Using Machine Learning and Deep learning with Imagery in ArcGIS

Ling Tang and Sangeet Mathew

SEE
WHAT
OTHERS
CAN'T

Artificial Intelligence

Support Vector Machine

Object Tracking

Caffe

Gradient Descent

TensorFlow

Random Forest

PyTorch

CNTK

GeoAI

Natural Language Processing

Keras

Scikit-learn

Machine learning

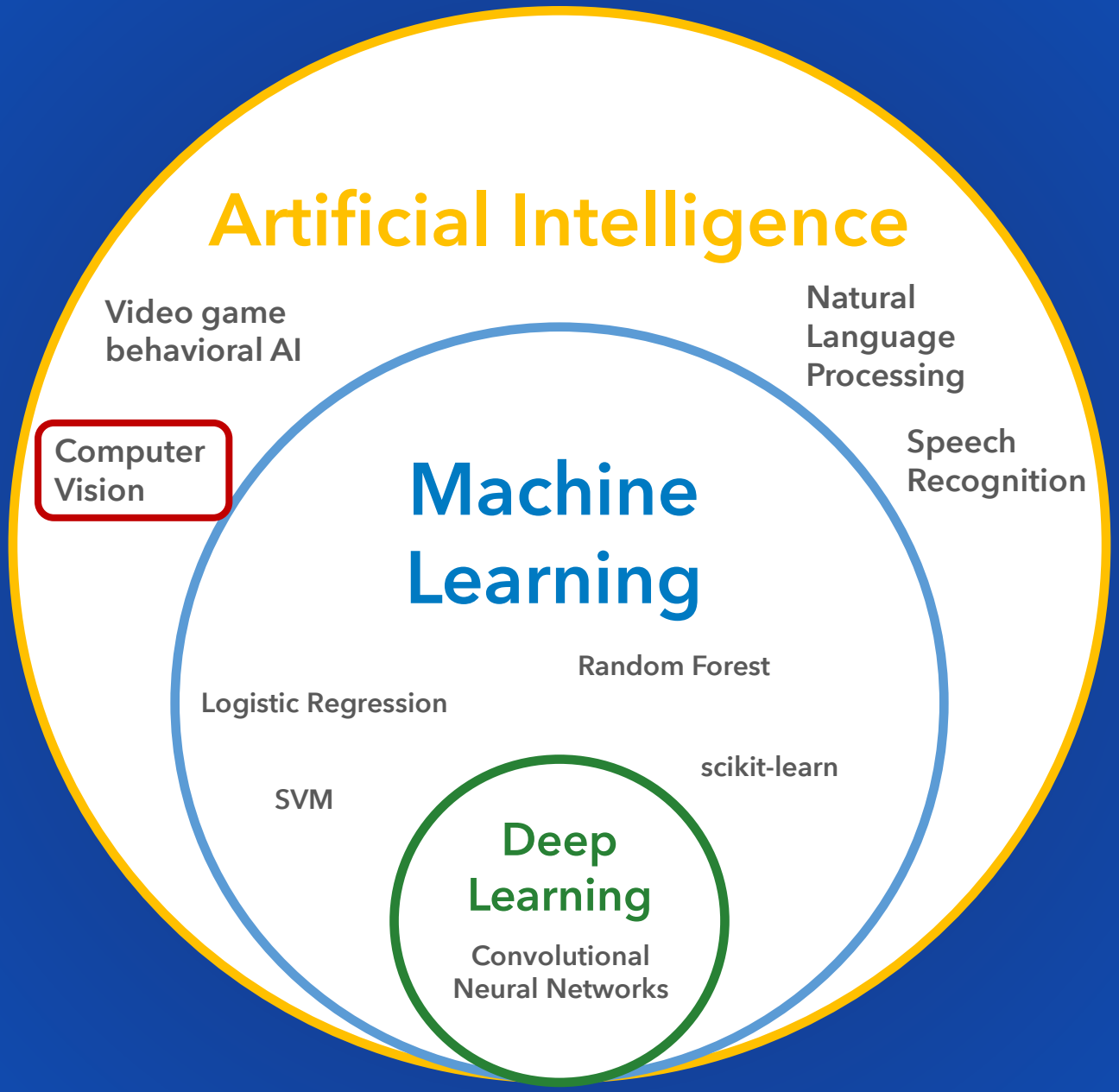
Computer Vision

Neural networks

Cognitive Computing

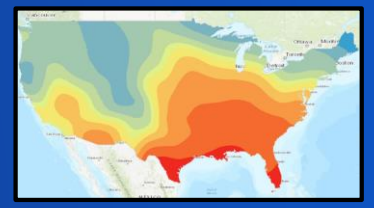
Object Detection

Deep Learning

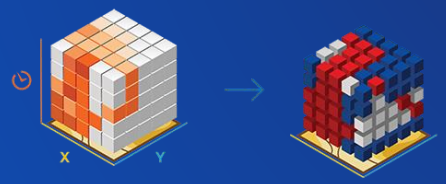

Artificial Intelligence
Video game behavioral AI
Natural Language Processing
Computer Vision
Speech Recognition
Machine Learning
Random Forest
Logistic Regression
scikit-learn
SVM
Deep Learning
Convolutional Neural Networks

