Pedestrian Isochrones Facilities Overlapping with Openrouteservice. An Easy, Fast and Opensource Indicator in Novara, Italy

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Abstract. The concept of proximity in planning requires the attention of scholars and decision-makers to the issue of accessibility to services within a walking distance, as part of the more general effort to make cities more resilient, sustainable, and healthy. From an operational side, rethinking cities according to the paradigm of proximity and accessibility to services on foot implies the need for time-based methodologies that can identify the areas that can be reached within a given time interval. These methodologies often use GIS network analy-sis tools, but can require long analysis times and high financial costs for software. This contribution proposes an indicator of walking accessibility to facilities that is simple, quick to compute, and built using free and open-source tools such as QGIS and Openrouteservice, in order to allow its broad replicability on different contexts. The indicator was successfully tested in the city of Novara, Italy, using the 5-, 10- and 15-min isochrones, identifying the areas from which all the selected facilities can be reached within this time interval.

Keywords: Openrouteservice · 15-min City · Chrono-urbanism · GIS

1 Introduction

Making cities more inclusive, safe, resilient and sustainable [1] requires an understanding and assessment of a substantial number of variables through a holistic and multidisciplinary perspective that addresses cities understood as complex systems. Many of the goals and pathways leading to urban resilience and sustainability are related to health and well-being, also with regard to the relationship with land-use and travel behaviour [2]: moreover, accessibility and transportation are key factors to consider in climate change mitigation actions and policies [3].

From this perspective, walkability improvement, pedestrian walk zones, traffic restrictions and nature-based solutions in public spaces impact on congestion, urban microclimate [4], quality of space [5] and consequently on individual health, improving the conditions of the commuting environment and promoting sustainable mobility. Basically, a walkable environment is positively correlated with effectively stimulating

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walking and cycling, influences the built environment quality [6]. One of the factors affecting the successful implementation of the above-mentioned measures relies on the distribution of the facilities and their accessibility on foot, that need to be assessed in order to identify the target areas. In this sense, methodologies based on network analysis are widely used, but may present problems of financial cost and data accessibility.

This research proposes an open-source, replicable, expeditious indicator based on the isochrones overlapping to identify basins of pedestrian accessibility to a set of everyday services. The indicator was tested in the municipality of Novara, Italy.

This contribution is structured in parts: Sect. 2 provides a brief State of the Art framing some proximity models and accessibility assessment methodologies. Section 3 illustrates, and the materials and methods used. Section 4 provides the results obtained, which are discussed in Sect. 5. Section 6 contains the conclusions. Appendix A includes some instructions for the usage of the software adopted.

2 State of the Art

Proximity as an element on which to build urban quality can be traced back to Howard's Garden City, Perry's Neighbourhood Unit, Christaller's Central Place Theory and the studies of Edward T. Hall, Jane Jacobs and French chrono-urbanism [7–9], but it has gained momentum and has been able to go outside the academic with the dissemination of models such as the Supermanzana [10] and Carlos Moreno's 15-min City [11], with additional influence among decision-makers during and after the Covid-19 pandemic [12, 13]. Despite a certain amount of criticism [14, 15], institutions such as the Cities Climate Leadership Group (C40) have officially promoted some of these models [16]. At a practical level, the evaluation of proximity services and accessibility is often performed through the use of GIS, network analysis and isochrones, that can be found in the work of Capasso Da Silva in Tempe [17], Ferrer-Ortiz in Barcelona [18], Pellicelli et al. in Cagliari [19] or through the space syntax methodology as in the work of Yamu & Garau in Vienna [20]. Other approaches employ multiple source data and methodologies, for example using cell phone data [21] or deep learning technologies [22].

Sometimes, especially with regard to models based on network analyses, the network used is made available under a proprietary licence. Other times, the data are both government data or from private providers: both of these conditions can raise challenges in the reproducibility of analyses and the standardisation of calculation procedures.

Starting from this context this contribution proposes a fast, cost-free, and open-source methodology for the calculation of a pedestrian service accessibility indicator, to help identify the areas from which it is possible to walk to all the identified services within a certain timeframe and the areas lacking services within a specific pedestrian accessibility radius, in order to provide a starting point for the identification and spatialisation of appropriate policies for the reduction of vehicular traffic and an increase in the liveability and health of the environment. Furthermore, this indicator could be integrated into broader evaluation frameworks of urban sustainability. The indicator is based on isochrones with respect to a set of Points of Interest (POIs), evaluating the overlap of the service areas originating from the calculation of POIs isochrones. This procedure employs the open source software QGIS and Openrouteservice, and open data from OpenStreetMap via the QuickOSM plugin.

