Delft University of Technology

Geo5011 - Geomatics in practice

GIS & BIM Integration

Intership report

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Abstract

This document describes the assignments and work completed for my internship at Esri Nederland as a MSc Geomatics student at Tu Delft university of Technology. The internship lasted 5 months, from October 1 to February 30, and involved a GIS & BIM integration related practical and research assignments, namely, Automated publishing Revit models to scene layer on ArcGIS Online, CAD - Civil 3D data direct read ArcGIS Pro, and IFC to Building Scene Layer. The results were different for each assignment. In this report, I will present the main research assignment - Automated publishing of Revit model to scene layer, in details. The deliverables of this project were a StoryMap and a GitHub repository of a functional script/script-tool, and a blog that describes how to create Python script geoprocessing tool. Furthermore, I will briefly give an overview of the other assignments carried out and their results.

Keywords Automation, Revit, ArcGIS Pro, Python API

1 Introduction

1.1 Esri - Nederland and BIM

The integration between GIS (Geographical Information System) and BIM (Building Information Modeling) is expected to be crucial to meet the market demands of easier and compatible data exchange between GIS and BIM software. This pushed Esri and Autodesk (main vendor of BIM and CAD softwares) to officially collaborate on the integration between these two worlds. Esri - Nederland company, as a market leader and main vendor of GIS software in the Netherlands, works closely with AEC companies and professionals who are active users of BIM data. This allows for better understanding of user demands and realization of the integration goals.

1.2 Department Research & Innovation - BIM

Research & innovation department works on finding innovative solutions for real world problems and market demands using all available GIS technology. There are many themes of interest for research possiblities. During the internship, I joined Research & innovation department, under supervision of Niels van der Vaart, with main focus on GIS & BIM integration topics. All activities and research conducted was carried out in collaboration with the BIM team which consist of: Janneke Korenromp - business manager, Marleen Mulder - product engineer, and Frank de Zoeten - senior business developer. BIM teams works closely with AEC companies and keeps up with latest technologies in order to give a better overview of what users' needs are and try to meet them.

1.3 Internship description

During the internship, three main research topics were sought:

1. Automated publishing of Revit model to scene layer on ArcGIS Online
2. AutoCAD Civil 3D objects in ArcGIS Pro 2.7
3. IFC feature classes to building scene layer in AGOL using ArcGIS Pro

For carrying out these tasks, I first followed tutorials that are offered online at ArcGIS developer website to get acquainted with the ArcGIS (online)-platforms and API's. Then, I focused more on each task requirements separately. In the remainder of this report, I will elaborate on these assignments and their results.

2 Automated publishing of Revit model to scene layer

Many ArcGIS users and AEC professionals publish BIM models to Web GIS for conducting analysis and/or for sharing it with other parties. For instance, changes are made to a Revit model in BIM360 or in Revit should be updated in the scene layer (hosted) model in ArcGIS Online. This workflow and many similar ones are repeated monthly, weekly, or daily even when it is required to share the most updated modification of your BIM data in near real-time. Therefore, I was asked to research the possibility of automating this workflow and similar ones. The exact workflow to be automated is demonstrated in the flowchart below Figure 1

