Visualization of origin-destination data & a generic zoning system for cities

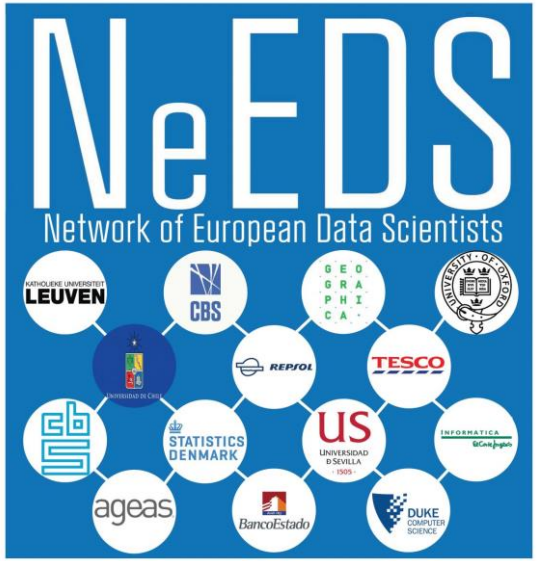
Results a secondment at the University of Oxford and visit to the University of Leeds.

Martijn Tennekes

Heerlen, September 22, 2020

Executive summary

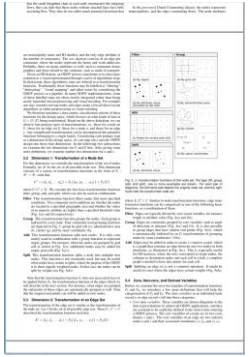
Secondment for 6 months



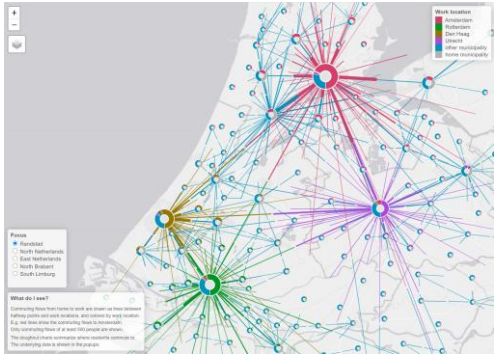
https://riseneeds.eu/

UNIVERSITY OF OXFORD

Output



Academic working paper on origin-destination visualization



A new visualization method, applied to commuting traffic

Collaboration with the **University of Leeds** on transport and mobility

First result: a zoning system for cities

Visiting researcher in Oxford

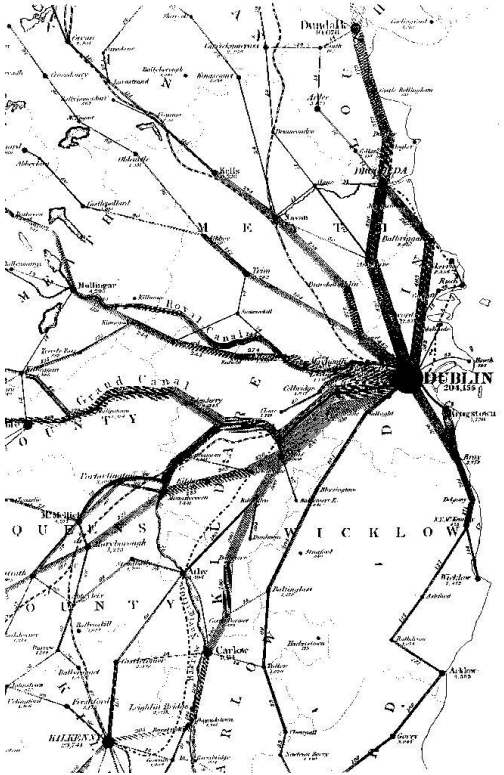
Computer Science building in Oxford

Martijn Tennekes (CBS) and Min Chen (University of Oxford)

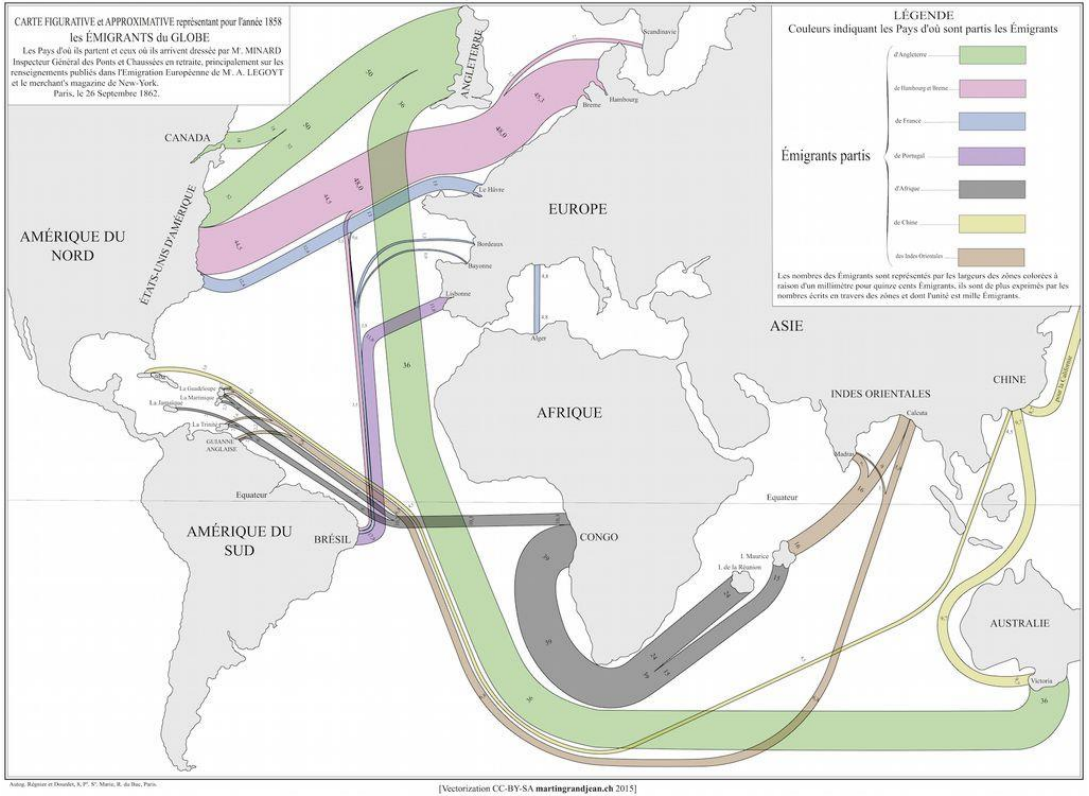
Origin-destination data

- **Origin-destination (OD)** data describe movements from origin to destination.
- Applications: **migration**, **passenger transport**, **export of goods**, **movement of animals**, **spreading of deceases**, etc.
- A ***raw*** OD dataset describes movements of individuals whereas an ***aggregated*** OD dataset describes countable flows of individuals.
- Example dataset: commuting flows between 390 Dutch municipalities.