3 Materials and Methods

In this section are presented the steps involved in designing a methodology for calculating a walking accessibility indicator, designed to be quick to calculate, simple and opensource.

This methodology seeks to spatialise and quantify those areas within the city characterised by the possibility of reaching or not reaching a series of facilities within a given walking time.

The methodology was tested on the municipality of Novara in north-western Italy, and consists of three main steps:

1. Points of Interests identification;
2. Isochrones calculation;
3. Isochrones overlapping and scoring.

The GIS software used is QGIS Desktop 3.30.0-s-Hertogenbosch in combination with the QuickOSM plugin using Openstreemap data for downloading, the Openrouteservice software installed as a local server for calculating isochrones, and the QGIS model Count Polygon Overlap.

After a brief description of the case study, the steps will be illustrated in the following sections. Please refer to Appendix A for an explanation of how to install and use Openrouteservice, which it is considered appropriate to describe in detail as it is relatively complex to deploy.

3.1 Description of the Case Study

Novara is a city of 101,727 inhabitants -163,654 with the urban agglomeration - (Euromobility, 2022) in eastern Piedmont, capital of the province of the same name and located barycentrically to Turin and Milan, the capital of Lombardy. The city has the second largest population in the entire Piedmont region, covers an area of 103.05 km2, is an important logistics and rice-growing centre and is home to the University of Eastern Piedmont (UPO).

The municipality is characterised by an urban fabric of Roman origin and subsequent expansions along the main road axes towards Milan, Alessandria, Turin, Valsesia and Lakes Orta and Maggiore, with a development that has resulted in a highly anthropised landscape: the current Regulatory Plan dates from 2003.

As far as mobility is concerned, Novara was endowed with a Urban Sustainable Mobility Plan (PUMS) in 2022, which contains some useful guidelines to orientate the application of the indicator. According to the plan, the city is subject to significant traffic being a logistic centre between Milan and Turin, which is not followed by an adequate level of infrastructure and local public transport service. In particular, the lack of closure of the outer ring road precludes a hierarchy of roads that loads some of the most important city streets with improper traffic, giving rise to congestion phenomena that are further aggravated by the modal habits of residents: 50% of residents prefer the car for movements within a radius of 4–5 kms. PUMS transposes the national PUMS

guidelines into twenty specific objectives for the city of Novara and twenty-two actions. Among these actions are

– Az.4) New pedestrian and bicycle accessibility in Novara Nord;
– Az.9) New pedestrian areas;
– Az.10) Low Emission Zones (LEZ);
– Az.11) Novara city of proximity: the '15 blocks.

These actions can be traced back to the pedestrian and proximity dimension at the centre of attention of the methodology presented in this contribution, synthesised by the PUMS in a post-pandemic perspective as the idea of '*transforming Novara into a neighbourhood city thanks to the combined arrangement of Zones 30 (real proximity areas) and pedestrian-cycling corridors where inhabitants can find themselves in a new community*' [23].

PUMS has already adopted the isochrones methodology in the context of A.11 by identifying seven 'blocks' from whose centroid the service area was presumably drawn. The seven blocks are: Historic Centre, Major Hospital, New Hospital Complex, University Area - Perrone Complex, University Area - Sant'Agabio Complex, Railway Station - Novara FS, Railway Station - Novara Nord (Fig. 1).

