Deep Dive into Deep Learning

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2021 ESRI
DEVELOPER SUMMIT

Who are we?

Vinay Viswambharan

Rohit Singh

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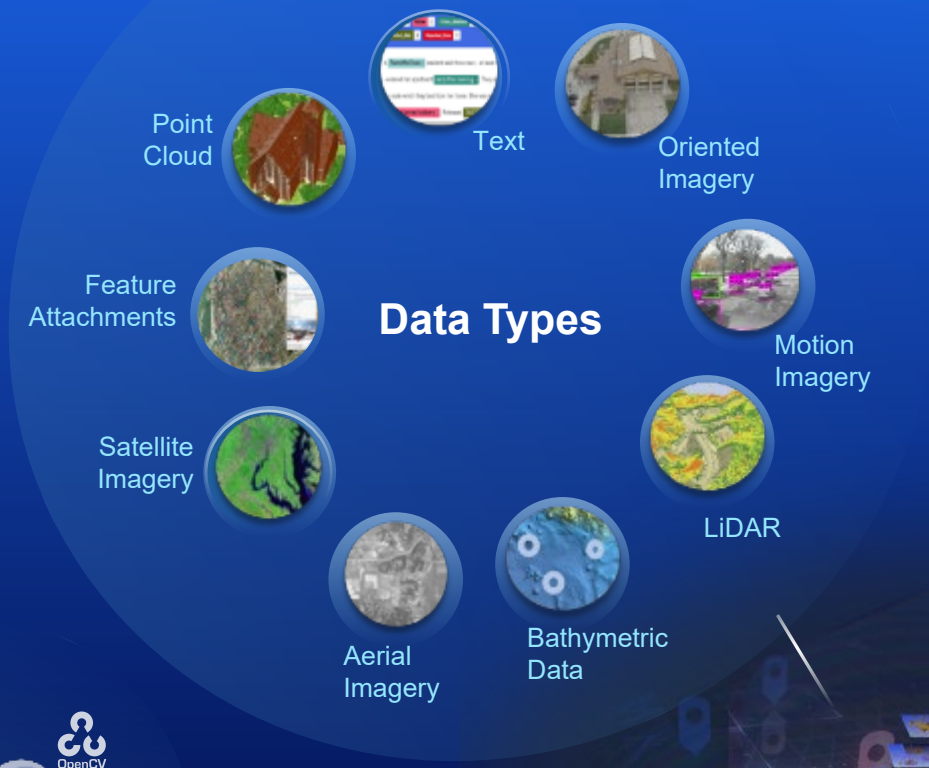
Deep Learning in ArcGIS

Different data types, tasks and integration



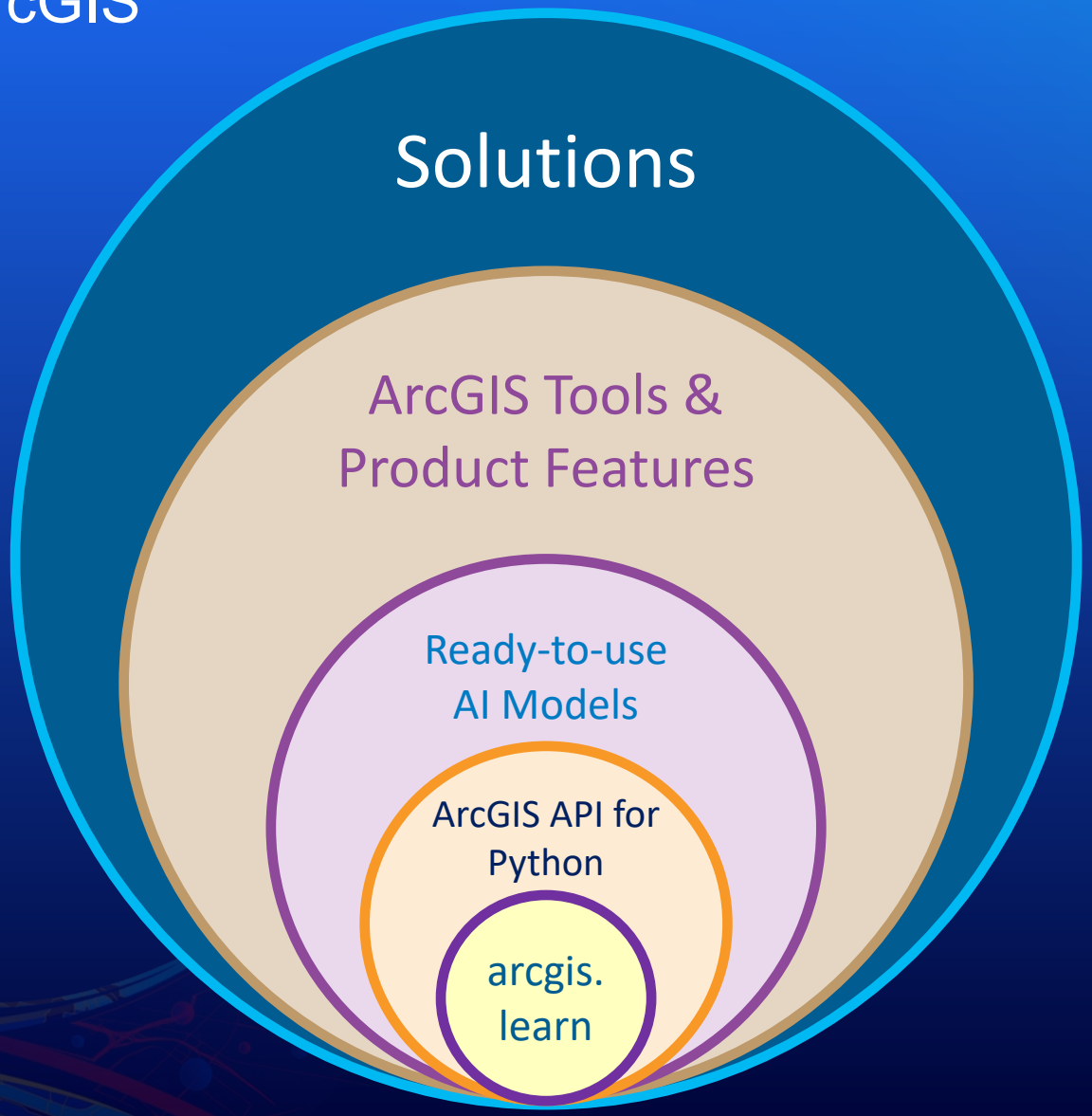
Integration

Why is deep learning important?

Traditional human data interpretation doesn’t scale….

- More sensors
- Large volumes of imagery and raw data
- Velocity of data
- Automation
- Accuracy

Deep Learning in ArcGIS



arcgis.learn

3D Point Cloud

Imagery

Tabular & Feature data

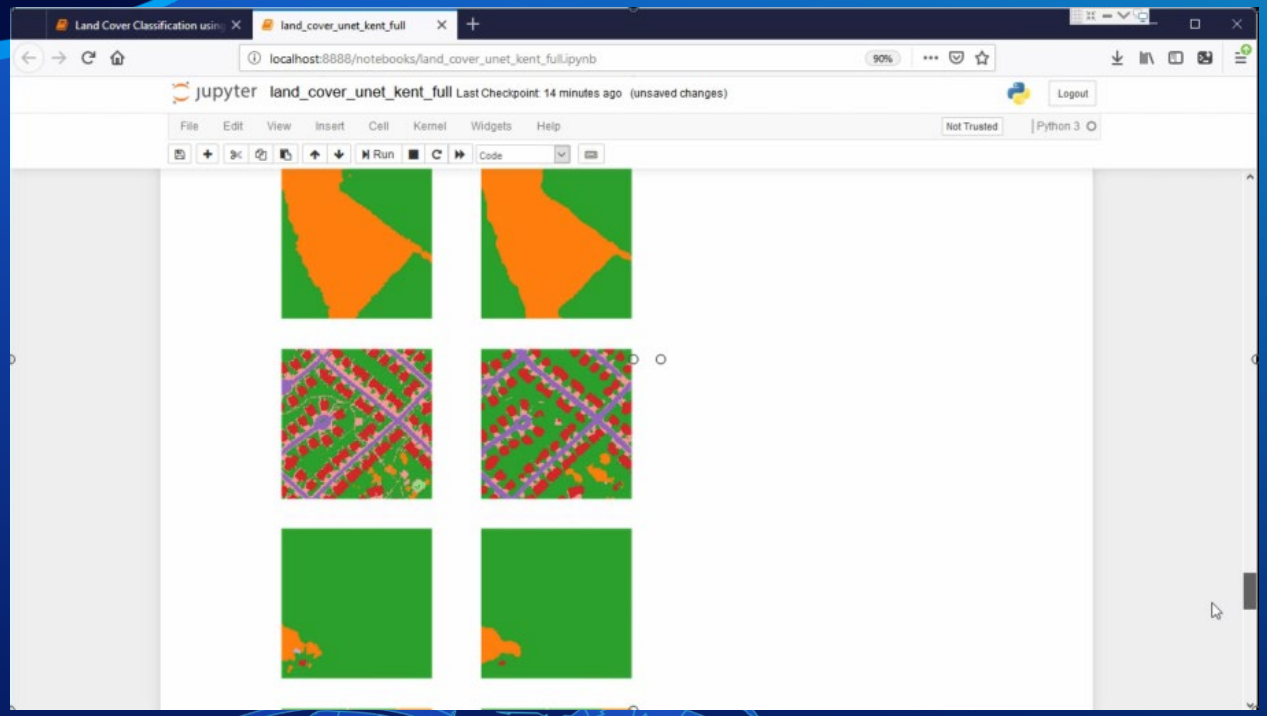
Unstructured Text

Scanned Maps

Time Series

Data preparation

Model Management



Land Cover Classification

Deep Learning with arcgis.learn

Deep Learning with

Imagery

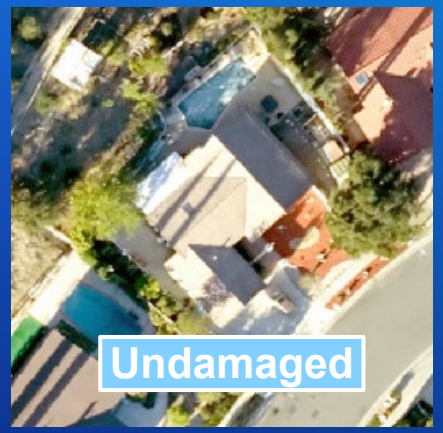
Object Classification Assign a label to a given image / geographical feature

