Exercise 2: Map building footprints with deep learning

How can I print an exercise to PDF format?

Introduction

Imagery can contain a wealth of information, from the number of buildings in a city to the health of vegetation. However, extracting this type of data from an image is more complicated than working with vector datasets. Historically, you would need to manually digitize each feature that you wished to extract from an image. This manual process could involve traditional image classification and could take weeks or years, depending on the size of the image. Deep learning automates the process of extracting features from imagery. However, one of the primary difficulties with using deep learning has been the time and effort necessary to train deep learning models to analyze the data. To make this process more efficient, Esri packaged several pretrained deep learning models for various uses. These deep learning packages allow you to use the power of deep learning without training a model. You can use ArcGIS Image for ArcGIS Online to analyze your data with deep learning models from ArcGIS Living Atlas of the World and extract the desired information for your work.

Scenario

Imagine that you are a GIS analyst for Henderson County in Texas, exploring ways to update the existing data in your county GIS. You have been provided an imagery layer from the National Agriculture Imagery Program (NAIP), which acquires aerial imagery during the agricultural growing seasons in the continental United States. With this NAIP imagery layer, you will use a deep learning package from Esri to begin extracting building footprints.

For more information about NAIP imagery in ArcGIS, see the NAIP Imagery group that is monitored by Esri.

This exercise provides a simplified starting point for what is often a much more in-depth workflow. The data and parameters used in this exercise are not intended to be a comprehensive list of what might be required for this type of analysis.

Note: The exercises in this course include View Result links. Click these links to confirm that your results match what is expected.

Estimated completion time in minutes: 30 minutes

Expand all steps | Collapse all steps

- Step 1: Open an imagery layer in a web map

In this step, you will add an imagery layer to a web map.

a If necessary, restore your web browser, and then in the top-left corner, click the Menu button and choose Home.

Note: If you closed your web browser, go to www.arcgis.com and sign in with your MOOC credentials.

b Near the top of the page, click Map to open a new web map in Map Viewer.

c In the Layers pane, click Add to search and add layers.

d In the Add Layer pane, click the My Content down arrow and choose ArcGIS Online.

e In the Search field, type **AthensTX_2018** and press Enter.

An AthensTX_2018 tiled imagery layer by Esri Training Services appears in the search results.

f In the lower-right corner of the AthensTX_2018 tiled imagery layer by Esri Training Services, click Add.

*Step 1f***: Open an imagery layer in a web map.*

The imagery layer appears in the web map and is rendered with the Natural Color band combination.

Your manager recommended that you map building footprints in a certain area, so you will add a focus area layer to the map.

g In the Add Layer pane, in the Search field, delete AthensTX_2018, and then type **building footprint focus** and press Enter.

h In the search results, locate the Building Footprint Focus Area feature layer by Esri Training Services, and then add it to the web map.

*Step 1h***: Open an imagery layer in a web map.*

i In the Add Layer pane, near the upper-left corner, click the Back button ‹.

j If necessary, in the Layers pane, for the Building Footprint Focus Area layer, click the Options button ··· and choose Zoom To.

k On the Contents toolbar, click the Save And Open button and choose Save As.

l In the Save Map dialog box, specify the following parameters:

- Title: **Building Extraction <your initials>**
- Tags: **Imagery in Action, Esri, Texas**
- Summary: **Web map for building extraction in Athens, Texas.**

m Click Save.

You are now ready to begin the process of extracting the building footprints.

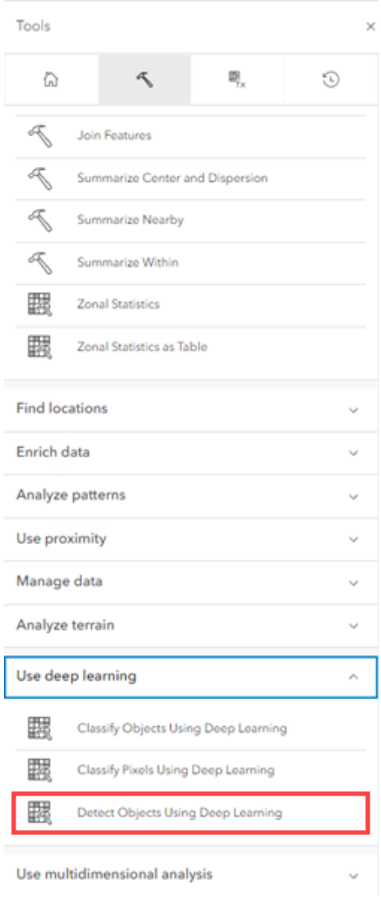
- Step 2: Extract building footprints

In this step, you will use deep learning to extract the building footprints.

