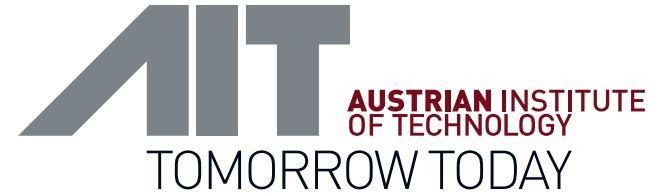




AGILE PhD School "GeoAI for social good"
Castellon de la Plana



Keynote

Mobility Data Science in the Age of AI

Anita Graser

2024-11-28

The presented work is partially funded by the EU's Horizon Europe research and innovation program under Grant No. 101070279 MobiSpaces, No. 101093051 EMERALDS, and No. 101021797 STARLIGHT.



~~STARLIGHT~~

OUTLINE

1. (Geo)AI > LLMs
2. The need for XAI for Geo
3. AI-based GI Assistants & how they work

(GEO)AI > LLMS



“Specialist Meeting” on GeoAI 2024, Vienna, Austria

(GEO)AI > LLMS

Google

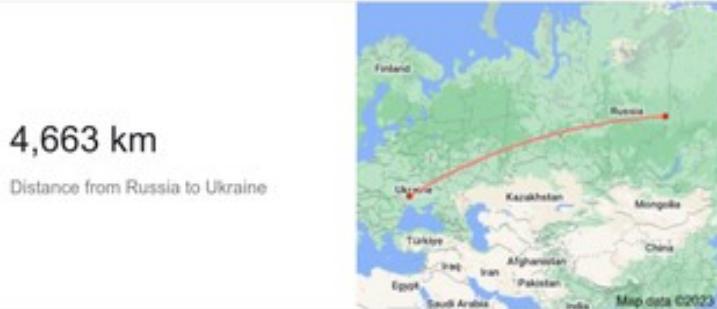
Distance between Russia and Ukraine

All News Maps Images Videos More Tools

About 86,600,000 results (0.55 seconds)

4,663 km

Distance from Russia to Ukraine



KC How far is Russia from Ukraine?

How far is Russia from Ukraine?

The distance between Russia and Ukraine depends on the specific cities or locations being considered. The two countries share a border that stretches over 2,295 kilometers (1,426 miles) from the Sea of Azov in the south to the Arctic Ocean in the north.

Russia and Ukraine share a border that is approximately 1,944 kilometers (1,207 miles) long. The distance between the two countries varies depending on the location, as the border is not straight and follows natural features such as rivers and mountains. The closest distance between the two countries is at the border between Ukraine's Kharkiv Oblast and Russia's Belgorod Oblast, where the distance is only about 8 kilometers (5 miles) apart.

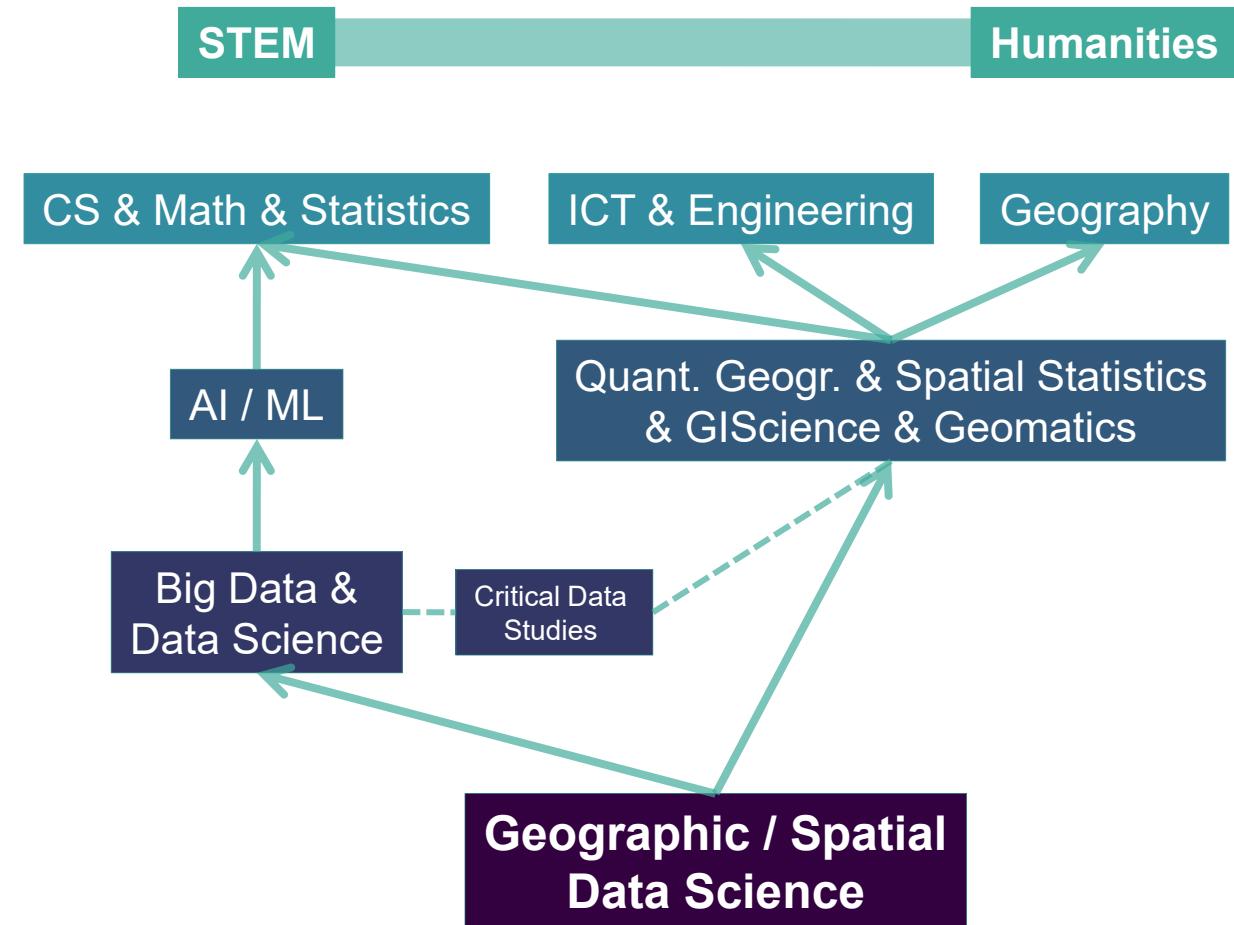
Image source: Janowicz, K. (2023). Philosophical Foundations of GeoAI: Exploring Sustainability, Diversity, and Bias in GeoAI and Spatial Data Science. arXiv e-prints, arXiv-2304.

GEOGRAPHIC DATA SCIENCE (GDS)

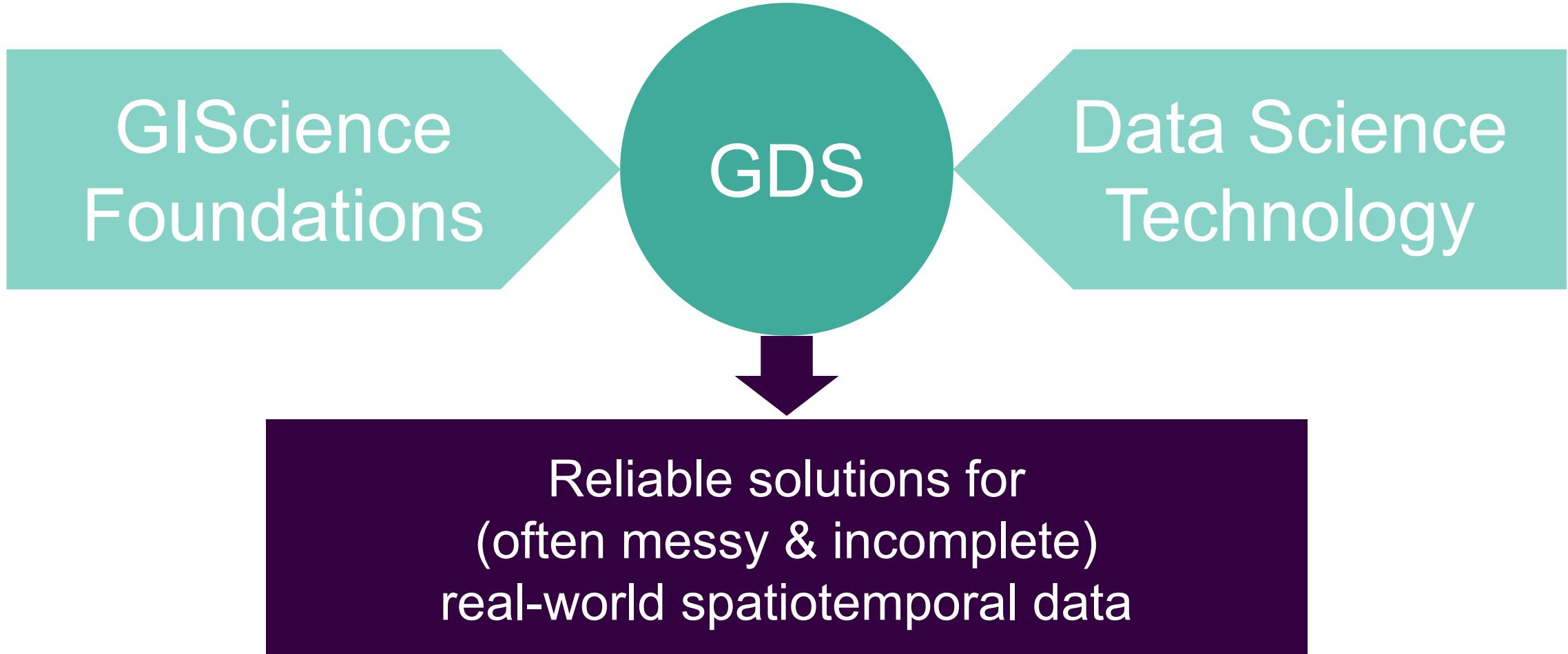
GIScience meets Data Science

Goal: communicate GIScience contributions **across domain borders**

„Data first“ approach, combined with geographic context



VISION



EXAMPLE APPLICATION ANOMALY DETECTION

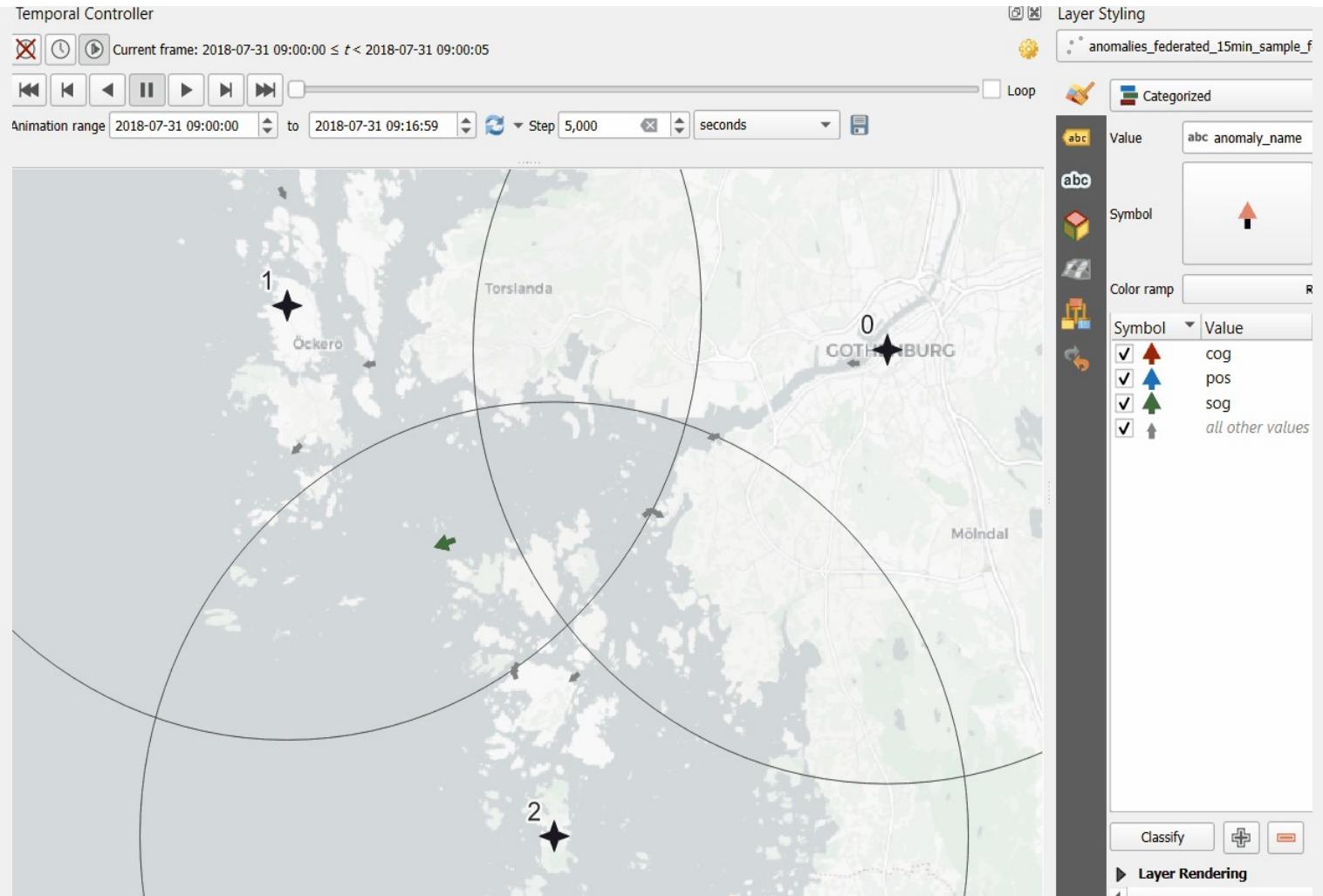
*"The 3rd officer of SELANDIA SWAN lost his footing and fell overboard between 1005 and 1010 local time. Within 15 minutes the crewmembers realized that the 3rd officer was missing and initiated the **man overboard** procedures. Several ships participated in the search.*



