

Consiglio Nazionale
delle Ricerche

01 Introduction

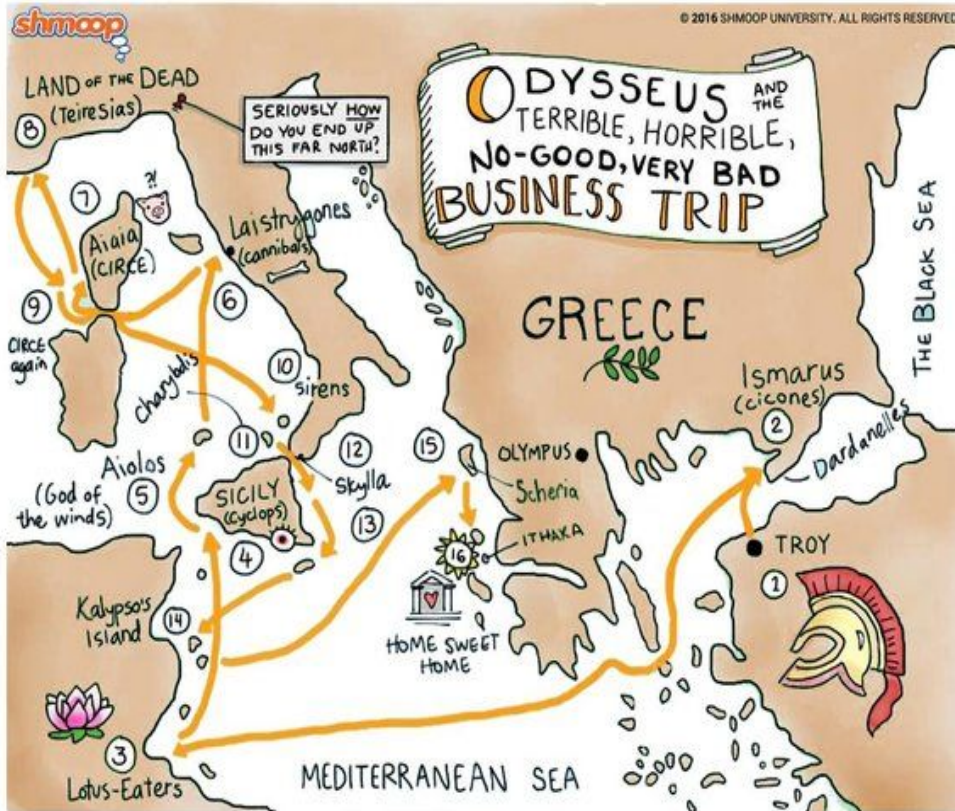
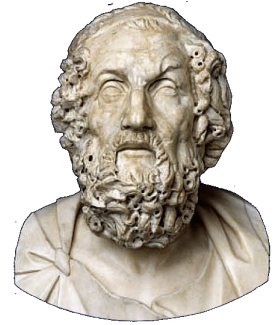
Geospatial Analytics

Transforming a (potentially large) set of isolated facts about **when** and **where** objects/people/phenomena **were** or **moved** into higher-level knowledge:

- Summarizing complex events and phenomena
- Providing insights about the general structure (global view)
- Identifying specific interesting patterns (local view)
- Enable predictions or educated guesses

Historical Examples

The Odyssey is the story of...a trajectory



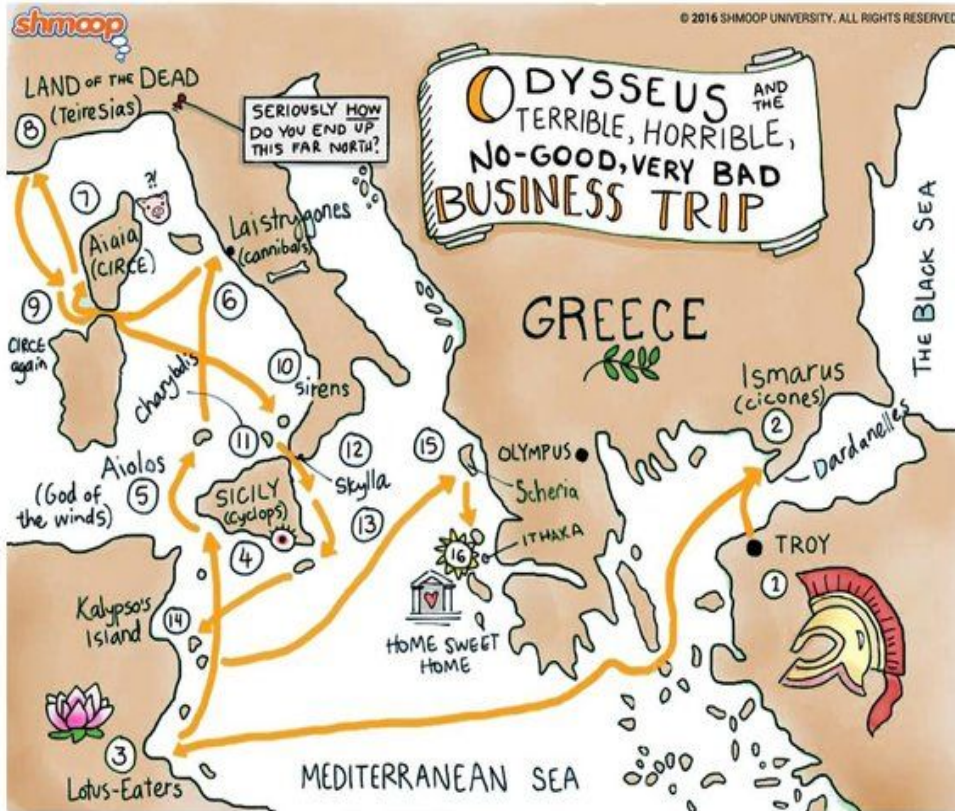
"A man who has been through bitter experiences and travelled far enjoys even his sufferings after a time"