a On the Settings toolbar, click the Analysis button to open the Analysis pane.

b In the Analysis pane, click Tools.

c Expand the Use Deep Learning section and choose the Detect Objects Using Deep Learning tool, as indicated in the following graphic.

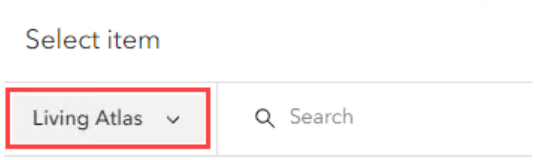


d In the Detect Objects Using Deep Learning tool pane, under Input Layer, click + Layer.

e Click AthensTX_2018 for the input layer.

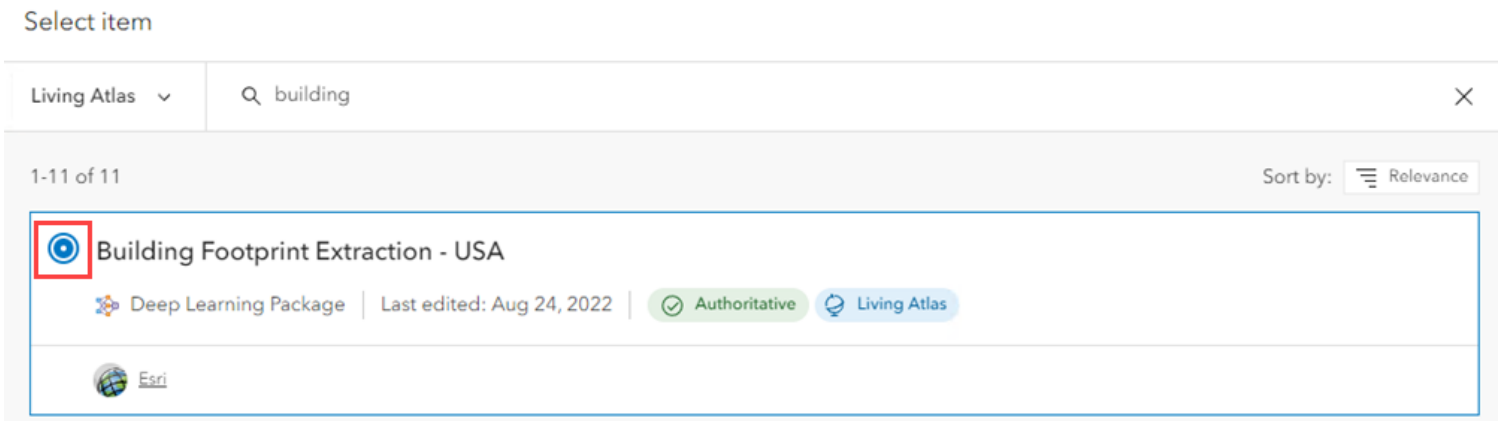
f Under Model Settings, click Select Model.

g In the Select Item window, click the My Content down arrow and choose Living Atlas.



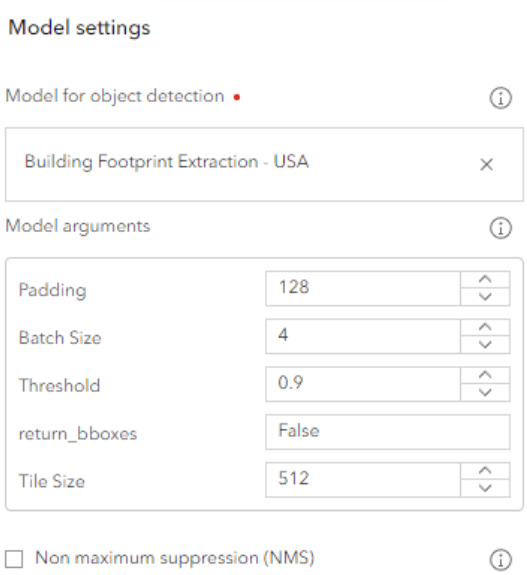
h In the Search field, type **building** and press Enter.

i In the search results, locate the Building Footprint Extraction - USA deep learning package and select it, as shown in the following graphic.



j In the bottom-right corner of the Select Item window, click Confirm.

k Under Model Arguments, verify that the deep learning model arguments populate.



