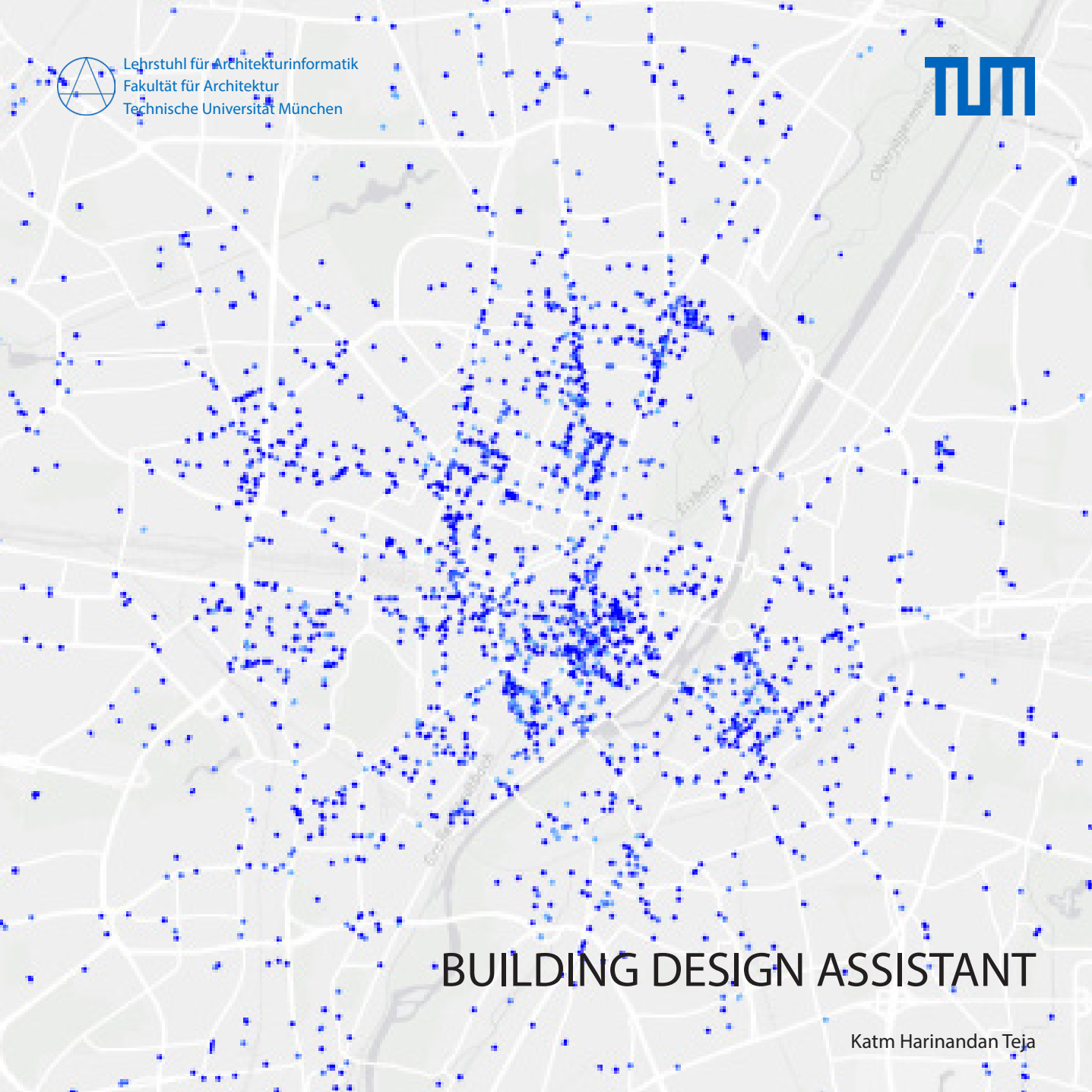
Lehrstuhl für Architekturinformatik
Fakultät für Architektur
Technische Universität München



BUILDING DESIGN ASSISTANT

Katm Harinandan Teja

Building Design Assistant

Lehrstuhl für Architekturinformatik
Prof. Dr.-Ing. Frank Petzold

Algorithmic Design
Zahedi Ata
Katam Harinandan Teja
03710066

Content

1. Project Idea
2. Implementation
3. Code Walkthrough
4. Results

Project Idea

At a high level the main goal of the project is to be able to assist building designers during the design process. Now lets discuss a scenario which best describes the projects use case.

