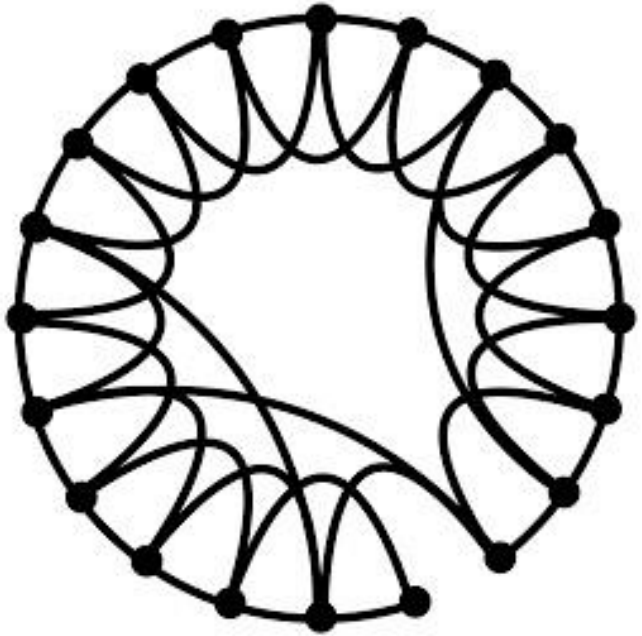
Networks video
What are take homes?

[redacted]



Social networks analysis

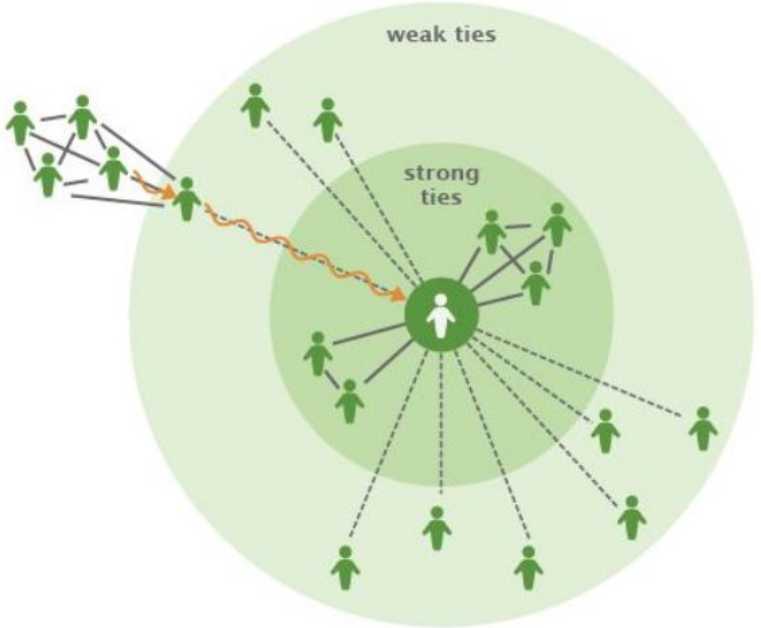
The Strength of Weak Ties[1]

Mark S. Granovetter
Johns Hopkins University

Analysis of social networks is suggested as a tool for linking micro and macro levels of sociological theory. The procedure is illustrated by elaboration of the macro implications of one aspect of small-scale interaction: the strength of dyadic ties. It is argued that the degree of overlap of two individuals' friendship networks varies directly with the strength of their tie to one another. The impact of this principle on diffusion of influence and information, mobility opportunity, and community organization is explored. Stress is laid on the cohesive power of weak ties. Most network models deal, implicitly, with strong ties, thus confining their applicability to small, well-defined groups. Emphasis on weak ties lends itself to discussion of relations *between* groups and to analysis of segments of social structure not easily defined in terms of primary groups.

A fundamental weakness of current sociological theory is that it does not relate micro-level interactions to macro-level patterns in any convincing way. Large-scale statistical, as well as qualitative, studies offer a good deal of insight into such macro phenomena as social mobility, community organization, and political structure. At the micro level, a large and increasing body of data and theory offers useful and illuminating ideas about what transpires within the confines of the small group. But how interaction in small groups aggregates to form large-scale patterns eludes us in most cases.

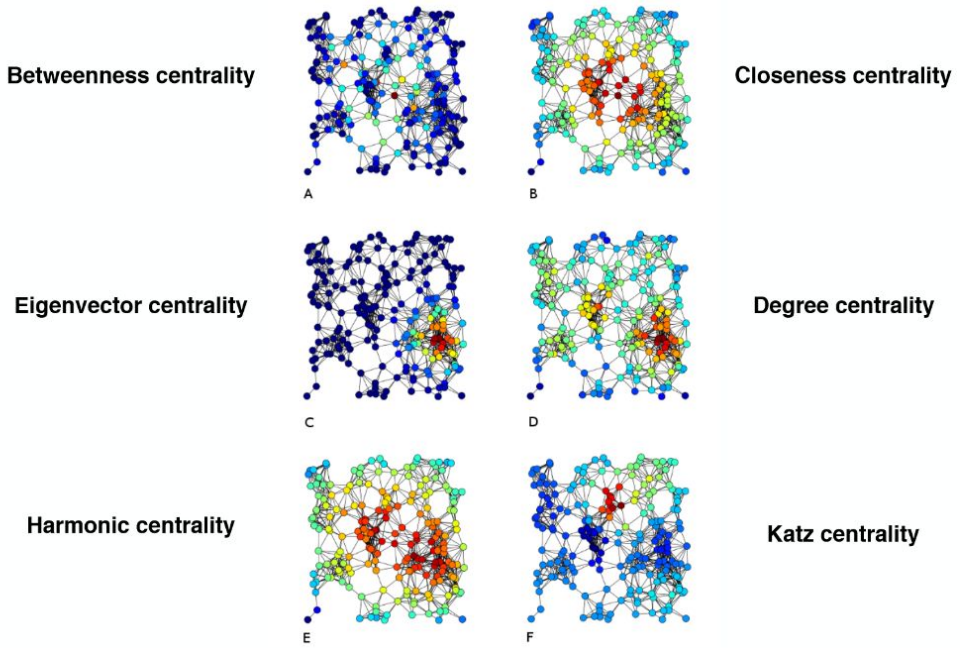
I will argue, in this paper, that the analysis of processes in interpersonal networks provides the most fruitful micro-macro bridge. In one way or another, it is through these networks that small-scale interaction becomes



Network measures:
Check calculation on networkx python library

Table 2: Definitions of network science terms and variables.

