Leveraging Deep Learning Techniques to Generate Urban Trees Inventory

2024

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Overview

- Background
- Define Deep Learning, Machine Learning, & AI
- Types of Deep Learning Models
- Licensing and Setup
- Demonstration
- Future Projects & Lesson Learned

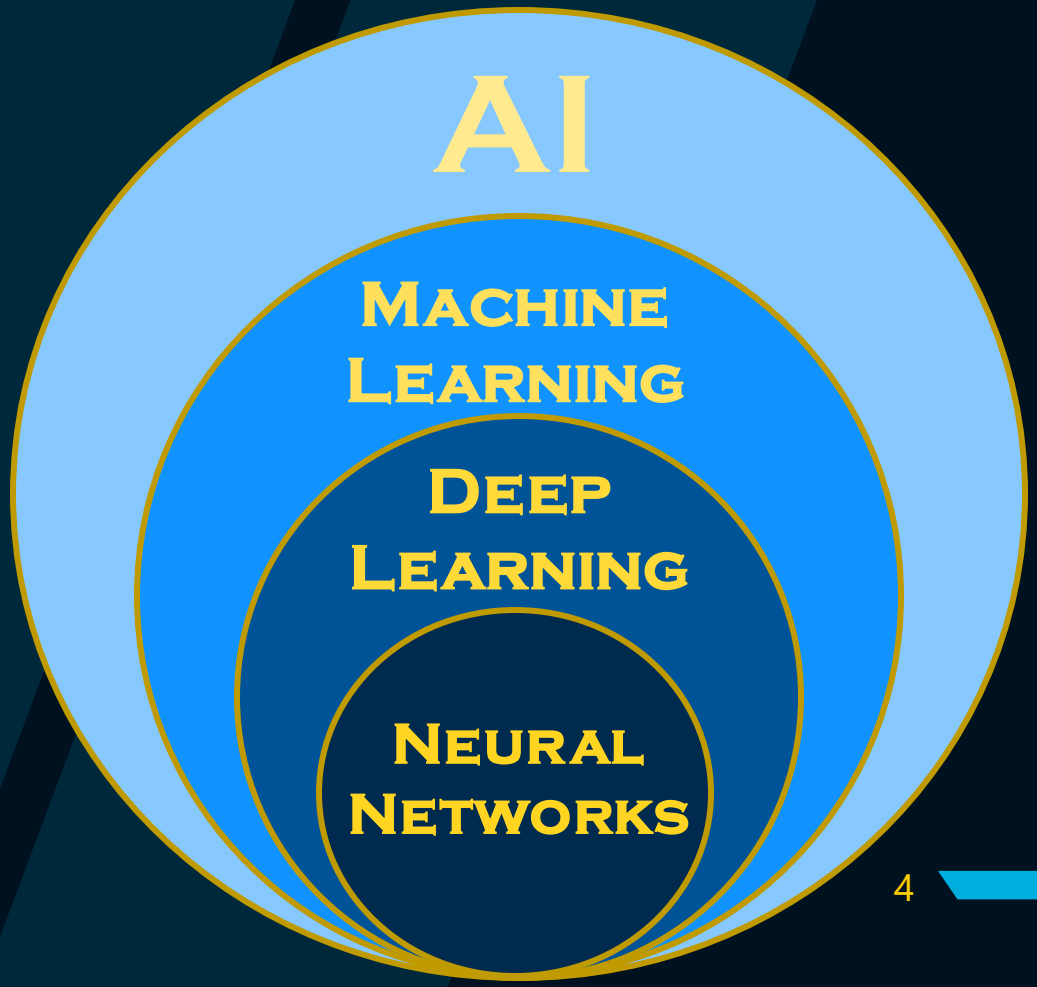
Background

Development Services & GIS

- City of Frisco Landscape Architect needed an inventory of trees along right of ways in residential areas
- Project was halted for years due to lack of manpower and resources
- Data was needed quickly for asset management directives from city management

