Ref. Ares(2022)718523 - 31/01/2022

Deliverable

D3.3 AI Algorithms and Simulation Tools. Initial.

Project Acronym:	URBANAGE
Project title:	Enhanced URBAN planning for AGE-friendly cities through disruptive technologies
Grant Agreement No.	101004590
Website:	www.urbanage.eu
Version:	1.0
Date:	14/01/2022
Responsible Partner:	TEC
Contributing Partners:	IMEC, UH
Reviewers:	Jurgen Silence, Andreas Hens (AIV) Elias Willberg (UH)
Dissemination Level:	Public x
	Confidential – only consortium members and European Commission

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004590

Revision History

Revision	Date	Author	Organization	Description
0.1	14/01/2022	Eneko Osaba Diana Manjarrés	TEC	Initial version
0.2	19/01/2022	Jurgen Silence Andreas Hens	AIV	Review
0.3	21/01/2022	Elias Willberg	UH	Review
0.4	25/01/2022	Jurgen Silence	AIV	Update FL case
0.5	24/01/2022	Christoph Fink	UH	Address reviewer comments
0.6	26/01/2022	Diana Manjarrés Eneko Osaba	TEC	Address reviewer comments
0.7	26/01/2022	Jurgen Silence	AIV	Address reviewer comments
1.0	31/01/2022	Diana Manjarrés Eneko Osaba	TEC	Final version

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List of abbreviations

Abbreviation	Explanation
DL	Deep Learning
ML	Machine Learning
AI	Artificial Intelligence
API	Application Programming Interface
CNN	Convolutional Neural Network
LIDAR	Light detection and ranging
OSM	Open Street Map
OTP	Open Trip Planner
DEM	Digital Elevation Model

1 Executive Summary

This document contains the description of the work done regarding the Artificial Intelligence (AI) Algorithms and Simulation Tools in the context of the first year of URBANAGE project. It starts by analyzing all the data sources that have been identified for each scenario (Santander, Flanders, Helsinki). It is important to highlight that not only the final usable datasets are detailed, but also the available and potentially desirable information.

Furthermore, this document also introduces the preliminary AI functionalities that will be contemplated in all the three environments: Santander, Flanders and Helsinki. These functionalities have been designed following all the work done in other project activities (such as the co-creation workshops, see D2.3) and also deeming the available data sources. For this reason, these functionalities have been built in order to give an answer to the end user's needs and also to the policy maker's requirements.

Lastly, this manuscript also introduces some considered existing frameworks, that will be potentially used for developing the planned functionalities.
Future versions of this document will present the evolution of these functionalities, the developments conducted under the umbrella of prototypes and the results provided by these prototypes.

2 Introduction

Today, cities and municipalities are aware of the need of include citizens in urban projects. In any case, despite it is widely known that the importance of the citizen engagement is crucial, it is still difficult for urban planners to guarantee the representation of all the citizen collective in new developments. In this regard, it is also complicated to find the key for really engaging citizens towards sustainable, scalable and inclusive cities.

Related to this issue, current European cities are experiencing a progressive ageing on their populations, giving rise to a set of problems and concerns that must be considered. Urban planners and policy makers seek for the active participation of senior citizens, introducing several initiatives and interventions that usually are not fruitful.

In this context, Artificial Intelligence has emerged as a promising knowledge field for tackling with ageing related concerns in cities. In this context, a growing number of cities and municipalities are embracing AI, developing different tools and mechanisms for building innovative age-friendly functionalities, i.e. route planners and simulations tools, and advance towards smart and inclusive cities.

In the context of URBANAGE, three different pilot cases are contemplated (Santander, Flanders and Helsinki), which will develop several age-friendly systems targeted to improve the quality of life of ageing citizens. These tools will be used by urban planners, policy makers and/or citizens.

This document is the first version of the *AI Algorithms and Simulation Tools* deliverable, which is included in the work produced in the first year by WP3 - *Data & Intelligence*. The objective of this deliverable is to describe *i*) the main aspects related to the data sources considered in this first phase of the project, ii) the preliminary AI functionalities planned for each scenario (Santander, Flanders and Helsinki), and iii) some potential existing frameworks that will inspire future developments on the project.

This document is organized in 5 additional sections. Section 3 consists of a general description of the work made around the topics dealt in this deliverable. Section 4 introduces the main data sources and information analyzed in this first step of the task D3.3. The following Section 5 is devoted to presenting the preliminary functionalities scheduled for each considered environments, which Section 6 delves into some existing interesting frameworks, which will be considered on the developments conducted on this project. Section 7 presents the conclusions and comments for the future steps until the end of the project, while Section 8 represents the references cited in this deliverable.

3 AI algorithms and simulation in URBANAGE

The scope of the tasks concerning this deliverable, T3.2, is to provide AI and data-related techniques with two different objectives. The first of these objectives is to provide means to support decision making processes for both urban planners and policy makers. The second of the objectives to cover by the developed techniques is to offer usable and valuable functionalities to guide ageing people on some specific daily decisions and routines, such as going to do the daily shopping, going to a medical centre or attending an activity in a civic centre.

As can be seen in the Deliverable D5.1 - *System Architecture & Implementation Plan*, all the work planned to be done in the task T3.2, concerning this Deliverable D3.3, falls within the module coined as *Data Analytics*. We show in Figure 1 the conceptual design of URBANAGE's software architecture, which has been directly extracted from the above mentioned D5.1.

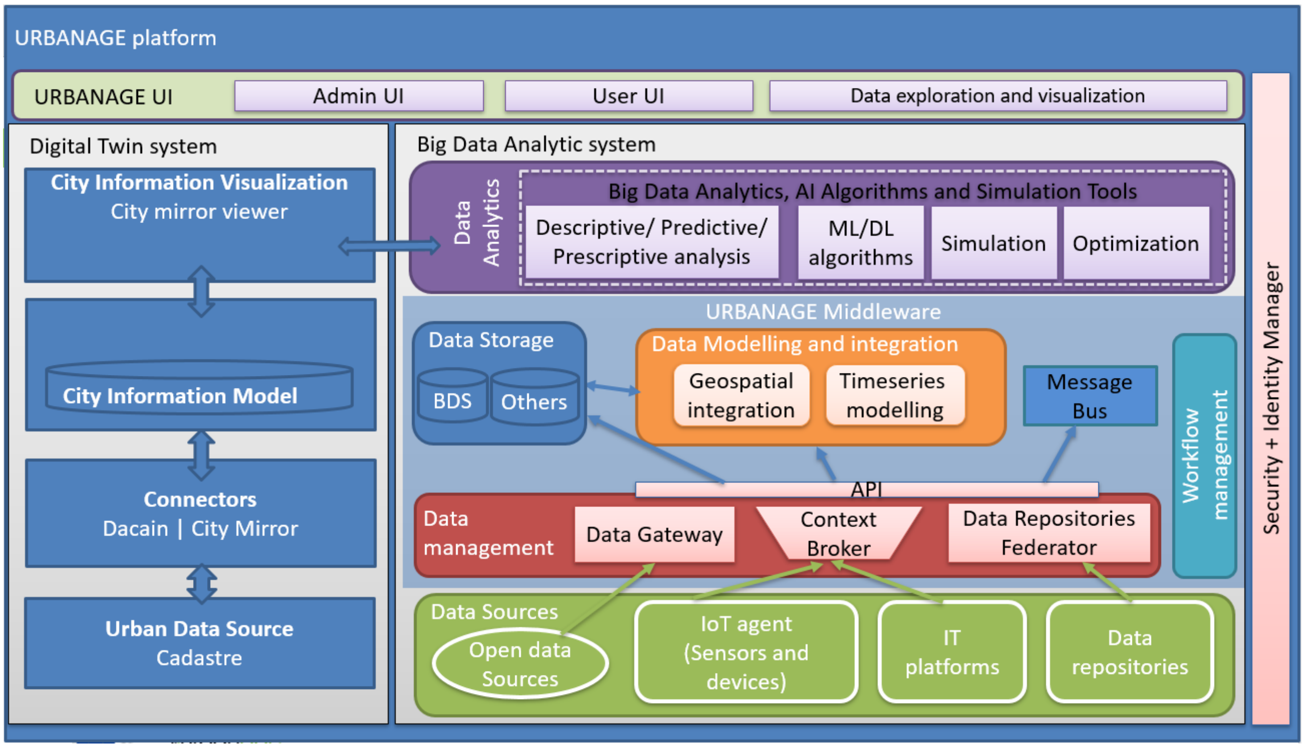

Figure 1 URBANAGE platform overview (obtained from D5.1).

