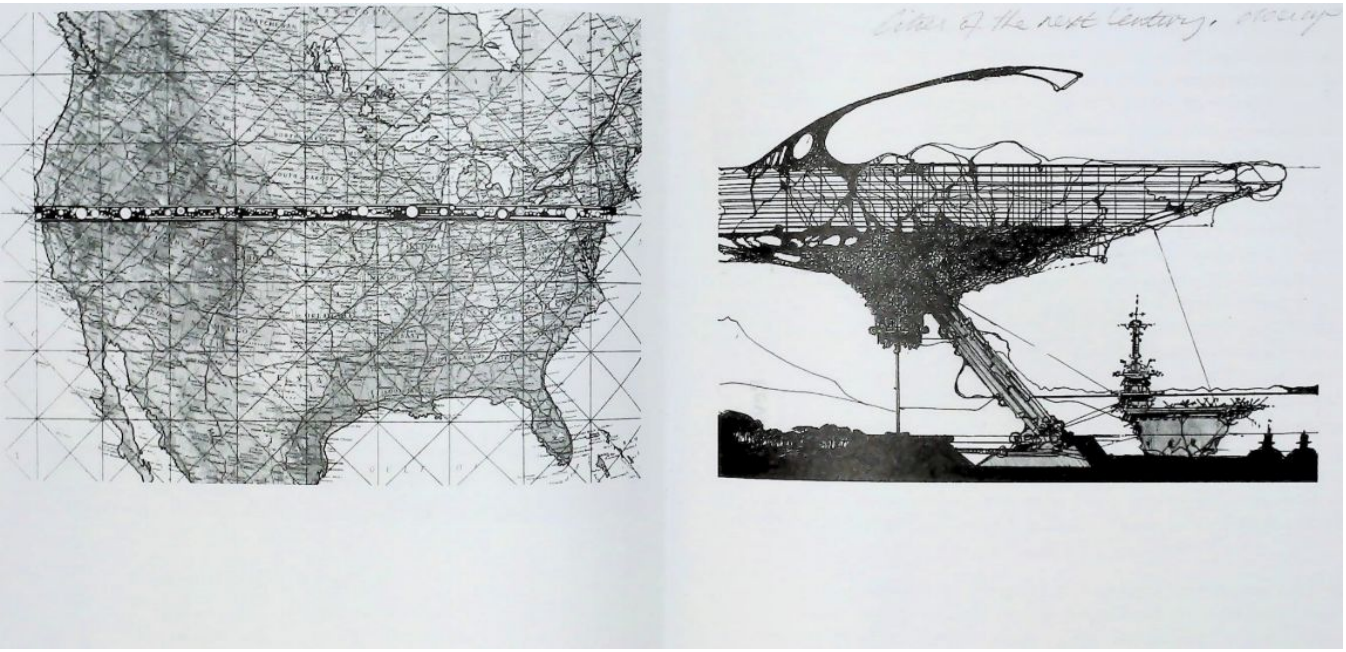

# Introduction: Networks in urbanism and architecture

L.Bauer lecture
LPI, Paris, France
SEA Mumbai, India

# Today (overview)

1. Introduction to networks, urbanism and architecture
2. Analysis of city systems
3. Projects discussions

Structure of each lecture **theory** **practice**

# Course topics

1. Examples of network theory used in urbanism and architecture
2. Introduction to networks theory
3. Examples of projects on city systems: participatory practice with citizens

theory

4. Discussions about projects

practice

# Part 1
# Examples where architecture, urbanism meets data science

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# Examples where architecture, urbanism meets data science

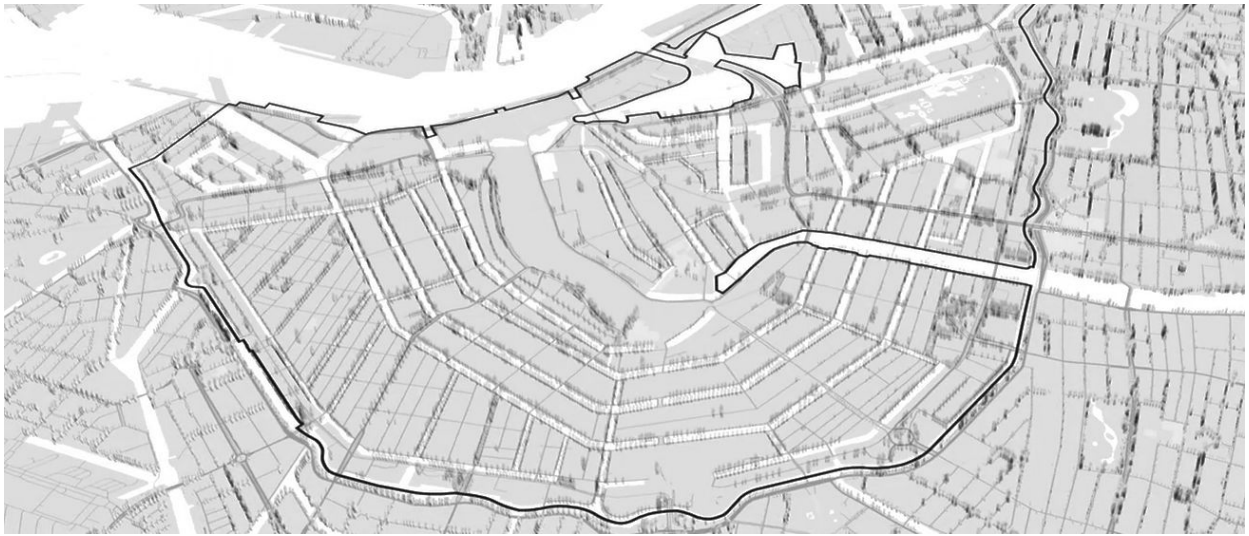

# Examples where architecture, urbanism meets data science

Chandigarh city construction, 1949
The Master plan prepared by Le Corbusier was broadly similar to the one prepared by the team of planners led by Albert Mayer and
Mathew Nowicki except that the shape of the city plan was modified. Head (The capitol complex)

- Heart (The city centre)
- Lungs (The leisure valley, innumerable open spaces and sector greens)
- Intellect (The cultural and educational institutions)
- Circulatory system (The network of roads, the 7Vs)
- Viscera (The industrial area)

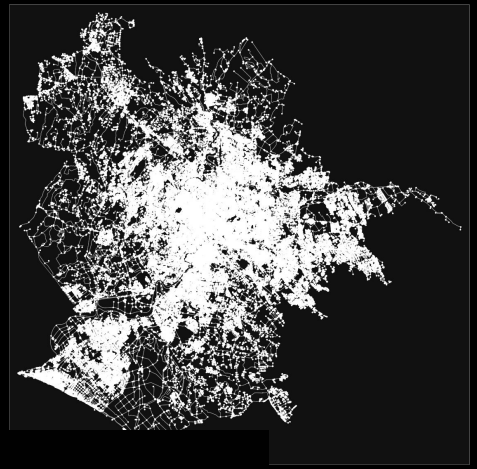
# Part 1
# Examples where architecture, urbanism meets data science:

City projects integration Carlo Ratti and physicist from Santa Fe university, post-occupancy phase, time: 21st century
https://senseable.mit.edu/



# Part 1
# Examples of projects on networks and city interface

# Main idea project on trees and city



- Our project centers on the relationship between trees and cities, their resemblance and potential for cooperation.
- We analyze several layers of city data:
  City map, which is a replica of trees which live in this city (Figure)
  Mobility patterns of people living in the city
  Citizens mapping the information about the city
- Through overlapping these three layers of the data we search new ways of integrating trees into the cityscape and maintaining the city structure alive.

