Generated Raster Zoning in a New Development Area *21/01/2020*

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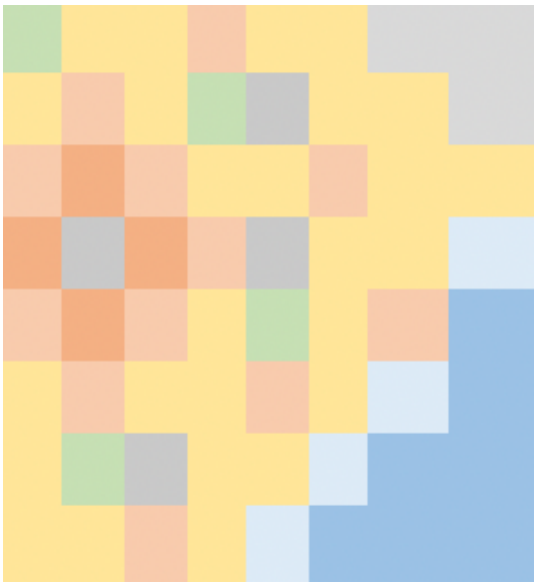

A Brief Introduction
A new train line is being built and multiple neighborhoods are planned to be built. Around every neighborhood several thousand people will live in what today is just plain land or other geographical features. Given the placement of a train station, can a neighborhood zoning code be created automatically, allowing for places of recreation, schools and shopping? This project seeks to generate a livable neighborhood for the future residents.

Project Background and Purpose
This project sets out to generate a simple zoning code for an area, given a map with simple geographical information. More specifically, a code is supposed generate zoning codes such as commercial, residential, mixed-use, recreational areas, and schools given a map of a desired train-station placement and geographical features such as water and hilly areas. This will be done by analyzing and generating raster data using the programming language Python. First, a map with simple geographical information will be created. From this map an analysis will be made, resulting in generated zoning of the area based on the geographical information.

The purpose of the project is to understand how geographical information can help generate possible future development schemes in a new area.

The project implies building the generative zoning model from scratch to understand what can be created by simply generating a zoning code automatically. The project will reflect a process of building a model. The presented results will not be a finished product; however, they will reflect of what analysis can be made given a new area.

A second purpose of the project is to understand and discuss possibilities and limitations of an automated zoning code.

Project Limitations
As the purpose can be applied in multiple levels of complexity an adequate set of limitations need to be set to realize the purpose within the scope of the project. Therefore, the following limitations have been set to the project:

- The raster map will be 8x8, obtaining 64 points.
- Every point in the raster will represent a block.
- The supplied geographical information will be limited to Water, Mountain and Land.
- The supplied geographical map will be created by the author. A train station will be placed in the geographical map.
- The generated zoning codes will be limited to Mountain, Water, Residential by water, Residential, Mixed-use, Commercial, Train station, Park, School.
- The tools for generating the zoning and will be discussed later on.

Project Formulation
Given a placement of a train station a zoning code will be generated in the 8x8 raster map. The generated zoning code will be analyzed on *how* the it was generated, and if it is a plausible zoning code.

Geographical Map
In an 8x8 map a train station as well as geographical information is set, presented in Figure 1 below. This geographical map will be the starting point for the generated zoning code result.

Figure 1. Geographical map with land-, mountain- and water-features as well as a set train station.

Project Analysis Procedure
This chapter will explain the procedure of creating the generated zoning. More in-depth descriptions on how these tiles will be supplied later in the report.

First, a commercial layer will be created. Then, the remaining livable tiles (in other words not the mountains, water, train station or commercial tiles) will be set as residential. After this, suitable residential tiles are set as mixed-use zoning tiles. Then parks are set out based on proximity. To help decide the amount of schools necessary in the area, a population distribution is created. Using the population distribution, the school tiles are then created. The final product is presented as a map with generated zoning codes as well as the calculated population distribution of the area.