More specifically, this *Data Analytics* module is composed by four different sub-components, which will guide the definition of the AI and data related functionalities described in the following Section 5:

1. *Descriptive/Prescriptive/Predictive Analysis*: the first goal of this sub-component is to extract significant information from all the data gathered in URBANAGE and described in the upcoming

Section 4 of this manuscript. This knowledge can be categorized in three different classes: *i*) *descriptive*, which obtains conclusions from the raw data; *ii*) *prescriptive*, which obtains the needed information and provides to the user different functionalities for guiding the decision-making process; and *iii*) *predictive*, which analyses the available data aiming for predicting future events.

2. *ML/DL Algorithms*: this module comprises machine learning and deep learning methods, able to obtain data and provide valuable predictive insights.
3. *Simulation*: the principal objective of this sub-component is to offer to final users a strong simulation tool. In the context of this project, this simulation module will congregate the mechanisms needed for building the simulation engine for the identification of the optimal location where to deploy urban furniture (such as mechanical ramps, lifts, among others). Among other functionalities, implemented tools will simulate a remarkable number of scenarios aiming to find the best possible locations for different urban furniture.
4. *Optimization*: this last sub-component module is comprised by the algorithms, heuristics and metaheuristics which will solve all optimization problems defined on URBANAGE. As an example, techniques and functionalities regarding the age-friendly route planning system will be placed within this sub-component.

Thus, tasks T3.2 aims to investigate and develop AI mechanisms and strategies that will be used to analyze and process the information offered by the *Data Management* module (developed in T3.1 of URBANAGE), with the main goal of design and implement advanced functionalities for an evidence-based decision-making process to be tested in the use cases. In addition to that, the work done in T3.2 will also contemplate the building of simulations engines that will permit to conduct physics-based behavior simulations. These simulations will be valuable for supporting service provisioning and urban planning activities, helping to evaluate changes, and the expected or degraded situations on public infrastructures and services.

It should be also highlighted at this point the importance of the *data sources* module, which can be found in the bottom part of the whole structure built on URBANAGE (shown in D5.1, and in Figure 1 of this deliverable). This module is the one that will feed the *Data Analytics* module with the required data for properly reach the stablished objectives. In this sense, four different data sources can be distinguished: *i*) Open data sources provided by municipalities, *ii*) Open data sources available on the web, *iii*) IoT sensors managed with a content broker and *iv*) Town councils' own data repositories on their own IT platforms or their own repositories.

Finally, it is also interesting to briefly highlight that the outcomes provided by the *Data Analytics* module, which is the one that will comprise the AI and data related functionalities described in this deliverable, will be introduced as output to the different City Information Visualizers developer in the context of URBANAGE. These visualizers will have the objective of gather the information calculated by the tools implemented on the *Data analytics* module and provide it to end users on a usable and friendly way.

4 Description of available data sources and their potential role in URBANAGE.

In this section, we describe the main data source that are available for each of the use cases contemplated in URBANAGE. Furthermore, we also describe some openly accessible data sources that can also be interesting for their use and some other ones that will be interesting to have. Lastly, for each data source, we explain their utility in the context of URBANAGE and AI functionalities.

Briefly explained, and as has been mentioned in previous Section 3, the data sources contemplated for feeding the AI and data tools developed on URBANAGE can be distinguished in four different categories:

1. *Open data sources provided by municipalities*. These data sources are openly provided by the municipalities of Santander, Helsinki and Flanders. Usually, this information is stored on freely available repositories, accessible through the official webpages of the municipalities.
2. *Open data sources available on the web*. The information provided by these sources can be obtained by openly available platforms and repositories. This information can be used by the developed tools as inputs. Some usually employed examples of this data sources can be the maps provided by Open Street Maps, or Digital Mesh or LIDAR files for altitude calculation provided by official public repositories.
3. *IoT sensors managed with a content broker*. This information is obtained directly from different IoT sensors employed for diverse purposes. This information is usually stored in private databases.
4. *Town councils' own data repositories on their own IT platforms or their own repositories*. Each municipality counts with private data which is obtained through different tools, such as data related to traffic or demography.

4.1 Santander

This first subsection aims to describe the main data sources that will be considered in the use case of Santander. We have divided this subsection into three different parts. The first one provides a review of the Santander open data platform, describing and analyzing each potentially interesting data source. After that, we describe some additional information sources that can be found into the web, which have been detected as important for the use case. Finally, we outline a set of additional sources whose usefulness could be potentially interesting (nice to have).

4.1.1 Data available at Santander Open Data

In this section we analyze the data that can be found in the current version of the Santander's Open Data platform[1]. For providing the conclusions drawn from this study, we show in a table the main information of each dataset that has been detected as potentially interesting. For each of these datasets, the title, description, and additional interesting comments have been offered.

Table 1: overview of potential datasets for Santander use case

Data Source	Description	Comments
Bus stops location	Location of the bus stops located in the city	This data can be also obtained from the GTFS of the public transportation, which can also be obtained from the same platform
Taxi Stop	Location of the taxi stops located in the city	This data can be useful in case we consider a taxi mode in the route planner. At this moment, this transportation type is not planned to be contemplated.
Parking spaces for people with reduced mobility	This data contains the location of the parking spaces for people with reduced mobility	This static data can be useful in case we consider this transportation mode in the route planner. In any case, it is not fully useful if we do not know if the parking space is free or occupied.
Historic – Induction loop data	This dataset provides historical data from the last seven days of measurements carried out by the magnetic loops and using the Control Center Municipal Traffic to regulate traffic and traffic light programming.	The data seems correct. This information could be useful for planning routes that avoid traffic, which is related to noise and pollution.
Cultural agenda	Dataset that provides information on the Cultural events programmed within the Municipality of Santander.	Data source unable to be reached at the time this analysis has been conducted.
Points of Interest	This resource contains the catalog of Points of Interest Santander City. In this dataset	This data is correct. We can use in order to detect those points potentially

[1] http://datos.santander.es/ - last visit: 4th October 2021.

	you can find museums, theaters, monuments, beaches, parks, etc ... Those City resources that can be attractive to tourists and also for citizens.	interesting for our users. Maybe it can be integrated with the city map.
Metereological Data	This dataset provides information about real time measurements from different sensors located in the city of Santander related to the environment, light, noise, temperature…	Despite this information is crucial, this data source is not usable, because the frequency of update makes it completely obsolete. If this data source will be used, it should be updated in real time.
Movil sensors_environmental measurements	This dataset shows real time information of the environmental measurements made by the sensors equipped in the Public Transport Vehicles, and maintenance of the city used by the Santander City Council for its daily management. The data is provided by Orion Context Broker, from the Fiware platform.	We can find here information about the CO, NO2 and temperature. It is interesting, but its update frequency makes it completely obsolete.
Calendar of Santander Public Holidays	Calendar of Holidays defined in the Municipality of Santander.	The data is OK, but it is difficult to find a functionality for using it.
Shops dedicated to retail sales	This dataset contains the Shops located in the Municipality of Santander mainly dedicated to retail sales.	This data could be interesting since it also contains Pharmacies.
Santander Gardens and Parks	This dataset contains the geographic representation of the parks located within the municipality of Santander.	This information can be obtained from other open sources such as the OSM, and also from the Digital Twin.
Road network of the Municipality of Santander	Geographical data relating to the road network of the Municipality of Santander	This data is also contained on different files such as OSM
Waste Containers	This resource provides information about the waste	This data source is interesting, mainly because we can obtain the temperature

	containers operating in the Municipality of Santander. Among other data, it offers information on position, capacity, and even measurements of the built-in sensor.	on each of the containers. In any case, this source should be further studied in order to know which containers are really usable. The frequency of update is acceptable (but it would be good if it is improved).
Bike lane network	Bike lane sections spread over municipality of Santander	This information is also contained on the OSM. Not yet defined if the routing planner features will include also bike routes.
Bike sharing facilities occupancy	Real Time update Stations existing municipal bicycle rental. The status of rental bike stations, number of existing and free anchors.	This information is also contained on the JCDecaux functionality, which is very reliable. Not yet defined if the routing planner features will include also bike routes.
Irrigation Sensors	This dataset provides information on measurements taken by sensors distributed in the city of Santander about soil humidity, relative humidity, wind speed…	In sense, this data could be very interesting, but it is completely obsolete, with only few data, and few measures.

