Using Machine Learning & Deep Learning With ArcGIS Imagery

SEE WHAT OTHERS CAN'T

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gistec

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ArcGIS as a Platform for Deep Learning

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ArcGIS is a Comprehensive Imagery Platform

Esri also have multiple partners to provide best of breed solutions

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Analysis

Extracting Information from Imagery

ArcGIS Pro
- Core capabilities
- Raster Functions

ArcGIS Spatial Analyst
- Raster Functions
- Distance modelling
- Hydrological modelling

ArcGIS Image Analyst
- Raster Functions
- Deep Learning
- Pixel Editor
- Multidimensional data
- Stereo
- Image Space
- Full Motion Video

ArcGIS Image Server
- Raster Functions
- Scaling using Raster Analytics

ArcGIS API for Python

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Artificial Intelligence

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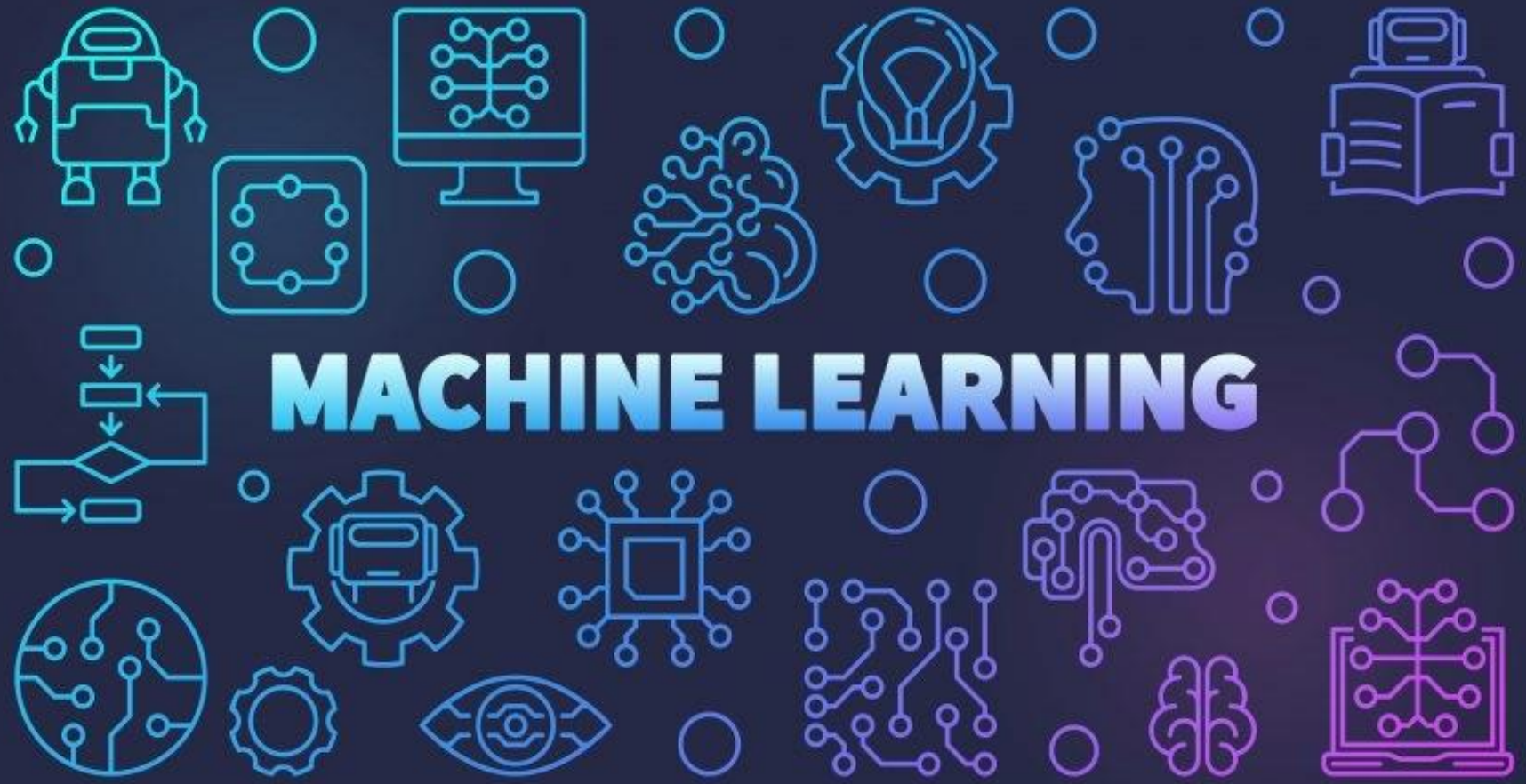