Homer, Odyssey

interactive map



The Odyssey is the story of...a trajectory



*“ma misi me per l’alto mare aperto
sol con un legno e con quella compagna
picciola da la qual non fui disertò.
L’un lito e l’altro vidi infin la Spagna,
fin nel Morrocco, e l’isola d’i Sardi,
e l’altre che quel mare intorno bagna.”*

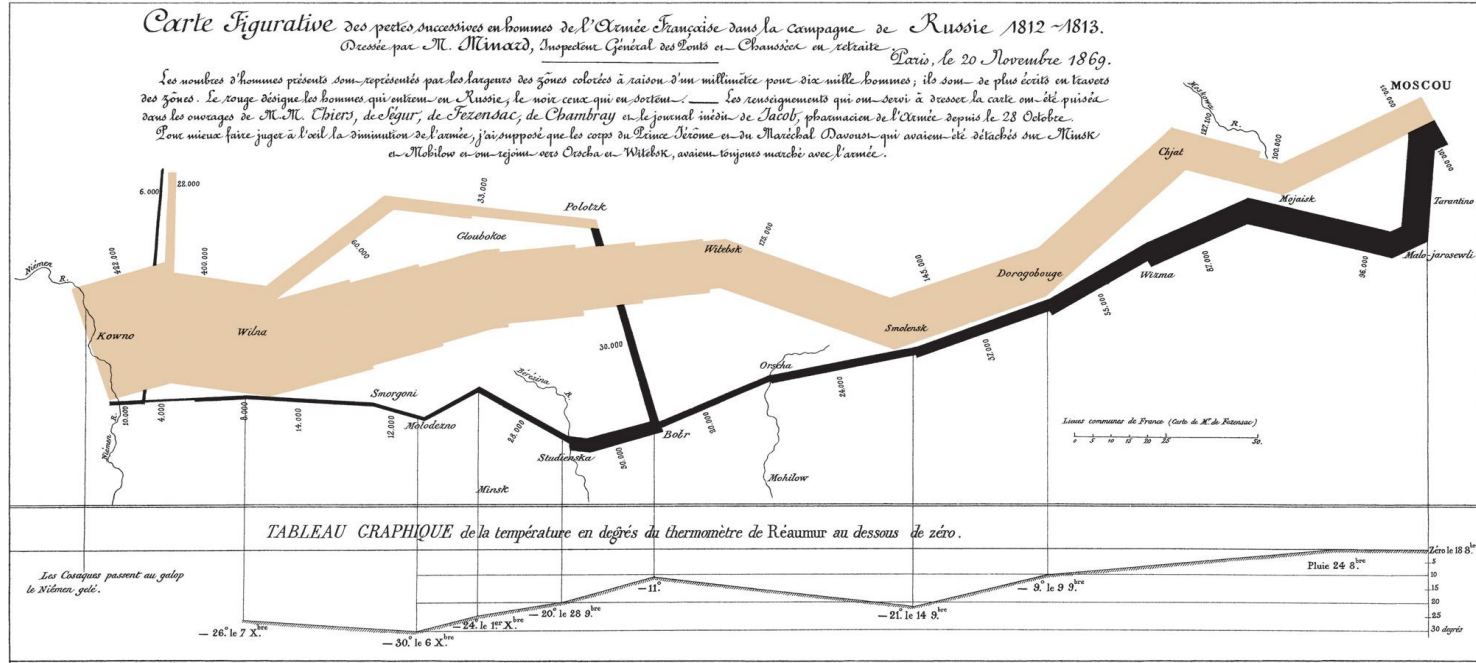
Dante’s Inferno, Canto XXVI

interactive map



French army in the Russian campaign (1812-1813)

