Using *Building Footprint Extraction - USA* model in ArcGIS Pro

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Introduction

This document explains how to use the Building footprint extraction - USA pre-trained model available on ArcGIS Living Atlas of the World. The model is used to extract building footprints from high-resolution (10–40 cm) imagery.

Building footprint layers are useful in preparing base maps and analysis workflows for urban planning and development. They also have use in insurance, taxation, change detection, infrastructure planning, and a variety of other applications.

Digitizing building footprints from imagery is a time-consuming task and is commonly done by digitizing features manually. Deep learning models are highly capable of learning these complex semantics and can produce superior results. Use this deep learning model to automate the tedious manual process of extracting building footprints, reducing time and effort required significantly.

Licensing requirements

ArcGIS Desktop – ArcGIS Image Analyst and ArcGIS 3D Analyst extensions for ArcGIS Pro ArcGIS Enterprise – ArcGIS Image Server with raster analytics configured ArcGIS Online – ArcGIS Image for ArcGIS Online

Model overview

- Input Raster, mosaic dataset, or image service.
- Output Feature class containing building footprints.
- Compute This workflow is compute-intensive, and a GPU with minimum CUDA compute capability of 6.0 is recommended.
- Applicable geographies This model is expected to work well in the United States.
- Architecture This model uses the MaskRCNN model architecture implemented in ArcGIS API for Python.
- Accuracy metrics This model has an average precision score of 79.1 percent.

Accessing the model

Download the Building Footprint Extraction - USA pre-trained model from ArcGIS Living Atlas of the World. Alternatively, access the model directly from ArcGIS Pro 2.7 (and later), or consume it in ArcGIS Image for ArcGIS Online.

Downloading the model

- 1. Browse to ArcGIS Living Atlas of the World.
- 2. Sign in with your ArcGIS Online credentials.
- 3. Search for **Building Footprint Extraction USA** and open the item page from the search results. Alternatively, download the pre-trained model from here.
- 4. Click the **Download** button to download the model. The downloaded DLPK file can be directly used in ArcGIS Pro, or uploaded and used in ArcGIS Enterprise. Additionally, you can even fine-tune the pre-trained model if necessary.

Preprocessing

Recommended imagery configuration

- Resolution High resolution (10-40 cm)
- Dynamic range 8-bit
- Bands Three bands (for example Red, Green, and Blue)
- Imagery Orthorectified imagery (both on-the-fly and persisted ortho products work)

(Note: Off-nadir imagery or imagery with a high obliquity angle will not produce suitable results)

Example - Processing Worldview-2 imagery

- 1. Open ArcGIS Pro and navigate to the image product in the **Contents** pane.
- 2. Expand the product (.imd file) and add the Pansharpen layer to the map.

| - | 052407812010_01 |
|-----|---|
| - 4 | 052467812010_01_P001_MUL |
| | 10FEB17183915-M2AS-052467812010_01_P001.IMD |
| | Multispectral |
| | Pansharpen |
| D | 10FEB17183915-M2AS-052467812010_01_P001.TIL |
| D | 10FEB17183915-M2AS-052467812010_01_P001-BROWSEJPG |
| D | 10FEB17183915-M2AS_R01C1-052467812010_01_P001.TIF |
| | |

- 3. Right-click the newly added layer and select Edit Function Chain.
- 4. Click **Stretch Function** in the function chain window to edit the stretch properties.



5. Change the **Stretch Properties**.

| Stretch Properties | Х |
|---|----|
| General Parameters | |
| Name | |
| Stretch Function | |
| Description | |
| Enhances an image by changing properties such as brightness, contrast and gamma through multiple stretch types. | |
| Output Pixel Type | |
| 8 Bit Unsigned | • |
| Learn more about this raster function | el |