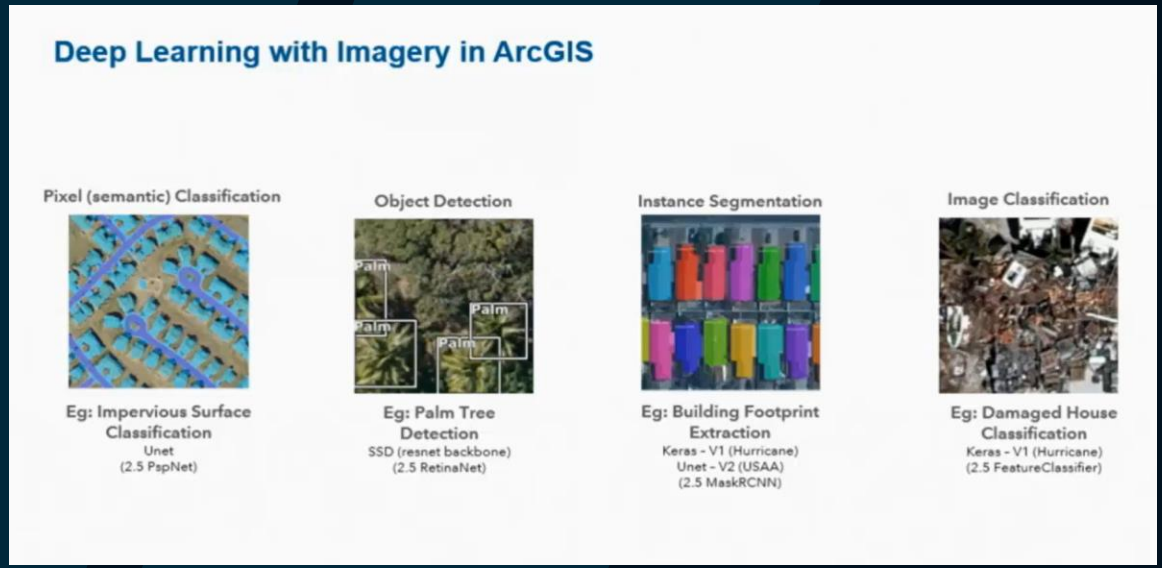
Deep Learning, Machine Learning, & AI

- **Artificial Intelligence (AI)** - Using machines to accomplish tasks that require some level of human intelligence. AI encompasses Deep Learning and Machine Learning
- **Machine Learning** - Uses data driven algorithms to automate prediction, clustering, and classification of datasets
- **Deep Learning** - A subset of Machine Learning that is based on neural networks that loosely mimic the human brain. It is an adaptable algorithm that expands on Machine Learning capabilities
- **Neural Networks** - powerful and highly adaptable models that learn how to extract and recognize complex patterns from large datasets by using a hierarchy of processing



Types of Deep Learning Models

- **Pixel Classification** – Uses Deep Learning models to classify rasters at the pixel level. Used for land classification
- **Object Detection** – Uses Deep Learning models to identify objects in imagery (e.g., trees, windmills, fire hydrants, power lines). A new model must be trained to identify different objects
- **Instance Segmentation** – Generates polygon boundaries for specific objects, such as, building footprints and land parcels
- **Image Classification** – Classifies image chips based on user training data (e.g., damaged houses, burn areas)



Licensing and Setup

- Image Analyst License
- Deep Learning Libraries (deep-learning-frameworks/README.md at master · Esri/deep-learning-frameworks · GitHub)
- ArcGIS Living Atlas (ArcGIS Living Atlas of the World)