ArcGIS Includes Machine Learning Tools

Classification



Prediction

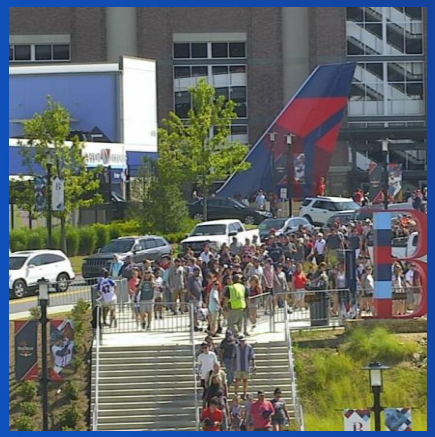


Clustering

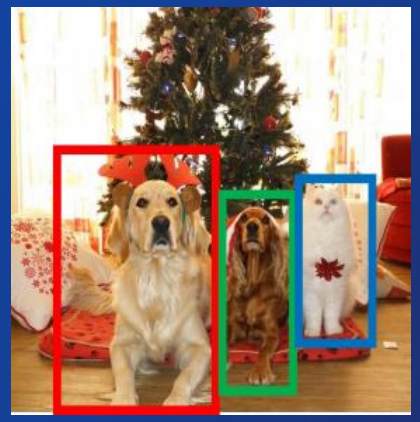
Deep Learning

Deep Learning : Computer Vision Use Cases

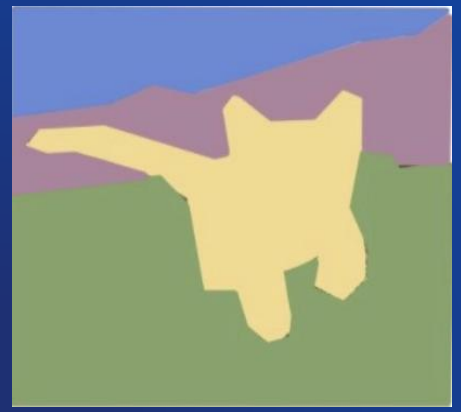
Image Classification



Object Detection



Semantic Segmentation



Instance Segmentation

Deep Learning in ArcGIS

Object Detection

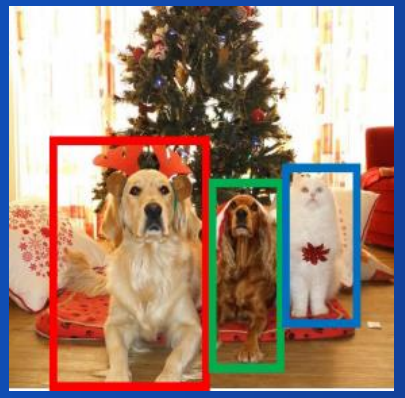
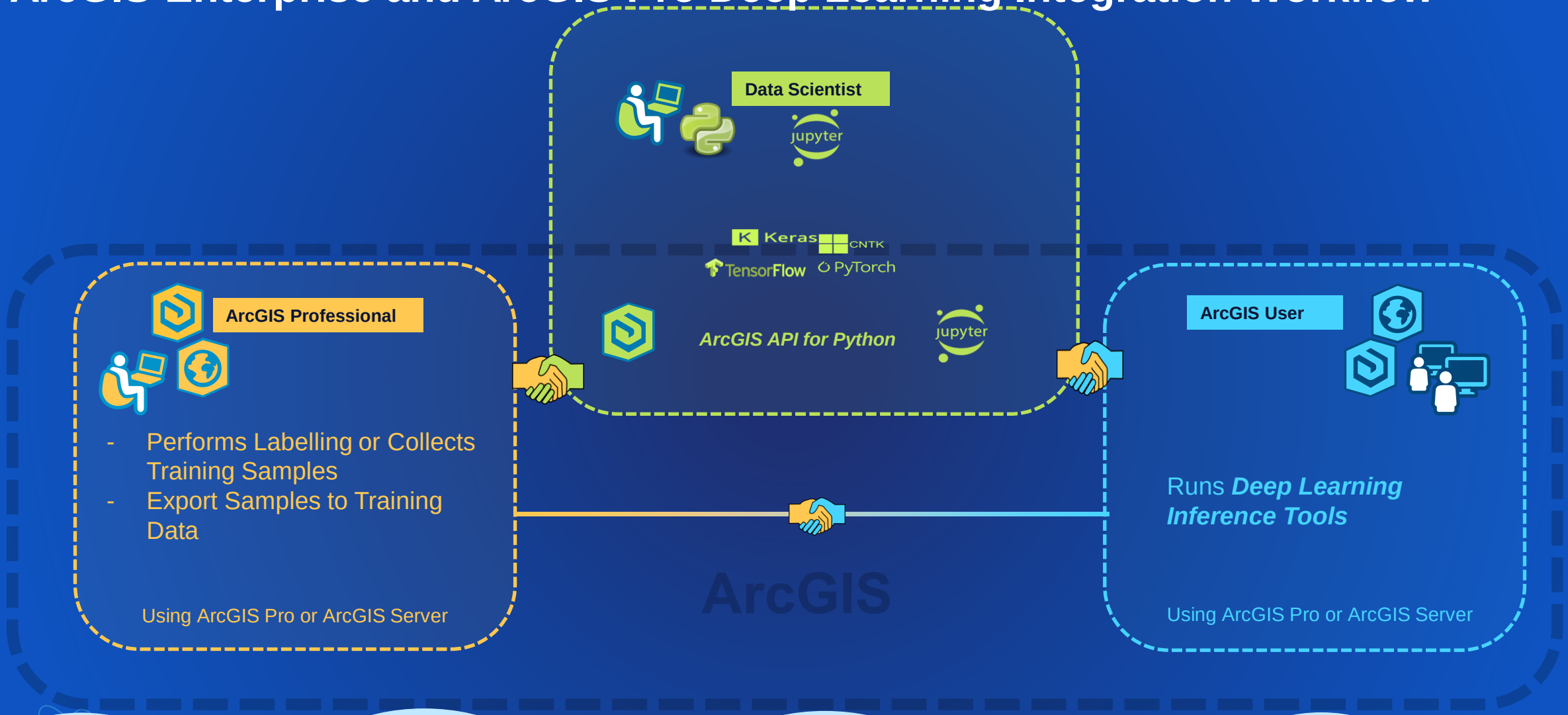


Image Classification

ArcGIS Enterprise and ArcGIS Pro Deep Learning Integration Workflow



Collect Samples → Export Training Chips → Train → Perform Inference

ArcGIS Deep Learning Workflow

Training Samples

Export Training Data For DL

ArcGIS Pro
ArcGIS Enterprise

Data Scientist, Prof Services

ArcGIS API For Python

Model Definition

Inference Function

DL Model

Detect Objects

Classify Pixels

ArcGIS Pro
ArcGIS Enterprise

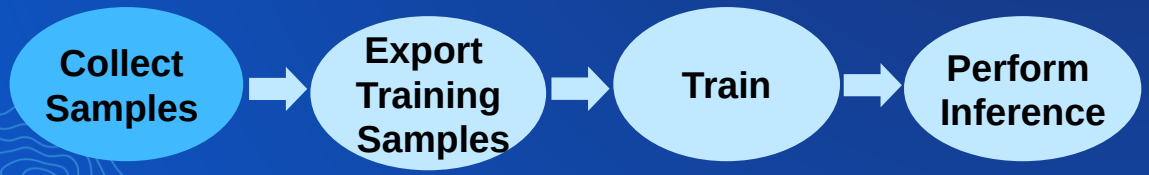
Collect Samples → Export Training Samples → Train → Perform Inference

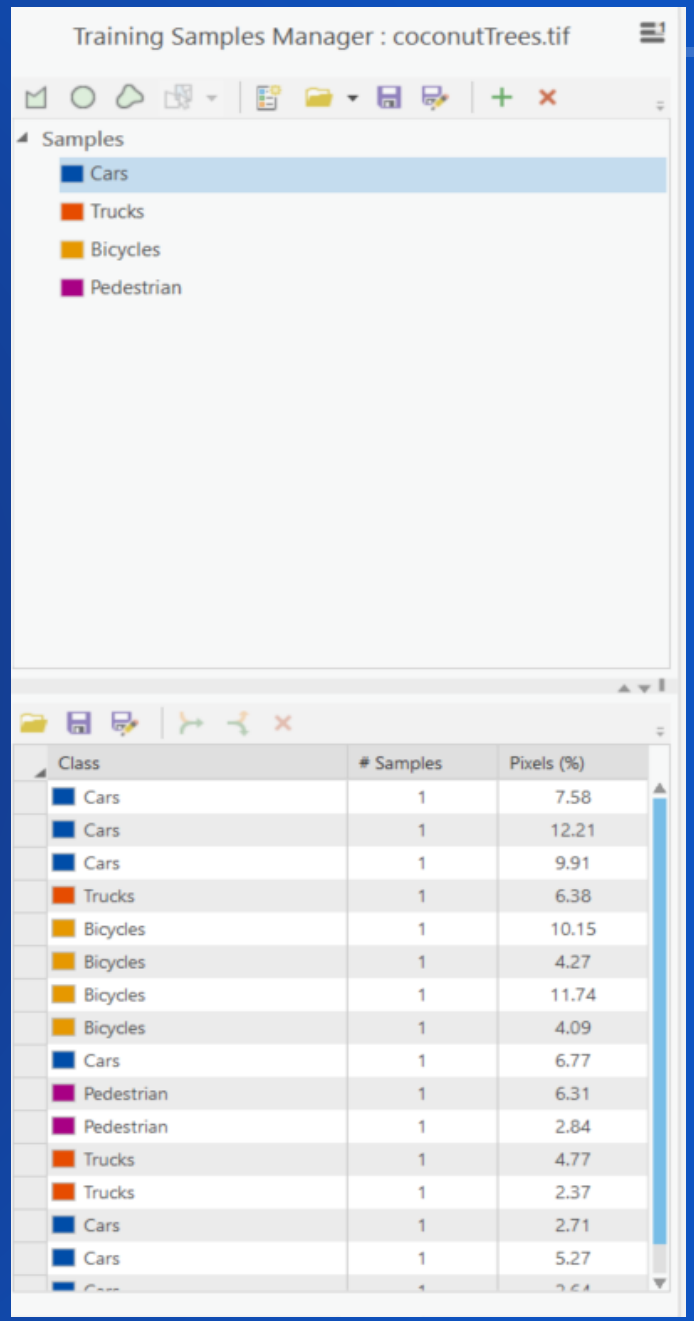
Support for Deep Learning Frameworks out of the box

	Detect Objects	Classify Pixels
TensorFlow	*Object Detection API*	*DeepLabs*
Keras	*Mask RCNN*	
PyTorch	*fast.ai - SSD*	
CNTK	*Faster RCNN by Microsoft*	*U-Net by Microsoft Azure*