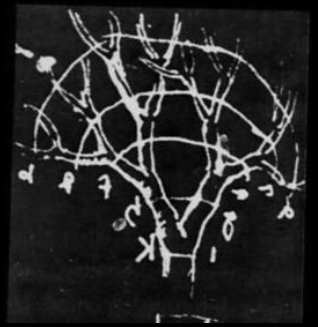
# Data types

- mobility data: depersonalised trajectories of citizens (Figure)
- trees data of all trees in Lazio and all remarkable trees
  https://www.politicheagricole.it
  https://dati.comune.roma.it/
- city data (structures of streets, buildings), citizen science in Rome
  http://www.alberidiroma.it/web/
  https://www.inaturalist.org/projects/city-nature-challenge-2019-roma


# Results and ongoing work

$$\sum_{i=0}^{N-1} N_{tr}(A_i, A_{i+1}) / \sum_{i=0, S_0=A_0}^{N-1} N_{tr}^{sh}(S_i, S_{i+1})$$

- We define and calculate green index for each trajectory of citizens from mobility data
- We estimate distributions for old trees parameters and identify the key trees in Rome
- We run the algorithm to identify shortest roots in city. We highlight arborescent structure of transport in the city data of Rome, inspired from past research on trees https://github.com/Liyubov



Try it yourself https://colab.research.google.com/drive/1ijDTSjtytAk863RmSBCWjBklkgL-UuLU?usp=sharing


Definition of the green index:
Then the green index of a trip is the relation between how many trees are there on the real trip path divided by the number of trees on the shortest path.
The green index we estimate helps us to understand whether people deviate their path more towards the more green path, rather the shortest path

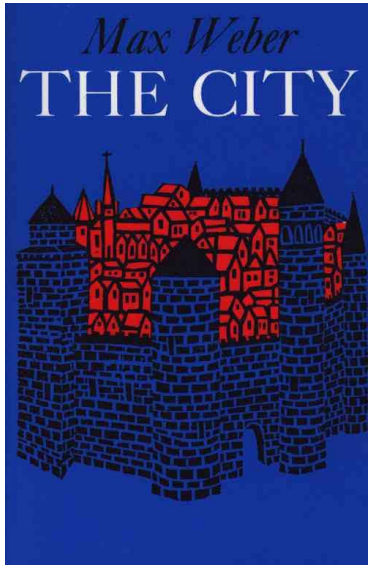
$$\sum_{i=0}^{N-1} N_{tr}(A_i, A_{i+1}) / \sum_{i=0, S_0=A_0}^{N-1} N_{tr}^{sh}(S_i, S_{i+1})$$

Arborescent structure of transport in tree was studied by Leonardo da Vinci. He estimated how the transport fluxes are distributed in the tree structure and found square root law, which may be applicable to fluxes in the city as well.

# Part 1

Understanding of our cities:

M.Weber "The city": sociologist, working and defining main urban structures from functional and not just spatial perspectives.

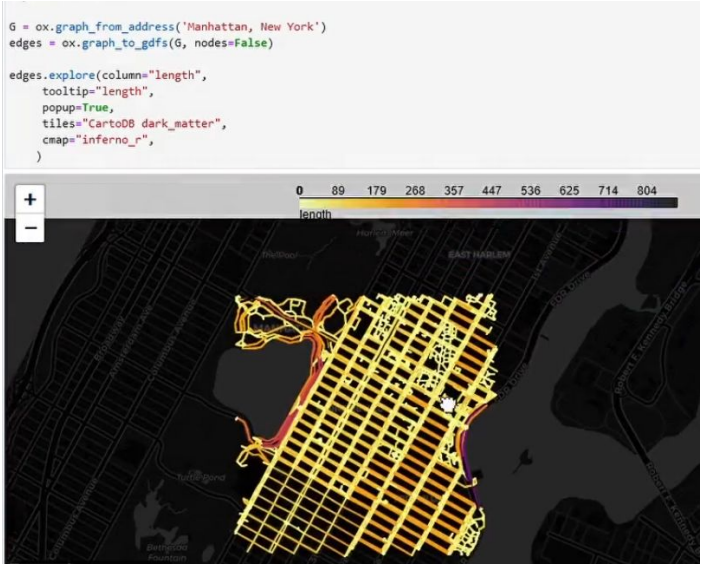


# Part 1

## Digitalising of our cities:

various projects talk about digital twins of our cities [Side walk Labs, USA], yet small data and missing data [Strelka projects] are important for the project:

if you cannot document something, yet you know it exists (e.g. water resources usage, pollution in the area), put and include it to the study.



# Part 2
## Network science introduction

# What will we need for the practical part

Standard libraries (Python): numpy, matplotlib, scikit learn, seaborn

Network libraries: networkx, osmnx (open street data)

Inspiration from

- Big data course from 2019 Marc and Liubov https://github.com/Big-data-course-CRI/materials_big_data_cri_2019
- Bruno Gonçalves / Data4Sci: https://github.com/DataForScience/Networks
- TidyTuesday https://github.com/rfordatascience/tidytuesday
- Michael Szell data course https://github.com/mszell

