Using Machine Learning and Deep learning with Imagery in ArcGIS

Ling Tang and Sangeet Mathew
ArcGIS Includes Machine Learning Tools

Classification

Clustering

Prediction

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

- Performs Labelling or Collects Training Samples
- Export Samples to Training Data

Runs Deep Learning Inference Tools

Collect Samples ➔ Export Training Chips ➔ Train ➔ Perform Inference
## Support for Deep Learning Frameworks out of the box

<table>
<thead>
<tr>
<th>Framework</th>
<th>Detect Objects</th>
<th>Classify Pixels</th>
</tr>
</thead>
<tbody>
<tr>
<td>TensorFlow</td>
<td>Object Detection API</td>
<td>DeepLabs</td>
</tr>
<tr>
<td>Keras</td>
<td>Mask RCNN</td>
<td></td>
</tr>
<tr>
<td>PyTorch</td>
<td>fast.ai - SSD</td>
<td></td>
</tr>
<tr>
<td>CNTK</td>
<td>Faster RCNN by Microsoft</td>
<td>U-Net by Microsoft Azure</td>
</tr>
</tbody>
</table>
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 Images
- Each Image has Labels
- Performs Data Augmentation
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, 155, 0]
  }
]
```
ArcGIS Deep Learning Workflow
Consume Deep Learning Models

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

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

Collect Samples ➔ Export Training Samples ➔ Train ➔ Perform Inference
Inference Tools

**Classify Pixels Using Deep Learning**

Runs the model on an input raster to produce 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
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
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

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

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 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 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.lean
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:
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

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