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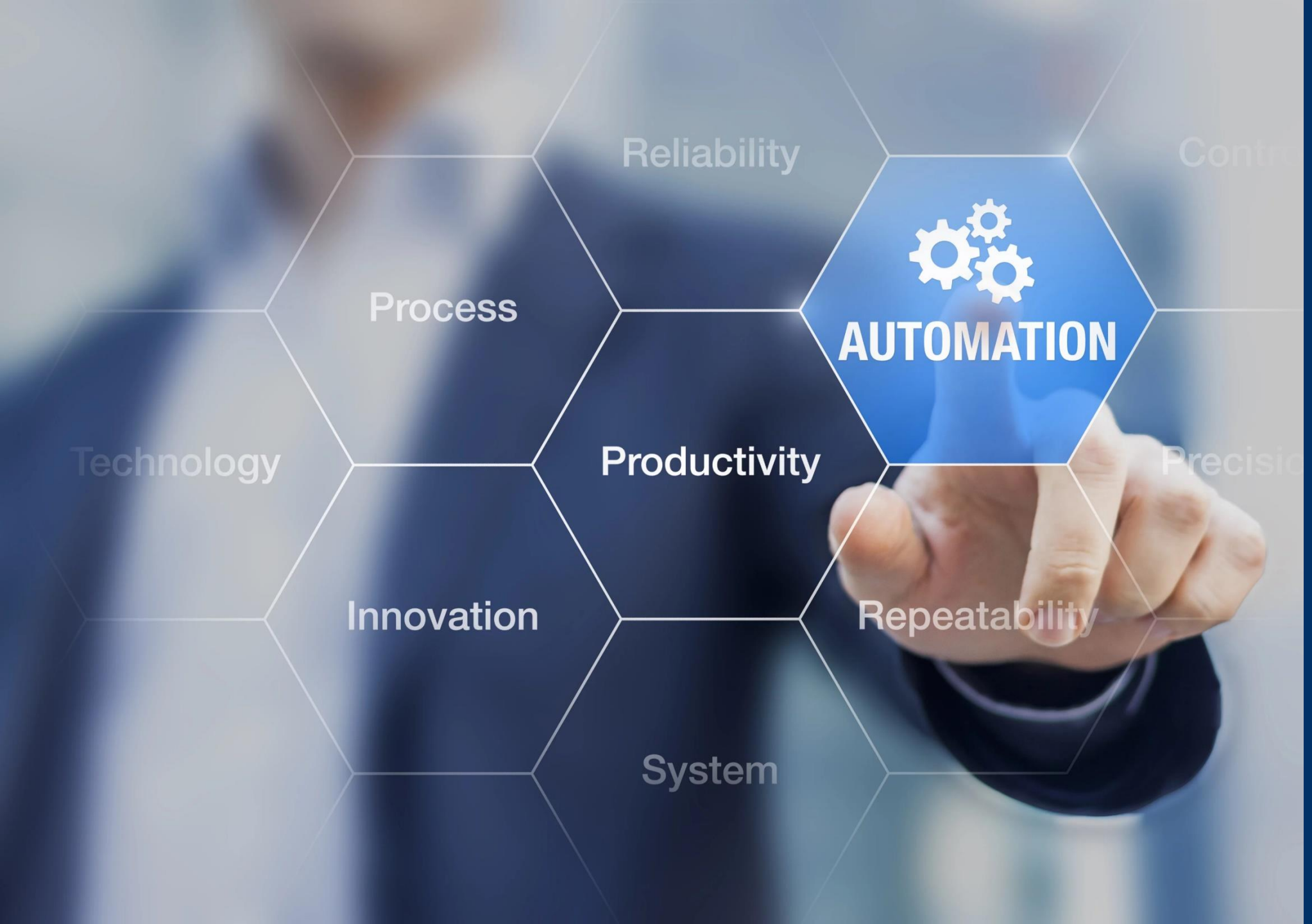
Reliability
Process
AUTOMATION
Technology
Productivity
Innovation
Repeatability
System