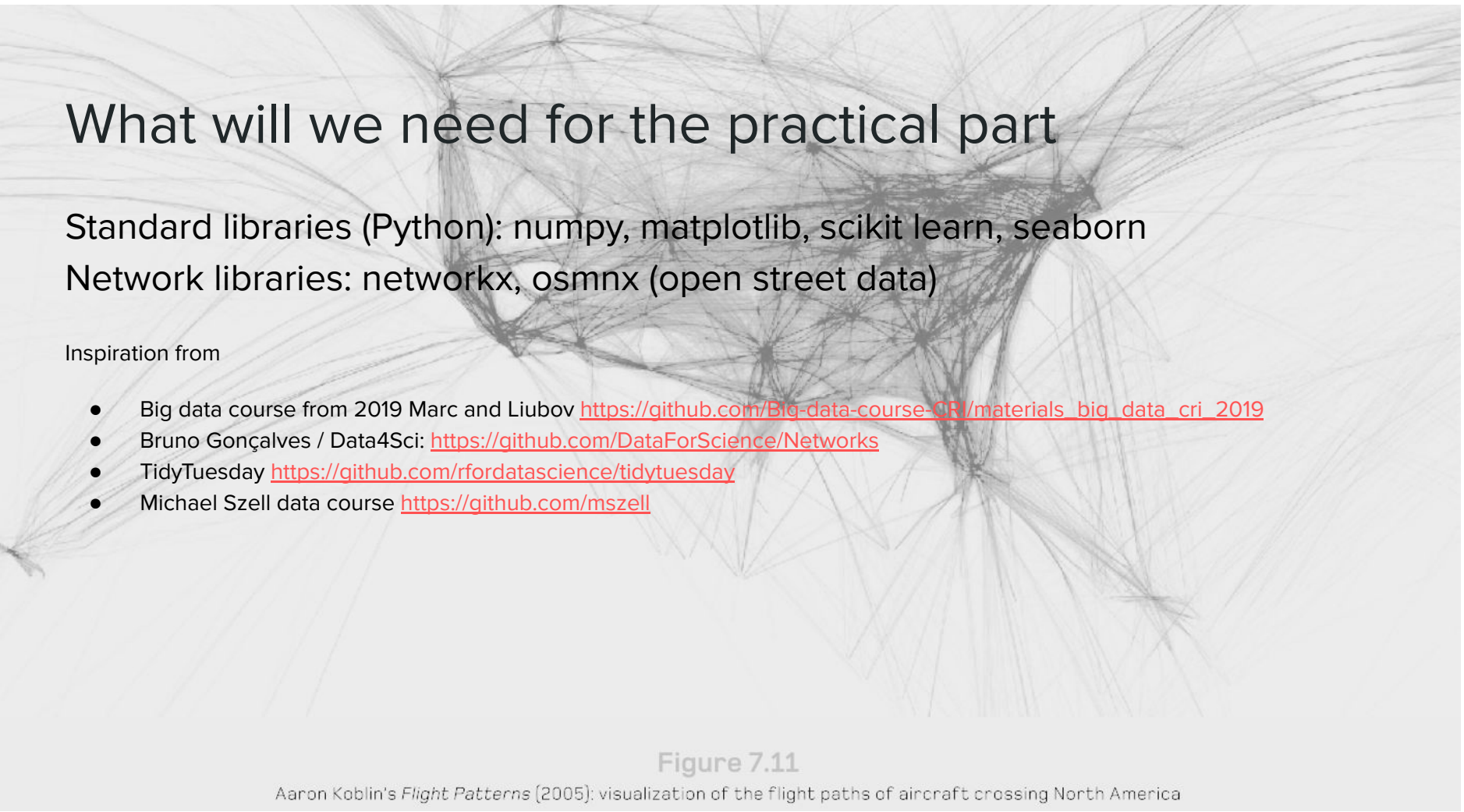
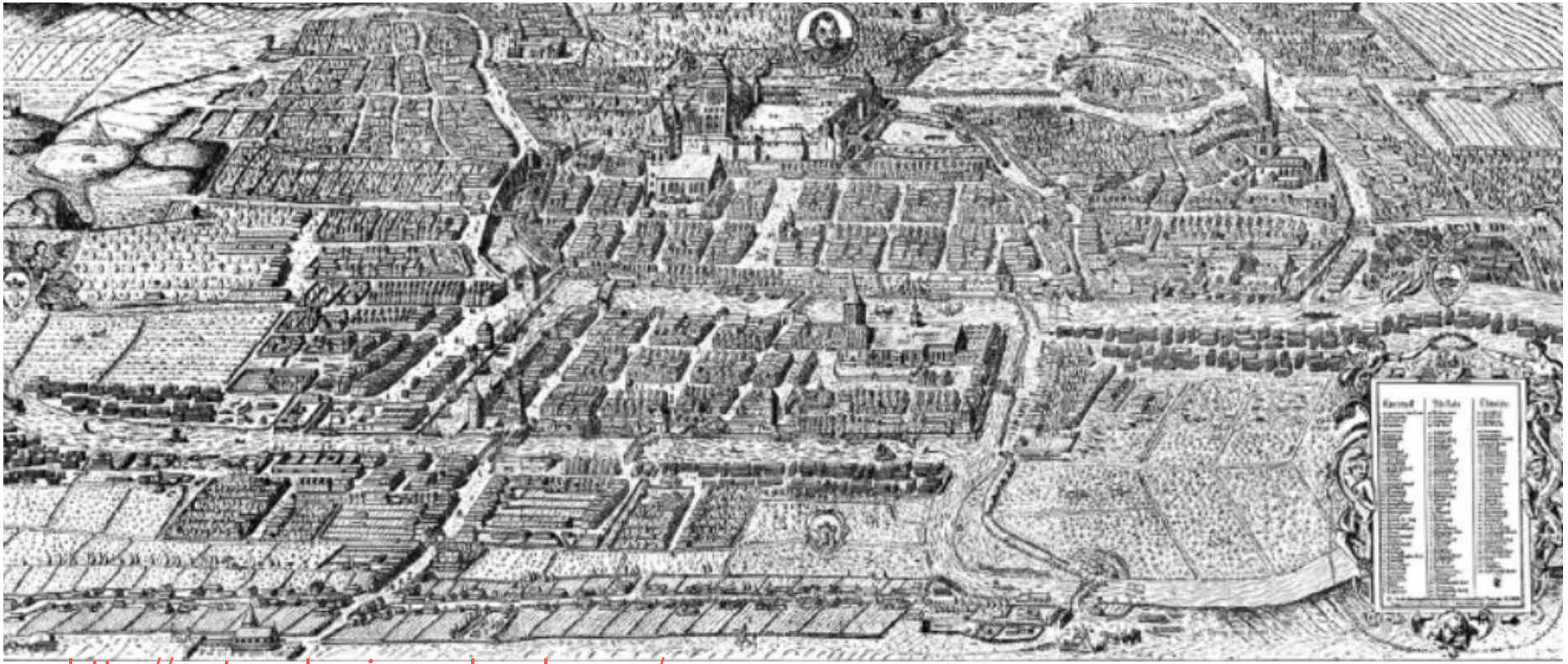


Figure 7.11

Aaron Koblin's *Flight Patterns* (2005): visualization of the flight paths of aircraft crossing North America

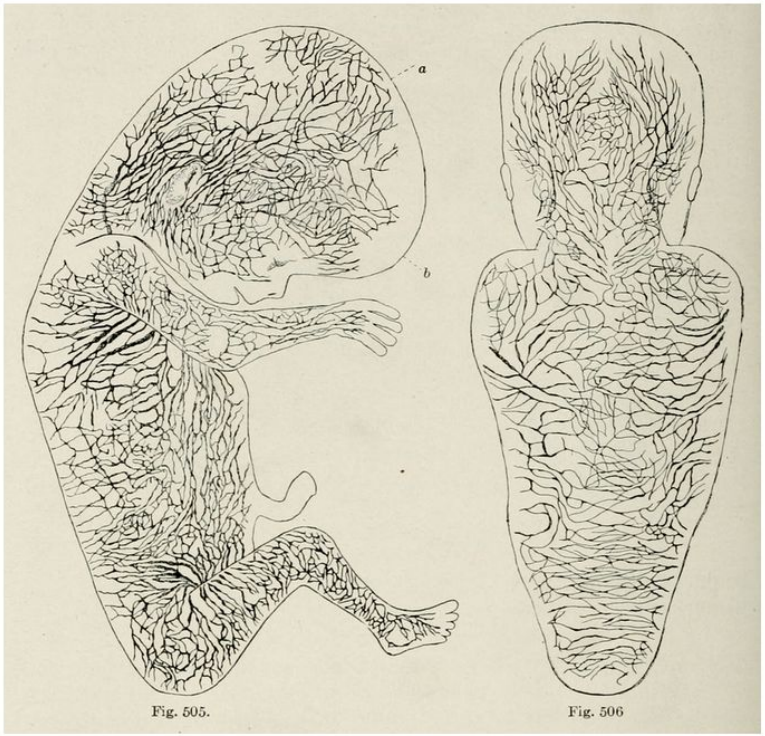
# Some resources we will use: network book



http://networksciencebook.com/


Why networks?

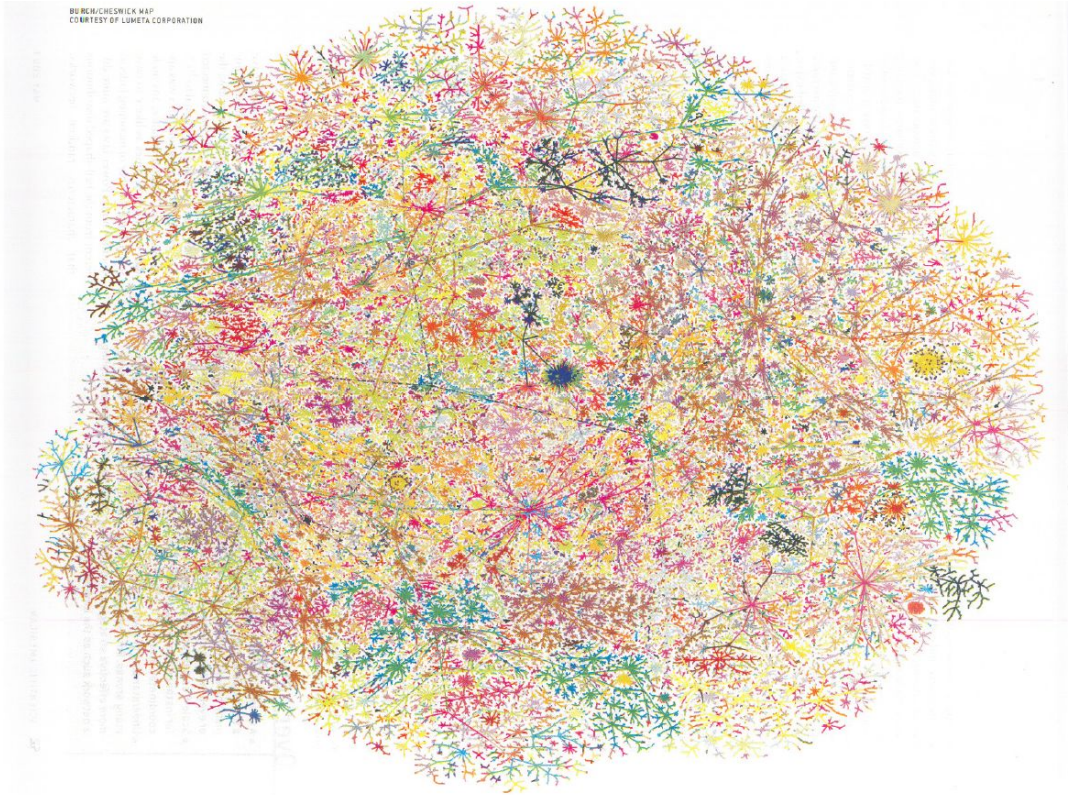
# Where you can find them?