Term/variable	Definition
N	number of nodes, N, in graph
E	number of edges, E, in graph
network density	ratio of the number of edges to the maximum number of possible edges $\frac{2E}{N(N-1)}$
distance, $d(n_i, n_j)$	shortest path between node i and node j $d(n_i, n_j)$ where $n_i, n_j \in N$
average shortest path length, L	average length of shortest path between pairs of nodes $L = \frac{1}{N(N-1)} \cdot \sum_{i \neq j} d(n_i, n_j)$
diameter, D	largest shortest path between nodes $D = \max_{n_i \in N, n_j \in N} d(n_i, n_j)$
closeness centrality	inverse of the sum of the length of the shortest paths between node i and all other nodes in the graph $C_i = \frac{1}{\sum_j d(n_i, n_j)}$
degree, k_i	number of edges attached to node i
average degree, $\langle k \rangle$	average number of edges per node in network $\langle k \rangle = \frac{1}{N} \sum_{n=1}^{N} k_i$
local clustering coefficient, c_i	number of edges between the neighbors of node i divided by the maximum number of edges between those neighbors $c_i = \frac{2\lvert e_{jk} \rvert}{k_i(k_i - 1)}$ where $n_j, n_k \in N_i$, $e_{jk} \in E$
average clustering coefficient, $\langle C \rangle$	average clustering coefficient of nodes in the network $\langle C \rangle = \frac{1}{N} \sum_{n=1}^{N} c_i$
modularity, Q	proportion of edges that fall within subgroups of nodes minus the expected proportion if edges were randomly distributed, range $[-1, 1]$
average efficiency, E_G	measure of how efficiently information is exchanged in the network $E_G = \frac{1}{n(n-1)} \sum_{i \neq j \in N} \frac{1}{d(n_i, n_j)}$
largest connected component	largest group of nodes in the network that are connected to each other in a single component
degree distribution, $P(k)$	probability distribution of node degrees in the network
γ	power-law exponent for the degree distribution
Small world structure	network with short average path lengths and relatively high clustering coefficient (relative to a random graph with similar density)
scale-free network	network with a degree distribution that is power-law distributed



Networks in nature
Processes on networks:
Day 3

Liubov Bauer lecture
LPI, Paris, France
SEA Mumbai, India

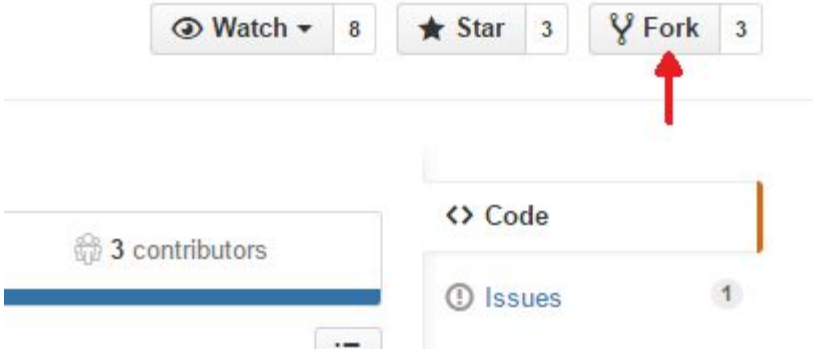
Course topics

1. Network theory reminder
2. Processes on networks
3. Examples of projects on city systems: participatory practice with citizens

4. Discussions about projects

Before we begin

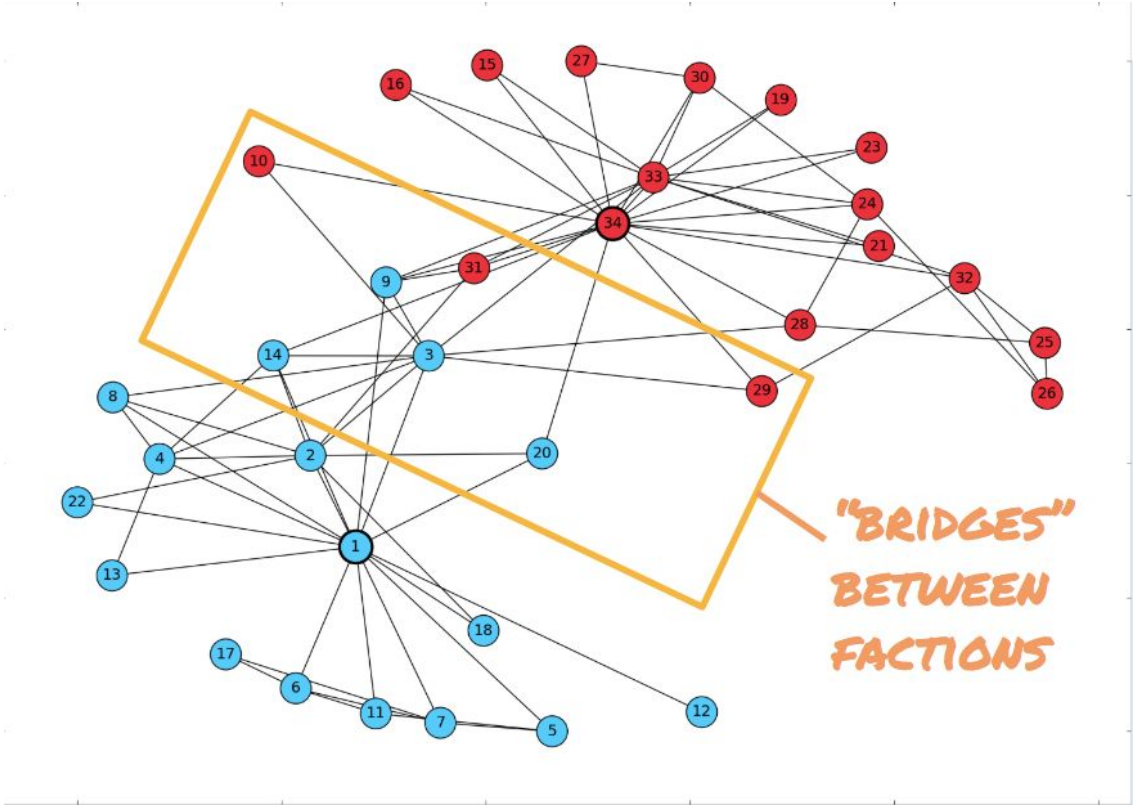
How to share your project and why to use open science framework?
How it can help you to contribute to the world or open analysis?