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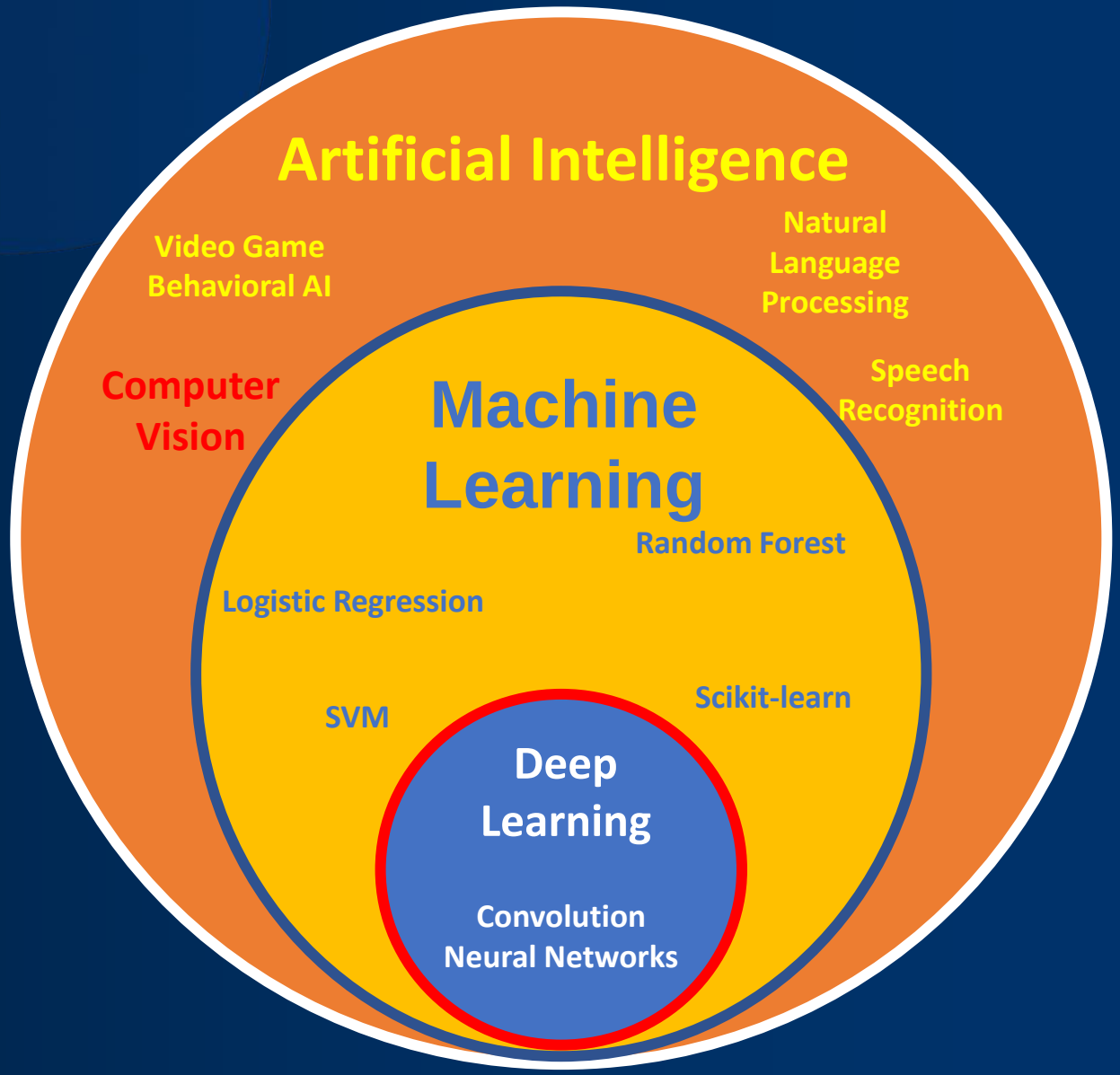
Recent Innovation

- **Artificial Intelligence**
  - AI is the ability of computers to perform a task that typically requires some level of human intelligence.
- **Machine Learning**
  - Type of engine that uses data driven algorithms to learn from data to give users the answers that's required.
- **Deep Learning**
  - **Type of machine learning,** and it refers to deep neural networks, that are inspired from and loosely resemble the human brain



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Caffe

Artificial Intelligence

Object Detection

Object Tracking

T-SNE

Support Vector Machines

Natural Language Processing

Machine Learning

Neural Networks

Cognitive Computing

Computer Vision

Theano

Keras

Dimensionality Reduction

CNTK

GeoAI

Deep Learning

TensorFlow

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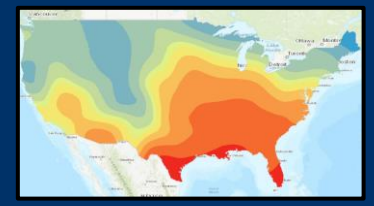
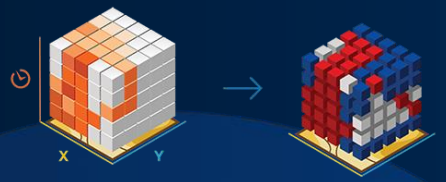
ArcGIS Includes Machine Learning Tools

Classification



Prediction



Clustering

ArcGIS

Deep Learning

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Machine Learning Tools in ArcGIS

Classification

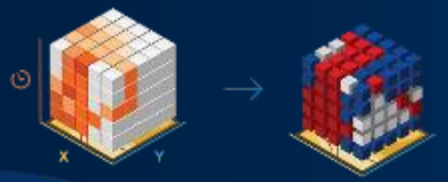
- Pixel & Object Based
- Image Segmentation
- Maximum Likelihood
- Random Trees
- Support Vector Machine

Deep Learning

- Generate training samples
- Detect objects
- Classify pixels

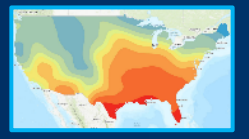
Clustering

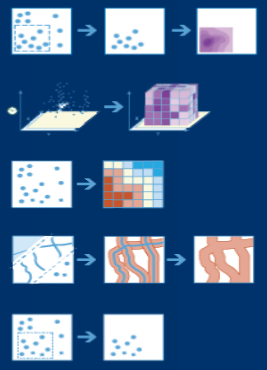
- Spatially Constrained Multivariate Clustering
- Multivariate Clustering
- Density-based Clustering
- Hot Spot Analysis
- Cluster and Outlier Analysis
- Space Time Pattern Mining



Prediction

- Empirical Bayesian Kriging
- Areal Interpolation
- EBK Regression Prediction
- Ordinary Least Squares Regression and Exploratory Regression
- Geographically Weighted Regression





