EuroFab Final Review

Eurofab team

2025-05-30

Agenda

1. Project overview
2. Morphometric model
3. AI vision model
4. Stakeholder engagement
5. Future work
6. Discussion

temporal dimension

structure of human settlements

Why urban fabric

Cities take up around 3% of the planet’s land but are home to more than half of humanity and responsible for 75% of carbon emissions[1].

1. United Nations (2020)

Why urban fabric

Urban fabric, the spatial layout of the physical elements that make up a city, mediates most activities their residents undertake, from heating their homes to accessing services, jobs and opportunities through sustainable modes of transport.

Why urban fabric

Easily available, comparable, and dynamic information on urban fabric would unlock new ways of understanding how cities are constantly evolving, what it means for their sustainability, and how effective policies can be designed to steer development in desirable directions.

Why now

In 2023, UN Habitat included urban fabric as one of the key ingredients required for effective sustainable design[1]

1. UN Habitat (2024)

Why now

There are currently very few instances of detailed, consistent, and scalable measurements of urban fabric and virtually none of them provide insight into its change over time.

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EuroFab vision

EuroFab paves the road for a world where stakeholders, from local authorities to supranational organisations, are able to track and monitor the pattern of urban development in detail directly relevant for planning and at scale.

we're getting there

Objectives

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Technical objectives

1. Specify, develop, and validate innovative methods integrating raster (satellite) and vector data in rich and explainable characterisations of urban fabric.

Technical objectives

2. Test the comparative performance of transformer-based (foundation) vision models against the baseline of convolution-based neural networks.

Technical objectives

3. Evaluate the selected models on two European regions.

Technical objectives

4. Develop open-source software, algorithms and open datasets that ensure the sustainability and usability of the project outputs beyond the initial funding period.

Technical objectives

5. Create the roadmap for a large-scale inference chain (i.e. covering all of Europe or parts of the globe) for the capability being developed.

Where we are

2.10.2 Bar/Gantt chart

WP code	Lead	WP Title	Time in months since KO											
			1	2	3	4	5	6	7	8	9	10	11	12
WP000	**CUNI**	**Project Management and Communication**												
WP100	**CUNI**	**Collaborative Stakeholder Requirements Consolidation**												
WP101	CUNI	Stakeholder mapping and context definition												
WP102	CUNI	Stakeholder requirements specification												
WP103	CUNI	Expert consultation												
WP200	**CUNI**	**Iterative Algorithm Design and Data Collection Sprints**												
WP201	CUNI	Morphometric Classification Homogenisation Protocol Development												
WP202	Turing	AI model design												
WP203	CUNI	Input data collection and preprocessing												
WP300	**Turing**	**Incremental Development and Processing Algorithm Implementation**												
WP301	CUNI	Morphometric Classification Homogenisation Protocol Development												
WP302	Turing	AI model development and training												
WP400	**CUNI**	**Verification of Novel Processing Capability in Representative Use Case and Results Dissemination**												
WP401	CUNI	Morphometric classification verification												
WP402	Turing	AI model inference and verification												
WP500	**Turing**	**Large-scale Inference and Operationalization Strategy Elaboration**												
WP501	CUNI	European morphometric classification strategy												
WP502	Turing	European space-time urban fabric strategy												
WP503	CUNI	Scaled up stakeholder engagement												
Deliverables														
MoM		Minutes of Meetings			x		x		x		x	x	x		x
MA		Meeting Agendas		x		x		x		x	x	x			
MPR		Monthly Progress Reports	x	x	x	x	x	x	x	x	x	x	x	x	
DF		Final Report												x	
ES		Executive Summary												x	
CCD		Contract Closure Document													x
D1		Technical note: Consolidated Stakeholder Requirements Specification				x									
D2		Technical Note: Algorithm Design and Theoretical Basis Description				x									
D3		Technical Note: Reference Data Selection				x									
S1		Software: AI Method for Urban Fabric classification and morphometric characterization									x			x	
D4		Technical Note: Test and Verification Results									x				
D5		Stakeholder Impact and Utility Assessment									x				
D6		Example datasets generated during Verification Exercises									x				
D7		Outreach and Communication Package												x	
D8		Technical Note: Large scale inference and Operationalisation Roadmap												x	
Meetings															
Kick Off			x												
Progress Meeting				x				x		x		x			
Design Review						x									
Operations Review											x				
Final Meeting															x
Milestones															
MS1								x							
MS2														x	

Morphometric model

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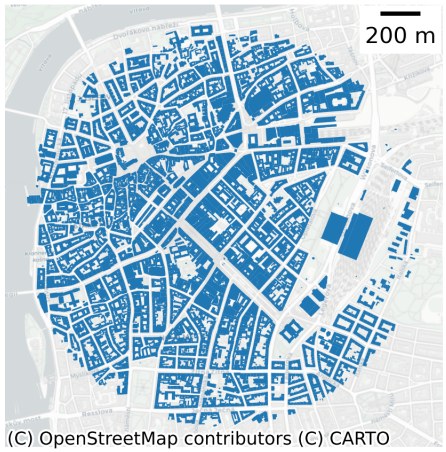
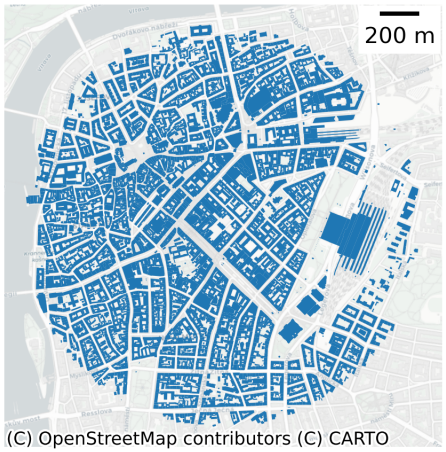
Morphological elements