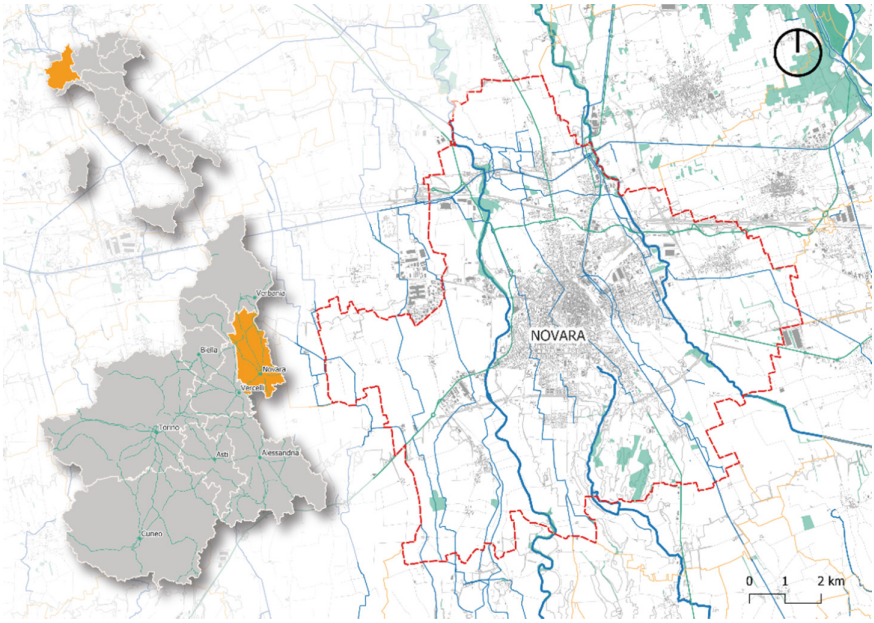

Fig. 1. Novara localization. Author's elaboration from OpenStreetMap and Regione Piemonte data.

3.2 Points of Interests Identification

This research refers to four of the six categories identified by Carlos Moreno in his 15-min City model: Commercial, Health care, Education, Entertainment, and the POIs identified by Staricco [9] further selected by the author in order to return a group of typical facilities of everyday life. The selected POIs, represented in Table 1 and mapped in Fig. 2, were all obtained from OpenStreetMap data downloaded through the QuickOSM plugin. If no point data were available, the centroid was calculated from the polygonal data. The process of choosing the POIs was conditioned by the availability of the data provided by OpenStreetMap and its structure. Since OSM is a volunteered geographic information (VGI) see [24, 25] and [26] for quality and reliability investigations: in particular, the third contribution focuses on POIs reliability.

Table 1. POIs selection for the isochrones analysis

Cluster	POIs name	Description	OSM key/value	Source
Commercial	Supermarket	Self-service large area store	'shop' = 'supermarket'	OSM
	Food and Drink	Includes cafes, bars and pubs	'amenity' = 'bar' AND 'amenity' = 'pub' AND 'amenity' = 'café'	
Health care	Pharmacy	Shop where a pharmacist sells medications	'amenity' = 'pharmacy'	
Education	Kindergarten	Education facility for children too young for regular schools	'amenity' = 'kindergarten'	
	School	Primary, middle and secondary school	'amenity' = 'school'	
Entertainment	Leisure Park	A municipal park	'leisure' = 'park'	
	Sport	Includes most common sport facilities: swimming, tennis, basketball, running, soccer	'sport' = 'swimming' AND 'sport' = 'tennis' AND 'sport' = 'basketball' AND 'sport' = 'running' AND 'sport' = 'soccer'	

3.3 Isochrones Calculation

In this stage, isochrones calculation was performed in three time intervals: 5, 10 and 15 min based on the literature consulted. The City of Novara in its PUMS explicitly refers to the 15-min City model, but literature considers also 5, 10 and 20 min (Staricco, 2022).



Fig. 2. Municipality of Novara – Points of Interest (POIs). Author's elaboration from OpenStreetMap data. Basemap Google Satellite.

In general, the choice of this parameter is closely related to factors such as the objectives of the analysis and the physical structure of the case study.

The software used for the isochrones is Openrouteservice, with a deployment in a local server running on Docker and through the interface offered by the QGIS ORS tools plugin with the Isochrones geoprocessing from Point Layer. Details can be found in Appendix A. Openrouteservice makes use of the Openstreetmap (OSM) network, and the isochrones are constructed on a pedestrian with an average speed of 5 km/h travelling through a set of segments classified according to the OSM attribute system. The parameters have not been changed from the default provided by Openrouteservice.

In order to speed up the calculation process, the algorithms were executed serially with the Execute as batch process command: from each layer containing POIs, isochrones were derived at 5, 10 and 15 min to allow the three different parameters to be visualised. The batch process for all 22 categories of POIs took 70,324 s to execute, which took place on an Intel Core i7 computer with 2.60 GHz, 16 GB of RAM and 4 GB of RAM dedicated to Docker where the Tomcat server with Openrouteservice was running. In Table 2, some summary statistics of the operations performed.