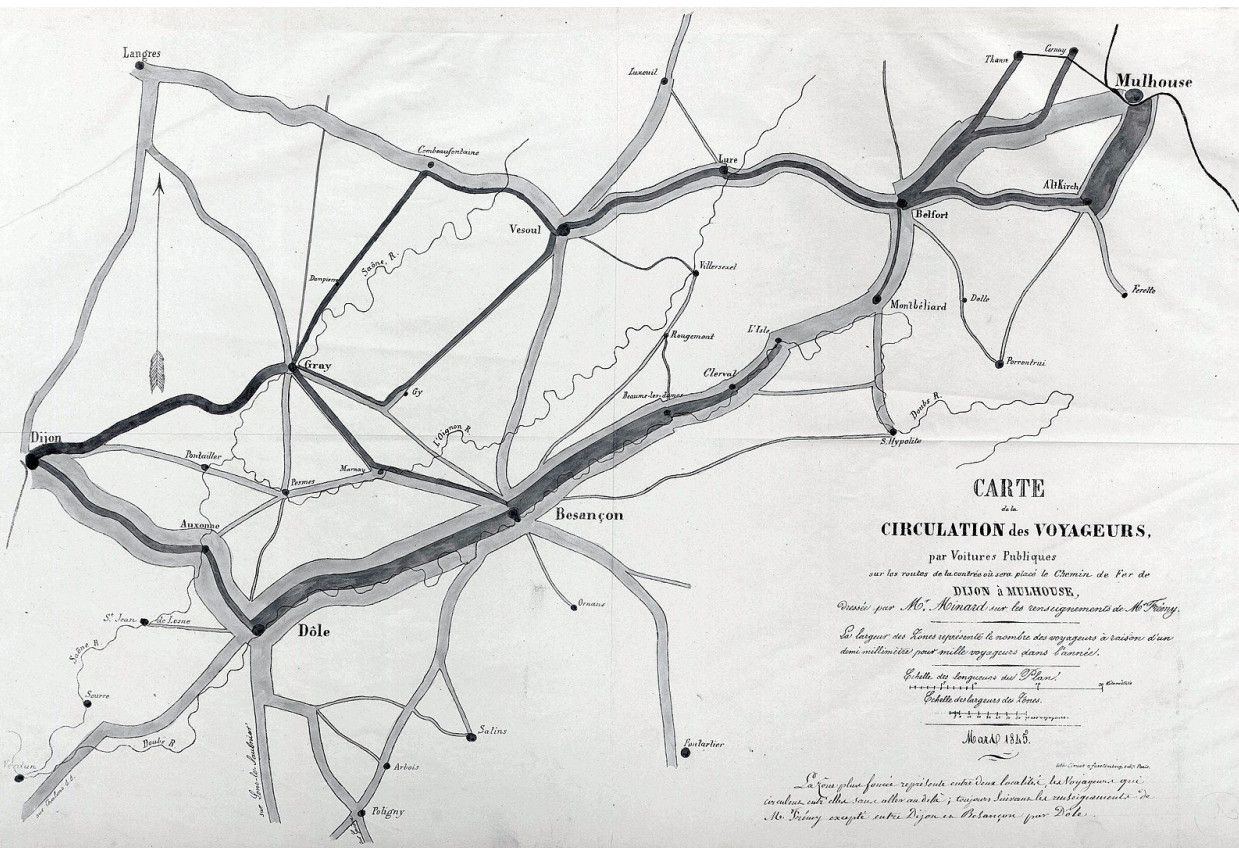
Charles Minard, 1869



Assé, par Regnier, à Paris. 5^{ème} Marie 51 9^{ème} à Paris.

Imp. Lit. Régis et Bourd.