4.1.2 Data available in other sources

In addition to the above described sources, there are other openly available, which could be interesting to use:

- *Open Street Maps*: the OSM file is essential for building the street map of the city, and for building the graph that is used by the AI engine for calculating routes.
- *GTFS files*: these files are crucial for obtaining information about public transportation routes, containing information about the stops, services, and many other aspects.
- *Digital Mesh or LIDAR files for altitude calculation*[2]: these files obtained from an official public repository are used in order to calculate the altitude of the different points of the city. This information about the altitudes can also be obtained in Geotiff format[3].
- *Open data about rental bikes*: despite this kind of routes would not be contemplated in the route planner, the information about this service (bike stations, real-time update…) is openly available[4].

[2] https://centrodedescargas.cnig.es/CentroDescargas/index.jsp - in *modelos digitales de elevaciones*
[3] http://dwtkns.com/srtm/
[4] https://developer.jcdecaux.com/#/opendata/vls?page=static

4.1.3 Additional Interesting Data

Considering the main functionalities that will contemplate the preliminarily defined route planner, the following information would be interesting to enhance the utility of the component:

- *Road works and maintenance works*: this information would be usable for avoiding users to go through streets or services that are unable to cross or to use.
- *Information about the urban furniture*: it is compulsory to count with a data source that informs about the placement of the whole urban furniture spread over the city (elevators, mechanical ramps, benches, public toilets…).
- *Illumination of streets*: this information could be a perfect addition for planning safe routes.
- *Air pollution*: several datasets can contemplate this information but none with the proper frequency. Its obtaining could be great for planning comfortable routes.
- *Paving type of streets*: the type of the pavements would be usable for accessibility purposes.
- *Streets occupancy*: this information could be useful for planning routes that avoid street without people (less safe) and prioritize going to semi-crowded streets (which feel much safer).

4.2 Flanders

This subsection describes the main data sources that will be considered in the use case of Flanders. Like the previous one, it is divided into three different parts: available data from public sources, Google Street View image data, and orthophoto & satellite imagery

4.2.1 Available data from public sources

The availability of (public) data sources for the Flanders pilot that are relevant in the framework of this deliverable are clearly described in chapter 4.2.3 (pilot case 1) and 4.3.3 (pilot case 2) of **Deliverable 6.1**.

The table underneath is derived from chapter 4.2.3 of Deliverable 6.1 and provides a good summary of the datasets we plan to use for the first pilot case.

Table 2: Flanders pilot case 1 - overview of potential datasets

Element	Location	Description	2D/3D	Green comfort index indicator?
Base layers				

OSM	DUET	OpenStreetMap (OSM) is a collaborative project to create a free editable geographic database of the world.	2D, 3D	No
Orthophoto & satellite imagery	DUET	Sentinel satellite images & data from ESA is free & full Open Data through the EU Copernicus-programme, which offers not only earth observation data but also in-situ data about our planet & Europe. Open Access Hub (copernicus.eu). For the Flanders region we publish (yearly) aerial images with higher resolution (25 cm) than the Sentinel images. These im-ages are already used 3-yearly - to extract greenery. Our previous results fit nicely, especially in urban areas.	2D	No
Public domain	To be created	Important to set the boundaries of the field of interest. Make a negative of the parcel plan and add green parcels owned by a public body.	2D	No
Terrain data	DUET	Important to visualize shadows and for the implant of the LOD2 buildings and trees.	3D	No
Buildings	DUET	LOD2 level for city of Ghent Shadows can be visualized (but not used in calculations) by using the combination of 3D map with buildings, terrain data and trees.	3D	No
Air quality	DUET	Air quality index for Flanders.	2D	Yes
Noise	DUET	Noise Flanders (based on traffic).	2D	Yes
Green comfort index	URBANAGE	Hexagon tiles with actual green comfort index score as **automatically calculated**. Hexagon colors are related to the scale.	2D	-
Heat stress + shadow				
Heat stress map	VMM	Helps to determine the green comfort index. The resolution of the map will be updated significantly in the near future. Data.	2D	Yes
Shadow map	VMM	If available in high resolution in time (work in progress). Shadow is also included in the heat stress map.	2D	No
POIs – street furniture				

Benches & picnic tables, public toilets, street lights, drinking fountains.	OSM	Option to update the OSM data layer inside the city using the *MapComplete* functionality. OSM-data model includes street lamps (as point objects) and street lighting (as an attribute of a road segment - lit Y/N).	2D, 3D	Yes
Google street object detection analysis for benches.	IMEC	2D, used to check if additional data can be gained from Google Street on top of existing datasets. *We pick out one street furniture type and make the analysis to demonstrate the approach. It is not our intention to do this exercise for all POIs.*	2D, 3D	No
Green infrastructure				
Trees	DUET	Will only be used to make a visual simulation of the shadow impact.	3D	No
Trees	Local datasets	Depending on what parameters that are available, indicators will be : • Presence of trees • Size canopy • Tree height • Tree type	2D	Yes
Green zones, greenery	OSM Groenkaart 2018	OSM has a good mapping of greenery Orthophoto-based green map (2018) can be used as well.	2D	Yes
Blue infrastructure				
Detailed water map includes all water elements.	GRB	All water parties, ranging from navigable waterways, rivers and lakes to ponds and small streams. All in one layer.	2D	Yes
Accessibility				
GIPOD database with information on road works.	GIPOD	Idea: visualise the accessibility of the green comfort zones with the highest scores.	2D	Yes
Accessibility of sidewalks	Local?	Not a lot information from the government (Local datasets). Only in Turnhout and Gent (old). Texture/substrate (hard/soft), height/width of pavements.	2D	Yes

Roads and paths	missing	Roads and paths for cyclists and pedestrians in recreational areas. Will be used as an indicator for the accessibility. Depends on measured parameters : • Availability • Quality (texture hard/soft)	2D	Yes

The same exercise was performed for the second pilot case. The table underneath is copied from chapter 4.3.3 of Deliverable 6.1.

Table 3: Flanders pilot case 2 - overview of potential datasets

Elements	Location	Comment
GP's	KSZ / RIZIV / De Sociale kaart	API planned (March 2022)
Hospitals, pharmacies, dentists	KSZ / RIZIV / De Sociale kaart	API planned (March 2022)
Informal care / home care	KBO / Provincies in cijfers	Cities uses a dataset from Locatus (biannual update)
Supermarkets	KBO / Provincies in cijfers	Cities uses a dataset from Locatus (biannual update)
Bakeries, butcheries, groceries	KBO / Provincies in cijfers	Cities uses a dataset from Locatus (biannual update)
Hairdressers	KBO / Provincies in cijfers	Cities uses a dataset from Locatus (biannual update)
Medical care centres	KSZ / RIZIV / De Sociale kaart	API planned (March 2022)
Age	Provincies in cijfers	Number of inhabitants, split by age
Gender	Provincies in cijfers	Number of inhabitants, split by gender
Family	RR / KSZ	Information about the household composition
Handicap (reduced mobility)	VAPH / NIC / DGPH / Vlaams Kadaster / Provincies in cijfers	Statistics regarding the amount of people, based on age and district (in Dutch: "arrondisement"), with the right for "income replacement and integration assistance" for the year 2020 can be found on this website and the dataset can be found on this link.