Visualization of origin-destination data

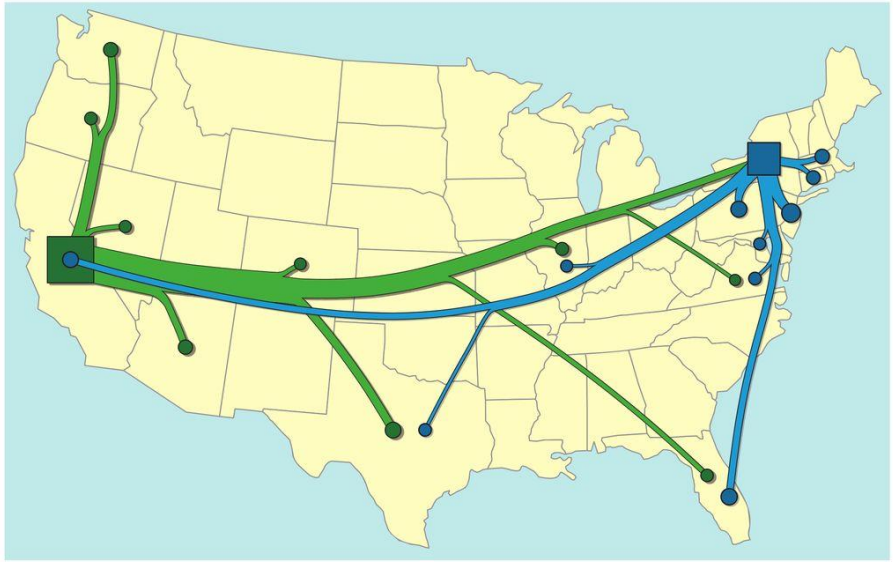


Public transport (Harness, 1837)

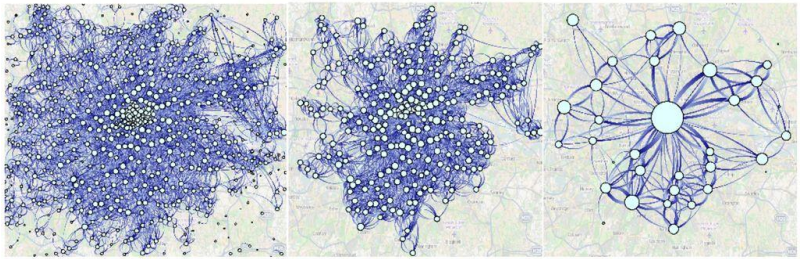


World migration (Minard, 1858)

Visualization of origin-destination data



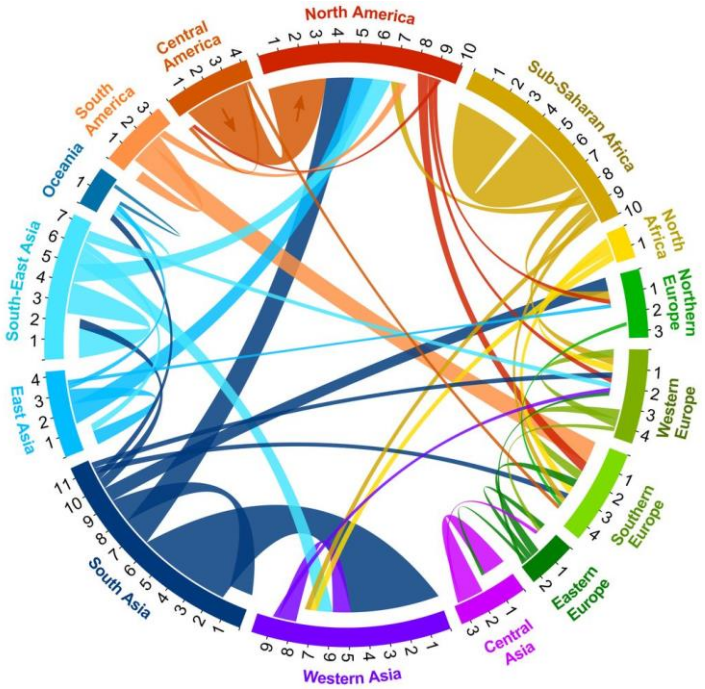
Spiral trees (Verbeet et al., 2011)



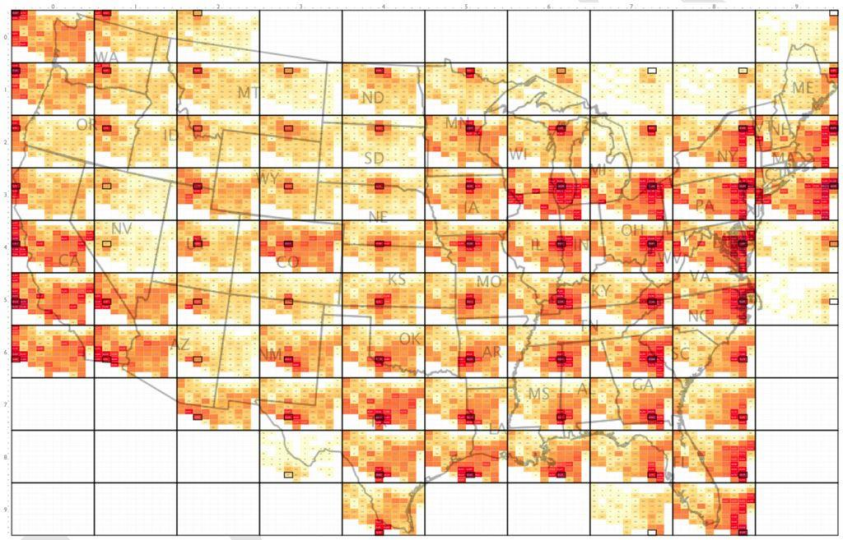
(a) Original flows (b) Filtered flows (c) Aggregated flows

MobilityGraphs (Landesberger et al., 2016)

Visualization of origin-destination data

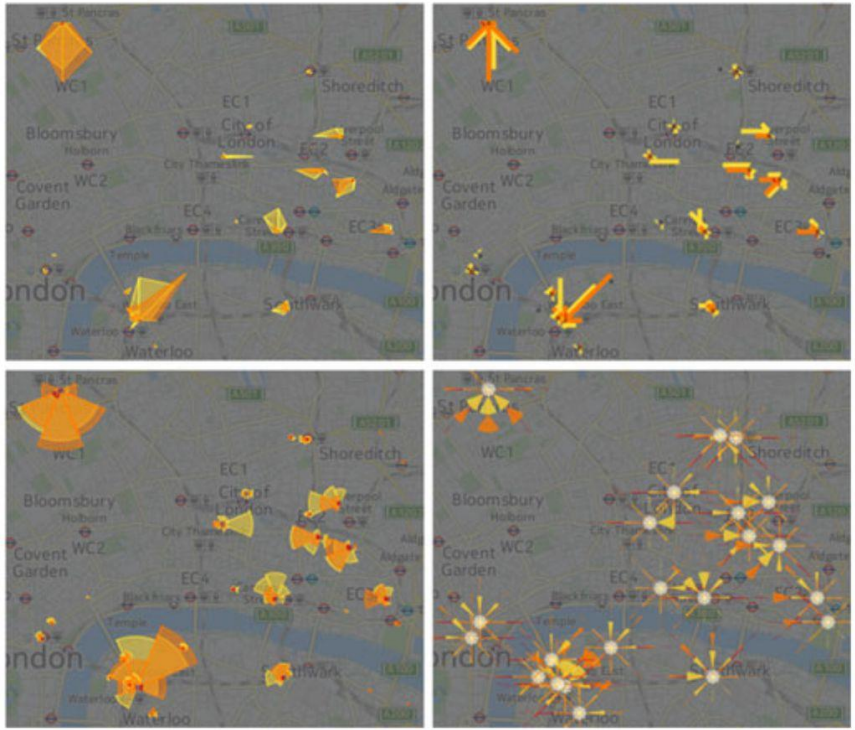


Circular plot (Abel et al., 2014)