© Ernst-Gert Schmidt
MarineTraffic.com



EXAMPLE APPLICATION ANOMALY DETECTION

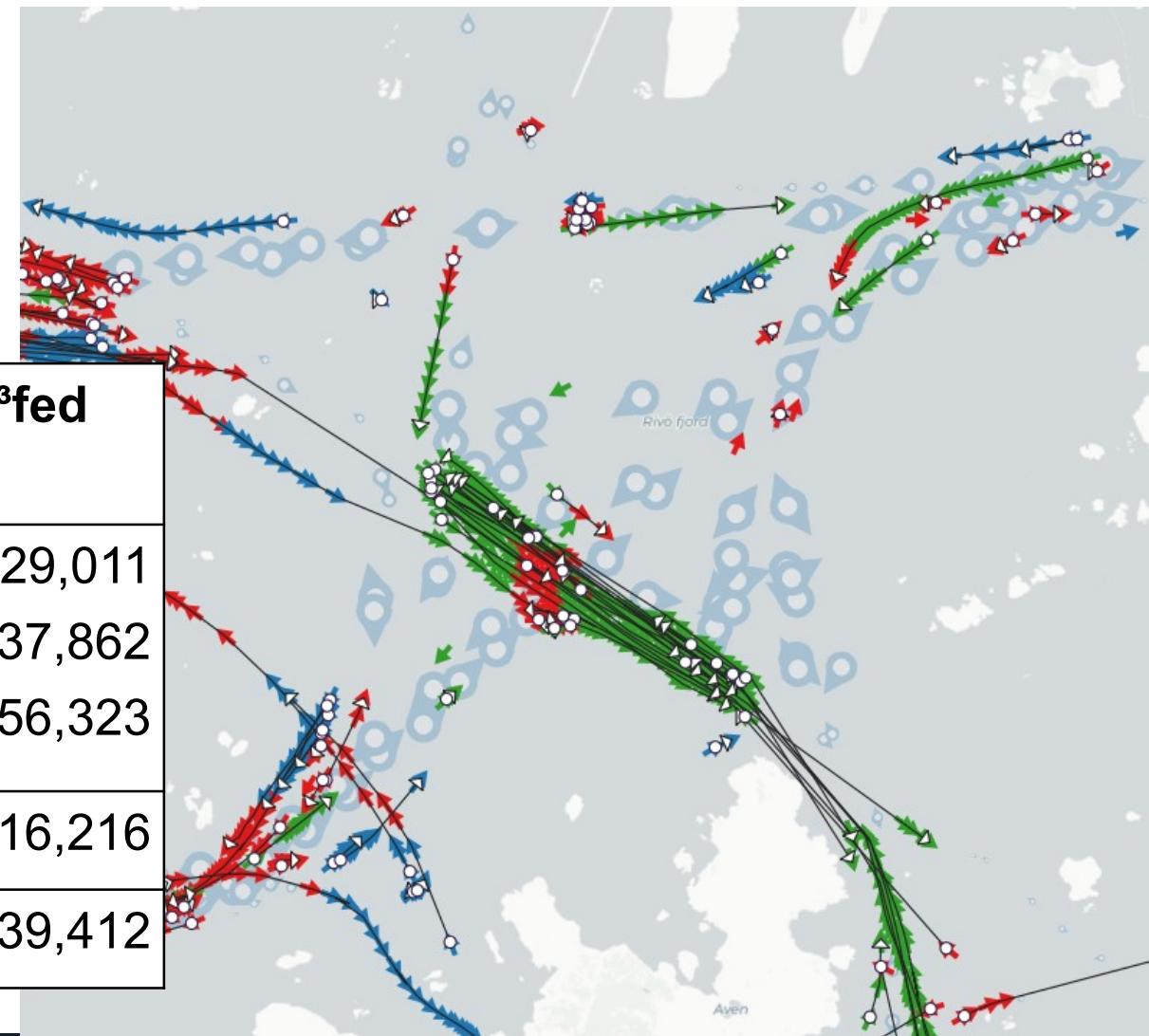


EXAMPLE APPLICATION ANOMALY DETECTION

Comparison of detected anomalies

Table: July 2018 results by anomaly type

	M³	M^{3fed}
Position anomalies	35,228	29,011
Speed anomalies	45,056	37,862
Direction anomalies	72,415	56,323
No anomaly	4,312,088	4,416,216
Total number of records	4,539,412	4,539,412



MOBILITY DATA SCIENCE

 RESEARCH ARTICLE **FREE ACCESS**


Just Accepted

Mobility Data Science: Perspectives and Challenges

Authors: Mohamed Mokbel, Mahmoud Sakr, Li Xiong, Andreas Züfle, Jussara Almeida, Taylor Anderson, Walid Aref, Gennady Andrienko, Natalia Andrienko, Yang Cao, Sanjay Chawla, Reynold Cheng, Panos Chrysanthis, Xiqi Fei, Gabriel Ghinita, Anita Graser, Dimitrios Gunopoulos, Christian S. Jensen, Joon-Seok KIM, Kyoung-Sook Kim, Peer Kröger, John Krumm, Johannes Lauer, Amr Magdy, Mario Nascimento, Siva Ravada, Matthias Renz, Dimitris Sacharidis, Flora Salim, Mohamed Sarwat, Maxime Schoemans, Cyrus Shahabi, Bettina Speckmann, Egemen Tanin, Xu Teng, Yannis Theodoridis, Kristian Torp, Goce Trajcevski, Marc van Kreveld, Carola Wenk, Martin Werner, Raymond Wong, Song WU, Jianqiu Xu, Moustafa Youssef, Demetris Zeinalipour, Mengxuan Zhang, Esteban Zimányi (Less) [Authors Info & Claims](#)

 ACM Transactions on Spatial Algorithms and Systems • Accepted on February 2024 • <https://doi.org/10.1145/3652158>

 Online AM: 07 May 2024 [Publication History](#)


0 185



Abstract

Mobility data captures the locations of moving objects such as humans, animals, and cars. With the availability of GPS-equipped mobile devices and other inexpensive location-tracking technologies, mobility data is collected ubiquitously. In recent years, the use of mobility data has demonstrated significant impact in various domains including traffic management, urban planning, and health

[Home](#) > [GeoInformatica](#) > Article

MobilityDL: a review of deep learning from trajectory data

 Research | [Open access](#) | Published: 28 May 2024

 (2024) [Cite this article](#)
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Anita Graser , Anahid Jalali, Jasmin Lampert, Axel Weißenfeld & Krzysztof Janowicz

 177 Accesses [Explore all metrics](#) →

Abstract

Trajectory data combines the complexities of time series, spatial data, and (sometimes irrational) movement behavior. As data availability and computing power have increased, so has the popularity of deep learning from trajectory data. This review paper provides the first comprehensive overview of deep learning approaches for trajectory data. We have identified eight specific mobility use cases which we analyze with regards to the deep learning models and the training data used. Besides a comprehensive quantitative review of the literature since 2018, the main contribution of our work is the data-centric analysis of recent work in this field, placing it along the mobility data continuum which ranges

MOTIVATION FOR THIS REVIEW PAPER

- Movement data is highly heterogenous
- Terms used in mobility research vary between scientific fields
- Abstracts are usually too vague
- Data processing descriptions are buried deep in the papers

It's hard to determine what kind of movement data has been used to train the model presented in a publication

KEY OBSERVATIONS

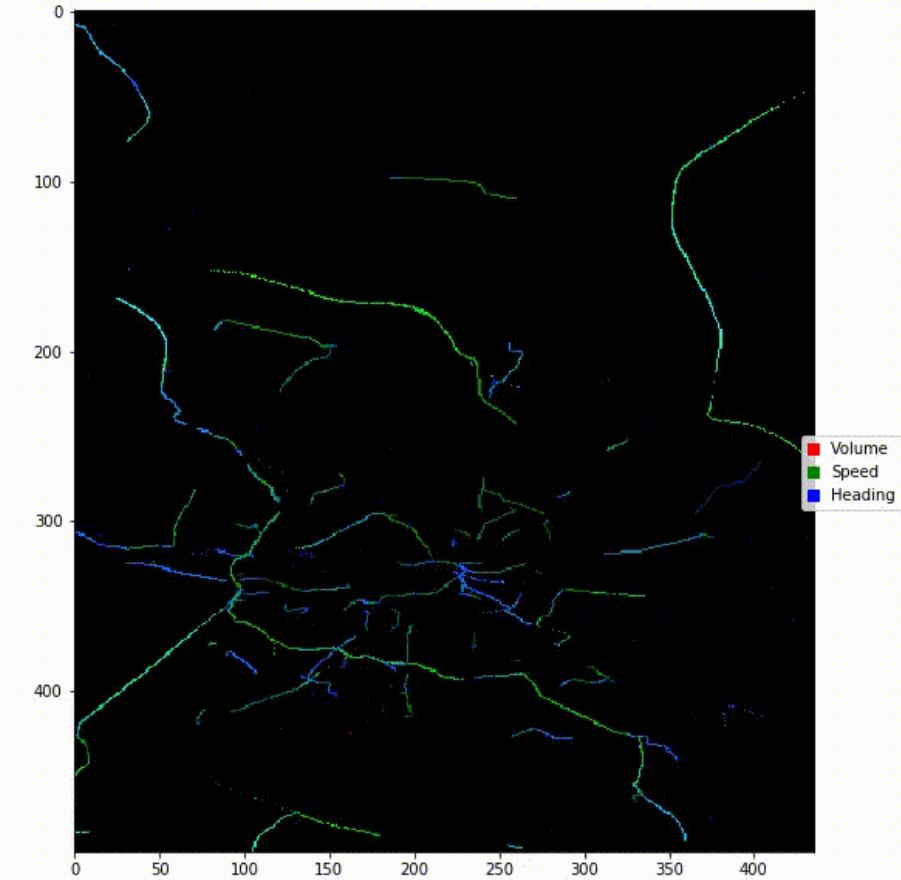
In most cases – even if trajectory data is used in the process – it is not used directly for training the neural networks

Instead, data engineering steps are applied that convert trajectories into

- More compact representations of individual trajectories (sparse trajectories) or
- Aggregations of multiple trajectories, e.g.
 - Time series of vectors, graphs, or images (movies)

Image source: <https://www.iarai.ac.at/traffic4cast/2020-competition//>

2018-01-15 02:30



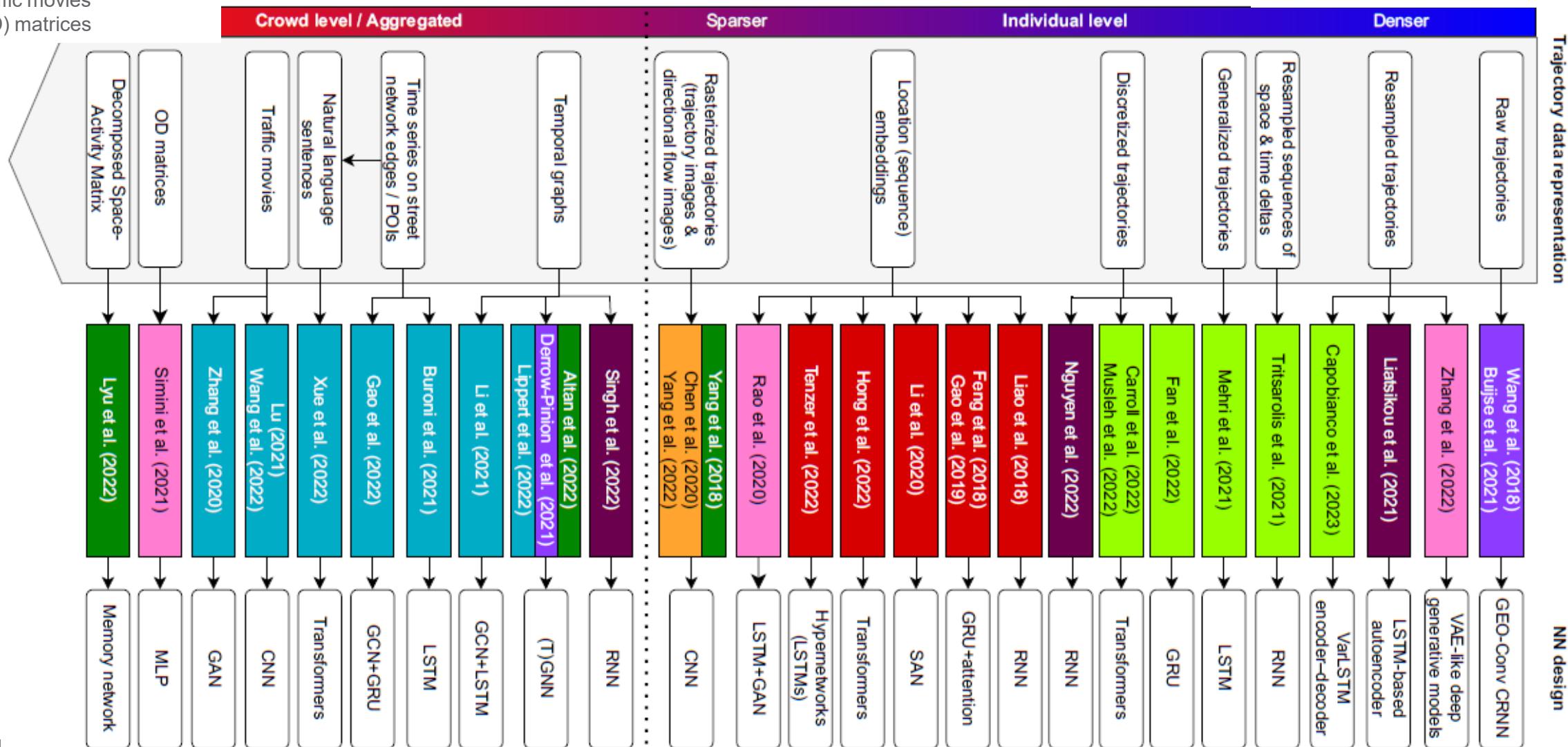
TRAJECTORY DATA REPRESENTATIONS

Individual-level

- Few papers deal with dense trajectories
- Discretization is popular
- Extreme form: trajectory rasterization