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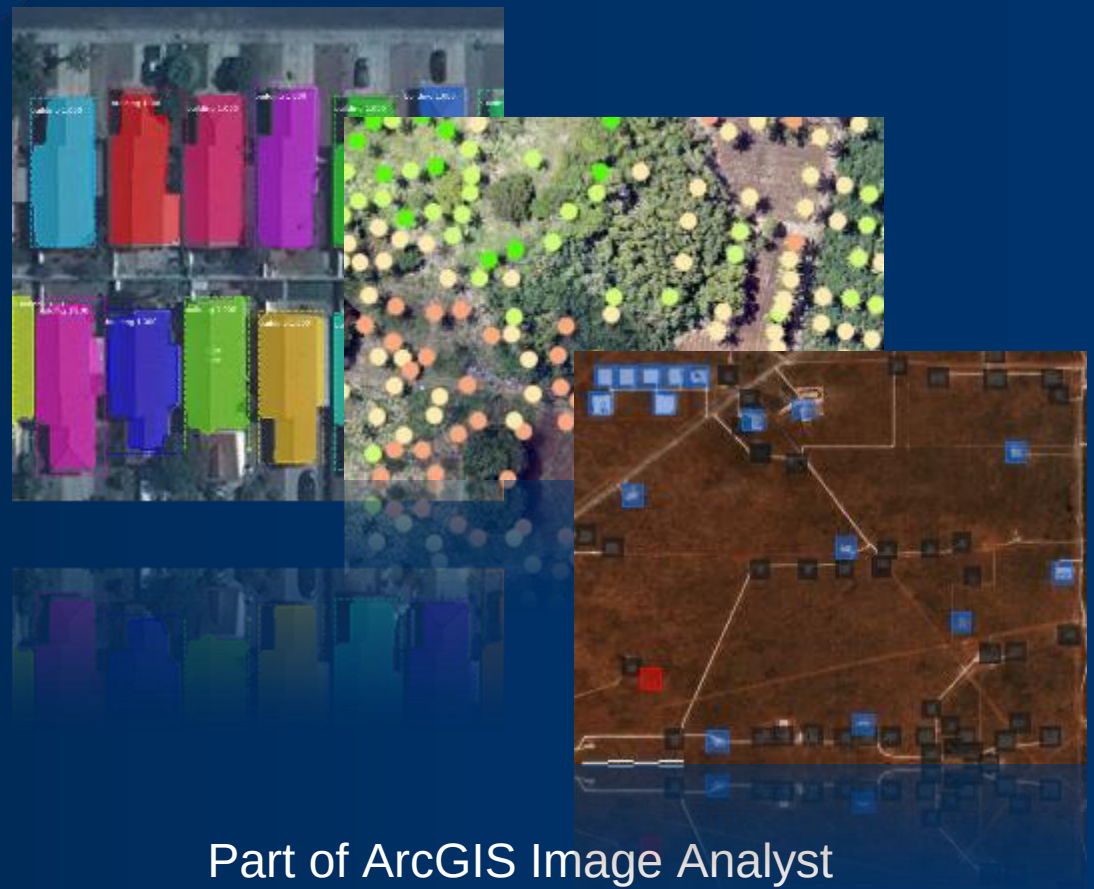
Deep Learning with Imagery in ArcGIS

ArcGIS supports end-to-end deep learning workflows

- Tools for:
  - Labeling training samples
  - Preparing data to train models
  - Training Models
  - Running Inferencing
- Supports all 4 imagery deep learning categories
- Supports image space, leverage GPU
- Clients
  - ArcGIS Pro
  - Map Viewer
  - Notebooks



Part of ArcGIS Image Analyst

Run distributed on ArcGIS Image Server

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Deep Learning

Key imagery tasks for deep learning

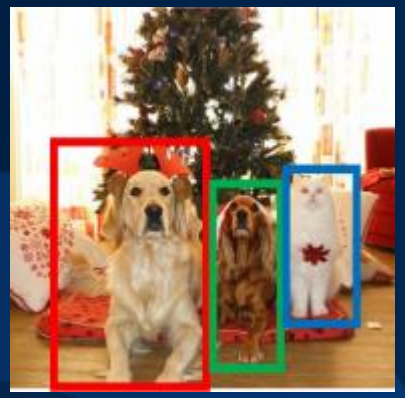
Impervious Surface Classification

Palm Tree Detection

Building Footprint Extraction

Damaged House Classification

Pixel Classification



Object Detection

Instance Segmentation

Image Classification

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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