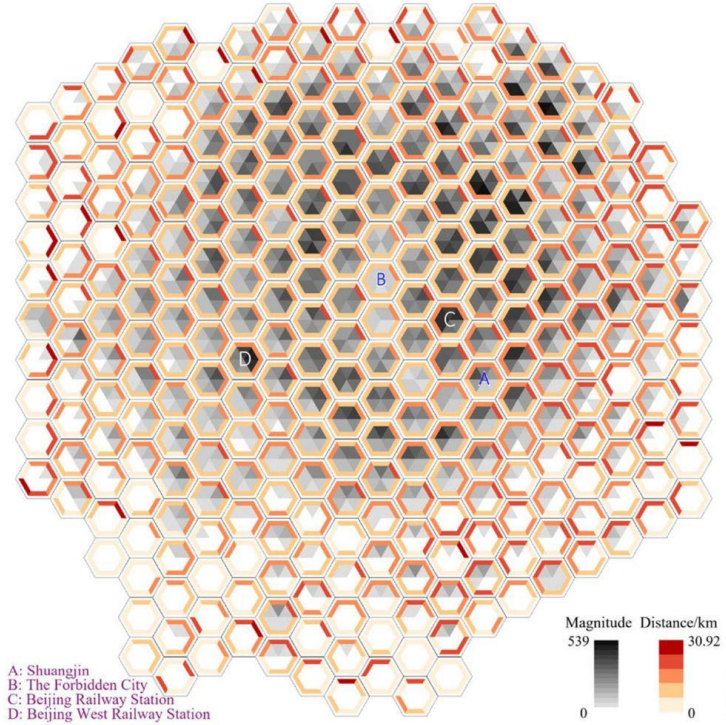


OD maps (Wood et al., 2010)

Visualization of origin-destination data



Flow diagrams (Adrienko et al., 2017)



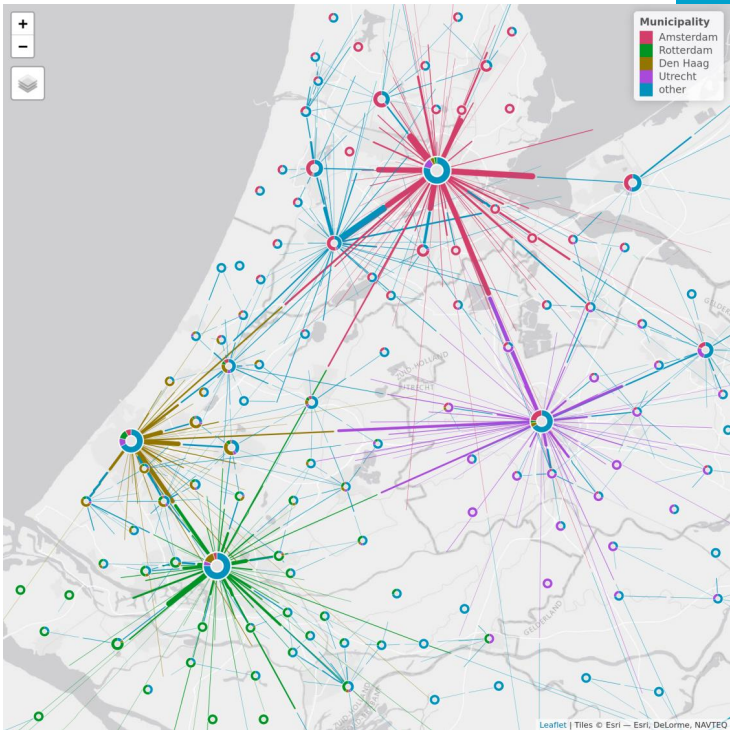
Pattern maps (Yao et al., 2019)

Design space of OD visualization

- Our aim was to **organize** existing OD visualizations systematically and **discover** new OD visualization methods.

- How? By introducing a **design space** which includes all OD visualization methods that are theoretically possible.

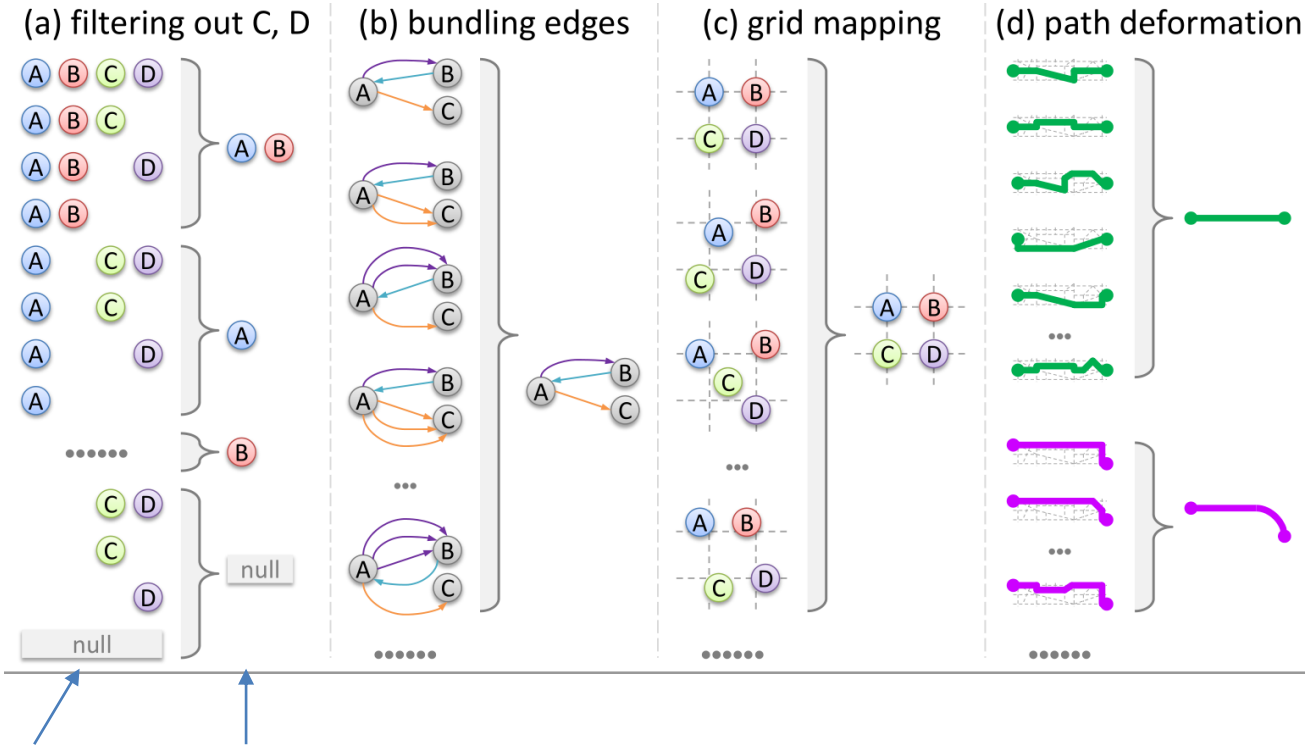
- Result: a design space of **four dimensions** using **information theory**, which enabled us to discover a **new OD visualization method**.