3.4 Isochrones Overlapping and Scoring

The counting of the number of overlaps was performed on three layers obtained from a dissolve process, also performed in batch, applied to the isochronous layers of the individual POIs. A QGIS model developed by Jenkins and in the public domain under

Table 2. POIs and Isochrones calculation statistics

Tomcat server ORS Docker container allocated RAM	4 GB
Number of POIs layers	22
Number of points	424
Isochrones calculated	1272
Total calculation time	70.324 s

the Creative Commons CC-0 licence was used to count the overlaps. The model, which can be visualised and edited directly from QGIS via the graphical modeler, is a chain of simpler geoprocessings, executed serially until a new layer is obtained with a column in the attribute table showing the number of overlaps.

The counting was performed on the 5-, 10- and 15-min isochrones in order to have three final results to analyse and compare.

As far as scoring is concerned, if the construction of the indicator is taken as a stand-alone activity as in this case, one can simply use the number of counted overlaps, possibly grouped and divided into classes.

If, on the other hand, the counting of overlapping isochrones is part of broader evaluative frameworks, it will be necessary to adapt the scale used to that of the general framework.

4 Results

In this section the results are described, dividing them into the three time-categories over which the analysis was performed: 5, 10, 15 min. Results interpretation and maps were performed within QGIS using the geoprocessing functions of the Plot family via the Python console. The results are analysed according to seven classes defined by the number of overlaps counted: class 7 indicates the maximum number of overlaps (positive) and so on down to the minimum of 1 overlap (negative).

4.1 5-min Overlapping

The analysis identifies four main polarities, which are developed around the five most relevant polygons out of the 11 total class seven. These areas, the most extensive, are distributed along the north-south axis of the built-up area and in the occidental area.

Of the five areas, the largest is the one extending in the quadrants defined by the intersection of Via Pina Ballario and Via Giulio Cesare. Within this area, characterised by the coexistence or the presence within a five-minute walk of all the services selected for the analysis, there are several recently built residential buildings along Via Paolo Fornara, Via Pina Ballario and Via Spreafico. The second largest area is located slightly further north along the axis of via Giuseppe Verdi and revolves around a commercial structure that is barycentric with respect to the identified overlays. Significant is the presence of residential buildings. The third and fourth areas tend to be contiguous and

are located east and west of the axis defined by Via Giulio Biglieri and Corso Torino. The area thus defined, west of the historic centre, contains a fair number of residential buildings. The last class seven area considered is defined by the presence of the 11 September 2011 park and is characterised by a mainly low-intensity residential fabric.

It is interesting to note that around the remaining class 7 polygons some clusters are generated that include class 6 polygons, in particular in the area between the railway line and the Sant'Agabio district, to the east of the historic centre. Other class 6 clusters are present along Via Luigi Camoletti, east of the San Paolo district, near Sant'Antonio to the north and near Pernate to the north-east (Fig. 3).



Fig. 3. Isochrones overlaps: 5-min walking. Author's elaboration from OpenStreetMap data. Basemap Google Satellite.

4.2 10-Min Overlapping

Compared to the analysis within five minutes, the one on 10 shows a continuous class 7 polygon that occupies a large part of the built-up area, excluding the peripheral areas that fall in class 6 anyway, except for the south-eastern edges of the built-up area in the prison area, east along the Corso Milano, north along the Via Verbano and in the Vignale area. Outside the main built-up area, it is evident that the inhabited areas south of Torrion Quartara and Olengo to the south-east and the hamlet of Casalgiate to the west remain outside the first two classes. As is to be expected, the north-west area hosting the Novara logistics hub is completely outside the identified polygons (Fig. 4).



Fig. 4. Isochrones overlaps: 10-min walking. Author's elaboration from OpenStreetMap data. Basemap Google Satellite.

4.3 15-Min Overlapping

In the latter case, the class 7 polygon indicating walking accessibility to all selected POIs tends to cover almost the entire built-up area, with the exception of the south-west area along Strada Statale 211 and the two northern expansions along Via Verbano and the Vignale area. On the other hand, the Sant'Agabio area along Corso Trieste falls into class 6. The logistics hub area is also excluded in this case (Fig. 5).

5 Discussion

The results obtained show a different level of capacity in capturing the distinctions between internal areas of the city depending on the time parameter chosen. The 15-min parameter, in particular, tends to be not very explanatory if the objective is to categorise the inhabited area of the city of Novara. Even the 10-min parameter may not be able to capture internal variations in the distribution of services, in a sense overlapping with the information in parameter 15. A comparison of the three visualization can be found in Fig. 6.