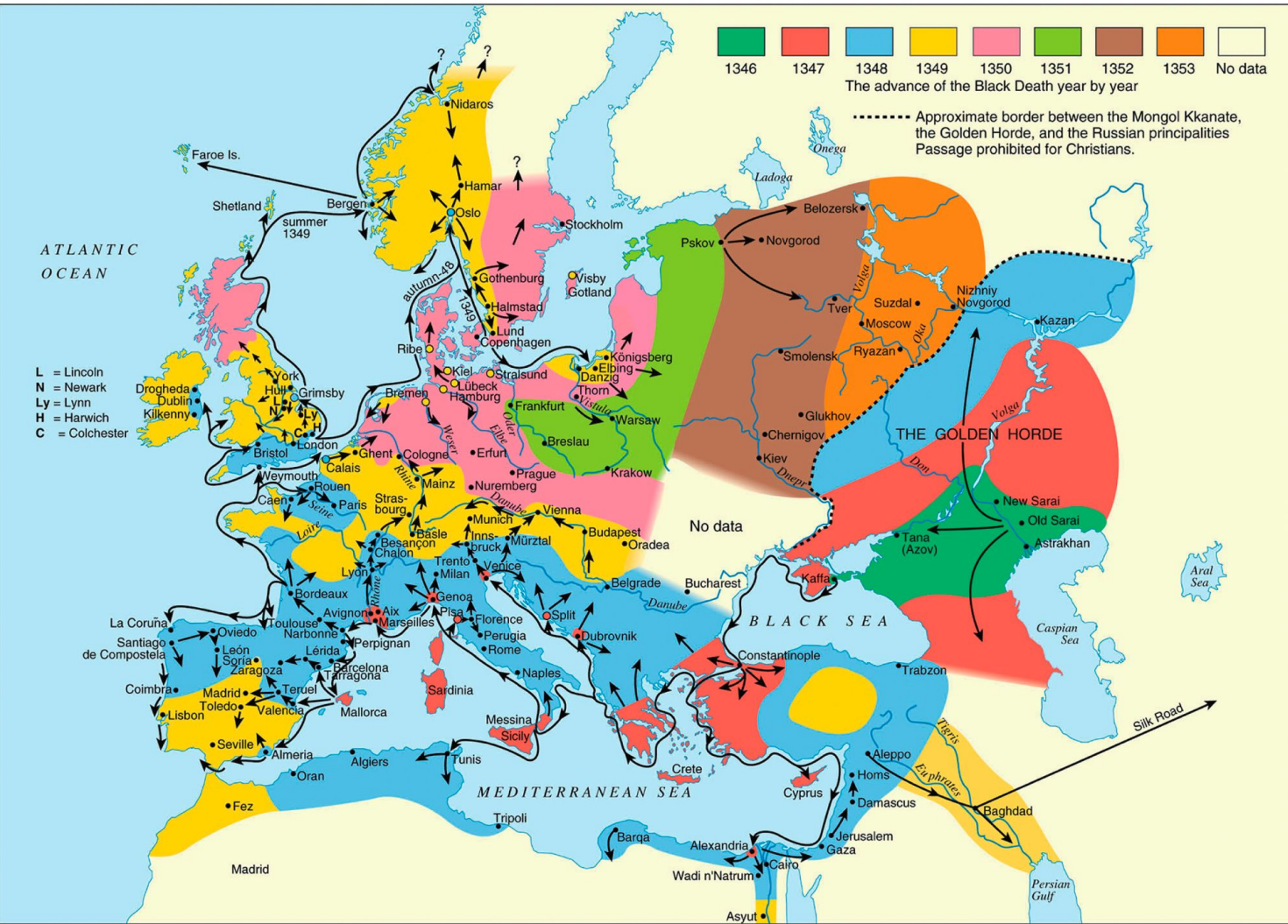




**Number of
passengers
between
Dijon and
Mulhouse**
Charles Minard, 1845



Spread of the Black Death (1346-1353)



Predicting criminals' trajectory

1930s



**IDENTIFICATION
ORDER NO. 1227
MAY 21, 1933.**

WANTED

**MRS. BOY THURSTON, alias BONNIE BARROW,
MRS. CLYDE BARROW, BONNIE PARKER.**

DESCRIPTION

Age, 29 years (1903); Height, 5 feet, 5 inches; Weight, 100 pounds; Build, slender; Hair, Auburn, bobbed; originally blonde; Eyes, blue; Complexion, fair; Scars and marks, bullet wound left foot next to little toe; bullet in left knee; burn scar on right leg from hip to knee; Peculiarities, walks with both knees slightly buckled.

RELATIVES:

Ray Thurston, husband, Texas State Penitentiary.
Mrs. J. T. [Name] Parker, mother, 1218 South Lamar St., Dallas, Texas.
Mrs. Billie Parker Moore, sister, 1218 South Lamar St., Dallas, Texas.
Robert [Name] Parker, brother, El Paso, Texas.
Bellie Gonzalez, half-sister, Norwood, Garza County, Texas.

CRIMINAL RECORD

Arrested sheriff's office, Kaufman, Texas, June 18, 1932 charge, burglary; released.

**DIVISION OF INVESTIGATION
U. S. DEPARTMENT OF JUSTICE**

WASHINGTON, D. C.

WANTED

**CLYDE CHAMPION BARROW, alias CLYDE BARROW, BOY
BART, JACK BALE, ELMOR WILLIAMS, ELYNN WILLIAMS.
NATIONAL MOTOR
VEHICLE THEFT ACT**

DESCRIPTION

Age, 29 years; Height, 5 feet, 7 inches, bare feet; Weight, 150 pounds; Build, medium; Hair, dark brown, wavy; reported dyed black; Eyes, hazel; Complexion, light; Scars and marks, shingle and anchor with "U.S.N." on right forearm; scar; girl's hair, left inner forearm; bullet wound through both legs just above knees.

RELATIVES:

Henry Barrow, father, Rural Route 8, Dallas, Texas.
Mrs. Lucile Barrow, mother, Rural Route 8, Dallas, Texas.
L. C. Barrow, brother, County Jail, Dallas, Texas.
Marie Barrow, sister, Rural Route 8, Dallas, Texas.
Mrs. Artie Winkler, sister, Senger Hotel Apartments, Dallas, Texas.
Mrs. Bellie Cowan, sister, Senger Hotel Apartments, Dallas, Texas.
Mrs. Jim Hockelroy, aunt, Marlinville, Texas.
Mrs. Belle Briggs, aunt, Dallas, Texas.
Frank Barrow, uncle, Garza, Garza County, Texas.
Jim Barrow, uncle, Stratton, Texas.
D. Brown, cousin, Marlinville, Texas.
Bertha Graham, cousin, Tyler, Texas.
Claude Lathicum, cousin, San Angelo, Texas.
Eddie Lathicum, cousin, San Angelo, Texas.

CRIMINAL RECORD

Criminal record and fingerprints can be obtained from Identification Order No. 1217, issued October 29, 1932.