Assume there is a rookie architect named Hari who is still trying to learn different architectural styles, techniques, patterns etc. and he recently joined a building design company. Within few days after joining his supervisor gave him a huge task. The task was to come up with a building models with floor plans etc. for a given land layout. Intially Hari got super excited for the project, but later he realised that he doesnt have much expertise in building design and all the supervisor has given him was the land layout on which the building will be built. Wanting to find the best design he opens revit and starts building the skeleton of the building. Within few minutes he got stuck, he had so many questions like how to prcoceed, where does he put the windows & doors, is the model he designed as per the standards etc but no answers.

Things would have been a lot easier for him only if he had some prefabricated building models which are very similar to the one he is building in shape, layout, orientation etc., that way he can get an idea as to where the key elements can be placed or if his building is as per the standards etc. This is same idea that the project is based on, to be able to assist building designers to design better quality models quickly.

In short the Building Design Assistant(BDA) assists the designer during the design phase by showing high standard building models that we that are very similar in structural layout to the one that the user is currently designing.

The final interface for the user might look like this.

Implementation

For the BDA to successfully execute the task, it has to understand the structure of the building that the user is trying to build and compare them with prefabricated models that are pre processed and stored in a repository.

To understand the structure of the building we need to extract meaningful features that best decribe the structure and layout of a building which can later be compared to check the similarity. One simple definition of a feature can be that „A feature is an individual measurable property or charactersitc of a phenomenon being observed“

After we decide on the feature set we extract these features for all the prefabricated models and project them to feature space. Feature space refers to the n-dimensions where your variables which in our case a building model live. Figure 1 shown below is 2 Dimensional feature space with Feature X and Feature Y as features and each point represents a variable from the data.

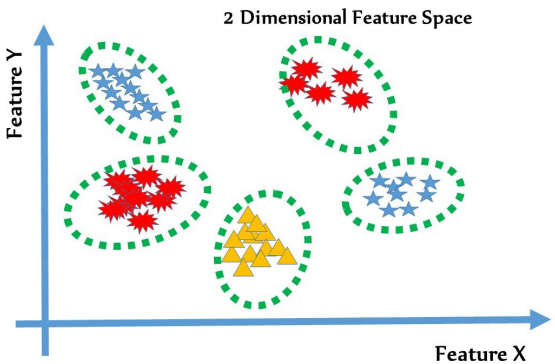


Figure 1

After some research the following feature set has been decided to be the best for the usecase.

1. Space - Wall volume ratio
2. Doors per space
3. Average space volume
4. Space volume variance
5. Average Space gyradius
6. Space gyradius variance
7. Footprint
8. Orientation
9. Circulation

All the features in the feature uniquely describe the structure and the layout of a building. The feature space in this case has 9 dimensions

Now lets discuss each of the features in the feature set in detail.

Features

1. Space - Wall volume ratio: It is the ratio of the volume of the walls in the building to the volume of the space in the building. This feature measures the amout of spatial segregation in the building. It distinguishes buildings with almost no partitions to a building with lot of seperations.

2. Doors per space: As the name suggests it is the number of doors per room. This measures connectivitiy of spaces

3&4. Space Volume Mean and Variance: It is the mean and variance of the volume of the rooms. This feature measures the size of the space and the extent to which the spaces vary in size

5&6. Gyradius Mean and Variance: Radius of gyration is formally defined as the radial distance of a point from the axis of rotation at which, if whole mass of the body is assumed to be concentrated. This feature calculates the mean and variance of the radii of gyration for all the rooms. This feature best measures the compactness of the spaces. Figures to the right shows you how this feature can distiguish two types of buildings.
In Figure 2 the building spaces are more spread out so the gyradius will be large when compared to the Figure 2 where the building space is concentrated towards the center.