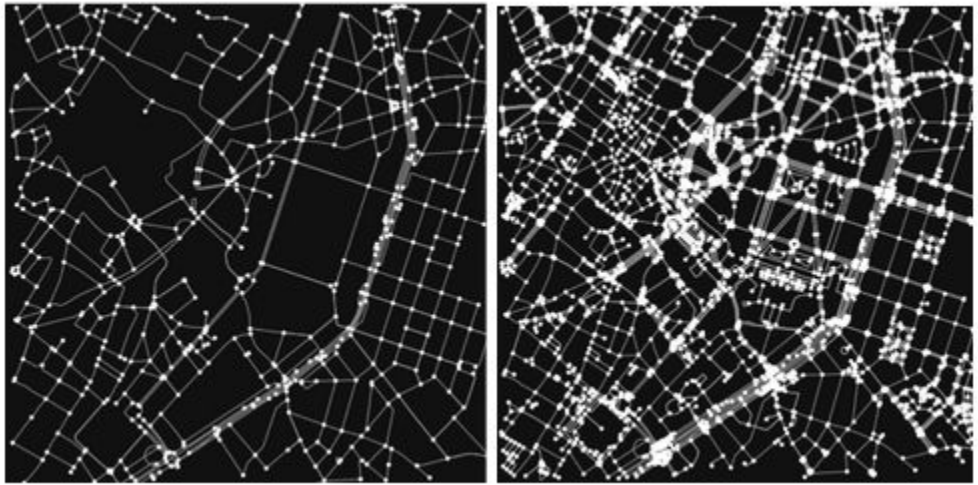
github.com

Part 1
Examples of social networks and networks in nature

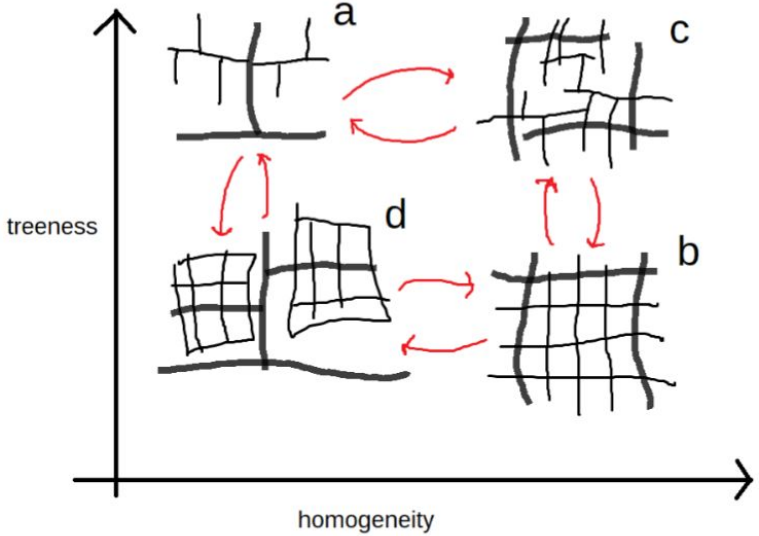
Analysis of communities



Spatial networks analysis
Osmnx networkx module for networkx analysis



Spatial networks analysis:
How cities evolve in time? What are the pathways of city evolution?



Spatial networks analysis
Airport networks which are those?