Bonny & Clyde

Predicting criminals' trajectory

1930s



The Bonny & Clyde task force





Tracking the movements of dissidents

1970s-1980s

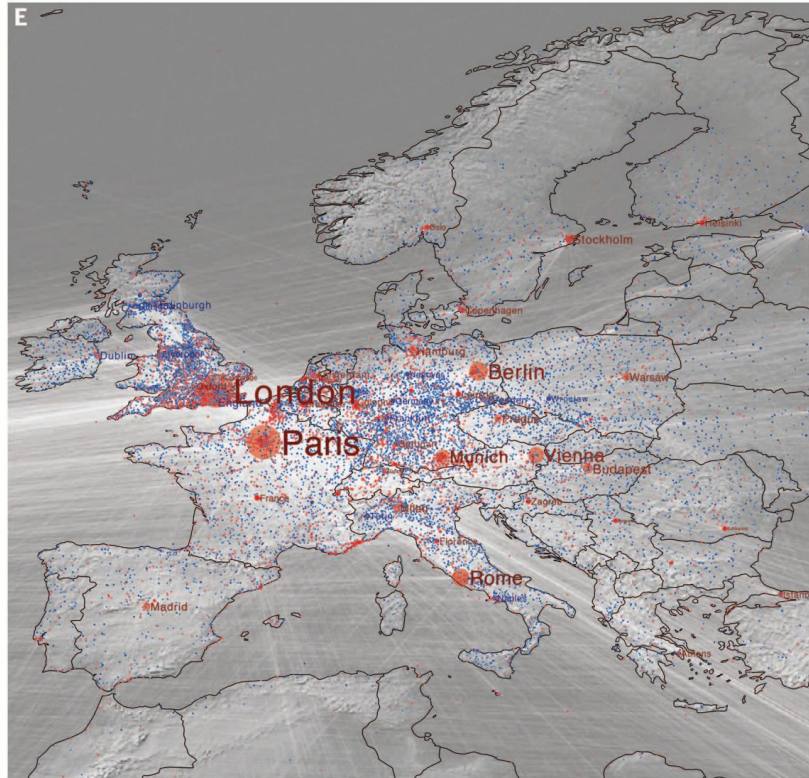
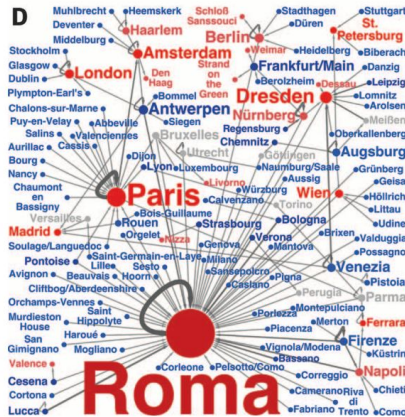
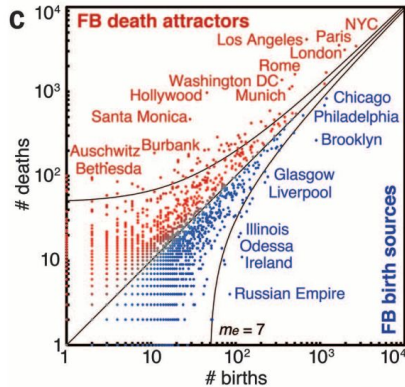


- Stasi sprayed a **radioactive solution** on the floors of the rooms where suspected dissidents met
- The solution adhered to dissidents' shoes, allowing agents to **track who attended a meeting** there
- Agents wore portable Geiger counters that activate when a suspected dissident was nearby

NewScientist



Birth and death place of notable individuals



birth sources ■ death attractors

- (C) Birth-death locations scatter plot, cumulated over all time with outliers colored as birth sources (blue) and death attractors (red)
- (D) Illustration of birth-death flows of antiquarians in the 18th century
- (E) Migration in Europe, with node size corresponding to PageRank