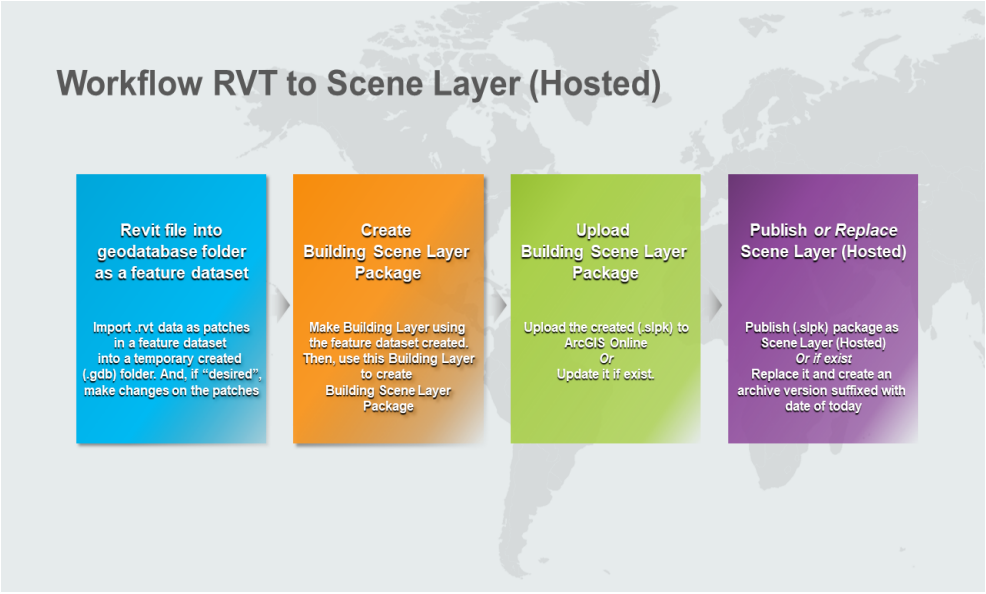

Figure 1: Flowchart - Workflow from Revit model to building scene layer Package, then to scene layer (hosted).

2.1 Methodology

For this assignment, ArcGIS API for Python - arcgispro-py3 environment was used which includes all Python libraries used by ArcGIS Pro and some other libraries, such as scipy and pandas. The main libraries used for this task are ArcGIS API for Python library and ArcPy Python package. All scripting work was done and documented on this GitHub repository which is also made freely available for open use.

2.1.1 Data used

For testing purposes, a small building model in Revit (.rvt) format was used. The file obtained from converting an IFC file using Revit software. The final script was tested using other big-size files in Revit format, however, they are not demonstrated in this report or elsewhere.

2.2 Workflow in details

The workflow is divided into two parts (here I will call them functions).

- Function 1 converts a Revit building model into a building scene layer package (.slpk) file in your local machine. This function executes the following pipeline:
  - Checking if the (.rvt) file at hand is modified since the last run (This is done by a helper function that can be turned on and off)
  - Creating a geodatabase folder in a local folder
  - Importing Revit data into the geodatabase created as patches in a feature dataset
  - If "desired" make some changes on the patches e.g. delete a discipline or add attributes.
  - Making building layer from the feature dataset
  - Creating a building scene layer package (.slpk) from the Building Layer
- Function 2 uploads a building scene layer package (.slpk) file to ArcGIS Online content. Then, it publishes it as a scene layer (hosted). If the (.slpk) file already exists in ArcGIS Online, it will be updated. And if the scene layer already exists, it will be replaced and the current version is saved as an archive.
  - Uploading (or updating) the created building scene layer into ArcGIS Online
  - Finally, publishing (or replacing) the scene layer (hosted); if the scene layer (hosted) already exists, the replace function will create an Archive[name of the file][today's date] version.

2.3 Results

The results of the assignments are few products that can be used differently.

2.3.1 StoryMap

This StoryMap explains the workflow and gives a very detailed description of how the Pythons script is implemented. It also elaborate on where in the code you can customize the Python script to meet your desires.

2.3.2 GitHub repository

This GitHub repository contains the following:

- **A Python file named BIMpublication:** this is the main Python script that can be used directly or modified by the user to fit their desire. The two function described in subsection 2.2 can be used separately. This file can also used for the automation using a stand-alone script and Windows task scheduler.
- **A toolbox file named BIMpublicationToolbox Figure 2:** this toolbox (the script is embedded) can be used directly in ArcGIS Pro and it runs the exact workflow that is described in subsection 2.2. It also offers the user to run only one of the functions (part of the workflow)