*Step 2k***: Extract building footprints.*

The deep learning model arguments are additional parameters that can be adjusted as needed to improve your analysis. They are populated by the tool from reading the Python module on the raster analysis server. Each argument is specified by the deep learning package that you choose. These arguments in the deep learning model are the ones used in the Building Footprint Extraction - USA package.

You will see that the confidence threshold is currently set to 0.9. This threshold means that if the model is at least 90 percent certain that a feature is a building, it will include it in the output. You will run the model with the default threshold and then determine whether it needs to be adjusted lower when you review the output.

For more information about deep learning models, go to ArcGIS Enterprise Help: Deep learning in Raster Analysis: Esri model definition file.

l Under Result Layer, for Output Name, type **AthensTestDeepLearning_<your initials>**.

- Hint

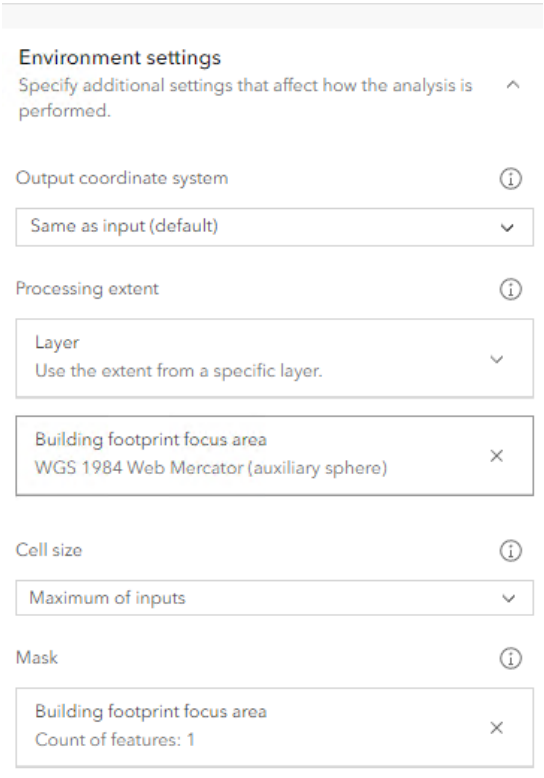
  You may need to scroll down in the Detect Objects Using Deep Learning pane to see the remaining settings for the tool.

m Expand the Environment Settings section.

n Under Processing Extent, click the drop-down list and choose Layer.

o Click + Layer and choose Building Footprint Focus Area.

p Under Mask, click + Layer and choose Building Footprint Focus Area.



*Step 2p***: Extract building footprints.*

q Click Estimate Credits to determine the number of credits consumed.

Note: If you see a credit warning, you selected the wrong layer for your analysis environments.

r Leave the remaining defaults and click Run.