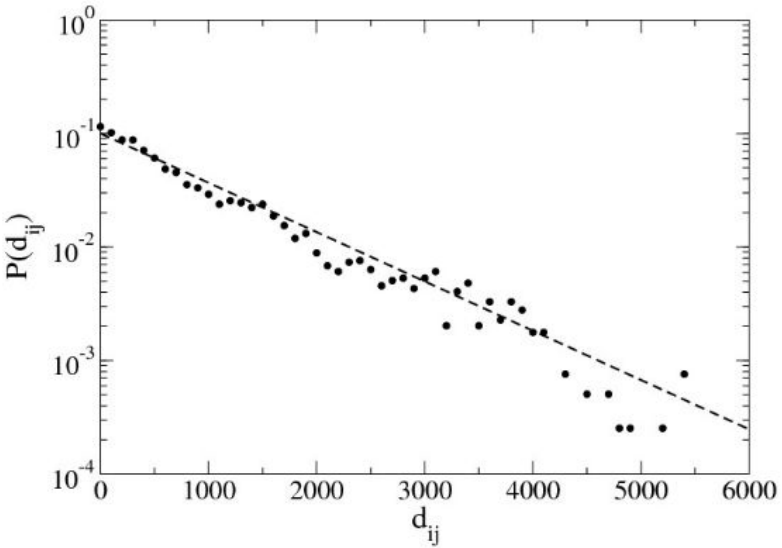
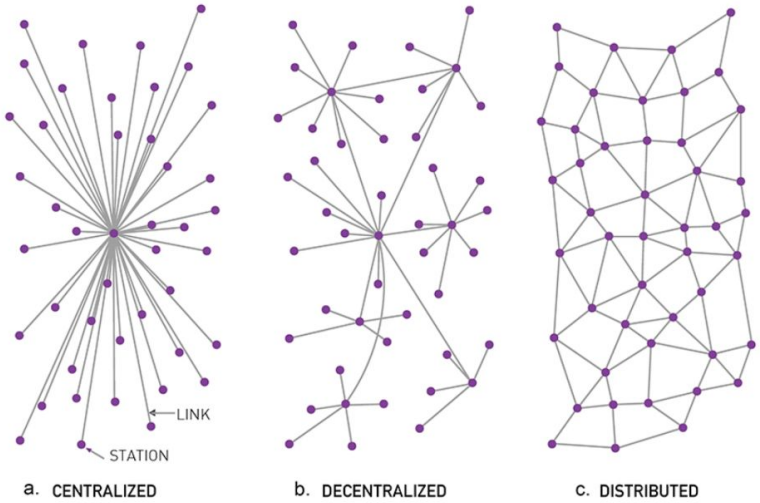


FIG. 7 Distribution of distances (in kms) between airports linked by a direct connection for the North American network. The straight line indicates an exponential decay with scale of order 1,000 kms. From [31].



Spatial networks analysis
Airport networks which are those?

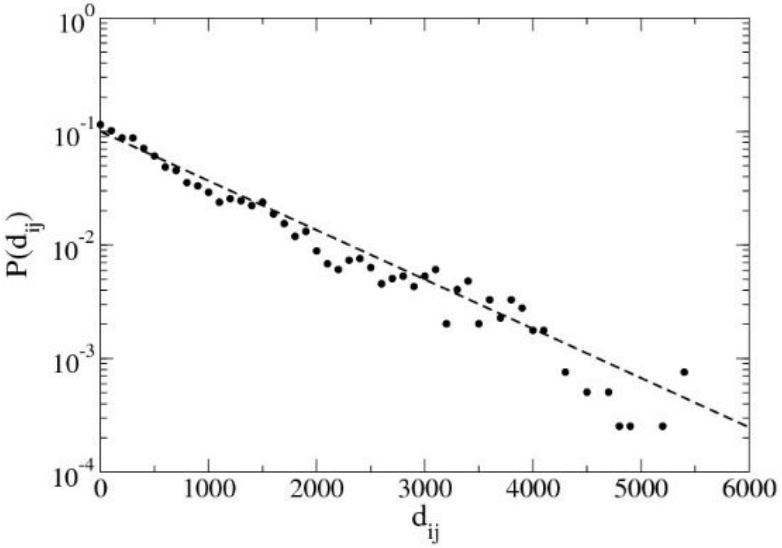
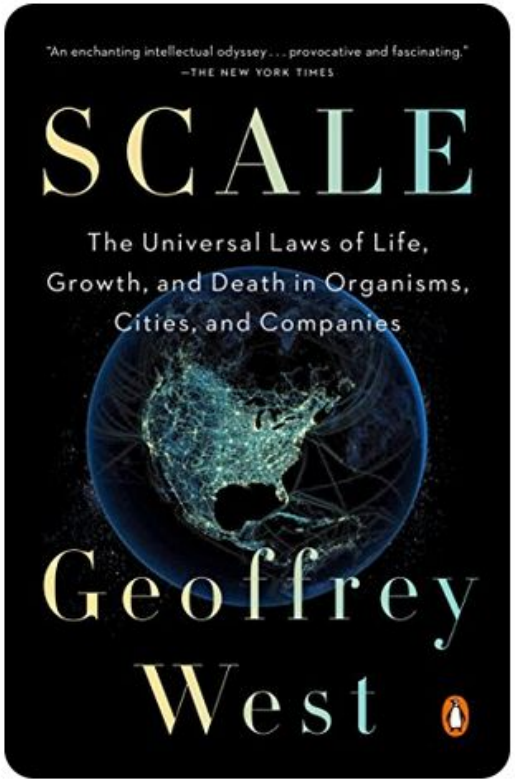


FIG. 7 Distribution of distances (in kms) between airports linked by a direct connection for the North American network. The straight line indicates an exponential decay with scale of order 1,000 kms. From [31].

Books and articles

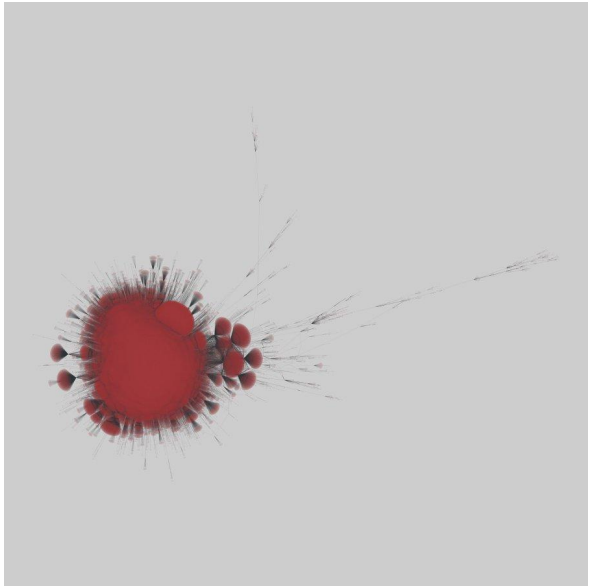
"Scale" on cities scaling properties by G.West



