Web Processing - Standardised GIS Analyses for Cable Route Planning

SEBASTIAN HEIDEN, Harz University of Applied Sciences, Germany

add as final part

CCS Concepts: • **Computer systems organization → Embedded systems**; *Redundancy*; Robotics; • **Networks** → Network reliability.

Additional Key Words and Phrases: datasets, neural networks, gaze detection, text tagging

ACM Reference Format:
Sebastian Heiden. 2022. Web Processing - Standardised GIS Analyses for Cable Route Planning. *J. ACM* 37, 4, Article 28 (February 2022), 5 pages. https://doi.org/XXXXXXX.XXXXXXX

1 INTRODUCTION

Sometimes, finding the shortest path is not sufficient. Additional parameters play also have to be taken into consideration. As the steepness of a road or the soil, play an important role for the building source cost of a road or pipeline . For planing the additional routes for a power grid, additional aspects as legal regulations and acceptance by the local population have to be taken in consideration. Also technical aspects, as the effects on the grid stability might be further points to consider.[8]

what is the least cost path

2 METHODS

We retrieve a set of different spacial data-sets from public sources as a basis to create the cost raster. Field of study are the counties of Cuxhaven and Osterholz in the state of Lower Saxony, Germany. Areas protected by different European and National conservation laws are provided by the German Environment Agency as Web Feature Service (wfs) [1].

The nation wide land coverage (ATKIS) with a scale of 1:250000 are provided by the Federal Agency for Cartography and Geodesy[3]. The nation wide power grid (tags: 'power': line) has been retrieved via OpenStreetMap.[7] Local data as houses at Level of Detail 1 are offered by the State Office for Geoinformation and Land Surveying of Lower Saxony[6]. In addition local planning geodata for the land usage are taken from from 'Metropolplaner' (Planing data Lower Saxony & Bremen)[5]

PyWPS[2] is used to offer the least cost path algorithm as a Web Processing Service (wps). The for the initial implementation of the least cost path algorithm the implementation for the QGIS-Plugin 'Least Cost Path'[4] has been taken into account.

The different layers from the different entities are optionally filtered, buffered and than rasterized. Filtering the layers of the files for special attributes enables to further differentiate further. For examples makes it possible to differentiate between heath and uncultivated land. Adding a buffer can be used either used to convert a line objects as power grids and streets into a polygon with the correct physical width, or to add minimum distance from an existing of planed area to the new power grid. Each of theses rasterized layers are given a weight, or cost that expresses the cost of using land covered by this layer. The costs of all layers of is aggregated with the maximum function. Thus, an area covered by multiple layers is uniformly used with the highest costs. For every area in the study area, that is not covered by any layer, is given the default cost. The costs has been grouped into different levels (see table 1) starting from preferential areas with very low costs, via no restrictions, which is the default, used when no other layers are covering the local area, to restricted, strongly restricted and prohibited areas with high costs. These higher costs resemble the degree how much a local area should be avoided, while routing the path. The ratio of the higher costs to the lower costs directly translates into the additional diversion in pixels the algorithm is willing to go, for avoiding an area of high costs. Thus, as prohibited areas describe a legal obligation, not to use these areas or only to the utmost minimum, the weight that resembles the costs for these types of areas, has to be especially high.

The rasterization transforms a vector into a raster. The rasterization can be executed in to different ways. In both ways, the rasterization can be imaged, as the old vector is layered over the new raster grid with the new given resolution and the new affine transformation and the coordinate reference system of the vector. Both rasterization techniques differ in who the pixels are selected, that describe, that a geo-object overlays the pixel. The pixels can either be described as overlaid with a geo-object, when either the center of that pixel is overlaid by the geo-object, or any part of the pixel is overlaid. Hence, the version with any part overlaid is called all touched True. The version where a overlaid pixel center is require is thus called all touched False. All touched False is considered the default (see figure 1).