More interesting, however, is the analysis that emerged from the use of the 5-min parameter, where a number of polarities emerge that allow one to distinguish areas within the built-up area. These areas, which tend to be those that gather around the highest scoring polygons in class 7, define portions of the territory in a favourable condition from the point of view of accessibility on foot to POIs used for the construction of the

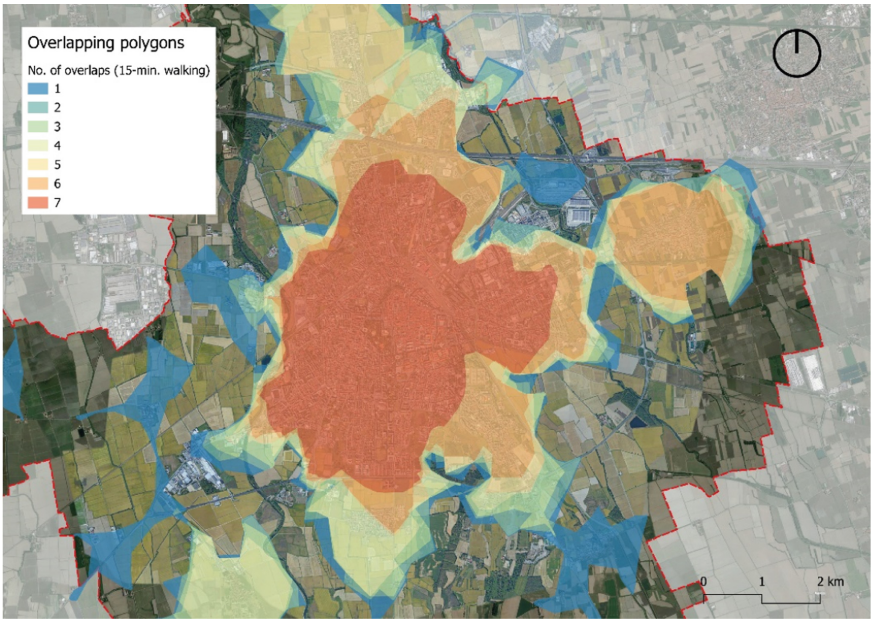

Fig. 5. Isochrones overlaps: 15-min walking. Author's elaboration from OpenStreetMap data. Basemap Google Satellite.

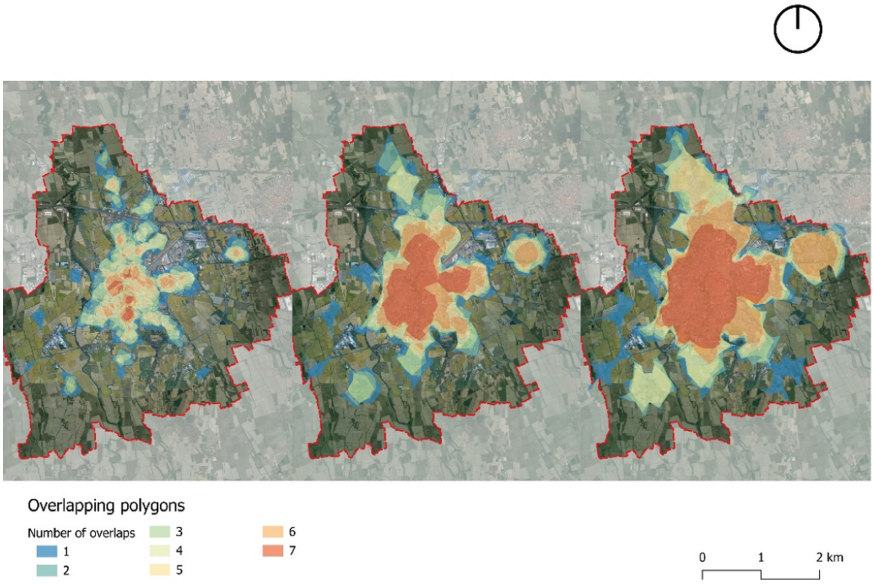

Fig. 6. Isochrones overlapping polygons comparison: left to right, 5, 10, 15-min walking. Author's elaboration from OpenStreetMap data. Basemap Google Satellite.

study. Similarly, the analysis with parameter 5 min highlights lower scoring territories (classes 2, 3, 4) always within the urbanised fabric of the city.