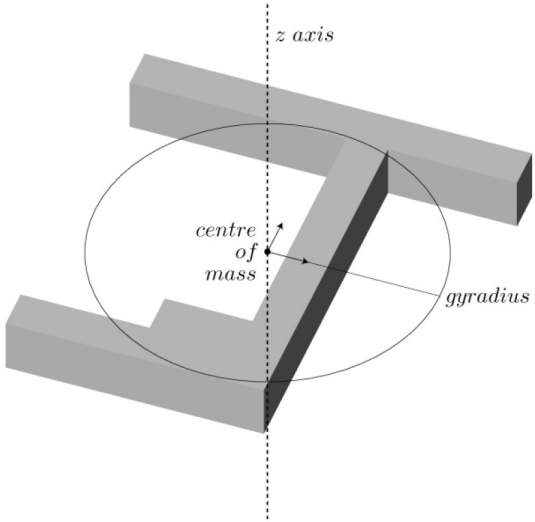


Figure 2

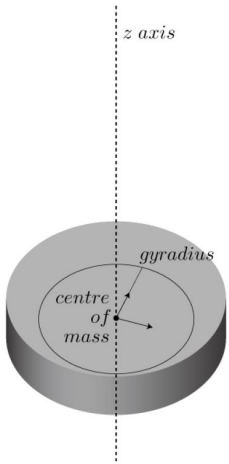


Figure 3

Features

7. Footprint: The shape of a building is the simplest and most intuitive proxy to qualify its style. The footprint feature measures the shape of the floor plan perimeter.
From a technical standpoint, this metric turns a given outline into a list of discrete values that can be compared to other building designs. We use an array of lines, stemming from a centroid of the building, to extract the area of the plan captured by each slice of space obtained. Figure 4 shows example of this feature.

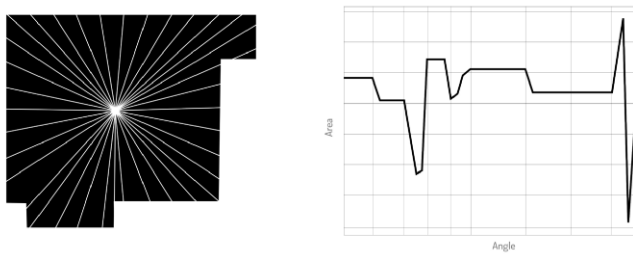


Figure 4

8. Orientation: As the name suggests it describes the orientation of the walls in the building.
From a technical standpoint, this metric extracts the walls of a given building and sums their length along each direction of space, from 0 to 360 degrees. Figure 5 shows you an example of this feature.

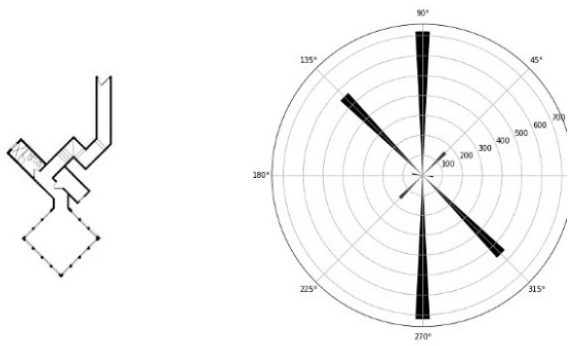


Figure 5

9. Circulation: This feature captures how people move across the building.
From technical standpoint it extracts the skeleton of circulations of a given floor plan and sums its length along each direction of space. Figure 6 shows you an example of this feature

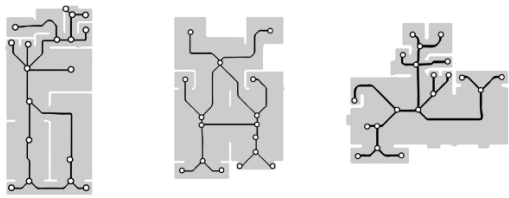


Figure 6

Code Walkthrough

Coming to programming of BDA, we use Dynamo and Revit to extract these features from a building. Revit is used to load a 3D building model and Dynamo is used to extract the revit elements and convert them into the feature set that we just described.

While the first four features are quite straight forward with Dynamo, the later features are a little tricky. Figures 7 - 9 shows the dynamo script for the 1. Space Wall Volume Ratio, 2. Doors per space, 3&4. Space Volume Mean and Variance extraction.
For 1 we extract the volume of the walls and rooms and divide to get the ration. For 2 we extract the total number of doors and total number of rooms and we divide the number of doors per space. For 3 we get all the volumes of roooms and find average and variance.

Figures 10 - 11 displays the dynamo script for 5&6: Gyradius Mean and Variance. We first get all the volumes and centroids of the rooms in the building and calculate the centroid of the building, then we calculate the distance to each of the room centroids fromt he building centroid to get the mean and variance of the gyradii.

Figure 12 displays the dynamo script to calculate the 7. Footprint of the building. This probably is the most difficult feature to extract among all the features in the feature set. To remind you this feature projects array of lines, stemming from a centroid of the building, to extract the area of the plan captured by each slice of space obtained. To obtain the same using Dynamo we first create 18 dummy surfaces that look like a pie piece with center at the centroid of the room and an angle of 20° each covering the entire 360°. Then we extract the floor surfaces, find the intersection of these floor surfaces with each of these dummy surfaces and store them as a vector with 18 values.

Figure 13 displays the code to calculate the 8. Orientation of the building. For this feature we first extract all the walls of the building, then we extract the normals of these walls to get the direction of the wall and then sum their length along each direction of space, from 0 to 360 degrees resulting in a 360 dimensional vector.