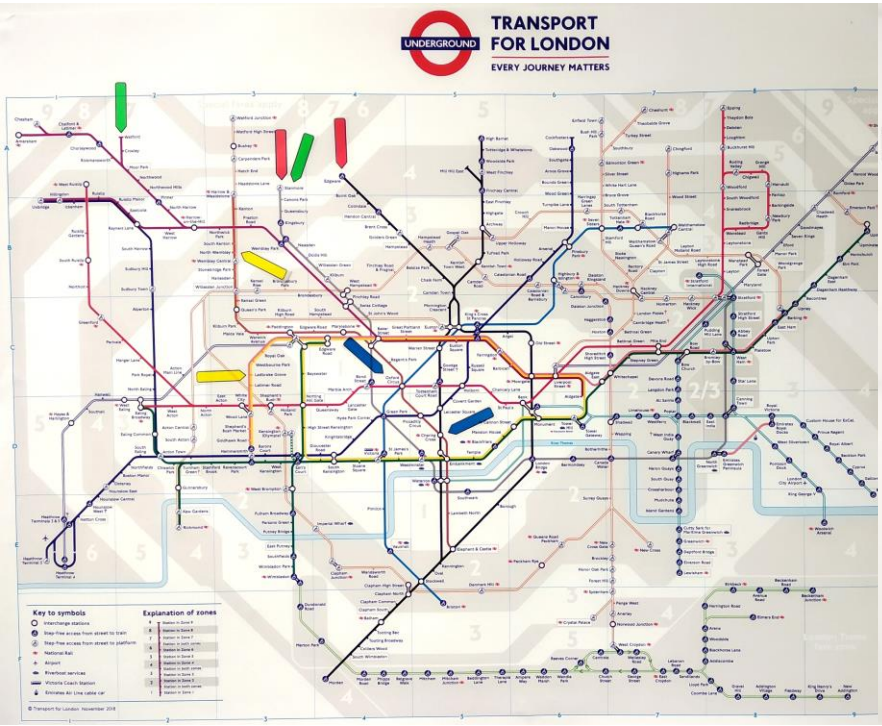
Information Theory

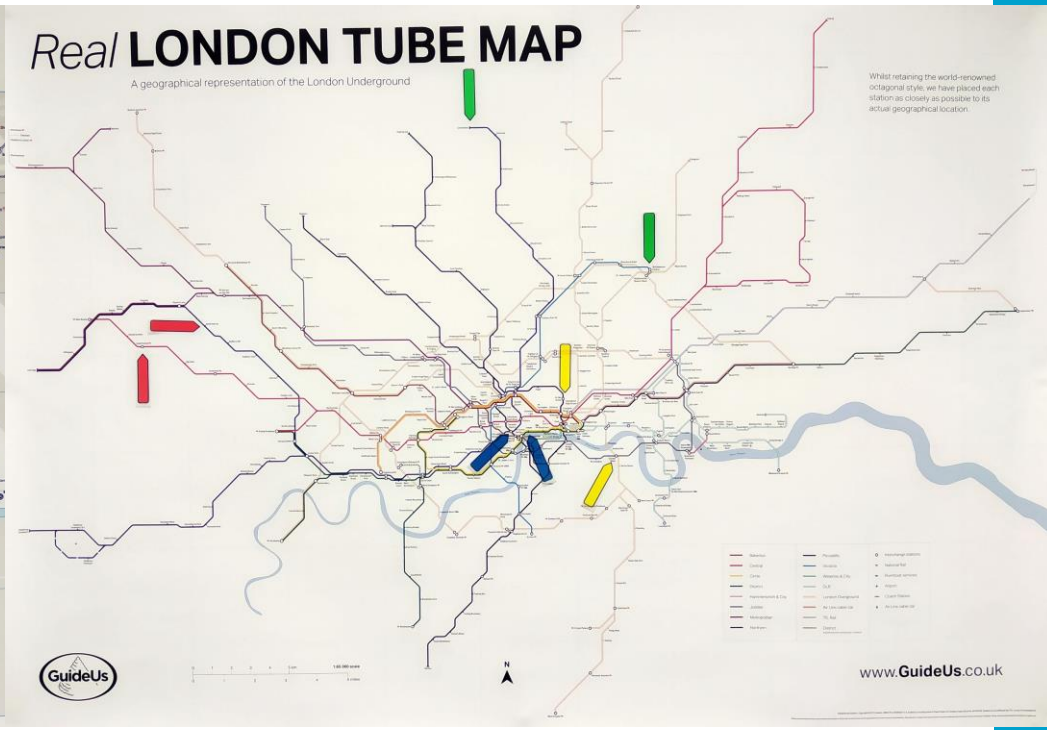
- **Information theory** studies the quantification, storage and communication of information.
- It is (almost) impossible to retrieve the original dataset from a data visualization.
- However, visualization is often much more effective than showing raw data tables. Why?
  - Global overview is often more important than local details.
  - Showing less information helps reducing the time cost and cognitive load.
- **Information loss** (entropy reduction) is key in data visualization. Central questions are: what information can be omitted and how?

Reducing information



Is realistic always better?