Network visualisaion

Can hairy ball be a good visualisation?
Discussions for class on visualisations

Linux kernel mailing list. A bipartite network of contributions by users to threads on the Linux kernel mailing list. 379554 nodes, 1565683 edges. https://networks.skewed.de/net/lkml_thread



Visualisations

For mobility data
Kepler.gl

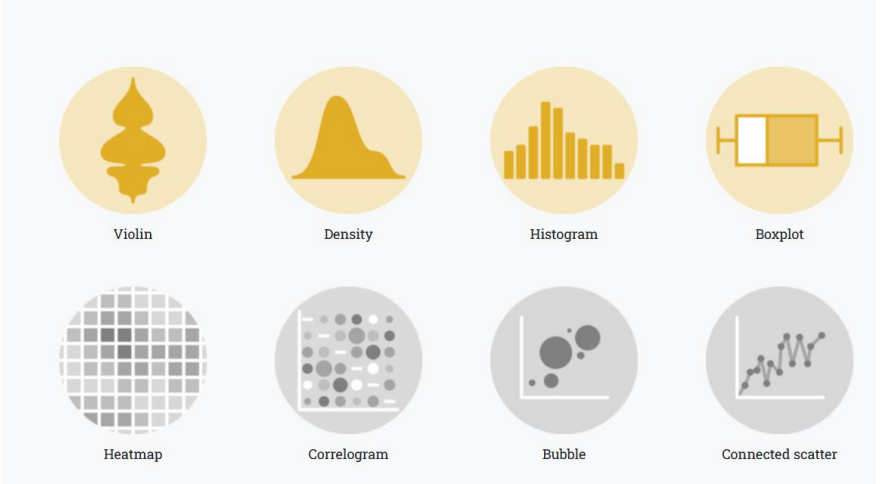
https://github.com/mickeykedia/Mumbai-Population-Map/blob/master/Ward_Level_Data.csv

See data examples on https://github.com/Liyubov/open_tree_data_analysis

Visualisations

For data visualisation

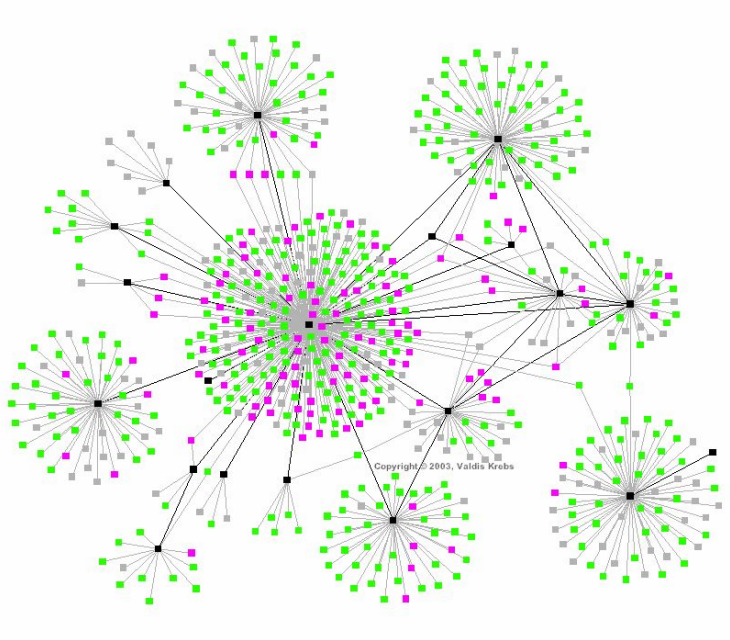
https://www.data-to-viz.com/#boxplot



Part 2
Processes on networks: epidemics spreading

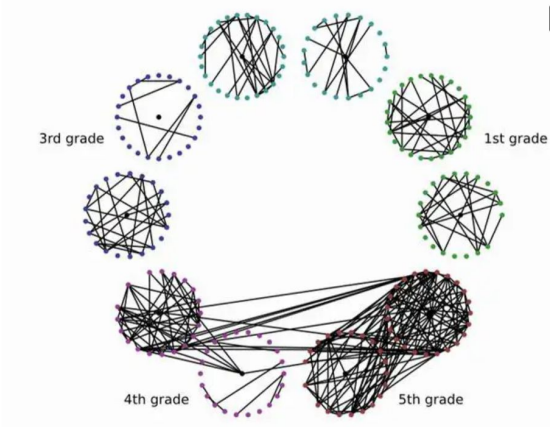
What are spreading processes on networks?

Any examples of spreading processes?