Keep in mind that both lists of thoroughly investigated datasets are a basis for further planning. Functional & technical analyses will be performed in the nearby future to see what data will be effectively used.

4.2.2 Google Street View image data

Google Street View provides a high coverage of panoramic shots of public roads of Europe. Originally only a part of the *Google Maps* service – where you could select a location and have a 360 view of the whereabouts, and "virtually" walk the streets – we can now access its' imagery using the *Google Cloud Static Street View API.* For each location or region of interest, a query can be launched to retrieve the available panoramas. These can then in turn be downloaded for further processing*.* Identifiable features such as faces of bystanders and license plates have been blurred. This results in a rich dataset which contains high quality footage of available (or lacking) infrastructure and road condition. The main utility of this dataset in the context of *URBANAGE* is to have visual evidence of the available street furniture for a given location.

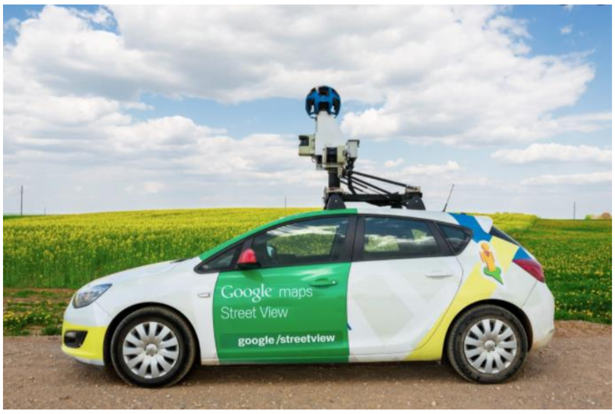

Figure 2 Google Street View car with camera mounted on top

Figure 3 Street View image capture

For the Flanders pilot, we plan to investigate whether *Google Street View* POI identification can be of extra value for the POI detection as defined by existing datasets.

For tasks such as POI detection, some deep learning models were pretrained using the CityScapes dataset. This dataset comprises of several urban scenes, where all elements in the landscape are divided into a number of classes. Some notable classes are: traffic sign, traffic light, sidewalk, vegetation, road, person. A deep learning model is then taught to automatically differentiate the targeted landscape elements in the picture and can do this for urban imagery it has never seen before. This allows us to automatically detect relevant POI's. A great benefit is that you can use these pretrained models out of the box. They are available online and don't require that you train the model from scratch.

Figure 4 CityScapes: image segmentation of urban areas

Some more details on the CityScapes dataset: it is a dataset produced in Germany in 50 cities. It comprises of 5000 annotated images with fine annotations and 20000 annotated images with coarse annotations. The object classes are listed in the table below.

Group	Classes
flat	road · sidewalk · parking+ · rail track+
human	person* · rider*
vehicle	car* · truck* · bus* · on rails* · motorcycle* · bicycle* · caravan*+ · trailer*+
construction	building · wall · fence · guard rail+ · bridge+ · tunnel+
object	pole · pole group+ · traffic sign · traffic light
nature	vegetation · terrain
sky	sky

4.2.3 Orthophoto & satellite imagery

Orthophoto & satellite imagery data provides a top-down photographic view – a rich source of information in terms of land-use and high-level landscape elements. These images are made available 4 times per year for the region of Flanders.

Green (natural), gray (urban) and brown / yellow (agricultural or barren) patches of land indicate its land-use. A typical application for satellite imagery may be to perform LUR (land-use regression) but in the context of the URBANAGE digital twin, it may also be feasible to perform prediction of Green Comfort scores. This is explained in more detail in Section 5.2.2. The main utility of this dataset is that we believe we may be able to infer green comfort characteristics from the image data. This is something we will learn when developing the associated use-case.

Figure 5 top-down photographic view.

4.3 Helsinki

Helsinki use cases 1 and 2 will focus on developing a new method for collecting, processing and utilizing citizen generated data. The focus in these use cases is on the IoT-device and collecting qualitative data from the citizens rather than utilizing existing datasets. The hand-held IoT-device is used to collect data regarding accessibility, mobility issues and points of interest. This data will be stored in general format (e.g. GeoJSON) which makes the data easy for potential reuse and integration into other services, such as existing map services, Digital Twin of the city of Helsinki and the upcoming URBANAGE platform. The general format makes the data easily convertible for future data analytics and integrable to other city services and data platforms.

Helsinki has an extensive catalogue of open data and application programming interfaces (www.hri.fi). In this regard, FVH and internal partners in Helsinki will continue exploring opportunities to integrate data collected in URBANAGE to existing data sets and Helsinki Digital Twin. To pilot the visualization and integration of data collected with the IoT-device, the data will be integrated to online map platform and visualized in similar fashion as the Helsinki service map.

4.3.1 Google StreetView imagery

For the proposed automated assessment of walkability metrics (see section 5.3.2) Google Street View imagery for the Helsinki metropolitan area is required. UH-DHL has access to a complete data set of all 326,978 street view panoramas from the Helsinki metropolitan region. Since these data are protected by Google's copyright and license, the possible scope of sharing them with other URBANAGE partners has to be assessed.

4.3.2 Data from IoT devices

A necessary input for the proposed functionality to automatically group and categorize citizen generated data (section 5.3.1) are data collected using the IoT devices of the Helsinki use cases 1 and 2 (see D6.1). The exact format and modalities of data collection have not been decided on. The data are expected to be in tabular format.

4.3.3 Historical feedback records to city departments

For the same task, an AI functionality to automatedly group and categorize citizen-generated data, historical feedback to the city departments is required as a training data set. These feedback records were recorded, e.g., via the city's Open311/GeoReport_v2 API (https://dev.hel.fi/apis/open311, currently this API is used mainly by the city's environment department, and (multiple?) other feedback systems exist in parallel). Feedback can be queried without authentication for up to 1 month prior.

4.3.4 Historical weather records

As training data for the task of predicting the likelihood of adverse weather conditions and subsequently less preferential conditions of road surfaces, historical weather records are required. The Norwegian metrological survey offer API access to historical weather records and forecasts: https://thredds.met.no/thredds/metno.html.

5 Preliminary AI functionalities per use case

In this section the principal AI functionalities per use case (Santander, Flanders and Helsinki) are described. For development purposes of the URBANAGE Platform, the project established a CI/CD (Continuous Integration and Deployment) process, that includes among the tools to be used, a code repository (i.e. GitLab). The code repository collects the prototypes of the main components (e.g. baseline tools, libraries, datasets, etc.) constituting the Artificial Intelligence and their future developments. The deliverable "D5.2 Initial Platform Prototype" provides details about the CI/CD process and the code repository.

5.1 Santander

In Santander two different use cases have been defined: one related to short term developments and the second one to long term.

For the former, the main objective is to provide comfortable routes for ageing people considering several variables such as: the state of the street, obstacles, noise, temperature, pollution, benches, public toilets, urban accessibility infrastructures, shadowed places among others. Moreover, each senior citizen will include their preferences in the tool so different customized groups will be considered based on mobility and cognitive aspects, impaired abilities, among others. Thus, the route planner tool will consider the particular needs of each customized group and send/ receive incidents or alerts if something changes in the city.

For the long-term use case, the aim is to provide a tool to the public administration about how to improve the age friendliness of a specific neighborhood (urban accessibility, access to public services….) helping them to make decision about which are the optimal places to install a mechanical ramp or a lift in order to minimize the route time or maximize the comfort of the route for ageing people or in which places is needed a specific public infrastructure (civic center, library …) or public space (parks or green areas). Urban planning should be an instrument for shaping the intentions and policies for the future of the city and in this regard, the existence of objective information based on the most real and updated data will make it possible to reliably establish the most important consequences of the possible alternatives that may be chosen.