Zoning Generation Descriptions
This chapter will briefly describe the methodology of generating the aforementioned zoning codes. The zoning code tiles will be presented in the same sequence as they were created, described in the Project Analysis Procedure chapter.

Commercial. The commercial tiles only consist of commercial activity, with no residential activity. The commercial layer will be set to be the tiles surrounding the train station. This is to reflect a shopping area surrounding main axis of movement, the train station.

Residential. The residential tiles show blocks with only residential development. First, all livable tiles are considered as residential. Multiple tiles will be changed to mixed-use, water-side housing, parks and schools.

Mixed-use. Mixed-use is defined in this project as residential housing with ground level commercial business. The mixed-use tiles are first placed instead of residential tiles which are next to commercial tiles. Mixed-use tiles also represent neighborhood restaurants, convenience stores, bars and grocery stores. Therefore, the simulation will create a zoning code with mixed-use tiles at the most three tiles (or blocks) away from any residential tile. The tiles are placed finding the placements which create the minimum sum of distances from all residential tiles in the neighborhood. The mixed-use tiles should be accessible for the whole neighborhood and should be spread out throughout the area. The tiles are placed until every residential house meets the aforementioned criteria.

Residential by water. The residential by water tiles defined as smaller residential project just by the water, leaving the remaining space to public and recreational space. This signifies a common space with a few residential units in the area. In the population distribution the residential by water tile will have a lot smaller population size. The residential by water tile is considered as public space.

Parks. Parks are necessary for the recreation and well-being of the neighborhood's citizens. Therefore, zoning dedicated for parks and public space have been generated. Similar to the mixed-use tiles, the park tiles are placed depending on the highest proximity from all residential blocks. Every residential tiles is at most four tiles (or blocks) away from public space tile, more precisely a residential by water or park tile.

Population distribution. The population distribution is not a tile. However, it is necessary to explain the population distribution before explaining the final generated zoning, schools. Assumed population of a block is 1000 people, assumed by having about six medium-high buildings in one block. The neighborhood is dense, but not inner-city dense. Depending on the tile and the neighboring tiles, a coefficient will be multiplied to the block population. Mixed-use tiles obtain a coefficient of 0.8, and every tile which is inhabitable and gets multiplied by a 0.95 coefficient for every neighboring mixed-use tile. The thought behind this is to allow for different sizing and usage of housing, possibly allowing for recreational locales in closer to the mixed-use housing, creating small concentrations of activities. Tiles next to water are multiplied with 0.4 for every neighboring water tile. This means that a mixed-use tile neighboring one water tile will have a population of 1000*0.8*0.4 = 360.

Schools. Schools are determined by the population in the neighborhood. One school is assumed to inhabit about 2000 students. The children ratio is assumed to be mirroring the child population in Japan in 2018, 12.3% (Watasuki & Griffiths, 2018). As the schools will replace the residential tiles the following equation was used to calculate the amount of school tiles: `num_of_schools = round((children_pop/population_school)/(1+(percentage_children*full_block/population_school)))`

The schools were placed to achieve the lowest summed distance from all residential blocks in the neighborhood.

Results – Generated Zoning

Given the procedure and geographical map already presented, the program built for this projected created a generated zoning code presented in Figure 2 and a population distribution given the generated zoning presented in Figure 3.

	A	B	C	D	E	F	G	H
0	F	R	R	X	R	R	M	M
1	R	X	R	F	R	R	R	M
2	X	C	X	R	R	X	R	R
3	C	T	C	X	S	R	R	V
4	X	C	X	R	F	R	X	W
5	R	X	R	R	R	R	V	W
6	R	F	S	R	X	V	W	W
7	R	R	X	R	V	W	W	W

Key

M	Mountain
W	Water
V	Water-line w/ residential
R	Residential
X	Mixed-use
C	Commercial
T	Train station
F	Park
S	School