Socio patterns

Or how people interact in classrooms

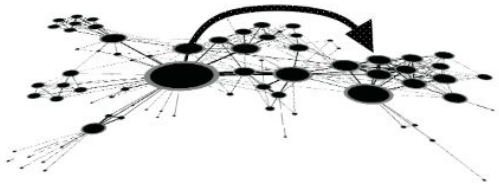


https://vimeo.com/31490438?embedded=true&source=vimeo_logo&owner=5516521

http://www.sociopatterns.org/

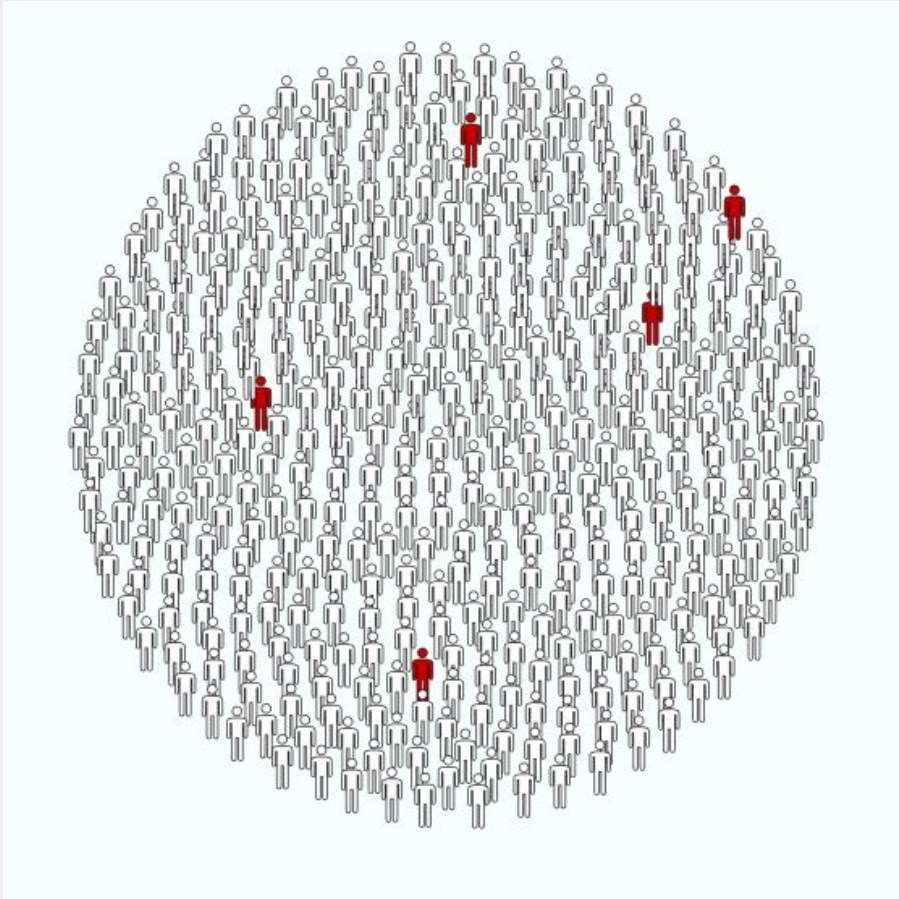
Socio patterns

Or how people interact in classrooms
Can this be used as post-occupancy study for buildings?



SIR model:

Susceptible individuals (S) can be infected by coming in contact with other infected (I) individuals.
Once infected they can transmit the disease until they recover (R) and become immune.
After some time immunity wanes and individuals become susceptible again:



SIR model

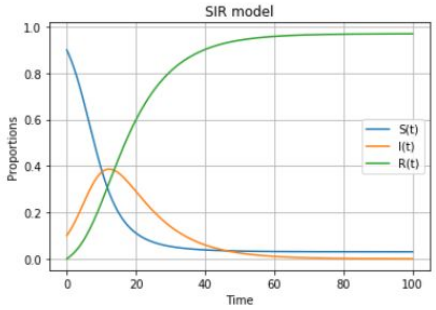
of epidemics spreading.

Make your own simulations of susceptible individuals count and on a network or in population

https://www.complexity-explorables.org/

https://github.com/Big-data-course-CRI/materials_big_data_cri_2019/blob/master/resources%20Python/spreading_on_networks.ipynb

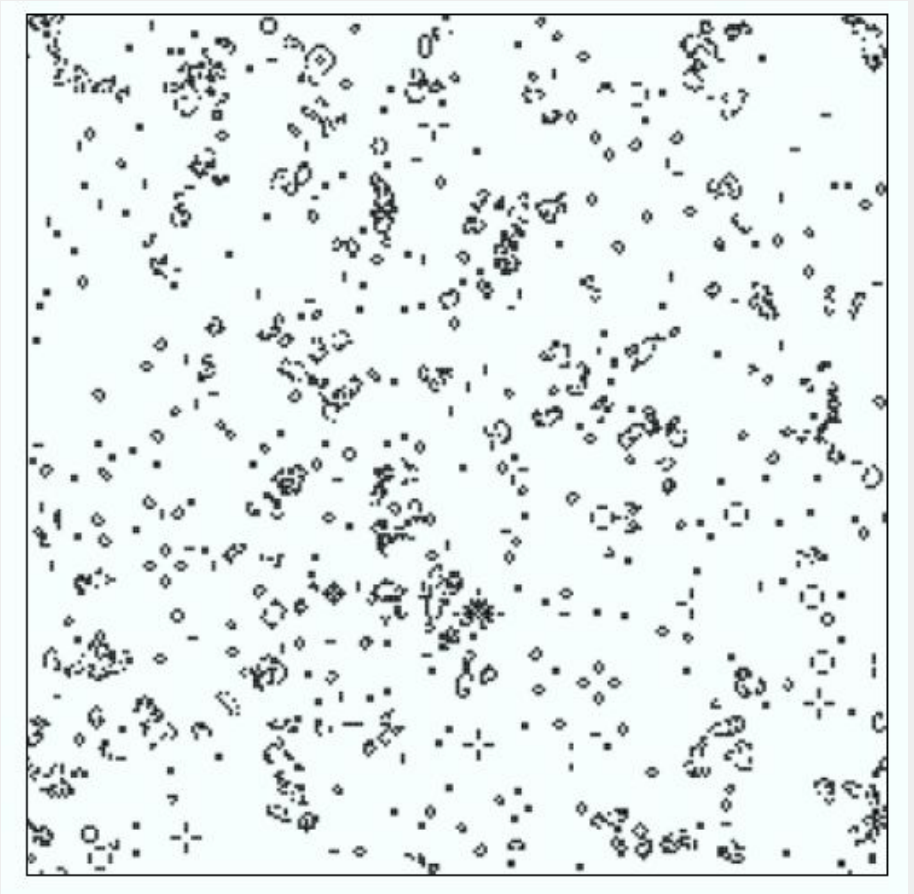
```
solution=scipy.integrate.odeint(SIR_model,[S0,I0,R0],t,args=(beta,gamma))
solution=numpy.array(solution)

plt.figure(figsize=[6,4])
plt.plot(t,solution[:,0],label="S(t)")
plt.plot(t,solution[:,1],label="I(t)")
plt.plot(t,solution[:,2],label="R(t)")
plt.grid()
plt.legend()
plt.xlabel("Time")
plt.ylabel("Proportions")
plt.title("SIR model")
plt.show()
```