Data Labeling: Training Samples Manager

- Add Labels
- Quickly Collect Samples
- Save Samples to a Feature Class





Export Training Data for Deep Learning Tool

- Exports Samples to Training
- Each Image has Labels
- Performs Data Augmentation

```
{
"Framework" : "e.g. CNTK",
"ModelConfiguration" : "some description",
"ModelType" : "e.g. ObjectDetection or ImageClassification",
"ModelFile" : "e.g. .\\trained.model",
"ImageHeight" : "e.g. 256",
"ImageWidth" : "e.g. 256",
"ExtractBands" : "e.g. [0, 1, 2]",
"DataRange" : "e.g. [0.1, 1.0] (optional)",
"ModelPadding" : "e.g. 64 (optional)",
"BatchSize" : "e.g. 8 (optional)",
"PerProcessGPUMemoryFraction" : "e.g. 0.8 (optional)",
"Classes" : [
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    "Value" : 10,
    "Name" : "10",
    "Color" : [
      214,
      174,
      82
    ]
  }
```
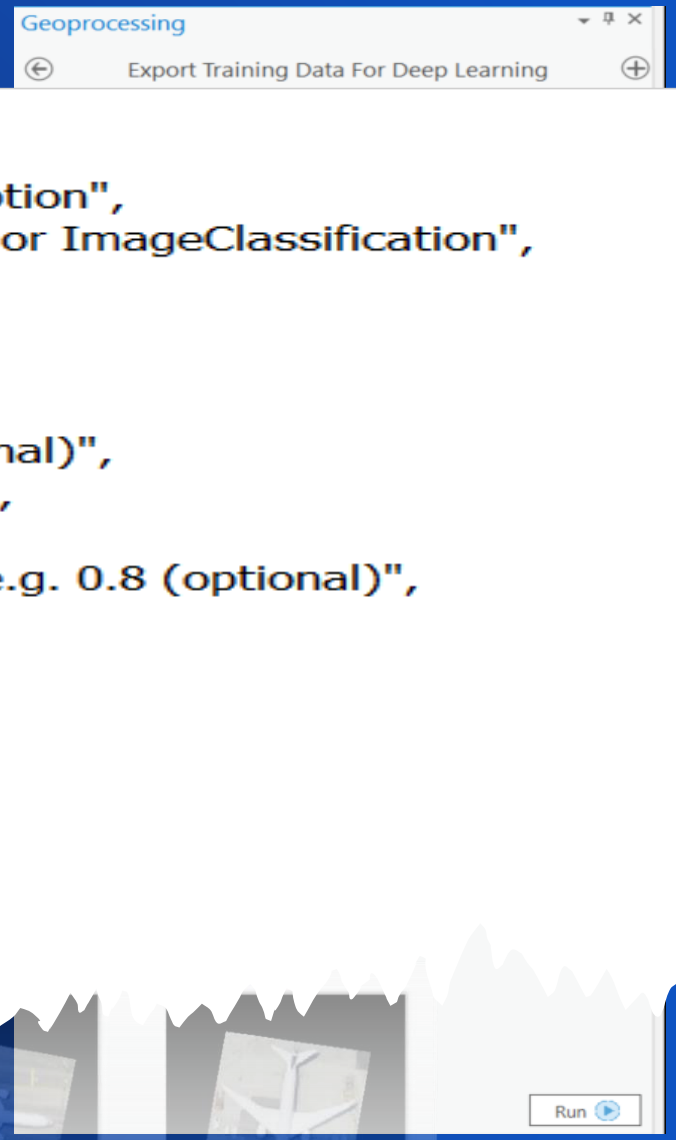
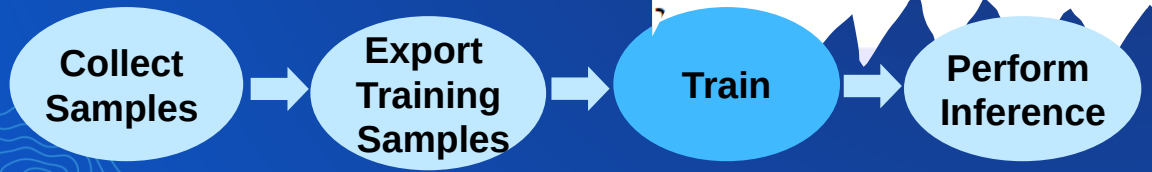



Collect Samples → Export Training Samples → Train → Perform Inference

Esri Model Definition File

- Trained Model file
- Deep Learning Package

```
{
   "Framework": "Keras",
   "ModelConfiguration": {
      "Name":"MaskRCNN",
      "Architecture":".\\mrcnn\\Buildingfootprints",
      "Config":".\\mrcnn\\Buildingfootprints"
   },
   "InferenceFunction": ".\\DeepLearning\\ObjectDetector.py",
   "ModelFile_HouseFootprints":".\\mask_rcnn_community_maps_0242.h5",
   "ModelFile_Damage":".\\Damage_Classification_Model_V3.h5",
   "ModelType":"ObjectDetection",
   "ImageHeight":320,
   "ImageWidth":320,
   "ExtractBands":[0,1,2],

   "Classes" : [
     {
       "Value": 1,
       "Name": "building",
       "Color": [0,  255, 0]
```



ArcGIS Deep Learning Workflow

Consume Deep Learning Models

Inference Tools

- Classify Pixels Using Deep Learning
- Object Detection Using Deep Learning
  - Non Maximum Suppression

Mod

- ArcGIS Image Analyst in Pro
- ArcGIS Image Server on Enterprise

Input Images

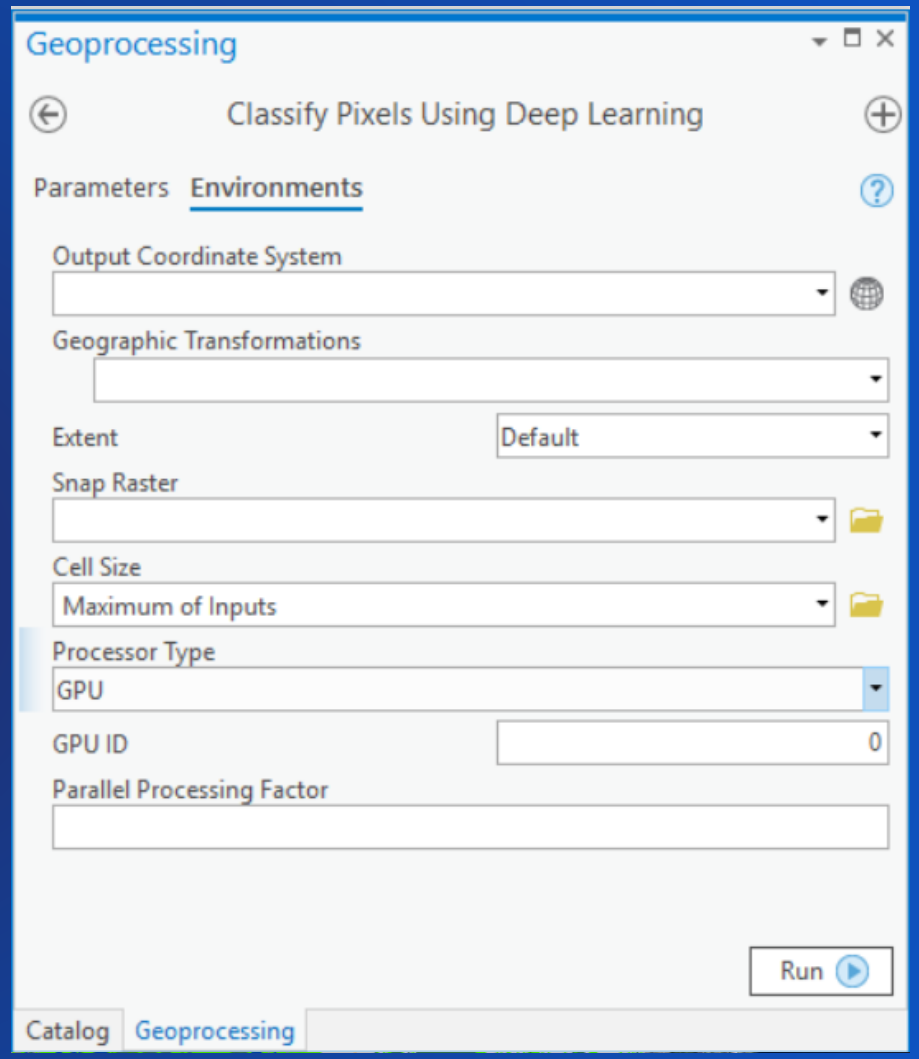
Collect Samples → **Export Training Samples** → **Train** → **Perform Inference**

Inference Tools

Classify Pixels Using Deep Learning

Runs the model on an input raster to product a classified raster, each valid pixel has an assigned class label.