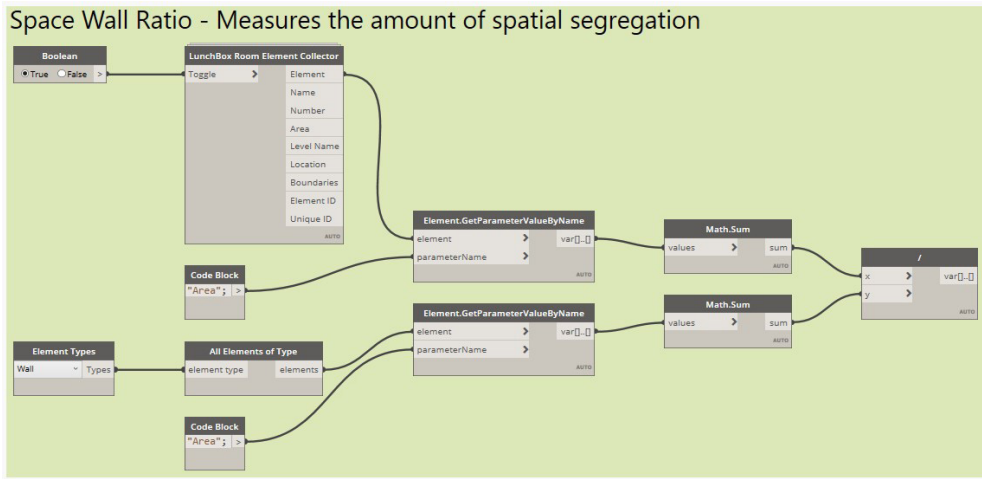


Figure 7

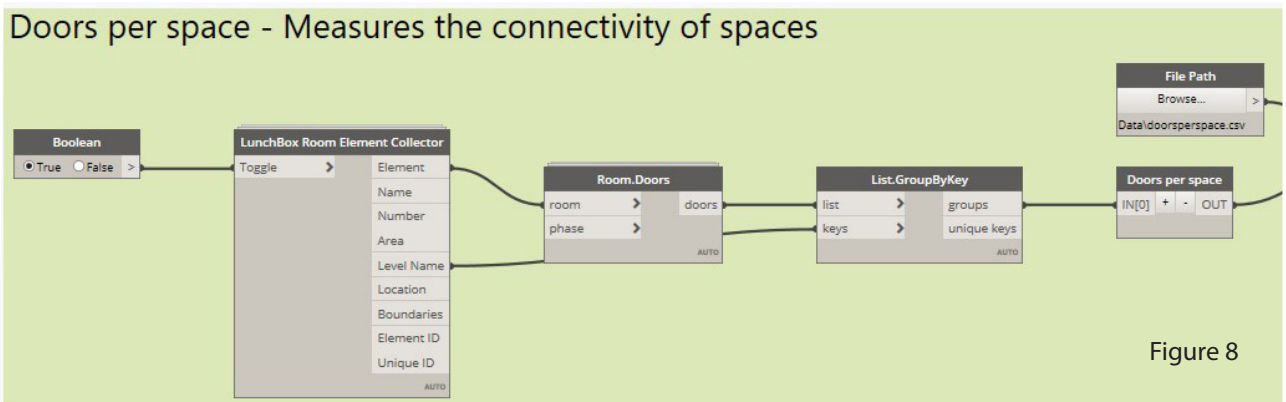


Figure 8