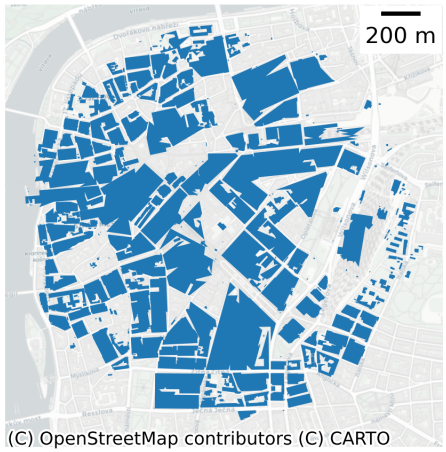
Cadastre buildings



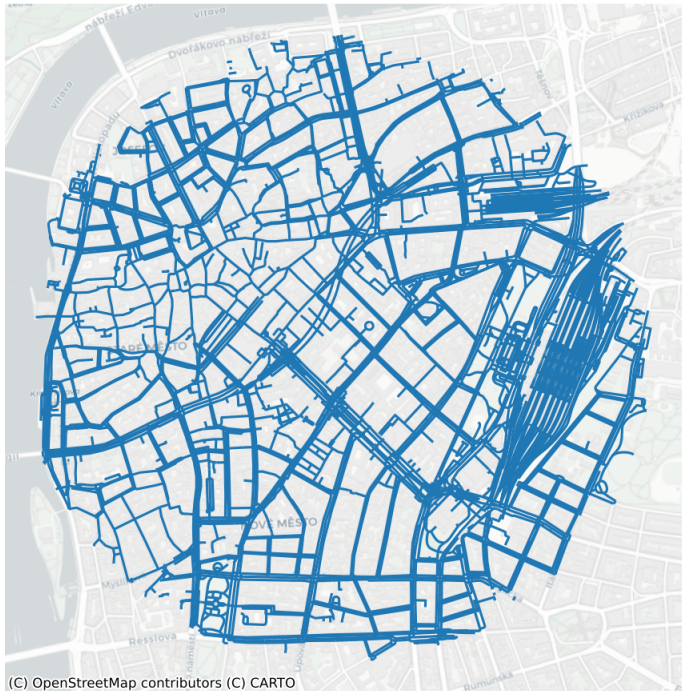
OV buildings



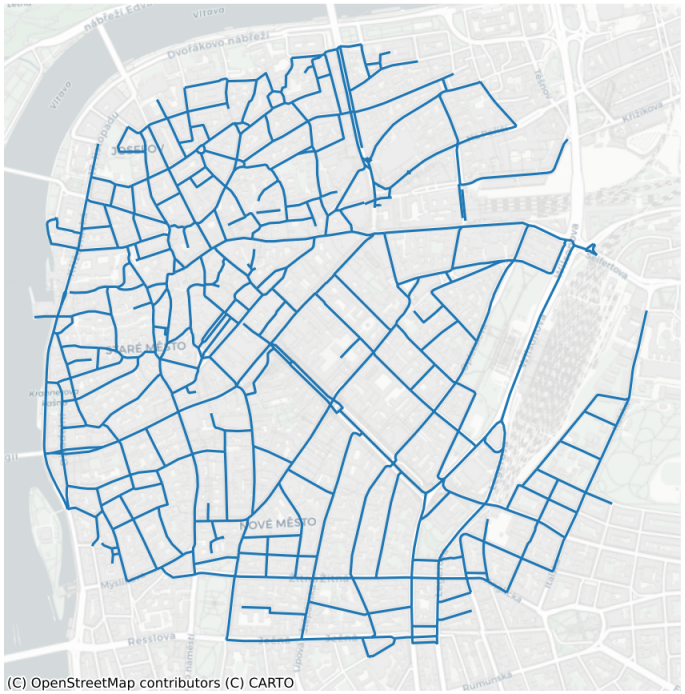
MS buildings



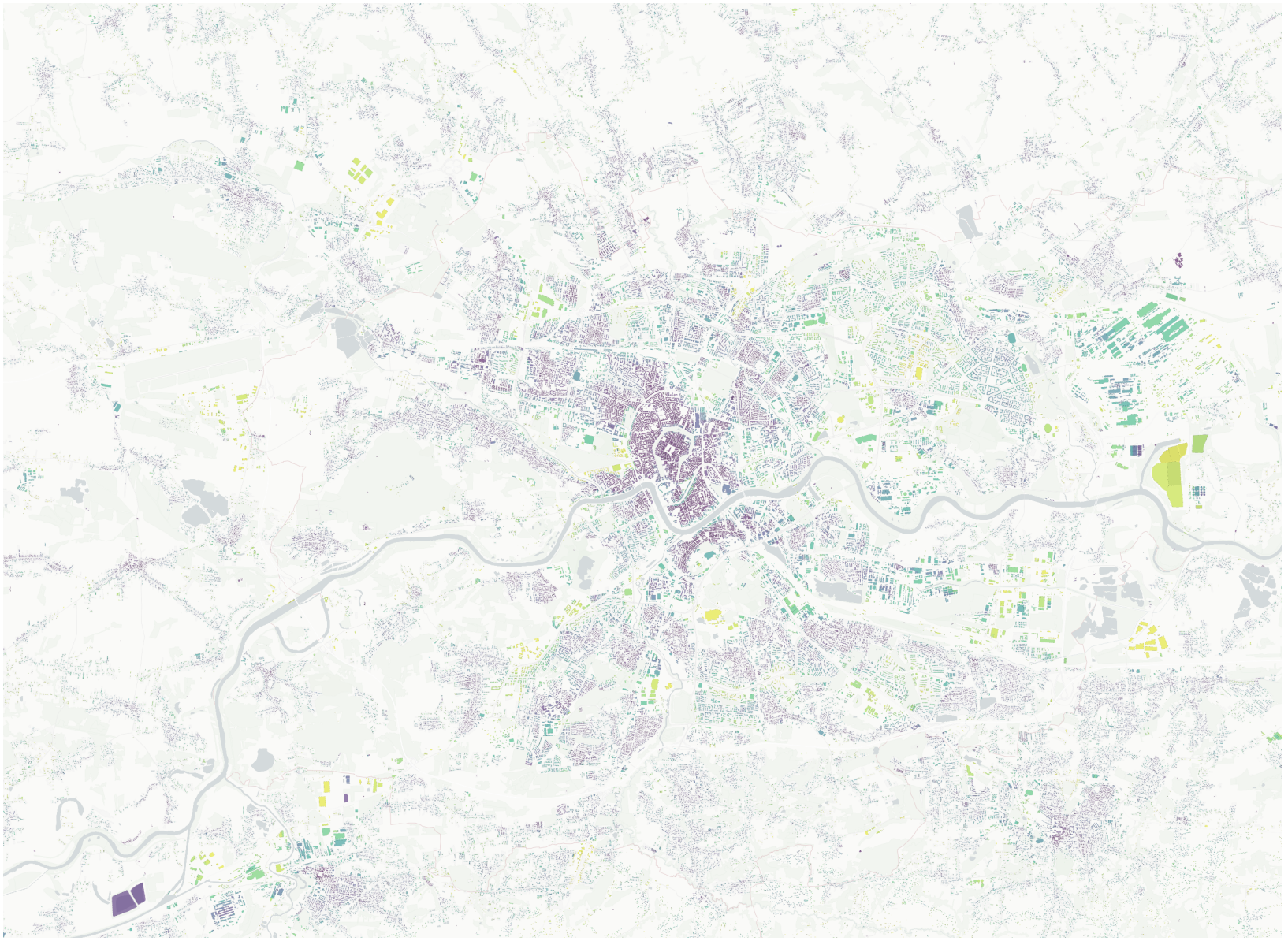
Unprocessed streets



Processed streets



Morphological characters



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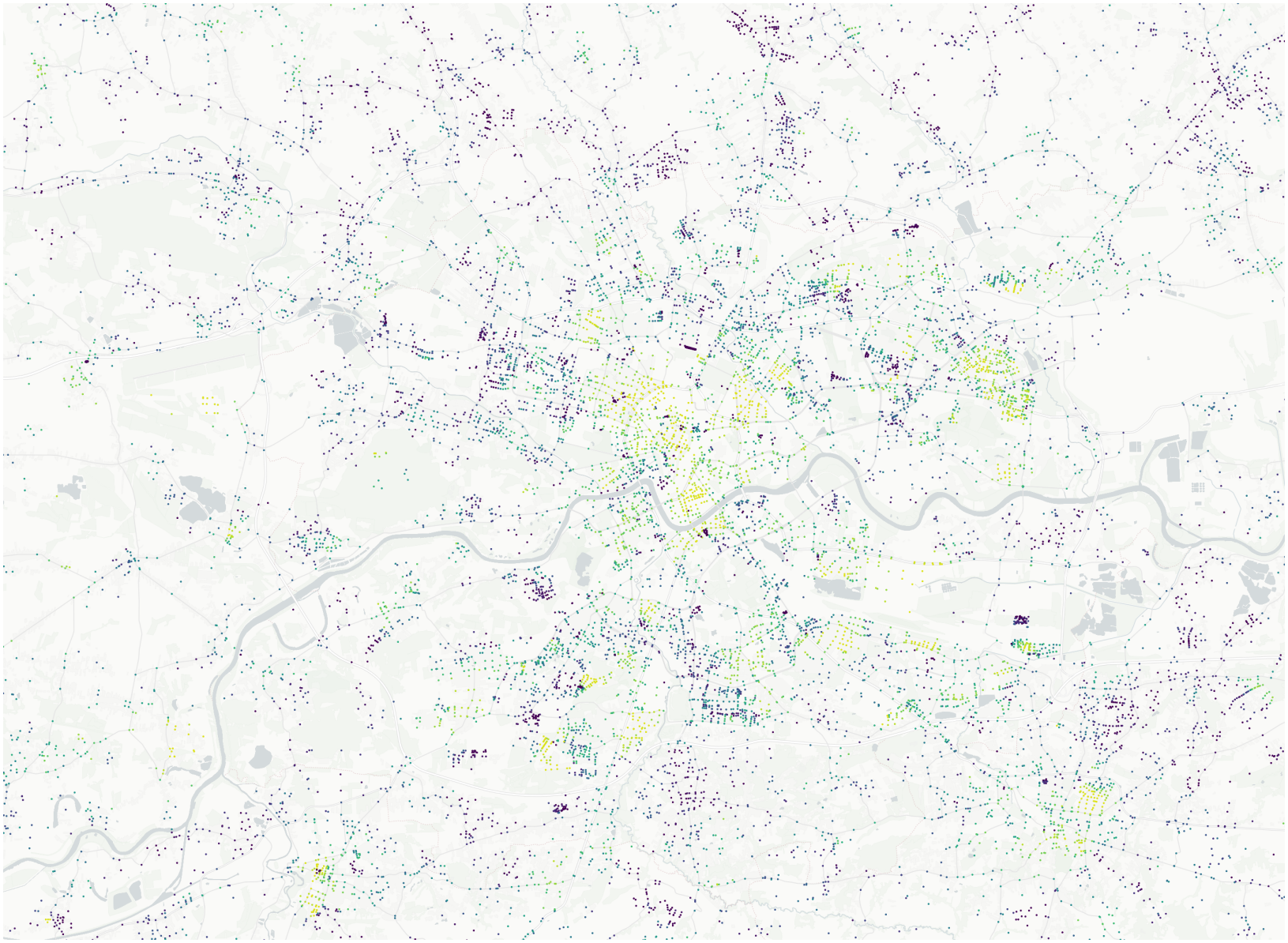