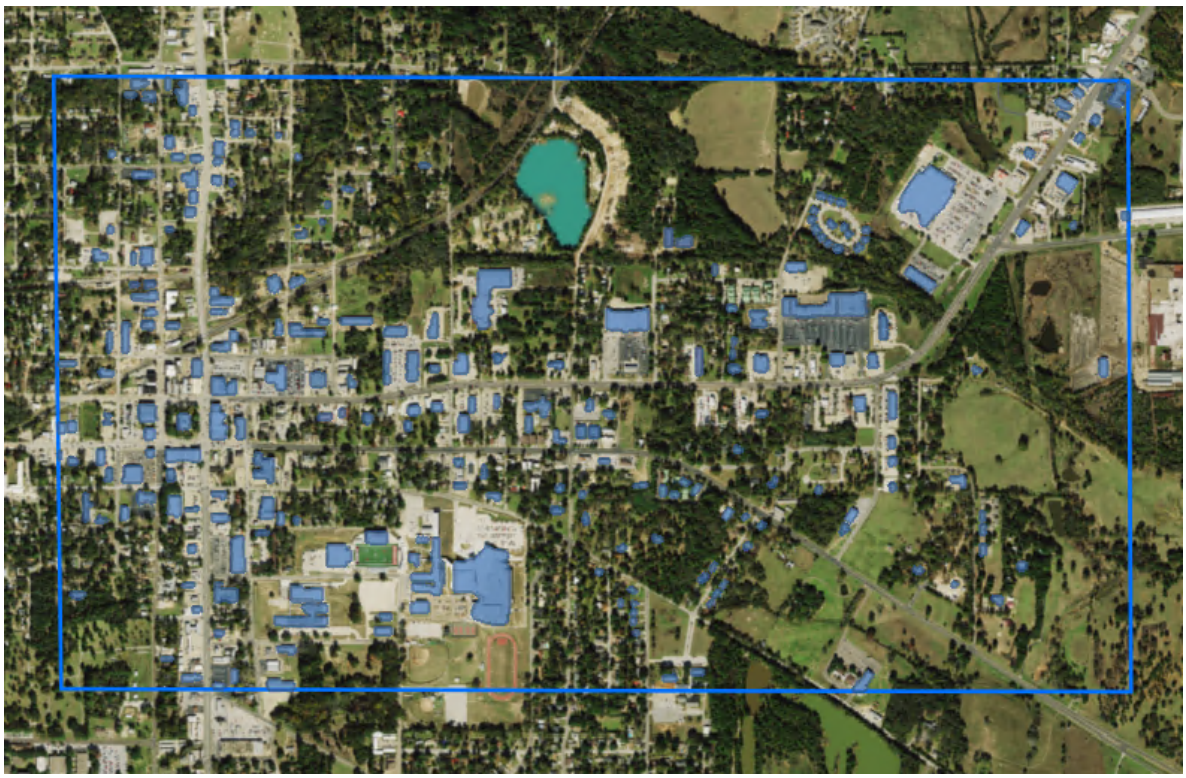
s When the pop-up appears near the bottom of the map, click View Status, as indicated in the following graphic.

The History pane displays the progress for the analysis.

Note: Processing will take some time to complete; give this process some time before clicking the web map.

When the analysis completes, the layer will appear in the Layers pane.

t On the map, notice the new feature layer's output for the deep learning model.



*Step 2t***: Extract building footprints.*

The feature layer displays blue polygons to represent the building footprints extracted from the NAIP imagery.

u After the layer finishes loading, save the map.

- Step 3: Review extracted buildings

In this step, you will review the extracted buildings in your focus area. The output polygons appear to capture many of the buildings in the area, but it is good practice to review the results before continuing further analysis.

a In the Layers pane, for the AthensTestDeepLearning layer, click the Options button ··· and choose Show Table to open the new layer's attribute table.

? Which two fields in the attribute table are important for your analysis?

- Answer
The Class field and the Confidence field

b For the Confidence field header, click the Options button ··· and choose Information.

c In the Confidence pop-up window, scroll down to Statistics.

What is the minimum value that is reported?

- Answer

The minimum value is approximately 90.08.

What is the average value that is reported?

- Answer

The average value is 95.22.

These values indicate that the confidence is very high in the polygons for this particular focus area.

d Close the Confidence pop-up window and close the attribute table.

e Zoom in to the lower-left area of the map and examine the quality of the extraction.

*Step 3e***: Review extracted buildings.*

After reviewing the output, you can see that some buildings have not been extracted. After considering the confidence values found in the feature layer, you see that none of the buildings in the trees have been found. This omission is most likely due to the deep learning tool not being confident in the buildings that it found in the trees and discarding them due to the confidence threshold.

f Zoom to the full extent of the study area again.

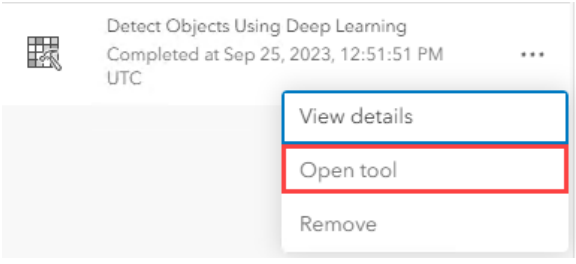
- Hint

In the Layers pane, for the Building Footprint Focus Area layer, click the Options button ··· and choose Zoom To.