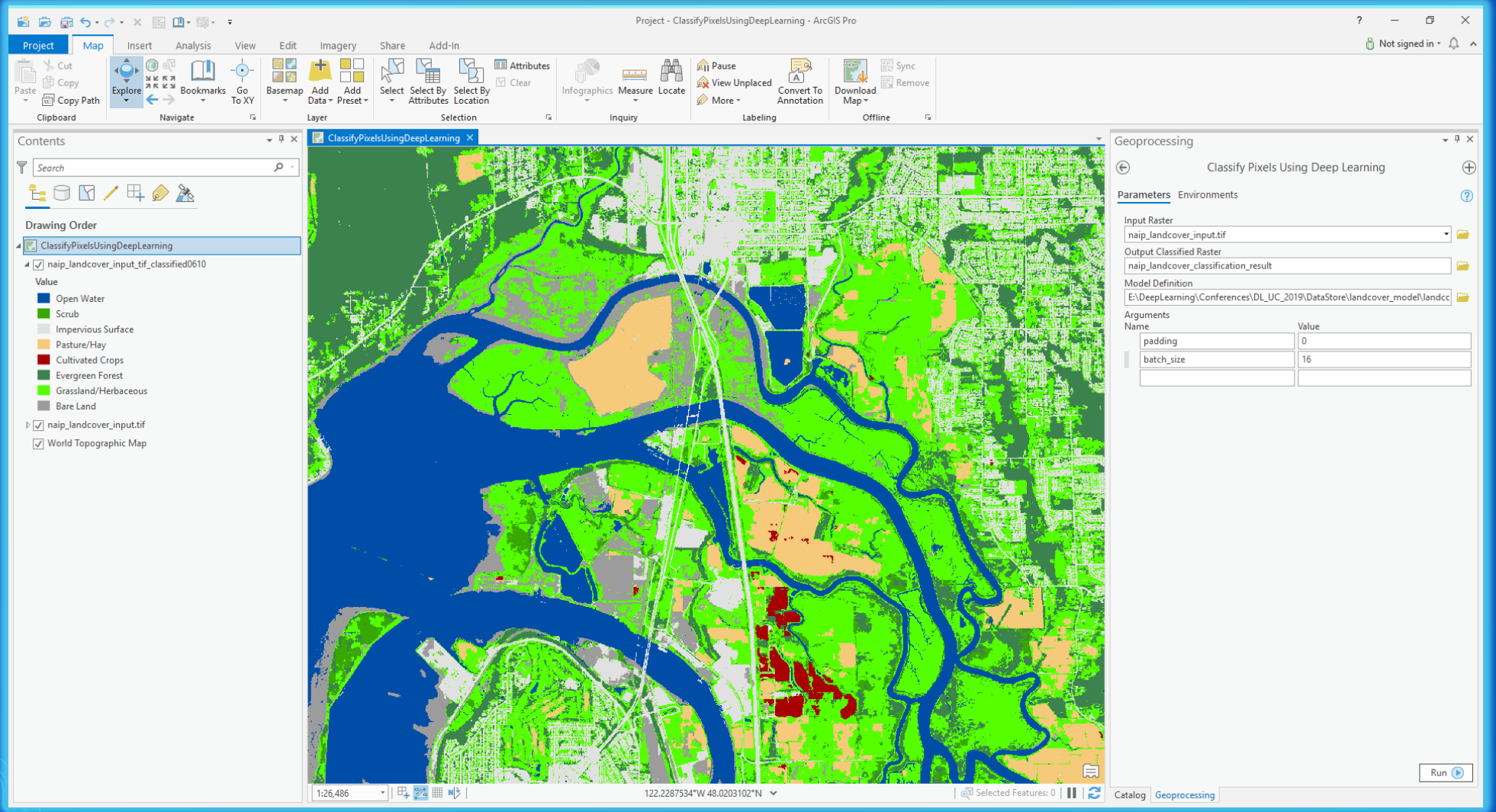
- Built-in Python Raster Function for TensorFlow and CNTK
- Mini-batch support
- Processor type: CPU or GPU
- Parallel processing in ArcGIS Pro
- Distributed raster analysis on Enterprise



- ArcGIS Image Analyst in Pro
- ArcGIS Image Server on Enterprise

Classify Pixels Using Deep Learning – Sample Use Case

Landcover Classification

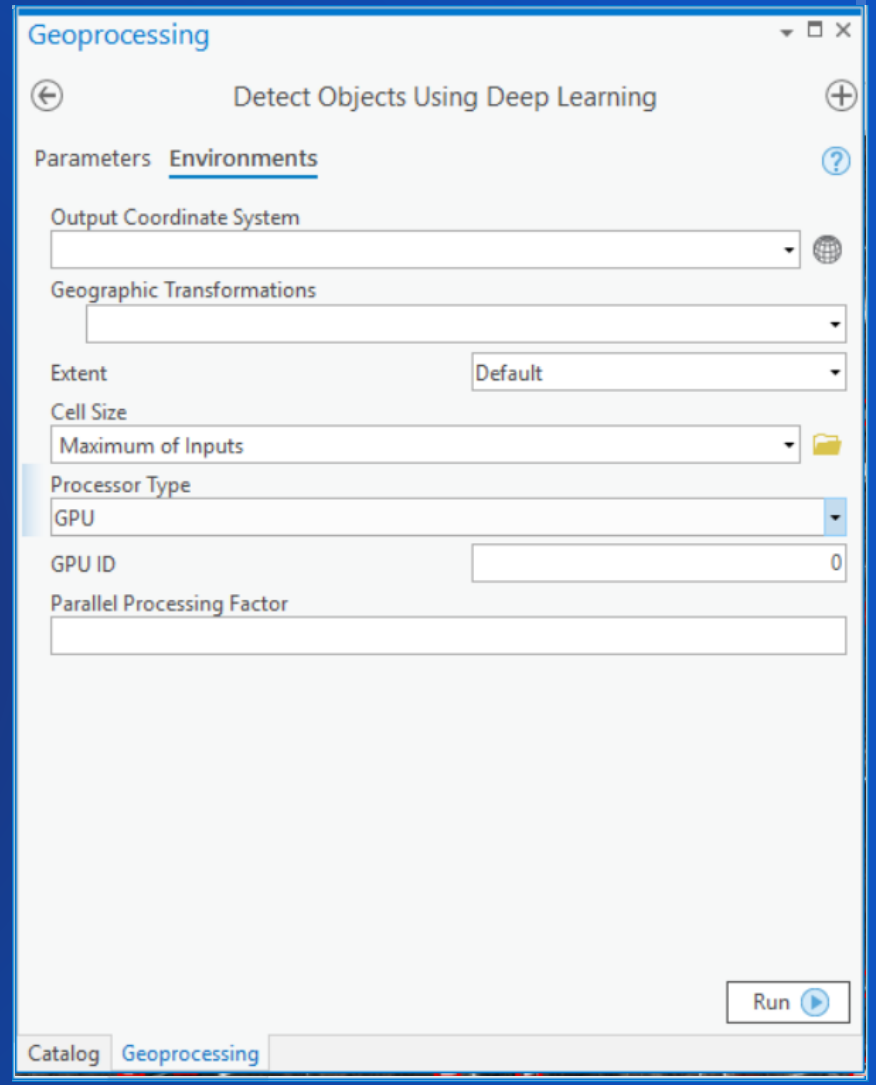


Inference Tools

Object Detection Using Deep Learning

Runs the model on an input raster to produce a feature class containing the objects it finds.