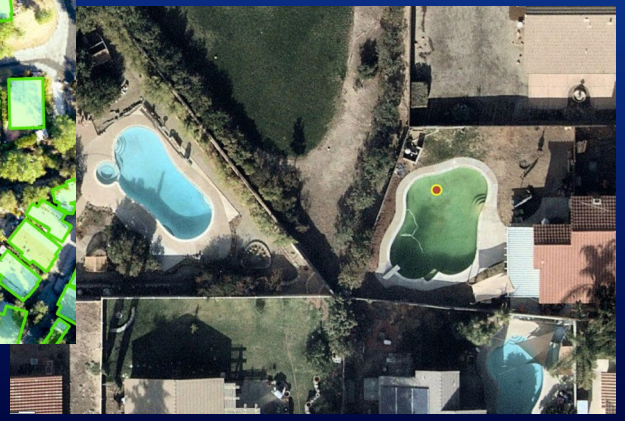
Model:

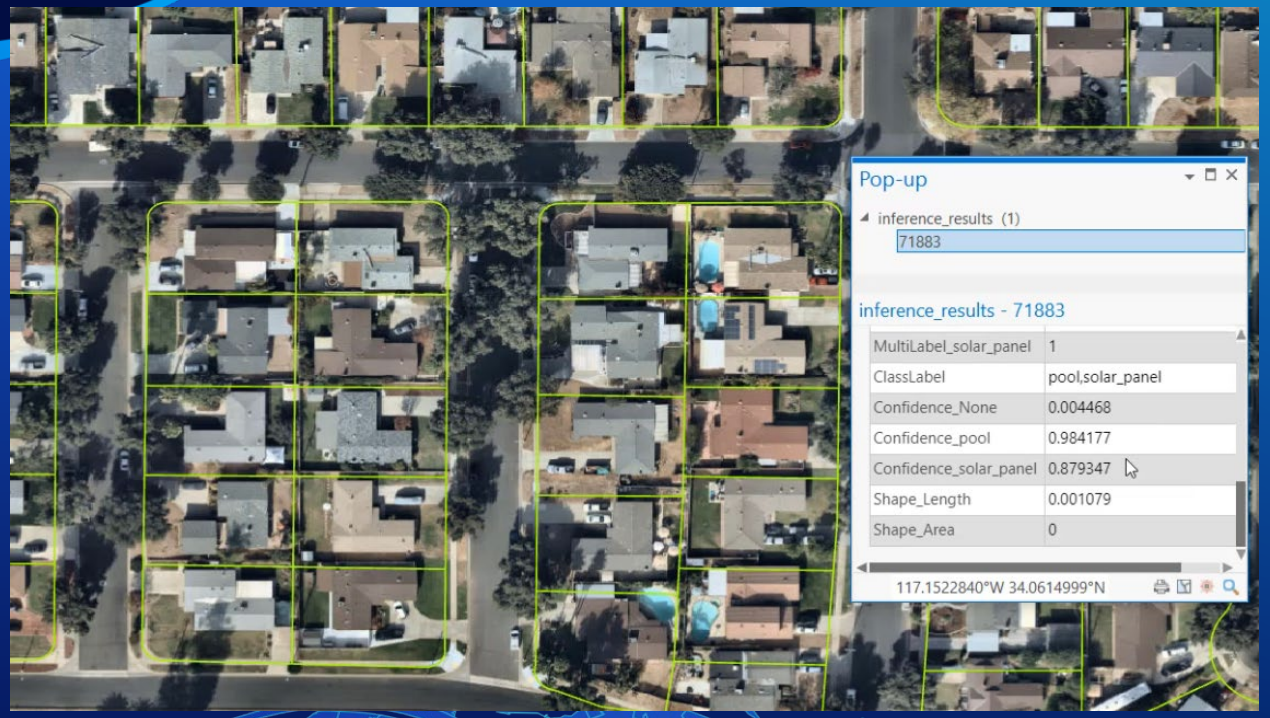
- **FeatureClassifier**

Applications:

- Damaged building classification
- Clean or ‘green’ pools…
- Broken/flashed insulators
- Identifying plant species







Multi-label Classification

Identifying pools and solar panels in property parcels

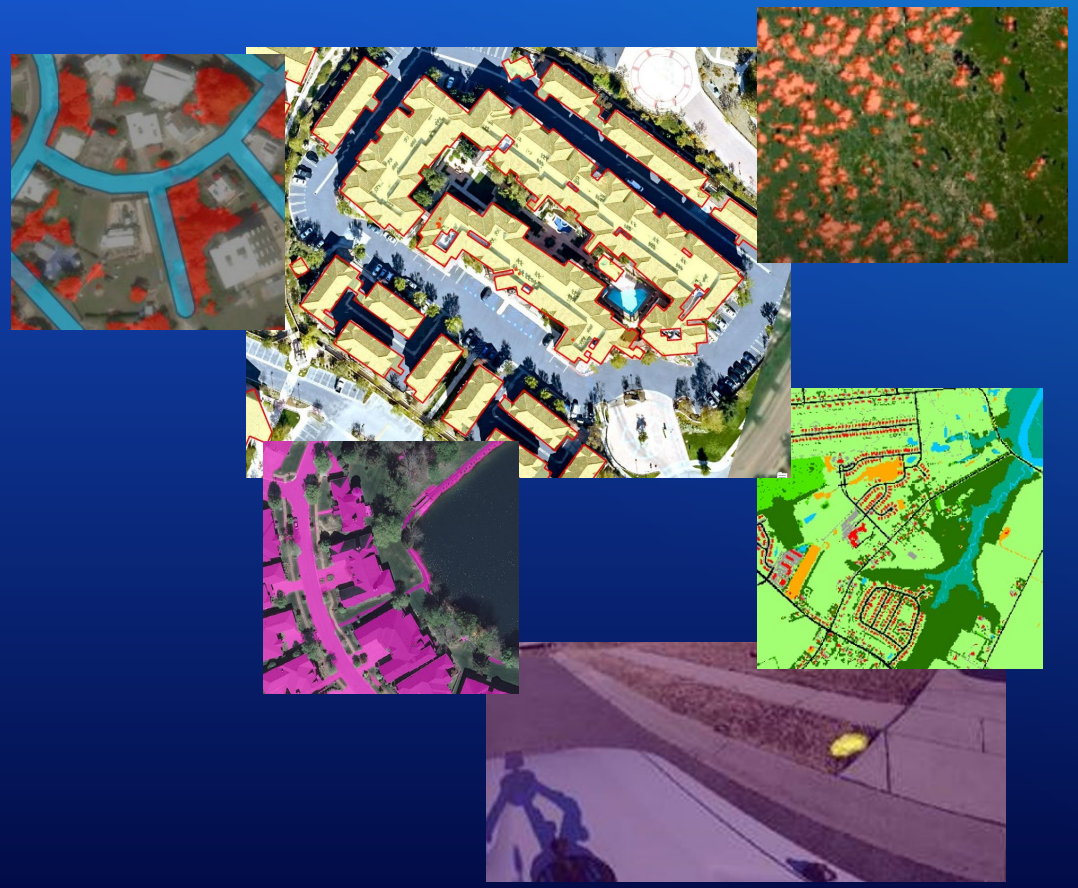
Pixel Classification Assign a label to each pixel

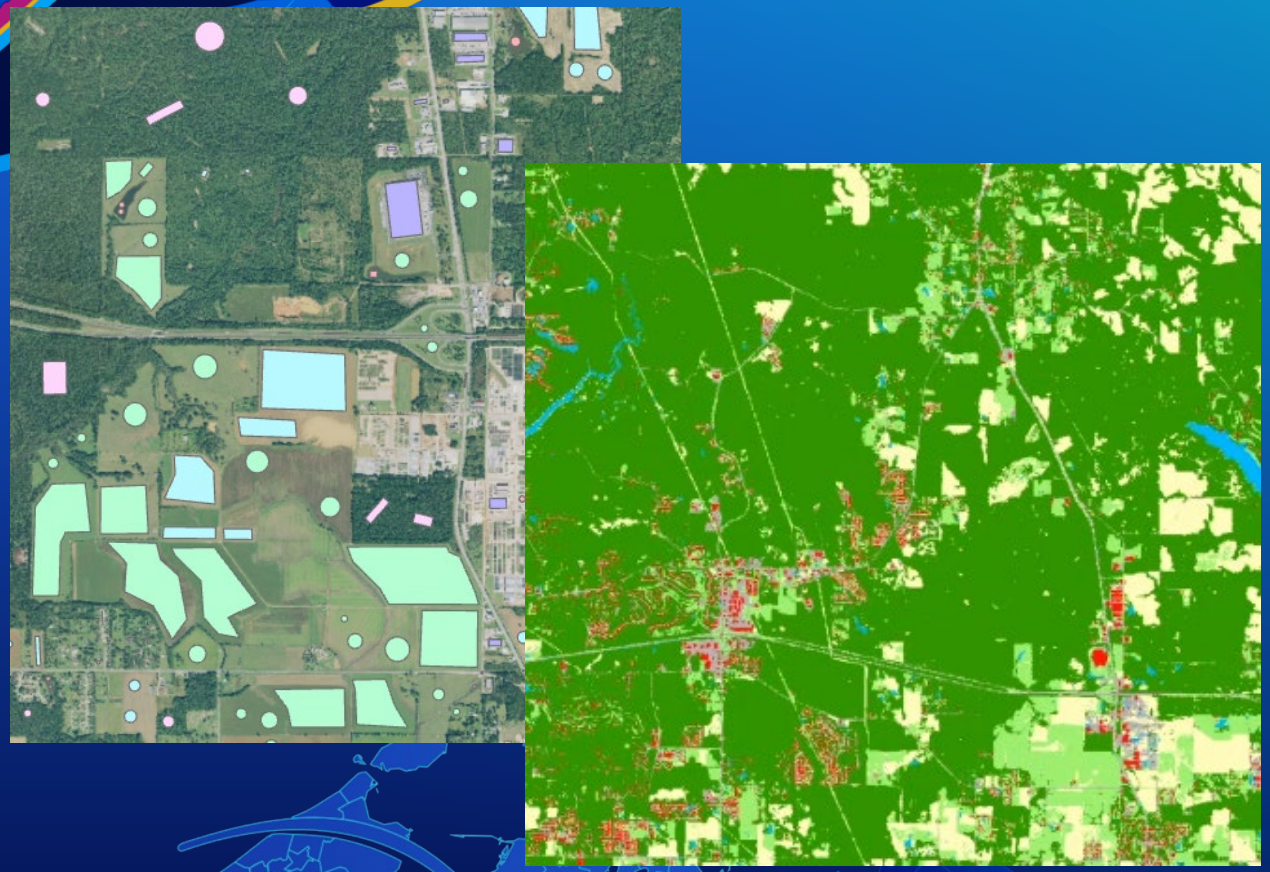
Models:

- UNetClassifier
- PSPNetClassifier*
- DeepLab*
- *PointRend support for better accuracy

Applications:

- Land Cover Classification
- Pervious/Impervious mapping
- Building Footprint Extraction
- Cloud detection
- Road detection
- Water Meters from oblique images





Land Cover Classification

Using sparse training data

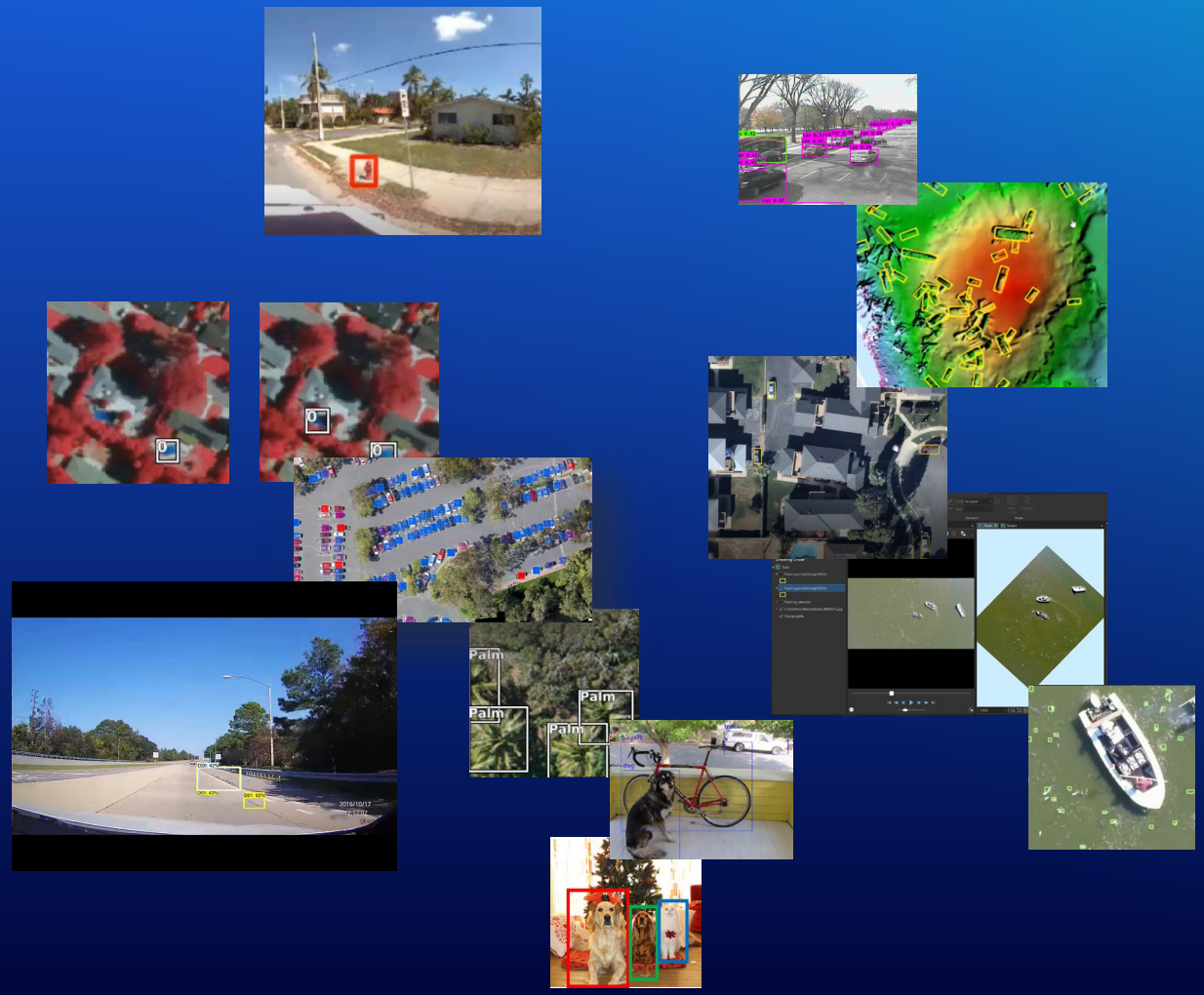
Object Detection Find objects and their locations (bounding boxes or polygons)

Models:

- SingleShotDetector
- RetinaNet
- YOLO
- FasterRCNN
- Mask RCNN

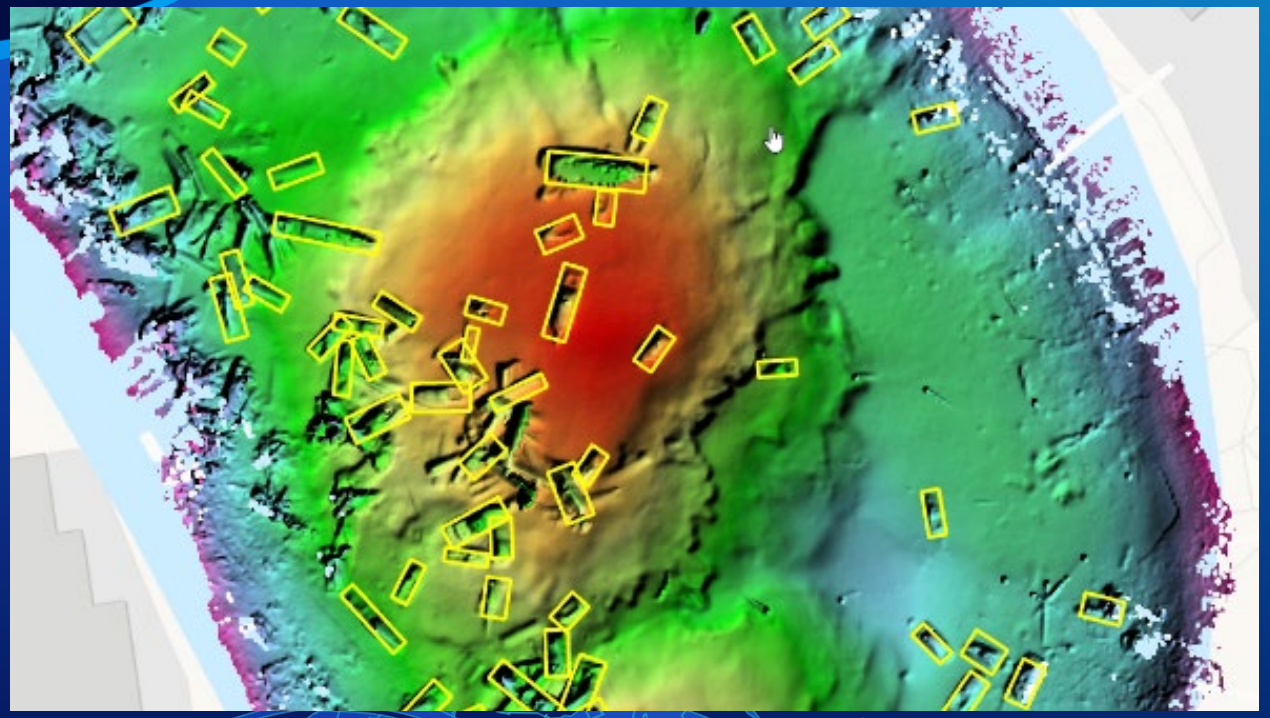
Applications:

- Detect trees, cars, airplanes, swimming pools, well pads
- Detect encroaching structures
- Moving objects like road cracks/catfish on **video**
- Road signs, and other assets in oriented imagery
- Detecting and counting vehicles
- Shipwrecks in **Bathymetric data**



Tree Inventory

Field data collection with Survey123



Detecting Shipwrecks

Deep learning on bathymetric data

Edge Detection Find pixels belonging to edges

Models:
- BDCNEdgeDetector
- HEDEdgeDetector

Applications:
- Residential parcel extraction
- Agricultural farm boundaries

Road Extraction Extract Roads from Aerial or Satellite Imagery

Models:
- MultiTaskRoadExtractor

Applications:
- Extract road networks
- Extract linear features like streams and parcel boundaries

Change Detection Identify areas of persistent change

Models:
- ChangeDetector (based on STANet)

Applications:
- Identify new buildings
- Identify new construction

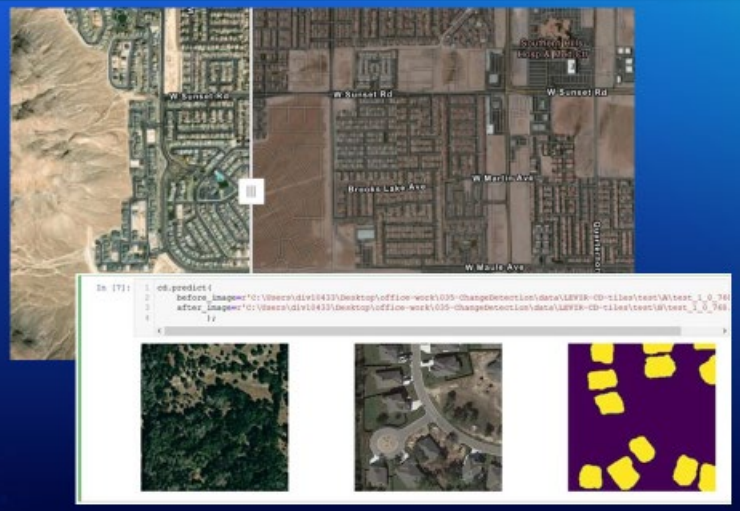
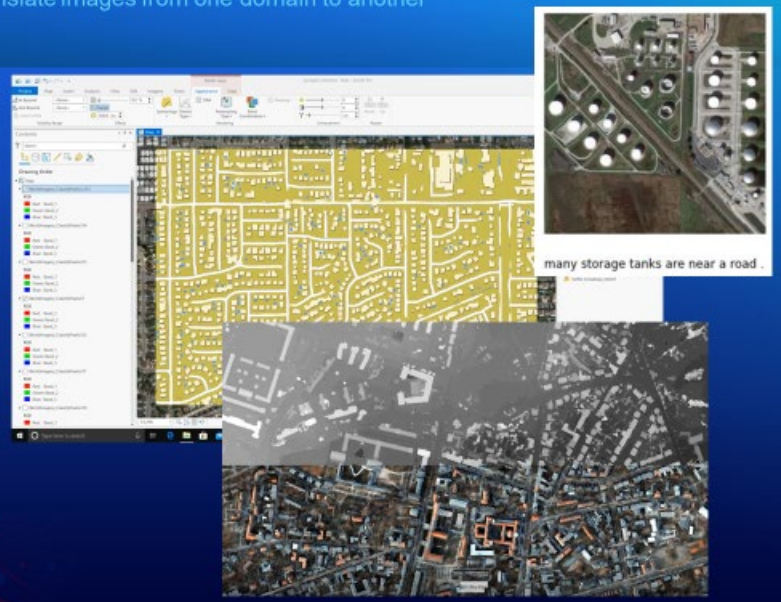