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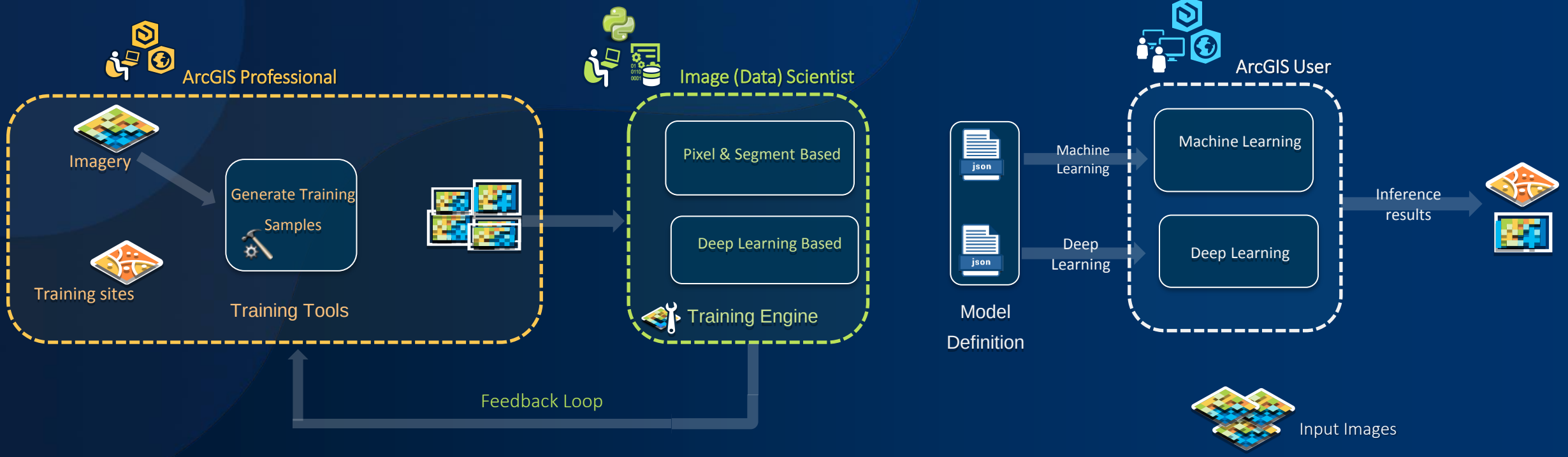
ArcGIS – Machine Learning Workflow

Detailed Workflow



Pixel & Segment Based:
- Maximum Likelihood
- Support Vector Machine
- Random Forest

Deep Learning Based:
- TensorFlow*
- CNTK*
- PyTorch*
- Custom*

*Run External to ArcGIS

Machine Learning:
- Support Vector Machine
- Random Forest

Deep Learning:
- TensorFlow*
- CNTK*
- PyTorch*
- Custom*
- + External via Python

*Requires framework installed

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Deep Learning Process

Sample UAV Data

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Initial Process

Samples

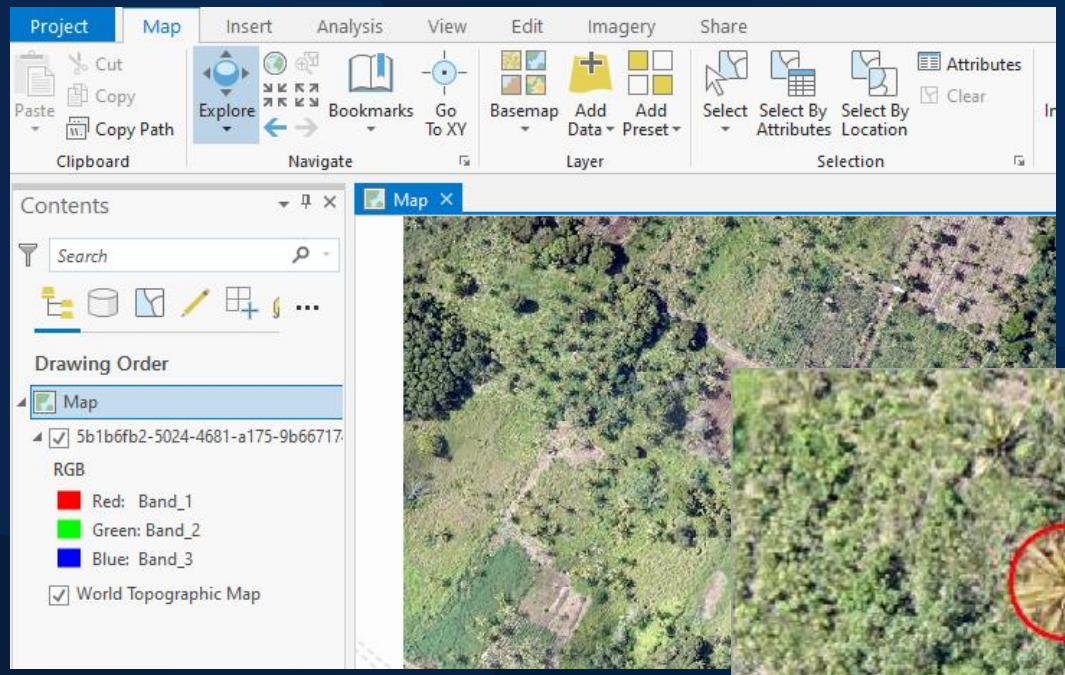

Image as viewed in ArcGIS Pro

Samples as Image Chips

Density of Sample collection

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SAMPLE IMAGE CHIP CREATION

Samples at multiple locations

Samples exported for Deep Learning

Export Training Data For Deep Learn...