It is considered that the number of overlaps between the isochrones generated by the POIs considered may constitute a meaningful indicator which can serve both as a quick exploratory evaluation aimed at identifying areas to be analysed with other methodologies, and as an indicator that can be integrated into evaluation frameworks. It is believed that some operational pointers can also emerge from a semi-simple GIS analysis with the overlay of other information layers. For example, as shown in Fig. 7, some of the routes identified inside one of the highest-scoring polygons can be improved in terms of walkability, traffic and quality of space.



Fig. 7. A 5-minute highest overlap area with reachable POIs and route network classification. Author's elaboration from OpenStreetMap and Regione Piemonte data. Basemap from Google Satellite.

It is believed that the of isochrones overlapping can provide a general overview to identify the "pedestrian potential" of some portions of the city, contributing to locating and implementing interventions towards public space quality.

The presented methodology has a number of advantages: once all the necessary software has been correctly installed, operations are carried out very quickly and with a fair degree of automation. The use of opensource data also allows high level of generalisation and replicability.

However, a number of critical issues emerged. First of all, a certain complexity in the software deployment of Openrouteservice should be noted.

Secondly, it is necessary to highlight the issue of data availability: in this study, it was decided to use the open data made available by OpenStreetMap and downloaded via QuickOSM, but it should be noted that the OSM data may present errors and imprecisions. It is therefore suggested to evaluate government data as an alternative to OSM data. Also in this regard, also a cross-check with demographic and occupational data could extend the level of detail of the analysis to include the dimension of living and workplaces.

A third issue concerns the selection of POIs: In this study, a literature review based on similar studies and empirical experience was adopted. However, the use of participatory methodologies for selection, and the weighting of individual POIs could be of some interest to further detail the analysis.

The fourth and final point to be highlighted concerns the choice of time parameter. This study used the 5-, 10- and 15-min time periods and then compared the results obtained. However, the choice of the time parameter depends on numerous factors and further research could investigate this further.

6 Conclusion

The experimentation conducted in the City of Novara showed that it is possible to use isochrones overlapping through the Openrouteservice software to obtain an indicator of pedestrian accessibility basins to a given service, which in the case study was most significant for the time threshold of 5 min compared to 10 and 15 min. The proposed indicator and its calculation methodology overcomes dependence on commercial services that may limit the use of network analysis techniques with GIS software. Despite some limitations, the tested methodology is considered promising for the technologies adopted, the speed of application, widespread availability of data, high level of automatization, open source nature and good replicability. Future developments may consider the use of this indicator in the context of broader sustainability assessment frameworks or use the presented methodology to identify areas of the city where analyses of spatial quality and liveability can be carried out. Also, similar analysis based on specific target groups can be investigated, considering for example children, elderly, etc. The main future developments of the research concern the use of this methodology to identify suitable areas for microclimate analysis, aimed at building the knowledge base for the implementation of resilience actions and policies. The identified ‘super isochrones’, because they represent areas potentially suitable for pedestrians, can serve as a focus for the development of quality urban blocks capable of stimulating modal diversion and implementing adaptation and mitigation actions. These areas, for example, can be conceived as the nodes of a pedestrian network designed to ensure high climate comfort through measures - such as nature-based solutions - that can achieve multiple objectives.

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Appendix A. Openrouteservice Deployment on Windows

Openrouteservice (ORS) is maintained by the GIScience Research Group of the Department of Geography at the University of Heidelberg [27], and offers opensource routing services built on OpenStreetMap (ORS), OpenAddresses, GeoNames and Who's On First data. ORS can be used via `maps.openrouteservice.org`, requesting a personal API key or configuring a localhost Tomcat server via Docker, allowing to avoid any use restriction. Docker, Git and WSL are required.

ORS GitHub repository can be cloned from command line with `git clone` https://github.com/GIScience/openrouteservice. To build the container in `openrouteservice` folder these subfolders should be created: `mkdir -pconf elevation_cache graphs logs/ors logs/tomcat`. The container can be generated with `docker compose up`, and is it possible to check the installation at http://localhost:8080/. Default geographical data can be changed cleaning the old data in folders `elevation_cache`, `data` e `graphs`, downloading the required `.pbf` (e.g. from http://download.geofabrik.de/) and modifying some settings in `docker-compose.yml` file, decommenting line `# -./your_osm.pbf:/ors-core/data/osm_file.pbf` and replacing with the name of the new `.pbf`. Regarding profiles, default installation only activates car profile. For other profiles, `docker/conf/ors-config.json` should be modified identifying the active profiles array and adding the new one.

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