GEOG 483 Tutorial Materials

Tutorial topic: 3D Building Creation & Visualization in ArcGIS Pro

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Introduction/Overview

In traditional GIS mapping and analysis, x and y are the two only dimensions used, which limits the visualization of ground features. Unlike the real world, in which features can be viewed from multiple angles, features can only be viewed from a top-down perspective in traditional GIS. However, 3D GIS can provide elevation as the third dimension, which could provide multiple looking aspects similar to the real world. This is particularly useful in some applications, such as city planning, city building modelling and analysis, as well as coastal modelling and analysis, in which elevation is a crucial factor for analysis (USC GIS Online, 2020). In this tutorial, we will focus on the modelling and analysis of city buildings. We will learn ways to create 3D buildings in ArcGIS Pro from a 2D building footprint layer, applying various symbology and share the created 3D buildings on the ArcGIS Online platform.

Approach
Part A: 3D Building Creation in ArcGIS Pro

Prerequisites:

- ArcGIS Pro software package (available on school lab computers)
- A 2D building footprint layer with a z-field (elevation data)

To create 3D buildings, a 2D building footprint layer that contains elevation information is required. In this tutorial, a polygon shapefile of heritage buildings in Stratford is provided. This shapefile contains a rough estimate of building heights. Notably, these heights do not accurately represent the actual heights of the buildings. If you want to achieve better accuracy in your analysis, you could create a Digital Surface Model (DSM) of your study area if LiDAR data is available. Mean building heights could be determined by averaging elevations at random points established for each building on top of the DSM. Please visit the following links for the relevant tutorials provided by ESRI:

- Creation of raster DSMs: https://desktop.arcgis.com/en/arcmap/latest/manage-data/las-dataset/lidar-solutions-creating-raster-dems-and-dsms-from-large-lidar-point-collections.htm
- Obtaining elevation information for building footprints: https://desktop.arcgis.com/en/arcmap/latest/extensions/3d-analyst/3d-buildings-obtaining-elevation-information-for-building-footprints.htm
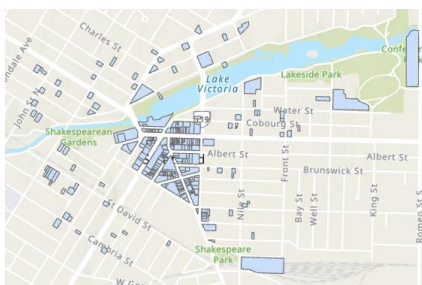

Figure 1: Stratford building footprint layer

Figure 2: Part of the attribute table of the building footprint layer

The steps to create a 3D representation of the Stratford building footprints are shown below:

1) Download the data ZIP file *(Stratford.zip)* from the attached materials.
2) Unzip *Stratford.zip* and save its unzipped contents to a local working folder.
3) Start ArcGIS Pro and click 'Local Scene' on the start page under 'New'. (Note: If you don't have ArcGIS Pro, you could sign up for an [ArcGIS free trial](#).)
4) Click 'Add Data' in the toolbar and browse to load the *Stratford_Heritage_Properties* layer and the *Stratford_DTM* from the *Stratford.gdb*.
5) Drag the DTM layer to the **Elevation Surface** section in the Contents pane. Under the **Elevation Surface** section, make sure that only the DTM is checked and placed under the label 'Ground'.
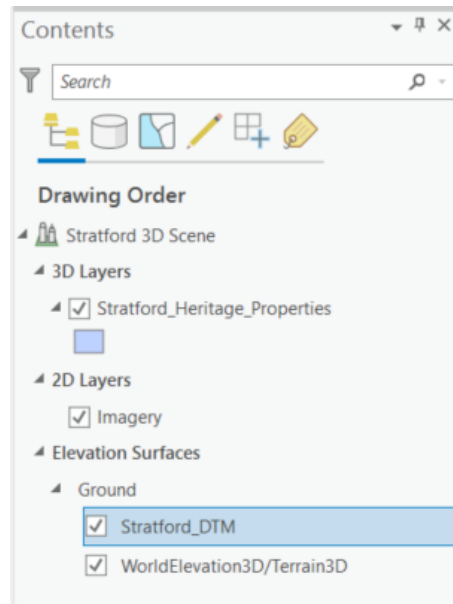