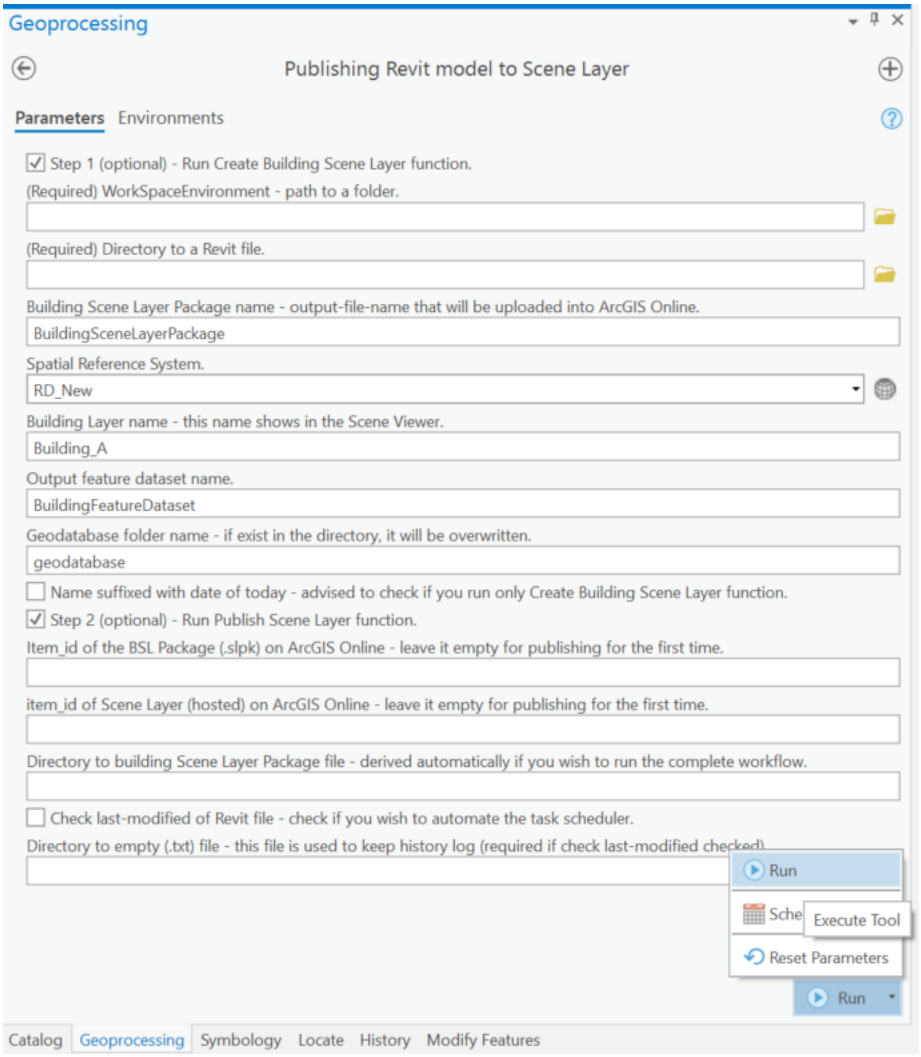

Figure 2: Geoprocessing script-tool - Publishing Revit model to scene layer.

2.3.3 Blog - Creating a geoprocessing script tool

A blog was written walk the reader through the steps of creating a geoprocessing Script Tool in ArcGIS Pro.

2.4 Discussion and Recommendation

- In the current version, this reads only models in Revit (.rvt) format. In the future, once it is possible in ArcGIS Pro, this script can be developed to read different files format of BIM data such as (.ifc), (.dwg), and Civil 3D (.dwg), etc.

- Moreover, it can be interesting to research and test using Data Interoperability Tools to import data from different formats such as the ones just mentioned. Furthermore, you can examine combining patches (feature classes) from different data type sources in one geodatabase folder, before publishing.

- At the moment this script takes as input a Revit model from a folder on your local machine. As an enhancement, this script can be much improved if it can access BIM data directly from BIM cloud. Moreover, the new functionality - detecting modified Revit files in BIM 360 - can be utilized to check before downloading BIM models.

- This workflow is quite heavy on the machine, and it requires a powerful processor if the Revit model at hand is slightly big. Therefore, a further improvement, combined with the third recommendation, would be to schedule this script to run on the Online Notebook to make optimum use of the online server.

In the remainder of the report, You will find a brief overview of the task AutoCAD Civil 3D objects in ArcGIS Pro 2.7

3 AutoCAD Civil 3D objects in ArcGIS Pro 2.7

For this assignment, this blog was written on Esri Geonet website. What I provide here below is a summary of this blog.