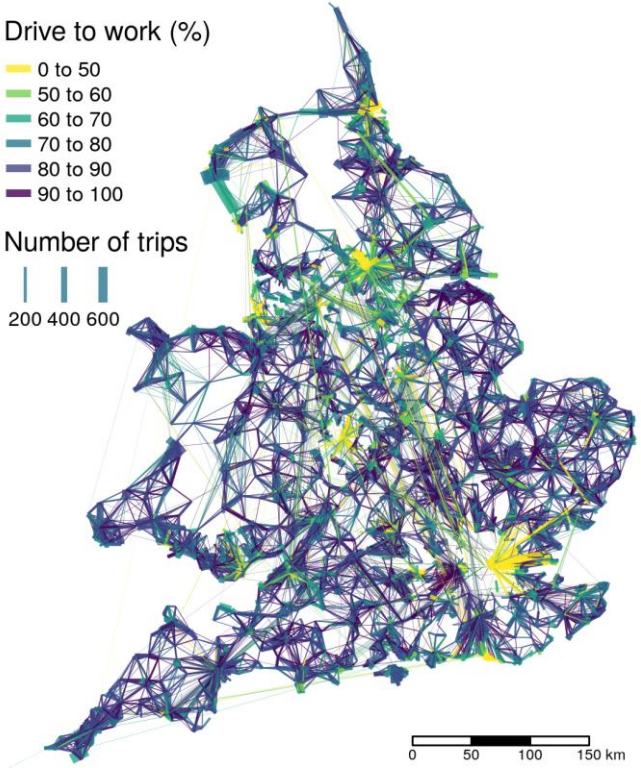


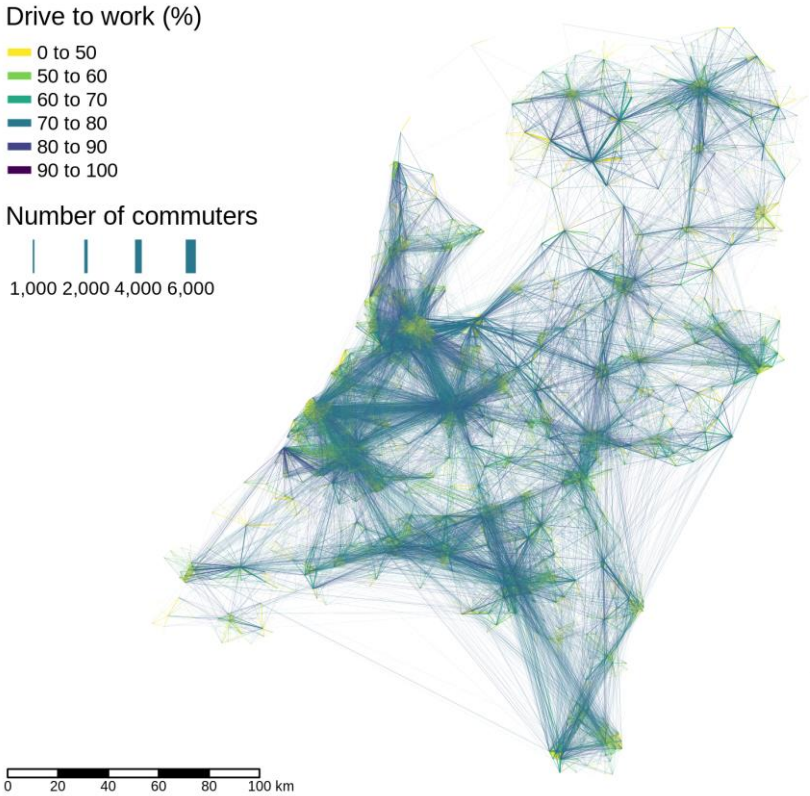


London Underground Map

Realistic locations

Background knowledge matters



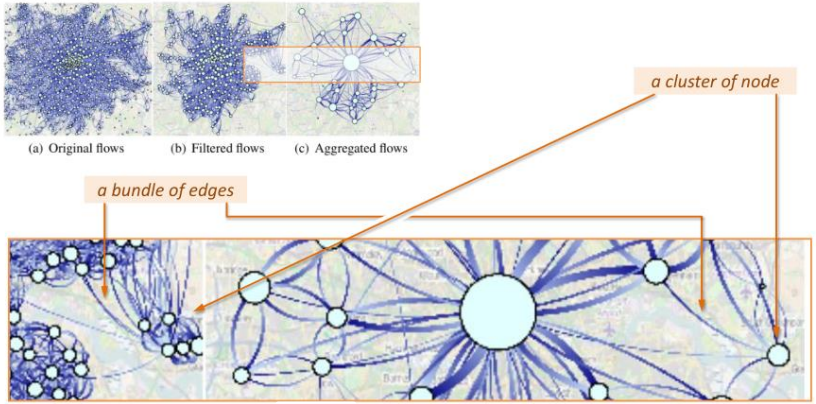


Without knowing the locations of the cities, it is hard to use these maps

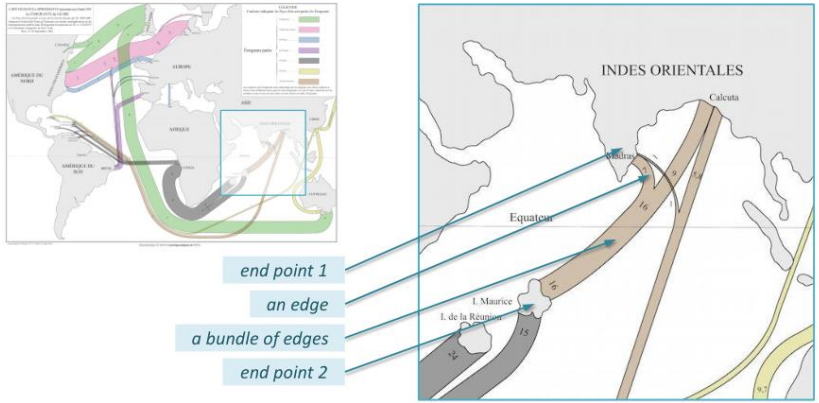
Our design space

- An OD dataset contains of **nodes** and **edges**.
- Our design space consists of four dimensions:
  1. Transformation of the node set
  2. Transformation of the edge set
  3. Transformation of individual nodes
  4. Transformation of individual edges
- Dimensions 1 and 2 process the data structure (e.g. grouping nodes).
- Dimensions 3 and 4 process visual attributes (e.g. coordinates).

Applied to exisiting OD visualizations



(a) MobilityGraphs
F_1: Group
F_2: Group and filter
F_3: Dimension Enhancement and Attenuation of (x, y)
F_4: Dimension Attenuation w.r.t. ordering,
dimension Attenuation w.r.t. direct path and length



(b) Flow map by Minard (1862)
F_1: Group (same coordinates)
F_2: Group (same nodes)
F_3: Geometric Deformation
F_4: Dimension Enhancement,
dimension Attenuation w.r.t. direct path and length