- Step 4: Re-extract building footprints

In this step, you will adjust the model arguments to find additional building footprints that were not extracted in the previous process.

a In the History pane, for the Detect Objects Using Deep Learning tool, click the Options button ••• and choose Open Tool, as indicated in the following graphic.



b In the Detect Objects Using Deep Learning tool pane, under Input Layer, confirm that Input Imagery Layer Or Feature Layer is set to AthensTX_2018.

c Under Model Settings, confirm that Model For Object Detection is set to use the Building Footprint Extraction - USA deep learning package.

Note: If the model is not listed, perform the following steps:

1. Click Select Model, and then in the Select Item window, click the My Content down arrow and choose Living Atlas.
2. In the Search field, type **buildings** and press Enter.
3. In the search results, select the Building Footprint Extraction - USA deep learning package and click Confirm.

d Under Model Arguments, change the Threshold value from 0.9 to **0.7**.

With the adjusted threshold, if the model is at least 70 percent certain that a feature is a building, it will include it in the output.

e Under Result Layer, for Output Name, type **AthensFinalDeepLearning_<your initials>**.

f If necessary, expand Environment Settings.

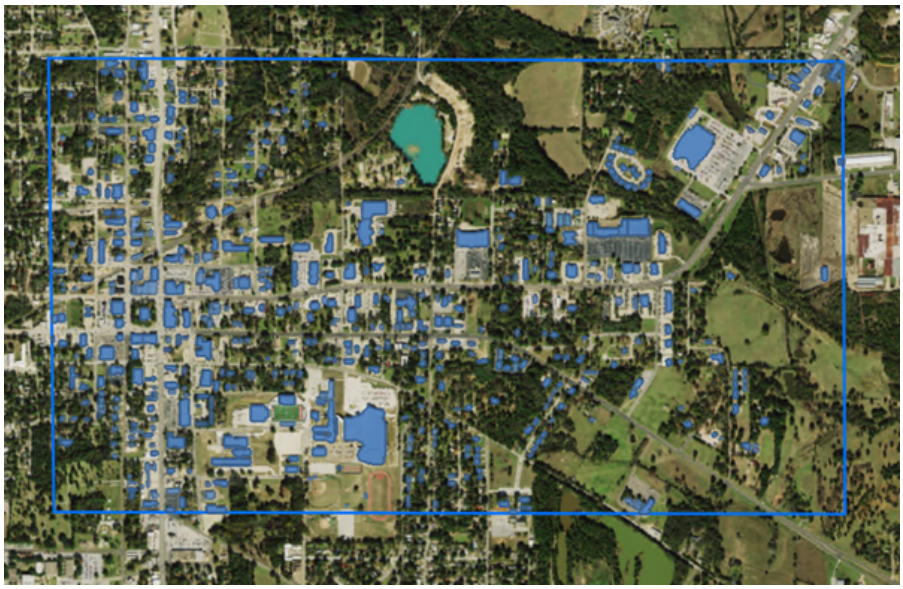
g Under Processing Extent, click the drop-down list and choose Layer.

h Click + Layer and choose Building Footprint Focus Area.

i Under Mask, confirm that Building Footprint Focus Area is listed.

j Click Estimate Credits to determine the number of credits consumed.

k Leave the remaining defaults and click Run.



*Step 4k***: Re-extract building footprints.*

Note: Processing will take some time to complete, so do not click away from the web map until the layer is loaded.

l In the Layers pane, verify that the AthensFinalDeepLearning_<your initials> layer has been added.

m Drag the AthensTestDeepLearning_<your initials> layer above the AthensFinalDeepLearning_<your initials> layer.

n Confirm that the AthensTestDeepLearning_<your initials> layer is selected.