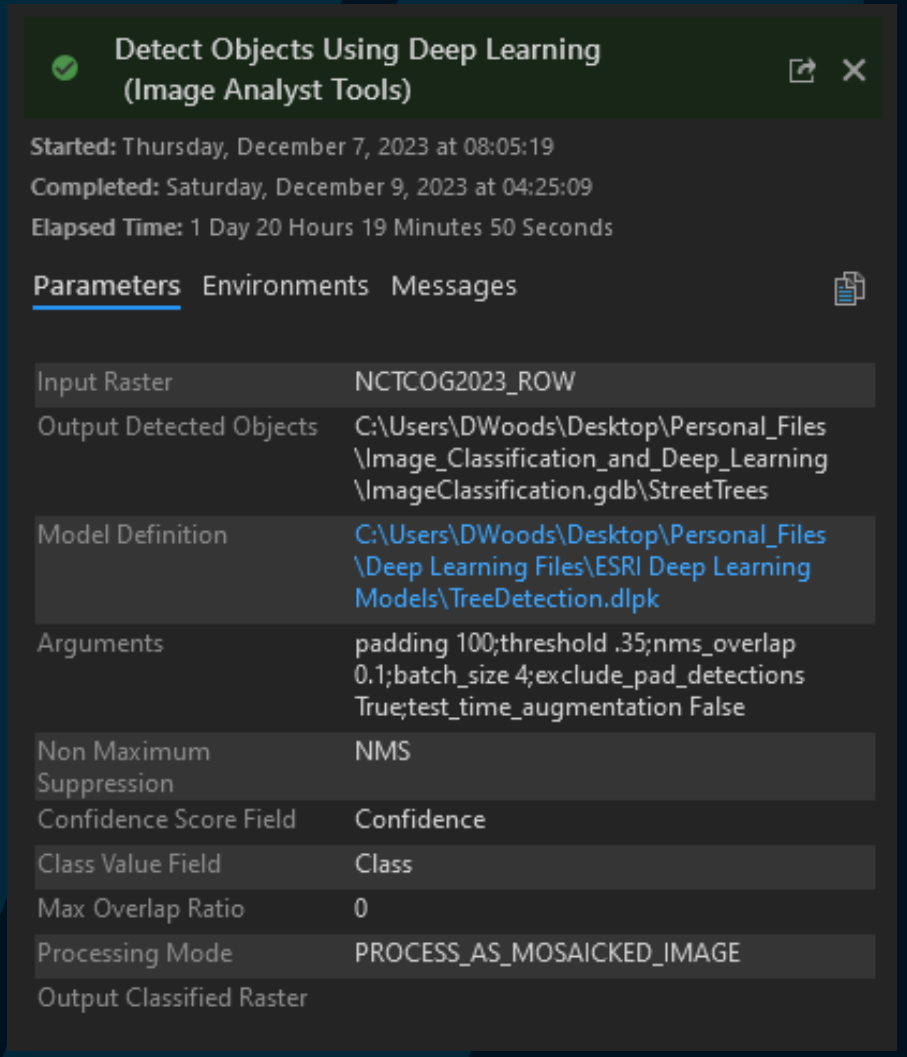
* **Note:** You will need to update and install the newest version of the Deep Learning Libraries to match whatever version of Pro you are operating out of. For example, I am running Pro 3.1; When I update to Pro 3.2, I will need to install the "Deep Learning Libraries Installer for ArcGIS Pro 3.2"

Demonstration

- **Padding –** Adds a border of cells around the image. This border is used to ensure that the image maintains its original size as it passes through the model. Padding is most relevant if you are detecting objects that are around the edge of your image
- **Threshold -** defines the required confidence level for object detection
- **NMS Overlap -** is the percentage of allowable overlap between features
- **Batch Size** - should be a square number, such as 1, 4, 9, 16, etc. If the input value is not a perfect square, the analysis will use the largest perfect square that is less than the input. Increasing the batch size can improve tool performance. However, as the batch size increases, more memory is used
- **Exclude Pad Detections -** allows you to exclude items in the padded areas

Results

- Original output contained 23,119 points
- After QC by Landscape Architect, we ended up with 47,200 points