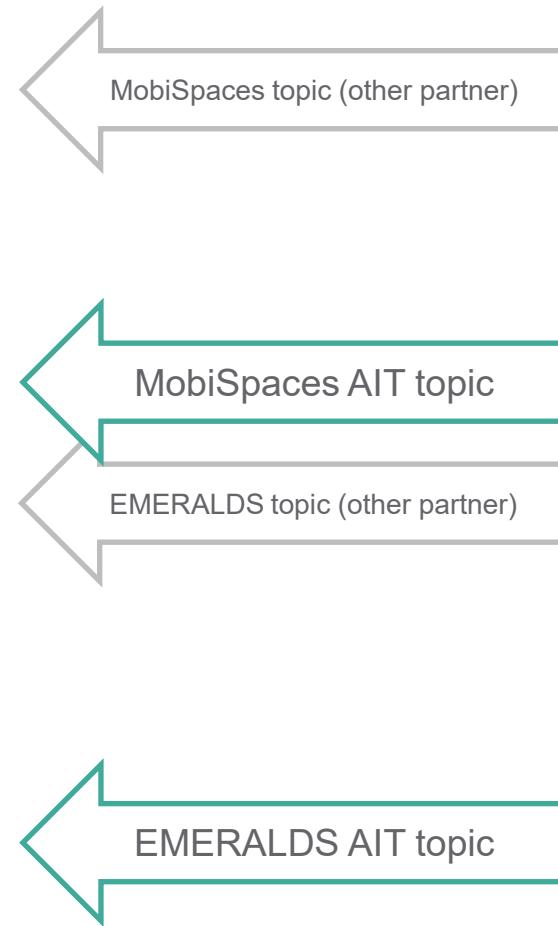
Crowd-level

- Street networks & graphs
- Traffic movies
- (OD) matrices



USE CASES & NEURAL NETWORKS FOR TRAJECTORY DATA

Use case	CNN	(C)RNN	LSTM	GRU	Transformer	GNN	Other
Trajectory prediction / imputation [2.1]			⇒ [41] ⇒ [5]	⇒ [54] ⇒ [13]	→ [6,43]		
Arrival time prediction [2.2]			⇒ [56,3]	⇒ [3]		⇒ [11]	
(Sub)trajectory classification [2.3]	→ [8,63]	⇒ [57]*	⇒ [57]*		⇒ [57]*		⇒ AdaNet: [57]*
Anomaly detection [2.4]		→ [44] ⇒ [51]	⇒ [33]				
Next location / destination prediction [2.5]	→ [16]	→ [14,32]		→ [16]	→ [24]		⇒ Hyper network: [53] → SAN: [30]
Synthetic data generation [2.6]			→ [47]			⇒ VAE-like: [65] → GAN: [47] ⇒ MLP: [50]	
Location classification [2.7]	→ [62]				⇒ [1]	→ Memory network: [38]	
Traffic volume / crowd flow prediction [2.8]	⇒ [58,36,27]	⇒ [27]	⇒ [4] → [31]	⇒ [60]	→ [17] ⇒ [31,34]	⇒ GAN: [66] ⇒ SAE: [27]	



USE CASES & NEURAL NETWORKS FOR TRAJECTORY DATA

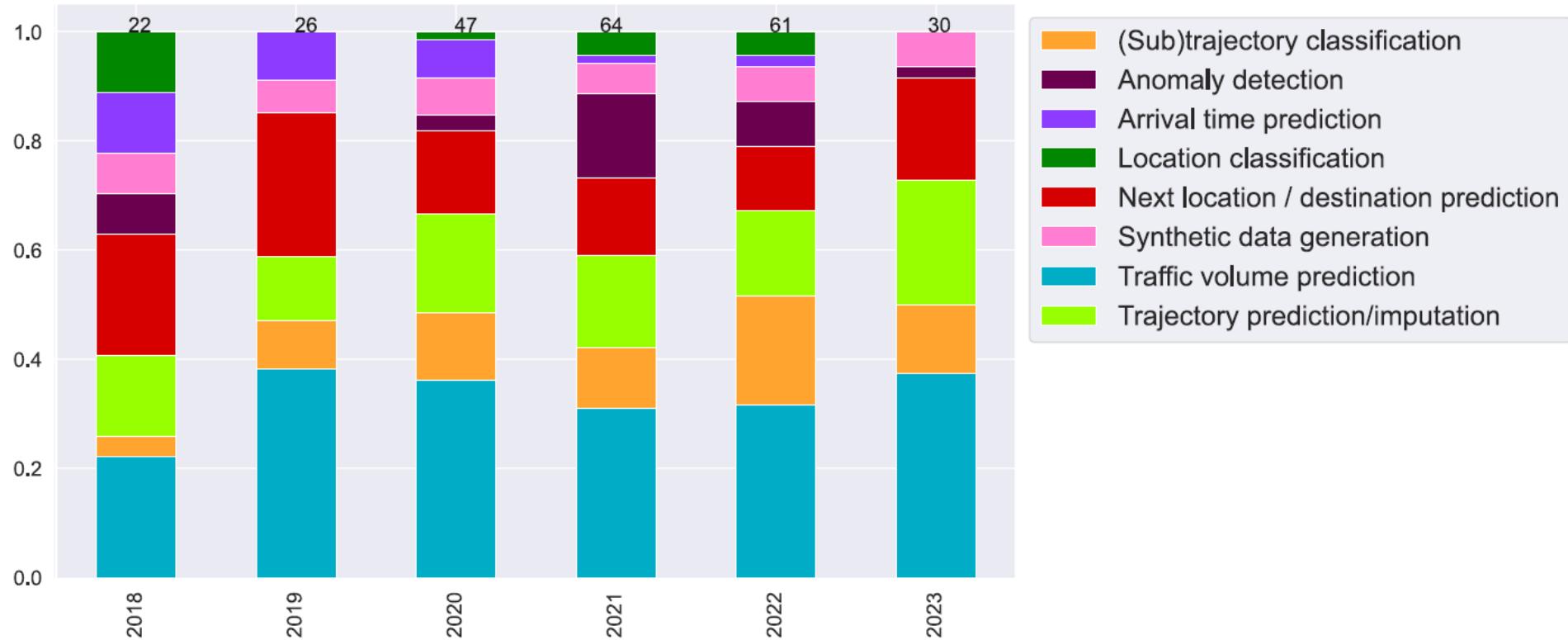


Fig. 2 Portions of publications by use case from 2018 to 2023. Total number of publications per year is displayed at the top of each bar

USE CASES & NEURAL NETWORKS FOR TRAJECTORY DATA

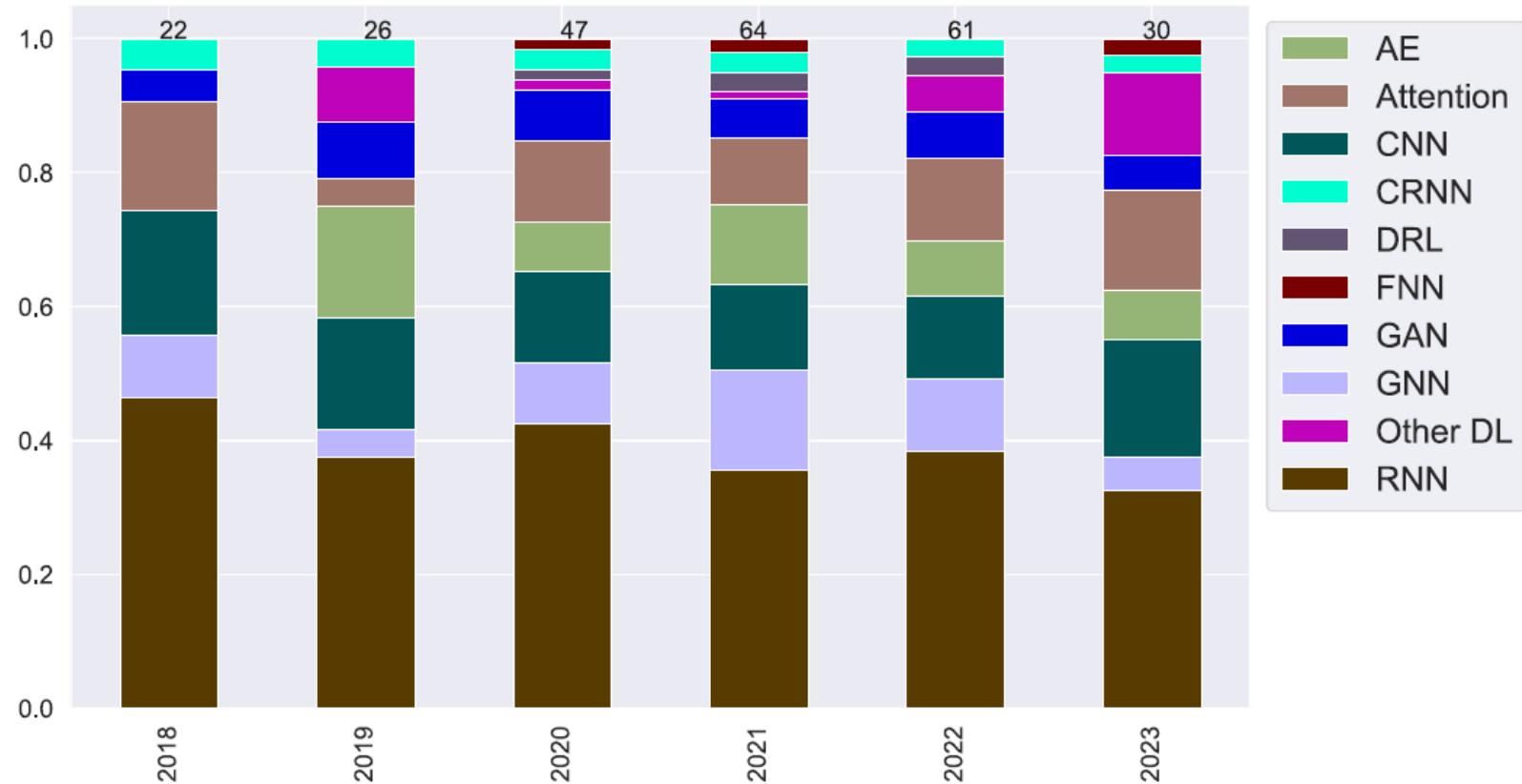


Fig. 3 Portions of publications by NN design from 2018 to 2023. Total number of publications per year is displayed at the top of each bar

EXAMPLES

3. TRAFFIC VOLUME PREDICTION [1/2]

Traffic volume prediction

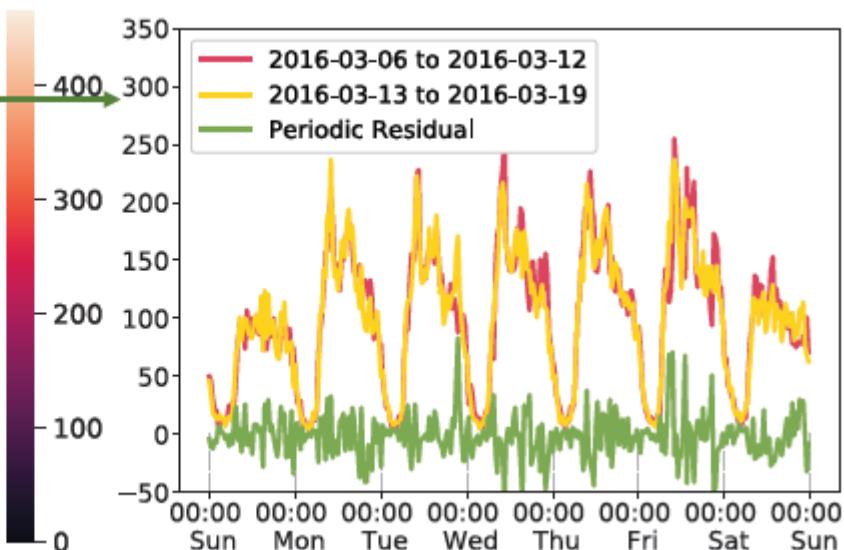
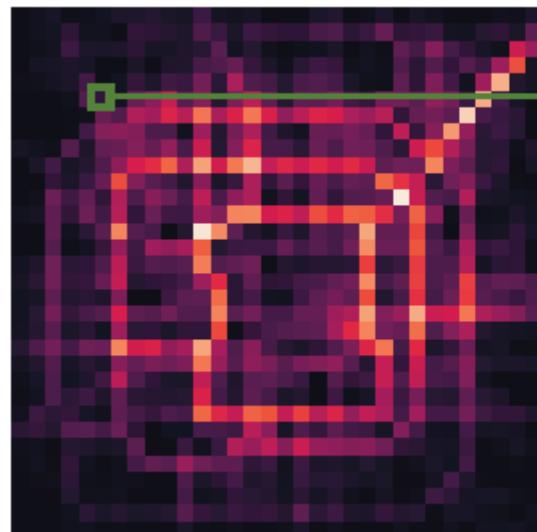
Lu (2021) CNN Traffic movies for 10 cities in 2019+2020 with
[24] (U-Net) 8 dynamic channels encoding traffic speed
and volume per direction and 9 static chan-
nels encoding the properties of the road maps

The multi-task learning randomly samples from all available city **traffic movies** (resolution: 495×436)

Wang et al. (2022) CNN Taxi trajectories from TaxiBJ in Beijing for 17 months and bike trajectories from BikeNYC in New York City for 6 months

Trajectories are converted to **flow/traffic movies** (32×32 for TaxiBJ & 16×8 for BikeNYC) with two dynamic channels encoding inflows and outflows

Li et al. (2021)
[33]



into a **movement**
enting the number
I phone tower node

to street network
etwork edge per

Buroni et al. (2021)
[11]

EXAMPLES

3. TRAFFIC VOLUME PREDICTION

Gao et al. (2022) [28] GCN+GRU Taxi GPS tracks in Xi'an, China collected from 1000 taxis for 3 months with a sampling interval of 5–30 s

Lippert et al. (2022) [34] Recurrent GNN Bird migration data in the form of trajectories and measurements from European weather radar network

Xue et al. (2022) [21] Transformers SafeGraph daily POI visit counts in NYC, Dallas and Miami

Zhang et al. (2020) [13] GAN Taxi GPS tracks in Shenzhen, China for 6 months

<i>Prompt A</i>	<p>Input: "Place-of-Interest (POI) 385 is a Limited-Service Restaurant. From June 17, 2020, Wednesday to July 01, 2020, Wednesday, there were 11, 11, 10, 12, 9, 12, 6, 13, 10, 15, 16, 8, 8, 13, 19 people visiting POI 385 on each day. On July 02, 2020, Thursday,"</p> <p>Target: "there will be 11 people visiting POI 385."</p>
-----------------	---