The Big Data era







Digital Footprints of Human Activity



Shopping
patterns



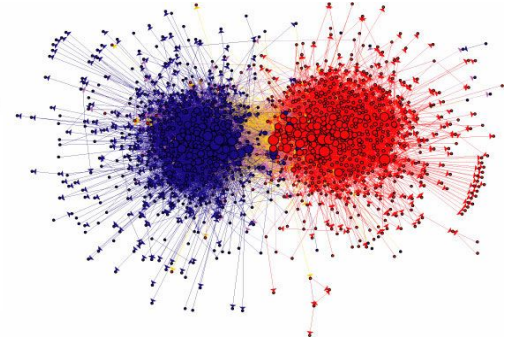
Digital Footprints of Human Activity



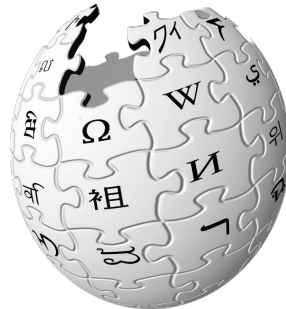
Shopping patterns



Social Ties



Opinions



WIKIPEDIA
The Free Encyclopedia

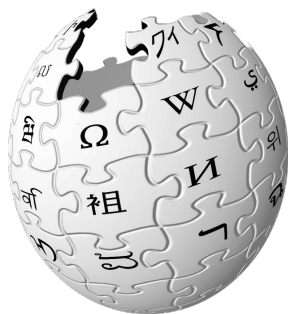
Digital Footprints of Human Activity



Shopping
patterns

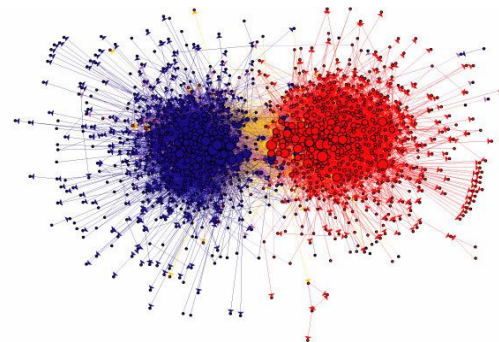


Opinions

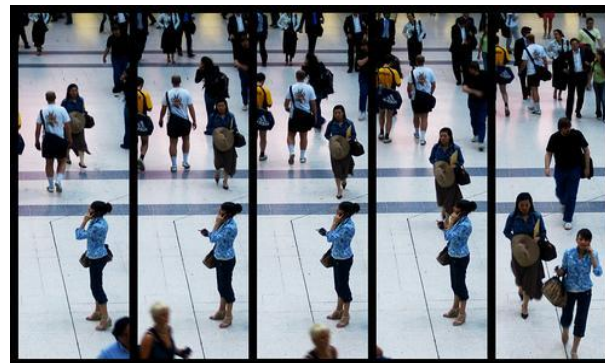


WIKIPEDIA
The Free Encyclopedia

Social Ties

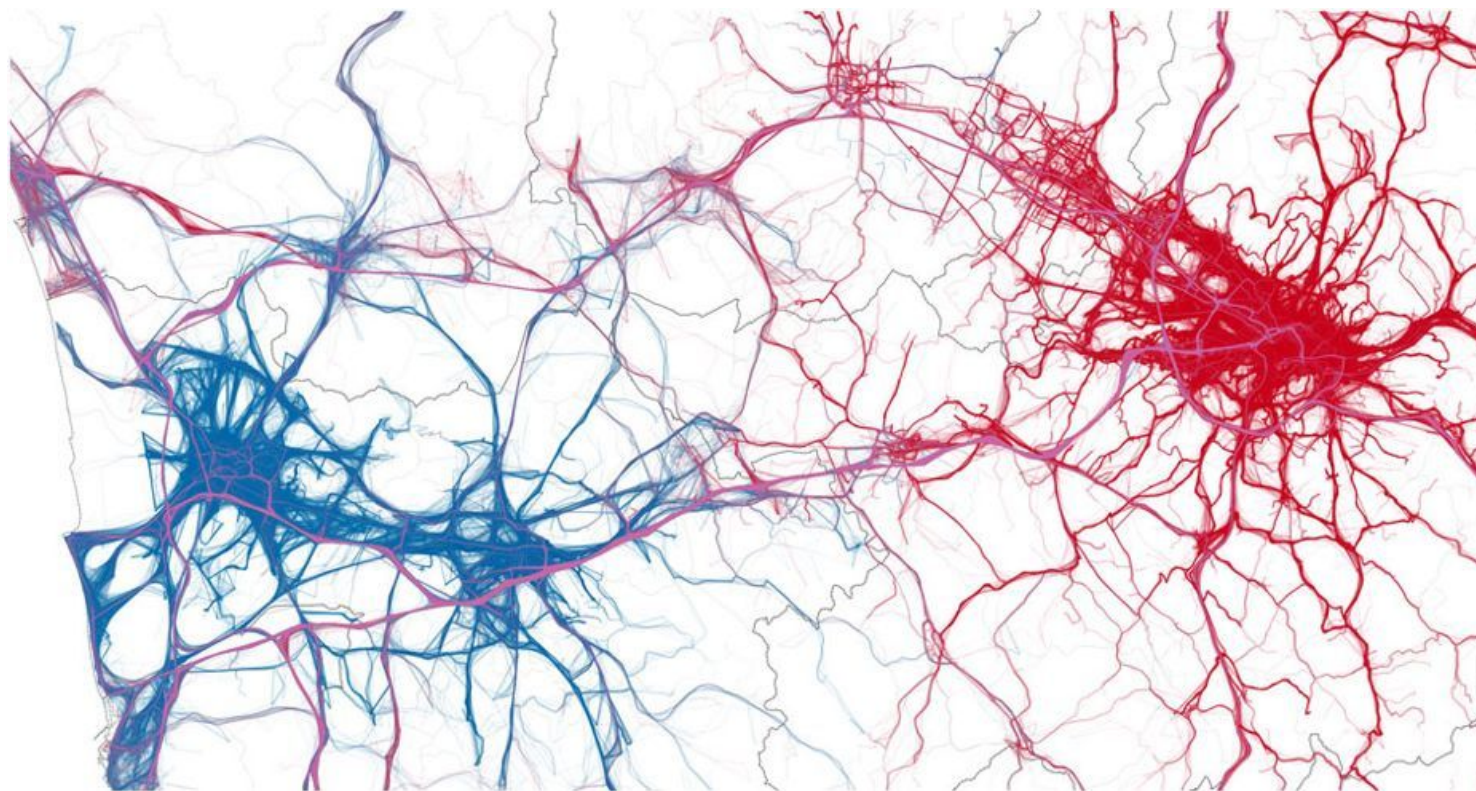


Movements



Digital Footprints of Human Activity

- **Volume:** the incredible amounts of data generated each second
- **Velocity:** speed at which vast amounts of data are being generated, collected and analyzed
- **Variety:** the different types of data we can now use
- **Veracity:** quality or trustworthiness of the data
- **Value:** the worth of the data being extracted