Conway game of life model

An attempt to describe life from deterministic point of view of cellular automata

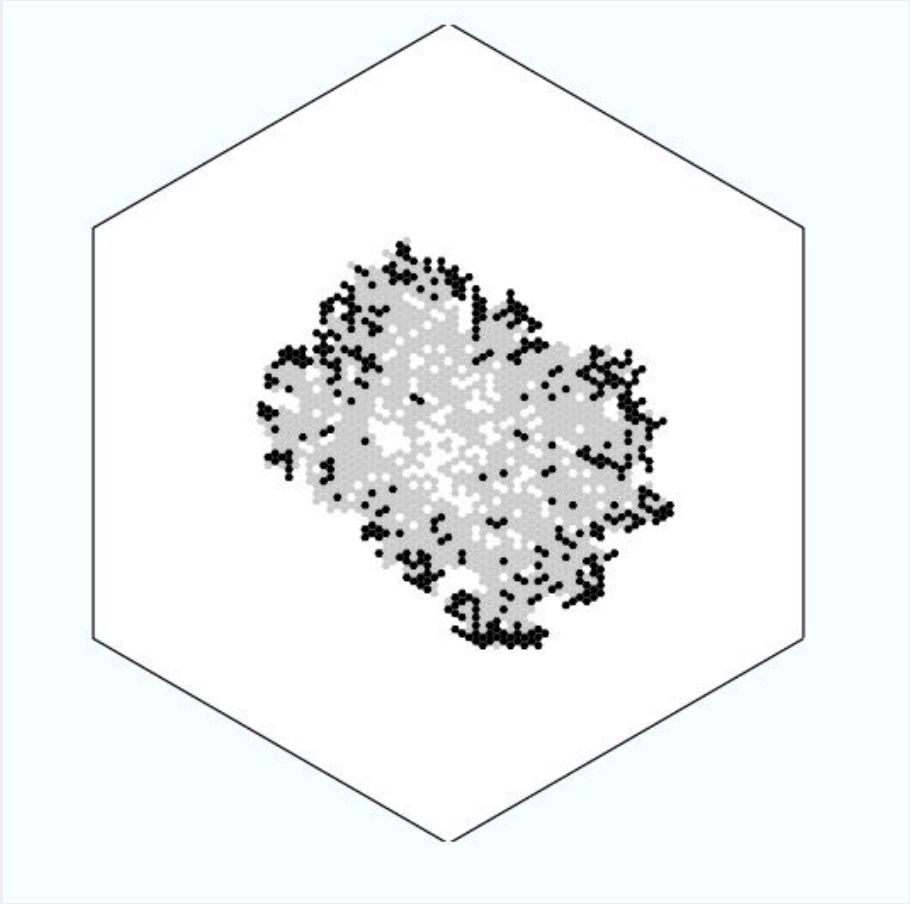
https://mathworld.wolfram.com/GameofLife.html



SIR model

of epidemics spreading with spatial parameter

https://www.complexity-explorables.org/slides/critical-hexsirsize/

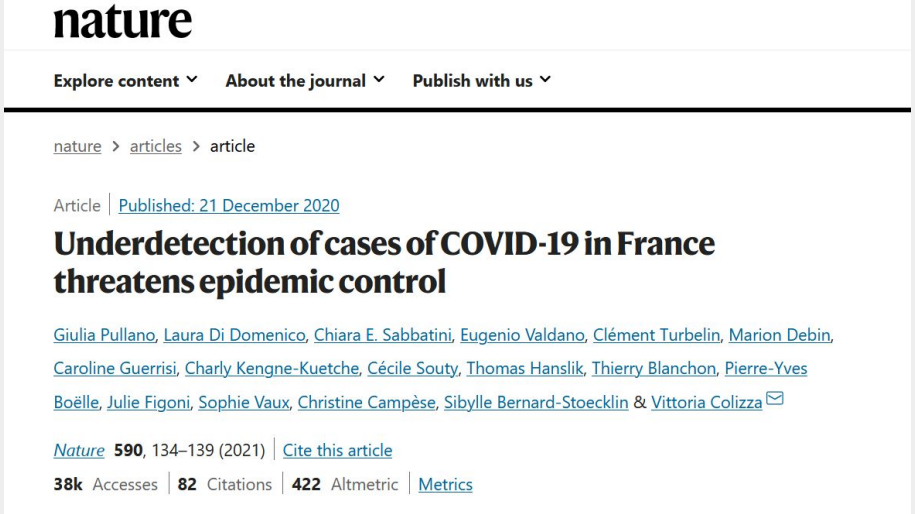


COVID19 models and predictions

of epidemics spreading with spatial parameter

V.Colizza et al.2021, Vespigniani et al.2021
Read only peer-review research

https://www.youtube.com/watch?v=gxAaO2rsdIs



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Article | Published: 21 December 2020

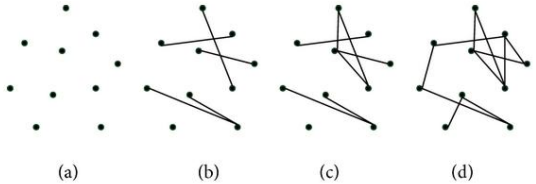
Underdetection of cases of COVID-19 in France threatens epidemic control