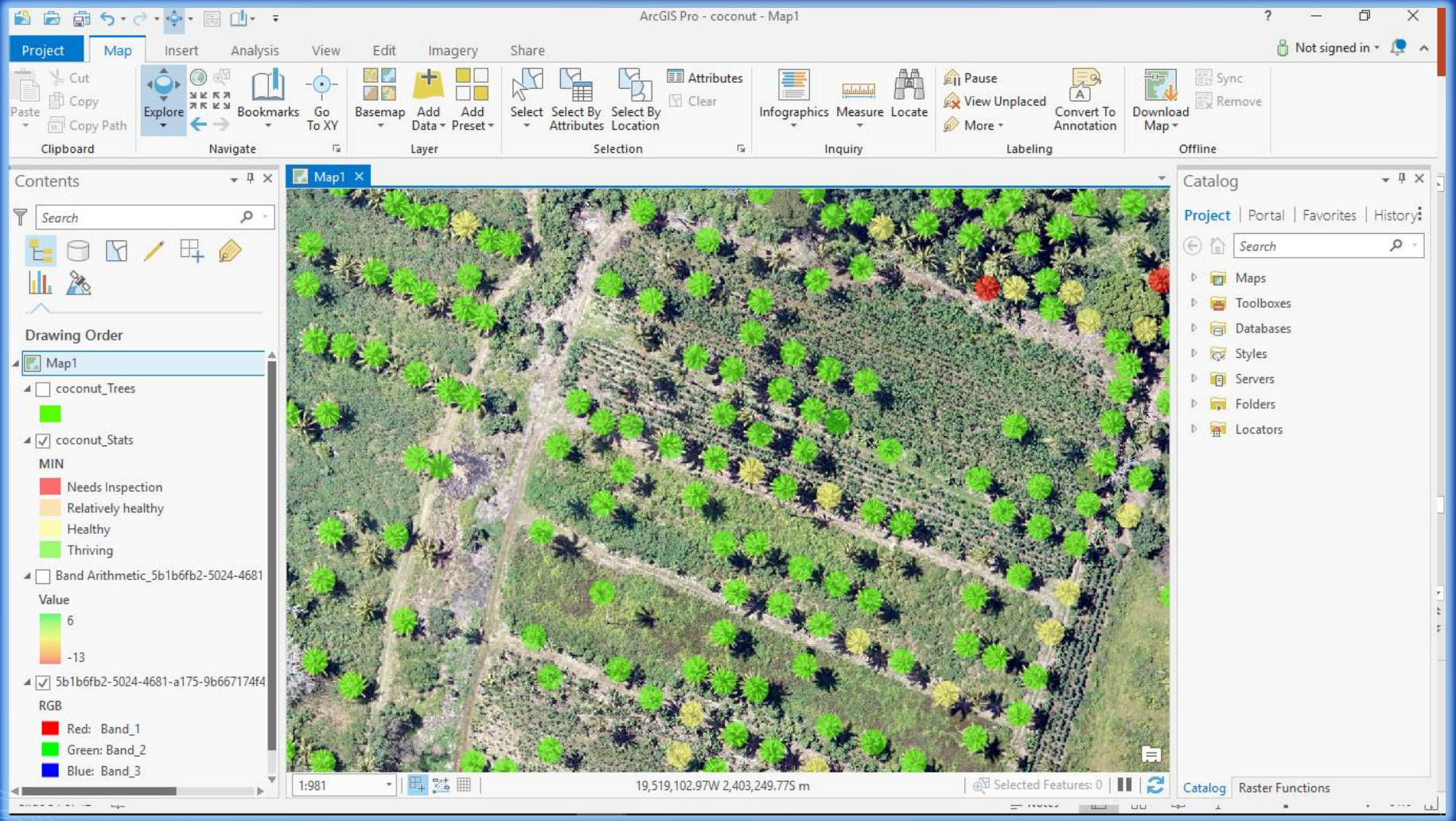
- Built-in Python Raster Function for TensorFlow, Keras, PyTorch and CNTK
- Mini-batch support
- Optional Non Maximum Suppression
- Processor type: CPU or GPU
- Parallel processing in Pro
- Distributed raster analysis on Enterprise



- ArcGIS Image Analyst in Pro
- ArcGIS Image Server on Enterprise

Object Detection Using Deep Learning – Sample Use Cases

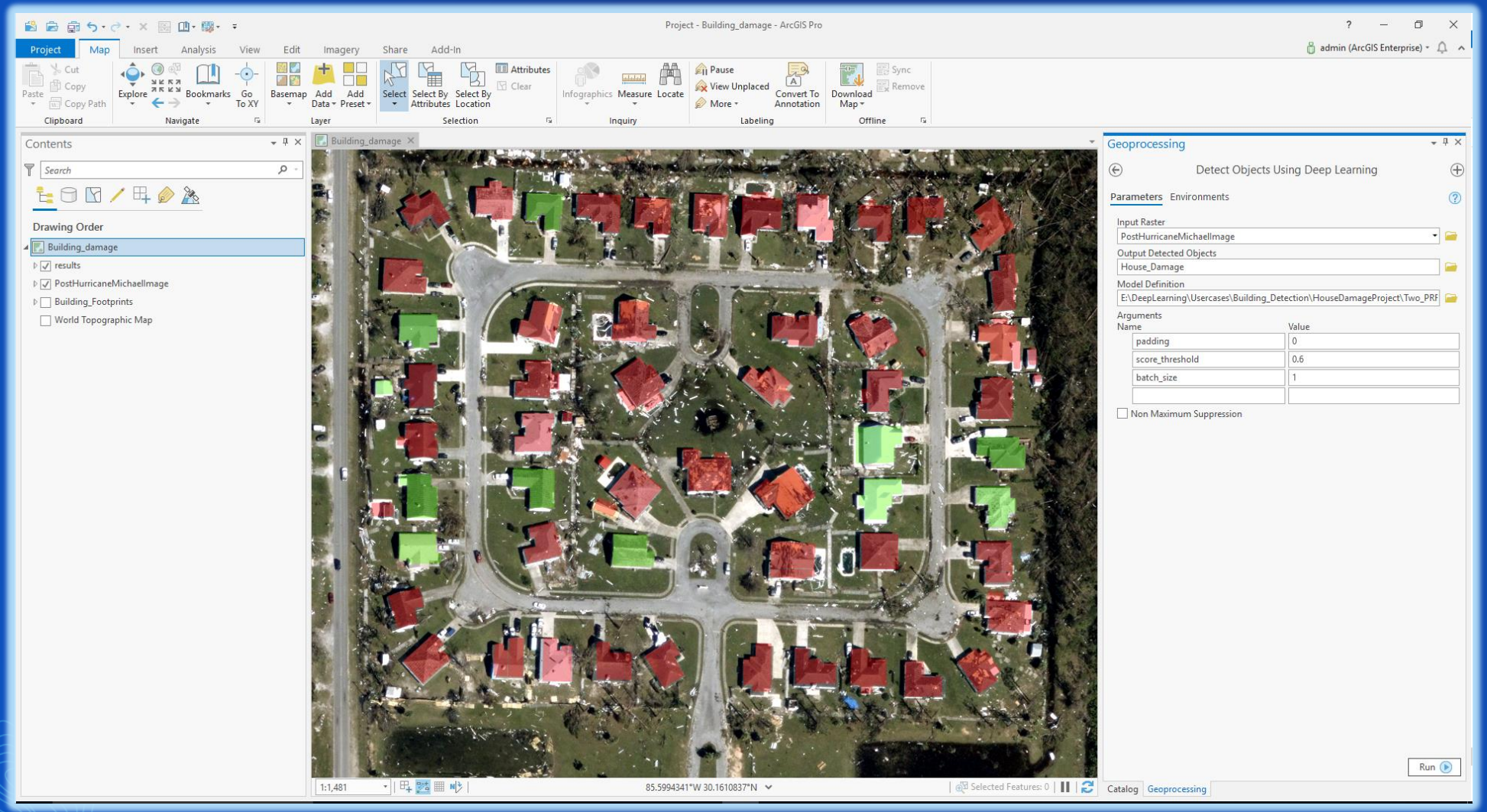
Palm Tree Detection and Health Assessment