| Stretch Properties | | | | × | | | |
|--|----------------|---|---|--------|--|--|--|
| General Parameters | | | | | | | |
| Raster | | | | | | | |
| <pansharpening function.outputraste<="" td=""><td>r></td><td></td><td></td><td>• 🧎</td></pansharpening> | r> | | | • 🧎 | | | |
| Туре | | | | | | | |
| PercentMinMax | | | | - | | | |
| Output Minimum | | | | | | | |
| 0 | | | | | | | |
| Output Maximum | | | | | | | |
| 255 | | | | | | | |
| Percent Clip Minimum | | | | | | | |
| 0.25 | | | | | | | |
| Percent Clip Maximum | | | | | | | |
| 0.5 | | | | | | | |
| > Statistics | S. Candidation | | | | | | |
| | | | | | | | |
| ✓ Gamma | | | | | | | |
| ✓ Auto Gamma | | | | | | | |
| ✓ Use Gamma | | | | | | | |
| Gamma | | | | | | | |
| Values | | | | | | | |
| a second second second | | | 1 | 1.73 | | | |
| | | | | 1.44 🗘 | | | |
| | | | | 1.52 | | | |
| | 1 | | 1 | ↓ 40 ▲ | | | |
| 1 1 1 1 1 1 1 1 1 | 1 | 1 | 1 | 1.49 🖵 | | | |
| | | | | | | | |
| Learn more about this raster function | | | | | | | |
| | | O | < | Cancel | | | |

6. Click the **Apply** button to apply the changes.



Using the model

- 1. Make sure you have downloaded the Building Footprint Extraction USA model and added the imagery layer in ArcGIS Pro.
- 2. Zoom to an area of interest.



3. Browse to **Tools** under **Analysis** tab.

| Project | Map Ins | sert Analy | sis | View | Edit Im | agery | Share |
|----------------|--------------|--------------|-------|------------------------------------|----------------------------------|---------------------------------|-------|
| 2 | }- 0 | * | | | 0 | | |
| History Python | ModelBuilder | Environments | lools | Ready Io Use Tools * | Feature Analysis • | Raster Analysis • | Sum |
| | Geopro | cessing | | La La | Po | rtal | |

4. Click **Toolboxes** tab in the Geoprocessing pane, select **Image Analyst Tools** and browse to Detect Objects Using Deep Learning **tool** under **Deep Learning**.



- 5. Set the variables under **Parameters** tab as follows:
 - a Input Raster Select the imagery.
 - b Output Detected Objects Set the output feature class that will contain the detected objects.
 - c **Model Definition** Select the pre-trained/fine-tuned model DLPK file.
 - d **Model Arguments** (optional) Change the values of the arguments if required.
 - e Non Maximum Suppression (optional) Toggle the checkbox as needed. If checked:
 - i Set the **Confidence Score Field** (optional).
 - ii Set the Class Value Field (optional).
 - iii Set the Maximum Overlap Ratio (optional).

| Geoprocessing | * ₫ × | | | | | | |
|---------------------------|------------------------|--|--|--|--|--|--|
| Detect Objects Us | ing Deep Learning 🕀 | | | | | | |
| Parameters Environments | . ? | | | | | | |
| Input Raster | | | | | | | |
| Redlands | - 📔 | | | | | | |
| Output Detected Objects | | | | | | | |
| Redlands_DetectObjectsUs | ingD 🦳 | | | | | | |
| Model Definition | | | | | | | |
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| Arguments | Velue | | | | | | |
| name | 100 | | | | | | |
| padding | | | | | | | |
| batch_size | 4 | | | | | | |
| threshold | 0.9 | | | | | | |
| return_bboxes | False | | | | | | |
| | | | | | | | |
| Non Maximum Suppress | sion | | | | | | |
| Confidence Score Field | | | | | | | |
| Confidence | | | | | | | |
| Class Value Field | | | | | | | |
| Class | | | | | | | |
| Max Overlap Ratio | | | | | | | |
| | | | | | | | |
| | | | | | | | |
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| | | | | | | | |
| | Run 🕟 🔻 | | | | | | |

Note: To access the model directly from ArcGIS Pro (supported in ArcGIS Pro 2.7 and later), click on the browse button and search for the model as depicted below.

| Model Definition | | | | | × |
|------------------------|----------------|--|-------------------|-------------------------|-----------------------|
| €) ⑦ 💽 « Living Atlas | Search Results | for 'Building Footprint Extraction – USA ' | • Ū ↓= ₹ | Building Footprint Extr | action – US/ × 🕞 |
| Organize 🔻 New Item 🔻 | | | | | === |
| 🔺 🙆 Portal | | Title | Туре | Date | Owner |
| My Content | | 🗞 Building Footprint Extraction - USA | Deep Learning Pac | 15-06-2021 10:47:03 | esri analytics |
| My Favorites | | | | | |
| 👂 🙀 My Groups | | | | | |
| My Organization | | | | | |
| ArcGIS Online | | | | | |
| Living Atlas | | | | | |
| 4 🛄 Computer | | | | | |
| 👂 🖈 Quick access | | | | | |
| This PC | | | | | |
| 👂 🤱 Sandeep Kumar | | | | | |
| Libraries | | 4 | | | |
| Network | | | Find more items | | |
| Nam | e | | | Deep Learning Mo | odel files (dlpk, e 🔹 |
| | | | | OK | Cancel |