- Hint

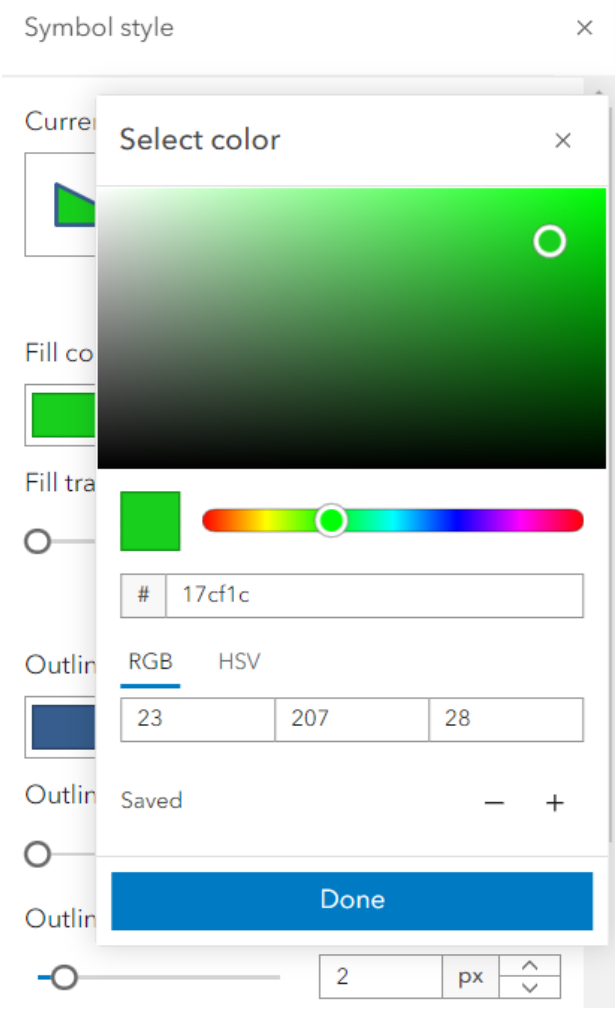
  A blue line to the left of the layer indicates that the layer is selected in the Layers pane.

o On the Settings toolbar, click the Styles button .

p In the Styles pane, for Pick A Style, under Location (Single Symbol), click Style Options.

q Under Symbol Style, click the the Edit button to open the Symbol Style pane.

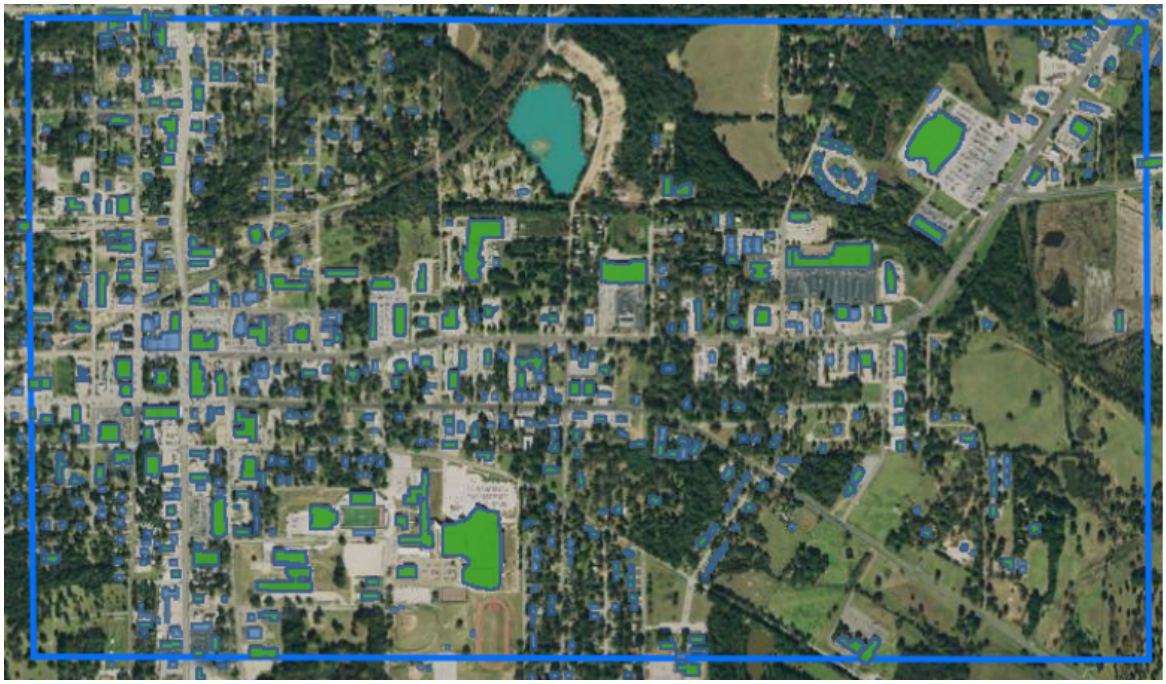
r Under Fill Color, click the Edit button , and then in the Select Color window, select a green color.