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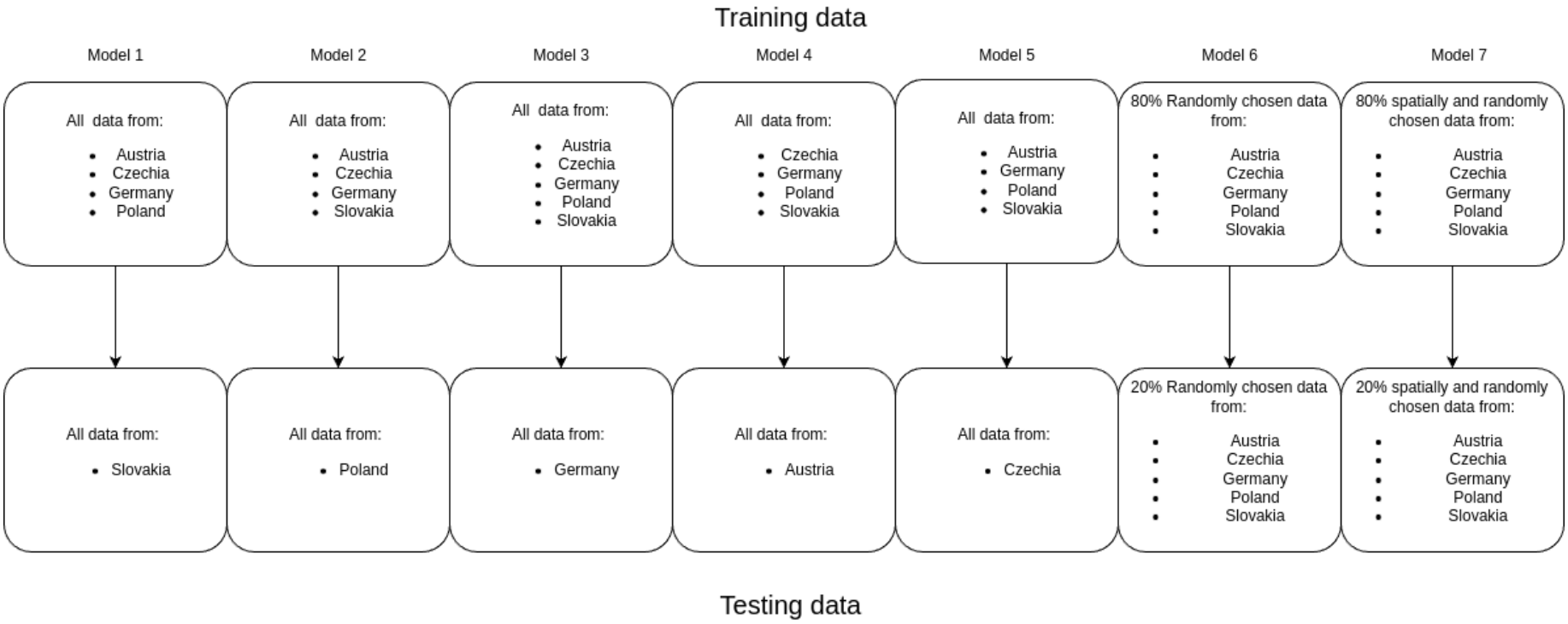
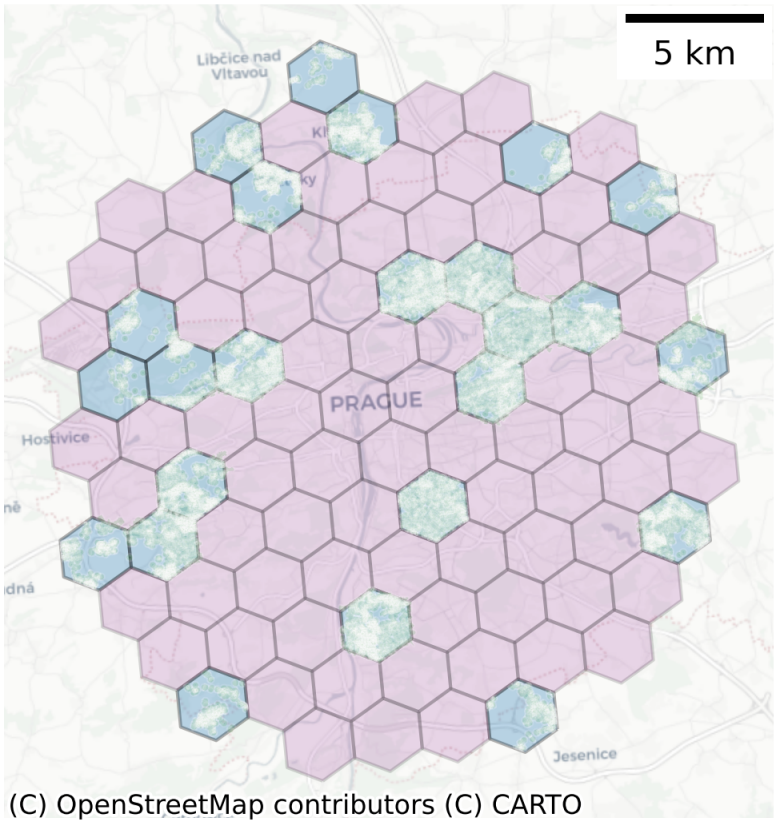
Modeling