Table 1. Used levels of costs, the applied numerical equivalent and example layer this cost have been used for.

Cost Level	Cost	Example
Prohibited	500	National Parks, Buildings
strongly Restricted	10	Bird Reserve
Restricted	5	Industrial Areas
No Restriction	0.5	Default
Preferential	0.1	Power Grid, Motorway Buffers

The completed list of layers and the processing applied to them, can be found in Supplement S1.

create the Supplement from the process-

Author's address: Sebastian Heiden, u38439@hs-harz.de, Harz University of Applied Sciences, Friedrichstrasse 57-59, Wernigerode, Saxony-Anhalt, Germany, 38855.

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from permissions@acm.org.
© 2022 Association for Computing Machinery.
0004-5411/2022/2-ART28 $15.00
https://doi.org/XXXXXXX.XXXXXXX

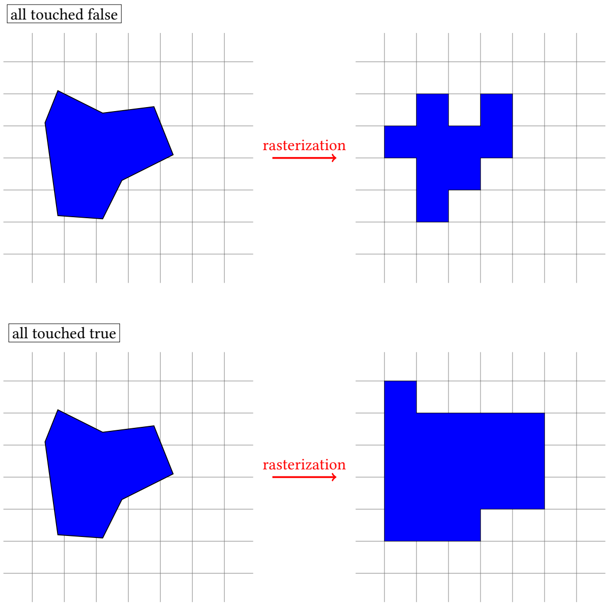


Fig. 1. Graphical example for rastering a vector (left blue), to a raster (right blue) with weither all-touched False (above), or all touched True (below).

3 RESULTS

In this chapter we want to show the different cost raster, that were created from the very same set of layers, but computed for different resolutions. From this different raster the cost paths are calculated and compared. In the last step the raster with lower resolution were used to calculate in a way, that they shall result in similar paths as if the paths were computed from a high resolution raster.

3.1 Cost Raster

3.2 Least Cost Paths

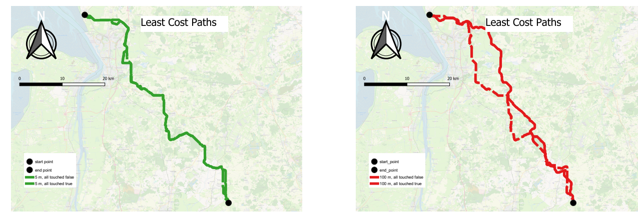
For each resolution the costs paths were estimated for the rasterization with setting all_touched False and all_touched True. The distance of both paths is calculated with the mean minimum distance. For every vertex P_i in the path L_1 the minimum between the vertex and the path L_2 is computed and afterwards the minimum distances are averaged (see equation 1).

$$d_{mean} = \frac{\sum_{i=1}^{n} d_{min}(p_i, L_2)}{n} \Bigg| p_i \in L_1 \tag{1}$$

Hence, the mean minimum euclidean distance between the two paths can used to compute the similarity. As different table 2 shows the distance between the two paths decreases with increasing resolution. In addition, this tendency is depicted in figure 3 for the calculated cost paths of 5m and 100 m resolutions.