Distension of the lymphatic vessels in the human foetus, from Franz Kreibel, *Manual of human embryology*, 1910

# What is network science?

The central idea in network science is that any node can influence other nodes, not only their direct connections. Such indirect influence happens through some external phenomenon—travel in a transportation network, information transfer in the Internet, vibrations in a spiderweb, etc.—and depends on how the network is connected. Thus, we can use the graph describing the interaction structure to understand how the system works, the roles of individual nodes, etc.
(Holme)



# What we will look at in network science?

1. Network measures
2. Networks in time and space
3. Networks from data

Hands on part: notebooks

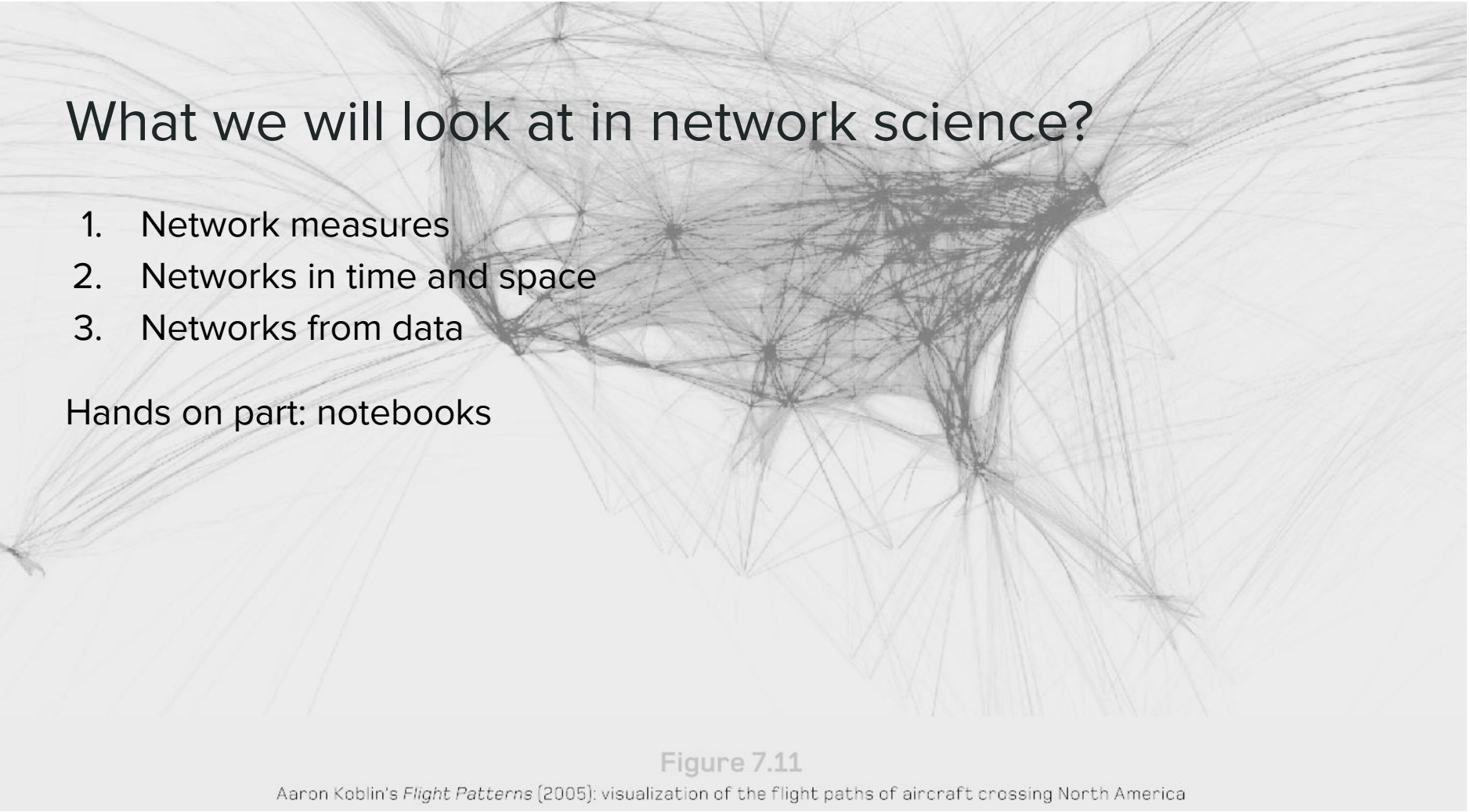
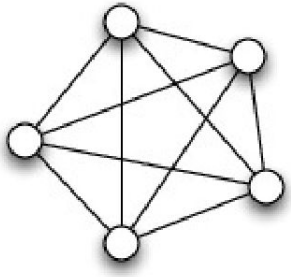


Figure 7.11

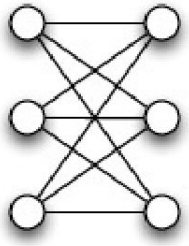
Aaron Koblin's *Flight Patterns* (2005): visualization of the flight paths of aircraft crossing North America

# Network theory history

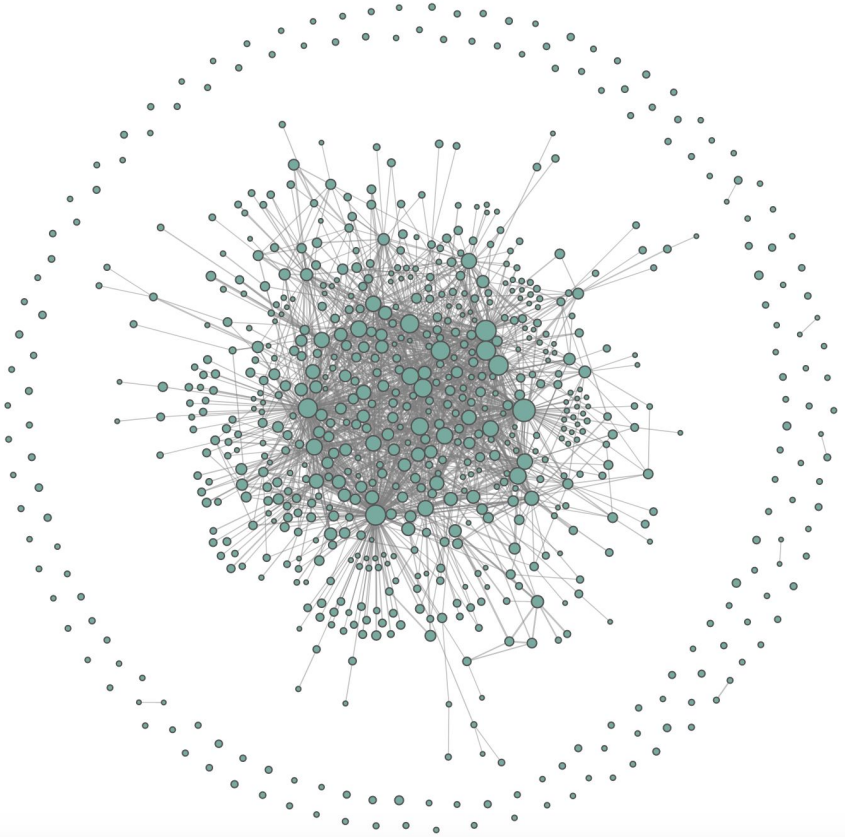
Soft matter physics and graph theory
https://sites.google.com/a/binghamton
work-concepts