Image Translation Translate images from one domain to another

Models:
- Pix2Pix
- CycleGAN
- Image Captioner

Applications:
- SAR to Optical Imagery
- Imagery to Map generation
- Annotate Imagery
- Increase image resolution



CycleGAN

Conversion of SAR to Optical imagery

Image Enhancement

Models:

- SuperResolution

Applications:

- Improved image interpretability
- Improved image resolution

SuperResolution

Improve quality and resolution of imagery

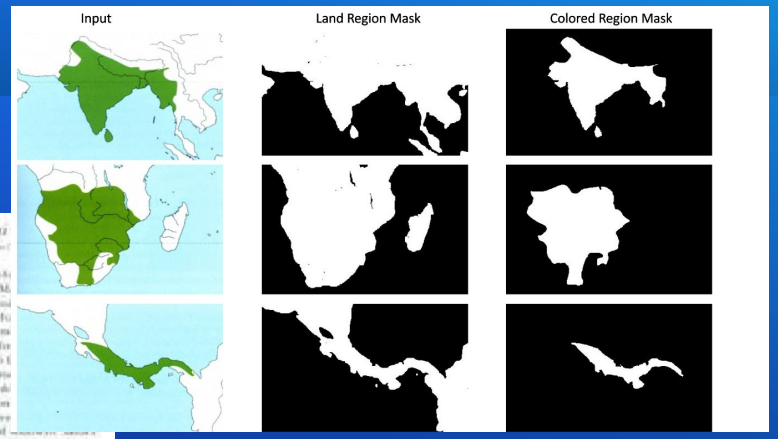
Scanned Map Digitization

Class:

- ScannedMapDigitizer

Applications:

- Digitizing scanned maps
- Georeferencing scanned maps



Deep Learning with

3D Point Clouds

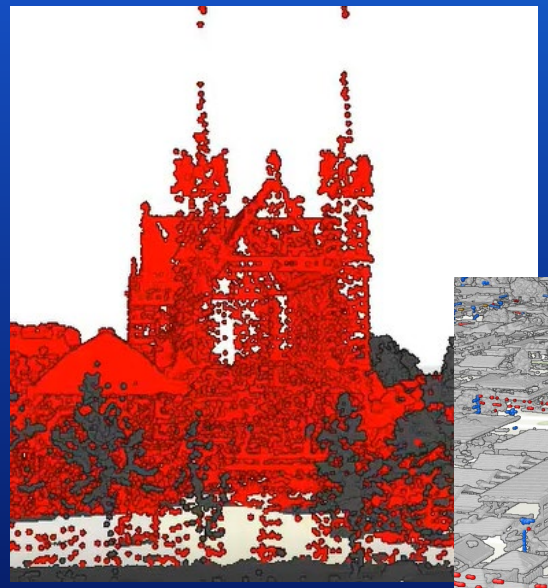
Point Cloud Classification

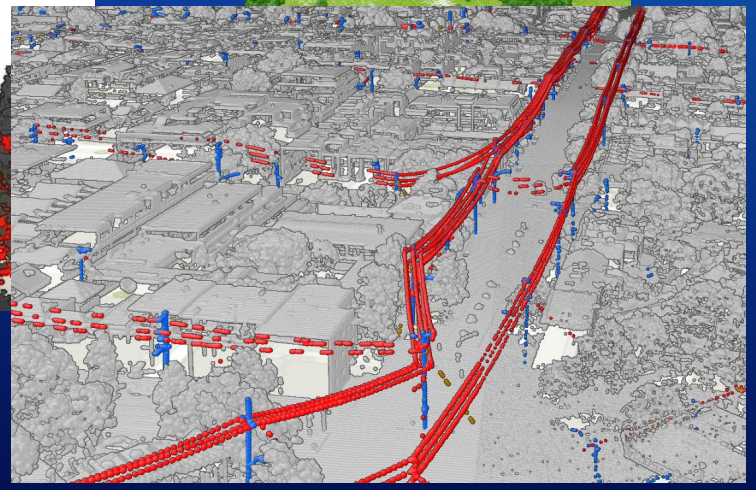
Models:

- PointCNN

Applications:

- Classifying point cloud data (buildings/ground, etc)
- Power line and utility poles extraction





Deep Learning with

Feature layers, Tabular & Time Series data

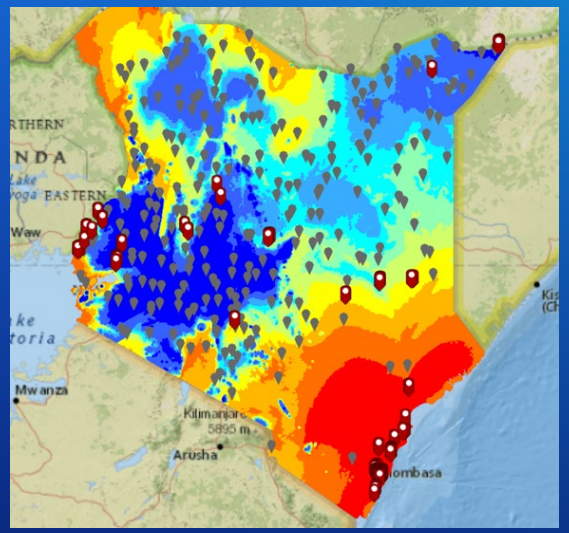
Feature layers, tabular & time series data

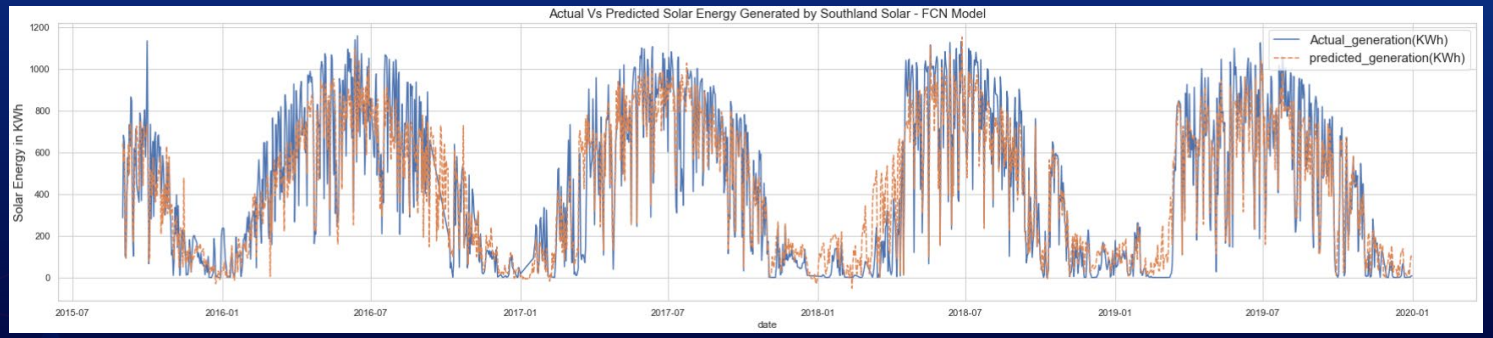
Models:

- FullyConnectedNetwork
- MLModel
- TimeSeriesModel

Applications:

- Dengue fever prediction
- Solar power plan efficiency prediction
- Integrating ArcGIS with Machine Learning models from scikit-learn
- Time Series prediction
- Anomaly / outlier detection





Deep Learning with

Unstructured Text

Text Classification

Models:

- TextClassifier

Applications:

- Classifying country of incomplete addresses
- Classifying tweets for vaccine hesitancy
- Categorizing crime based on incident reports

Address	CountryCode	Confidence
45, REBECA AGUILAR, PUNTA ARENAS, MAGALLANES Y DE LA ANTARTICA CHILENA	CL	1.000000
2120, POCURO, ESTACIONAMIENTO 309, PROVIDENCIA, METROPOLITANA DE SANTIAGO	CL	1.000000
2681, MOSCONI GENERAL AV.	AR	1.000000
237, 백제고분로19길	KR	1.000000
2461, BONNY DR, COCOA, BREVARD, FL, 32926	US	1.000000
37, Schiefer, 8350	AT	0.997607
29, LATHAM STREET, YARRABILBA, QLD, 4207	AU	1.000000
118a, Hauptstraße, 8740	AT	1.000000
13A, BO LLANO, 39409	ES	1.000000
131, Поддубного, БОСТАНДЫКСКИЙ РАЙОН, АЛМАТЫ	KZ	1.000000
SN, CALLE 37, CIUDAD DEL CARMEN, Carmen, Campeche	MX	1.000000
12, Kościelna, Gołubie, kartuski, pomorskie, 83-316	PL	1.000000
12, Werfelstraße, 1170	AT	1.000000
7, SCOTT STREET, MOUNT HOPE, NSW, 2877	AU	1.000000
5422, GROUSSAC, PAUL	AR	0.999999
17, Morelvej, 8920	DK	1.000000
２１２號, 三興路東勢段, 平鎮市, 東勢里	TW	1.000000
48, Częstochowska, Czarny Las, częstochowski, śląskie, 42-233	PL	1.000000
92H, Moste, Moste, Komenda, Osrednjeslovenska, 1218	SI	1.000000
5551, ECHEANDIA	AR	0.999999
16, Rue de la Republique, Amilly, 28300	FR	1.000000
６號, 東森路５５巷, 楊梅市, 永寧里	TW	1.000000
4A, Serupvej, 8600	DK	1.000000
62, 18 DE JULIO (VILLA GUADALUPE), 15562	UY	1.000000
1-3, HEPNER PLACE, NORTH GEELONG, VIC, 3215	AU	1.000000
143, STAGNERO DE MUNAR, MARIA, 15069	UY	1.000000
S/N, CR NUEVALOS, 50230	ES	1.000000