5.1.1 Age-friendly route planner

The main goal of the age-friendly route planner is to provide comfortable routes for ageing people in order to improve the user experience in the city for senior citizens. The comfortability is measured by different variables, such as the state of the streets, obstacles, noise, temperature, or pollution among others. The comfortable route planner system considers these variables to achieve the best “comfortable” route. However, the way the variables are considered in the route planner is different for obstacles (non-passable streets) or environmental variables (noise, pollution, etc). There are some variables, such as obstacles in the streets, that will disable some paths. For the remaining variables, such as noise, pollution or temperature, the user will specify his/her preferences.

The comfortable route planner system is based on Machine Learning (ML) techniques and optimization algorithms and iteratively simulates different routes optimizing the comfortability measurement. Thus, the final route solution copes with the optimal route in terms of comfort for ageing people.

The route planning tool is adapted to the particular needs of each *customized groups*. These groups are considered in order to take into account the diversity of needs and requirements in this segment of population: mobility and cognitive aspects, impaired abilities, among others. The tool must integrate not only the ability to customise its functionality for different groups but also incorporate the precise data that allows for the correct performance for all of them.

On the other hand, since people's routes through the city are often stable, for instance activities such as going to do the daily shopping, going to a medical centre or attending an activity in a civic centre, provide routes that have been chosen at some point in the past, conditioned by citizens' capacities and the city's infrastructures. If at some point in time, any of these parameters change (citizens' capacities and/or city's infrastructures), these routes will be modified. If the capabilities of senior citizens change, the user should change the personal settings in the tool. However, if the city's infrastructure changes due to a construction work or a breakdown in an escalator, a change of position of a bus stop or bus line service, the user will receive an incident alert. Thus, the route planner provides information in both directions, so users receive incident alerts or events if something changes in the city. Moreover, users can also provide information to the tool about the problems encountered along their daily routes.

The information on the most popular routes together with the number of users on those routes is of great value for municipal services to provide a better service to the citizen, e.g. organize the schedule of civil works in order to minimize the number of citizens affected, selection of activity places that less affect the senior citizens routes. The information about the most popular streets and routes will be obtained from the route planner tool.

5.1.2 Simulation tool for long-term urban planning

The aim of the simulation tool for long-term urban planning is to provide a tool capable of measuring the age friendliness neighborhood index of a specific neighborhood. The principal user is the public administration that will be able to improve this index and take decisions about the installation of public services, green areas or urban accessibility improvements based on the results of the tool per neighborhood. In order to develop the above-mentioned tool that provides the age friendliness neighborhood index of a specific neighborhood, different metrics must be investigated and developed for the specific use case.

In Santander the complicated orography of the city and the aging of population will be considered to address important challenges such as *sustainability*, i.e. strong demand for better and new municipal services, areas of urban expansion of the city and new road networks needed, future location of playgrounds, benches and other related street furniture. For all these reasons, urban planning is something complex, of great impact (in terms of time and depth) and in which a multitude of general factors coexist. In addition, urban planning should be an instrument for shaping the intentions and policies for the future of the city, something that is the responsibility of politicians and senior officials. However, the existence of objective information based on the most real and updated data will make it possible to reliably establish the most important consequences of the possible alternatives that may be chosen.

Moreover, regarding the urban accessibility improvements, the simulation tool for long-term urban planning will provide optimal places to install a mechanical ramp or a lift in order to minimize the route time or maximize the comfort of the route for ageing people.

This simulation tool is based on Machine Learning (ML) techniques and optimization algorithms and copes with the restrictions or complexity of movement of older people. Therefore, the simulation-based optimization tool considers the deployment of vertical transport and automatic ramps in the context of global multimodal urban mobility and accessibility. Also, a demographic evolution of the population must be performed to be able to characterize the neighborhood population in the long-term and obtain the age friendliness neighborhood index.

5.2 Flanders

For the Flanders pilot, two pilot cases were worked out as described in **chapter 4.2.5.1** of **Deliverable 6.1**. Artificial intelligence will only be used in the **first pilot case**. Artificial intelligence has an added value in three specific application domains:

1. Measuring the public domain
2. The calculation and calibration of the green comfort index
3. The analysis of *Google Street View* & orthophoto/satellite imagery to detect POI-objects in the landscape

5.2.1 Measuring the public domain

Goal: Finding comfortable, shadow-rich rest places on the public domain on a region-wide scale in an automated way by using techniques to recognize these places including their accessibility and other indicators listed in the table in chapter 4.2.1 (last column).

AI use: The use of AI as an automated detection technique help assessing effectively shadow-rich and accessible places.

Actions:

- Select public domain locations
- Select semi-public domain locations (e.g. shopping centra, hospital gardens)
- Measure various parameters of the indicators listed in the table in chapter 4.2.1 (last column).
- Create an integrated data layer (3D, containing the relevant information)
- Updating process based on improved data and improved machine learning outcomes

5.2.2 Calculation of the green comfort index

Goal: Once the comfortable, shadow-rich rest places on the public domain are detected as described in chapter 5.2.1, it is important to assess the suitability by calculating a suitability score.

AI use: AI can be used to calculate a heat stress score that matches the user's perception.

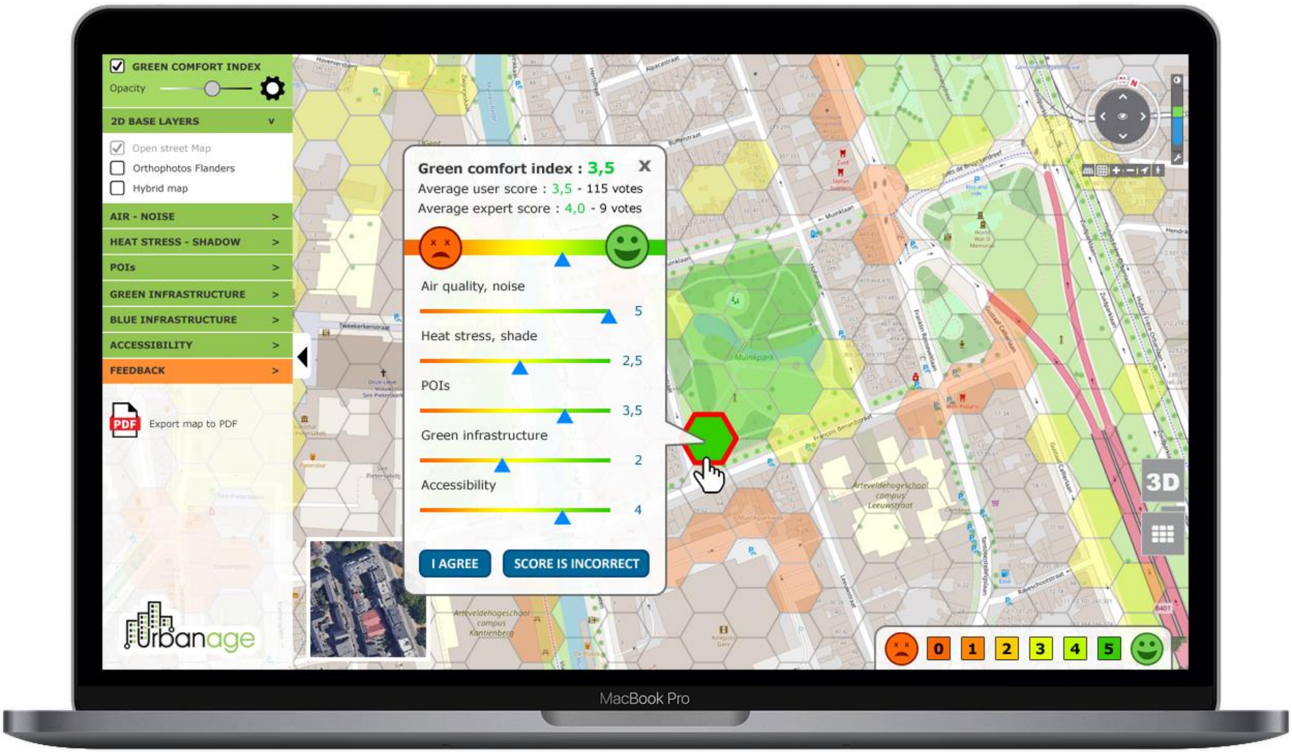

Figure 6 Green Comfort index layer with clickable hexagon tiles

The green comfort index is a calculation (to be performed for each **hexagon tile** on the map above), based on the measurement of various indicators.