ArcGIS Learn Lesson – Use Deep Learning to Assess Palm Tree Health
https://learn.arcgis.com/en/projects/use-deep-learning-to-assess-palm-tree-health/lessons/detect-palm-trees-with-a-deep-learning-model.htm

Object Detection Using Deep Learning – Sample Use Cases

Building Footprints Detection and Post Hurricane Damage Assessment

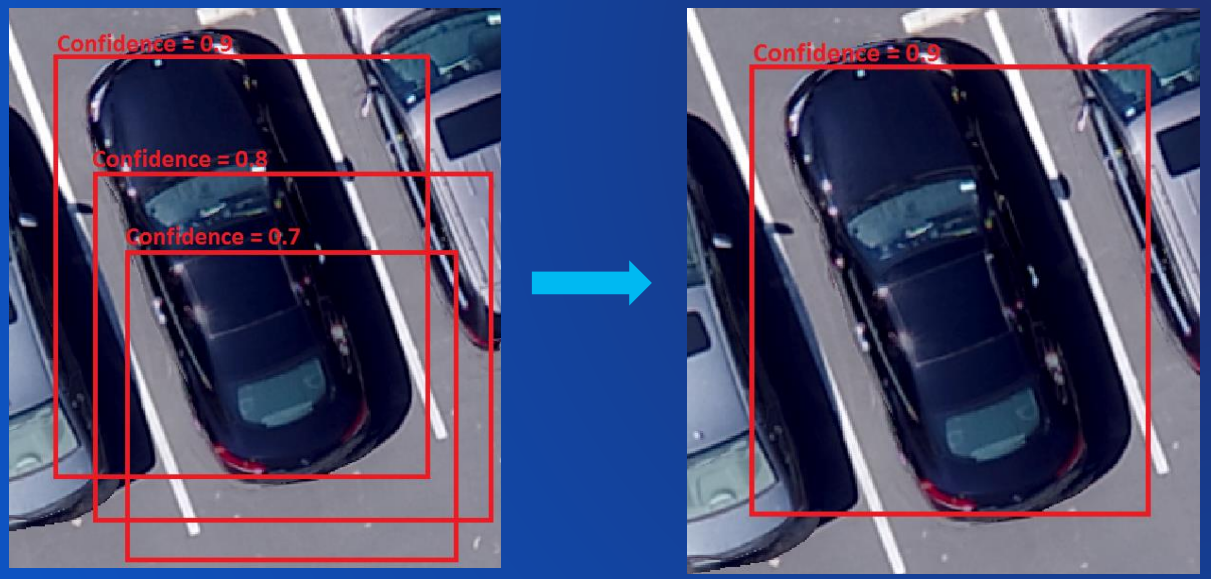


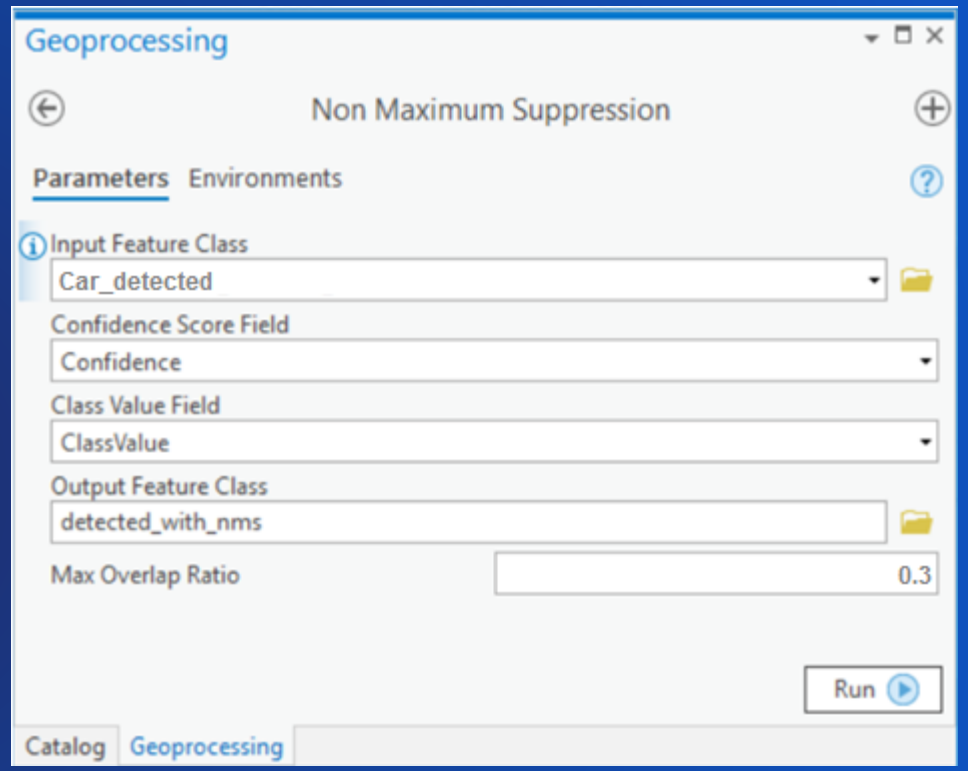
Inference Tools

Auxiliary

Non Maximum Suppression

Removes duplicate features from the output of the Detect Objects Using Deep Learning tool





- ArcGIS Image Analyst in Pro
- ArcGIS Image Server on Enterprise

Extend Deep Learning Capability in ArcGIS

Python Raster Function

- Python code understandable by ArcGIS Deep Learning inference tools
- Class template containing pre-defined methods
- Built-in Python Raster Function support for well-known deep learning model configurations
- Custom Python Raster Function support for other third-party model configurations

Built-in support

PYTORCH
TensorFlow
Keras
Microsoft
CNTK

EMD file using custom Python Raster Function

```
{
    "Framework": "arcgis.learn.models._inferencing",
    "InferenceFunction": "ArcGISObjectDetector.py",
    "ModelConfiguration": "_DynamicSSD",
    "ModelFile": "wellpad_model_UC_2019_1.pth",
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    "ImageWidth": 224,
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        0,
        1,
        2
    ],
    "Classes": [
```

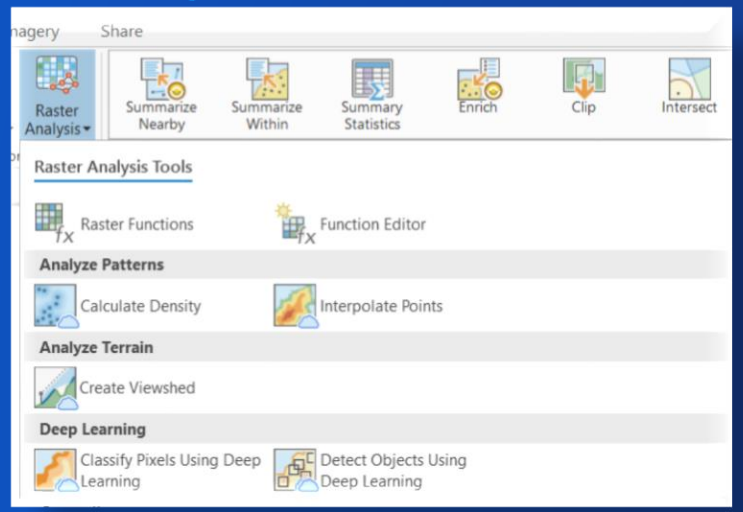
Resources:

Deep Learning Python Raster Function GitHub Repo:
https://github.com/Esri/raster-deep-learning