$K_5$

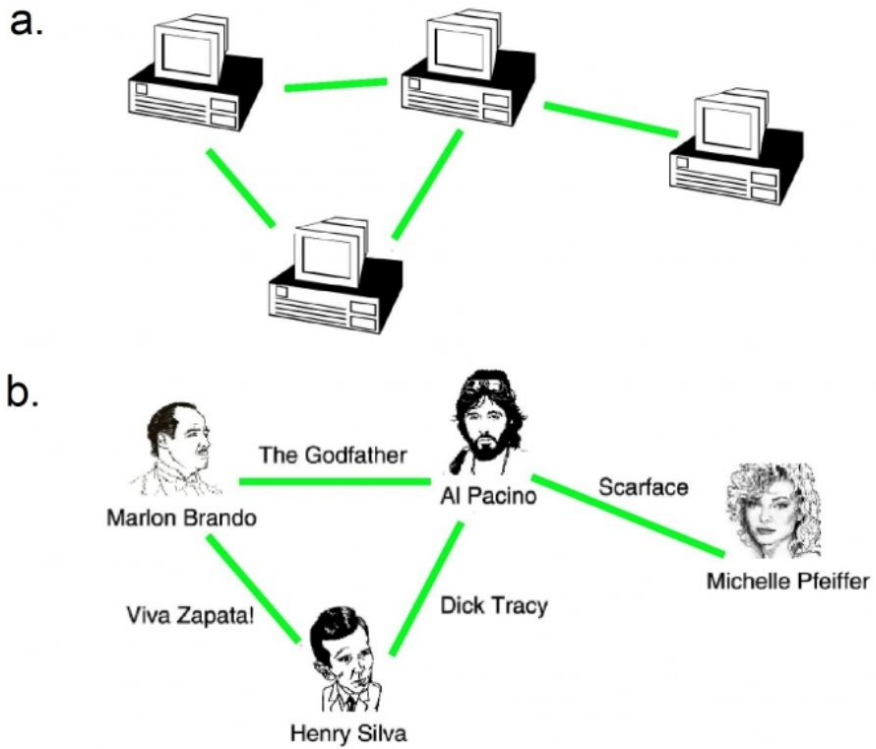


$K_{3,3}$

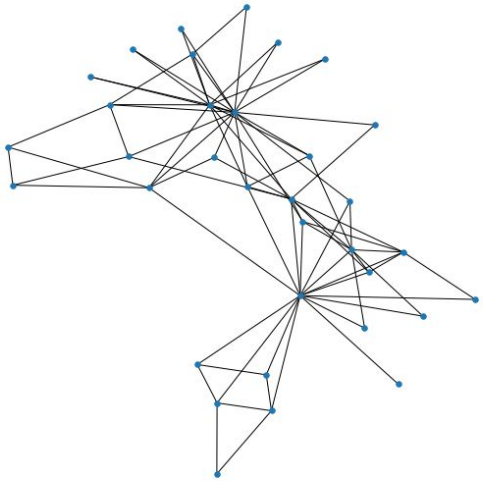


# Network theory history

Graph vs. network



# Can anything be presented as a network? What cannot be presented and why?



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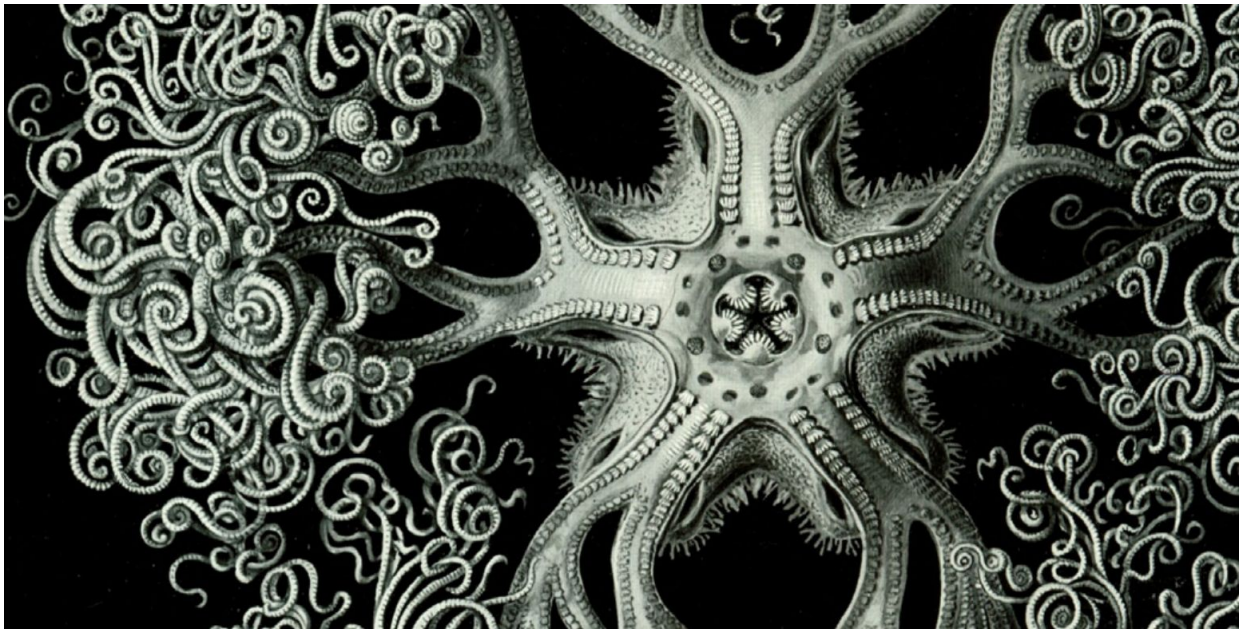
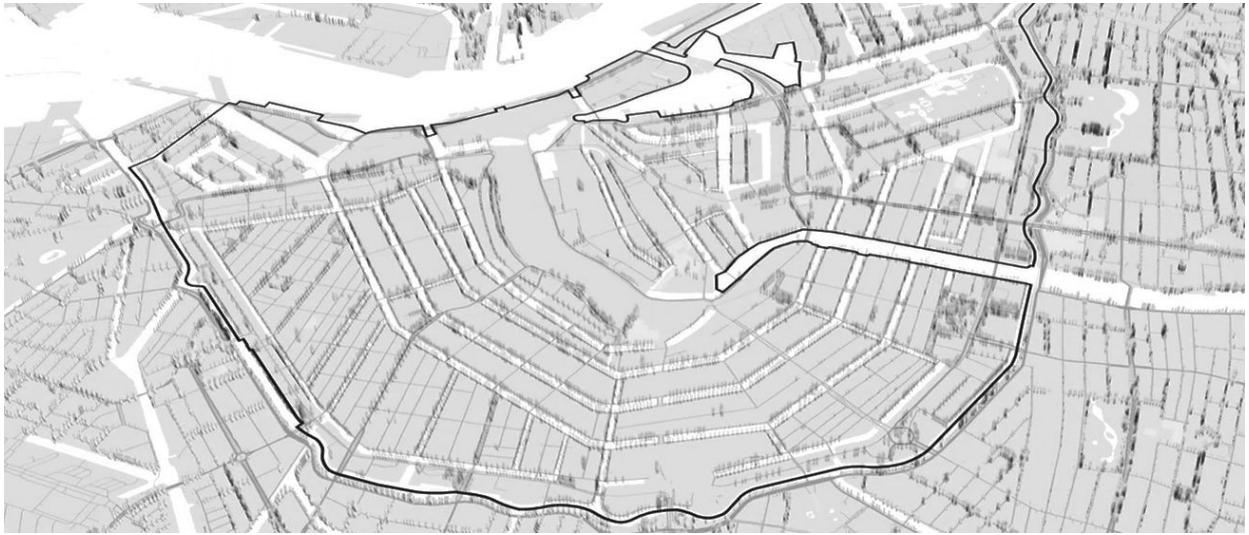