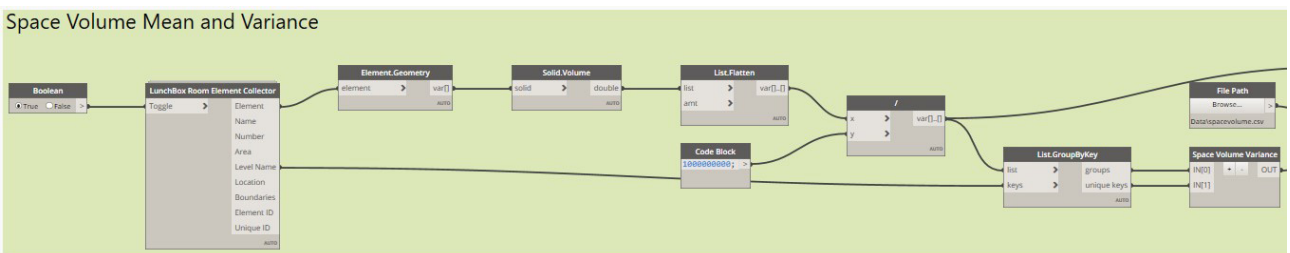


Figure 9

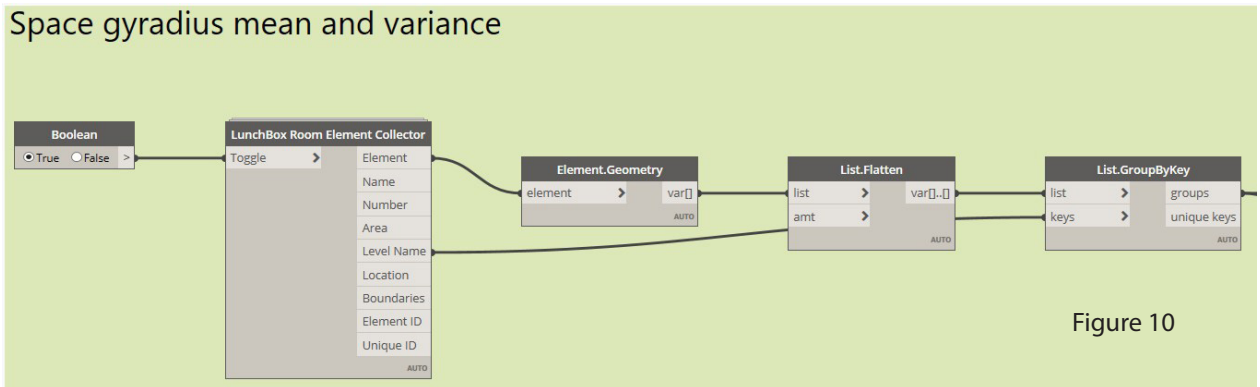
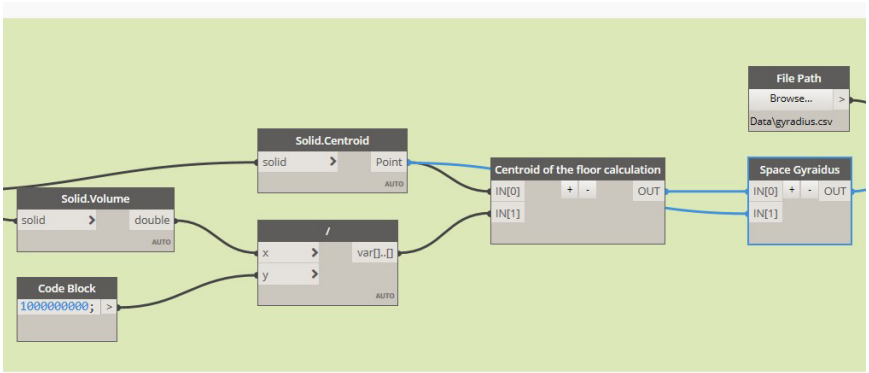