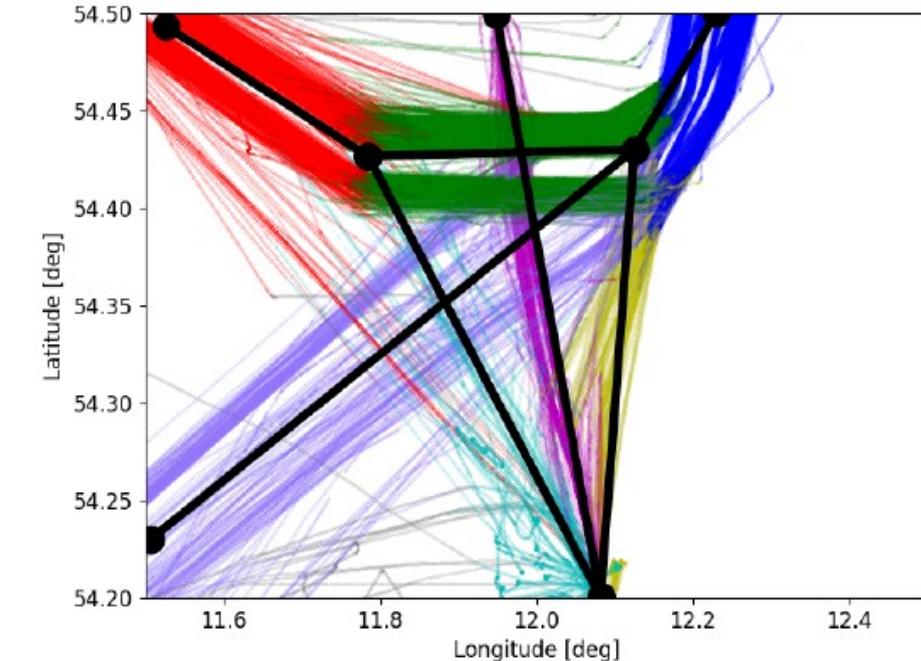
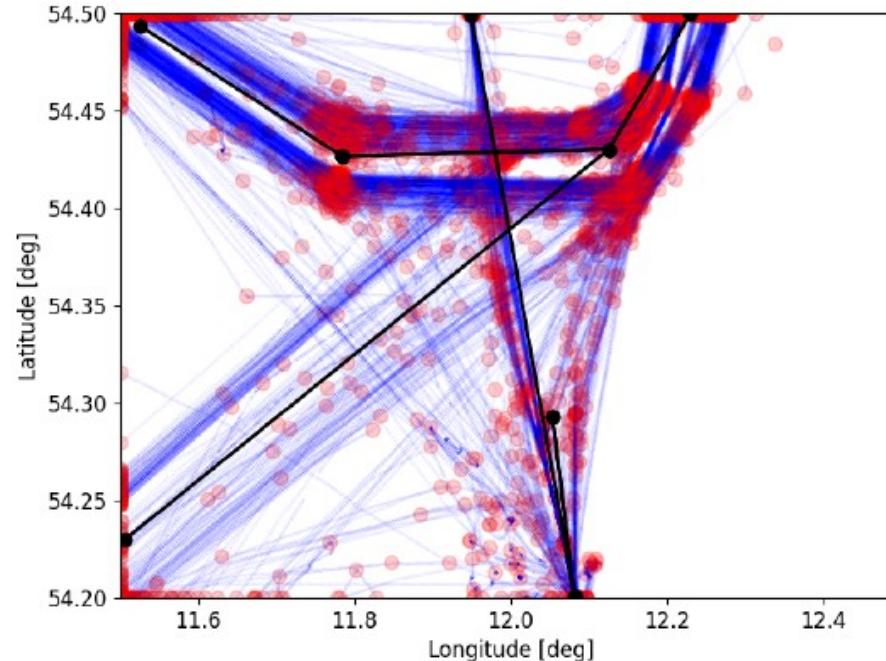
<i>Prompt B</i>	<p>Input: "From June 17, 2020, Wednesday to July 01, 2020, Wednesday, there were 11, 11, 10, 12, 9, 12, 6, 13, 10, 15, 16, 8, 8, 13, 19 people visiting POI Limited-Service Restaurant on each day. On July 02, 2020, Thursday,"</p> <p>Target: "there will be 11 people."</p>
-----------------	--

	<p>Historical visitation data are translated into natural language sentences to fine-tune pre-trained NLP models</p>
--	--

EXAMPLES

7. ANOMALY DETECTION

Anomaly detection	
Liat-sikou et al. (2021) [25]	LSTM-based AE
Nguyen et al. (2022) [42]	Probabilistic RNN



Singh et al. (2022) [43]	RNN regression model	Ship AIS tracks in the Baltic sea region and near Bremerhaven, Germany for two months (including a comparison between satellite-based and coastal AIS)
--------------------------	----------------------	--

Trajectories are resampled and interpolated at the 60s and converted into a **graph** with nodes representing turning points for the vessel trajectories and edges representing the sea lanes traveled by vessels

REPOSITORIES

Published implementations have not been substantially updated/maintained
→ Negative impact on potential for reuse



Design



Implementation

Table 4 Neural network implementations published together with their reviewed papers, ordered by ML library and stars

Ref	Model/System Name	Code Repository	Stars	Last updated
PyTorch				
[14]	DeepMove	https://github.com/vonfeng/DeepMove	131	08/19
[56]	DeepTTE with GEO-Conv layer	https://github.com/UrbComp/DeepTTE	127	06/20
[50]	DeepGravity	https://github.com/scikit-mobility/DeepGravity	57	12/21
[66]	Curb-GAN	https://github.com/Curb-GAN/Curb-GAN	25	02/20
[24]	n/a	https://github.com/mie-lab/location-mode-prediction	9	07/23
[34]	FluxRGNN	https://github.com/FionaLippert/FluxRGNN https://zenodo.org/record/6921595	3	07/22
[3]	Deep Train Arrival Time Estimator	https://github.com/basbuijse/train-arrival-time-estimator	2	07/21
[13]	n/a	https://github.com/fanzipei/crowd-context-prediction/tree/master	0	02/21
[60]	AuxMobICast	https://github.com/cruiseresearchgroup/AuxMobICast	0	11/22
[65]	TrajGen	https://github.com/tongjiyiming/TrajGen	0	10/20
TensorFlow				
[31]	n/a	https://figshare.com/articles/dataset/Prediction_of_human_activity_intensity_using_the_interactions_in_physical_and_social_spaces_through_graph_convolutional_networks/11829306/1	122	03/21
[44]	GeoTrackNet	https://github.com/CIA-Oceanix/GeoTrackNet	67	10/20
[51]	Uncertainty EDL Graph	https://github.com/sansastra/uncertainty_edl_graph	8	07/21
Keras				
[47]	LSTM-TrajGAN	https://github.com/GeoDS/LSTM-TrajGAN	42	01/23
[8]	CNN-SMMC	https://github.com/rechardchen123/Ship_movement_classification_from_AIS	19	04/20
[4]	Tutorial on traffic forecasting with DL	https://www.kaggle.com/code/giobbu/lstm-encoder-decoder-tensorflow	9	09/21
[33]	BMDA anomaly detection	https://github.com/marialatsikou/BMDA_anomaly_detection	0	02/21

The stars column lists the number of Github stars, Kaggle upvotes, or Figshare/Zenodo downloads of the respective repository as of July 2023

CONCLUSIONS

Mobility data engineering

- Common data preprocessing workflows should be standardized
- Further uptake of trajectory analysis libraries, such as Trackintel, MovingPandas & scikit-mobility

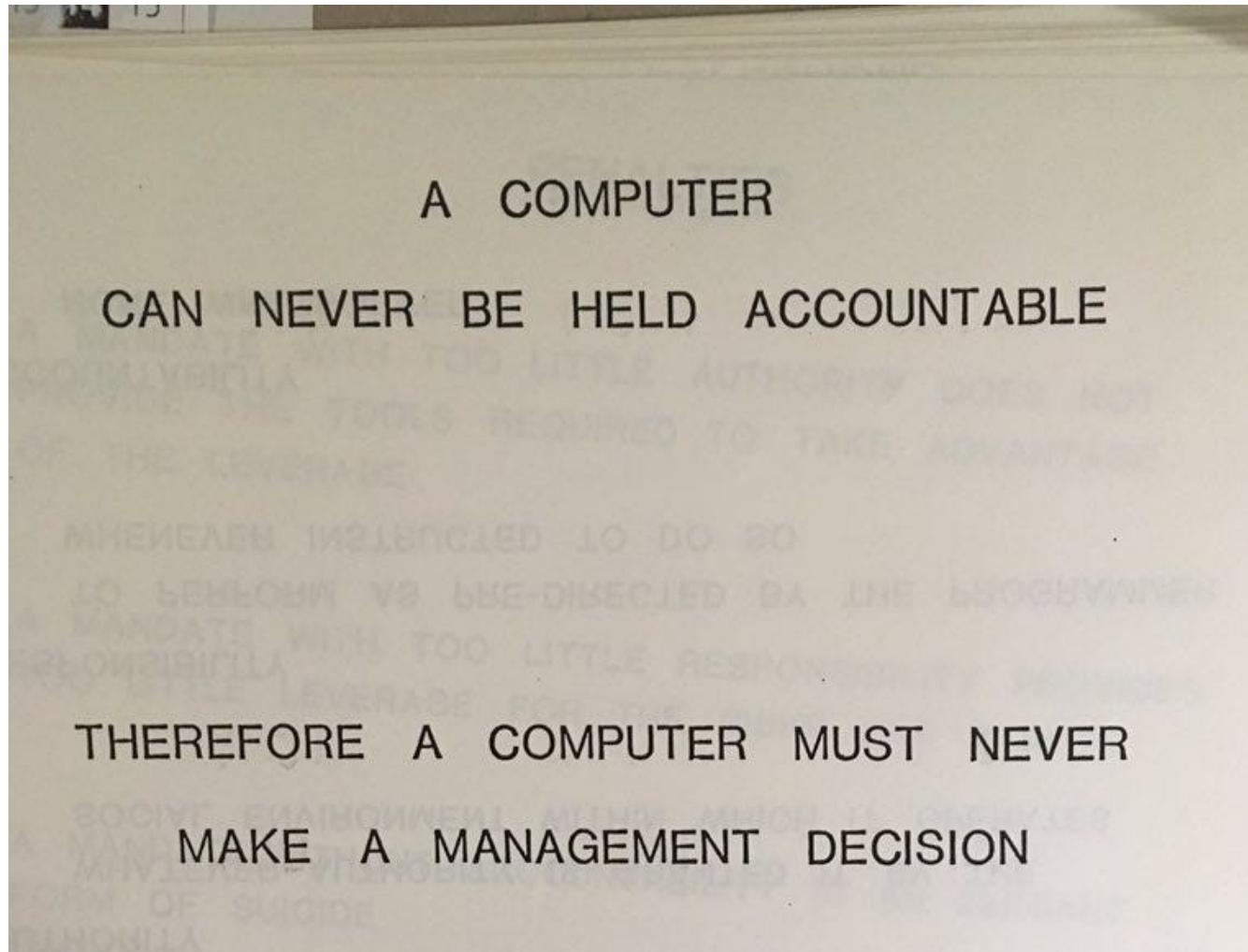
Neural networks research for mobility

- Expected increase in popularity of GNNs
- Reproducibility & reusability of results should be improved