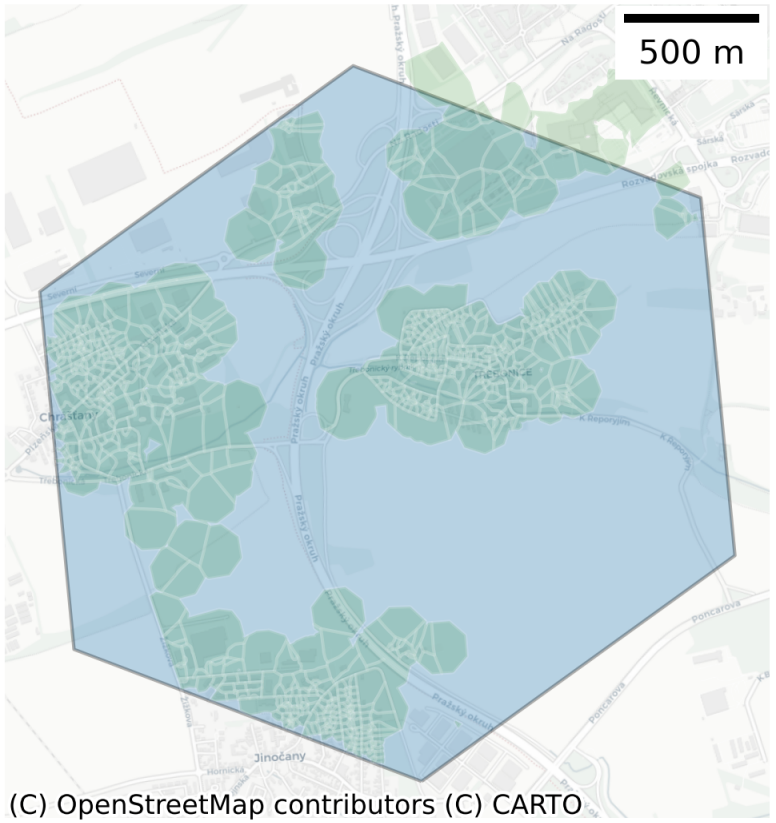

Training data
Model 1
All data from:
Austria
Czechia
Germany
Poland
Model 2
All data from:
Austria
Czechia
Germany
Slovakia
Model 3
All data from:
Austria
Czechia
Germany
Poland
Slovakia
Model 4
All data from:
Czechia
Germany
Poland
Slovakia
Model 5
All data from:
Austria
Germany
Poland
Slovakia
Model 6
80% Randomly chosen data from:
Austria
Czechia
Germany
Poland
Slovakia
Model 7
80% spatially and randomly chosen data from:
Austria
Czechia
Germany
Poland
Slovakia
All data from:
Slovakia
All data from:
Poland
All data from:
Germany
All data from:
Austria
All data from:
Czechia
20% Randomly chosen data from:
Austria
Czechia
Germany
Poland
Slovakia
20% spatially and randomly chosen data from:
Austria
Czechia
Germany
Poland
Slovakia
Testing data

Example spatial train/test split for Prague.



(C) OpenStreetMap contributors (C) CARTO

Data in a single test cell from the Prague set.



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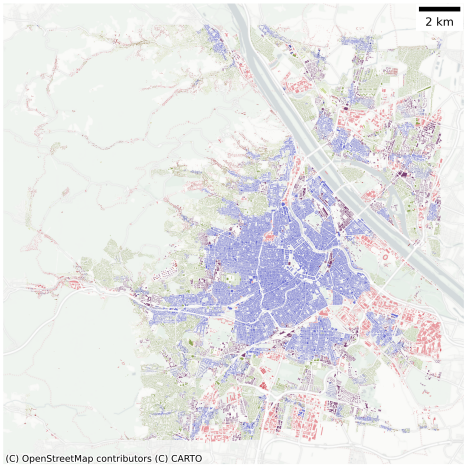
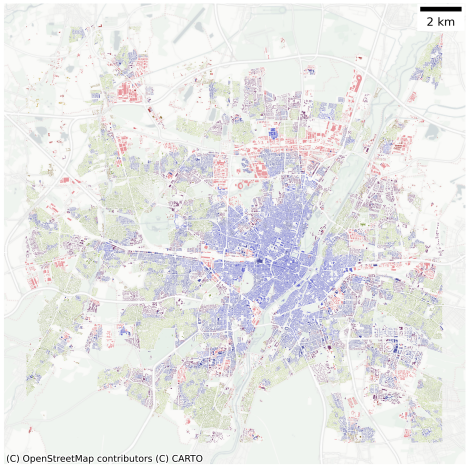
Results

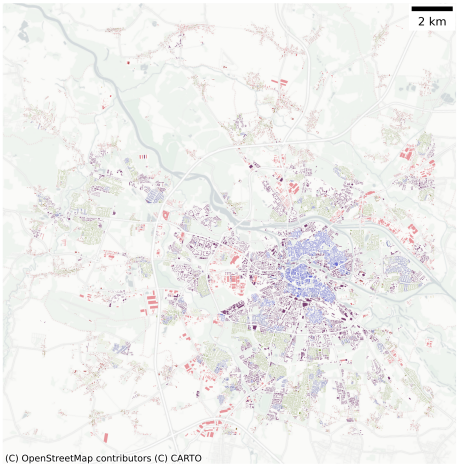
Vienna



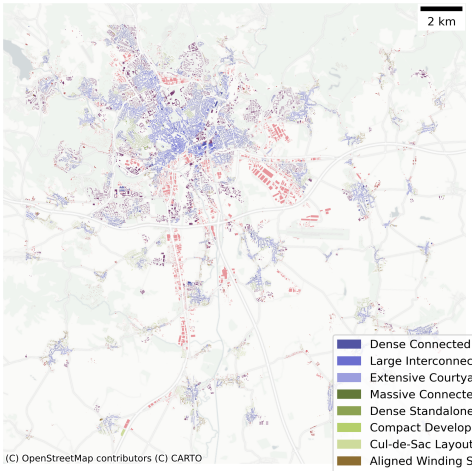
Munich



Wroclaw



Brno



- Dense Connected Developments
- Large Interconnected Blocks
- Extensive Courtyard Complexes
- Massive Connected Aggregations
- Dense Standalone Buildings
- Compact Development
- Cul-de-Sac Layout
- Aligned Winding Streets
- Sparse Rural Development
- Large Wide-Spaced Complexes
- Dispersed Linear Development
- Linear Development
- Sparse Open Layout
- Sparse Road-Linked Development
- Large Utilitarian Development
- Extensive Wide-Spaced Developments