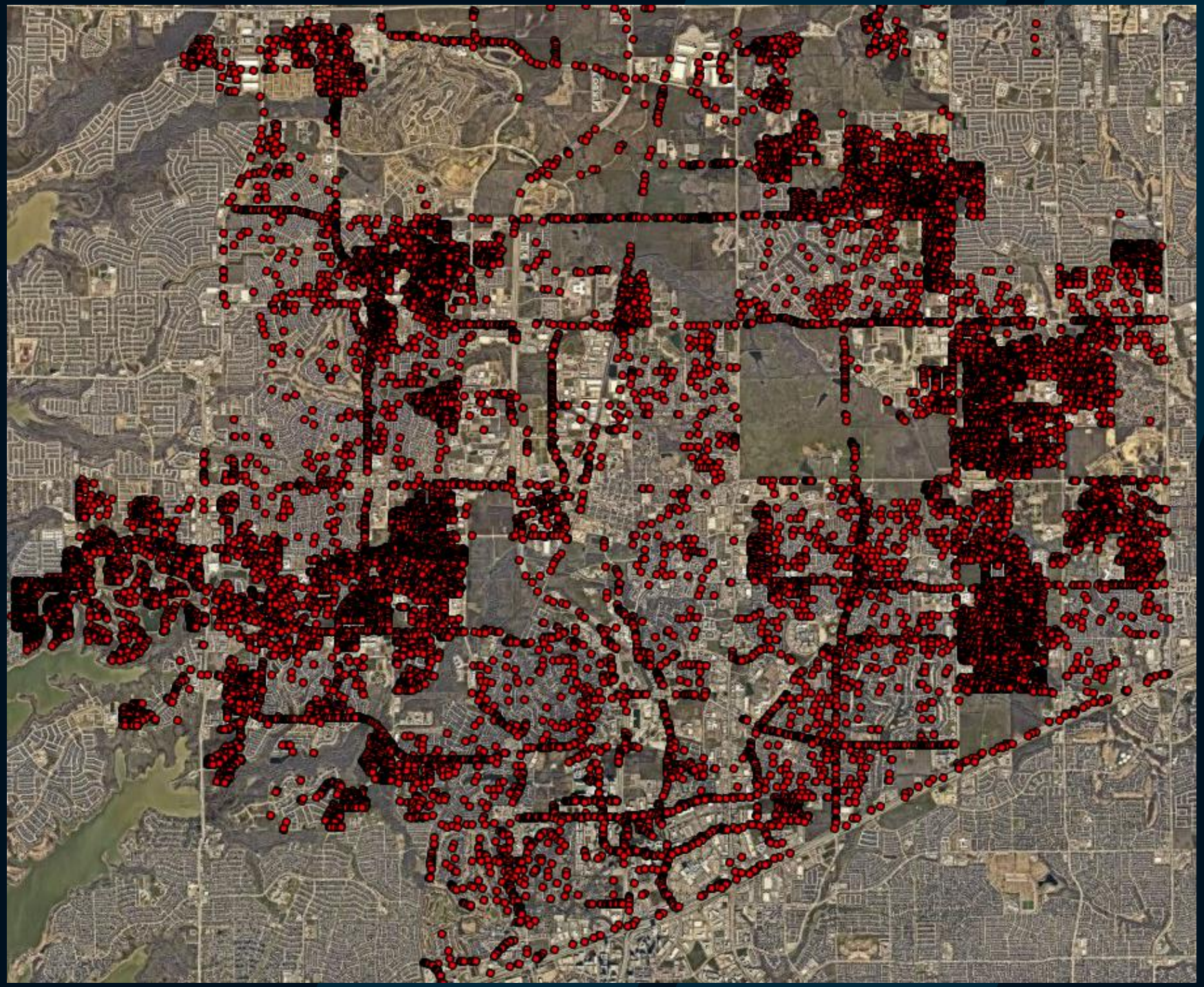


Detect Objects Using Deep Learning
(Image Analyst Tools)

Started: Thursday, December 7, 2023 at 08:05:19
Completed: Saturday, December 9, 2023 at 04:25:09
Elapsed Time: 1 Day 20 Hours 19 Minutes 50 Seconds

Parameters | Environments | Messages

Input Raster	NCTCOG2023_ROW
Output Detected Objects	C:\Users\DWoods\Desktop\Personal_Files\Image_Classification_and_Deep_Learning\ImageClassification.gdb\StreetTrees
Model Definition	C:\Users\DWoods\Desktop\Personal_Files\Deep Learning Files\ESRI Deep Learning Models\TreeDetection.dlpk
Arguments	padding 100;threshold .35;nms_overlap 0.1;batch_size 4;exclude_pad_detections True;test_time_augmentation False
Non Maximum Suppression	NMS
Confidence Score Field	Confidence
Class Value Field	Class
Max Overlap Ratio	0
Processing Mode	PROCESS_AS_MOSAICKED_IMAGE
Output Classified Raster	



Future Projects

- Pavement Detection
- Building Footprints
- Tree Canopy
- LiDAR Classification

Lessons Learned

- Deep Learning workflows require an in-depth QC process
- Accuracy tends to decrease at larger scales
- Deep Learning is a great tool for generating and classifying data

References

- Deep Learning Using ArcGIS | Learning Plan (esri.com)
- ArcGIS Deep Learning Tools for Imagery | Esri Training Seminar
- Detect Objects Using Deep Learning (Image Analyst)—ArcGIS Pro | Documentation

Questions & Contact Info

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