Future research should address

- Model transferability
- Benchmark availability
- Model explainability

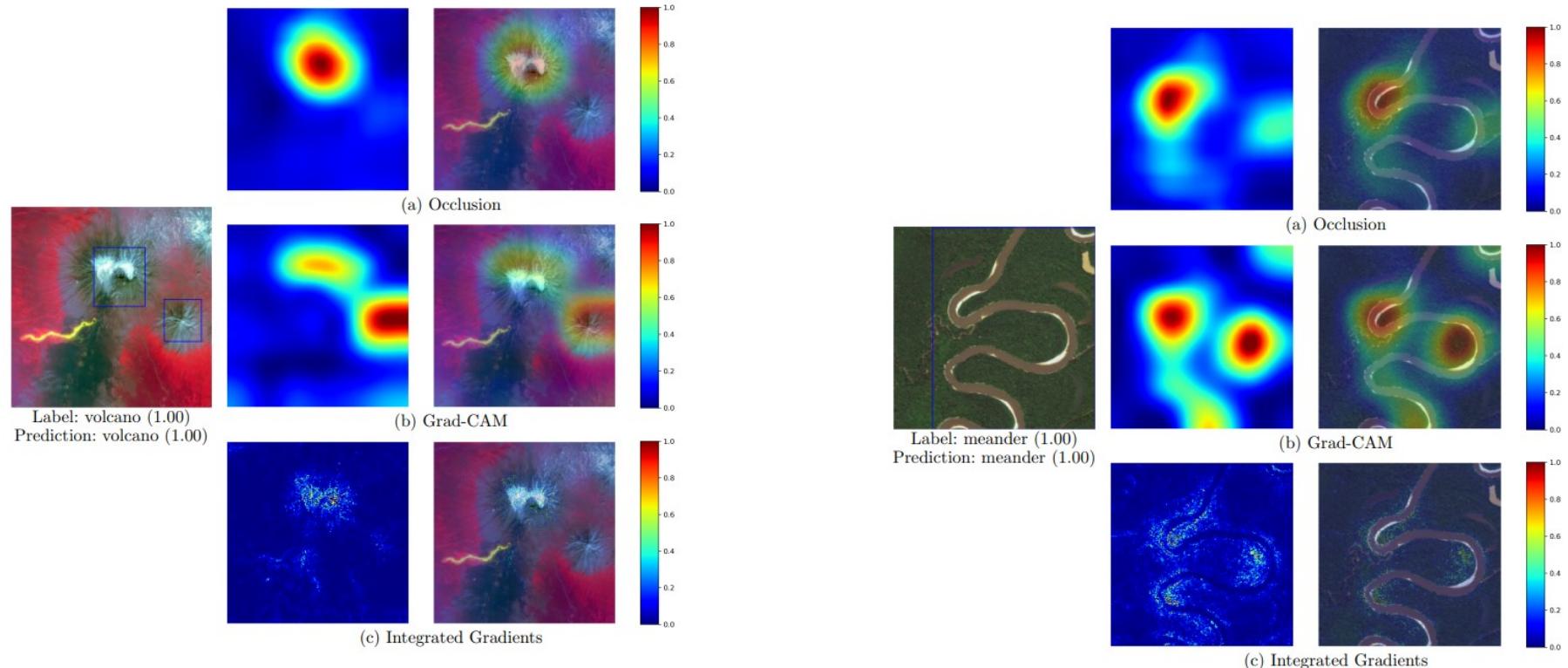
THE NEED FOR XAI FOR GEO



GEOSPATIAL EXPLAINABLE AI

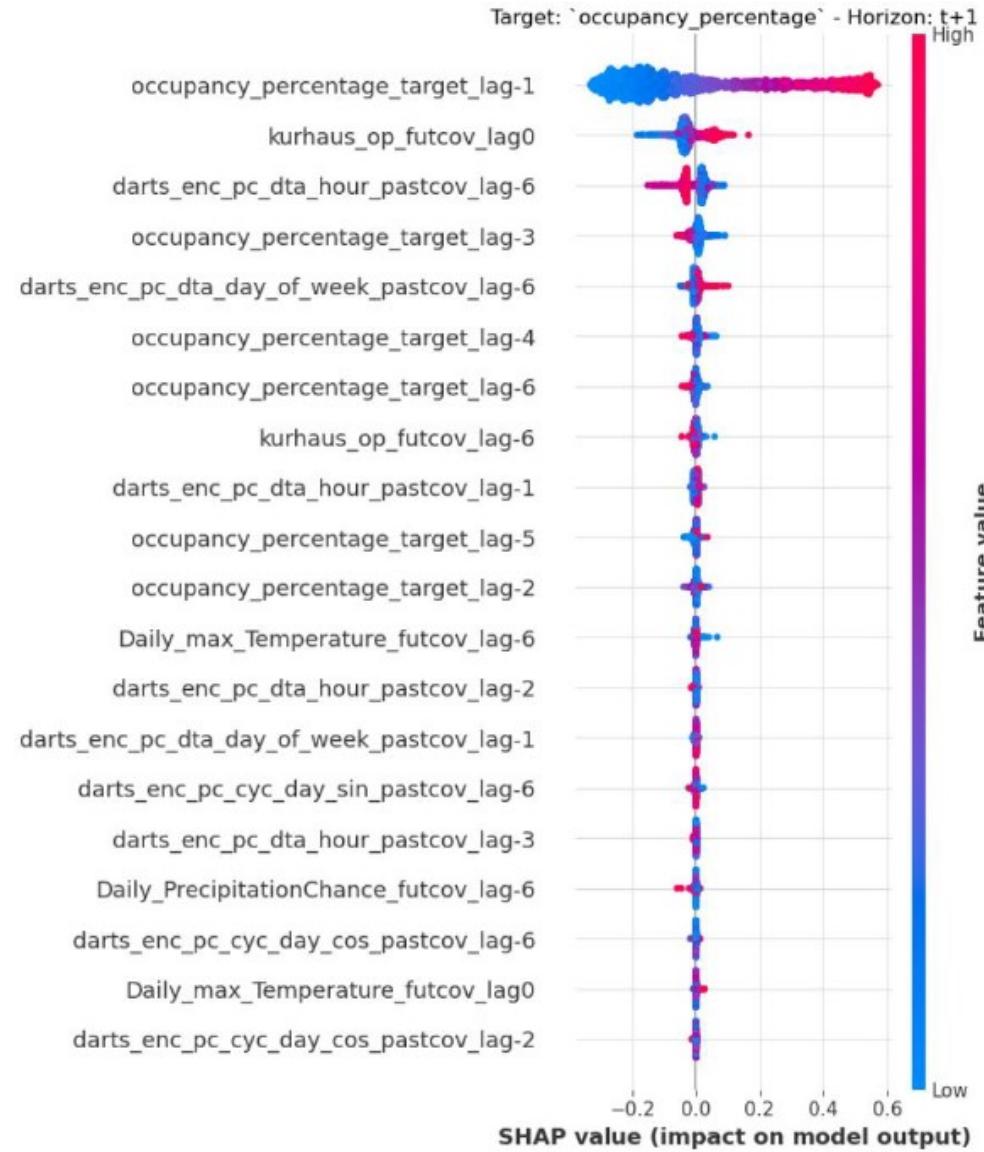
With this rise of **Geospatial AI** (GeoAI), there is a growing need for **explainability**, particularly for GeoAI applications where **decisions can have significant social and environmental implications**.

The challenges of integrating eXplainable AI into geoAI (Xing et al., 2022)



C.-Y. Hsu and W. Li. Explainable GeoAI: can saliency maps help interpret artificial intelligence's learning process? an empirical study on natural feature detection. International Journal of Geographical Information Science, pages 1–25, 2023

GEOSPATIAL EXPLAINABLE AI



GEOSPATIAL EXPLAINABLE AI

Prediction interval	Parking	XAI method	F1	Recall	Precision	Balanced Accuracy
22.07.21-22.11.01	Garage Parklaan	Surrogate DecisionTree	99.29%	99.67%	98.91%	99.67%

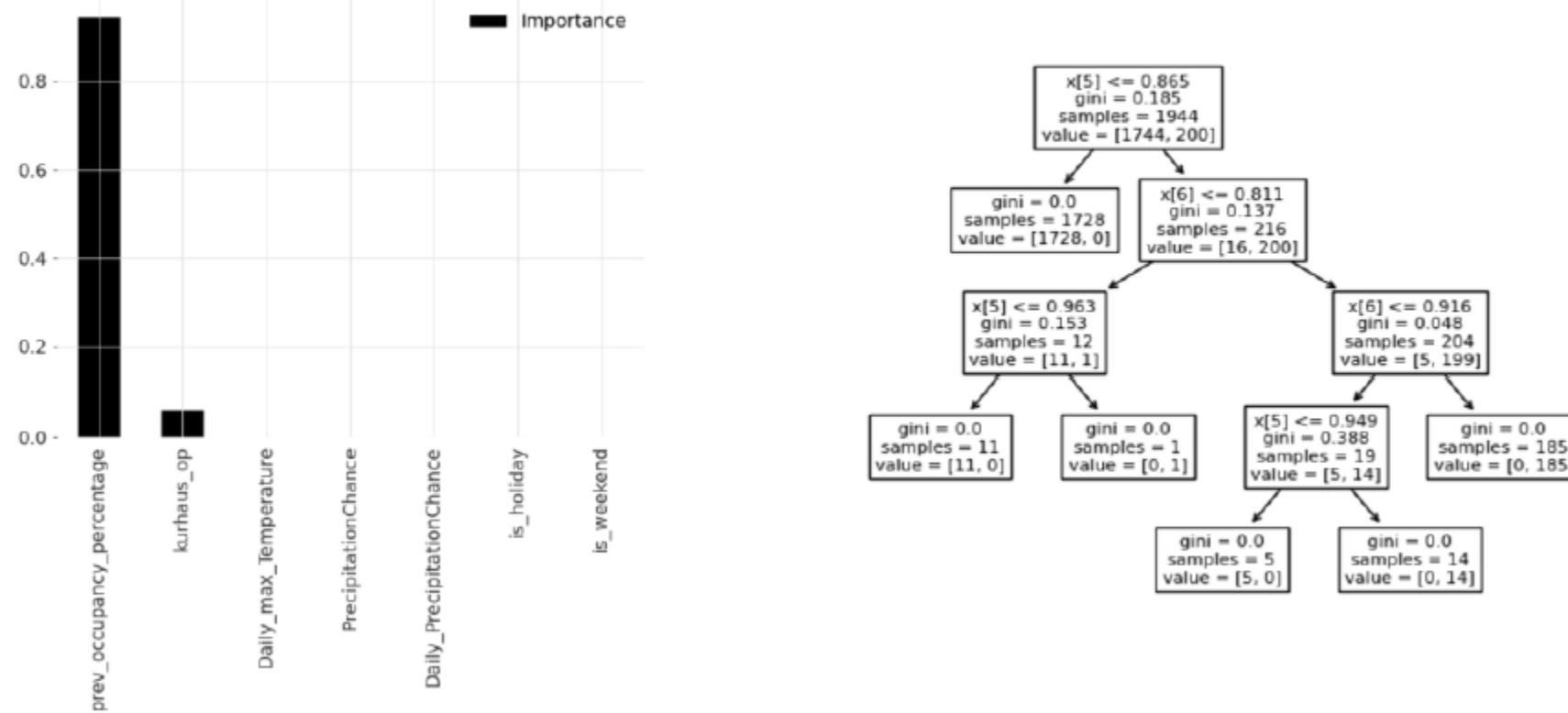


Figure 3-27: Illustration of the Global Surrogate decision Tree on Parklaan Adaboost Classifier.

GEOSPATIAL EXPLAINABLE AI

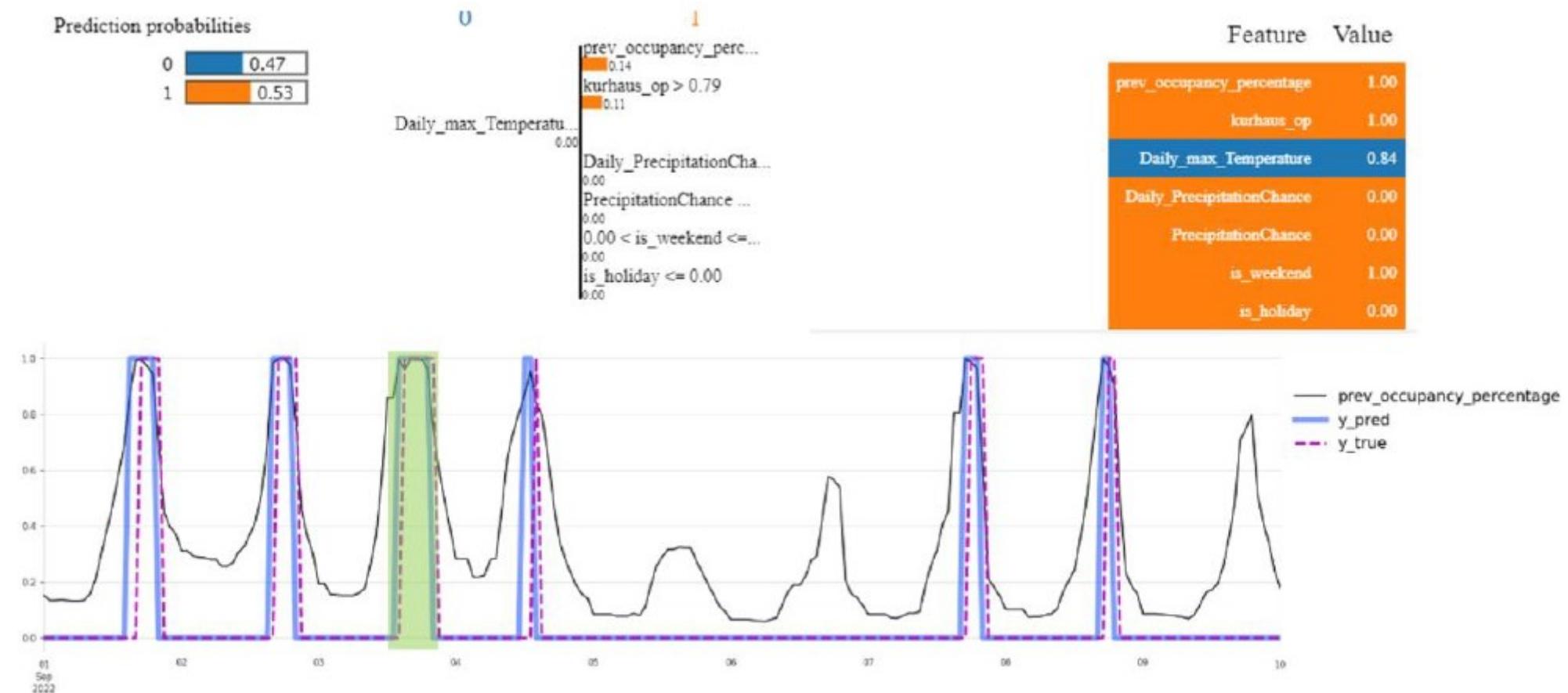
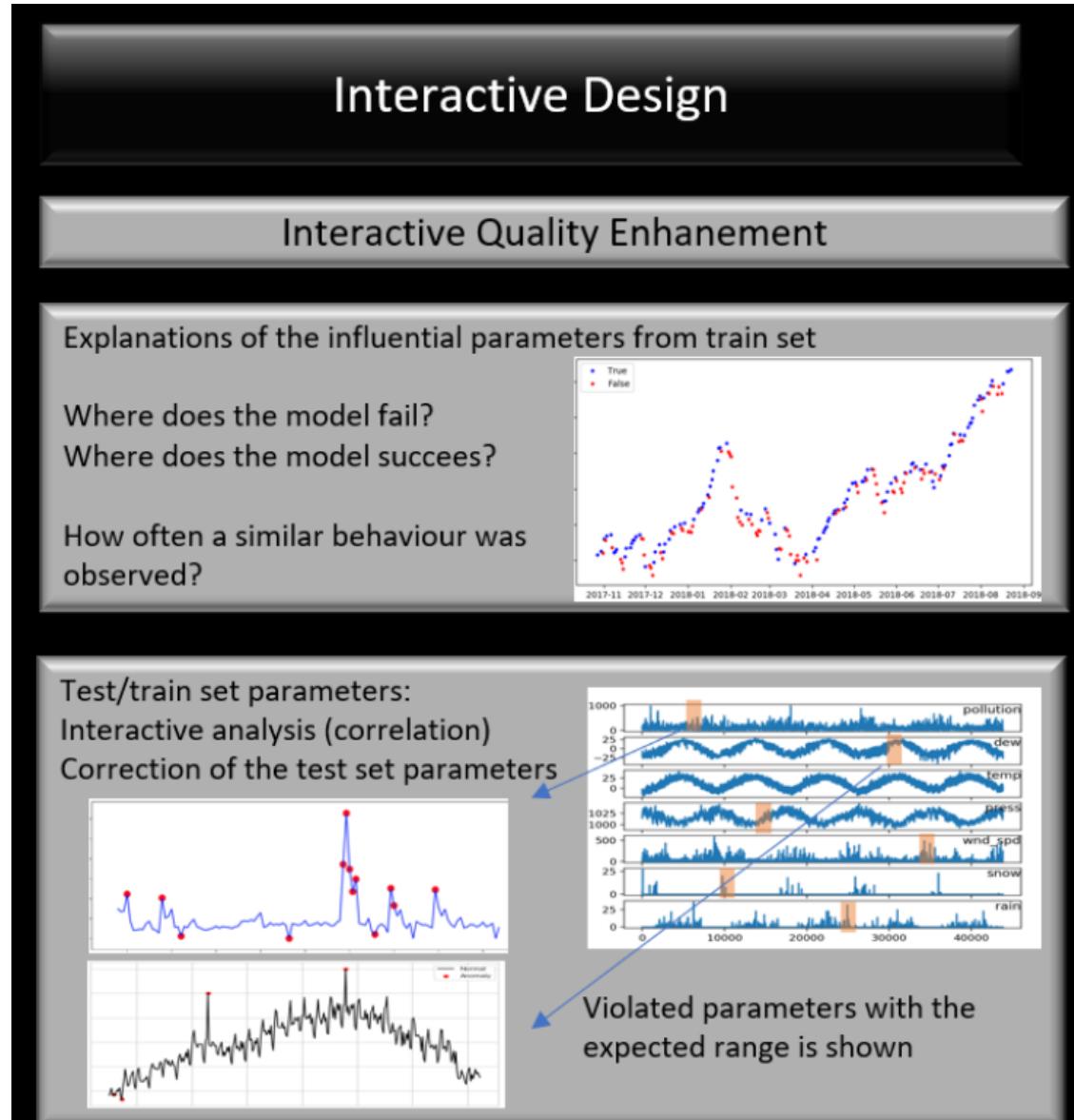
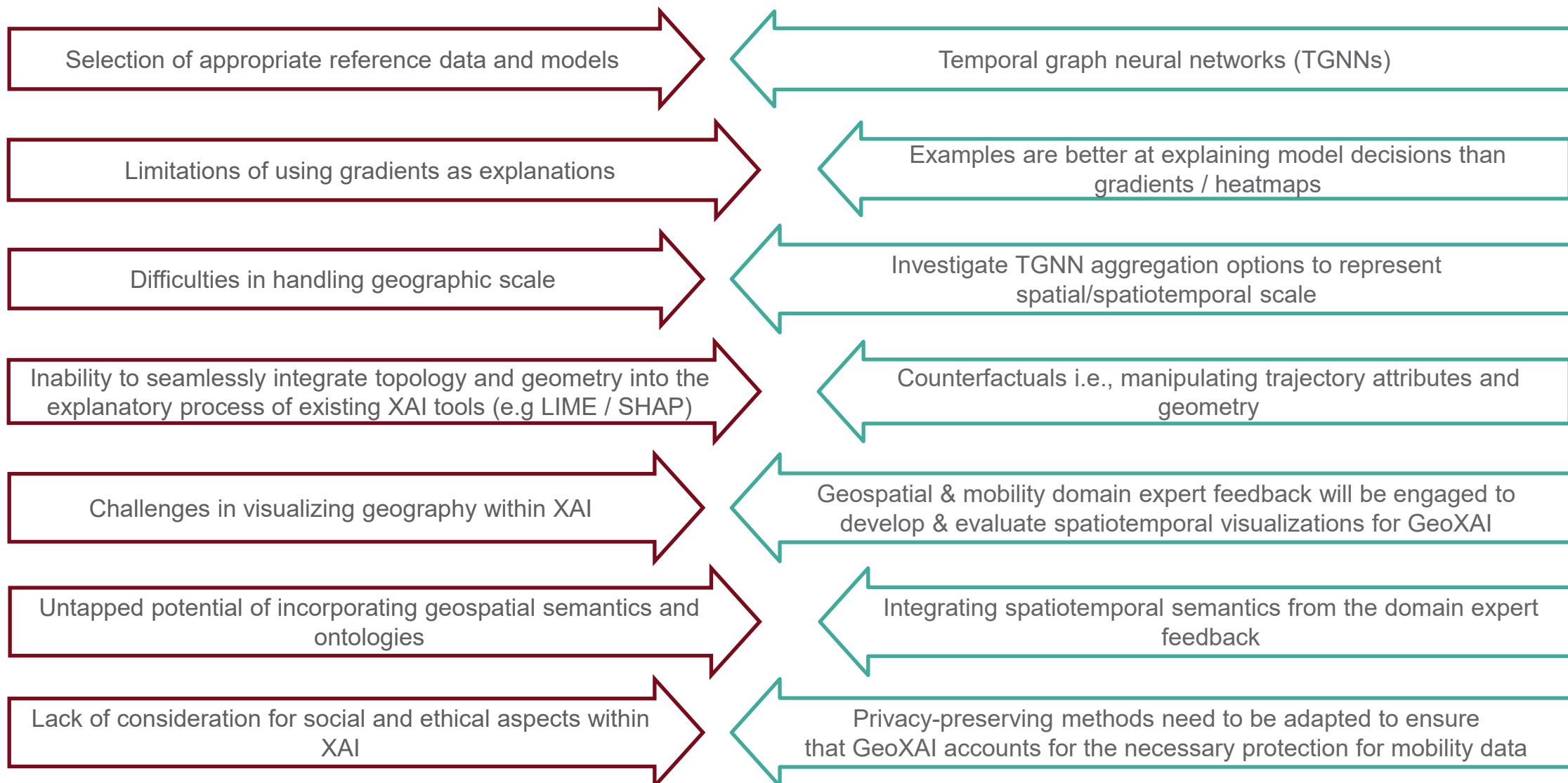