Parameters | Environments

Input Raster
Kolovai Palms

Output Folder
ImageChips

Input Feature Class Or Classified Raster
PalmTraining

Class Value Field
Classvalue

Buffer Radius: 0

Image Format
JPEG format

Tile Size X: 448

Tile Size Y: 448

Stride X: 128

Stride Y: 128

Output No Feature Tiles

Meta Data Format
PASCAL Visual Object Classes

Start Index: 0

Run

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- Support for Deep Learning out of the box

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

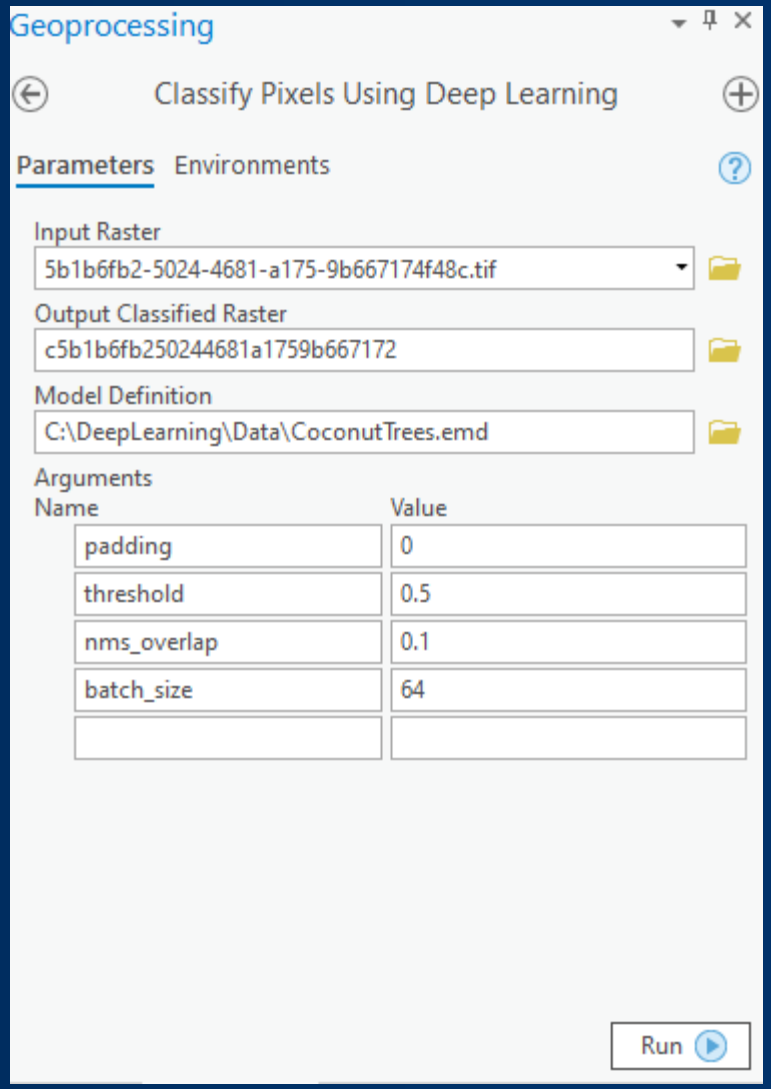
Tensor Flow: end-to-end open source platform for machine learning
Keras: Open-source neural-network library written in Python. Capable of running on top of TensorFlow, CNTK and other platform
PyTorch: Open source machine learning library used for computer vision and natural language processing, primarily developed by FB AI Research Lab
CNTK: Microsoft Cognitive Toolkit, previously known as CNTK - a deep learning framework developed by Microsoft Research

Inference Tools

- **Classify Pixels using Deep Learning**

Runs the model on an input raster to produce 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



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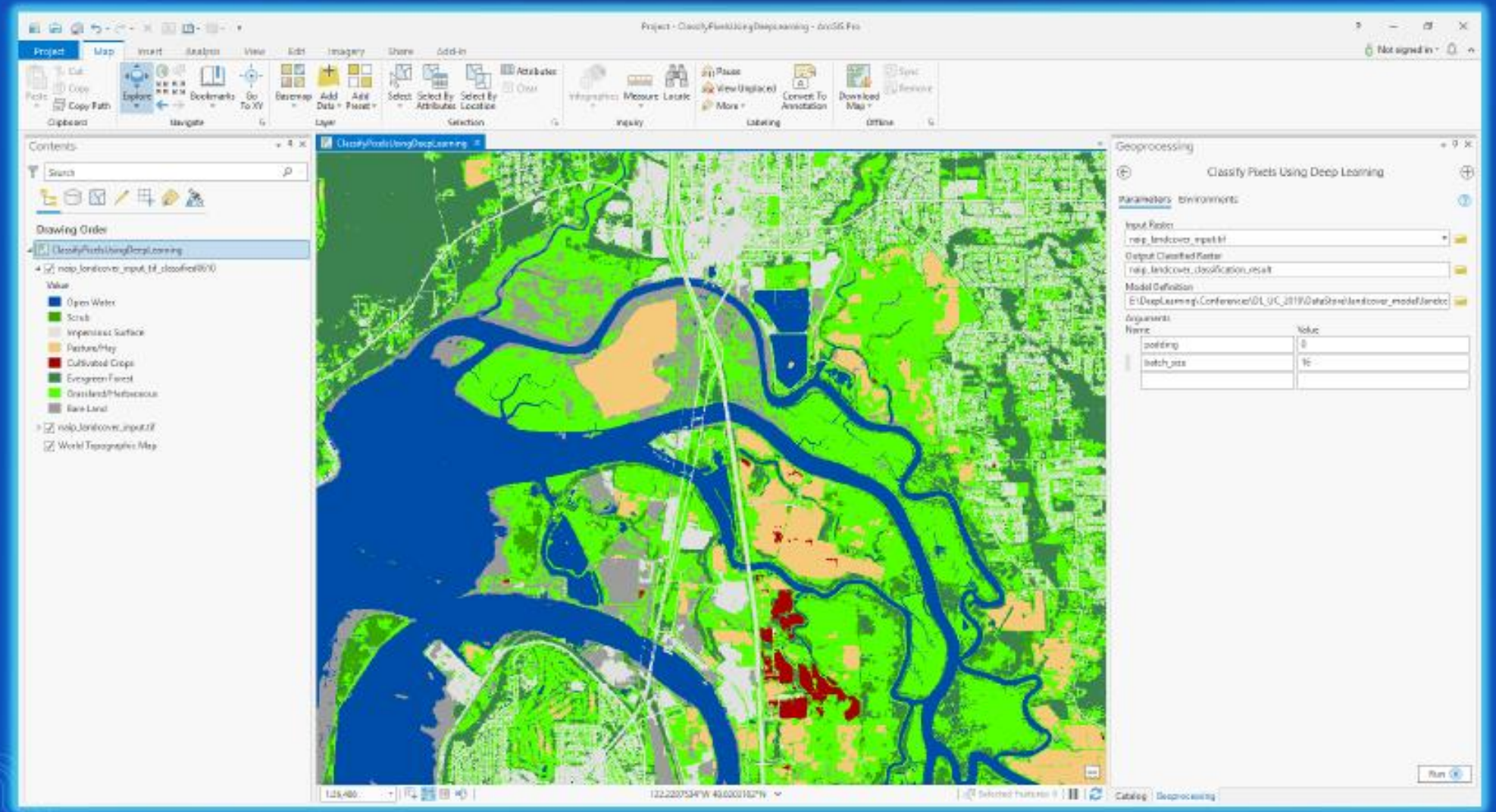
Classify Pixels Using Deep Learning – Sample Use Case