Dutch commuting

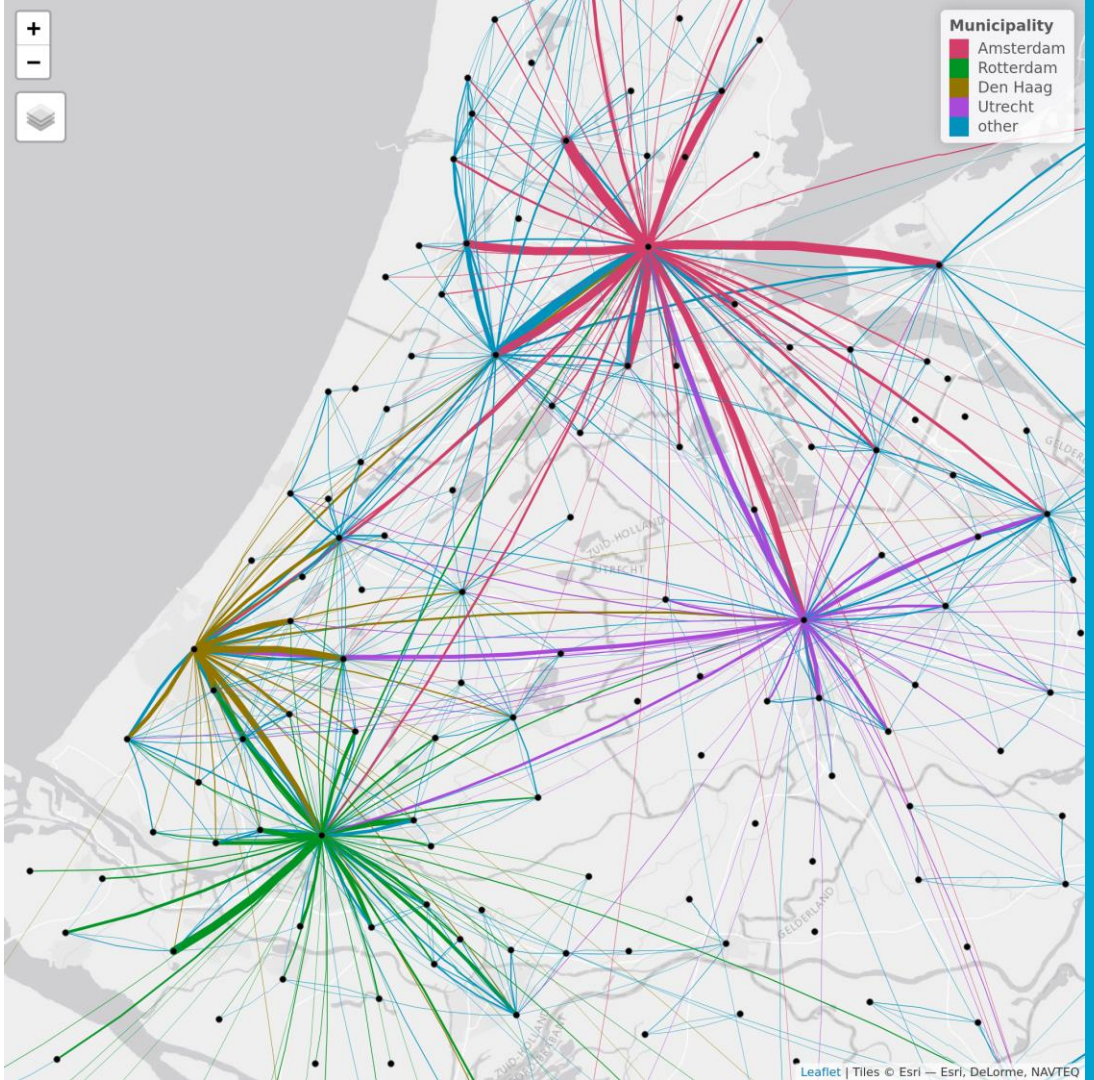
Transformations:

- F1: nodes are grouped by municipality
- F2: edges are grouped by same pair of nodes
- F4: missing arrowheads: dimension attenuation

Dutch commuting

Transformations:

- F2: filtering of edges
- F4: color coding: dimension enhancement



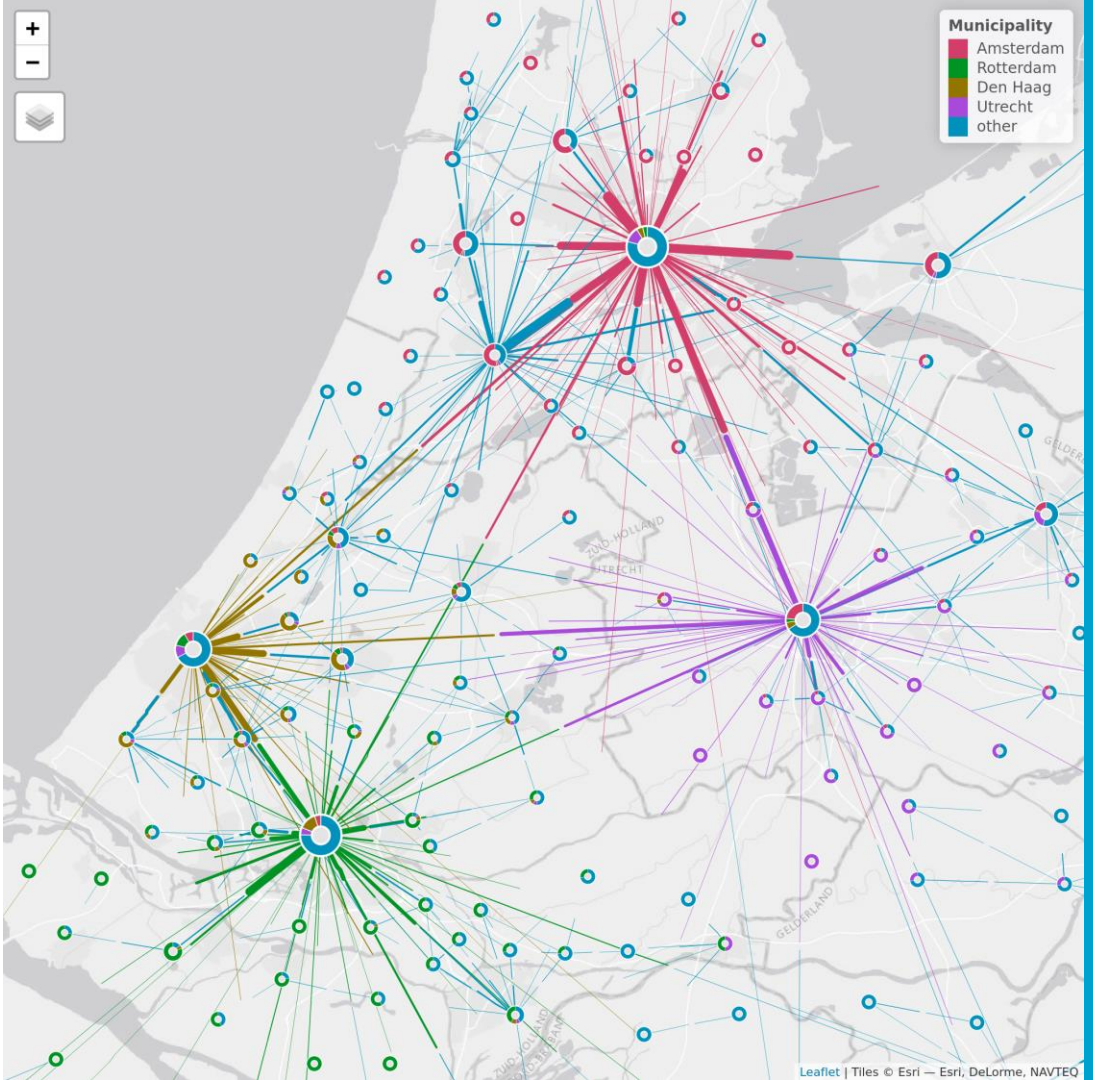
Dutch commuting

Transformations:

- F3: doughnuts: dimension enhancement
- F4: half-edges: dimension attenuation (length and direct path)