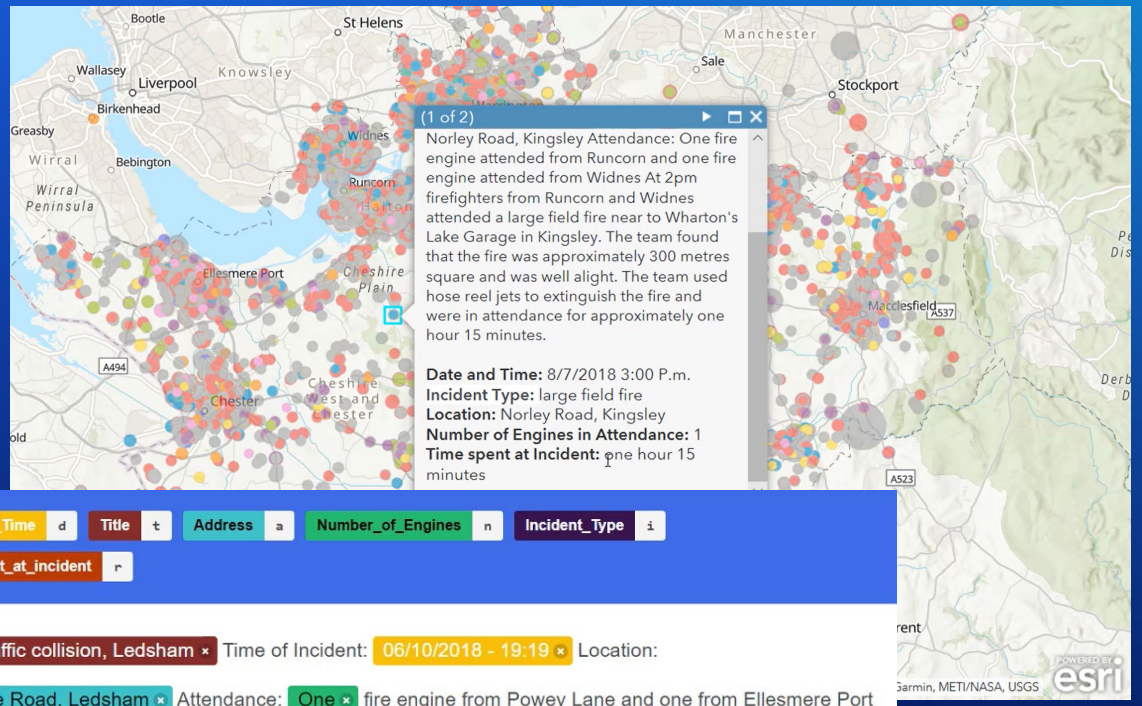
Named Entity Extraction

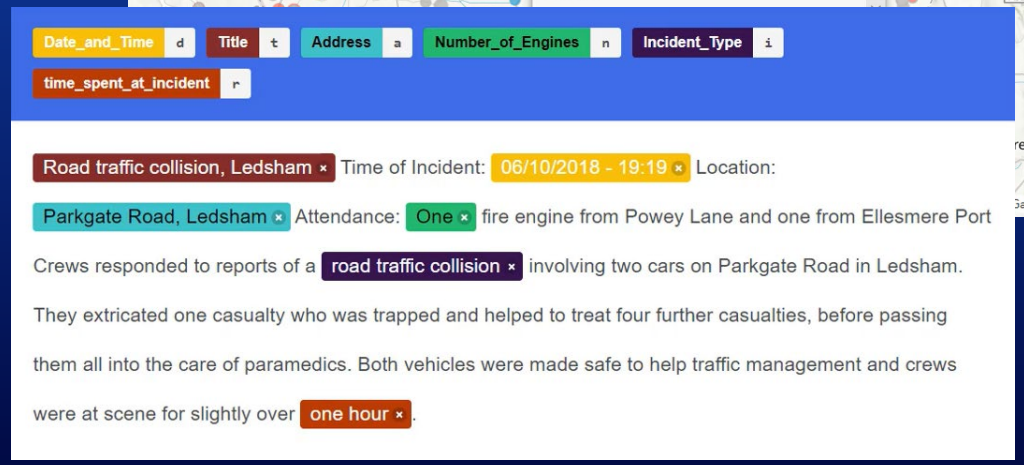
Models:

- EntityRecognizer

Applications:

- Extracting entities and relationships from text reports
- Parsing unstructured text and converting to spatial information
- Extracting fire incidents from fire reports





SequenceToSequence

Converts one sequence to another of the same or different length

Suitable for:

- Translation
- Summarization
- Question Answering

1005 W SH174 HWY Austin, TX	→	1005 W State Hwy 174, Austin, TX
3101 E STHY 38 Redlands, CA	→	31010 E State Hwy 38, Redlands, CA
13350 I40 FRONTAGE RD NW, Jurupa Valley, CA	→	13350 I-40 Frontage Rd NW, Jurupa Valley, CA
5559 N COUNTY RD 757 RD, Jonesboro AR	→	5559 N COUNTY RD 757, Jonesboro, AR

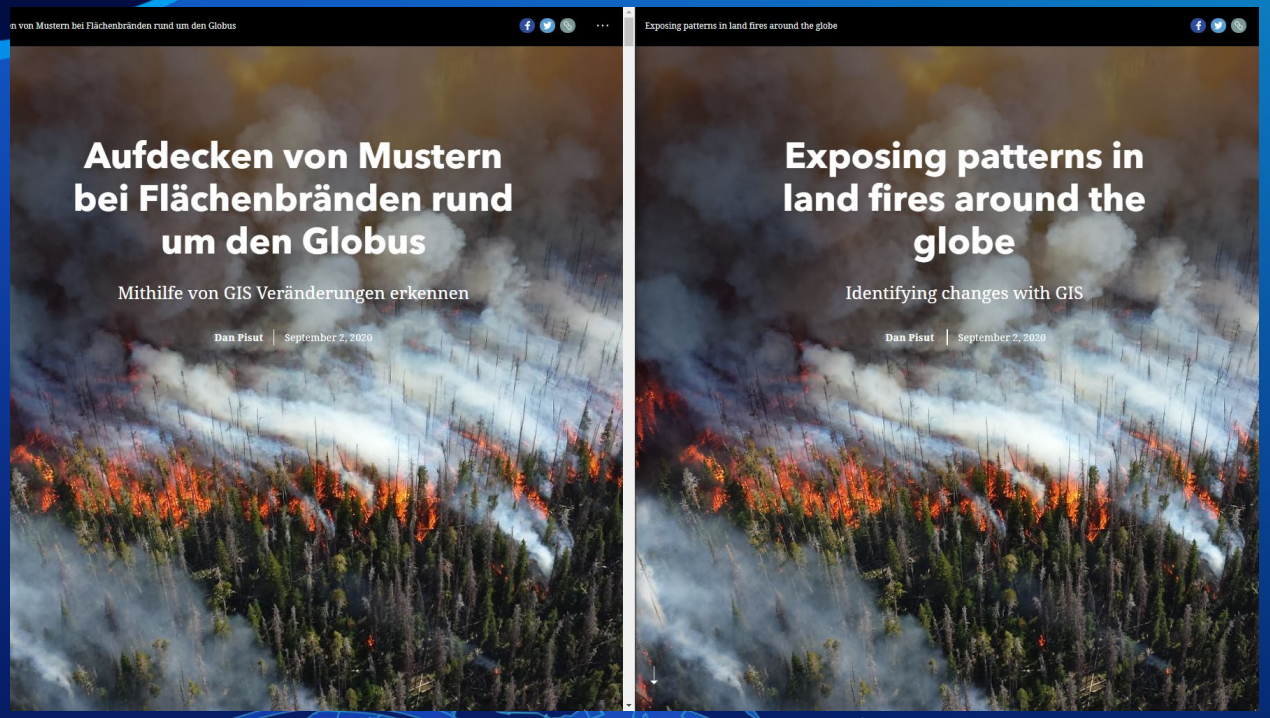
text	target	pred
6342.0, e mt vernom rd, wdterloo, ua, 50703.0, us	6342.0, e mt vernon rd, waterloo, ia, 50703.0, us	6342.0, e mt vernom rd, waterloo, ia, 50703.0, us
1315.0, west donald streey, watrrloo, iowa, 50703.0, us	1315.0, w donald st, waterloo, ia, 50703.0, us	1315.0, w donald st, waterloo, ia, 50703.0, us
1318.0, ewst 6th street, awterloo, iwoa, 50702.0, us	1318.0, w 6th st, waterloo, ia, 50702.0, us	1318.0, w 6th st, waterloo, ia, 50702.0, us
719.0, newton srteet, waterloo, iowa, 50703.0, us	719.0, newton st, waterloo, ia, 50703.0, us	719.0, newton st, waterloo, ia, 50703.0, us
3539.0, lafayette rd, eavnsdale, ia, 50707.0, us	3539.0, lafayette rd, evansdale, ia, 50707.0, us	3539.0, lafayette rd, evansdale, ia, 50707.0, us
807, 12th st ne, msaon ctiy, ia, 50401, us	807, 12th st ne, mason city, ia, 50401, us	807, 12th st ne, mason city, ia, 50401, us
636, 3rd strwet sourh east, mason ciy, iowa, 50401, us	636, 3rd st se, mason city, ia, 50401, us	636, 3rd st se, mason city, ia, 50401, us

Inference-only models

Ready to use models for processing unstructured text

Models:

- TextTranslator
- TextSummarizer
- TextGenerator
- QuestionAnswering
- FillMask
- ZeroShotClassifier



TextTranslator

Translate StoryMap to another language

Why arcgis.learn?

- Integrated with ArcGIS
- Simple, consistent API
- Large collection of geospatial deep learning models

