

Tutorial for analyzing the scaling structure of building façades

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In this tutorial a step by step guide is provided which shows how a building façade can show many different scales if it is constructed well.

I. Introduction

Many buildings nowadays are constructed without scaling in mind. They end up to become big boxes of concrete, steel and glass. This is most likely detrimental to our health and well-being. Older traditional buildings have always had much more structure, it is much more clear where the entrances are located and they are much nicer to look at. One of the reasons why is because the structure of those buildings are perceived at many different scales. This tutorial will use a schematic of the saint Peters basilica in Vatican City as an example to indicate the different levels of scale. And also how to discover these multiple levels of scale in structures.

II. Data resource and software requirements

This tutorial uses ArcMap as software to show and visualize the scaling properties of the st. Peters Basilica. One schematic drawing of the front façade of the Basilica is provided as a starting point. You will also need to calculate head/tail breaks (https://en.wikipedia.org/wiki/Head/tail_breaks) and for that an excel calculator is made (<https://github.com/ChrisdeRijke/HeadTailBreaksCalculator>). With the tutorial are also the shapefiles as seen in the figures throughout which can also be used to analyse the living structure of the Basilica.

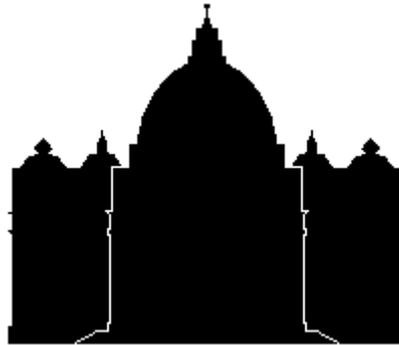
III. Creating and identifying the scaling structure

Something which has living structure has shapes across different scales, with more shapes in the smaller scales and less shapes in the larger scales. To start off with we have two scales, the smallest scale which consists of all shapes present, the schematic shows all shapes in the smallest available scale. Then additionally there is the largest scale, which consists of the outline of the building, or the whole.



The largest scale is in the left, while the smallest scale is to the right. There are several scales in between though. For example, the second largest scale can be seen as the main building in the center with a left and a right side, as seen on the next page. As long as all structures have scaling in them and there are at least 3 scales, the object has living structure. Between scales, the amount of shapes are between 2-3x the shapes in the previous scale. So for example, between the first and second scale the number of shapes are 1 and 3. This is a multiplication of 3, which is acceptable. However the last scale has 273 shapes,

therefore there seem to be more possible scales in between in this building. Note that there are multiple ways of interpreting the different scales and which parts of the buildings belong to them, people are not all the same, and they perceive objects differently. What does remain the same is the overall structure and notion of far more smaller than large things.



To do this for yourself in arcgis you will have to open the original schematic and merge shapes together so that they form larger coherent shapes as a representation of the different scales.

1. First open the schematic in arcgis by *add data* -> "*Basilica_Facade*".
2. Next export the added schematic to double it, this way you have a fresh shapefile to adjust into a new scale. *Right-click* on the "*Basilica_Facade*" layer and select *Data > Export Data*. Save it as *Basilica_Facade_1* indicating the first scale.
3. Open the editor toolbar by selecting *customize > Toolbars > Editor*. In the editor toolbar click *Editor > Start Editing*. (If it prompts you, select the "*Basilica_Facade_1*" layer.)
4. In the *Table of Contents* only select the layer you are editing ("*Basilica_Facade_1*"). Then with the  in the editor toolbar you can select shapes by dragging a box around them. For the first scale, select all shapes and in the editor toolbar go to *Editor > Merge*. Click yes when it prompts you how to merge, it does not matter what is selected. Go to *Editor > Save edits* when you are satisfied with the result to save the layer.
5. Now you should have created the first scale with only one shape. Now for the next scale, use the same process: Copy the original schematic to start with and follow steps 2 – 4. Between scales, you have to multiply the shapes in the previous scales between 2-3, so if the second scale consists of 3 shapes (see top of the page), the next scale must have around 6 to 9 shapes optimally.