Link prototype:

http://www.mtennekes.nl/viz/commutingNL

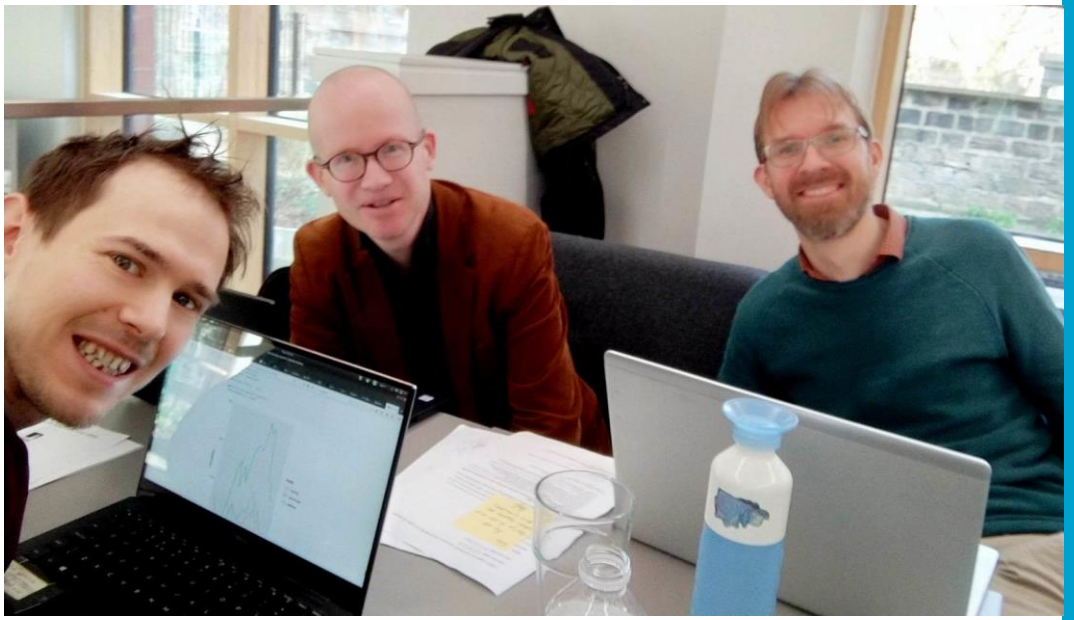


Discussion

- Information Theory has proven to be useful in visualization.
  - “Less is more”: reducing information often leads to better visualizations.
  - User and task dependency.
- A design space for OD visualizations enforces users to think about which information to loose and which to show.
- Doughnut map with halfway lines works well for commuting data, but not necessarily for other OD datasets.

Collaboration with University of Leeds

- Institute of Transport Studies (ITS) department
- Mobility, cycling infrastructure, public transport, etc.
- Hackathon
- First project: a generic zoning system for cities
- Method, draft paper, and an R package ready

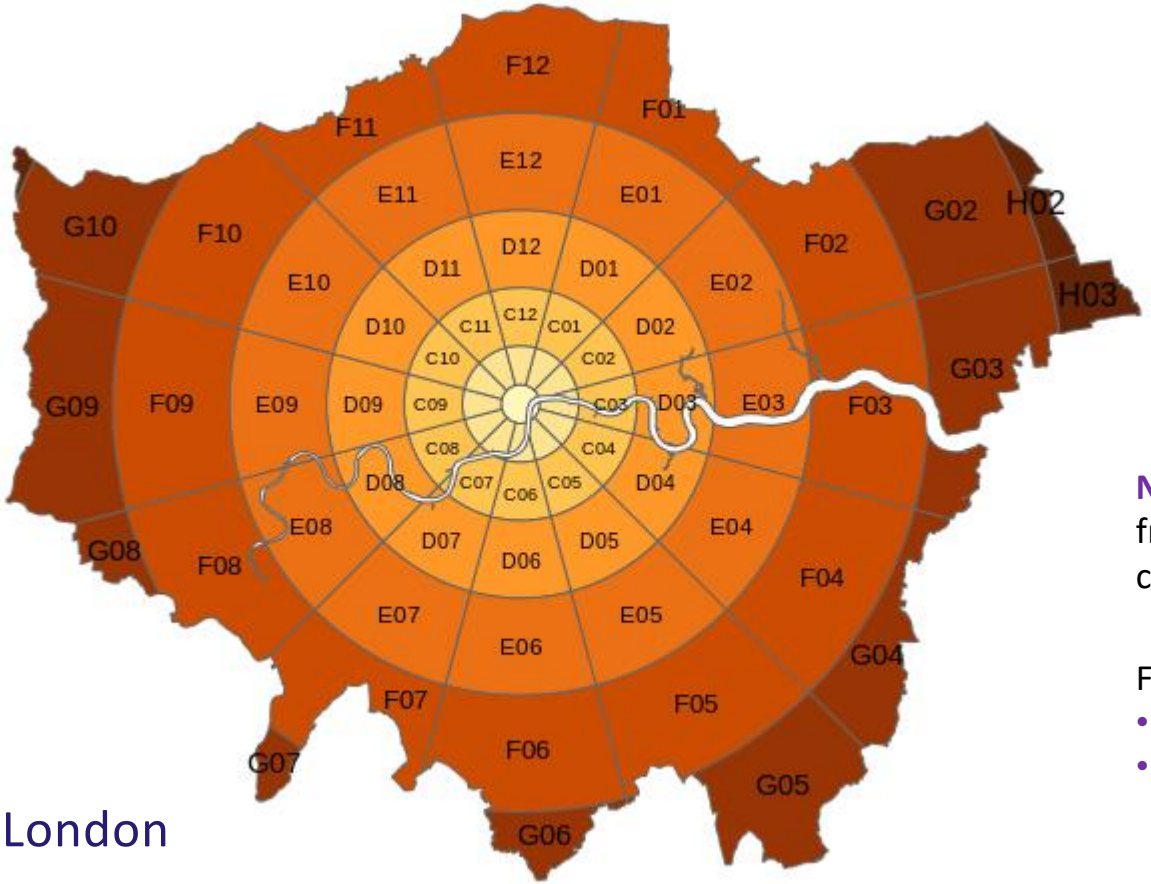


Robin Lovelace (associate prof., Univ. of Leeds), Marko Roos and Martijn Tennekes (CBS)

A generic zoning system for cities

- Why?
  - For general navigation.
  - For statistical comparison between cities
  - For transport modeling.
- Current administrative regions vary a lot between and within cities (e.g. postal code, neighbourhoods etc.).
- A tiling system (e.g. 100 x 100 meter tiles) is generic, but does not take the city structure into account.
- We introduce a generic zoning system for concentric cities called **ClockBoard**
- R-package **zonebuilder**: https://github.com/zonebuilders/zonebuilder

ClockBoard



Letters A – G represent the rings

Distance to centre	Annulus height
15 km	
	E: 5 km
10 km	
	D: 4 km
6 km	
	C: 3 km
3 km	B: 2 km
1 km	A: 1 km