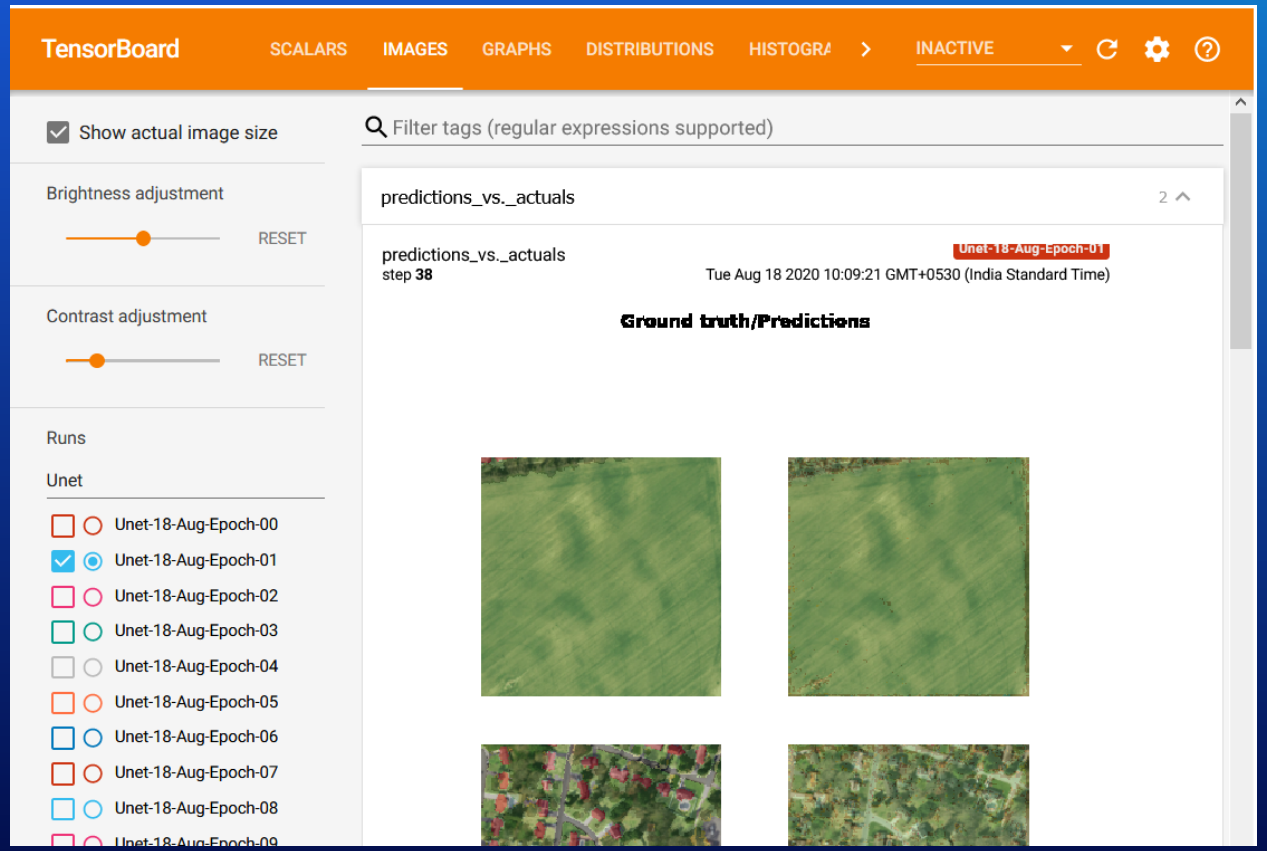
```
from arcgis.learn import prepare_data, Model

data = prepare_data('path/to/data')
model = Model(data)
model.fit(10)
model.show_results()
model.save()
model.predict()
```

TensorBoard support

Applications:

- Visualize model training by monitoring loss graphs
- Visualize intermediate results while model is training
- Supported for all models



Easy installation of deep learning dependencies

- Deep Learning Libraries installer (ArcGIS Pro and Enterprise)
- arcgis_learn conda metapackage (Anaconda)
- arcgis_dl_backbones metapackage (for disconnected users)

Select Anaconda Powershell Prompt (anaconda3)

```
(arcgis_dl) PS C:\Users\Admin> conda install -c esri arcgis_learn
Collecting package metadata (current_repodata.json): done
Solving environment: failed with initial frozen solve. Retrying with
Solving environment: failed with repodata from current_repodata.json,
Collecting package metadata (repodata.json): done
Solving environment: done
```

Python API

Automation

Spatially enabled DataFrame

Sample Notebooks

Dashboard

Map widget

GIS Administration

Try it Live

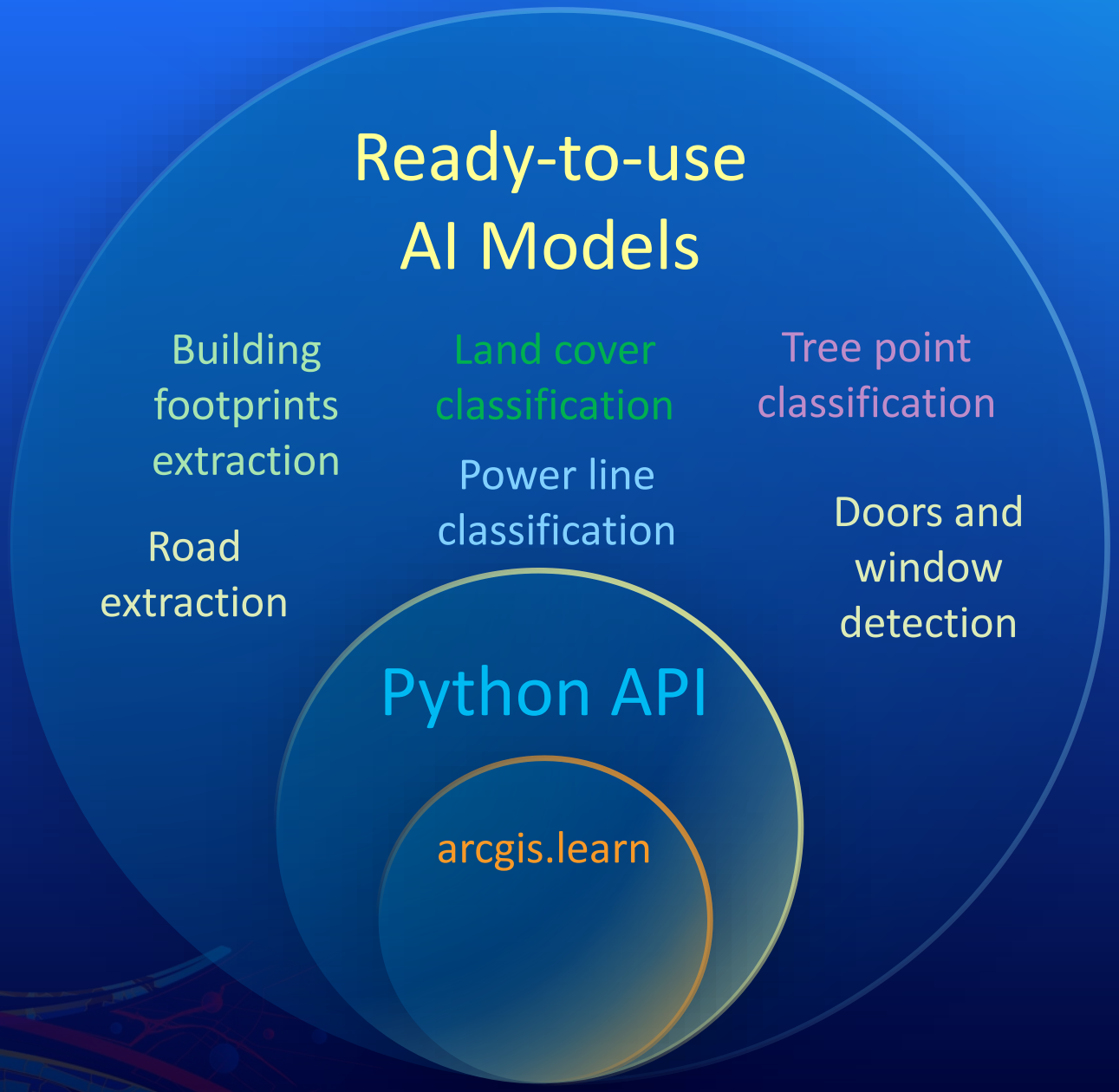
conda packages

Geoanalytics

Raster analysis

Apps

arcgis.learn

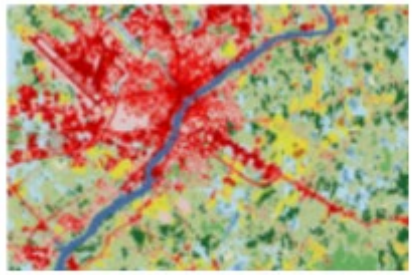

Ready-to-use
AI Models
Building footprints extraction
Land cover classification
Tree point classification
Power line classification
Road extraction
Doors and window detection
Python API
arcgis.learn

Ready-to-use Imagery models in Living Atlas

Building Footprint Extraction - USA

Deep Learning Package By esri_analytics

Deep learning model to extract building footprints from high resolution satellite imagery. This model was trained using Esri's World Imagery.



Land Cover Classification (Landsat 8)

Deep Learning Package By esri_analytics

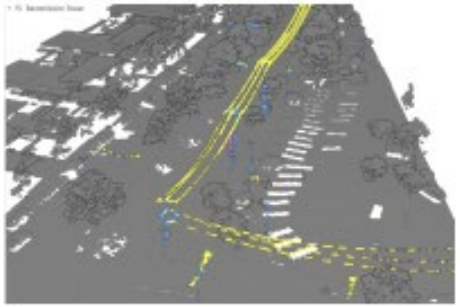
Deep learning model to perform land cover classification using Landsat 8 imagery. The resultant imagery will be classified into 20 classes based on a modified Anderson Level II classification system as used by the National Land Cover Database.

Windows and Doors Extraction

Deep Learning Package By esri_analytics

Deep learning model to extract windows and doors in building data displayed in 3D views. This model was trained using the Open Images Dataset.

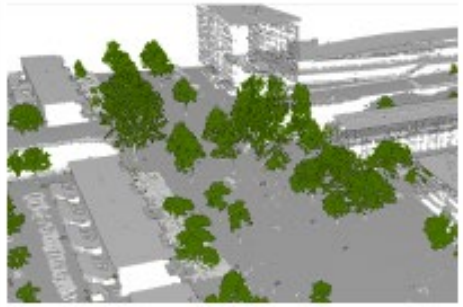
Ready-to-use 3D models in Living Atlas



Power Line Classification

Deep Learning Package By esri_analytics

Deep learning model to classify wire conductors, transmission towers and wire structure connectors from a point cloud dataset. This model is targeted for features along streets.