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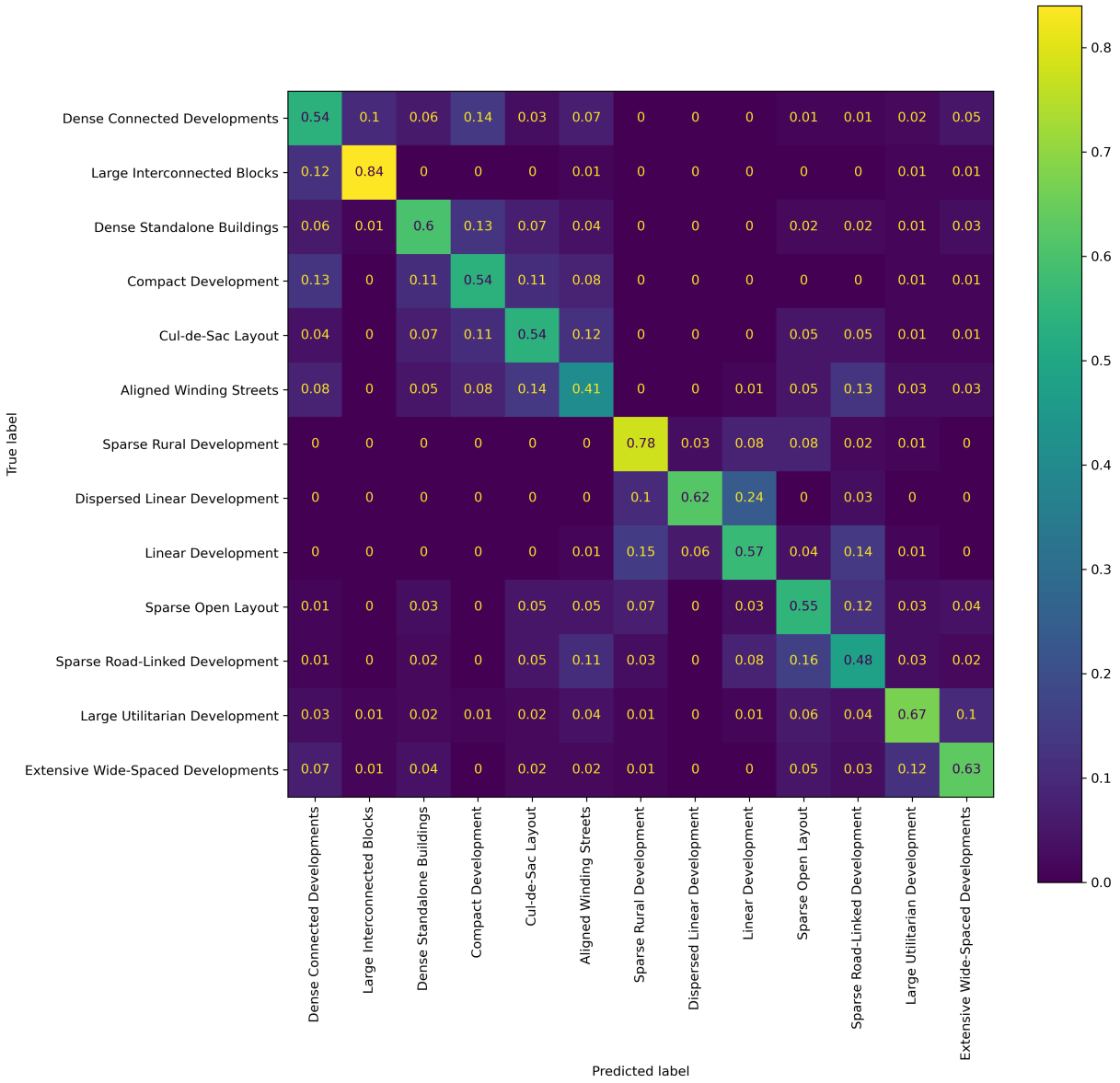
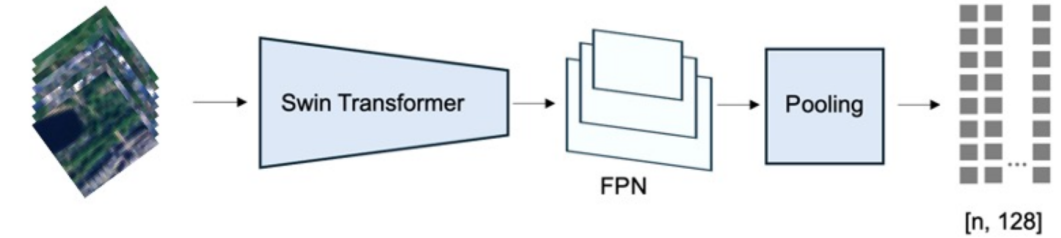
Confusion Matrix

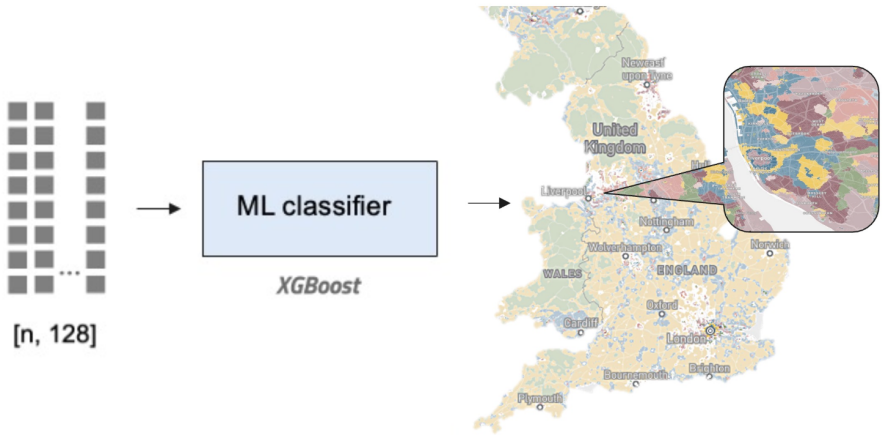

Dense Connected Developments 0.54 0.1 0.06 0.14 0.03 0.07 0 0 0 0.01 0.01 0.02 0.05
Large Interconnected Blocks 0.12 0.84 0 0 0 0.01 0 0 0 0 0 0.01 0.01
Dense Standalone Buildings 0.06 0.01 0.6 0.13 0.07 0.04 0 0 0 0.02 0.02 0.01 0.03
Compact Development 0.13 0 0.11 0.54 0.11 0.08 0 0 0 0 0 0.01 0.01
Cul-de-Sac Layout 0.04 0 0.07 0.11 0.54 0.12 0 0 0 0.05 0.05 0.01 0.01
Aligned Winding Streets 0.08 0 0.05 0.08 0.14 0.41 0 0 0.01 0.05 0.13 0.03 0.03
Sparse Rural Development 0 0 0 0 0 0 0.78 0.03 0.08 0.08 0.02 0.01 0
Dispersed Linear Development 0 0 0 0 0 0 0.1 0.62 0.24 0 0.03 0 0
Linear Development 0 0 0 0 0 0.01 0.15 0.06 0.57 0.04 0.14 0.01 0
Sparse Open Layout 0.01 0 0.03 0 0.05 0.05 0.07 0 0.03 0.55 0.12 0.03 0.04
Sparse Road-Linked Development 0.01 0 0.02 0 0.05 0.11 0.03 0 0.08 0.16 0.48 0.03 0.02
Large Utilitarian Development 0.03 0.01 0.02 0.01 0.02 0.04 0.01 0 0.01 0.06 0.04 0.67 0.1
Extensive Wide-Spaced Developments 0.07 0.01 0.04 0 0.02 0.02 0.01 0 0 0.05 0.03 0.12 0.63
True label
Dense Connected Developments
Large Interconnected Blocks
Dense Standalone Buildings
Compact Development
Cul-de-Sac Layout
Aligned Winding Streets
Sparse Rural Development
Dispersed Linear Development
Linear Development
Sparse Open Layout
Sparse Road-Linked Development
Large Utilitarian Development
Extensive Wide-Spaced Developments
Predicted label
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0