The indicators can be found in the table in chapter 4.2.1 (last column).

- Indicator information may be dynamic, so the calculations need to be done on the fly at each request, **making use of the most recent datasets**.
- Further, **corrections** can be made by logged in users and professionals/specialists. These calculations need to be taken into account as well. The weight of professional feedback must be stronger than the weight of the feedback given by non-professional citizens.
- The availability of an indicator in a hexagon tile may influence surrounding hexagons.
- The parameters included in the calculation of the green comfort index are not the same for all individual older persons. The relevance of the parameters may also fluctuate in time. That’s why we offer the opportunity to visitors with an account to **switch parameters on/off**, presenting them an alternative calculation of the green comfort index.

These aspects make the calculation of the green comfort index quite complex. Especially the integration of the user- and expert updates is something that needs to be continuously evaluated and updated depending on the results. This self-learning mechanism combined with the expert simulation results can be a basis for the introduction of artificial intelligence (AI). An AI solution corrects the green comfort scores, making them more reliable every day.

The green comfort index can be determined in 4 steps.

Step1: Definition of the Public domain zones where the green comfort score will be calculated

- Create overview map of the public domain
- Define Hexagon zones (10*10 meter) on the public domain

Step 2: Calculate a green comfort score for every hexagon

- For each of the indicators listed in the table of chapter 4.2.3 (last column), a **weight factor** will be defined. When determining the green comfort index score for an individual hexagon on the map, the varying weight factors of all indicators will be taken into account.
- Also, **surrounding hexagons will be influenced** when scoring the green comfort index of a hexagon. For example, when a map hexagon covers some trees, the weight factor for trees will count for 100% for this hexagon. Since also for the surrounding hexagons, the trees are nearby and reachable, the weight factor for trees will be taken into account as well, but in a lower degree (for instance 50%).
- Indicators may have some properties that can influence the weight factor as well.
  As an example, tree height, width and density influence the amount of generated shadow and for benches, different degrees of comfort can be defined depending on its physical characteristics.

Step 3: Score the green comfort manually to provide a basis for comparison:

- Logged in users and professionals/specialists can give a manual score for each hexagon. These scores will be taken into account with a certain weight factor as well. The weight factor for professionals & specialists will be higher.
- Also, the weight factor will be influenced by the number of manual corrections and the standard deviation of the suggested corrections.

Step 4: Calculating the difference between the calculated and the perceived score:

Calculating the difference between the calculated score (adapted to max 100) and the perceived score (max. 100) for each hexagon. (using a different color scale for higher and lower perceived scores compared to the calculated scores).

5.2.3 Google Street View & orthophoto/satellite imagery

The **third AI-application** is the use of *Google Street View* and orthophoto/satellite imagery to detect and localise (green) zones and POIs in the landscape.

As stated in chapter 4.2.2., we plan to investigate whether *Google Street View* POI identification can be of extra value for the POI detection as defined by existing datasets, to make datasets more qualitative.

As the senior citizen suffers a reduced flexibility in terms of mobility, it becomes important to map out whether a given area lends itself to comfortable and hazardless passing through or prolonged stay. The availability of a walkway, street furniture such as benches, and cover from nature such as shelter or trees can greatly benefit the mobility experience of the end-user.

Street furniture data (benches, shelter, foliage, …) are often either inexistent or poor maintained and incomplete. Using the *Google Street View* API, we can automatically gather imagery data of the to-be-investigated area.
Street View imagery is a rich data source combining a coordinate with a 360° view of the environment. The availability of important infrastructure to allow for accessibility is easily assessed using this data source.

An area under investigation can be scored based on the availability data:

- Are there benches?
- Are there streetlights?
- Is a walkway / bicycle lane present?
- Is there shelter or natural cover in the immediate vicinity?
- Are there bus stops?

Furthermore, we will use landscape detection models to segment the *Google Street View* data and discover natural elements (trees, foliage, green pastures). Using these techniques, we can detect hotspots which are suitable for senior citizens and (more importantly) which locations are not suitable. These findings will in turn inform urban planners to adapt existing infrastructure to be more age-friendly and update outdated datasets.

5.2.4 Simulation tools

As described in detail and illustrated by numerous mock-ups in D6.1, simulations tools can be used to analyze the impact of POI implantations in the city on the green comfort index. More precisely, check story 4 in that document (simulation of city adjustments by gamification).

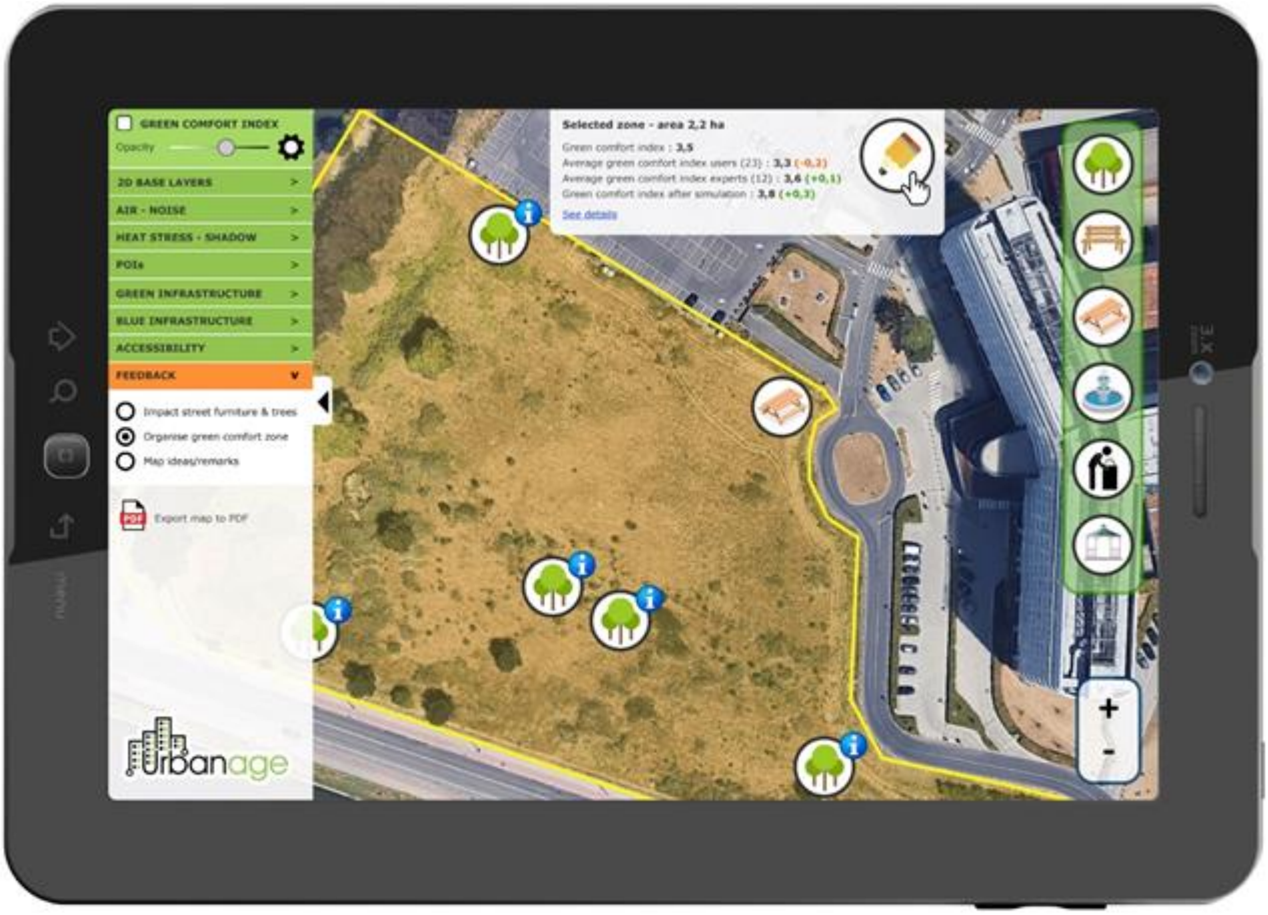

Figure 7 mock-up for expert mode of the POI impact analysis tool.