See the following example on how to construct the different scales. This goes from $3 > 6 > 14 > 36 > 87 > 273$. Note that the final step is $\times 3.1$, but that is very close to three, so that is still acceptable. Also note that more and more detail is showing up in each scale, but that each scale itself is also a logical schematic / sketch of the basilica.

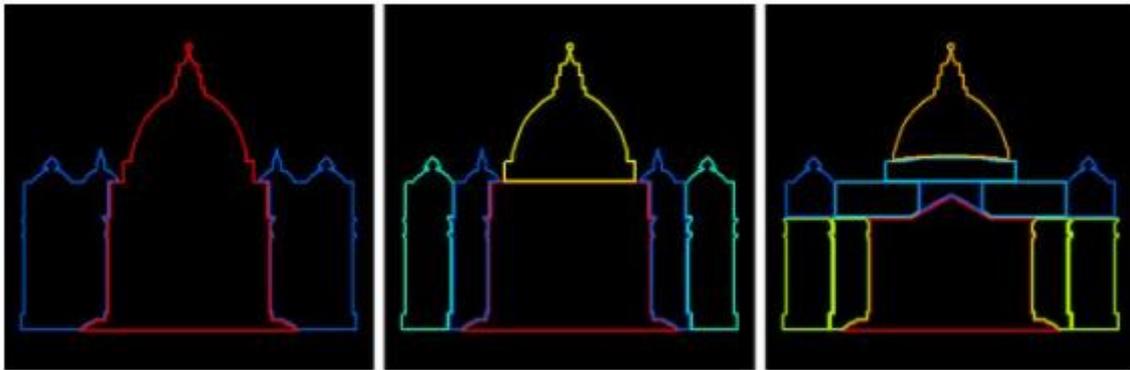


IV. Analysing the scaling structures in the living structure

Not only does each individual scale show a scaling structure of far more smaller structures than large ones, but also the overall progression between scales is scaling. To determine the scaling structure of any one scale, we can use the area of the shapes. To calculate the area we have to create a new column

in the attribute table and calculate the area on it.

1. Open the attribute table of a created scale (*Right-click > Open attribute table*) and add a field by clicking the  button under table and selecting *Add field*. (Note that you have to be out of edit mode to be able to add a field, if it is greyed out, go to the editor toolbar and select *Stop editing*) Call the created field *area* and select a *Long Integer* as its type.
2. To calculate the area right click the header *area* of the newly created column and select *Calculate Geometry* and calculate the Area.
3. For further analysis you can export the table to be able to open it in excel by clicking on the table button again and selecting *Export...* If you save it as a .txt or .csv file you can open it in excel by using the *Import data from text/csv*. With the area column you can calculate its head/tail breaks and use that to classify the different shapes in the scale. Do that for multiple scales and you can have a look how the living structure looks like from a building façade.



Larger shapes are in warmer colors, while smaller and more numerous areas are in colder colors. Your own set of scales may be different looking, but if they generally consist of more smaller structures than large ones you have also shown the living structure of a façade. For facades with much less living structure, it will be much harder to generate different versions, because due to a lack of scaling it becomes impossible to see the façade differently. Therefore in a sense, the more variations of different scales can be constructed the more living the structure actually is. On the other hand, due to the nature of the scaling law, many alternative versions of the above image will most likely be very similar or only slight alterations.

Acknowledgement

This tutorial is mainly based on the work done in de Rijke et al., 2020 which has been transferred into a step by step guide after discussions with Prof. Dr. Bin Jiang during our research into living structure. In an attempt to educate more people in the concept of living structure a set of tutorials was made indicating living structure across different scales.

References

- de Rijke C. A., Macassa G., Sandberg M., and Jiang B. (2020). Living Structure as an Empirical Measurement of City Morphology. *ISPRS International Journal of Geo-Information*, 9(11), 677.
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- Jiang B. & Huang J. T. (2021), A new approach to detecting and designing living structure of urban environments. *Computers, Environment and Urban Systems*, 88, 101646.