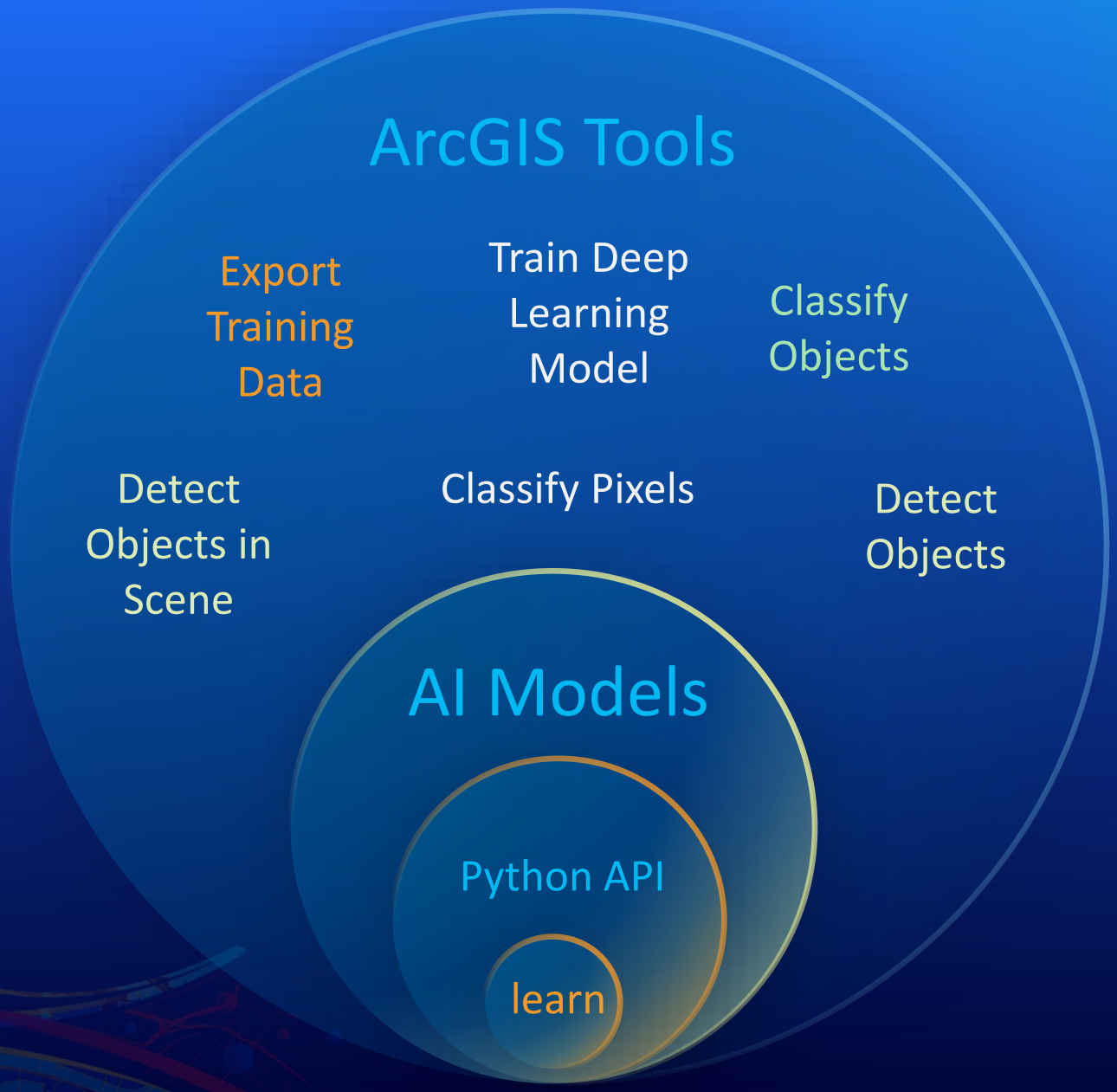
Tree Point Classification

Deep Learning Package By esri_analytics

Deep learning model to classify points representing trees in point cloud datasets.

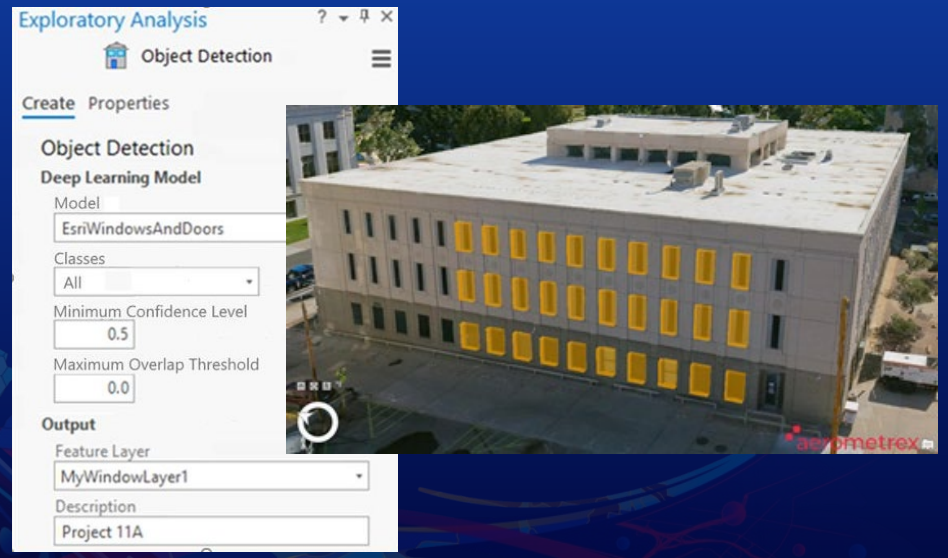
Building Footprints Extraction

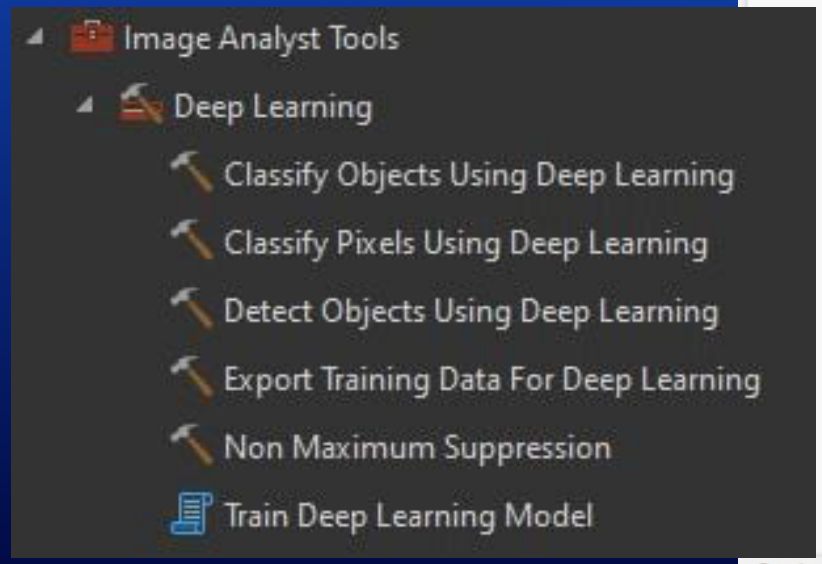
Using Esri’s pre-trained model

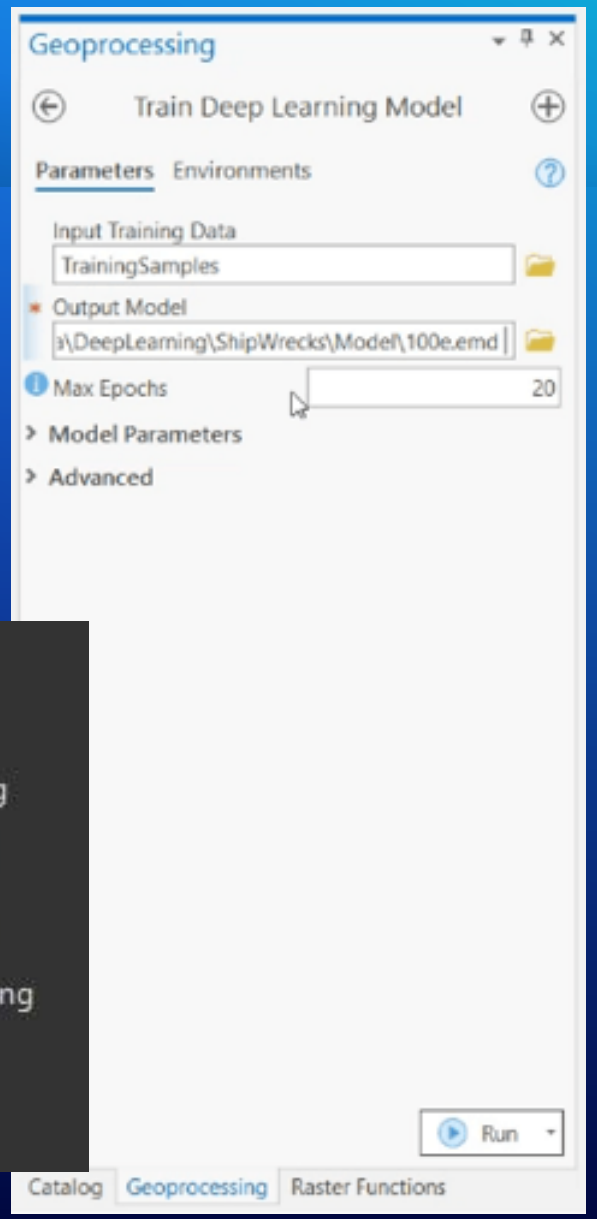

ArcGIS Tools
Export Training Data
Train Deep Learning Model
Classify Objects
Detect Objects in Scene
Classify Pixels
Detect Objects
AI Models
Python API
learn

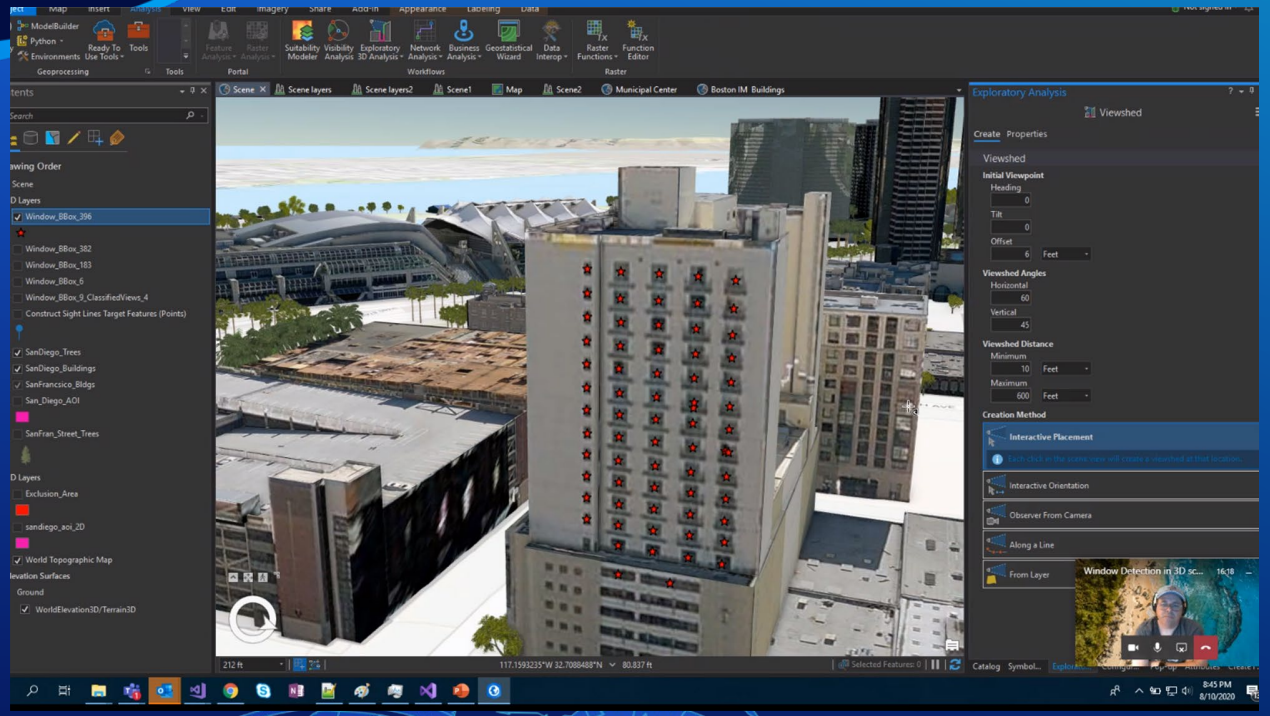
Imagery Deep learning tools in ArcGIS Pro