Pappalardo et al., Returners and Explorers dichotomy in Human Mobility, Nature Communications 6, 8166 (2015).
<https://doi.org/10.1038/ncomms9166>





**The rest of the city rises and leaves the house to begin a new day.
And our insight around driving behaviour increases second by second, minute by minute.**

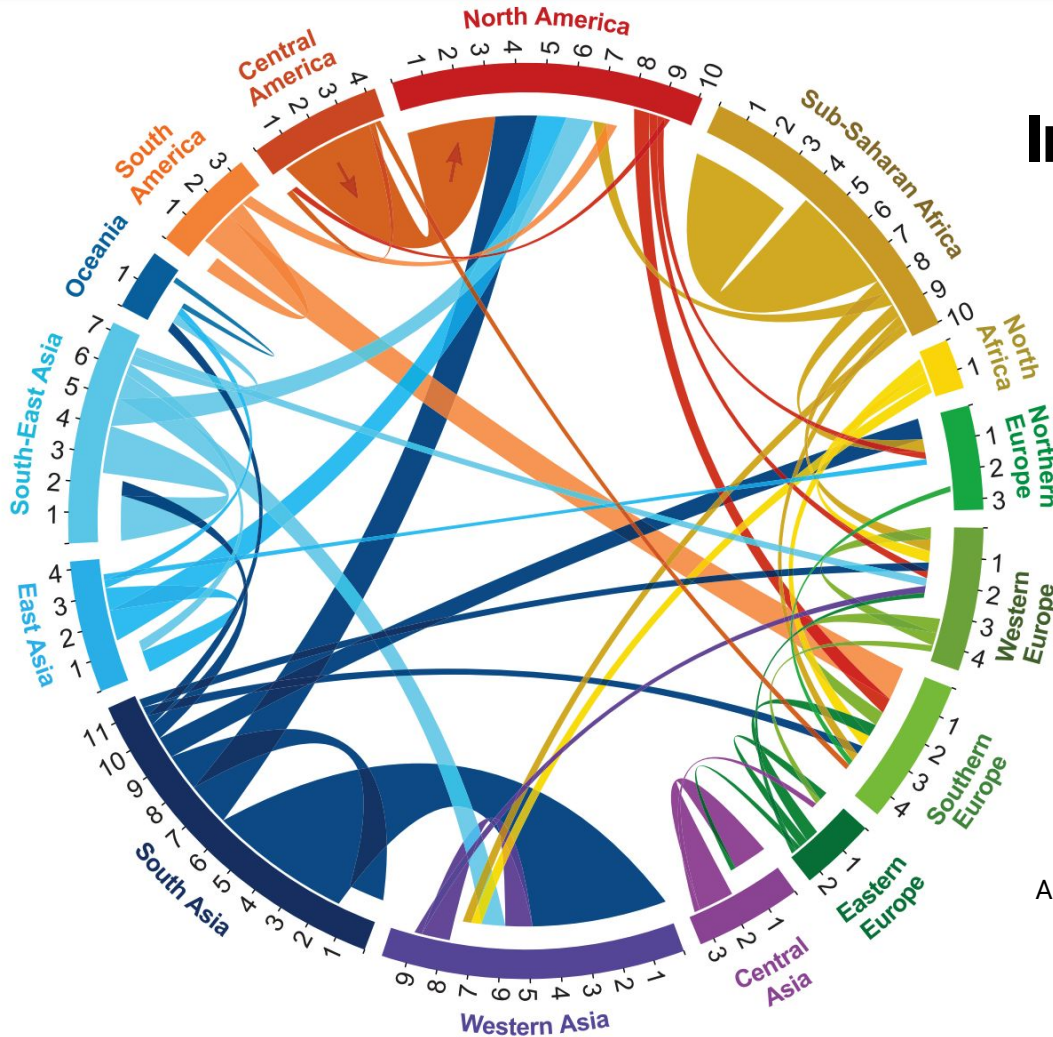




Ships trajectories: <https://www.shipmap.org/>

International migration flows

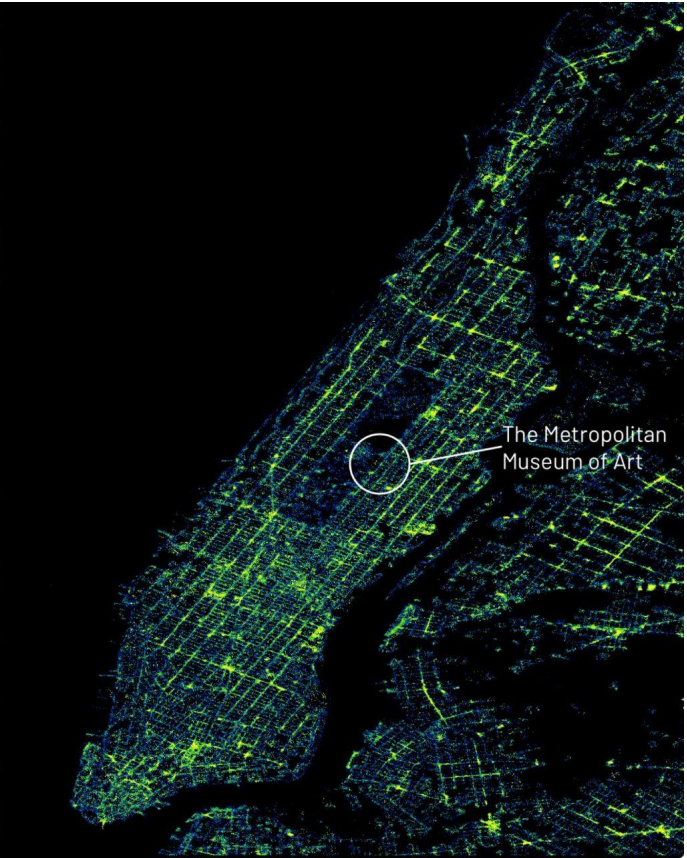
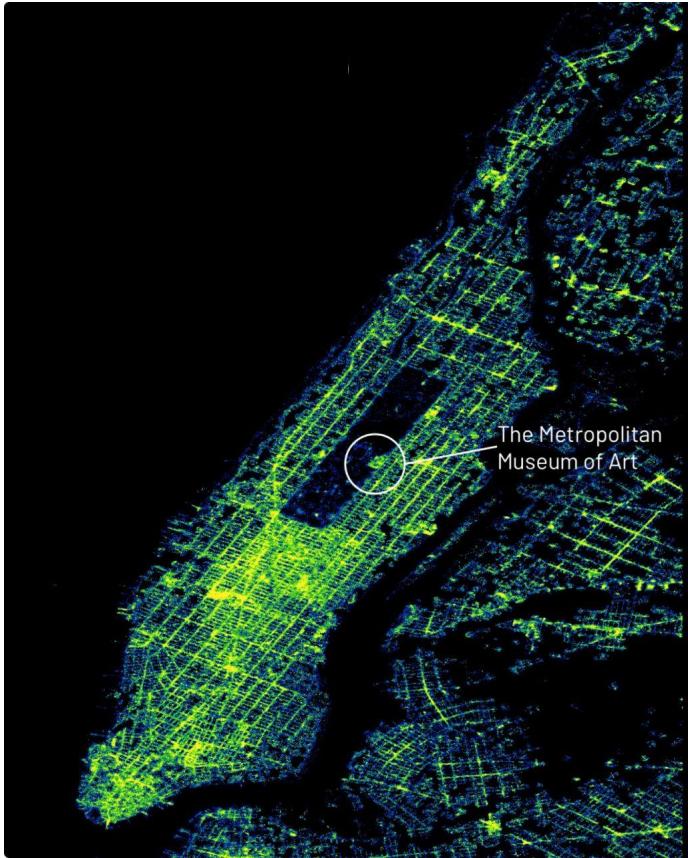
2005-2010



- number of migrants (inflows and outflows) in millions between and within world regions
- (only flows containing at least 170,000 migrants)

Abel and Sander, Quantifying global international migration flows, *Science* 343.6178 (2014): 1520-1522.







Lucchini et al., Living in a pandemic: changes in mobility routines, social activity and adherence to COVID-19 protective measures. *Scientific Reports* 11, 24452 (2021). <https://doi.org/10.1038/s41598-021-04139-1>





CO2 emissions on roads



Böhm et al. Gross polluters and vehicle emissions reduction. Nature Sustainability 5, 699–707 (2022).
<https://doi.org/10.1038/s41893-022-00903-x>



What will you learn in GSA?

Module 1: Spatial and Mobility Data

- Basic concepts
 - Geographic coordinates systems, Vector data model
- Data types
 - Trajectory, Flows, Tessellations
- Spatial and Mobility data
 - Mobile Phone Records, GPS traces, Social media records, POIs, Road Networks