Figure 10

Figure 11



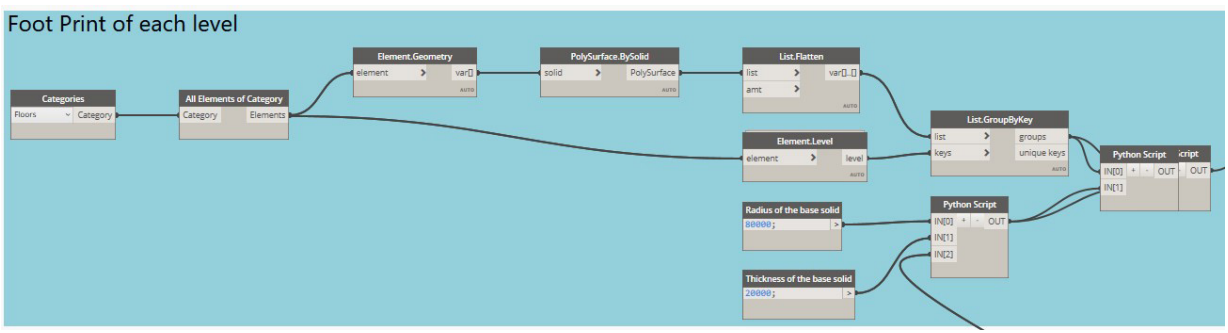


Figure 12

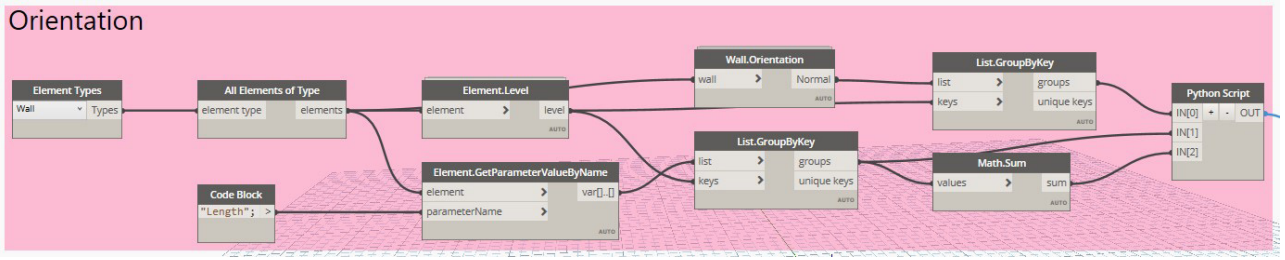


Figure 13

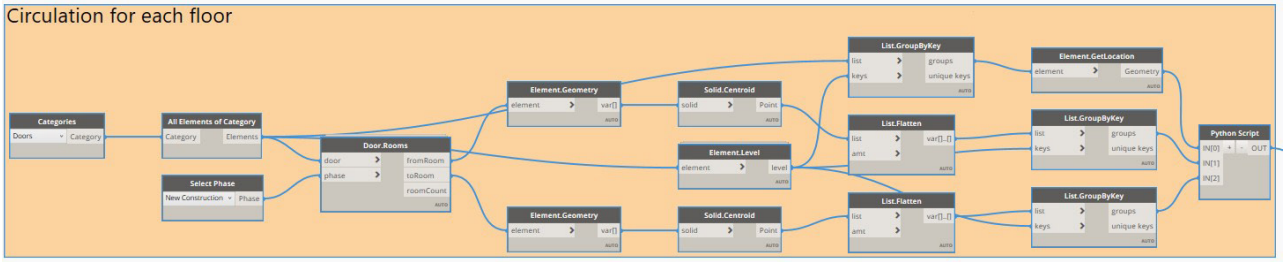
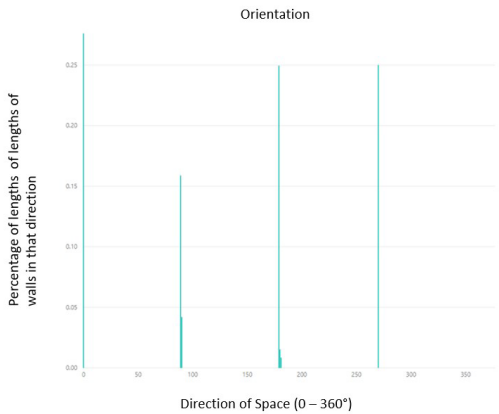
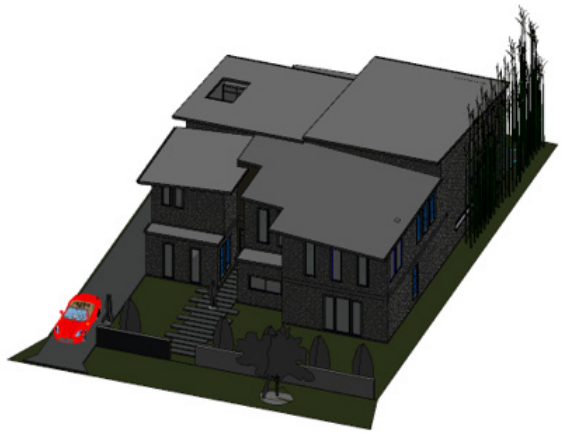


Figure 14

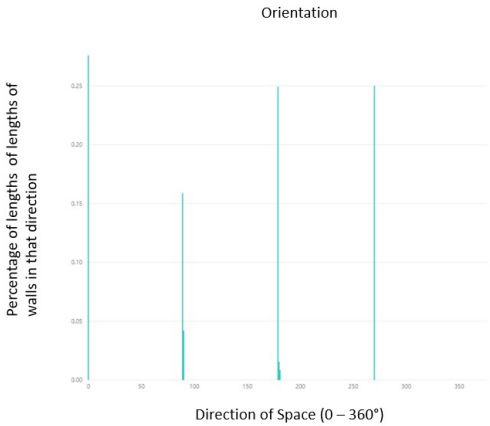
Figure 14 shows the Dynamo code for calculating 9. Orientation of the building. To extract this feature we first get all the doors and its to-room and from-room using Clockwork plugin in Dynamo. Then for each door we add a line from the centroid of the from-room to the centroid of the door and a second line from centroid of the door to the to-room. Once these lines are created we sum the lengths of these lines along each direction of space, from 0 to 360 degrees.