AI vision model

Approach



Step 1



Step 2

Spatial signatures as ground truth data

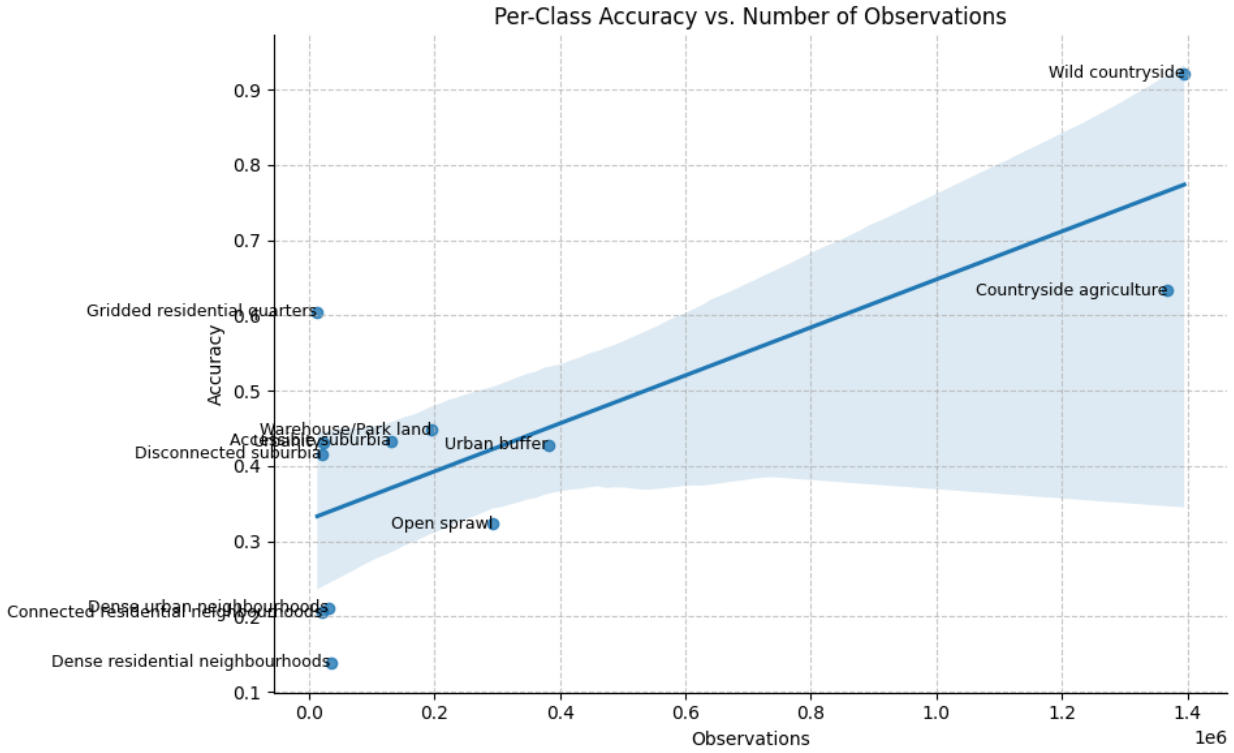
- Spatial signatures framework (Arribas-Bel & Fleischmann 2022)
- Proxy due to its conceptual alignment with the morphometric model


STRATFORD
Kilburn
Camden Town
Stratford
DAGENHAM
London Zoo
East Ham
GREENFORD
City of London
Southall
Ealing
NOTTING HILL
CANARY WHARF
Kensington
Westminster
Chiswick
River Thames
CHELSEA
Greenwich
Woolwich
ERITH
PECKHAM
Hounslow

Classifier

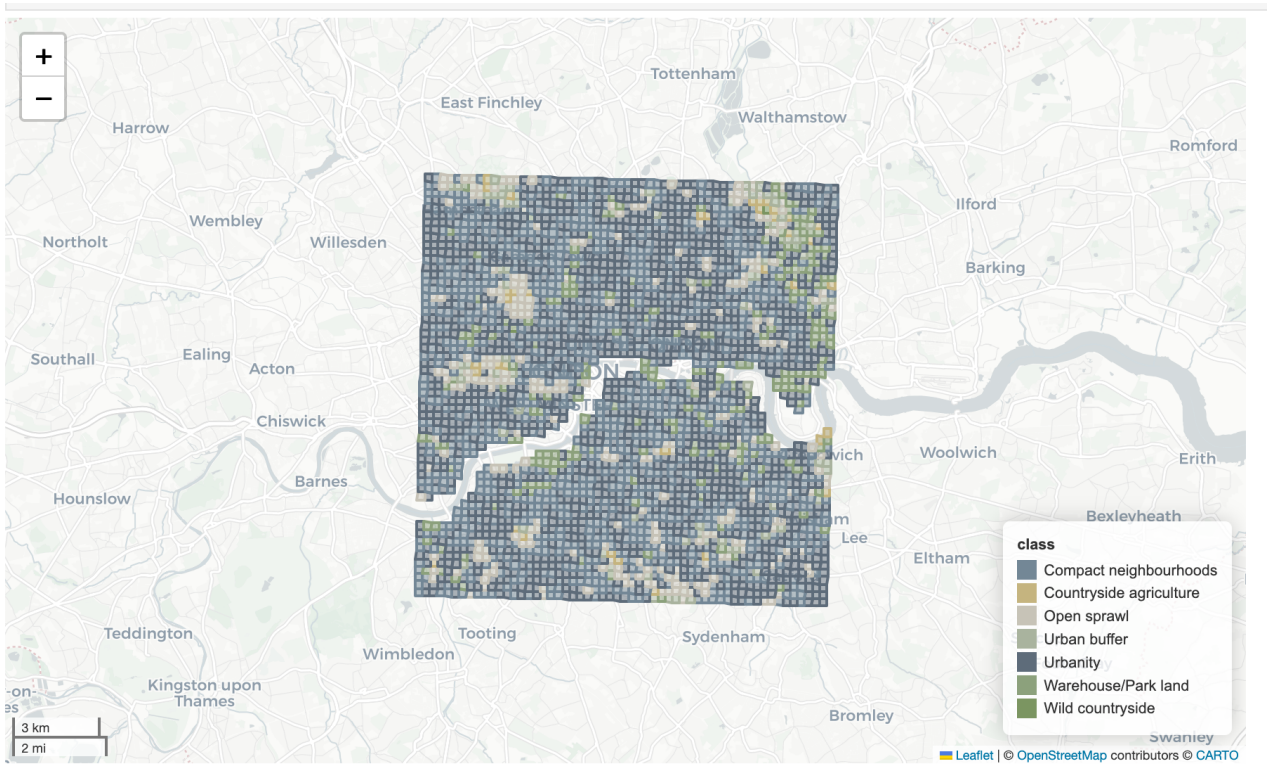
Classes (K)	Spatial Context	Accuracy	Macro Accuracy	Macro F1 Score
7	None	0.4924	0.3856	0.3389
7	H3 (res 5)	0.6959	0.5713	**0.5221**
12	None	0.4617	0.2666	0.2127
12	H3 (res 5)	0.6654	0.4328	0.3654

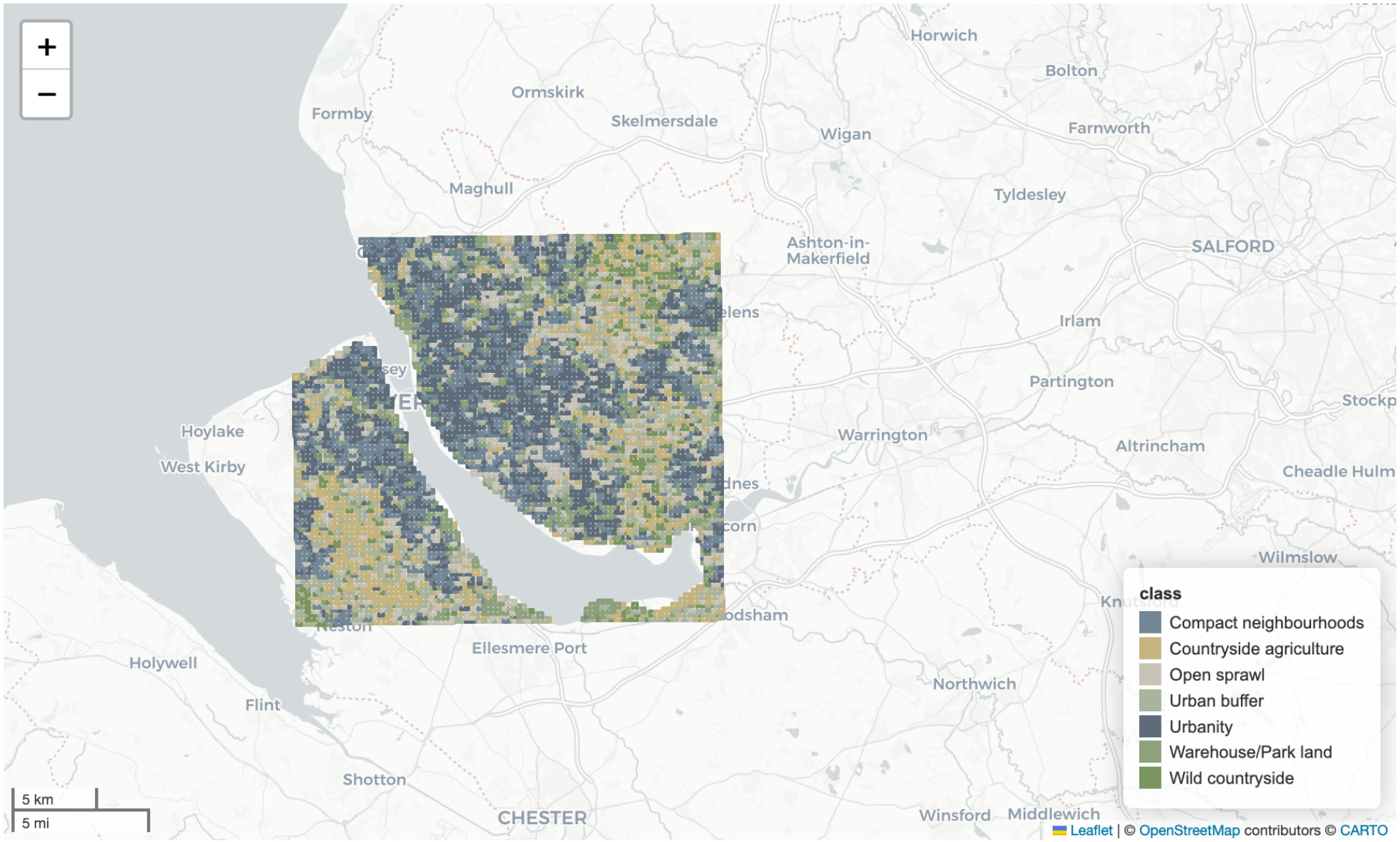
The more training data the better



Number of observations vs accuracy

Examples


Tottenham
East Finchley
Walthamstow
Harrow
Romford
Ilford
Wembley
Northolt
Willesden
Barking
Southall
Ealing
Acton
Chiswick
Barnes
Hounslow
Woolwich
Erith
Bexleyheath
Lee
Eltham
Teddington
Tooting
Sydenham
Wimbledon
Kingston upon Thames
Bromley
3 km
2 mi
class
Compact neighbourhoods
Countryside agriculture
Open sprawl
Urban buffer
Urbanity
Warehouse/Park land
Wild countryside
Leaflet | © OpenStreetMap contributors © CARTO


Horwich
Bolton
Ormskirk
Formby
Skelmersdale
Wigan
Farnworth
Maghull
Tyldesley
Ashton-in-
Makerfield
SALFORD
Irlam
Partington
Hoylake
West Kirby
Warrington
Altrincham
Cheadle Hulm
Wilmslow
Ellesmere Port
Holywell
Flint
Northwich
Shotton
CHESTER
Winsford
Middlewich
5 km
5 mi
class
Compact neighbourhoods
Countryside agriculture
Open sprawl
Urban buffer
Urbanity
Warehouse/Park land
Wild countryside
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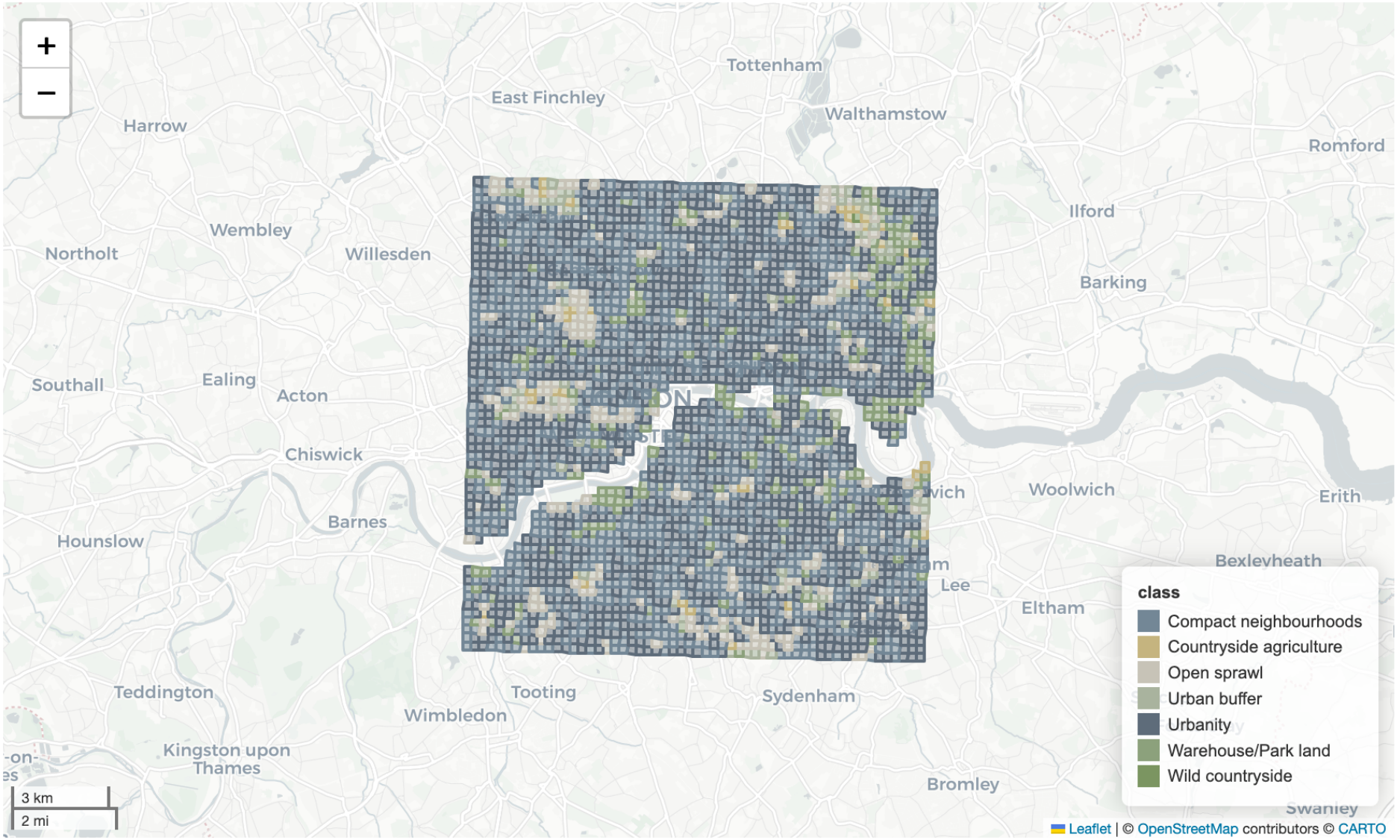
Tottenham
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Acton
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Woolwich
Erith
Barnes
Hounslow
Bexleyheath
Lee
Eltham
Teddington
Tooting
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3 km
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class
Compact neighbourhoods
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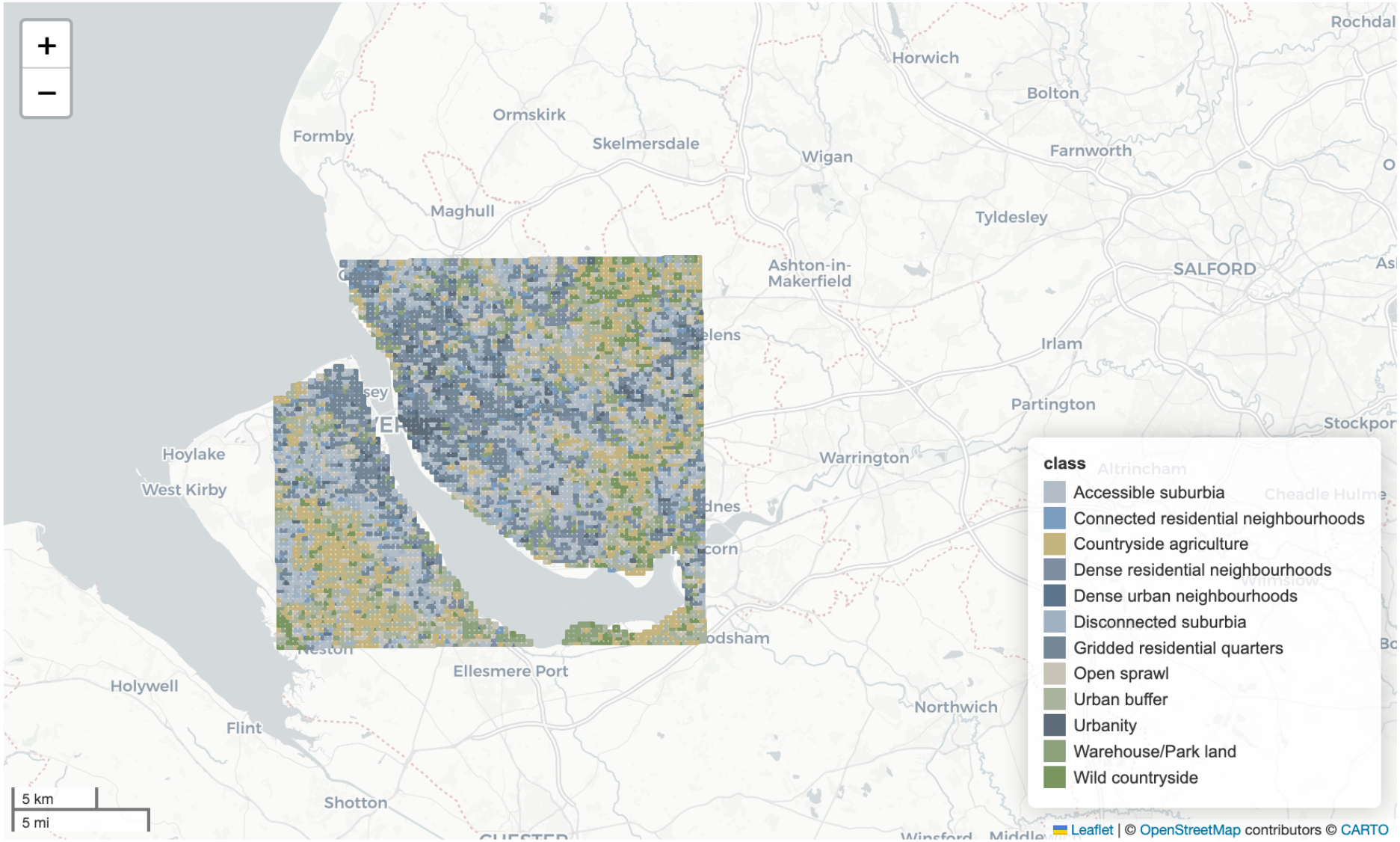
Leaflet | © OpenStreetMap contributors © CARTO


Rochdal
Horwich
Bolton
Ormskirk
Formby
Skelmersdale
Wigan
Farnworth
Maghull
Tyldesley
Ashton-in-
Makerfield
SALFORD
Irlam
Partington
Hoylake
West Kirby
Warrington
Altrincham
Ellesmere Port
Holywell
Flint
Northwich
Shotton
5 km
5 mi
class
Accessible suburbia
Connected residential neighbourhoods
Countryside agriculture
Dense residential neighbourhoods
Dense urban neighbourhoods
Disconnected suburbia
Gridded residential quarters
Open sprawl
Urban buffer
Urbanity
Warehouse/Park land
Wild countryside
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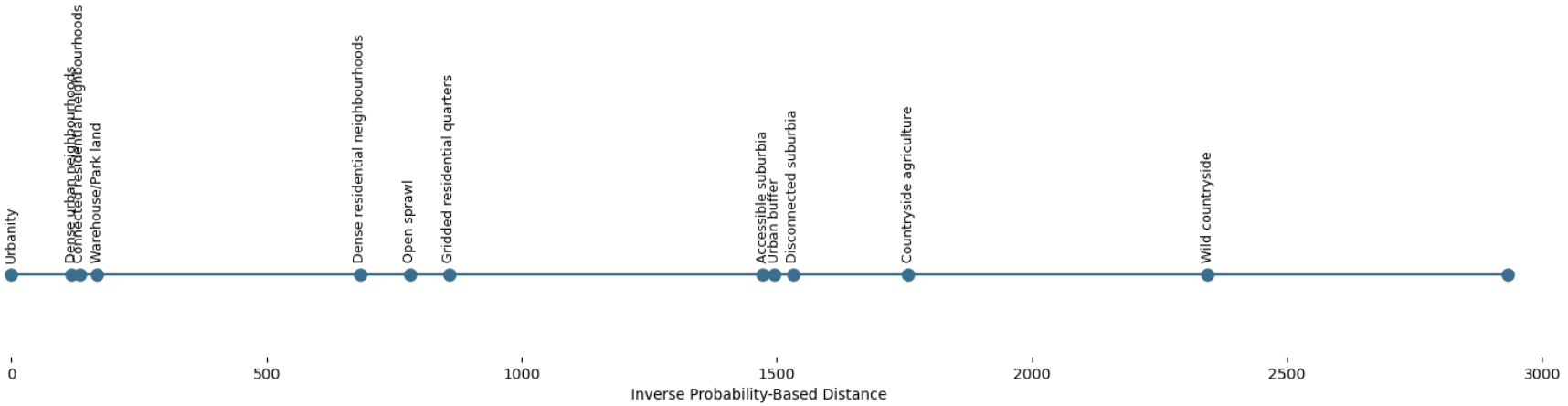
Temporal predictions



Outputs

Software and datasets

- Interactive morphometric web application
- Morphometric characterisation pipeline for Microsoft Building footprints
- Morphometric characterisation pipeline for Overture Maps Building footprints
- AI Method for Urban Fabric classification and morphometric characterization
- AI temporal data cube of Urban Fabric classifications

Stakeholder engagement

Major stakeholder engagements

- European Covenant of Mayors
- SSVA (Construction Sector Development Agency of the Ministry of Environment, Lithuania)
- Prague Institute of Planning and Development (IPR)
- 4ct

Influence on project

- Format of the final data product and its presentation method
- Inclusion of Construction Sector Development Agency of the Ministry of Environment, Lithuania (SSVA)
- Extending the morphometric pipeline to incorporate Overture Maps
- Strategic direction for the follow-up study

Takeaways

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- Data Integration
- Taxonomy Description and Naming
- Comparative Urban Analysis
- Expanding Data Coverage
- Reducing Manual Effort in Land Use Analysis
- Geographical Scale of Results
- Taxonomic Tree & Evaluation
- Input data quality

Future work

The overarching strategy for scaling and productionalising the EuroFab system involves three principal phases.

European classification of Urban Fabric

Using the morphometric pipeline to generate detailed urban classification at a pan-European scale.

Challenges & Strategy

- **Alignment with Cadastral Classification**
- **Heterogenous data sources**
- **Data Gaps**
- **Unknown urban fabric types**
- **Model Tuning and Optimisation**

European classification of Urban Fabric across time (AI model)

Training the AI vision model on the outputs from step one, to fill data gaps and to produce a temporal classification based on historical satellite data.

Challenges & Strategy

- **Leveraging Copernicus Services**
- **Leveraging the new morphometric classification results as ground truth**
- **Generalisability Testing**:
- **Evaluation of urban predictions across time**
- **Methodological processing**

Expanded Stakeholder engagement

Third, productising the refined classification results and expanding stakeholder engagement activities. This will be crucial for driving user adoption and facilitating the derivation of secondary indicators and specialised datasets tailored to specific applications, such as regional development analysis or climate change impact assessments.

Challenges & Strategy

- **Workshops and conference work**
- **Closer Engagement with Specific Cities and Regions**
- **Collaborations & co-development**
- **Developing derived products**
- **Supporting Third-Party Development of Derived Products**

Discussion

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