*Step 4r***: Re-extract building footprints.*

s Click Done to close the Select Color window, and then close the Symbol Style pane.

t Click Done to close the Style Options pane, and then click Done to close the Styles pane.



*Step 4t***: Re-extract building footprints.*

u In the map, zoom in to the middle of the focus area to view the results.

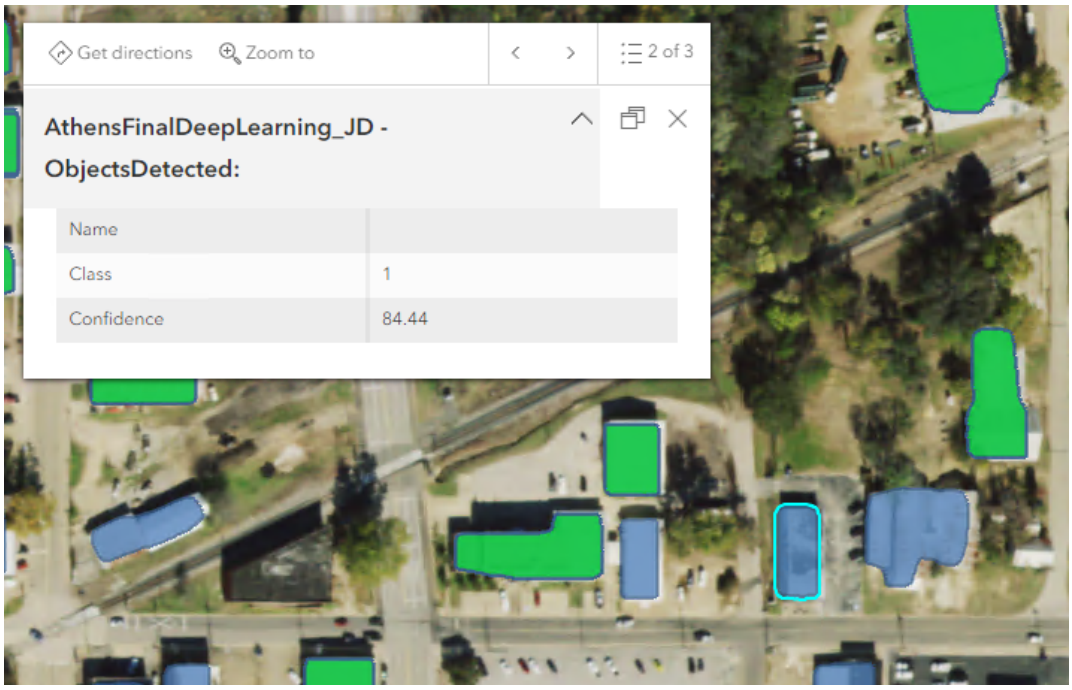
*Step 4u***: Re-extract building footprints.*

When zoomed in, you can see that the new blue polygons now represent many of the buildings that were missing from the first analysis.

v Click one of the blue buildings to view the fields in the new feature layer.

w If necessary, in the pop-up window, near the upper-right corner, click the Dock button .

x In the pop-up window, near the upper-right corner, click the Next Feature button › to navigate to the AthensFinalDeepLearning_<your initials> information.



*Step 4x***: Re-extract building footprints.*

In the preceding graphic, you can see that the confidence value for the selected building is 84.44. This extracted building was previously not included because the confidence value was below 90. By adjusting the threshold value in the model argument, you allowed extracted buildings with a lower confidence value to be included.

If this process was to be used for actual collection of extracted buildings, then the threshold value might be further adjusted to find the optimal threshold.

y Save the map and close the web browser.

In this exercise, you learned how to use prebuilt deep learning packages in ArcGIS Image for ArcGIS Online to extract building footprints from an imagery layer. You also learned how to improve results by modifying the model arguments.