Figure 3-28. LIME's output on one true positive sample for Parklaan.



CHALLENGES OF XAI FOR MOBILITY



AI-BASED GI ASSISTANTS & HOW THEY WORK

1. ChatGPT

The dataset appears to contain geolocation data with the following columns:

1. X: Longitude coordinate.
2. Y: Latitude coordinate.
3. **fid**: Feature ID, a unique identifier for each row.
4. id: Identifier for a specific point in the trajectory.
5. **sequence**: Sequence number indicating the order of points.
6. **trajectory_id**: Identifier for the trajectory, which likely groups points that belong to the same journey.
7. **tracker**: Identifier for the tracking device or individual.
8. t: Timestamp indicating when the data point was recorded.

The dataset records geographic coordinates (longitude and latitude) along with additional identifiers and timestamps, likely used for tracking the movement of a device or individual over time. [→]

how long are the trajectories

The lengths of the trajectories in the dataset are as follows:

- Trajectory 1: 466 points
- Trajectory 2: 897 points
- Trajectory 3: 1810 points
- Trajectory 4: 1864 points
- Trajectory 5: 871 points [→]

calculate the geographic length of the trajectories using the geospatial information

To calculate the geographic length of the trajectories, we need to compute the distances between consecutive points in each trajectory and then sum these distances. We'll use the Haversine formula to calculate the distances between points based on their latitude and longitude coordinates.

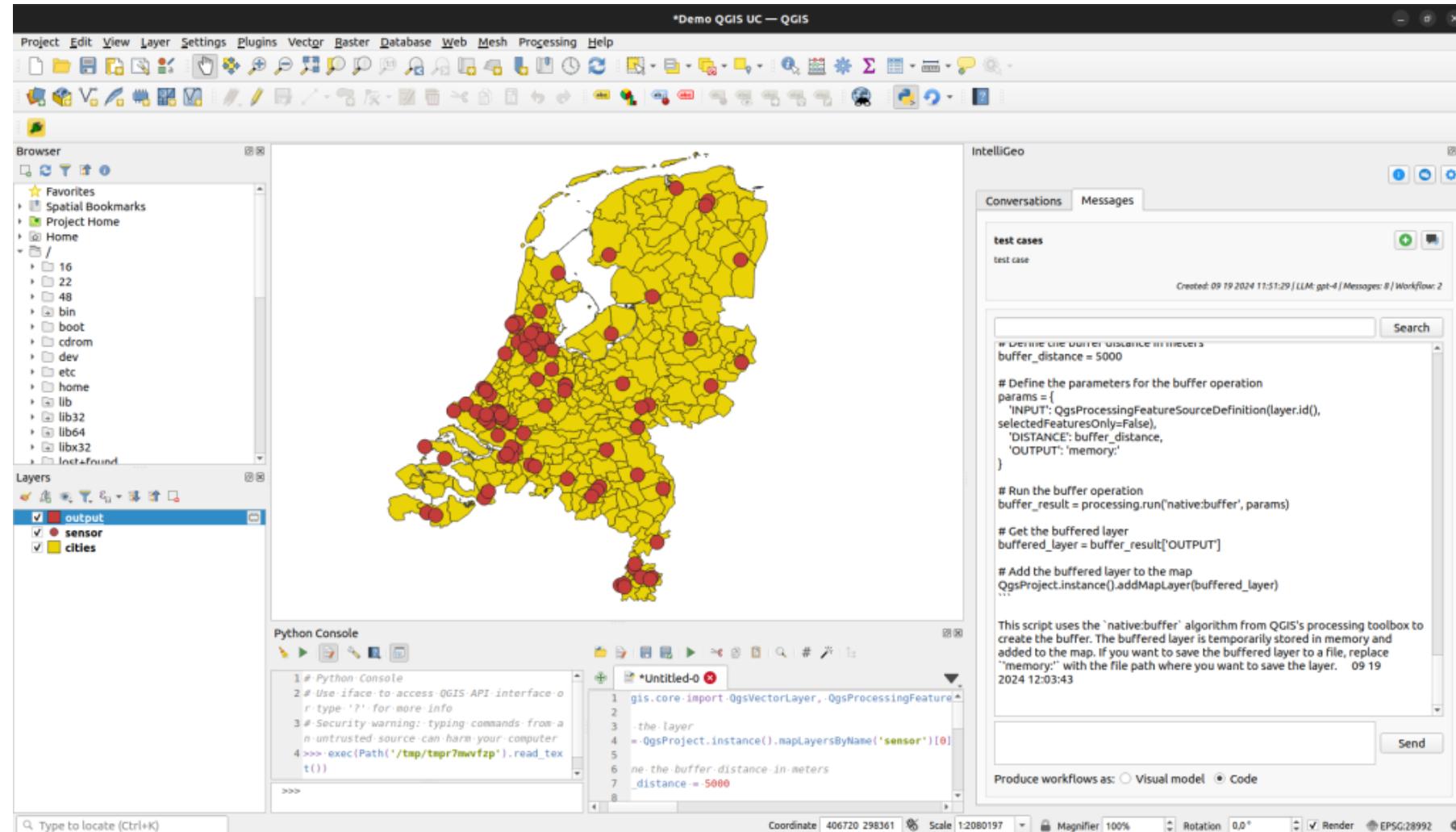
Let's proceed with this calculation.

The geographic lengths of the trajectories have been calculated and presented in the table. If you have any further questions or need additional analysis, feel free to ask! [→]

AI-BASED GI ASSISTANTS & HOW THEY WORK

2. IntelliGeo plugin

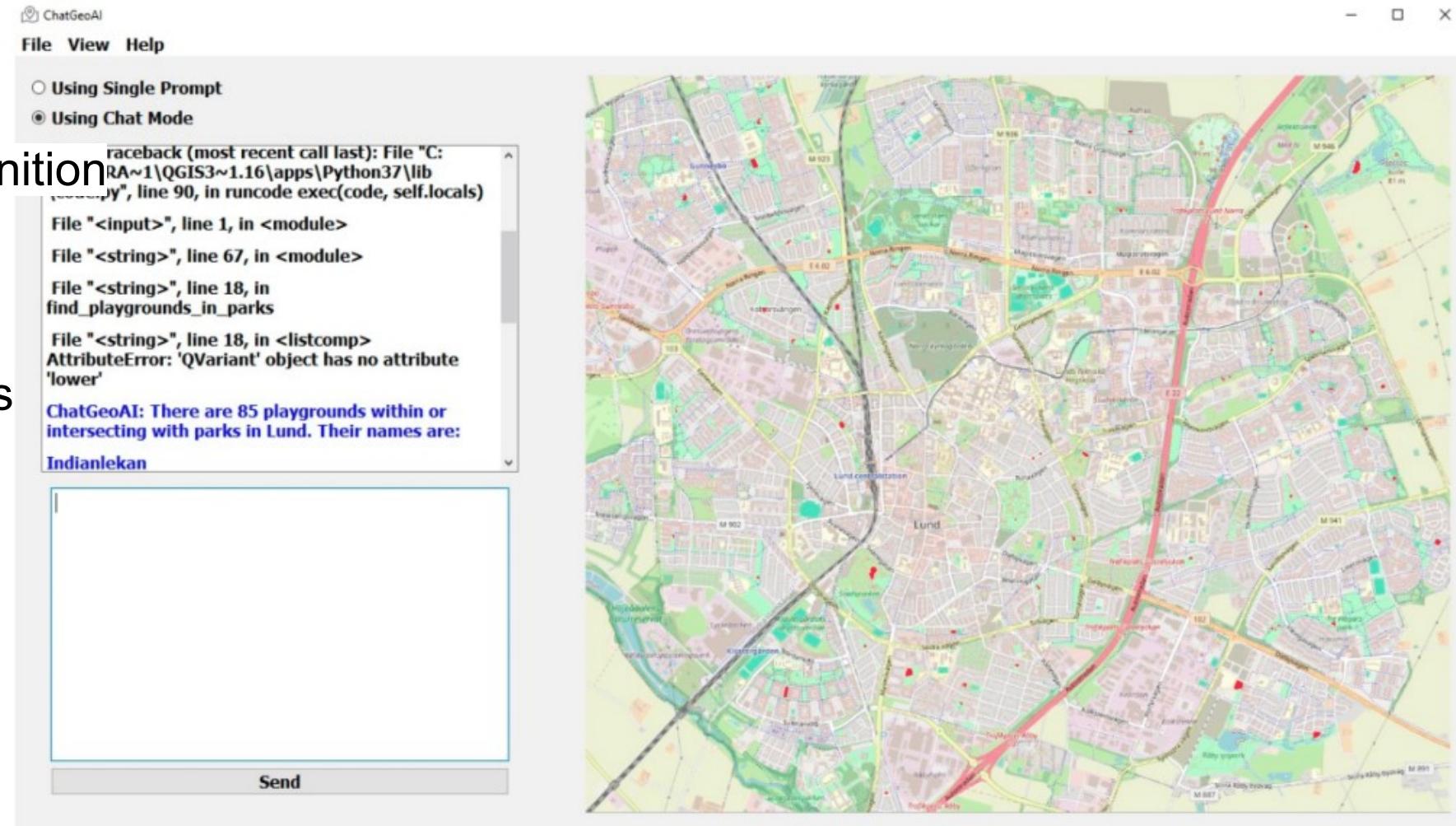
... generating PyQGIS scripts or graphical models



AI-BASED GI ASSISTANTS & HOW THEY WORK

3. ChatGeoAI

... fine-tuned Llama 2
 & spaCy for entity recognition
 & WorldKG ontology
 to write PyQGIS code
 that can perform
 geospatial analysis tasks
 on OSM data.