- Preprocessing mobility data
 - Filtering, compression, stop detection, trajectory segmentation, trajectory similarity and clustering
- Practice: open-source tools for geospatial analysis
 - Shapely, GeoPandas, folium, scikit-mobility, osmnx, and more

Module 2: Patterns and Laws

- Spatial analysis
 - point patterns, spatial autocorrelation, GWR
- Individual mobility patterns
- Collective mobility patterns
- Practice: analyze mobility data with scikit-mobility

Module 3: Predictive and Generative Models

- Prediction
 - Next-location prediction
 - Crowd flow prediction
 - Spatial interpolation
- Generation
 - Trajectory generation
 - Flow generation
- Practice: mobility prediction and generation in Python

Module 4: Applications

- Human mobility & epidemic spreading (COVID-19)
- Urban Segregation models
- Navigation Principles
- Estimating Pollution
- AI & Mobility

Material

- [book] [Introduction to geographic information systems](#), Kang-Tsung Chang, McGraw-Hill
 - Chapter 1
- [paper] [Human Mobility: Models and Applications](#), Barbosa et al., Physics Reports
 - Section 1 (Introduction)

Homeworks

to be delivered by Thursday, 22nd 2022, 08:59 CET



Homework 1.1

Find interesting cases in history of people trying to track movements and/or migrations

- Write a blog post about it! (3 pages max, excluding figures)
 - Include references (to papers, blog posts, newspaper articles, videos, or whatever)
- Your blog post could be published on the [SoBigData blog](#)