# Part 3

Examples of projects on city systems: participatory practice with citizens

Citizen assemblee - definitions and concepts

https://en.wikipedia.org/wiki/Citizens%27_assembly



# Project #2:
# iNaturalist citizen science community study

Method development to study city community characterise users activity and attrition: who are core-members of participants, how and why users stay or come back?

https://arxiv.org/abs/2112.02693
https://github.com/correlaid-paris/citizen_science_inaturalist



**Computer Science > Social and Information Networks**

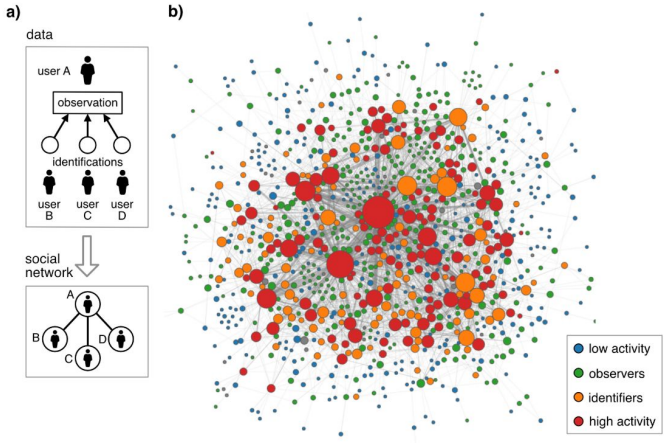
*[Submitted on 5 Dec 2021]*

**iNaturalist citizen science community during City Nature Challenge: new computational approach for analysis of user activity**

Liubov Tupikina, Frank Schlosser, Vadim Voskresenskii, Katharina Kloppenborg, Florence Lopez, Albrecht Mariz, Anna Mogilevskaja, Mułł Haklay, Bastian Greshake Tzovaras

Analysing patterns of engagement among citizen science participants can provide important insights into the organisation and practice of individual citizen science projects. In particular, methods from statistics and network science can be used to understand different types of user behaviour and user interactions to help the further implementation and organization of community efforts. Using publicly available data from the iNaturalist community and their yearly City Nature Challenges (CNC) from 2017-2020 as an example; we showcase computational methods to explore the spatio-temporal evolution of this citizen science community that typically interacts in a hybrid offline-online way. In particular, we investigate the user types present in the community along with their interactions, finding significant differences in usage-behavior on both the level of engagement and the types of community tasks/roles and how they interact with the network of contributors. We expect that these computational analysis strategies will be useful to gain further understanding of other citizen science communities and projects.

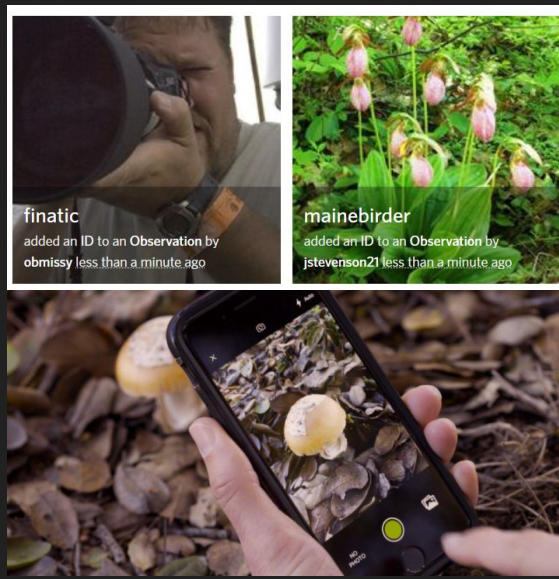
Comments: 9 figures, 29 pages, submitted to this https URL
Subjects: **Social and Information Networks (cs.SI)**; Physics and Society (physics.soc-ph)
Cite as: arXiv:2112.02693 **[cs.SI]**



# iNaturalist citizen science data

Users contribute voluntarily on a platform.

| | id | observed_on_string | observed_on | time_observed_at | time_zone | user_id | user_login | created_at |
|---|---|---|---|---|---|---|---|---|
| 0 | 11479007 | 2018-04-27 7:52:34 am BST | 2018-04-27 | 2018-04-27 07:52:34 UTC | UTC | 159021 | muki | 2018-04-27 07:06:17 UTC |
| 1 | 11480212 | 2018-04-27 8:39:41 am BST | 2018-04-27 | 2018-04-27 07:39:41 UTC | London | 664459 | lucyrobinsonnhm | 2018-04-27 08:02:52 UTC |
| 2 | 11480902 | Fri Apr 27 2018 08:34:31 GMT+0100 (GMT+1) | 2018-04-27 | 2018-04-27 06:34:31 UTC | Amsterdam | 908315 | tess26 | 2018-04-27 08:42:01 UTC |
| 3 | 11481097 | Fri Apr 27 2018 09:54:35 GMT+0100 (GMT+1) | 2018-04-27 | 2018-04-27 07:54:35 UTC | Amsterdam | 796473 | bryonycross | 2018-04-27 08:54:45 UTC |
| 4 | 11482247 | 2018-04-27 8:42:21 am BST | 2018-04-27 | 2018-04-27 07:42:21 UTC | London | 664459 | lucyrobinsonnhm | 2018-04-27 10:09:55 UTC |

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# Project: emotional maps crowdsourced data from citizens in Rome, Karlsruhe, Milan, Brussels

- We analyze patterns of mobility and city tree data in Rome
- We collect citizens' memories from people about trees
- Development of green index for walks in cities for citizens

Collaboration Vlad (UKR, strelka), Olga (FR, Sorbonne), LPI (
Sony labs (IT, Sapienza), Starts EU

## Project Summary :

As a continuation of the EDEN project and part of STARTS.EU project, **"Trees in cities"** is a project that focuses on cities' green spaces, specifically on urban trees and their potential effect on life of people. Starting with two datasets: depersonalised human trajectories (with induced noise) and open data of trees in Rome. We analyze the layered geospatial data. For this we use statistical spatial analzsys and introduce new measure, green index, to assess the information about the city walks.

This project tackles the issue of integration of trees into the cityscape, and is largely motivated by post-COVID city crisis recovery and how keep cities greener and more suitable for people to live in.

## Hypothesis :

When walking, people prefer to walk in streets with trees rather than palces without trees. Unfortunately, mobile mapping apps currently fail to suggest that experience as they are able to offer only the shortest routes. Our hypothesis is that based on the people's trajectories and trees data that we have, with hard evidences we can find that people prefer the green path over the most straight-forward way when walking.