Figure 3: The Contents pane with the Stratford DTM added

6) Open the attribute table of the building footprint layer. Make sure that the z-value field exists in the table. Close the attribute table after checking is done.
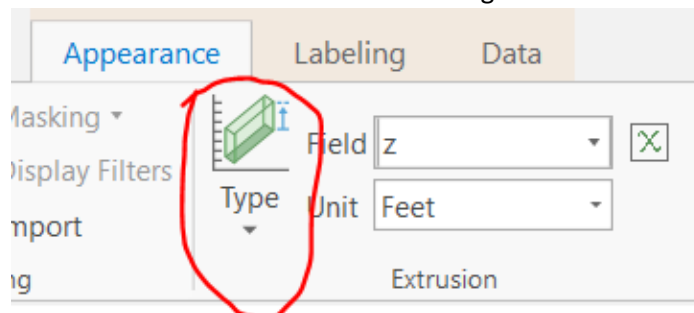

Figure 4: The Extrusion toolbar ('Type' button in red circle)

7) Select the building footprint layer and navigate to the Extrusion toolbar (Feature Layer > Appearance).
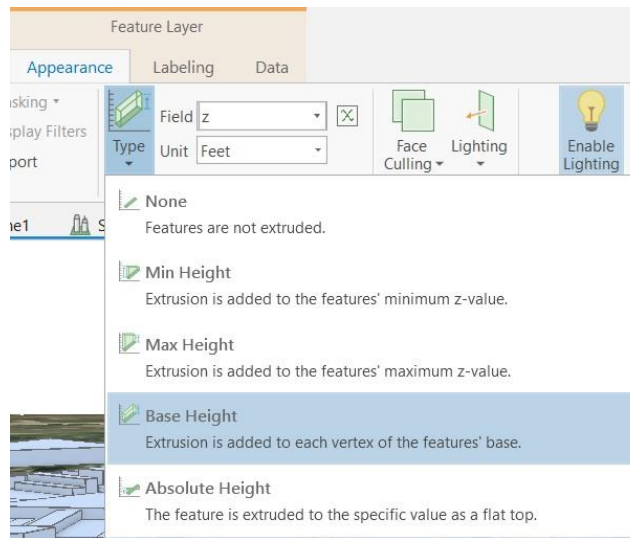8) Click the 'Type' button in the Extrusion toolbar to activate a drop-down menu.

Figure 5: The drop-down menu for extrusion type

9) In the drop-down menu, select 'Base Height' for this set of building footprints to add extrusion to each vertex of each building's base (Note: We are doing this so that each vertex is extruded rather than only the minimum/maximum elevation value found within each building).

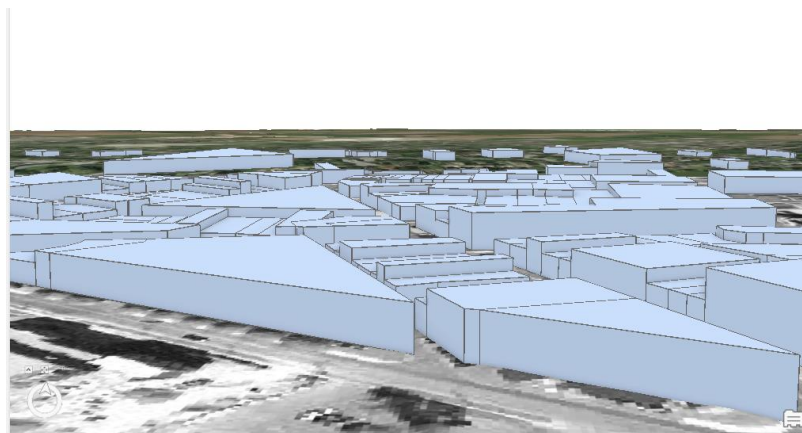10) Then, for the **Field** entry, select 'z' in the drop-down menu and select 'Feet' as the **Unit**.

Figure 6: 3D buildings (extruded building footprints)

11) Well done! The 3D buildings are now created by extruding the footprints. It looks like the buildings are not visually appealing. Don't worry! Let's now take these 3D buildings and complete the next part to symbolize the buildings. If you are not satisfied with the flat roof visualization and want a greater variety of roofs to be shown, please complete the roof extraction tutorial provided by ESRI: https://learn.arcgis.com/en/projects/extract-roof-forms-for-municipal-development/ (This is optional for this tutorial).

Part B: Symbolizing 3D Buildings

Part B1: Customized textures and colours

In ArcGIS Pro, you could customize the texture and/or colour for each face of a 3D building. Here are the steps for customizing the 3D buildings:

1) In the toolbar at the top, select **Analysis** > **Tools**, then the **Geoprocessing** pane would appear.
2) Type the keyword 'layer 3d' in the search bar of the **Geoprocessing** pane.
3) Select the 'Layer 3D To Feature Class' tool. (Note: Please ensure the 3D Analyst extension is enabled in ArcGIS Pro. If not, please go to **Project** > **Licensing** > **Configure your licensing options**, and check the checkbox near **3D Analyst**. You may need to purchase a license to obtain the extension if it is not available.)
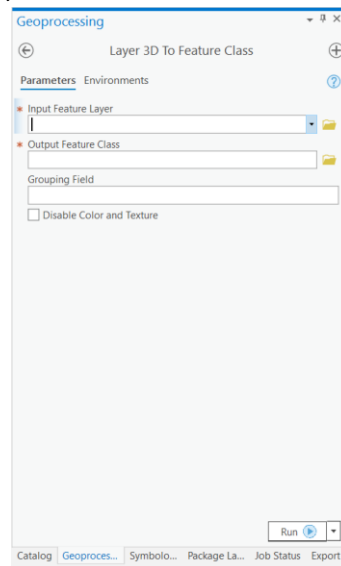

Figure 7: Layer 3D To Feature Class tool

4) For the **Input Feature Layer**, choose the extruded building footprint layer from the drop-down menu.
5) For the **Output Feature Class**, browse to find your local working folder, and save the file name to be *Stratford_Multipatch*.
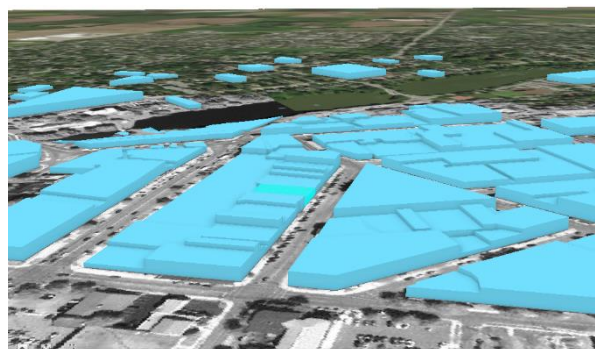6) Leave the Grouping Field blank and keep the 'Disable Color and Texture' unchecked.

Figure 8: Stratford Building Multipatch Layer

7) Click 'Run' to run the tool.

8) After the tool has finished running, you should get a Multipatch layer, which does not have dark solid lines at the edges of each building. You should get similar results as what is shown in Figure 8.
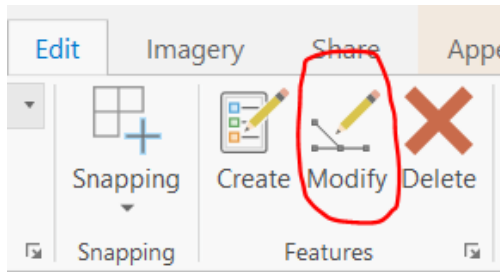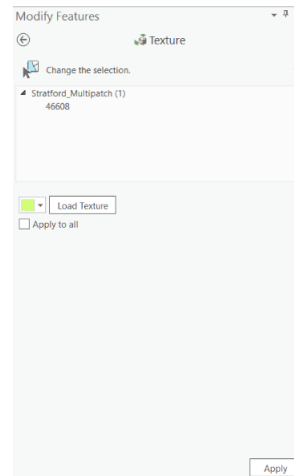

Figure 9: Modify button in the Edit toolbar

Figure 10: Texture section in the Modify Features pane

9) Once you have created the Multipatch building layer, the next step is to click **Edit > Modify** (Figure 9) to begin editing the Multipatch features.
10) The **Modify Features** pane would then appear. In the list displayed, select **Multipatch Texture**, which is under the **Reshape** section of the list.

11) The **Texture** section will appear under the **Modify Features** pane. Click on **Change the selection** and click on a building feature in the Multipatch layer. The code identifying each building would appear in the window when selected.
12) You can choose to change the colour from the drop-down list OR load texture externally from an image file. (Picture formats such as JPG, PNG and TIFF are accepted.) (You can browse the **FacadeTextures** folder provided for some sample textures provided by ESRI)
13) Click on a surface of the selected building and click **Apply** to apply the colour or texture you have chosen. If you want to apply your colour or texture to all surfaces of the selected building, check the box for **Apply to all** before clicking **Apply**.
14) You can repeat steps 11-13 for the buildings in the dataset you want to customize.
15) Congratulations! You have completed this part for customizing the texture and colour for 3D buildings. For the next part of this tutorial, we will try to apply pre-defined textual templates to the 3D buildings.

Part B2: Symbolizing buildings using pre-defined templates

ESRI has built some pre-defined templates for 3D building texture. We will try to use a template called **Int_City_2014** for this part. Here are the steps to apply the pre-defined templates:

1) Click **Insert > Import** Map to load the *Stratford 3D Scene.mapx* map from your working folder. Make sure all the content, including the *Create-New-Content* folder, is saved under your working folder.

2) After importing the map, copy and paste the <u>extruded 3D building layer</u> (NOT the Multipatch layer), which you created in Part A, into the Contents pane under **3D Layers**.
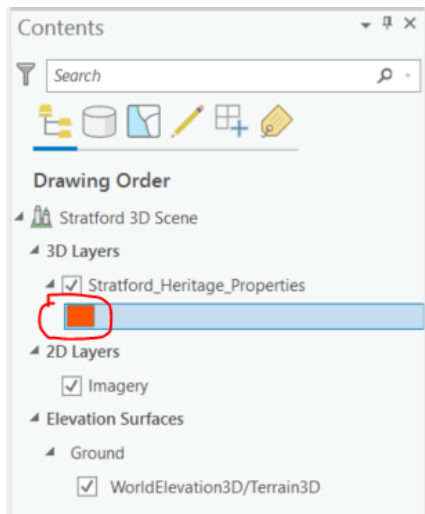

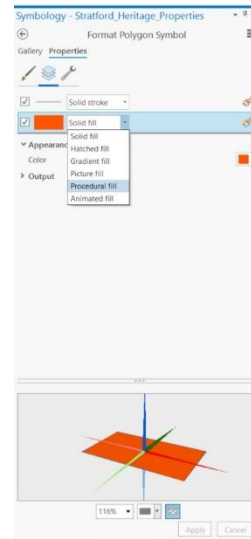*Figure 11: Contents pane with the heritage building layer*

Figure 12: Format Polygon Symbol tool window

3) Under the 'Type' dropdown menu in the Extrusion toolbar, select 'None'.

4) Double-click the symbology under the 3D building layer (circled in red in Figure 11).

5) The **Format Polygon Symbol** tool will appear on the right. Click the **Layers symbol** and then click the **Solid fill** drop-down menu and select **Procedural fill** (Figure 12).

6) Hit the **Rule** button to open the **Select Rule Package** window.

7) Navigate to the **Int_City_2014.rpk** file (Working folder > **Create New Content > Files > RPK**)

8) You should see the building type as Office Building as the default. Try changing to other types of buildings (such as Apartment Building and Residential Building) and observe the differences in the visual effects.

9) For **BuildingShape**, you could also select the building shape that you like. Select **L-Shaped** if you cannot decide.

10) For the **TotalHeight** field, select the **z** field from the drop-down menu. Click OK.

11) Leave all other fields unchanged and click **Apply** to apply the rule package updates to your extruded building layer.

Figure 13: Styled Stratford buildings using the rule package

Excellent! You have now done symbolizing the 3D buildings using a pre-defined rule-based package. You may want to share these results with your friends. There are several ways listed below:

- If you want to share parts of your 3D buildings, you could click **Share > Map** to export your results.
- If you want to share the styled layer (either the styled extruded layer or the Multipatch layer), you could right-click on the layer under **Contents** pane and click **Sharing > Share As Layer Package**. You could either upload to ArcGIS Online or save the file locally and send the file manually.
- Note: There is an option in ArcGIS Pro to share the multipatch layer as a web layer. Please note that the layer may not be visible on the ArcGIS Online Web Scene due to technical limitations with a large amount of textual graphics.

Conclusion/Summary

3D buildings are buildings with both location and elevation information. They could be created by extruding 2D building footprints given there is an elevation (z-value) field. The created 3D buildings can be symbolized manually by adjusting the surface colour and textures. Moreover, the buildings can also be symbolized using pre-defined rule package templates, which contain textual information for various building types, such as residential and office buildings. The 3D buildings altogether could form a city model, which could be further investigated and shared among planners, consultants and government officials. It is noted that there are still some technical limitations on ArcGIS Online for showing the styled 3D buildings in Web Scene currently. Thus, the styled 3D buildings can only be shared as a layer package, which needs to be open using ArcGIS Pro software, but not as a web layer. An alternative option for sharing is to export parts of the Scene containing the styled 3D buildings as a map image and send it to others.

Appendix

References

ESRI (2019). Create Multipatch Features and Texture Editing [PDF]. Retrieved from
https://downloads.esri.com/learnarcgis/3d/create-multipatch-features-and-texture-editing.pdf

ESRI (n.d.). Apply textures to a multipatch feature. Retrieved from https://pro.arcgis.com/en/pro-app/help/editing/apply-textures-to-a-multipatch-feature.htm

USC GIS Online (2020). 4 Uses of 3D GIS. Retrieved from https://gis.usc.edu/blog/4-uses-of-3d-gis/

Credit

- The heritage building layer and the DTM layer are kindly provided by Prof. Robert Feick from the School of Planning at the University of Waterloo. The building layer is used in the course GEOG/PLAN 387 for teaching purposes.