The image shows a screenshot of the ChatGeoAI application. At the top, there's a menu bar with 'File', 'View', and 'Help'. Below it, two radio button options are shown: 'Using Single Prompt' (unchecked) and 'Using Chat Mode' (checked). The main area contains a text-based conversation:

```

raceback (most recent call last):
  File "C:\RA~1\QGIS3~1.16\apps\Python37\lib\site-packages\qgis\processing\utils.py", line 90, in runcode
    exec(code, self.locals)
File "<input>", line 1, in <module>
File "<string>", line 67, in <module>
File "<string>", line 18, in find_playgrounds_in_parks
File "<string>", line 18, in <listcomp>
AttributeError: 'QVariant' object has no attribute 'lower'

ChatGeoAI: There are 85 playgrounds within or
intersecting with parks in Lund. Their names are:
Indianlekan
  
```

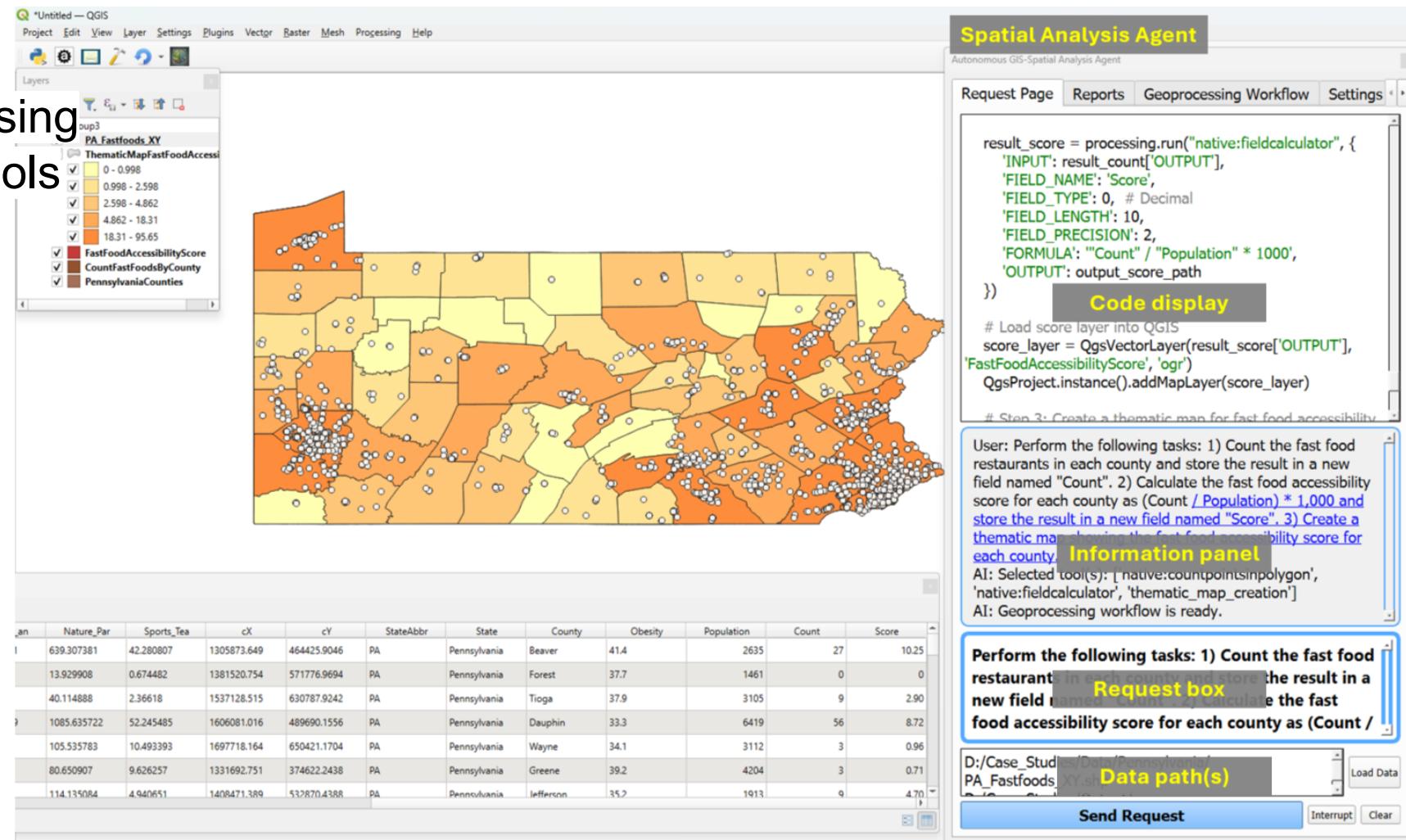
At the bottom of the text area is a large empty input box for typing messages, and a 'Send' button at the bottom right.

To the right of the application window is a detailed map of Lund, Sweden, showing streets, buildings, and green spaces. The map is color-coded by land use, with roads in black and green areas representing parks and playgrounds.

AI-BASED GI ASSISTANTS & HOW THEY WORK

4. SpatialAnalysisAgent

... leverages QGIS processing tools, and other external tools such as, e.g., Geopandas, Rasterio, seaborn, etc.



<https://github.com/Teakinboyewa/SpatialAnalysisAgent>

It doesn't matter if we are talking about classic ML, DL, or LLMs ... all GeoAI requires solid spatial data analysis software

MOBILITY DATA SCIENCE SOFTWARE DEV

Python

-  [PyMove](#): Python library to simplify queries and visualization of trajectories and other spatial-temporal data. (first GH commit: 2018-09-09)
-  [MovingPandas](#): Trajectory classes and functions built on top of GeoPandas. (first GH commit: 2018-12-16)
-  [Traja](#): Python tools for 2D spatial trajectory data. (first GH commit: 2019-01-13)
-  [trackintel](#): a framework for spatio-temporal analysis of movement trajectory and mobility data. (first GH commit: 2019-01-20)
-  [scikit-mobility](#): Mobility analysis in Python. (first GH commit: 2019-04-28)
-  [MovinPy](#): Process and analyze mobility data. (first GH commit: 2020-07-23)
-  [HuMobi](#): a library for human mobility analyses implemented in Python. (first GH commit: 2021-06-02)
-  [PTRAIL](#): parallel computation library for Mobility Data Preprocessing and feature generation. (first GH commit: 2021-05-31)
-  [TransBigData](#): transportation spatio-temporal big data processing, analysis and visualization. (first GH commit: 2021-10-17)

C++

- [Tracktable](#) (with Python API): moving object trajectory analysis in C++ and Python. (first GH commit: 2016-04-10)
- [MEOS](#) (with Python API): Mobility Engine, Open Source is a C++ library which makes it easy to work with temporal and spatio-temporal data. (first GH commit: 2020-04-19)
- [MoveTK](#): a library for computational movement analysis written in C++. (first GH commit: 2020-09-09)

R

- Review paper: [Joo, R., Boone, M. E., Clay, T. A., Patrick, S. C., Clusella-Trullas, S., & Basille, M. \(2020\). Navigating through the R packages for movement. Journal of Animal Ecology, 89\(1\), 248-267.](#)

Databases

- [MobilityDB](#): A geospatial trajectory data management & analysis platform, built on PostgreSQL and PostGIS. (first GH commit: 2019-02-17)
 - [mobilitydb-python](#): Python driver for MobilityDB.
 - [mobilitydb-sqlalchemy](#): MobilityDB extensions for SQLAlchemy

USAGE EXAMPLES

"GeoPandas and MovingPandas [...] were used to analyze the GPS data collected and calculate the thirteen spatio-temporal metrics"

Van Deursen et al. (2024). Recreation specialization: Resource selection functions as a predictive tool for **protected area recreation management**. **Applied Geography**.

"This framework extends MovingPandas, a widely used and open-source trajectory analytics and visualization tool."

Kotis & Soulardis (2023). ReconTraj4Drones: A Framework for the Reconstruction and Semantic **Modeling of UAVs' Trajectories** on MovingPandas. **Applied Sciences**.

"Stop points are extracted from the GPS trajectories using the Python framework MovingPandas"

Golze & Sester (2024). Determining user specific **semantics of locations** extracted from trajectory data. **Transportation Research Procedia**.

"The implementation combines several open source tools such as Python, MovingPandas library, Uber H3 index, Neo4j graph database"

Elayam et al. (2022). A hierarchical **graph-based model for mobility data** representation and analysis. **Data & Knowledge Engineering**.

"The historical voyages are processed with the movingpandas library"

Lei et al. (2024). **Predicting vessel arrival times** on inland waterways. **Ocean Engineering**.

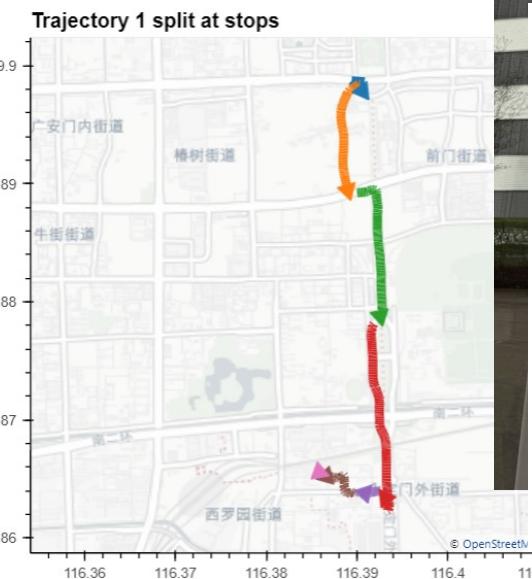
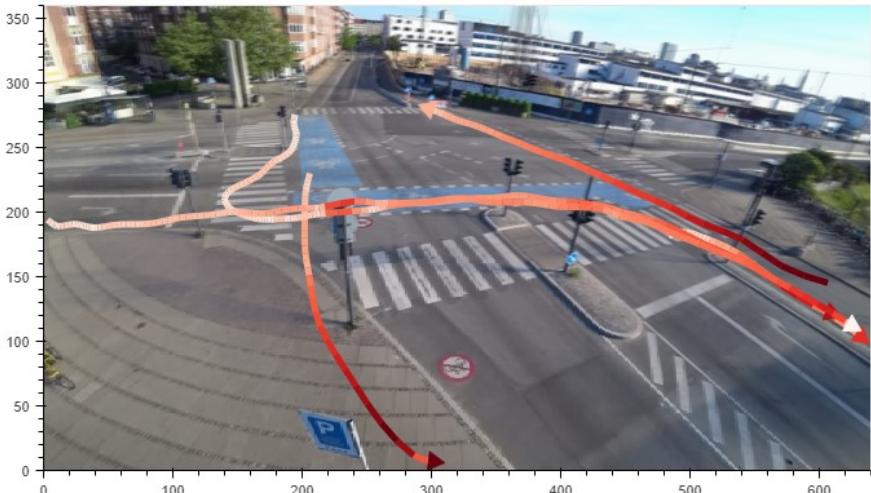
"We combined the Python libraries scikit-Mobility and MovingPandas to pre-process position data"

Depellegrin et al. (2020). The **effects of COVID-19 induced lockdown measures** on maritime settings of a coastal region. **Science of the Total Environment**.

<https://github.com/movingpandas/movingpandas?tab=readme-ov-file#scientific-publications-using-movingpandas>

SCIENTIFIC SOFTWARE DESIGN CHOICES

- Accessibility
 - e.g. ease of installation, onboarding of new contributors
- Generalizability vs. specialization
 - Human / animal / vehicle / other movement
 - Geographic coordinates \leftrightarrow any coordinates
 - Processing \leftrightarrow Exploration



MOVINGPANDAS INTEGRATIONS



- The free analysis platform for animal tracking data hosted by the Max Planck Institute of Animal Behavior uses MovingPandas TrajectoryCollections as their default Python IO type.



- This QGIS plugin integrates mobility analytics tools from various libraries (including MovingPandas) into a common toolbox



- MovingPandas is available on cloud platforms such as Snowflake which power SaaS offerings such as [carto.com](#)



<https://carto.com/blog/urban-mobility-insights-with-movingpandas-carto-in-snowflake>

Model Edit View



Algorithms

- Vector geometry
- Vector overlay
- Vector selection
- Vector table
- Vector tiles
- Bivariate Polygon Renderer
- DataPlotly
- GDAL
- Hqgis
- Models
- ORS Tools
- qgis2web
- QuickOSM
- Scripts
- Trajtools
 - Basic
 - Create trajectories
 - Event extraction
 - Extract OD points
 - Extract stop points
 - GTFS
 - Extract segments
 - Extract shapes
 - Privacy
 - Home and work attack
 - Trajectory overlay
 - Clip trajectories by extent
 - Clip trajectories by polygon la...
 - Intersect trajectories with pol...
 - Trajectory splitting
 - Split trajectories at observatio...
 - Split trajectories at stops
 - Split trajectories at time interv...