3.1 Introduction

The new release of ArcGIS Pro 2.7 supports direct-read of AutoCAD Civil 3D objects. It generates CAD features that are included in a Civil 3D file, and add feature classes that are derived from the same content in a different representation. This task is carried out to examine the feature objects that are generated when directly reading a Civil 3D file in ArcGIS Pro. To present an overview of how Civil 3D data is read and structured in ArcGIS Pro, I will compare the data (objects) in Civil 3D and ArcGIS Pro.

3.2 Methodology

To examine the difference, a Civil 3D file that contains a pipe network and 3D objects will be used. Moreover, the comparison considers the following two workflows:

1. Using CADToGeodatabase GP tool
2. Direct-read of Civil 3D in ArcGIS Pro 2.7.

To do so, the following questions will be addressed:

- When importing Civil 3D data, what do we see in ArcGIS Pro?
- What are the geometry types of the data imported in ArcGIS Pro? And can the resulting feature classes be published into ArcGIS Online?
- How good can ArcGIS Pro handle Civil 3D data?

3.3 Results

What do we see in ArcGIS Pro when importing Civil 3D data, and what does direct-read show?

Both approaches show exactly the same data structure and layers imported have the same feature classes that behave the same in ArcGIS Pro. The direct-read in the file I used showed an extra feature layer which is Polygon. This layer shows up in the direct-read of ArcGIS Pro despite being empty, whereas CADtoGeodatabase tool excluded the empty feature layer, see Figure 3.

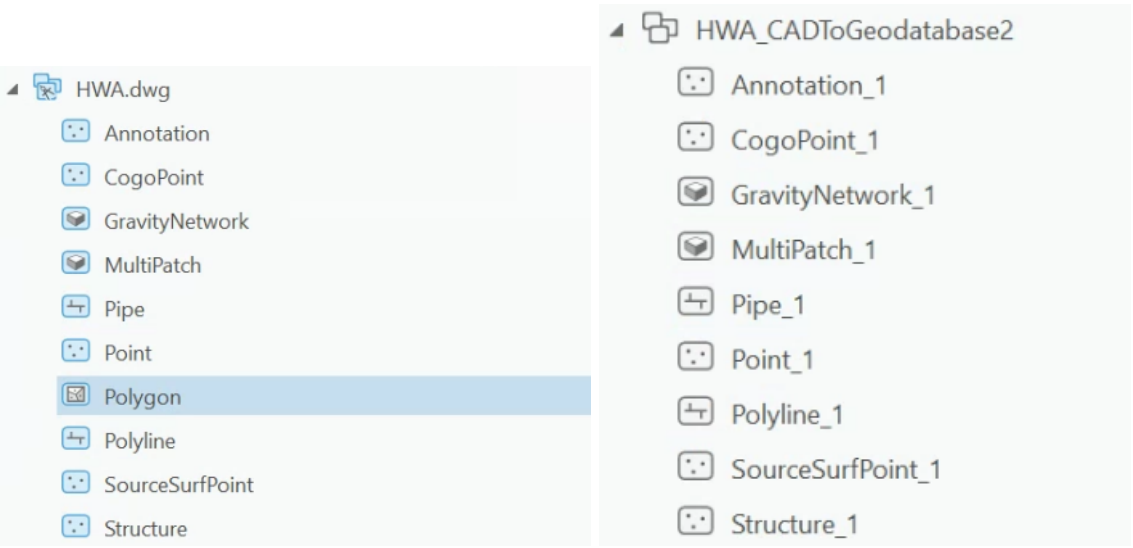

Figure 3: Direct-read (left) vs CadToGeodatabase tool (right) structure

Direct-read also shows some sort of costume symbology of the layer, for example, the figure below shows a standardized symbology of elements that try to mimic the data structure in Civil 3D. Even though these layers are actually empty.

Figure 4: Symbology structure of the the feature-layer Structure

What are the geometry types that we see in ArcGIS Pro? Can the resulting feature classes be used in ArcGIS Online?