- 6. Set the variables under **Environments** tab as follows:
 - a) **Processing Extent** Select Current Display Extent or any other option from the dropdown menu.
 - b) Cell Size (required) Set the value to 0.3. (Note: 0.3 meters is the raster resolution.)
 - c) **Processor Type** Select CPU/GPU as per the need. (Note: If GPU is available, it is recommended to select GPU and set **GPU ID** to specify the GPU to be used.)

| Geoprocessing | ≁ ù × |
|----------------------------|---------------------|
| Detect Objects Using | g Deep Learning 🕀 |
| Parameters Environments | ? |
| ✓ Output Coordinates | |
| Output Coordinate System | |
| | - |
| Geographic Transformations | |
| | • |
| ✓ Processing Extent | |
| Extent | As Specified Below |
| -117.09188979935 | → -117.076536128651 |
| J33.4679211871359 | ★ 33.47794455937 |
| ✓ Parallel Processing | |
| Parallel Processing Factor | |
| | |
| ✓ Raster Analysis | , |
| Cell Size | |
| 0.3 | - |
| ✓ Processor Type | |
| Processor Type | |
| GPU | - |
| GPU ID | 0 |
| | |
| | Run 🕟 🔻 |

7. Click **Run** to execute. As soon as processing finishes, the output layer is added to the map.

Postprocessing

Follow the steps below to improve the visual appearance of the extracted building footprint features.

1. Browse to **Tools** under **Analysis** tab.

| I | Project | Map In: | sert Analy | /sis | View | Edit Im | agery | Share |
|---|----------------|--------------|--------------|-------|-------------------------|----------------------------------|---------------------------------|-------|
| | ~> 🖂 | 200 | × | -8- | | 9 | | |
| | History Python | ModelBuilder | Environments | Tools | Ready To Use Tools ▼ | Feature Analysis • | Raster Analysis • | Sum |
| | | Geopro | cessing | | G. | Po | rtal | |

2. Click **Toolboxes** tab in the Geoprocessing pane, select **3D Analyst Tools** and browse to Regularize Building Footprints tool.

| Geoprocessing 👻 🖣 🗙 |
|---|
| Find Tools |
| Favorites Toolboxes |
| 🔺 💼 3D Analyst Tools |
| 🔺 🚔 3D Features |
| 🔨 Add Z Information |
| 🔨 Buffer 3D |
| 🔨 Difference 3D |
| 🔨 Enclose Multipatch |
| 🔨 Feature To 3D By Attribute |
| 🔨 Inside 3D |
| Intersect 3D |
| 🔨 Intersect 3D Line With Multipatch |
| is Closed 3D |
| 🔨 LAS Building Multipatch |
| 🔨 Minimum Bounding Volume |
| 🔨 Near 3D |
| Regularize Adjacent Building Footprint |
| Regularize Building Footprint |
| 🔨 Simplify 3D Line |
| 🔨 Union 3D |
| 🔨 Update Feature Z |
| CityEngine |
| E CONTRACTOR OF |

- 3. Set the variables under **Parameters** tab as follows:
 - a. Input Features Select the imagery layer.
 - b. Arguments (optional) Change the values of the arguments if required.
 - c. **Output Feature Class** Set the output feature class that will contain the regularized building footprints.

| Geoprocessing | ≁ ↓ × |
|--|----------|
| Regularize Building Footprint | \oplus |
| Parameters Environments | ? |
| Input Features wi do mix 35e test20 | |
| Method | |
| Right Angles | - |
| Tolerance | 1 |
| Densification | |
| Precision | 0.25 |
| Output Feature Class | |
| wi_do_mix_35e_test20_reg | |
| | |

4. Click **Run**. As soon as processing finishes, the output layer is added to the map.

Here is a close look at the results:

