The influence of the visible views of the urban environment on cyclists' route choices

Committee Members

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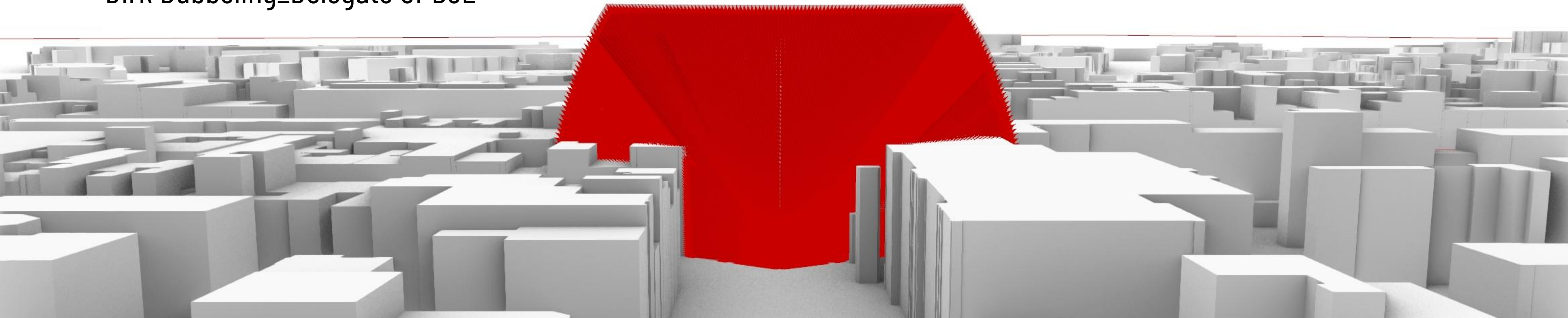
P5 presentation

18/04/2019



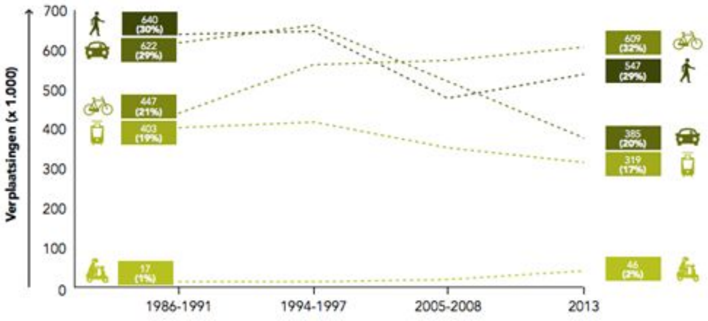
Contents

Introduction

- Urbanization; Cities continue to grow > Need for sustainable mobility
- Cycling as an active mode:
    - Healthy, sustainable, efficient
    - Preferred mode for daily activities
    - Increasing popularity > in Amsterdam has increased by 43% in the past 25 years

Better insight of mobility patterns and route choices of cyclists > Understanding of measurable & perceived attributes

Hypothesis: Urban environment affects where cyclists travel



Aantal verplaatsingen (x 1.000) van/naar/binnen Amsterdam door bewoners per werkdag naar vervoermiddel, 1986-2013 (tussen haakjes is modal split weergegeven)

Research Question

To what extent do the directly visible views of the urban environment influence the route choices of the cyclists and how these different views can be measured?

Sub-questions

Q1. Which determinants of the urban environment that have been identified in prior studies can be implemented in the current research?

Q2. How the cyclist's route choices will be examined?

Q3. What is the added value of the point cloud, compared to the use of 2D data, as a method for investigating the visibility of cyclists in outdoor environment?

Q4. What is the role of space syntax in the current research?

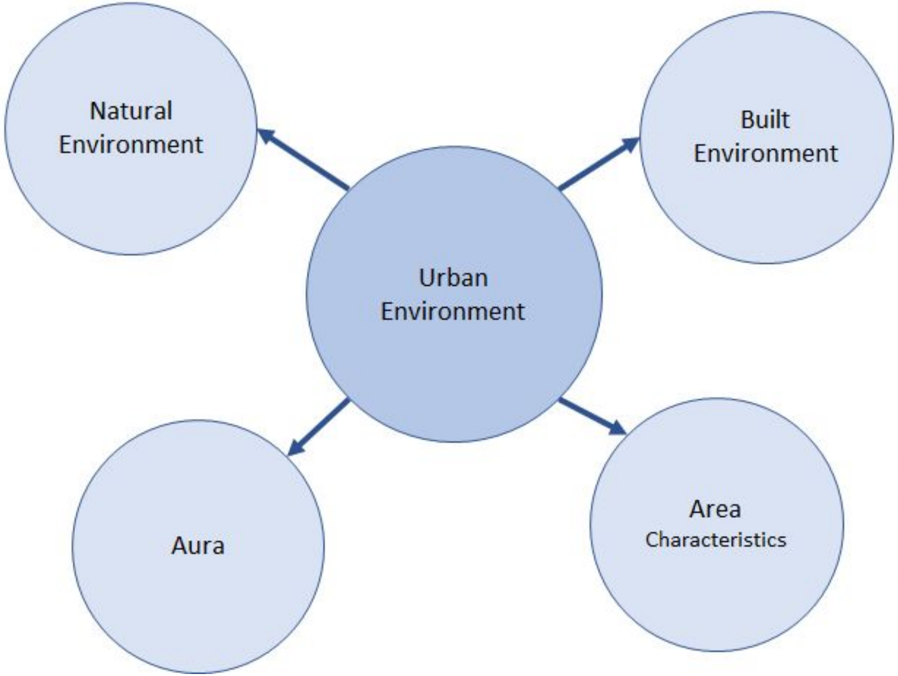
Q5. Which cyclists' routes should be used for the current research and how they can be filtered?

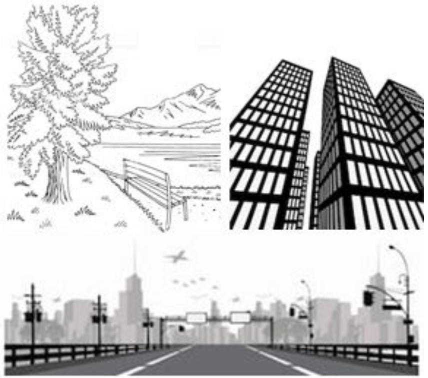
Q6. What is the proper number of observer points to be create for the visibility analysis?

Q7. What are the differences between the routes of the cyclists and the alternatives?

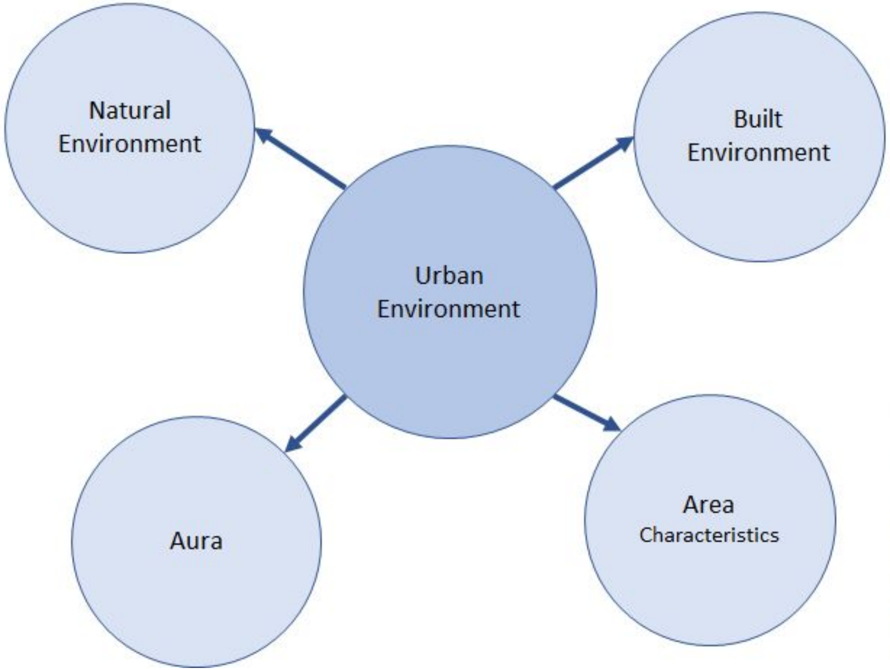
Literature research

Determinants





Determinants

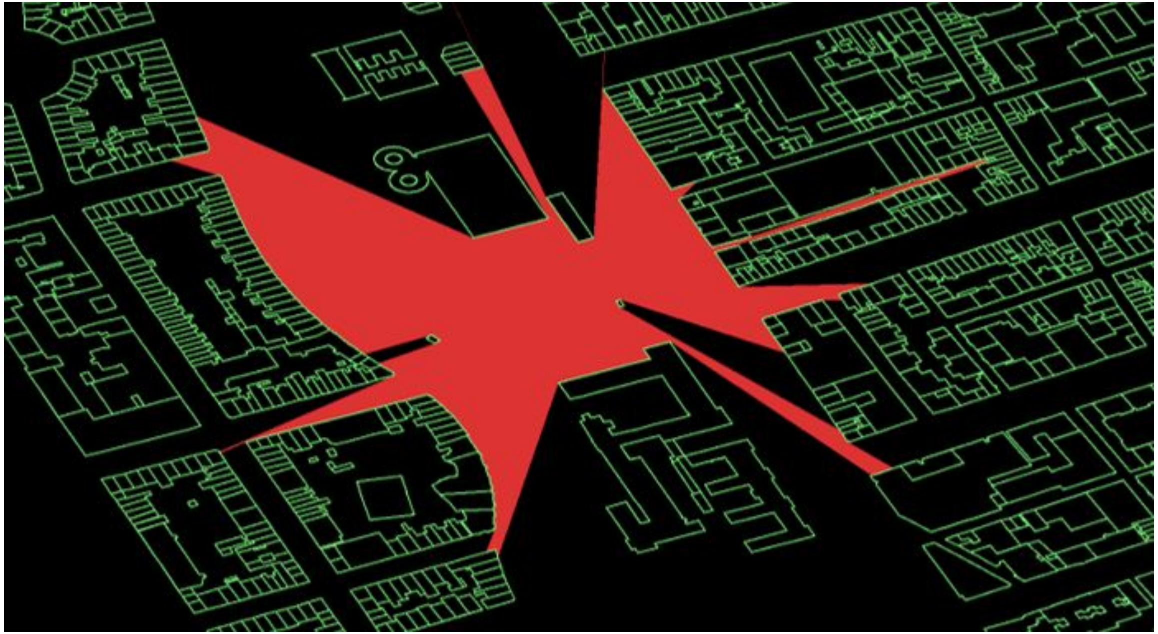


What to measure?

Spatial Openness

"The amount of space perceivable to the viewer."
(Kaplan et al., 1989)

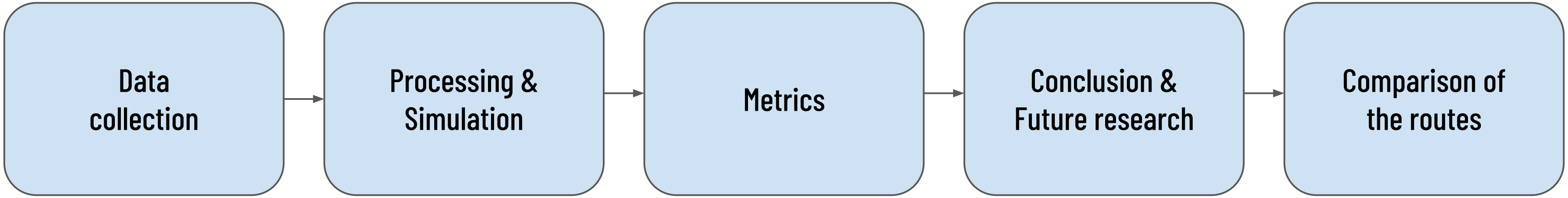
How to measure?



3D Isovist

"The set of all points visible from a specific vantage point in space and with respect to the urban environment"

Methodology



Case study: Amsterdam, NL

Datasets & Tools

Datasets

Fietstelweek 2015 - GPS actual routes

OSM alternatives - Openrouteservice

2D data - BGT and BAG

AHN3 Point Cloud

OSM street Network

Urban Atlas – Copernicus 2012

Tools

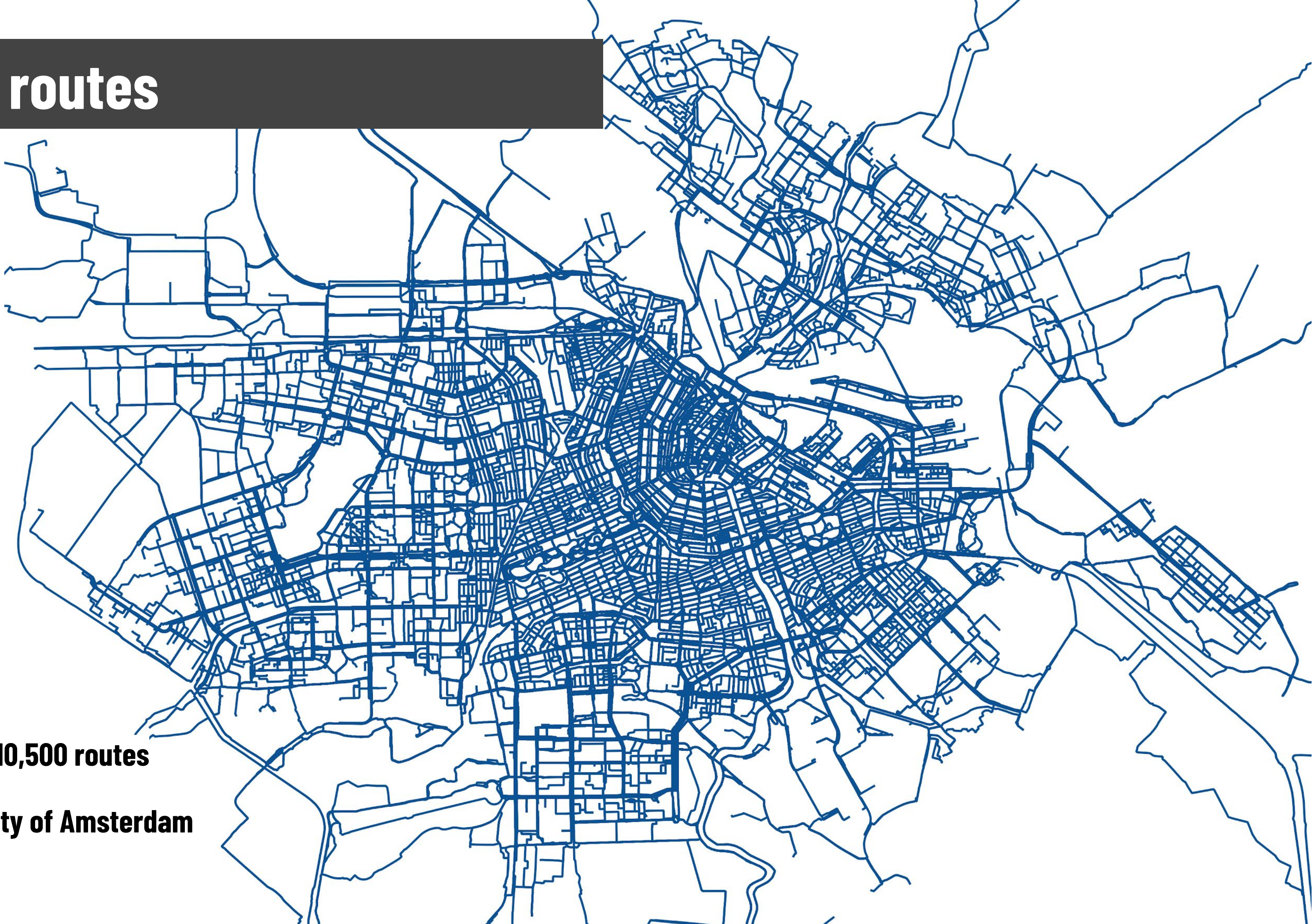
ArcGIS

PostgreSQL

Rhino 6

QGIS

GPS routes

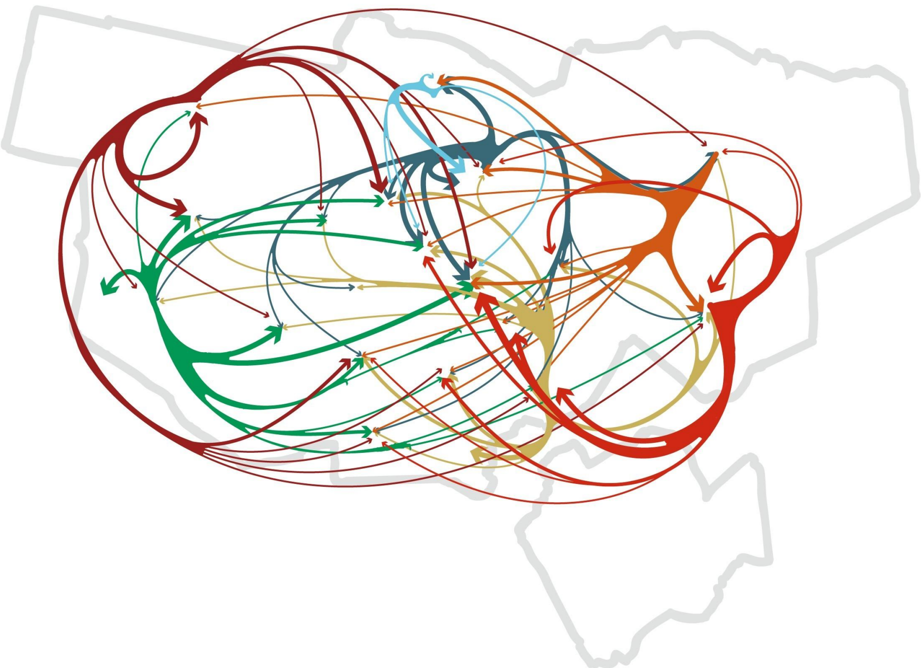


Almost 10,500 routes

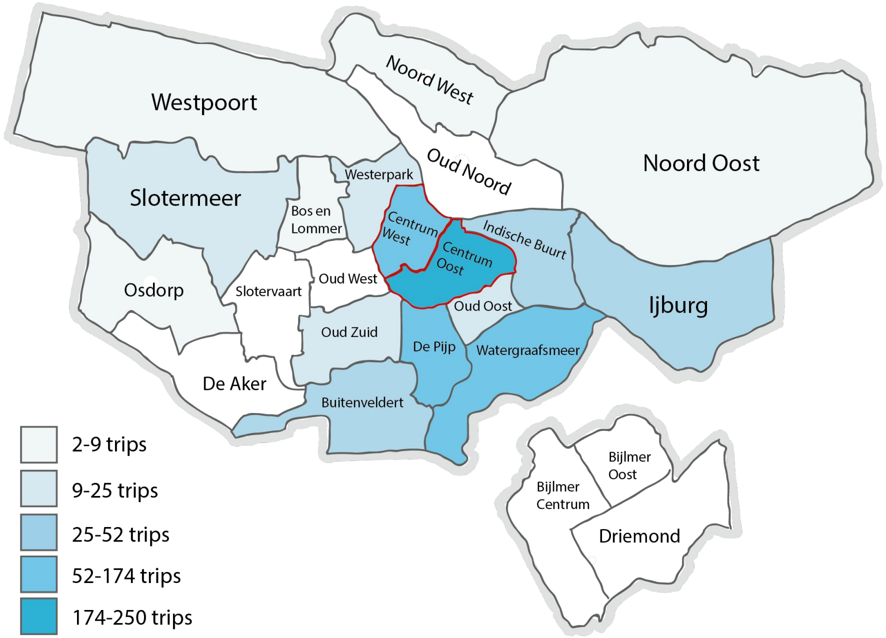
in the city of Amsterdam

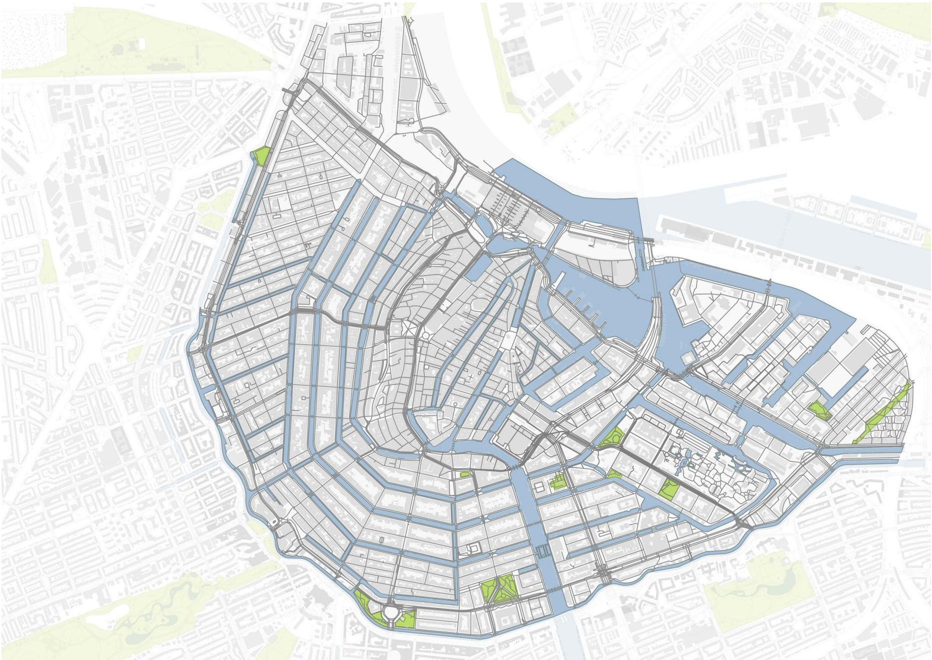
Cyclists' movements

Top 3 Origins	Top 3 Destinations
Centrum West	Centrum Oost
Centrum Oost	Oud-Zuid
Indische Buurt	Oud-Noord



Specifying the area





Alternatives

Possible choices:

1. Compute shortest paths (pgROUTING)
2. Ask for alternatives through APIs
   a. Google Directions
   b. BING Routes
   c. OSM Openrouteservice

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Requirements:

1. Users can access through smartphones

Alternatives

Possible choices:

1. ~~Compute shortest paths (pgROUTING)~~
2. Ask for alternatives through APIs
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Requirements:

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2. Free of charge

Alternatives

Possible choices:

1. ~~Compute shortest paths (pgROUTING)~~
2. Ask for alternatives through APIs
   a. ~~Google Directions~~
   b. ~~BING Routes~~
   c. OSM Openrouteservice

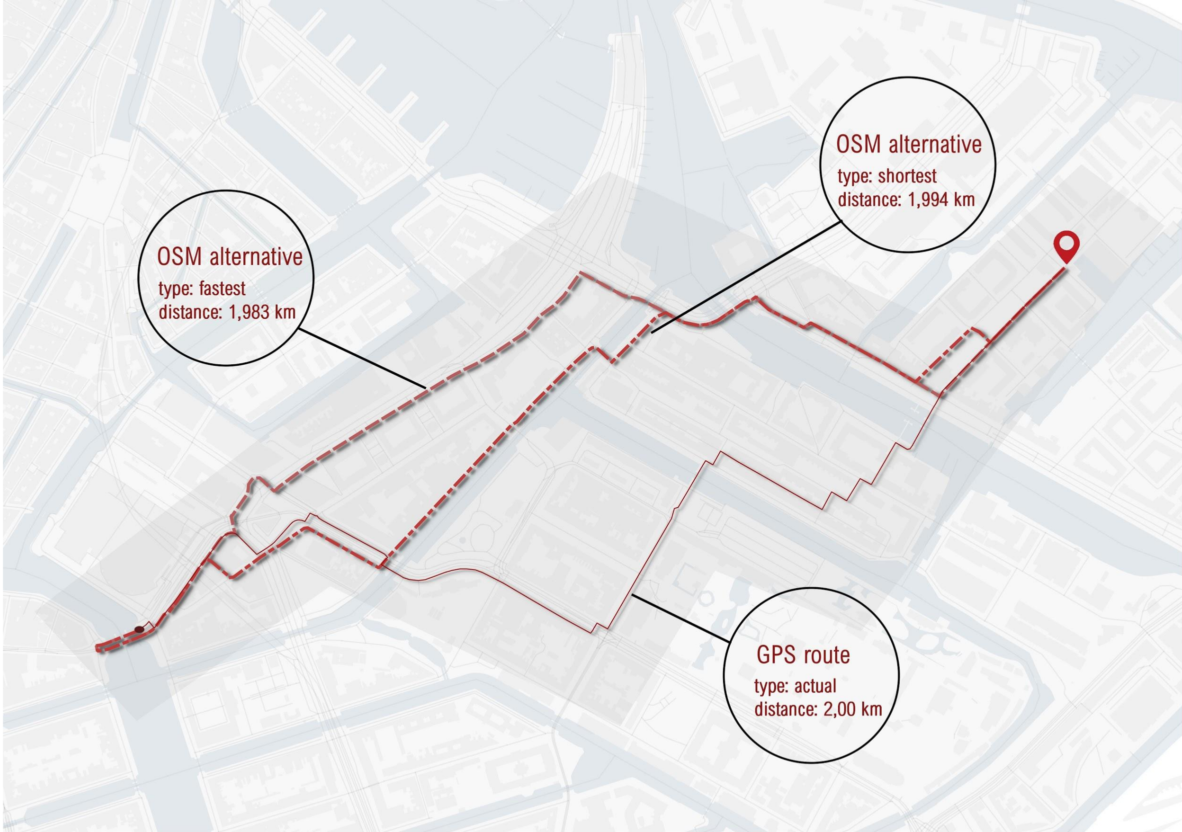
Requirements:

1. Users can access through smartphones
2. Free of charge

OSM Openrouteservice API:

1. Up to 2,500 requests per day
2. Up to 3 alternatives:
   a. fastest,
   b. shortest,
   c. recommended

GPS & OSM alternatives

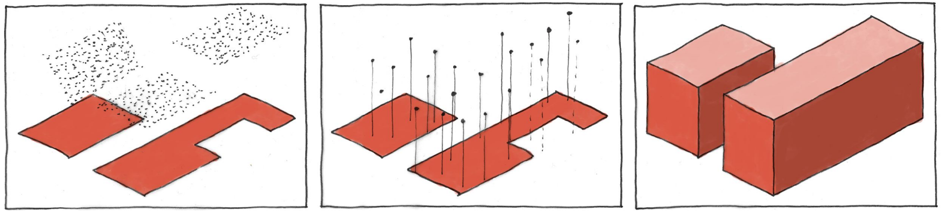



```
import requests

body = {"coordinates":[[4.905717,52.359085],[4.922028,52.37152]],"attributes":["avgspeed","detourfactor"],"extra_info":["waycategory"],"preference":"fastest","geometry":"true"}

headers = {
    'Accept': 'application/json, application/geo+json, application/gpx+xml, img/png; charset=utf-8',
    'Authorization': '[redacted]'
}
call = requests.post('https://api.openrouteservice.org/v2/directions/cycling-regular', json=body, headers=headers)

print(call.status_code, call.reason)
print(call.text)
```


- "routes": [
- {
+ "summary": { /* 2 items */},
- "segments": [
+ { /* 5 items */}
],
- "bbox": [
4.90125,
52.358462,
4.922091,
52.371508
],
"geometry": "qkq~Hqc}\\dAdHBRBN?@WJHz@Db@z@bH@P@VC@a@JK@E@GB}DrAOFE_@QeBY}CAKWqB
- "way_points": [
0,
132
],
- "extras": {
+ "waycategory": { /* 2 items */}
}
}
],
+ "bbox": [/* 4 items */],
- "metadata": {
"attribution": "openrouteservice.org | OpenStreetMap contributors",
"service": "routing",
"timestamp": 1555250057571,
+ "query": { /* 7 items */},
+ "engine": { /* 2 items */}

Generate 3D environment

3D Buildings



3D Street network

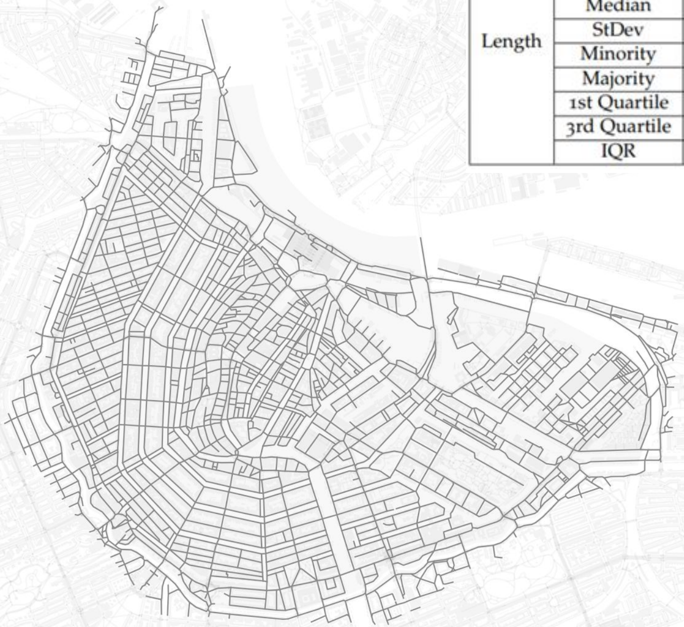
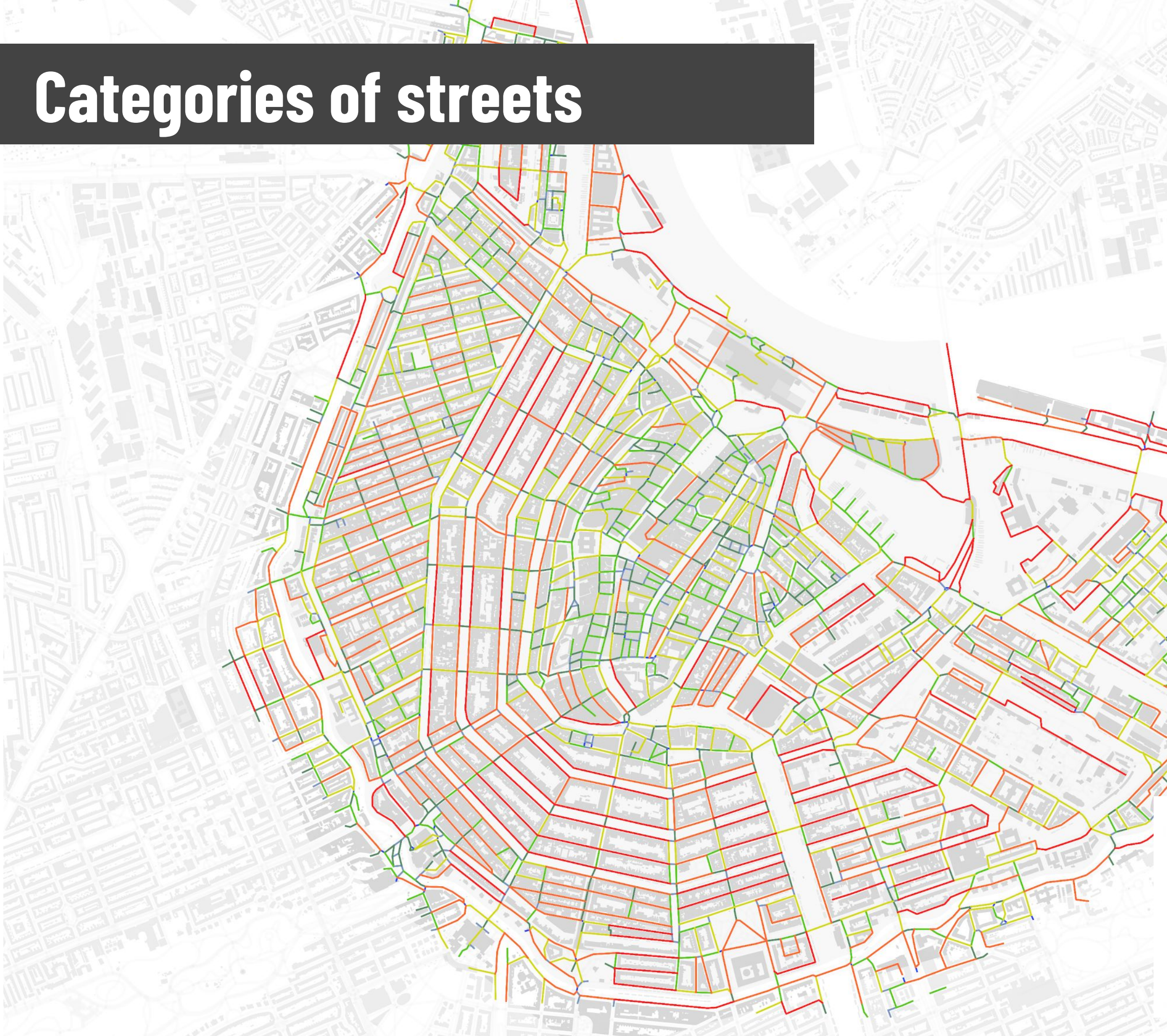


Table 4.5: Statistics about the simplified network and the OSM network

Statistics		Network	
		OSM	Simplified Network
Number of segments		6086	2701
Number of nodes		26426	5402
Length	Min	0.10966	9.0
	Max	2487.01803	624.0
	Mean	69.578810	77.80340
	Median	32.083215	62.0
	StDev	119.4276695	58.32972
	Minority	0.10966	9.0
	Majority	3.38003	28.0
	1st Quartile	11.78447	38.0
	3rd Quartile	79.20152	100.0
	IQR	67.41704	62.0

Categories of streets



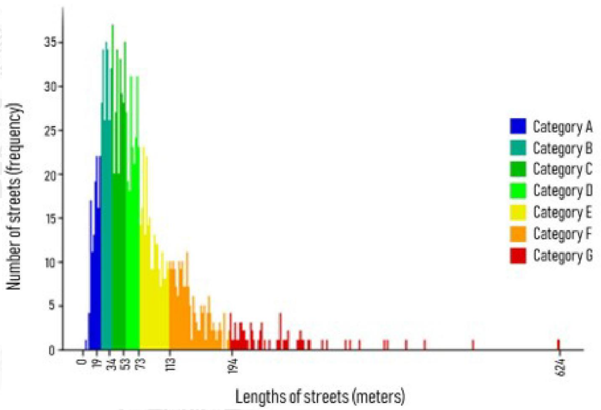


Table 4.6: Categorization of the street segments based on the nth percentile.

Category	Percentile (Pi)	Lengths (m) intervals	Number of segments
A	P5	[5, 19)	145
B	P20	[19, 34)	411
C	P40	[34, 53)	550
D	P60	[53, 73)	518
E	P80	[73, 113)	549
F	P95	[113, 194)	405
G	P100	[194, 624]	136

Granularity

Maximum distance of visibility – 50m

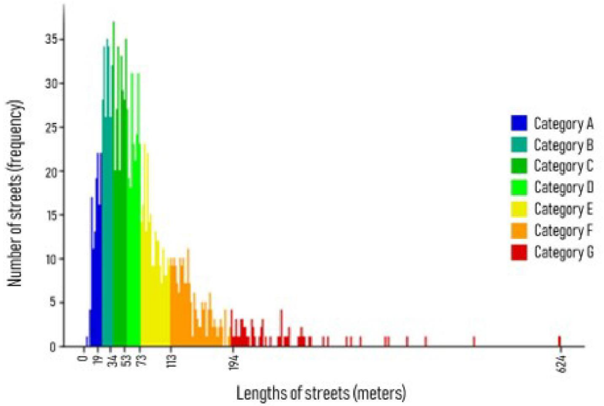
Rejected:

150m

- Computational time: 45min for 50pts
- Not representative for: % sky

100m

- Computational time: 35min for 50pts
- Not representative for: % sky



Category	Percentile (Pi)	Lengths (m) intervals	Number of segments	Granularity
A	P5	[5, 19)	145	3 pts
B	P20	[19, 34)	411	4 pts
C	P40	[34, 53)	550	4 pts
D	P60	[53, 73)	518	5 pts
E	P80	[73, 113)	549	5 pts
F	P95	[113, 194)	405	6 pts
G	P100	[194, 624]	136	8 pts

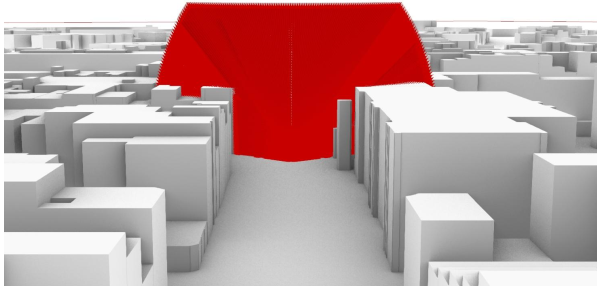
Visibility analysis

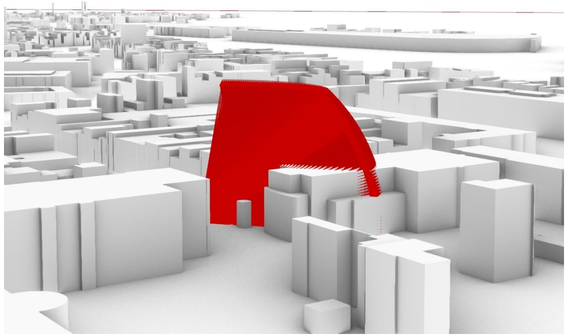
Length of ray: 50m

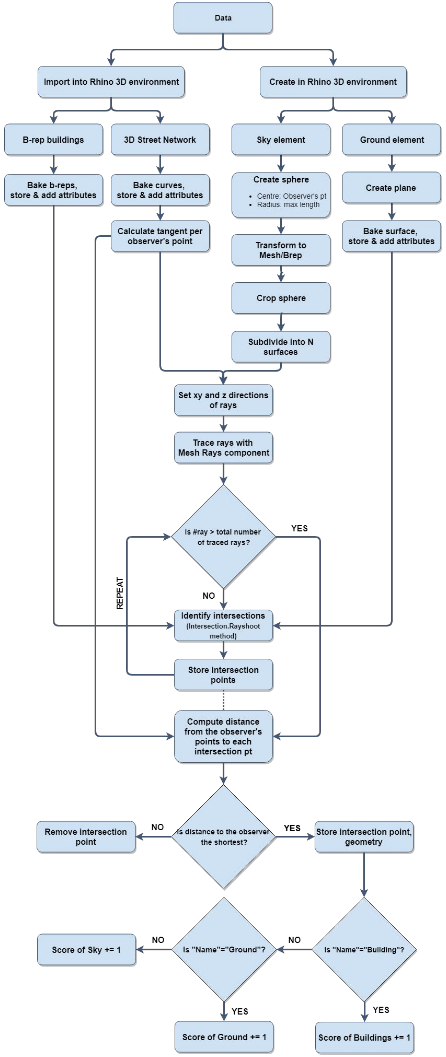
Vertical angle: 90 degrees

Horizontal angle: 100 degrees

Resolution: 200



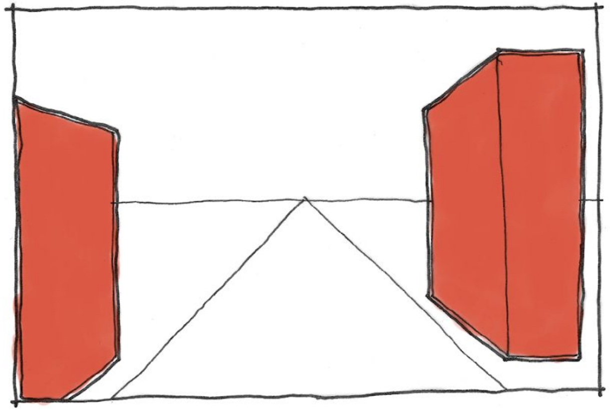




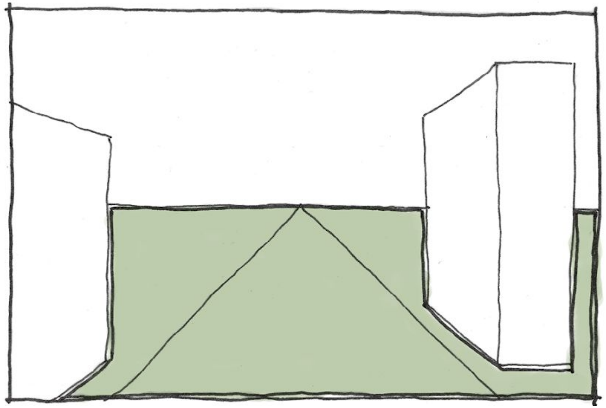
Visibility analysis

Metrics

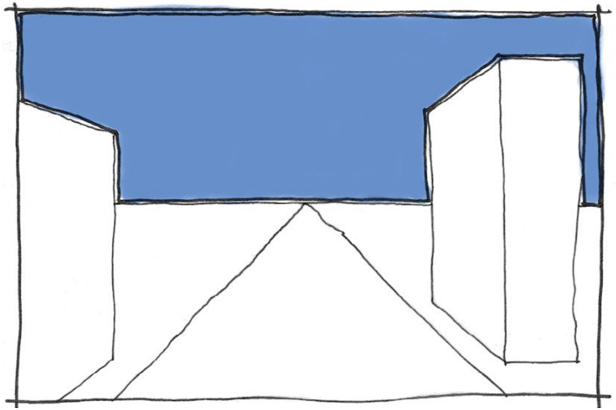
Metrics - Spatial Openness



% of visible buildings



% of visible ground



% of visible sky

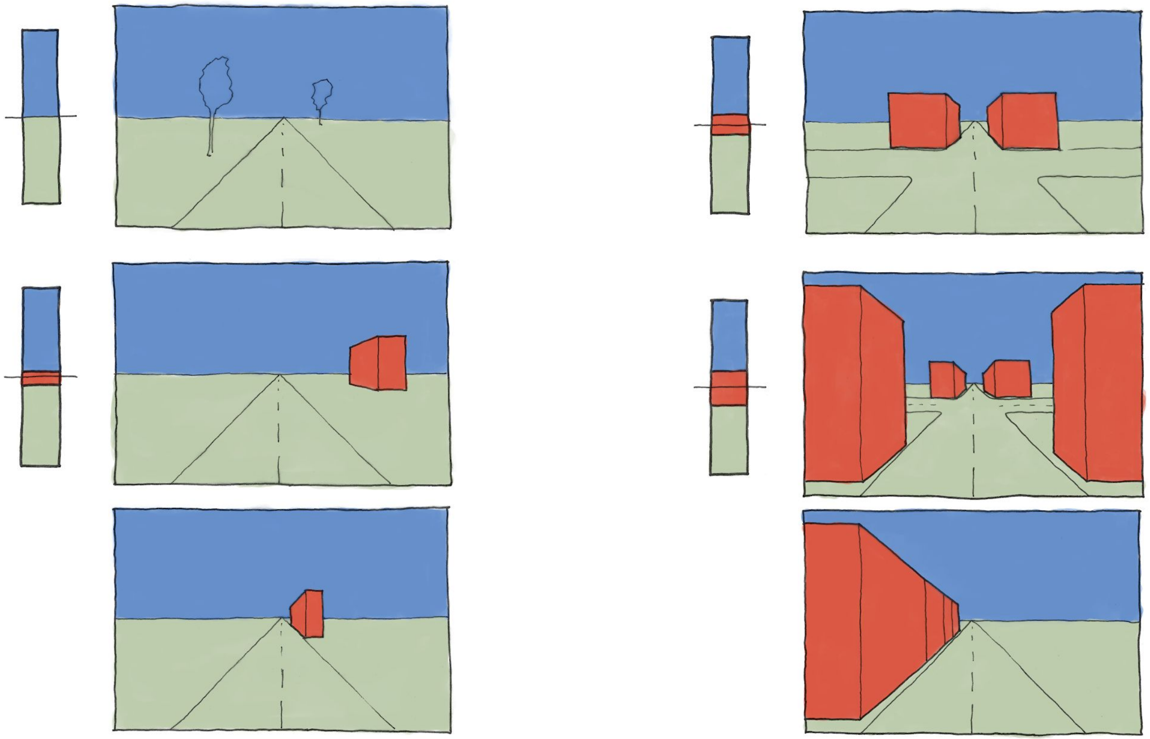
Ratio buildings:ground

Ratio buildings:ground

Ratio buildings:sky

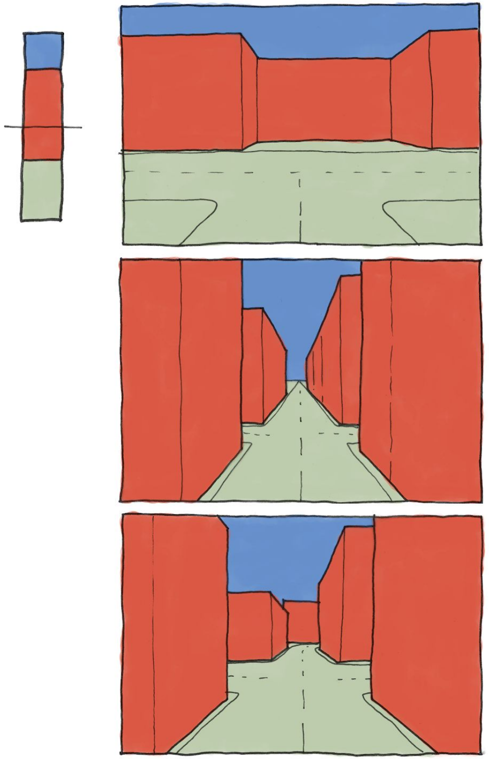
Metrics - Street Profiles

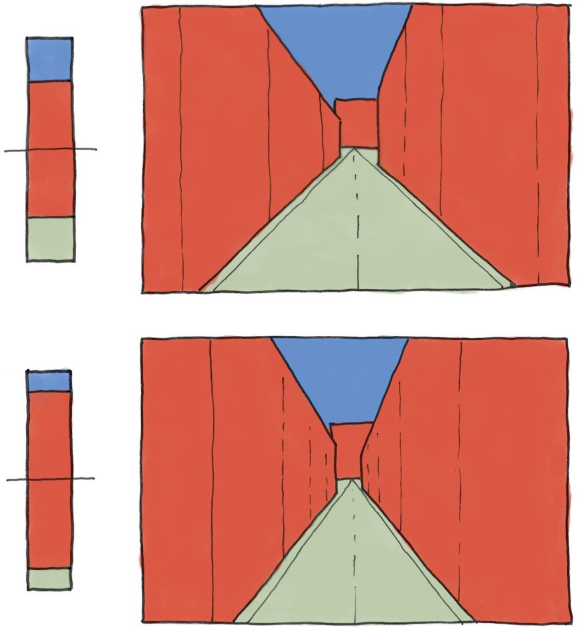
2. Street Profiles



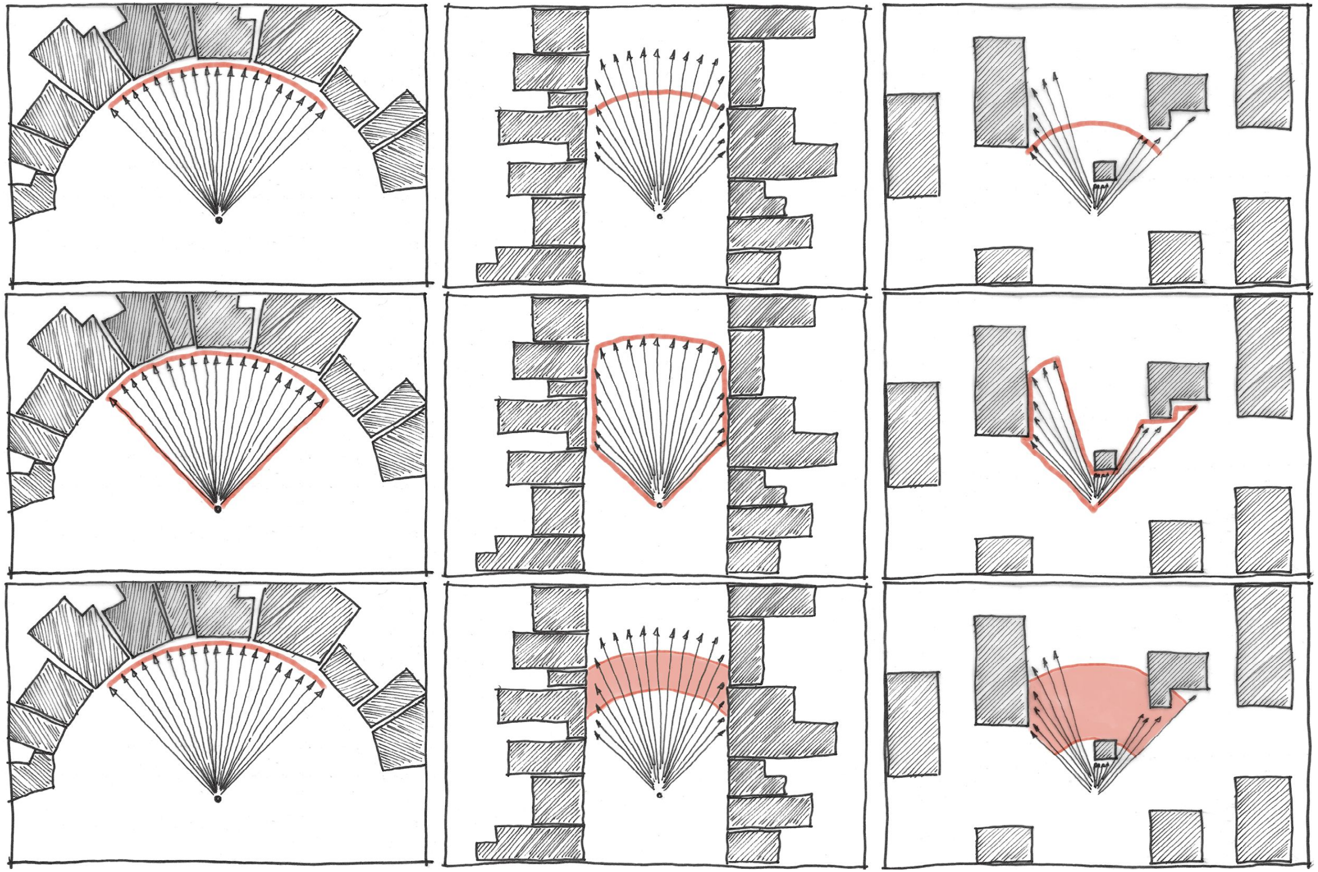
Metrics

2. Street Profiles





Shape of 3D isovist



Median

Kurtosis

Standard Deviation

Aggregation on street network level

1.Geometric mean

Calculation of Geometric Mean for $x_1, x_2, \ldots, x_n$ changing factors

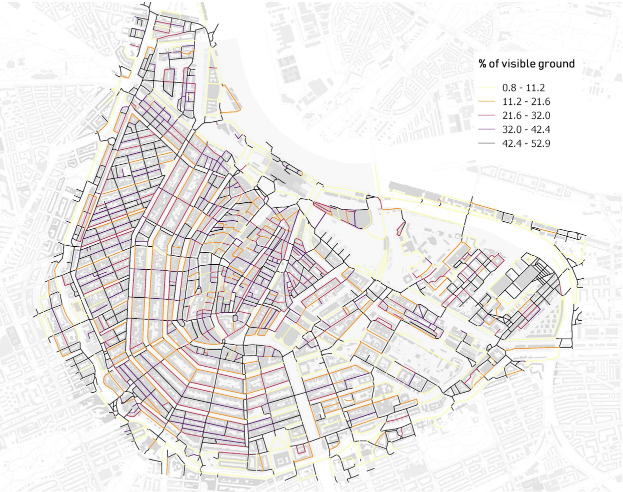
$$\prod_{i=1}^{n} x_i = \sqrt[n]{x_1 x_2 \ldots x_n}$$

2. Standard deviation

3. Mode

Metric	Aggregation Method
Sky (%)	Geometric Mean
Buildings (%)	Geometric Mean
Ground (%)	Geometric Mean
Buildings:Sky	Geometric Mean
Buildings:Ground	Geometric Mean
Sky:Ground	Geometric Mean
Median	Geometric Mean
Kurtosis	Standard Deviation
Standard deviation	Geometric Mean
Street Profile	Mode

Aggregation on street network level

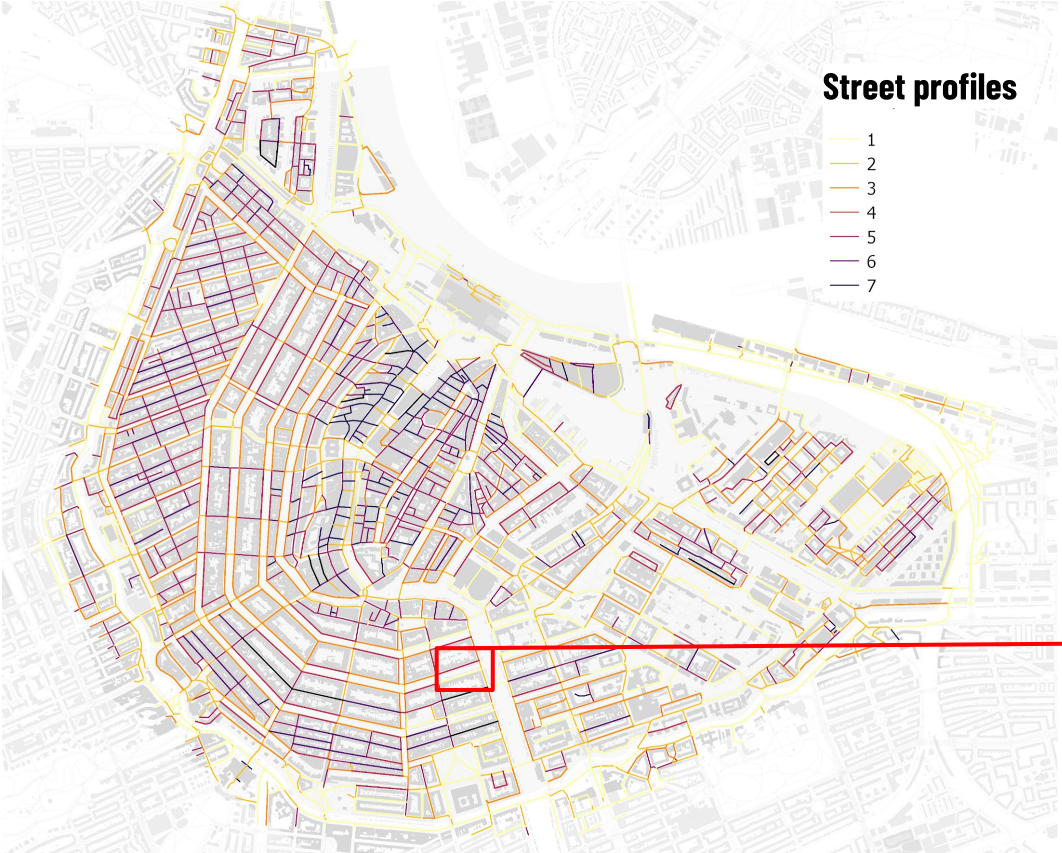


% of visible sky

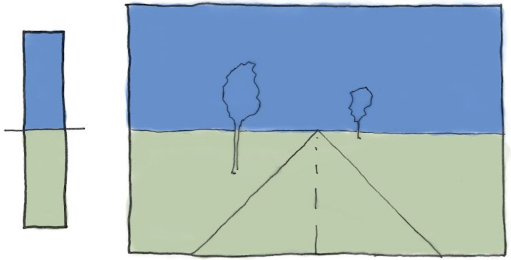
% of visible buildings

% of visible ground

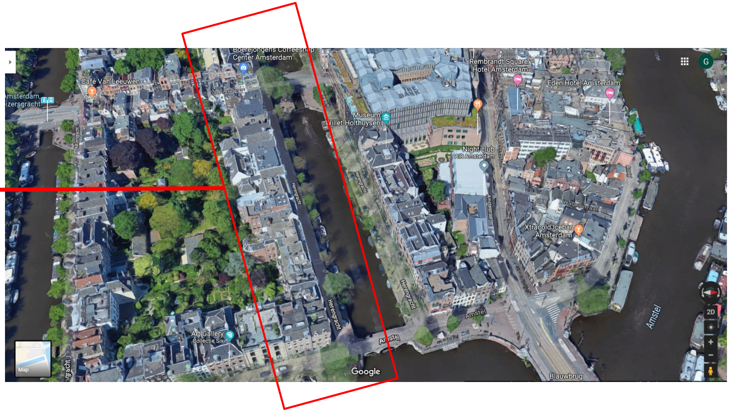
Aggregation on street network level



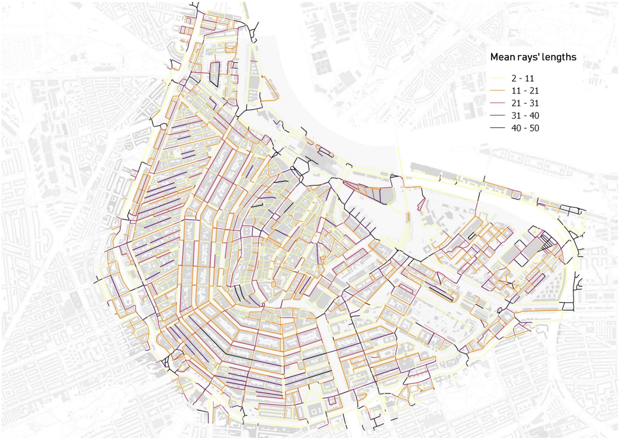
Identified as #1



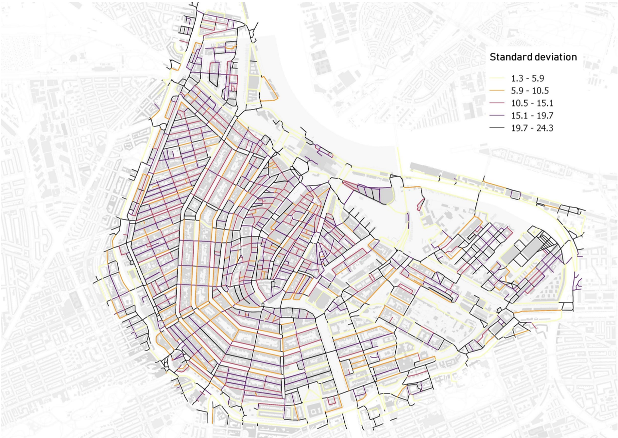
but....



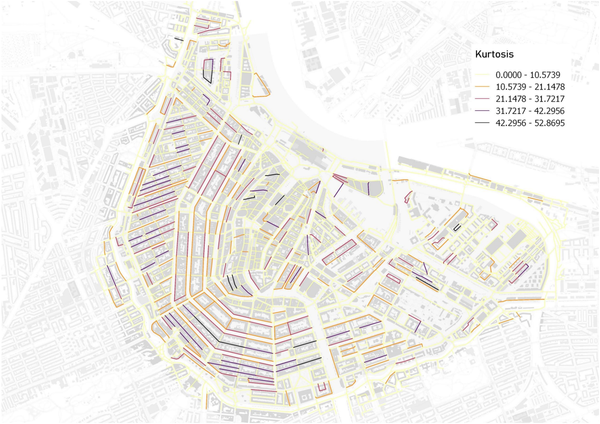
Aggregation on street network level



Median



Standard deviation



Kurtosis

Aggregation on route level

Segment matching

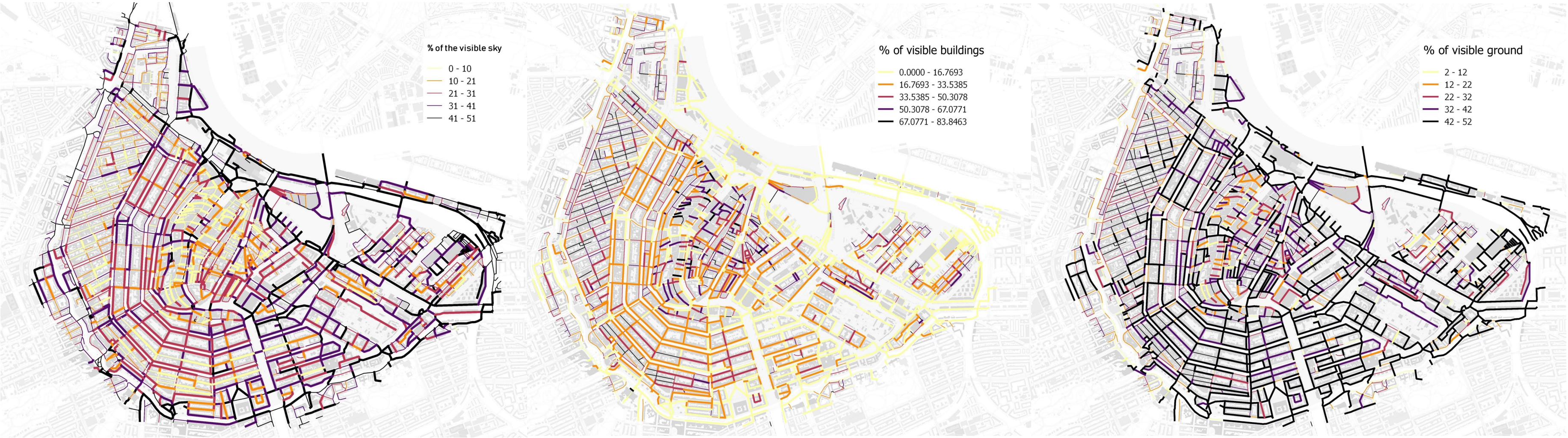
Aggregation methods:

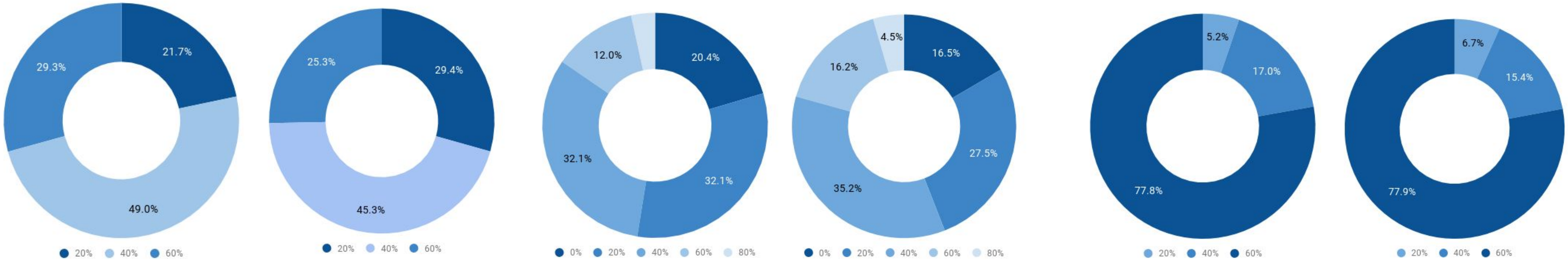
1. Standard deviation
2. Median

tripid integer	median_sky double precision	Std.Dev_sky double precision	median_blds double precision	Std.Dev_blds double precision	median_grd double precision	Std.Dev_grd double precision	median_kurtosis double precision	Std.Dev_kurtosis double precision	median_median double precision	Std.Dev_median double precision	median_stDev double precision	Std.Dev_stDev double precision	category integer
583355313	37.64053093	9.881262743	13.09038075	12.79632207	47.18296895	5.282846727	0.119533986	0.908967076	21.18355174	11.85934794	21.00282264	1.753844923	2
583547983	32.05523011	13.98992161	19.31017207	16.23135044	45.34726209	7.671030937	0.196155746	1.426435813	16.04261876	10.01230302	20.15365019	4.748306016	2
584244033	29.84223853	11.82134499	22.54540586	15.80861606	44.70199862	2.485896957	0.244490623	0.457363693	12.15415634	11.26972269	20.39363364	2.348997148	5
589116080	32.64939025	12.08311047	19.19265313	18.33938592	46.08772936	10.19524142	0.237758016	1.698547411	20.56537877	9.967593521	20.60144892	3.238388006	2
591512884	33.58011556	11.38745835	17.2268856	16.54079242	44.6577443	6.651303594	0.22673725	1.382636793	17.27140157	9.760459815	20.27029994	2.125045794	2
591580491	30.32346469	9.707456108	23.56762264	10.00460894	44.35916673	2.65330954	0.310727912	0.74810825	12.8372377	6.17868658	20.32278367	2.577535443	2
591715484	26.56294392	14.08391437	26.54951826	16.27295718	45.76667277	1.984365877	0.404776325	0.549683823	15.85736771	12.75072295	19.57399762	3.098697902	5
592027612	34.76089046	11.13848614	18.11236513	13.98469113	46.04947328	5.413157797	0.140565556	0.457418839	19.76870996	11.8924107	20.76082419	1.942725989	2
592384567	32.64939025	8.585108165	20.65952309	11.80300989	45.42860168	5.706384237	0.271370564	0.433086591	14.46335789	7.015141418	20.37836804	1.787975144	2
593403756	32.90347903	9.38123872	21.08872122	13.0426178	46.04947328	5.912795894	0.185977638	0.432267618	14.13435302	7.950560979	20.56388902	1.923901482	2
595859229	31.4810827	10.21051027	22.75613533	11.78074173	44.55569599	3.33909482	0.220040903	2.42210808	12.77540654	8.969963649	20.3577974	2.872475478	2
596424426	31.12088163	8.031986122	21.48969393	11.22085627	44.81938517	2.227508311	0.203100887	0.319122422	12.45802433	5.175462354	20.44812221	1.968024911	3
596598382	32.59899525	11.82057568	21.08872122	17.76041186	46.08772936	9.855867347	0.199749869	1.644915996	20.08679697	9.169091879	20.38819946	3.101919138	2

Results

Results _ Qualitative analyses





Results _ ANOVA analyses

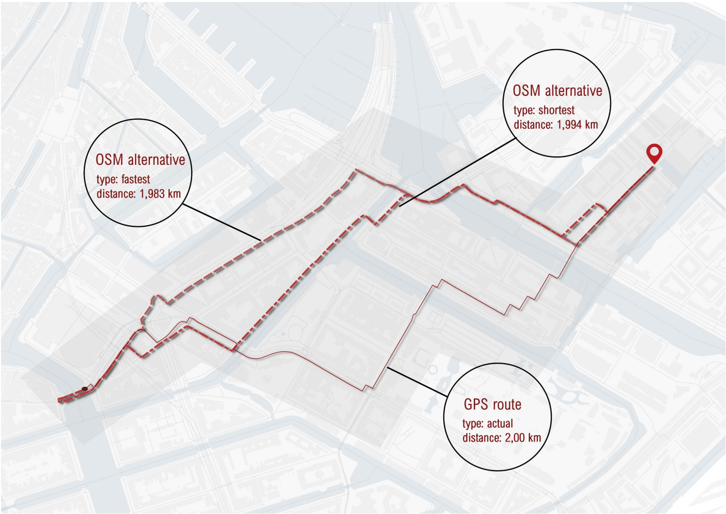
Tukey's and Games-Howell post hoc tests

Coding types of routes:

1: GPS route - 2: Fastest route - 3: Shortest route - 4: Recommended route

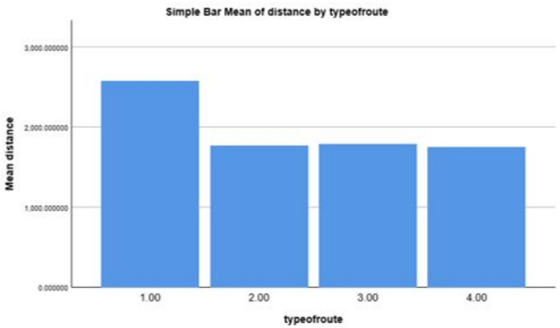
Dependent variables:

- StDev of Sky,
- StDev of Buildings,
- StDev of Ground,
- StDev of Standard deviation of length of rays,
- StDev of ratio buildings/sky,
- StDev of ratio buildings/ground, and
- Distance



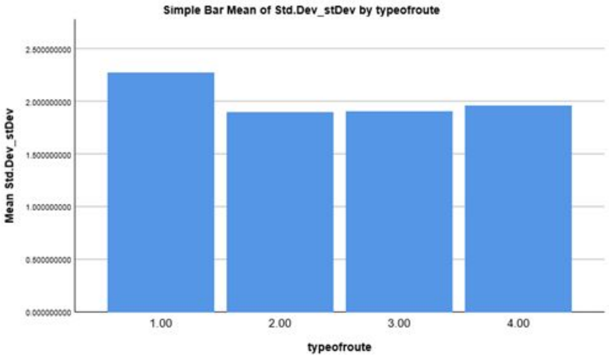
Results _ ANOVA analyses

Distance



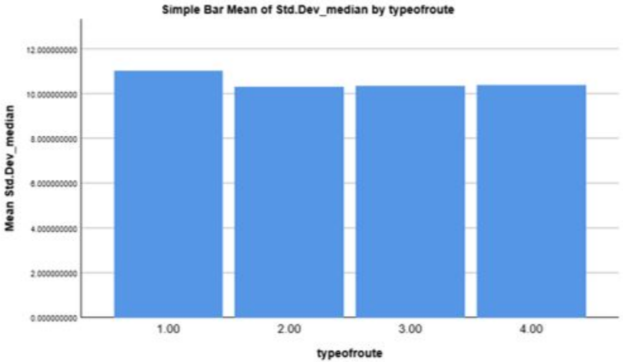
Cyclists are following longer routes

StDev of StDev



Cyclists are following routes with different street profiles

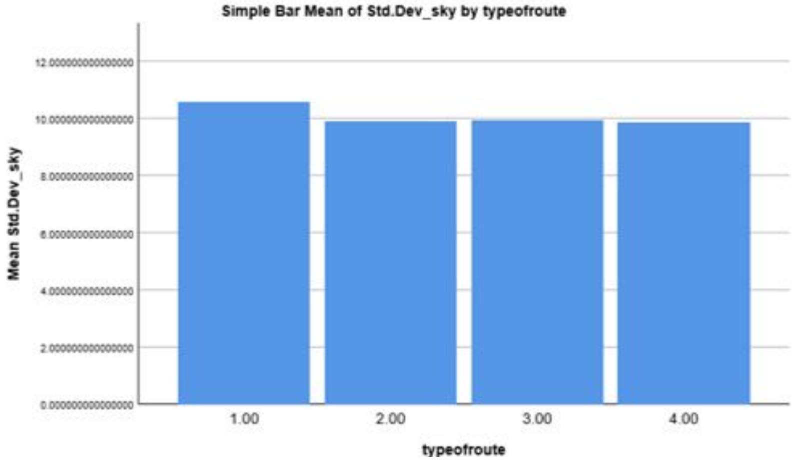
StDev of Median



Cyclists are following non-homogeneous routes

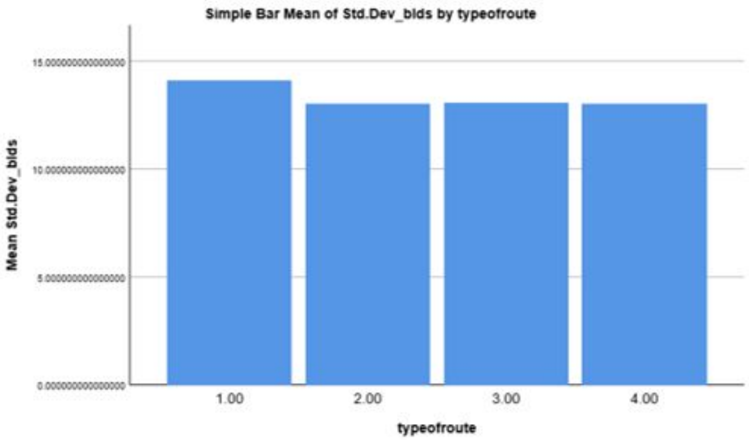
Results _ ANOVA analyses

Variations in visible sky



Cyclists are following routes with more variations in the visible sky

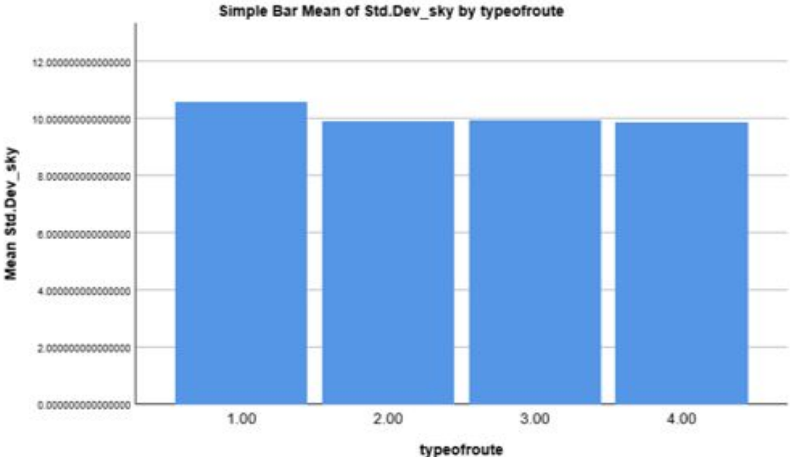
Variations in visible buildings



Cyclists are following routes with more variations in the visible buildings

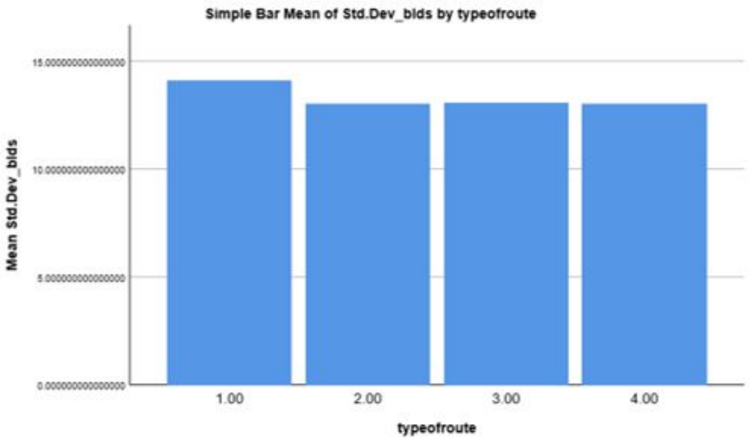
Results _ ANOVA analyses

Variations in ratio buildings:sky



Cyclists are following routes with more variations in the ratio buildings:sky

Variations in ratio buildings:ground



Cyclists are following routes with more variations in the ratio buildings:ground

Conclusion & Future research

Conclusion - Results

Cyclists don’t follow the shortest or fastest routes but seek for variations in the built environment and non-homogeneous routes.

- Planning of cyclists’ accessibility to the street network not limited to fastest and shortest routes
- In busy neighborhoods, cyclists are following secondary streets even when bicycle lanes do not exist
- Variations of buildings is an important difference but when combined with sky or ground
- Ground element gives a non-significant difference - Street infrastructure (Requires higher level of detail?)

Conclusion - Methodology

Methodology succeed to capture the 3D environment of the routes and add value to the 2D methodology

Openrouteservice API suggestions are limited to streets with bicycle lanes

Threshold of merging route or centreline leads to misinformation (recommended routes)

Aggregated street profiles did not succeed to capture the 3D environment but have potentials

Statistical Analysis - Did not capture connection between the metrics

Definition of streets' categories leads to overlaps

Good performance of Rhino but slower when using Python and rerun of visibility analyses at streets with a lot of information

Take home message

Cyclists prefer to travel through routes with variations in the built environment without considering travel time/distance

The 3D isovist methodology captures the visible views and add value to Space syntax methodology

It can help to define design guidelines and give a deeper insight of the cyclists' route choices

Future research

Investigation of application in more GPS routes and study areas

Sensitivity analysis - Is the centreline the appropriate way to explore the visibility of a cyclist?

Details to the ground element - Define water, greenery

Landmarks and gravity points should be included

Investigation of decision points (intersections) and turns

Application of suggested methodology - Visibility Graphs

Thank you! :)

Complete methodology

RQ: To what extent the directly visible views of the urban environment influence the route choices of the cyclists and how these views can be measured?