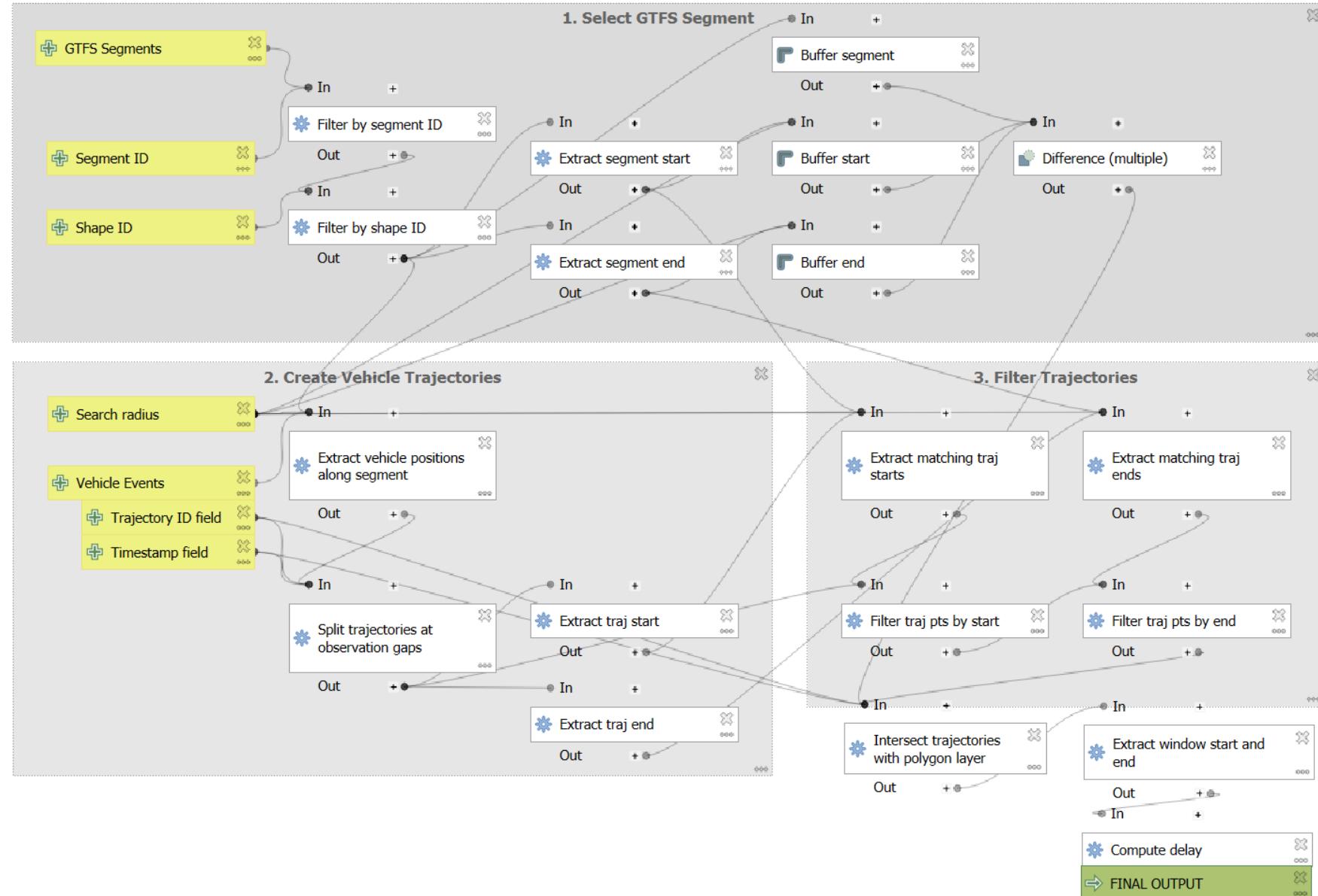
Inputs Algorithms

Model Properties

Name UC3_PTTravelTime_v5

Group EMERALDS

Variables Model Properties





> START



OUTPUT



Workflows

EMAC23 WF -
Interaction with
human
infrastructure

example fishers in New York

My Apps

App Browser

User Manual

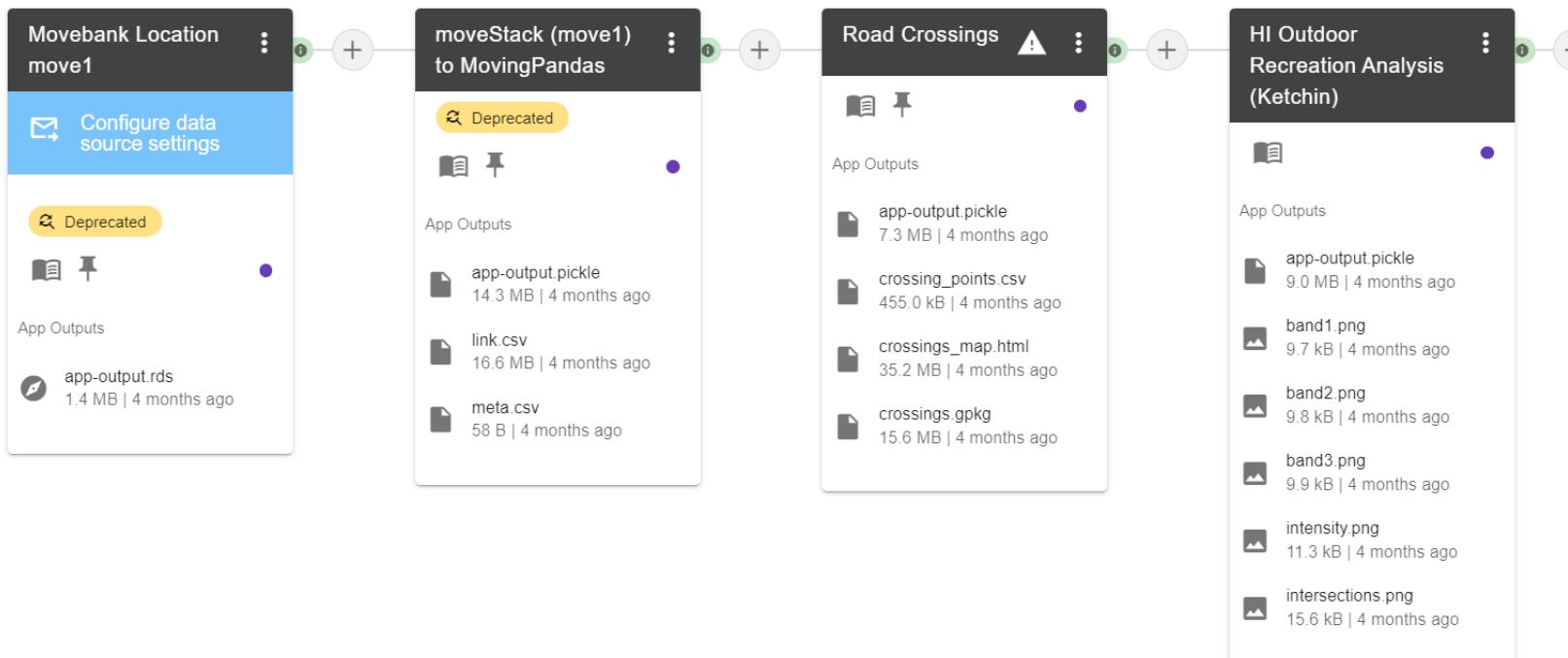
Forum

News: App Deprecation

EMAC23 WF - Interaction with human infrastructure: example fishers in New York •

Workflow *EMAC23 WF - Interaction with human infrastructure*

To minimise the constantly growing conflict between humans and wildlife in areas like southern and eastern Africa, interactions of wild animals with human infrastructure like roads, fences or villages have to be quantified. Such could allow the extraction of hotspots of interaction and define possible mitigation measures. Write an App that indicates where tracked animals interact with some type of man-made structure, focus to extract either main sites or times of conflict and related interesting behaviour. Use freely available environmental data like open street map.



General MoveApps Terms

Privacy Policy

Software Policy

Citation Guidelines

Imprint



Workflows



My Apps



App Browser



User Manual



Forum



News: Resource Increase

App Browser

MoveApps makes analysis Apps available for interactive use in workflows. See below a list of all Apps with Categories and other information. Apps can be searched by Name and Keywords or filtered by Class(es) and/or Category(s). Click an App name to be directed to the App Details that also contain links to the documentation, code and issues.

Use Apps of the category **Translator** to translate your data into an alternative data type and then be able to use more Apps with additional functionality, for details see "[How to connect Apps with Translators](#)".

 Search
 movin

Class

Category

App ↑	Classes	Categories	Input / Output
 move2_loc to MovingPandas <small>mapping R poc transformation Python</small>	Helper	Translator	 move2::move2_loc  MovingPandas.TrajectoryCollection 
 MovingPandas to move2_loc <small>mapping R poc transformation Python</small>	Helper	Translator	 MovingPandas.TrajectoryCollection  move2::move2_loc 



Include deprecated Apps

Rows per page:

100 

1-2 of 2



TRENDS & CHALLENGES

Increasing number of mobility data science tools

Persistent fragmentation of the research community

Ongoing stream of methodological / ML publications

Increasingly stricter data privacy regulations

Research into privacy-protecting solutions

Centralization of AI

Fragmented developer & user base

Reinventing the wheel & no critical mass

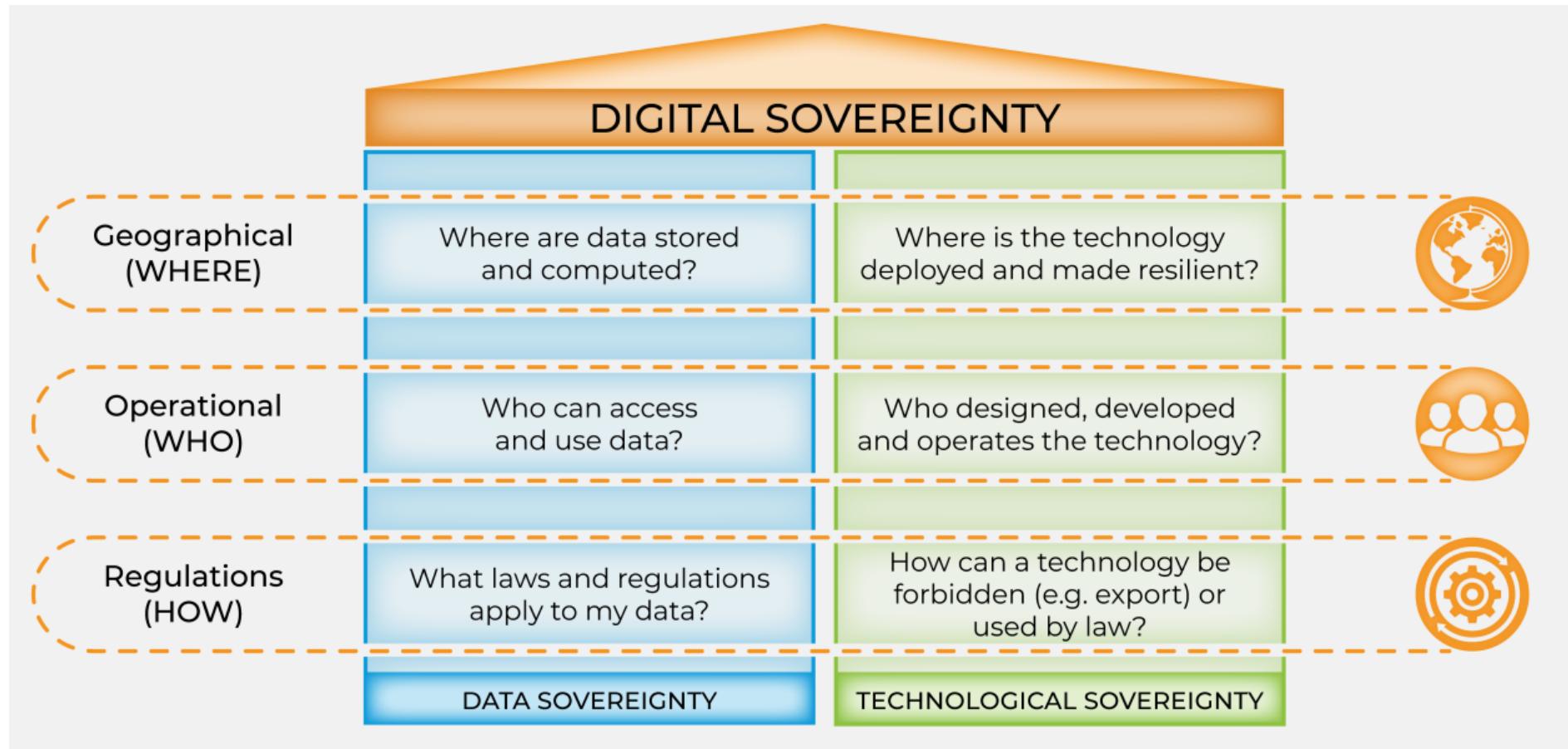
Comparisons hampered by lack of common benchmarks

Limits reproducibility of case studies

Lack of commonly agreed best practices

Focus on digital sovereignty needed

DIGITAL SOVEREIGNTY

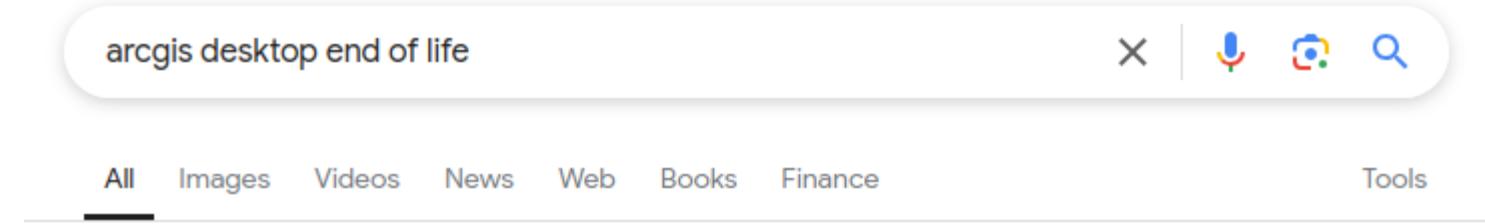


Original creativity: Atos | Infographic redesign by Antonio Grasso

 @antgrasso

 @agrassoblog

DIGITAL SOVEREIGNTY



Note: ArcGIS Desktop is in mature support and will be retired **March 1, 2026**. There are no plans for future releases of ArcGIS Desktop, and it is recommended that you migrate to ArcGIS Pro. See Migrate from ArcMap to ArcGIS Pro for more information.



Esri

<https://desktop.arcgis.com> > system-requirements > latest



[ArcGIS Desktop 10.8.x system requirements](#)

DIGITAL SOVEREIGNTY

what version of geopandas are you using?

Analyzed ^

```
python
import geopandas as gpd

# Display the version of GeoPandas
gpd.__version__
```

Always show details |  Copy code

Result
 '0.10.2'

 0.10.2
 Oct 16, 2021

I'm using **GeoPandas version 0.10.2**. This version might have compatibility issues with some geometries or newer `shapely` objects, which is likely causing the errors. Upgrading to a more recent version (e.g., 0.12 or later) might resolve these issues. [i-]

What Version is in your training data?

 My training data includes information up to September 2021. At that time, the latest version of GeoPandas was **0.9.0**, released on February 28, 2021. Subsequent updates, such as versions 0.10 and later, are not covered in my training data.

DIGITAL SOVEREIGNTY

As part of this effort, please note the following changes to Earth Engine:

- Starting **September 16, 2024**, we will begin limiting [quotas*](#) for accounts without Cloud projects, and most new Earth Engine features will only be available to users of Cloud projects.
- Starting **November 13, 2024**, all Earth Engine access will require a [Cloud project](#).



Koen Hufkens, PhD [koen_hufkens](#) 71d

This has been a long time coming, and not the end of it either. The slow squeeze of Google Earth Engine has started.

First came the commercial offerings, now they are pushing people by default to Google Cloud (i.e. have your credit card on the ready).

For those on the free tier, you will see less capacity (stronger quota). And, you will be squeezed, again and again. The market uptake is high enough, so the free ride is over.

#GoogleEarthEngine #GEE #Google #enshitification

https://mastodon.social/@koen_hufkens/113148137617417272

DIGITAL SOVEREIGNTY



OSGeo

Projects ▾ Resources

The Open Source Geospatial Foundation

QGIS

GDAL

GeoPandas

Welcome JS tags.html.js x

```
1 module.exports = (scope) => `<div class="tags">
2 ${scope.tags.map(tag => `
3 ${() => { tag.classes = (
4 .p(tag.name.matches('
5 ))).join('') }}${tag.name}>
6 <a href="${tag.link}" class="tag">
7 ${tag.name}</a></div>`;
8`)
```

(🔥)

JS article.html.js x

```
1 module.exports = (scope) => `<article>
2 <header>
3 <h1><a href="${scope.link}">${scope.title}</a></h1>
4 </header>
5 ${require('./tags.html.js')(scope)}
6 <div>
7 ${scope.body}
8 </div>
9 </article>`;
10`)
```

Run LLMs Locally Using Ollama

JS video.html.js x

```
1 module.exports = (scope) => `<article>
2 <header>
3 <h1><a href="${scope.link}">${scope.title}</a></h1>
4 </header>
5 ${require('./tags.html.js')(scope)}
6 <div>
7 ${scope.body}
8 </div>
9 </article>`;
10`)
```

ANITA GRASER

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