- Deep Learning tools in Image Analyst toolbox (License: Image Analyst Extension)
- Interactive Object Detection (map exploration)







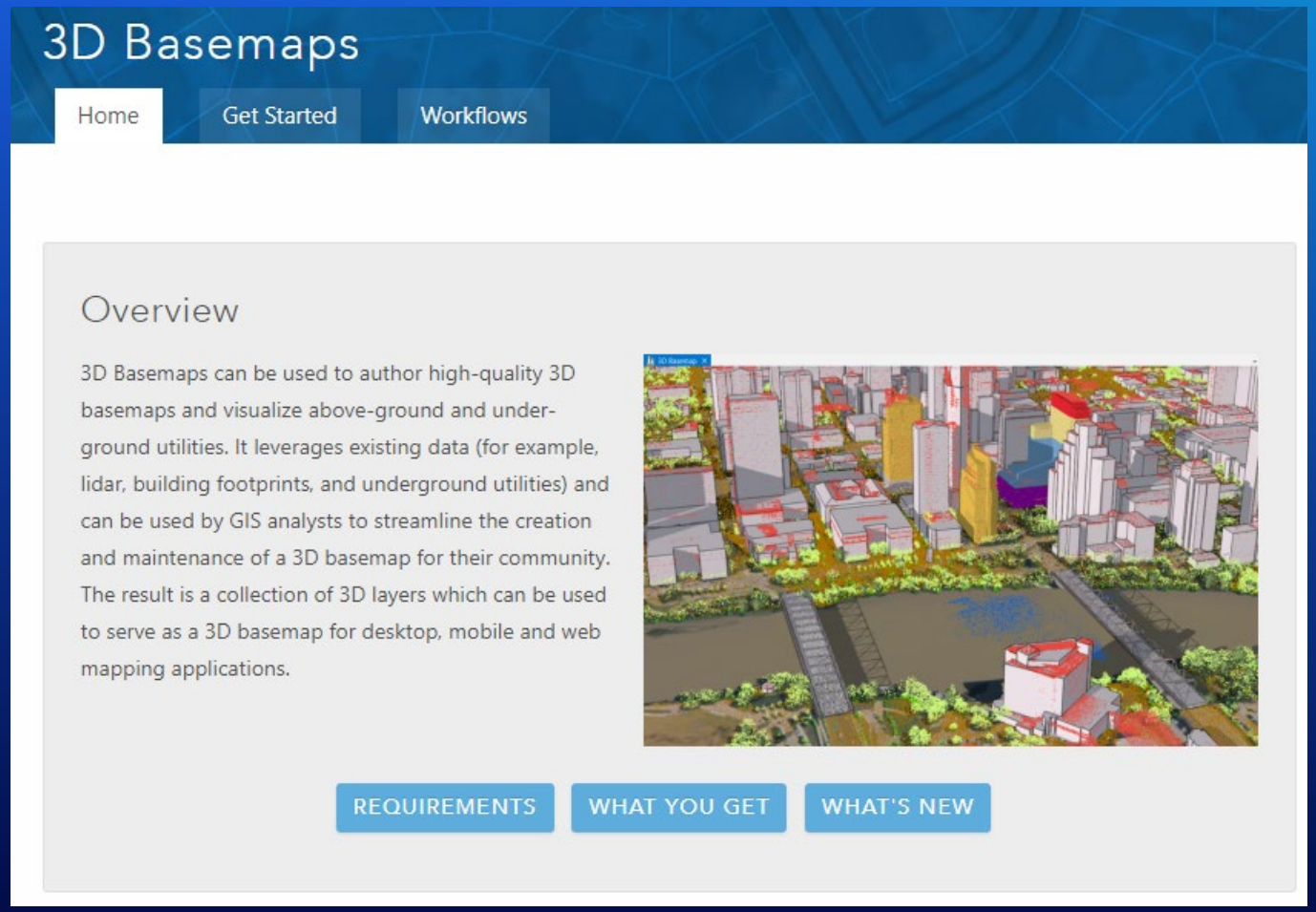


Detecting features on-the-fly

Using 3D exploratory tools for object detection

3D Basemaps solution

- Tree point classification from lidar
- Extraction of trees using cluster analysis
- Sample Notebook for fine tuning model



Deep Learning in ArcGIS

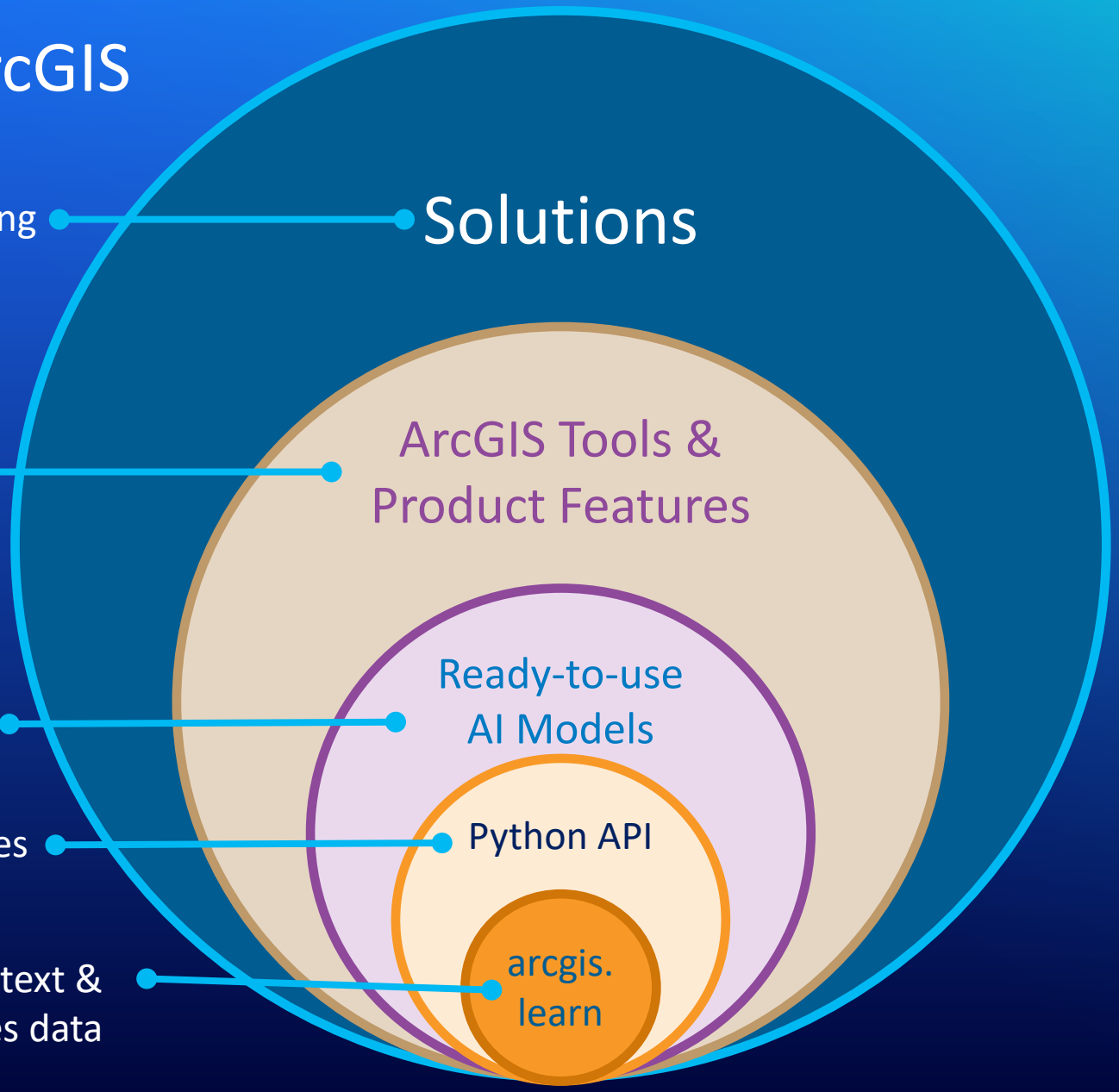
3D Basemaps Solution enabled with deep learning

Improved Deep Learning tools in Image Analyst
Detect Objects tool in Map Exploration

Ready-to-use Geo-AI models on Living Atlas

Many new deep learning samples and guides

30 deep learning models for imagery, 3d, tabular, text & timeseries data



Key Takeaways

ArcGIS has powerful deep learning capabilities!

- Suite of tools for Deep Learning workflows
- All imagery categories/tasks and more..
- Variety of training model types
- Variety of clients
- Massively scalable
- Powerful API for developers and data scientists
- Ready-to-use AI models
- Robust image management to complement deep learning
- Rich tools to perform down stream analysis

Additional resources

arcgis.learn module in ArcGIS API for Python

- developers.arcgis.com/python
  - **Samples**
  - **Guide**
  - **API Reference**

GitHub Repo

- github.com/arcgis-python-api

Medium GeoAI Blog

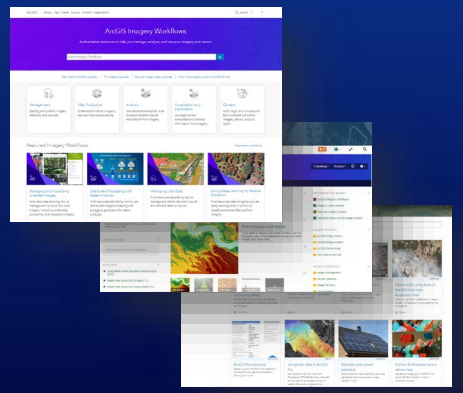
- medium.com/geoai

Deep learning Workflows

- https://doc.arcgis.com/en/imagery/workflows/resources/using-deep-learning-for-feature-extraction.htm

YouTube Videos

- Deep Learning and GeoAI playlist in ArcGIS channel
- Search for “ArcGIS Deep Learning”



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