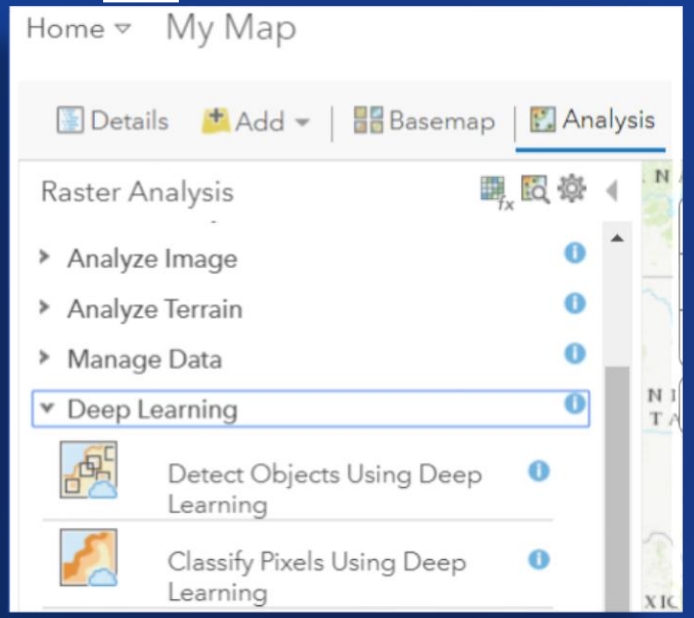
Python Raster Function Wiki:
https://github.com/Esri/raster-functions/wiki/PythonRasterFunction

Enterprise Deep Learning User Experience

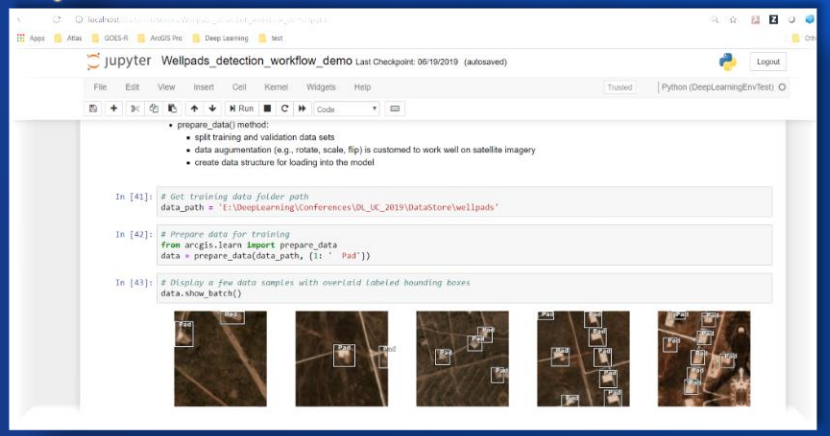
ArcGIS Pro



Web Map Viewer



ArcGIS API for Python with Notebook



Run large inferencing tasks using distributed raster analysis

Deep Learning in ArcGIS API for Python

Make model training easier using arcgis.learn module

Export Training Data

arcgis.learn.export_training_data

Prepare Training Data

arcgis.learn.prepare_data

Train Models

arcgis.learn.SingleShotDetector
arcgis.learn.UnetClassifier
arcgis.learn.FeatureClassifier

Model Management

arcgis.learn.list_models
arcgis.learn.Model
- Model.install
- Model.uninstall
- Model.query_info

Run Inference at SCALE

arcgis.learn.detect_objects
arcgis.learn.classify_pixels

Current Release: 1.6.2
More to come …….

Disaster Assessment

Case Study

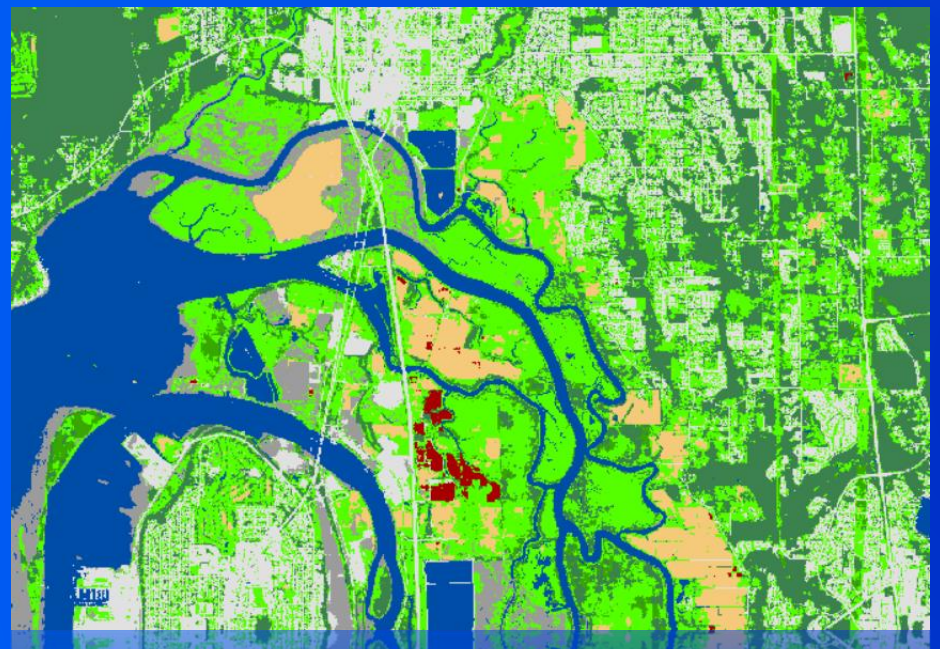
Disaster Assessment

Rebuilding after destructive events such as Hurricane Michael is difficult and requires informed planning.

Use deep learning to identify damaged housing quickly after the event, then use data enrichment to understand the estimated cost of damage as well as the impacted population to make informed decisions about the rebuild process.

Disaster Assessment

Sangeet Mathew



Demo – Scalable Inference on ArcGIS Enterprise

Landcover classification

Ling Tang

Oil Well Pads Change Detection

Case Study

Oil Well Pads Change detection

Oil and gas companies need a convenient way to frequently monitor the drilling activities that have been occurring at very large scale (e.g., basin level) in a timely manner

Integrated deep learning workflow in ArcGIS allows to easily train the well pads detection model and perform scalable inferencing tasks on vast area