In ArcGIS Pro documentation, you can find the supported geometry type of Civil 3D objects in ArcGIS Pro. For instance, pipes and Structure points types in Civil 3D are polyline and points types in ArcGIS Pro respectively. Moreover, In ArcGIS Pro, there are two 3D feature layers: Multipatch and Gravity work which represent Civil 3D data in 3D. However, the Multipatch feature class doesn't contain the attributes of the Civil 3D objects. Therefore, if you were to use the Multipatch feature, you need to populate the required attributes to it from the required feature layer such as pipes. This can be done using the Add Join tool using Handle as Input Join Table Field. In this way, you can have a 3D multipatch layer that contains all attributes and can be used in ArcGIS Online. Note that this might be not the case if you have a 3D Solid object in Civil 3D. The Multipatch feature class can be uploaded and share across ArcGIS Online as a 3D scene layer. However, attention should be paid to the reference system. If you would like to share Multipatch layer in ArcGIS Online, you should have a file with a defined spatial reference system if it is directly read by ArcGIS Pro. Otherwise, you must use CadToGeodatabase GD tool to define the desired reference system.

3.4 Conclusion

It is safe to say that ArcGIS Pro handles the complex setup of Civil 3D data well. However, for leveraging its power, the Civil 3D file at hand should be clean, well-designed, and does not contain noise. Engineers and designers that work with Civil 3D or other designing software tend to put all

drawings and information in one file. This causes ArcGIS Pro to produce undesired results when trying to create a 3D representation of Civil 3D data. ArcGIS can be optimally used by first understanding how Civil 3D data are organized within a file; secondly understanding how ArcGIS Pro read and structure the data imported from Civil 3D. This will allow you to structure the data in a way that guarantees best practice.

4 IFC feature classes to building scene layer in AGOL using ArcGIS Pro

For this assignment, this blog was written on Esri GeoNet website. What I provide here below is a summary of this blog.

4.1 Introduction

Building scene layer service is increasingly used among BIM-GIS users to share 3D BIM data on ArcGIS online environment. One example is 3D models in Revit (.rvt) format that is directly readable as a Building Layer in ArcGIS Pro, or they can be converted into feature classes using BIMtoGeodatabase tool. Either approach can be followed to create building scene layers packages from (.rvt) data to be published to ArcGIS Online. Industry Foundation Class (.ifc) file is another data format that will be addressed in this blog. It is wildly used among AEC professionals for exchanging 3D models. Since the road map in this article shows that IFC format is going to be supported in ArcGIS Pro on the near-term, it is worth mentioning that the workflow explained in this blog about IFC data can be applied on data from a different file format. Moreover, data from different sources can be combined in one building scene layer using ETL tools (combining data is not tested for the purpose of this blog). This blog solely explains a way around to creating a building scene layer package in ArcGIS Pro using feature classes derived from an (.ifc) file. Note that, in order to implement this workflow, you need to install the Data Interoperability extension. Links to the documentation of the GP tools that are used for this workflow are provided for each step, this includes pieces of code example that are useable in Python API. For if you would like to automate this workflow using Python API, refer to this StoryMap and this GitHub repository (for that you need a bit of scripting skills in Python).

4.2 Methodology

For this task, a Revit file and an IFC file of the same model were used for testing. The original file was provided by Marleen Mulder in IFC format. Using Revit software, the file was read and saved in Revit format. This grants me two models to compare data schema and be able to tell the difference. Not much about the comparison is mentioned here. Only results and the final workflow are showed and explained step by step in the blog. In this report, I will only share results and the discussion and recommendation .

4.3 Results

IFC to Building Scene Layer workflow in ArcGIS Pro:

1. Import the IFC at hand into ArcGIS Pro using quick import tool (from Data interoperability toolbox).
2. Create a new feature dataset in a geodatabase file using Create Feature Dataset tool.
3. Export all 3D features into the dataset created using Feature Class To Geodatabase tool, or simply drag the 3D features into the Feature Dataset layer within the catalog pane. **Before moving to the following step, it is important, for leveraging the power of the Building Explorer in ArcGIS Online, to name a feature class *ExteriorShell*.** It can be any feature class that is not empty. ExteriorShell feature is necessary for the Building Exploror in ArcGIS Online so that it shows the model in layers
4. Create building layer using Make Building Layer tool. **Note it is important to have a feature class named ExteriorShell as explained in the previous step.**
5. Create Building Scene Layer Package tool, using the building layer at hand, now produces an (.slpk) file that show disciplines' layers in ArcGIS Online.
6. If you now upload the (.slpk) file generated to ArcGIS Online, it will show layers in disciplines similar to a one derived from a Revit file
7. At this phase, you can change the discipline of some feature classes/layers, if you would like to. This can be done by simply dragging them to the desired discipline layer.