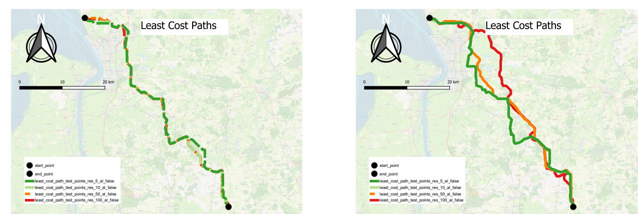
At the same time the differences in the aggregated costs stay constant. When normalize the aggregated costs by the resolution. Than On one hand it can be seen, that the all_touched False under estimate the costs and that this tendency scales linear with the resolution. On the other hand, the all_touched True least cost over estimates the aggregated costs on a linear scale of the resolution. Therefore,

Interpretation



(a) resolution of 5 m. (b) resolution of 100 m.

Fig. 2. Figures of the least cost paths. Contrasting the paths for different resolutions. Using OpenStreetMaps as base map.



(a) all touched false. (b) all touched true.

Fig. 3. Figures of the least cost paths. Contrasting the changes of the least cost paths for the different results, depending on the parameter all_touched. Using OpenStreetMaps as base map.

the difference for the normalized least cost paths is reduced on scale by the resolution.

show map

Comparing the all_touched True rasterization and all_touched False for the same resolution in contrast with the paths of all_touched False rasterization at the different resolutions the later paths are more similar. The mean average distance between the 100 m resolution run and the 5 m resolution run is 257.97 m.

Option add 2.5 m and 25 m

The similarity of all all_touched False runs is higher than, the similar between the all_touched False and all_touched True runs with the same resolution, except for the highest resolution.

Hence, in an overall perspective paths of the all_touched False runs stay in a similar region, while paths of the all_touched True coverage strongly to the paths all_touched False runs. This behaviour is depicted in figure 3. On a more detailed level, it can be seen, that also the Paths of all_touched converges the all_touched True path. But the extent is smaller. The length of the the paths only differs to a maximum of about 10 %. The least path distance for higher resolutions can be lower, because new paths, between regions that are forbidden in higher resolution can open. On the other side the length of the paths can increase, because with higher resolution more vertices will be used.

The zonal stat (see table 3) for a buffer of 100 m (5 m) around the path has been used, to estimate the percentage of which costs levels are around the path. When using all_touched True rasterization with higher resolution the tendency is to use a higher percentage of the Preferential Level and less the NoRestriction Level. The ratio of the 100 m buffered least cost path, strongly shifted to Levels lower costs. There is no strong tendency for the all_touched False least

Interpretation:

Interpretation: In-

Table 2. Least cost paths as length for the different resolution (res) of the rasters, including the mean minimum distance (mmd) and the aggregated (agg) costs. From the agg costs the differences of the agg costs and the corrected (corr) agg by resolution are given.

res /m	$length_{al=f}/m$	$length_{al=t}/m$	mmd /m	agg $cost_{al=f}$	agg $cost_{al=t}$	Δ costs	corr agg $costs_{al=f}$	corr agg $costs_{al=t}$
5	76136.27	78002.00	126.04	18665.923	19616.756	-850	93329.6	97584.77
10	75430.10	77936.57	277.92	8931.245	9731.175	-799.95	89312.45	97311.75
50	76135.02	70619,95	1140.01	1409.023	2300.073	-891.05	70451.15	115003.65
100	76283.80	74120.73	1946.41	640.516	1572.268	-931.7	64051.6	167226.8

used regions

cost paths.

3.3 Faster Processing of the Cost Path Algorithm

Check why values are so different for 5 m all touched False –> simplified line.

The original least cost path QGIS plug-in uses stops the least aggregation of the costs after the final end point has been found. This early stopping might result in sub optimal paths around the end points. For further calculation the search for the least cost paths has to be refactored and split the aggregation of the raster for the search of the path. To be able to construct a full aggregated cost raster, aggregated cost path in further steps will be computed completely. For the calculation of the least cost paths. The finally least costs paths should between the least cost paths of the lower resolution, with a tendency to be nearer The first step to optimize the calculation speed is, only the calculated the least cost paths for this smaller area.