Also, the second Flanders pilot case contains simulation elements. In order to improve the decision-making, we plan to create two new map layers that can be easily combined with existing datasets and models or data driven applications.

- The first layer indicates the **age distribution** of the citizens throughout the city. This should help the policy makers to indicate the areas where older are living.
- The second layer shows the distribution of people with a **reduced physical mobility** in the city. There are different sources of health information that can be explored. It is the aim to visualize the information in a more detailed but anonymized way.

When both are **combined**, it should be possible for policy makers to indicate the historic and present demographic distribution of older people with a reduced mobility as well as to make **predictions (simulations)** (based on models analyzing historic and current data) on how it will evolve in the future.

5.3 Helsinki

In Helsinki three use cases have been designed to improve accessibility, service delivery and urban planning based on citizen generated data. AI has potential to assist planning in data collection, grouping, simulation and visualisation.

For the Helsinki metropolitan area, both a routing planner that considers greenery, noise and air pollution, and a greenery inventory based on Google Street View imagery have been implemented in earlier projects (cf. Toikka et. al, 2020 [5]; Helle et al., 2021 [6]). The data produced in these projects can be considered input data for a new iteration of the Helsinki digital twin, see the cited articles and their supplementary information for details.

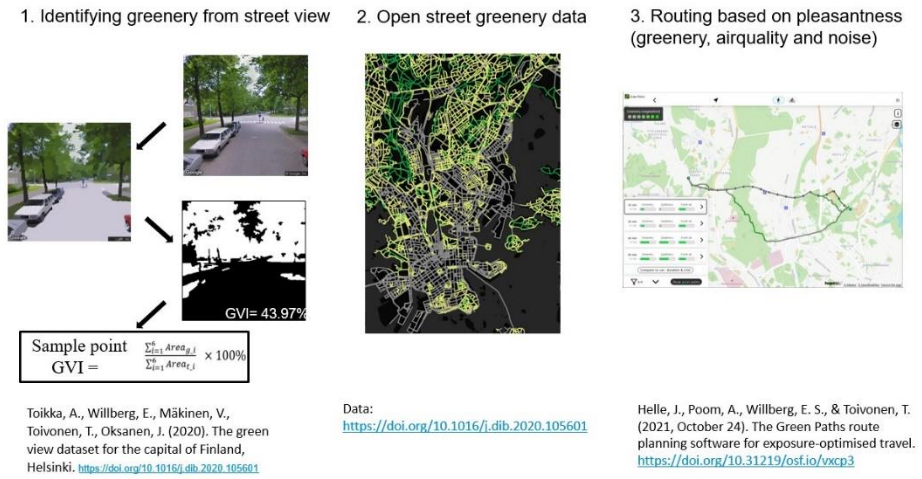

Figure 8 Route planner and greenery inventory

In this light, for the Helsinki use case, we will go one step further, and add cutting-edge functionalities. Note that at this time, the list of AI functionalities proposed is a suggestion, and most likely exceeds the scope of URBANAGE. As such, all of the suggested features could be implemented either with reduced functionality, or in a proof-of-concept manner to be incorporated in future projects.

We propose to evaluate three different functionalities that could benefit from employing an Artificial Intelligence workflow. (1) feedback submitted to the city, whether originating from the IoT devices deployed as part of one of the Helsinki use cases for URBANAGE or from the numerous online forms the city departments provide, could be categorised and grouped according to its content, and assigned to the most relevant city departments; (2) Street View images could be analysed using computer vision methods to assess the walkability metrics of street segments and neighbourhoods; (3) the likelihood of adverse weather conditions could be predicted using a model trained on historical weather records.

5.3.1 Automated grouping and categorization of citizen generated data

On this first functionality, AI techniques could be used for categorizing the collected feedback data (see UC1 in D6.1) and Points of Interest data (see UC2 in D6.1). Data is automatically categorized based on particular attributes, but AI might be useful in aggregation of geographical data points. Additionally, AI might also be useful for grouping and identifying parts of data (e.g. by using particular terms or keywords from text comments) and directing the feedback to a particular city department for required action. For instance, a model could learn from a history of feedback records that have been manually assigned to a certain city department. AI might also have potential for any future visualization of the generated data, e.g., AI could be used for generating quick visualizations, like heat maps or clusters, that might be useful for spatial analysis and urban planning.

5.3.2 Automated assessment of walkability metrics from Street View imagery

Image segmentation algorithms could be used to assess additional metrics of walkability beyond the share of greenery (Green View Index, GVI, cf. Toikka, et al., 2020 [7]), such as the metrics set forward in the work of Danish architect Jan Gehl (cf. Ewing & Handy, 2009 [8], for an overview of quantifiable factors). This includes, for instance, metrics such as urban complexity, enclosure, tree canopy, street width, human scale, sense of comfort, and coherence. Many of these factors could potentially be derived from Street View imagery, as many of them can be expressed visually. Techniques that could be employed include image segmentation and custom-trained deep learning models derived from user-annotated training data. As this suggested functionality is bleeding-edge, the methods and techniques are yet to be explored, evaluated and developed.

While the factors that make up the concept of a ‘human-scale city’ are not directly addressing older people, older people are, in fact, most affected by lack of walkability, and outcomes from the co-creation sessions show that feeling ownership and identifying with their neighborhood are especially important for older people.

Beyond that, a large-scale analysis of the metrics of ‘human scale’ of a city has not been carried out, and artificial intelligence methods seem promising. This would be a major contribution to the scientific literature.

5.3.3 Predict weather conditions’ impact on walkability from historical weather records

As has been identified in the co-creation sessions of all three pilot cases, weather and climate have an important influence on older peoples’ mobility and accessibility. For instance, in Helsinki, winter maintenance and the potential for slippery road surfaces, play an important role for whether or how older people move about in the city. Similarly, heat (and lack of shadow) has been identified as an important factor for older people in Santander and Flanders, and poor weather in general (such as rainy weather, or wind) have been brought up as factors that impede or even prevent older people from accessing places of their everyday lives.

An AI algorithm could learn from historical weather records to predict the likelihood of adverse weather conditions in a city, or in parts of a city, to provide an additional input for, e.g., routing algorithms that try to accommodate the specific requirements of older people. For instance, if a certain likelihood of slipperiness is predicted, routing algorithms could default to a slower, more careful, walking speed; if hot weather is expected, the routing could prefer shadowy paths and account for additional stops in shadowy places on the way; if rain is likely, routing for public transport could minimize walks outdoors, e.g., for changing vehicles.

In contrast to using real-time weather information, the proposed AI algorithm could predict the likelihood of adverse weather conditions for arbitrary dates, and thus could help in planning long-term and mid-term actions, such as changes in urban greenery, public transport schedules, or street furniture.

6 Description of existing frameworks for its use in URBANAGE

In this section the different existing frameworks that can be used in URBANAGE project from the AI perspective are described. These include Open Trip Planner, MLFlow and TensorFlow.

6.1 Open Trip Planner

As can be read in the OpenTripPlanner web page[5], *OTP is an open source platform for multi-modal and multi-agency journey planning. It follows a client-server model, providing several map-based web interfaces as well as a REST API for use by third-party applications. OTP relies on open data standards including GTFS for transit and OpenStreetMap for street networks. OTP deployments now exist around the world and OTP is also the routing engine behind several popular smartphone applications.* Several advantages make OTP a platform appropriate for being used as route planning system:

- It is fully open source, meaning that it is adaptable to the requirements and the specific need of the user.
- It efficiently works with Open Street Maps, providing the structure for automatically using it.
- It is integrated with other data standards, such as GTFS for the use of public transportation or DEM for the using of altitude information.
- It is clearly documented, and it has a wide community on its behind. These facts make easier to understand the platform and solve any potential problem.