4.4 Discussion and recommendations

1. This workflow is tested on a model in IFC format, however in this blog it is not tested what attributes are imported with the model. Therefore, it is advised to review that before adopting the workflow. And you might need to apply some process to populate data from 2D features/classes to 3D feature classes.
2. Building Layer and Building Scene Layers are designed based on Revit files schema. This means that Disciplines and layers within the Disciplines follow the schema of Revit files. And generalizing that on IFC or other data format such as CAD and Civil 3D is difficult. Note, it is expected that ArcGIS Pro will support direct read of IFC data soon (not official yet)
3. This workflow works on data in one GDB file stemming from one source. Combining data from different sources and in multi GDB files is possible, however that requires deeper understanding the data structure if you wish to change on it, especially within the disciplines.

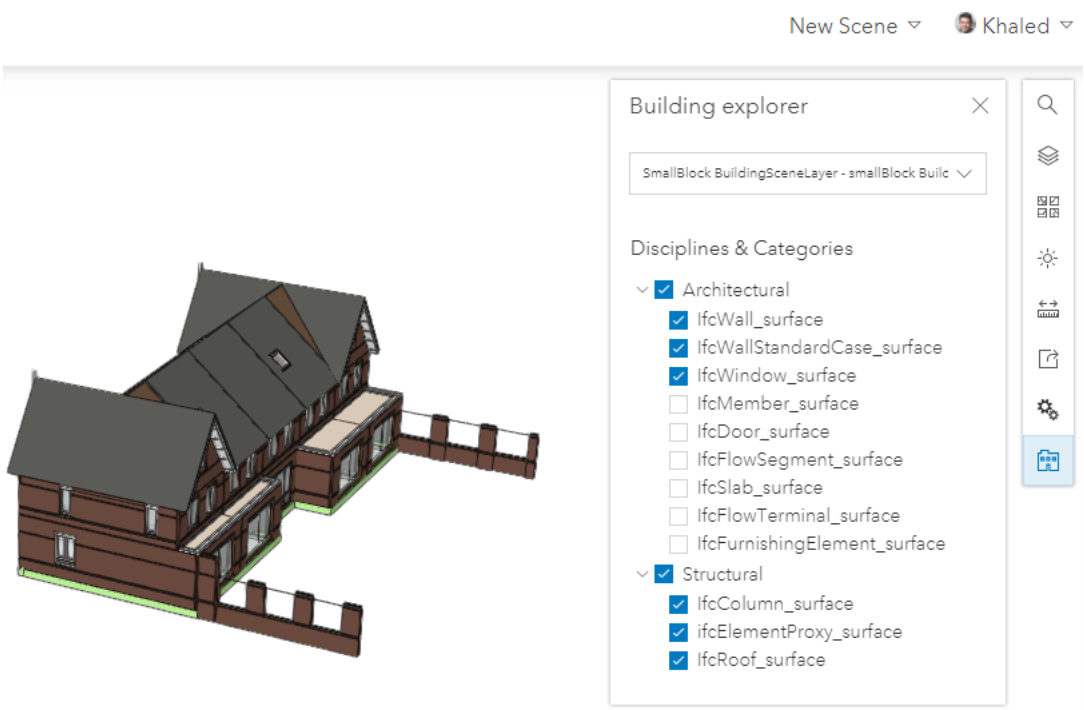

Figure 5: Resulting Building Scene Layer from IFC data in ArcGIS Online

5 Reflection

This internship offered me a an insightful experience in applying Geomatics in practice. More specifically, I got the chance to acquire valuable knowledge in the field of GIS&BIM integration and I was able to have a good understanding of market in this field. Furthermore, I was updated on the latest technologies offered by Esri in the field of 3D web-GIS application and its usage. The tasks conducted during my internship gave me a hands-on experience in automating workflows using Python API. That's being mentioned, I was able to deliver a stand-alone script and a geoprocessing script-tool that can be used to automate the workflow - publishing Revit model to scene layer. The resulting products of this task were documented and made available in this GitHub repository, which can be used as a starting work-frame to develop a customized similar workflows.