ArcGIS Deep Learning Workflow

End-to-end from raw imagery to structured information products

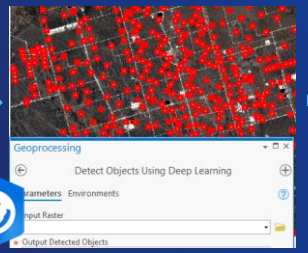
Imagery

Labelling

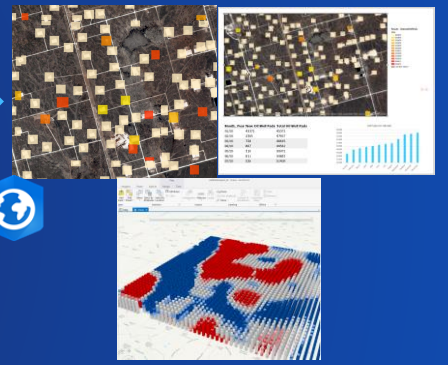
Data Prep

Train Model

Detect Objects



Analysis



Field Mobility, Monitoring

ArcGIS in use for each step of the deep learning workflow

Run Model Inference at Scale Using Raster Analytics

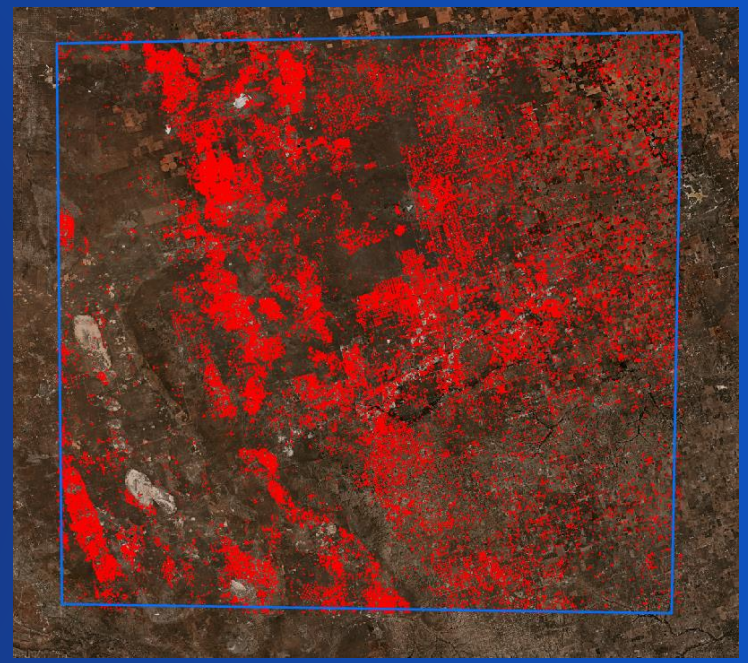
Benchmark Test

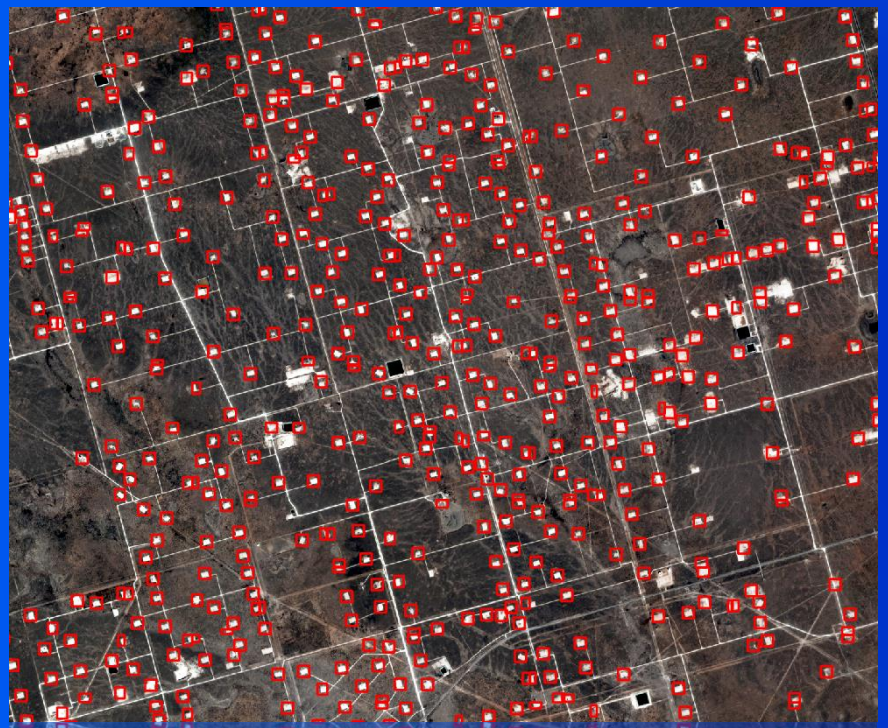
Enterprise version: 10.7.1
Image Server nodes: 4

Instances: AWS p2.xlarge
GPU: NVIDIA K80 (12GB)

No. of detected well pads : **51,042**

Time used: 6 minutes 56 seconds





Demo – ArcGIS API for Python arcgis.learn

Oil well pads detection

Ling Tang

Take Away

- Have an easy way to extend the Deep Learning capabilities to any support Framework/Model Configuration .
- Out of the box Support for most common Deep Learning Frameworks
- Leverage the powerful Raster Analytics capabilities to distribute model inference tasks.
- You can easily train the model using ArcGIS API for Python.

Coming Soon…

- An end to end solution in ArcGIS Pro (Training included)
- Enhanced Training Methods
- A new Inference Tool for Image/Object Classification
- New tools to improve the User Experience for Deep Learning Workflows in ArcGIS

Related Sessions

ArcGIS API for Python:
Integrating ML & DL
Tues 1:15–2:00pm
Demo Theater 8

ArcGIS Pro:
Intro the Image Analyst
Wed 1:15–2:00pm
Ballroom 06D

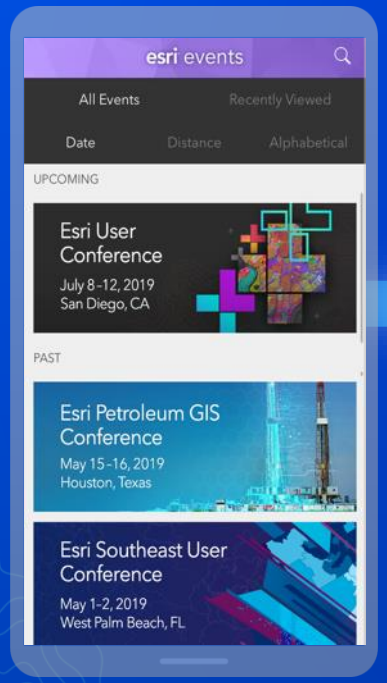
ArcGIS Pro:
Using Imagery & Deep Learning
Thurs 12:15–1:00 pm
Demo Theater 2

ArcGIS Enterprise:
Raster Analytics in
ArcGIS Image Server
Thurs 2:30–3:30pm
ROOM 08

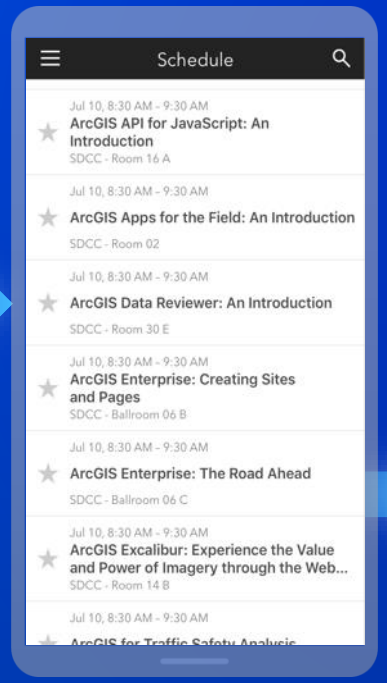
ArcGIS Enterprise:
Deploying Distributed
Raster Analytics
Thurs 8:30-9:30am
ROOM 05A

Please Share Your Feedback in the App

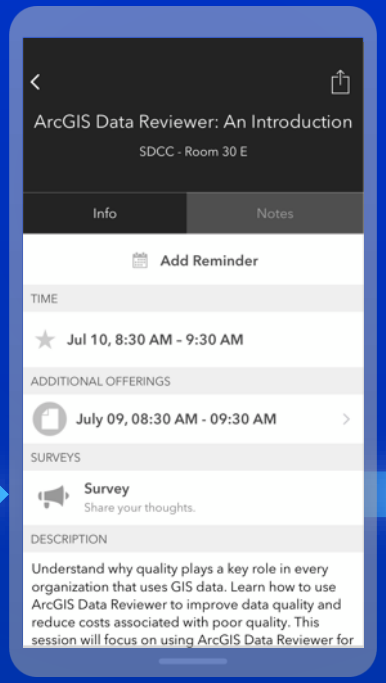
Download the Esri Events app and find your event



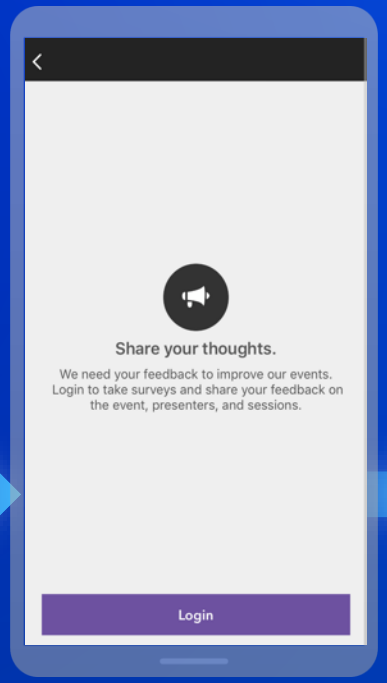
Select the session you attended



Scroll down to "Survey"



Log in to access the survey



Complete the survey and select "Submit"