Landcover Classification



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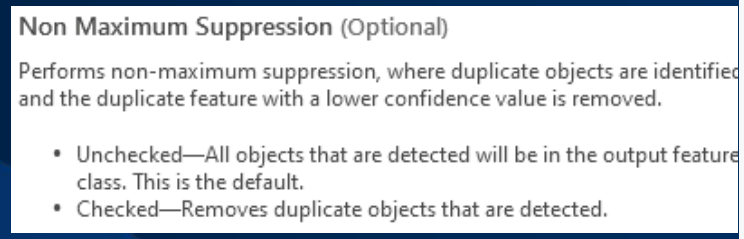
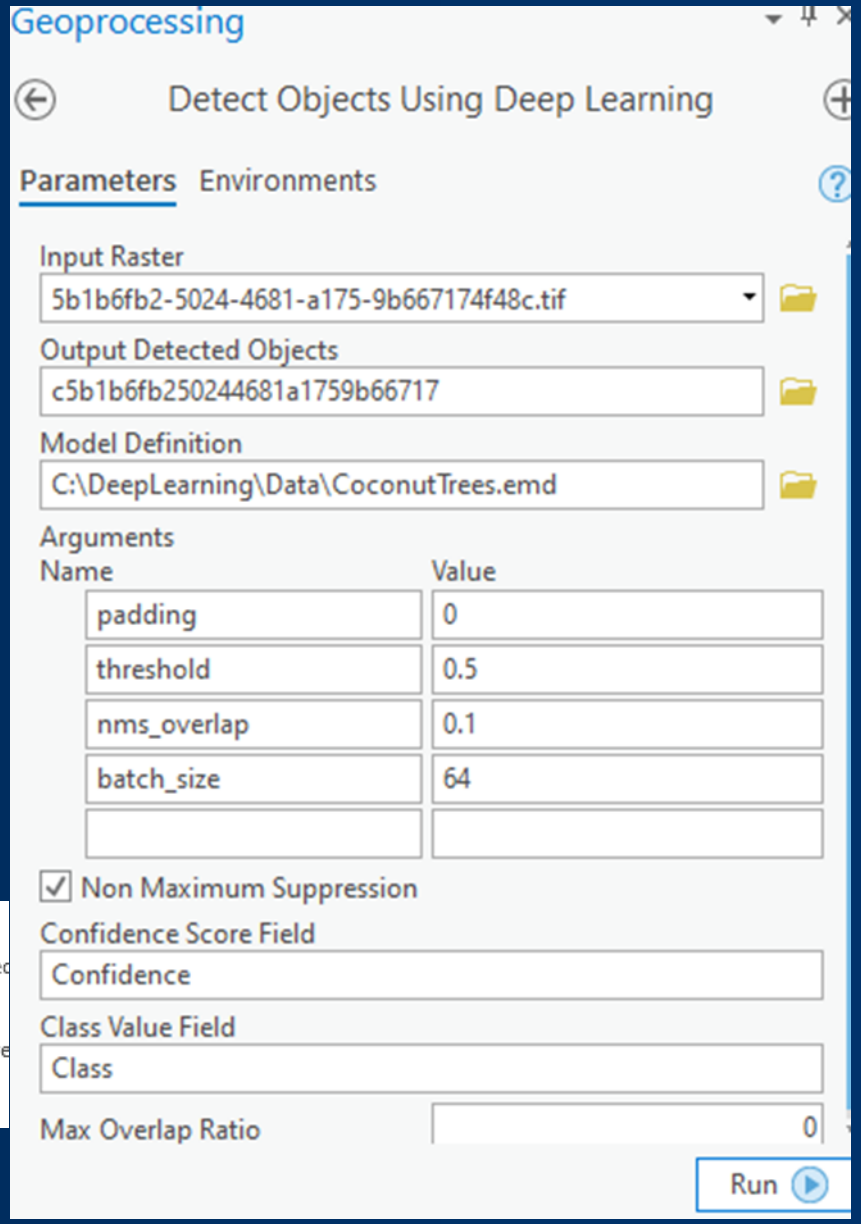
Inference Tools