## Tools :

Python
Pandas
Matplotlib
Seaborn
Geopandas
Geopy
Folium
Scipy
Pysal
Osmnx
Networkx

## Methods :

- Quantitative analysis of layered geographical data
- Temporal and spatial analysis: distributions of jumps lengths and jump distances
- Defining and estimating "Green Index"

sum (trees)_i / len (trip)

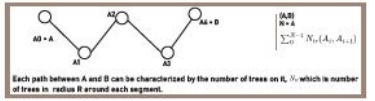
## Challenges :

- Working with layered geographical data
- Plotting geographical data in different map formats
- Plotting from two or more datasets together in one figure
- Finding metrics for calculating or categorizing data

## Learnings and outlook:

As my last field of research was related to architecture and urbanism, I had worked with architectural and urban data, but I didn't have the knowledge and skills to analyze them properly. During this internship, I was surprised to see how we can draw various conclusions using different tools and methods. I also benefit from being in a research project at every step, seeing and applying new ways to get different conclusions. Furthermore, I learned more about optimizing codes to work faster and better with big datasets.

For further projects, I am glad to know that I ca
skills I obtained through this intern
projects I have done before.




Each path between A and B can be characterized by the number of trees on it, $N_r$, which is number of trees in radius R around each segment.

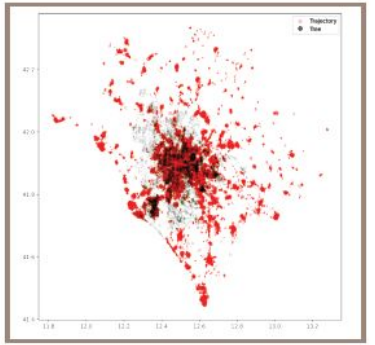
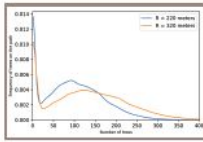


Fig 1. We show two datasets : the tree data from and the mobility data. The axis correspond to lat and lon coordinates. We focus on Lazio region, specifically then narrowing down the focus on Rome area.

Fig 2. Frequency of trees on the paths in radius 220 and 320 meters



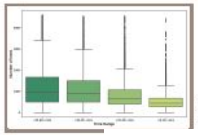


Fig 3. Number of trees in different time categories

Sony CSL

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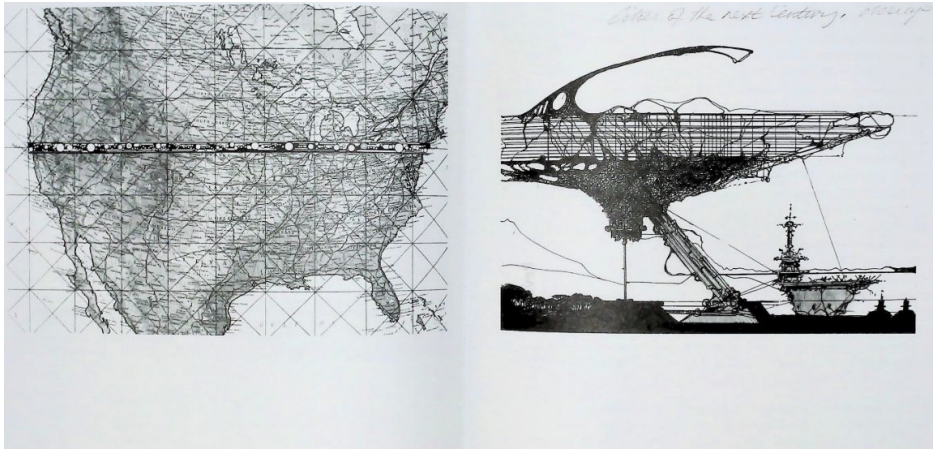
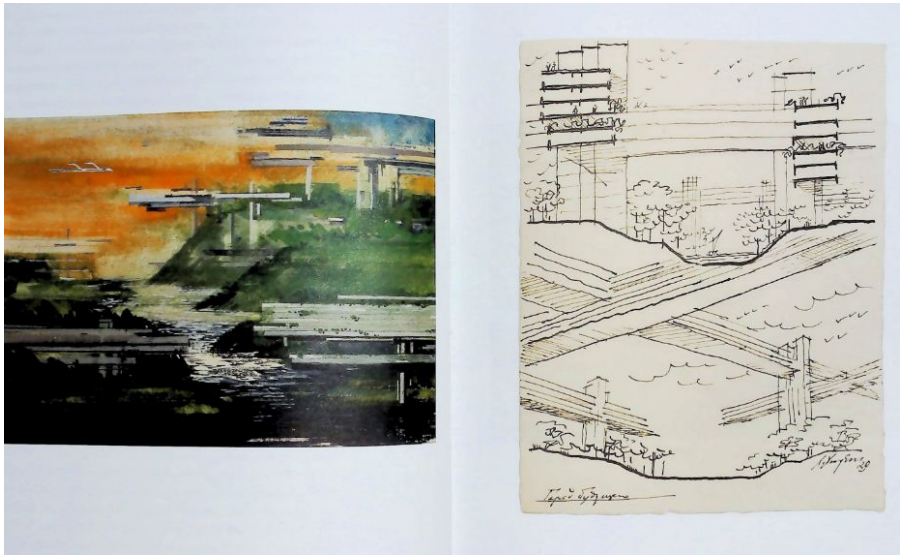
S+T+ARTS
SCIENCE + TECHNOLOGY + AR

# Some books

## “The World as an Architectural Project”



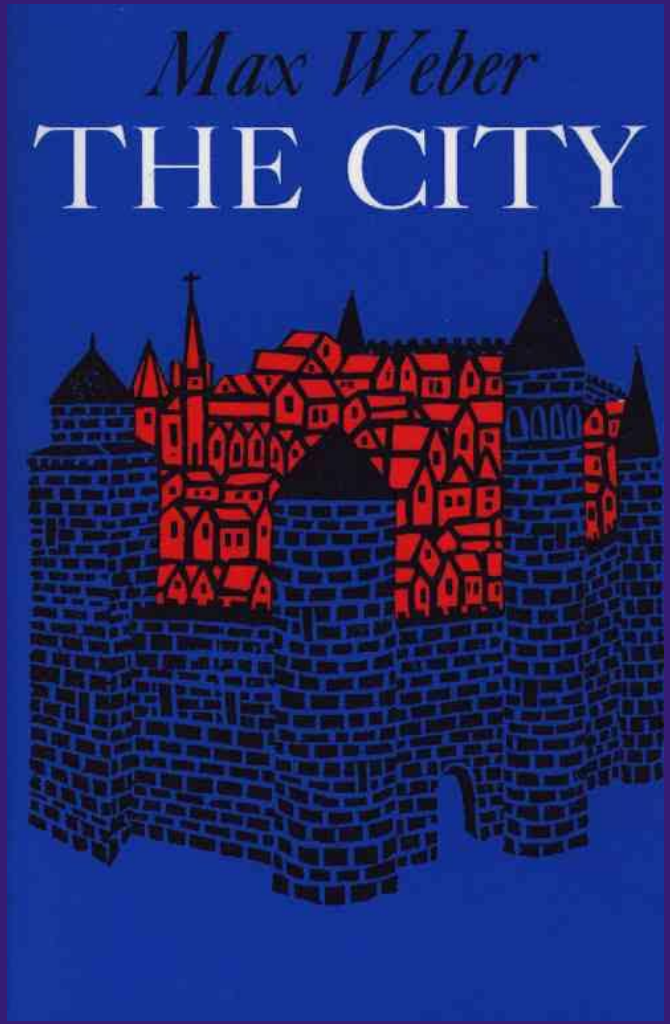


**Some links to read and follow**

City Interaction lab channel for additional lectures
https://youtu.be/aR4FuIM3VXc