The main code of OTP has been developed using JAVA as programming language, and it can be obtained from the GitHub of Open Trip Planner Project (https://github.com/opentripplanner/OpenTripPlanner). This GitHub project includes the complete OTP code, which can be openly used and modified, as well as a client with testing purposes. As can be observed in the GitHub project, the downloaded code "*includes a REST API for journey planning as well as a map-based Javascript client. OpenTripPlanner can also create travel time contour visualizations and compute accessibility indicators for planning and research applications.*"

Thus, an OTP base project can be executed on different platforms, and it can compute and suggest itineraries optimizing different criteria, such as the duration, the length, the cost, or the environmental friendliness among others. For conducting these calculations, the OTP should be fed by different data sources. We list here some of the most frequently used ones:

- **Digital Elevation Model (DEM)**: This data source is employed for setting the elevations of the streets. The route planning acquire this information and it automatically assigns the corresponding elevation to the entire street network. Additionally, this source is provided to the OTP in GeoTIFF format, and it has been openly obtained from databases such as *SRTM Tile Grabber*[6].

[5] http://www.opentripplanner.org/
[6] http://dwtkns.com/srtm/

- **Open Street Map (OSM) file**: Being one of the most important data sources, the OSM map file is employed to build the complete street network, necessary for properly calculating the routes. This map files can be openly obtained from *Planet OSM*[7] platform, using *BBBike*[8]. Through this platform, OSM files can be downloaded in *Protocolbuffer Binary Format* (PBF) format, containing all the nodes, ways and relations necessary to build the map. In this way, the OSM files are automatically taken by the OTP, building the full road network.
- **GTFS files**: these files define a common format for public transportation schedules and associated geographic information. Thus, GTFS is employed for providing the route planner with public transportation information. This way, the planner can consider all available services, choosing the one that fits better with the scheduling requirements.

With all this, as an indicative material, we shown in Figure 10 a possible architecture of an OTP project, in which the OTP route planning module is feed by the three mentioned data sources above defined, but also with other information such as the status of the streets or any kind of external data (such as traffic information).

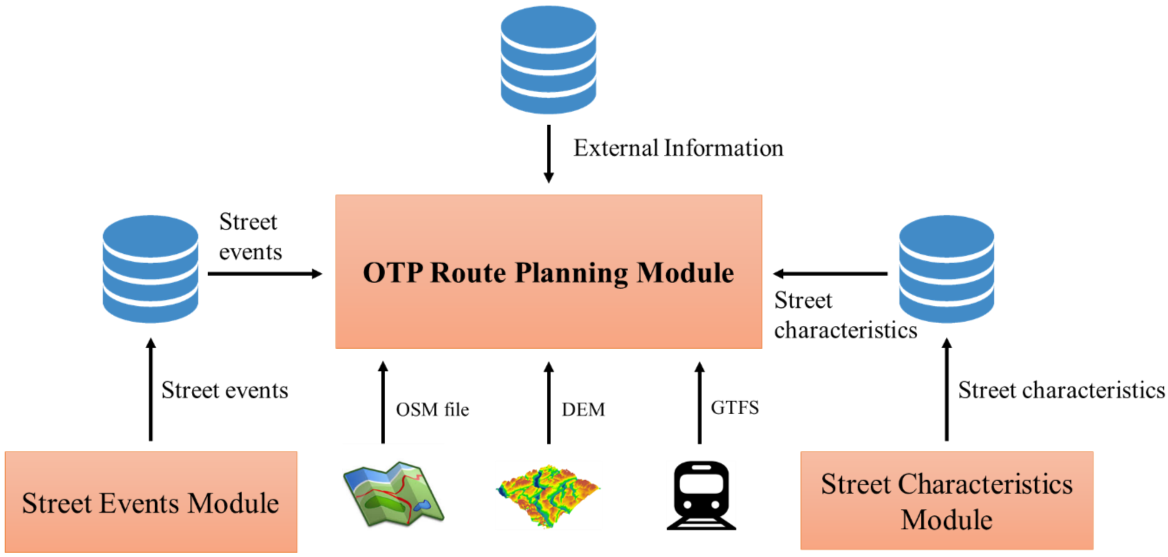

Figure 9 indicative architecture of an OTP project

6.2 Street View downloader

UH-DGL developed a Python tool and library [13] to download images from the Google Street View images. The tool takes a geographical extent polygon as an input and downloads metadata and images of all Street View panoramas within this extent. Street Viewdownloader's basic principle of operation is to (1) download a street network for the specified extent from OpenStreetMap, (2) generate an equidistant set of points along that street network, (3) query the Street View Static API for the Street View panorama closest to each of these

[7] http://planet.osm.org
[8] http://download.bbbike.org/osm

points, and, finally, (4) download six images with a horizontal field of view of 60° each. Metadata (including location) are saved in a GeoPackage file. This library can be useful for both the Flanders and the Helsinki use cases, in which Street View imagery is to be analyzed using computer vision methods.

6.3 MLFlow

MLFlow is an open source platform that allows to manage the end-to-end Machine Learning lifecycle. It permits to track the experiments and easily compare the results (Tracking module), package the ML code in order to share it with other data scientists or transfer to production (Project module), deploy models employing a variety of ML libraries (Models module) and finally, provide a central model store to collaboratively manage the full lifecycle of a model (Model registry module).

ML-flow can be used with any ML library and any programming language. In URBANAGE Python is one of the programming languages used to provide AI functionalities.

Regarding the different modules that MLFlow offers, in the URBANAGE project the Tracking module is considered as the most relevant one. It allows to keep track of the experiments and compare results from different users. The ML optimization algorithms usually need many runs to achieve optimal results and some algorithm parameters need to be optimized. Therefore, MLFlow allows to experiment easily with a wide range of datasets, tests, data preparation steps, algorithms and build a model that optimizes a target or metric considering the results obtained from the different tests in an efficient way.

6.4 TensorFlow

TensorFlow is an end-to-end open source platform for Machine Learning. It has a comprehensive, flexible ecosystem of tools, libraries, and community resources. Moreover, it allows researchers to push the state-of-the-art in ML and developers to easily build and deploy ML-powered applications.

TensorFlow was originally developed to conduct machine learning and deep neural networks research, but the system is general enough to be applicable in a wide variety of other domains, as in the AI models developed in the URBANAGE project.

In URBANAGE Python is one of the programming languages used to provide AI functionalities and in this context, TensorFlow provides stable Python and C++ APIs, as well as non-guaranteed backward compatible API for other languages.

As Tensorflow is usually employed for deep learning algorithms, its use in URBANAGE would be conditioned to the amount of available data per use case.

7 Conclusion

This manuscript has presented the first advances conducted under the umbrella of the task T3.2 of URBANAGE - *AI Algorithms and Simulation*, part of the WP3 – *Data & Intelligence*. On the first part of this document, the principal considered data sources for each pilot case have been described, giving a special attention to those that have been finally employed in the planned functionalities.

After describing the principal sources of information, the specific AI functionalities that will be deployed on each pilot case have been described. All these functionalities, despite being preliminary, have been designed with the main goal of giving an answer to the worries and necessities arisen in the co-creation workshops conducted under the umbrella of URBANAGE project.

Finally, this document finishes highlighting some remarkable frameworks, such as *Open Trip Planner*, *Tensor Flow* or *ML Flow*, which will be potentially used for the development of the functionalities planned for each scenario. Once more, it is crucial to spotlight that this does not mean that these platforms will be finally employed, but they will at least inspire the design and implementation of the scheduled functionalities.

Further work on this task contemplates the final definition of the AI functionalities for each pilot case, as well as the development of all the three AI algorithm prototypes.

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[4] https://developer.jcdecaux.com/#/opendata/vls?page=static

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[12] http://download.bbbike.org/osm

[13] https://Streetviewdownloader.readthedocs.org/