- **Detect Objects Using Deep Learning**

Runs the model on an input raster to produce feature class containing the object 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 ArcGIS Pro
- Distributed raster analysis on Enterprise





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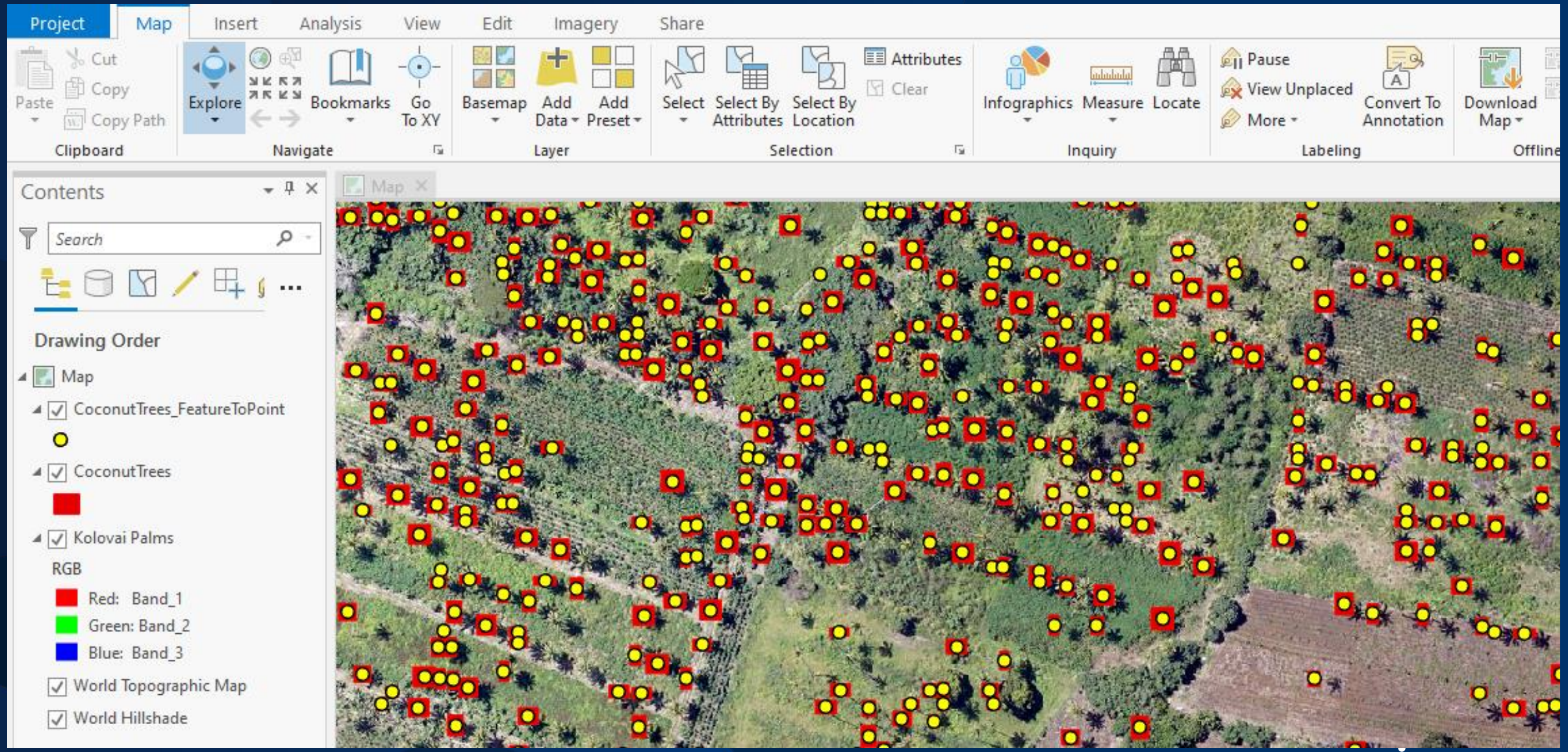
Object Detection using Deep Learning – Sample Output



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Deep Learning in ArcGIS API for Python

Make model training easier using arcgis.learn module

Current Version 1.7.0

The **arcgis.learn module** is based on PyTorch and fast.ai and enables fine-tuning of pretrained torchvision models on satellite imagery

- Prepare Training Data
  - arcgis.learn.prepare_data
- Export Training Data
  - arcgis.learn.export_training_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

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Take Away

- **Easy way to extend 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.**
- **Users can easily train the model with ArcGIS API for Python**

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Thank you!

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