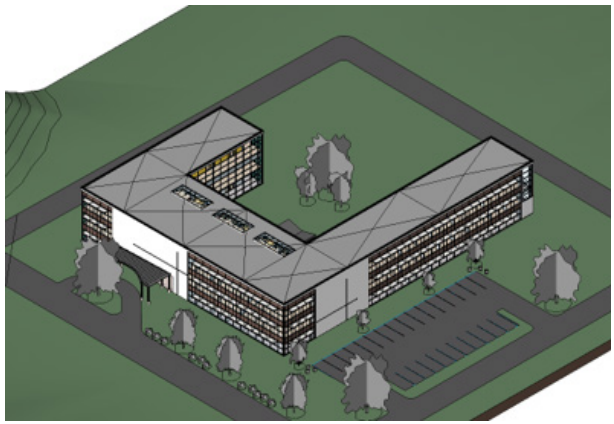
Results





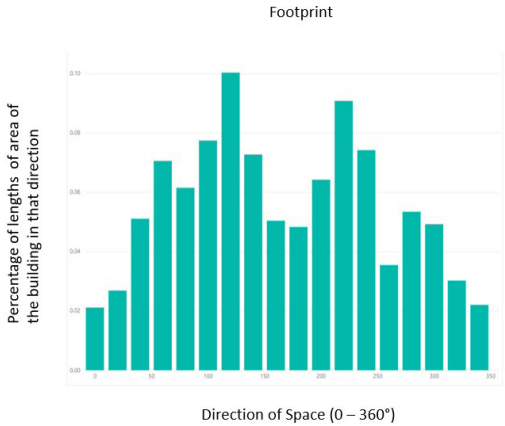
Orientation feature extracted fo the building shown to the right

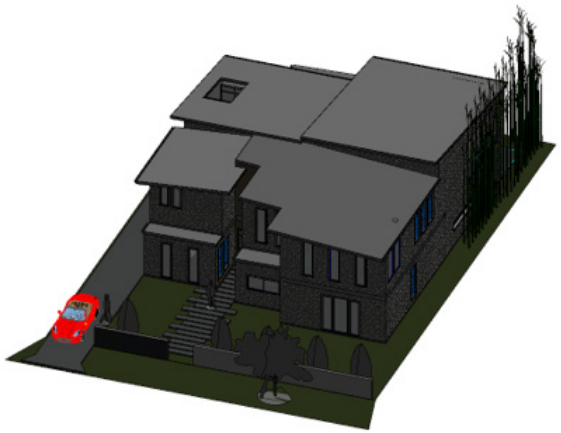




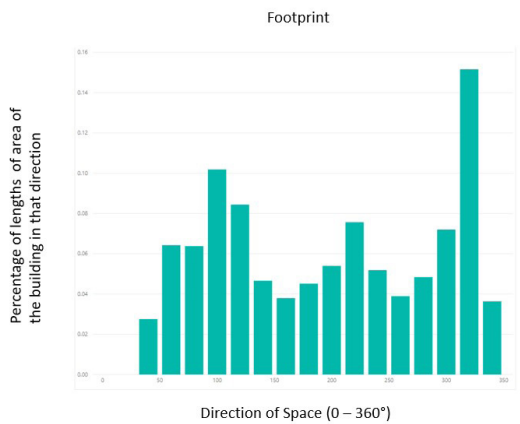
Orientation feature extracted for the building shown to the right

