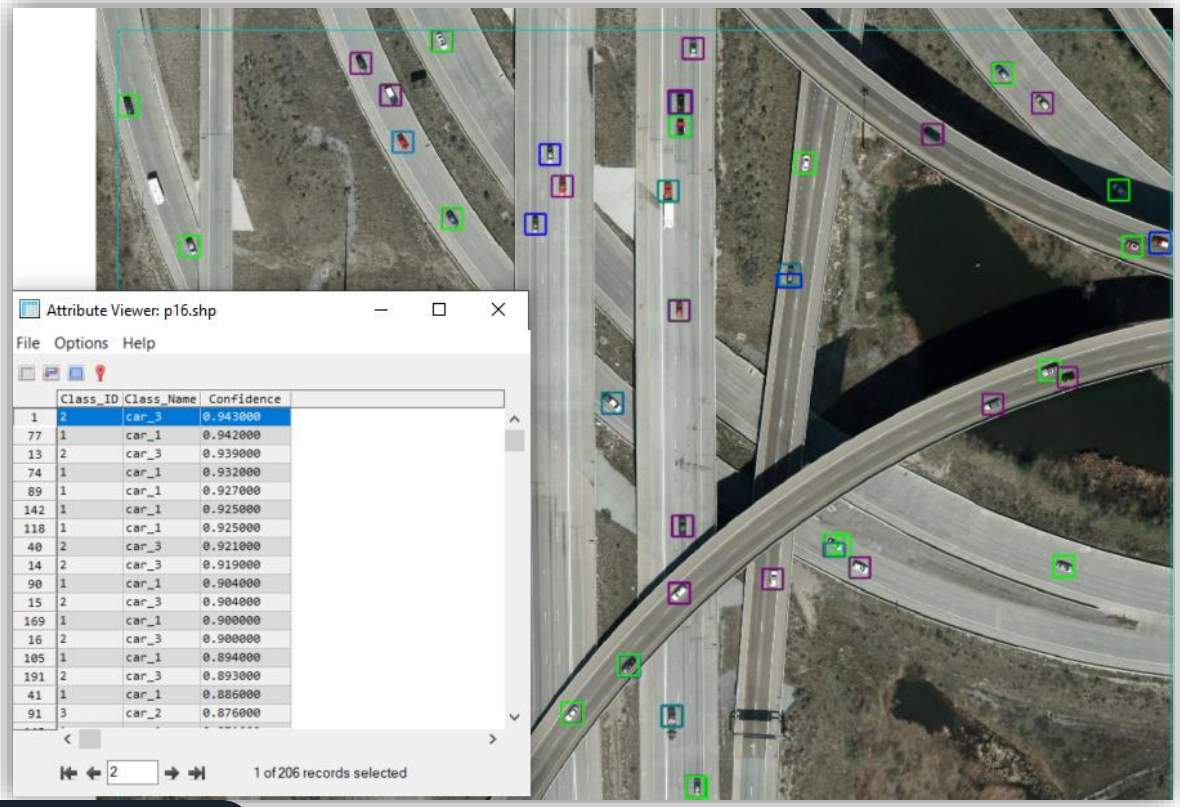
Data Source: Sentinel 1 (SAR)

Turn Arrows



Vehicle Detection





Data Source: RGB aerial imagery

Object Detection vs. Pixel Classification

Feature	Object Detection	Pixel Classification
Label types	• Bounding box	• Points, polylines, or polygons
What is used for training?	• Source data, bounding boxes, and box classes • Each bounding box is a training sample, so there are few to learn from	• Source data and classification image (i.e. mask) • Each pixel is a training sample, so there are many to learn from
Epoch for training	• Recommended 60-75 minimum • Target loss should be <=0.2; loss=0.5 will likely produce bad results	• Depends on feature and training data, can get good models at 20 epochs • Loss can vary, lower the better
Size of features	• Minimum: 25 pixels across (architecture limitation) • Maximum: 400 pixels across (patch size limitation)	• Minimum: At least one pixel (no sub-pixel detections) • Maximum: Can learn features larger than your patch size
Relative size of classes	• Don’t train a model with classes that vary dramatically in size • For example: Not the best idea to detect parking lots and cars	• Size is not as important • Multi-class size differences can impact performance because of class balance
Model output	• Bounding box, class, and confidence/score	• A class or probability for each pixel

Questions and Discussion

Release details: https://www.l3harrisgeospatial.com/Support/Maintenance

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