3.3.1 *Compare least cost paths, for overlay of both rasterizations.*

3.3.2 *Restrict search to a minimum sized bounding box.*

3.3.3 *Restrict search to a convex hull.*

3.3.4 *Restrict search to reachable points.*

3.3.5 *Compare the different Solutions.*

3.3.6 *Check solution for least cost path between different points.*

really needed

4 DISCUSSION

discuss aggregation with max vs sum

discuss other methods. Off algorithmic speed-ups

discuss other technical

5 RELATED WORKS

6 CONCLUSION

ACKNOWLEDGMENTS

...

REFERENCES

[1] 2015. Schutzgebiete in Deutschland. https://geodienste.bfn.de/schutzgebiete?lang=de

[2] 2016. Welcome to the PyWPS 4.3.dev0 documentation! — PyWPS 4.3.dev0 documentation. https://pywps.readthedocs.io/en/latest/index.html

[3] 2021. Digitales Landschaftsmodell 1:250 000 (Ebenen). https://gdz.bkg.bund.de/index.php/default/open-data/digitales-landschaftsmodell-1-250-000-ebenen-dlm250-ebenen.html

[4] 2022. LeastCostPath/dijkstra_algorithm.py at master · Gooong/LeastCostPath. https://github.com/Gooong/LeastCostPath

[5] 2022. Metropolplaner. https://metropolplaner.de/metropolplaner/

[6] 2022. OpenGeoData.NI. https://opengeodata.lgln.niedersachsen.de/#lod1

[7] Geoff Boeing. 2017. OSMnx: New methods for acquiring, constructing, analyzing, and visualizing complex street networks. *Computers, Environment and Urban Systems* 65 (Sept. 2017), 126–139. https://doi.org/10.1016/j.compenvurbsys.2017.05.004

[8] Benjamin Schäfer, Thiemo Pesch, Debsankha Manik, Julian Gollenstede, Guosong Lin, Hans-Peter Beck, Dirk Witthaut, and Marc Timme. 2022. Understanding Braess' Paradox in power grids. *Nature Communications* 13, 1 (Sept. 2022), 5396. https://doi.org/10.1038/s41467-022-32917-6 Number: 1 Publisher: Nature Publishing Group.

A RESEARCH METHODS

A.1 Part One

A.2 Part Two

B ONLINE RESOURCES

Table 3. ratio (r) of Category percentages of each least cost path for a buff of 100 m (5 m) around the least cost path.

resolution /m	all touched	$r_{Preferential}\%$		$r_{NoRestriction}\%$		$r_{Restricted}\%$		$r_{stronglyRestricted}\%$		$r_{Prohibited}\%$	
5	False	4.7	(5.4)	58.7	(58.9)	8.8	(8.4)	0.7	(0.7)	27.1	(26.7)
10	False	19.6	(33.5)	68.5	(64.5)	1.0	(0.8)	0.8	(0.3)	10.1	(0.9)
50	False	20.4	(33.2)	68.0	(66.2)	0.9	(0.1)	0.7	(0.0)	10.1	(0.5)
100	False	21.1	(30.7)	69.1	(68.8)	1.1	(0.0)	0.7	(0.0)	7.9	(0.4)
5	True	18.9	(28.5)	67.3	(66.4)	1.3	(1.6)	1.0	(0.5)	11.5	(3.0)
10	True	18.9	(33.7)	66.6	(63.4)	1.6	(1.4)	1.4	(0.6)	11.5	(1.0)
50	True	9.1	(13.0)	75.7	(83.0)	3.9	(2.0)	4.2	(1.6)	7.1	(0.4)
100	True	7.0	(10.1)	73.8	(81.9)	5.5	(3.9)	8.5	(3.6)	5.2	(0.4)

Received 20 February 2007; revised 12 March 2009; accepted 5 June 2009