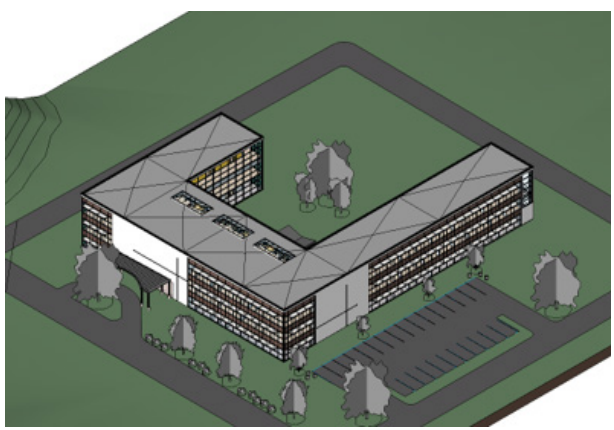
Results





Footprint feature extracted fo the building shown to the right





Footprint feature extracted for the building shown to the right

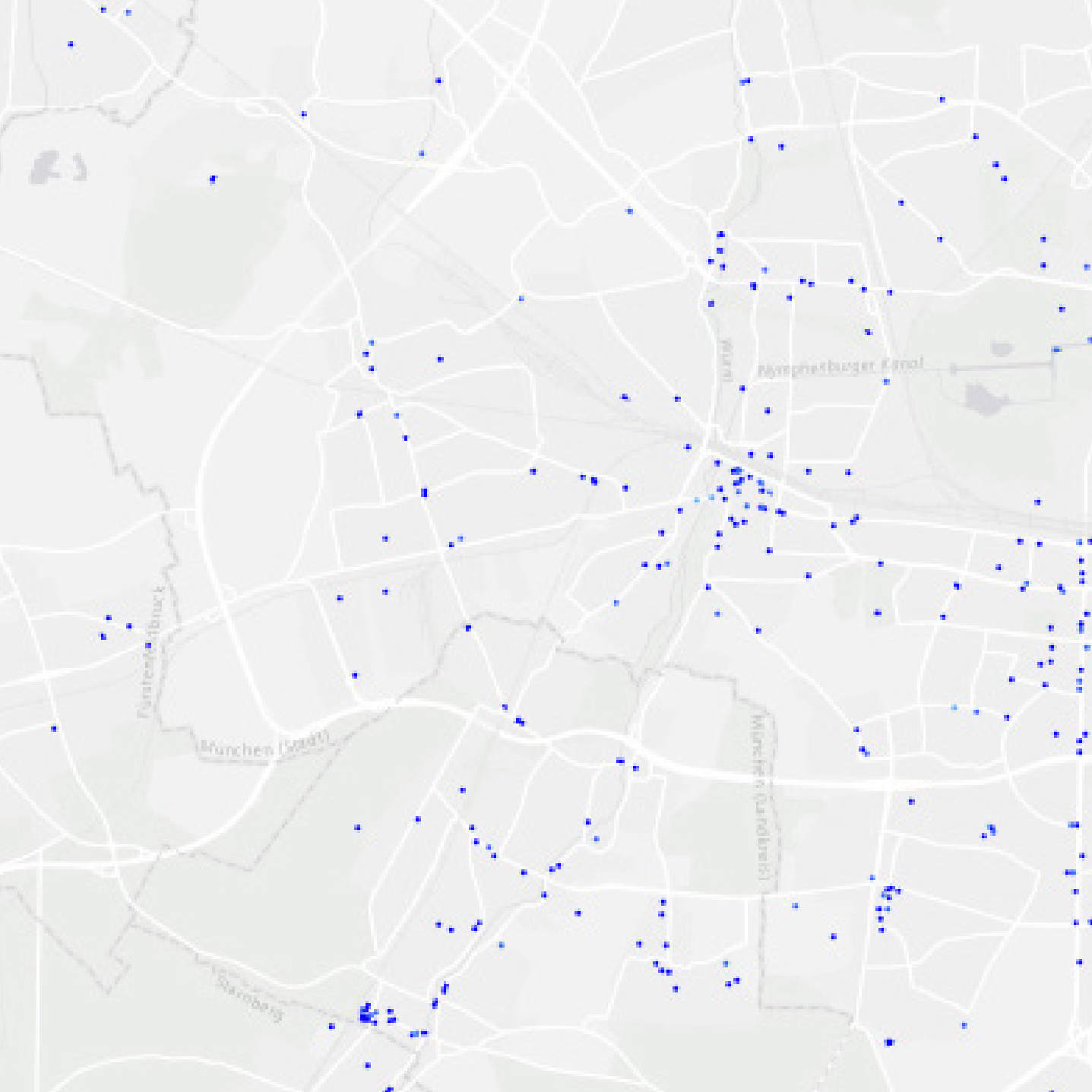
Results

In the results shown for the Orienation we can see from the bulding plans that almost all the walls are either at an angle of 0° or 90° or 180° or 270° or 360° which can be obsereved in the graph we extracted as well.

In the results shown for Footprint we can observe some interesting things captured by this feature. For the first design just by looking at it we can say that the are is almost evenly spread, the same is observed even in the graph. While for the second building design we can see there is a huge gap in the top portion of the design which can be seen in the feature we extracted with 0 area of intersection between 0 to 40° space direction.

About me!

Name: Harinandan Teja Katam
Matriculation Number: 03710066
Semester: 2
Email Address: hari.katam@tum.de
Mobile Number: +49 1736903319


Nymphenburger Kanal
Pasing-Obermenzing
München (Stadt)
Moosach (Landkreis)
Garching