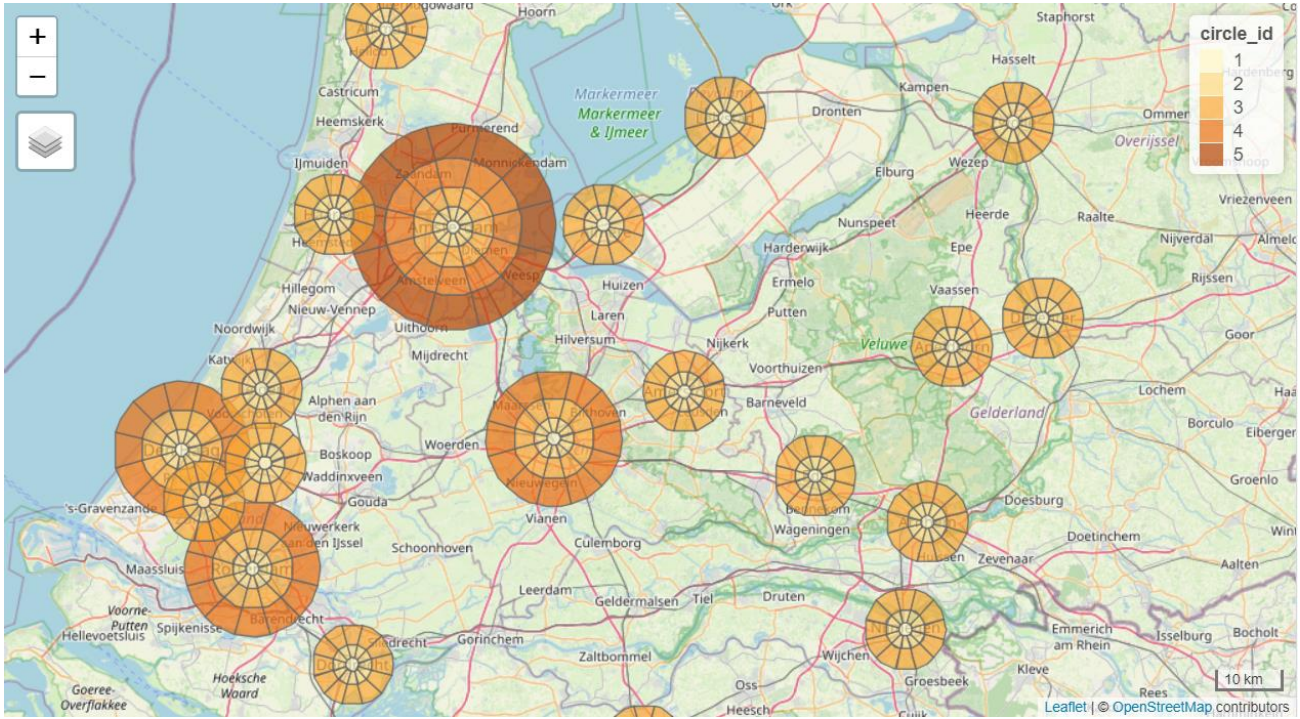
Numbers 1-12 represent the direction from the centre, analog to the hours of a clock.

For instance zone **D06** means:

- **D**: 6-10 km from the city centre,
- **06**: six o'clock = south.

London

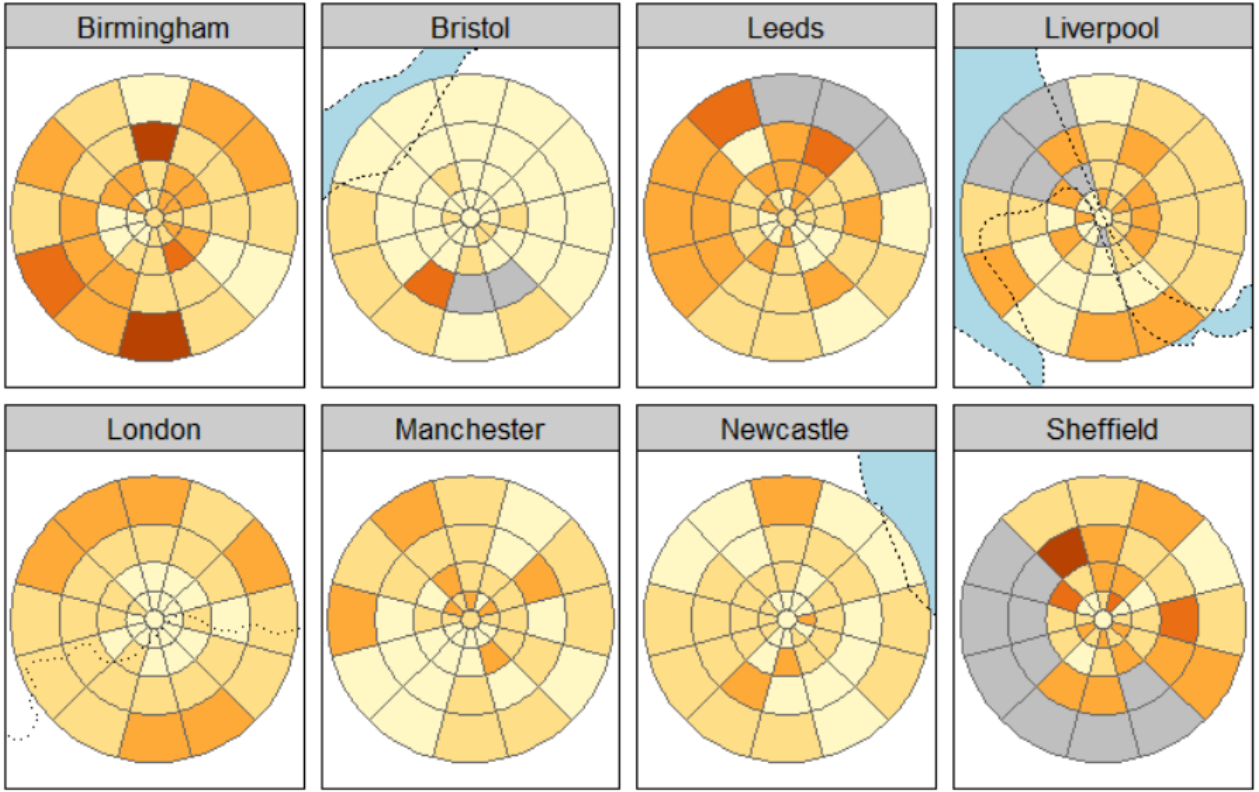
Dutch cities



Research questions:

- Where exactly is the centre?
- How to deal with overlap (e.g. The Hague and Delft)?

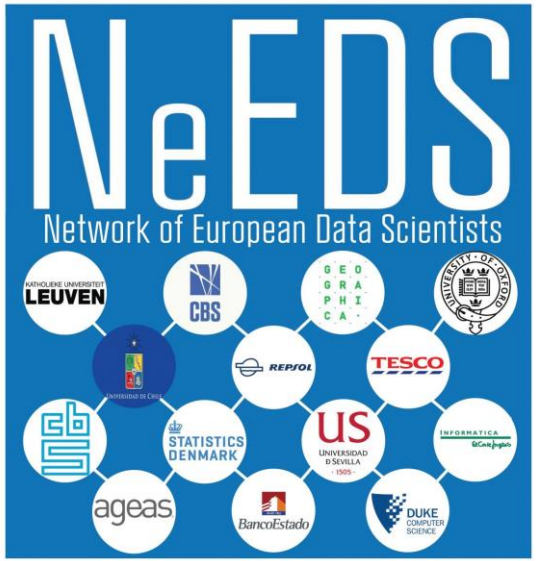
How safe are UK cities for cycling?



Discussion

- ClockBoard: a simple yet intuitive zoning system
- Not all cities are concentric
- Some cities have two centres:
  - Merged cities (e.g. Buda-pest)
  - Old town and financial district
- How to deal with overlap (e.g. The Hague / Delft)?

Acknowledgements



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