Figure 2. Generated zoning code with key explaining every tile

	A	B	C	D	E	F	G	H
0	0	950	950	800	950	1000	0	0
1	902	800	902	0	1000	950	1000	0
2	800	0	800	902	950	800	950	1000
3	0	0	0	800	0	950	950	400
4	800	0	800	902	0	950	320	0
5	902	800	902	1000	950	1000	152	0
6	1000	0	0	950	800	152	0	0
7	1000	950	800	950	380	0	0	0

Key

Mountain
Water
Water-line w/ residential
Residential
Mixed-use
Commercial
Trainstation
Park
School

Figure 3. Population distribution of the neighborhood, with colors explaining the zoning code of the tile

In the two figures a zoning for the new development with a placed train station is suggested. One can observe the scattered mixed-use tiles allowing for proximity to commercial activity from every tile. It is also noticeable that the schools are centrally placed to be close for all

residents. The parks are all on the left side of the neighborhood, which is due to the residential by water tiles on the right side are considered to be public space. In Figure 4 the total population and number of every tile is presented. The results and purpose will be discussed in the chapter Discussion below.

```
Total population: 35966
Total tile amounts R: 27. T: 1. C: 4. X: 12. F: 4. S: 2. V: 4. W: 7. M: 3.
```

Figure 4. Total population of neighborhood and the number of tiles in the suggested zoning code.

Discussion

Using simple assumptions, geographical analysis and raster operations a suggested zoning code has been generated. The generated zoning is not enough to be employed on a potential new deployment. However, it helps understand how a neighborhood can be built using generated zoning codes and the available geographical information. This concluding chapter will consist of three parts. The first part will discuss the flaws and areas of improvement of the program and result. The second part will discuss what the results presents, and possible advantages. The final part will discuss further developments of the project.

For a neighborhood of 35 000 people, the presented simple zoning code is too granular. Zoning codes are usually on a building specific level and are not as course as the presented result. This is due partially to the raster data used to generate the zoning. The raster data is used for simplification to generate the codes. This only allows for full blocks of one use, creating very large schools and just residential blocks. However, this is partially countered by the mixed-use and public space by water tiles. Further, the zoning random generated zoning doesn't have to be the best for a specific area. For example, the project cannot create an adaptive commercial area around the train station or around the water side of the neighborhood, as the public space can give attractive views welcoming a lot of people and potential customers. Also, the program cannot create parks larger than one block, as this might be more attractive for the neighborhood. The results instead present smaller public spaces scattered around the neighborhood.

On the contrary, the result gives a brief overview of what a zoning could look like. The result will maybe act more as a template for detail work to be created by an urban planner. In the presented results small centers with both a park and a school in the neighborhoods are noticeable. This is due to that these blocks have the highest proximity to the whole neighborhood. These centers can be important for urban planners in an analysis of a new development. A realistic use of the program is to understand focal points with high proximity for the studied neighborhood. The generated code can therefore give an understanding of central points in a new development, only analyzed through geographical information. The generated code can have the purpose of being a template or starting point for urban planners to decide a less granular zoning code.

With this being said, the project needs to be further developed to realize the possibility of automatically generated zoning to be a template for urban planners. First, a non-raster approach can be taken; however, with the cost of simplicity. The generated zoning is produced by logic and randomness, in a linear way. One area of improvement is to

understand similar neighborhoods or sub-areas to generate the zoning code using machine learning. This approach could help create different patterns of residential, commercial, or public space, depending on what is asked for.

Concludingly, the simple project created an understanding on how geographical information can be used to generate zoning. Using machine learning and more advanced analysis tools, more detailed and non-linear zoning can be created. This would then act as a template for new developments, saving time on creating different zoning codes.

References

Wakatsuki, Y. Griffiths, J., 2018. *Number of children in Japan shrinks to new record low*. CNN. Can be found at: https://edition.cnn.com/2018/05/07/health/japan-child-population-record-low-intl/index.html [2020-01-21]

Code

See attached AE_code.py for the python code used in the project.