Network book
http://networksciencebook.com/

Traditional old yet new book
M.Weber

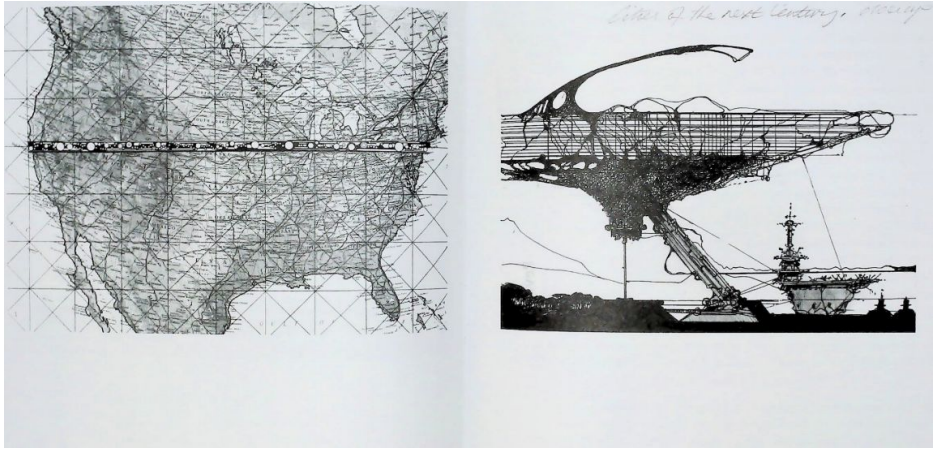


# Assignments

1. Describe your projects in the past https://docs.google.com/spreadsheets/d/1mavwYKPbf2fkP-rVforqFhjWeogx8vIgS1m9WlsAtx4/edit?usp=sharing

2. Choose and read one section of the book on networks
(to present or discuss in the next session of the course)http://networksciencebook.com/

3. Choose the subject to work on:
A. connected to your previous project
B. from the list of topics https://docs.google.com/spreadsheets/d/1mavwYKPbf2fkP-rVforqFhjWeogx8vIgS1m9WlsAtx4/edit?usp=sharing
C. from the list of networks in the repository https://networkrepository.com/inf-openflights.php



# Ideas on projects

1. Document city evolution (google capture timelapse) of a chosen city in India or elsewhere. Document it qualitatively or quantitatively. Use data on historical maps (*). Explain why you chose the city, what is special in the city evolution. Use network indicators combined with city indicators (economical, social, environmental).

2. Describe a chosen city using network concepts, e.g. degree, or other measures (betweenness) and come up with some additional network concepts, which could help to describe the city. E.g.inspired by the description of Chandigarh city (heart of a city, lungs, vessels). Create new ways to describe city infrastructure nature inspired. What is special in the network of this chosen city?

3. Document urbanisation of a chosen city. Describe existing issues with the urbanisation, which aspects could be shown with the network structures. Use data on planned vs. non-planned cities. Compare planned vs.non-planned cities. What network indicators can be good for documentation of the city urbanisation?

4. Document rural,urban communities in fixed spatial areas. If you do not have access to data, try to design what is needed to collect (survey). What are the most plausible methods to document them using technologies vs. using alternative documentation methods: define research questions of the study, define possible outcomes, define available methods and time-line

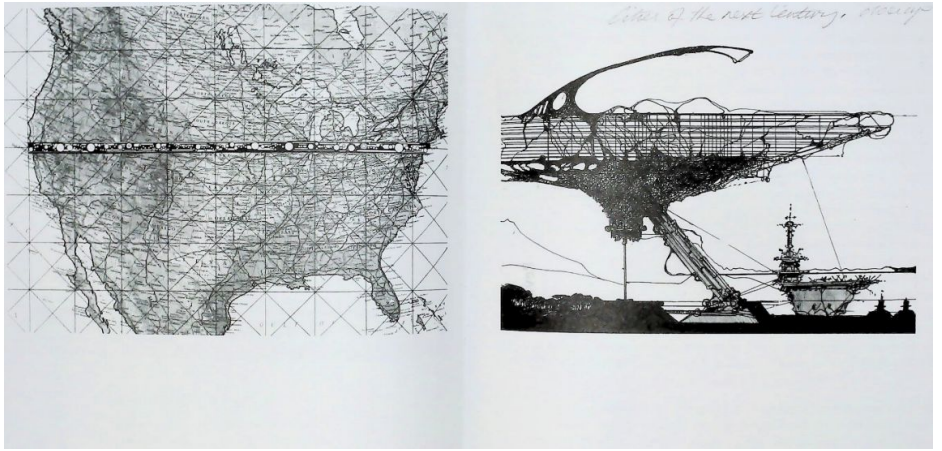
5. Choose the city in India or other country, try to find some open data for this city and visualise this data on the map of the city. Open data on pollution or noise in cities.

6. Green areas in cities: choose the city, find information missing trees or green spaces in cities (in India or elsewhere), try to find illustrate with data (number of trees, density) E.g.https://github.com/Liyubov/open_tree_data_analysis
7. Data inspired speculations: 3D vs. 2D networks of cities:
   Compare networks geometry pf cities and city amenities: are there simpler ways to make cities greener or making them more sparse? Calculating Utopia for our cities (depends on data for Indian cities). Design network infrastructure in space (Autocad, blender)
8. OPEN project!!

# Assignments

Projects delivery (share in google document or slides, pdf):

1. **Formulate research questions** you want to answer (1-2)
2. Describe the motivation of your project, why did you choose to work on it
3. Describe methods you would like to use (network methods, quantitative or qualitative)
4. What data do you have? Describe if you have any missing data. How would you use it if you would have the data
5. **Present 2-3 images you did** to illustrate your project, e.g. plot of a city, diagrams of data visualised (with google charts, python, Gephi, autocad, blender etc.)



# Research project ideas

Private vs. public space distribution

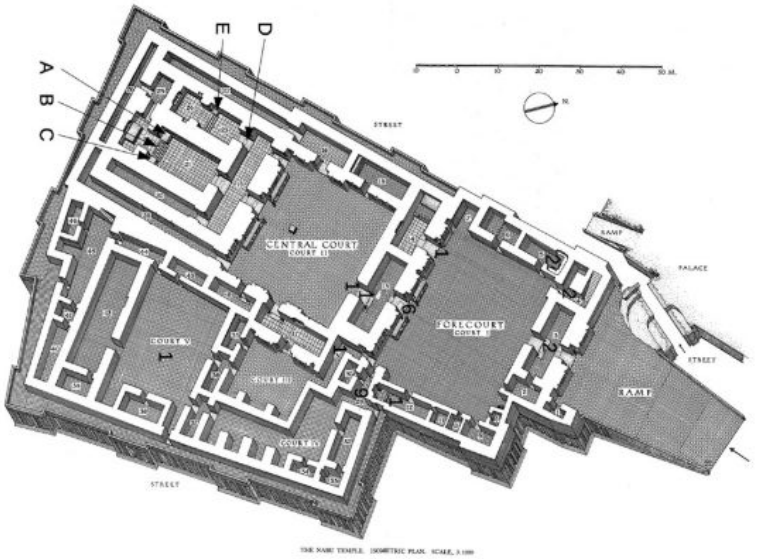



**Figure 3.7:** Plan of the Ezida temple in Dur-Šarruken, with the locations of inscribed elements (marked with letters A–E abandoned tablets (marked by numerals) added by the author. The bridge to the palace is to the northwest, tablet storage the west wall (5, 15), and the gods' cellas to the southwest (21–4). The *akītu*-suite with throne room (42) and 'seven-day (35) is in the southeast wing. Maximum dimensions *c.* 170 × *c.* 120 metres (Loud and Altman 1938: pl. 67; courtesy of th ental Institute of the University of Chicago).

# Practical part

Let us use google colab and github
Github intro by correlaid

```
G = ox.graph_from_address('Manhattan, New York')
edges = ox.graph_to_gdfs(G, nodes=False)

edges.explore(column="length",
     tooltip="length",
     popup=True,
     tiles="CartoDB dark_matter",
     cmap="inferno_r",
    )
```