Giulia Pullano, Laura Di Domenico, Chiara E. Sabbatini, Eugenio Valdano, Clément Turbelin, Marion Debin, Caroline Guerrisi, Charly Kengne-Kuetche, Cécile Souty, Thomas Hanslik, Thierry Blanchon, Pierre-Yves Boëlle, Julie Figoni, Sophie Vaux, Christine Campèse, Sibylle Bernard-Stoecklin & Vittoria Colizza

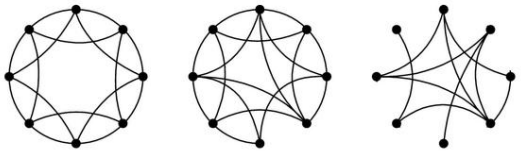
Nature **590**, 134–139 (2021) | Cite this article

38k Accesses | **82** Citations | **422** Altmetric | Metrics

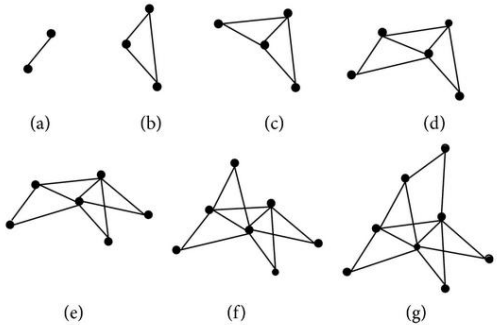
Network growth models



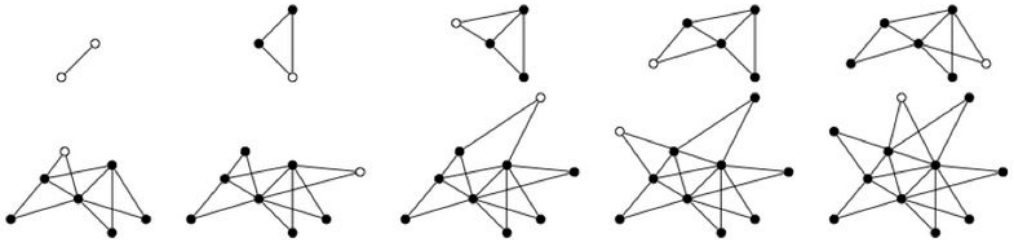
(1) ER random network



(2) WS small world network



(3) BA scale-free network



Projects presentation format

Slide 1:
Describe research question, motivation, challenges or history of the question

Slide 2-3:
Describe your methods, how you tried to solve the problem

Slide 4 or 4-5: results and conclusions

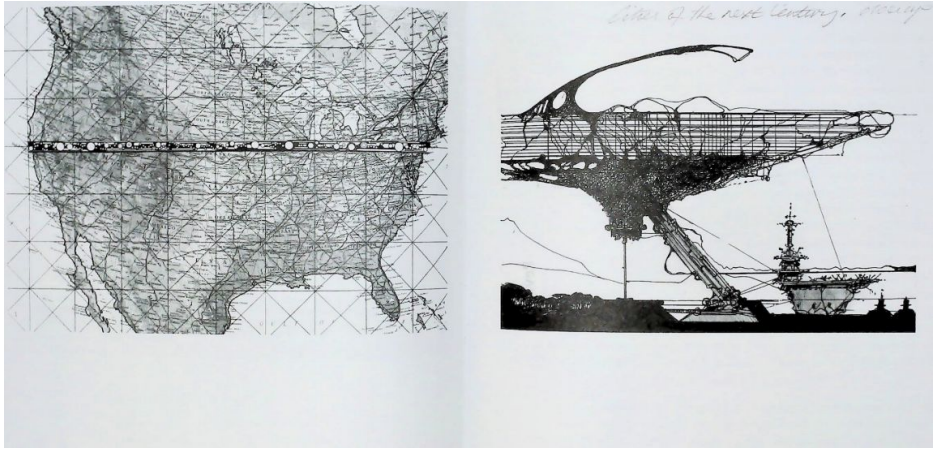
Not more 7 mins
Share it on github!

Projects

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

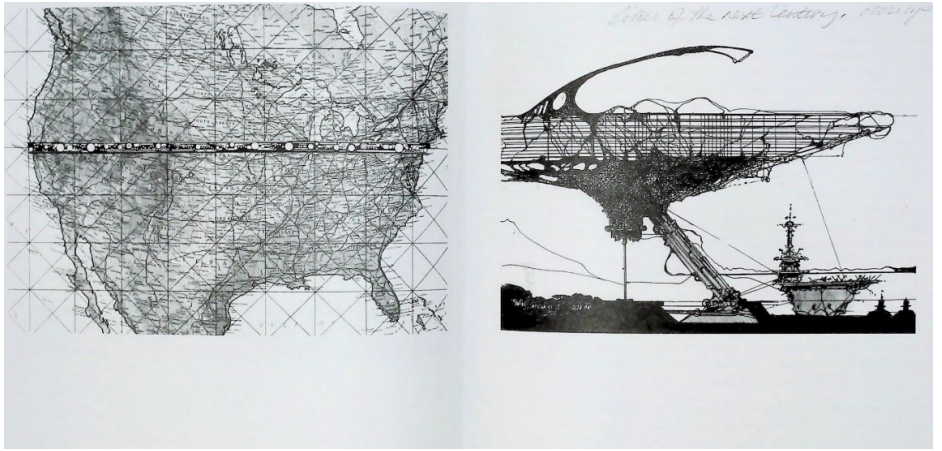
5. Choose the city in India or other country, try to find some open data for this city and visualise this data on the map of the city. Open data on pollution or noise in cities.

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

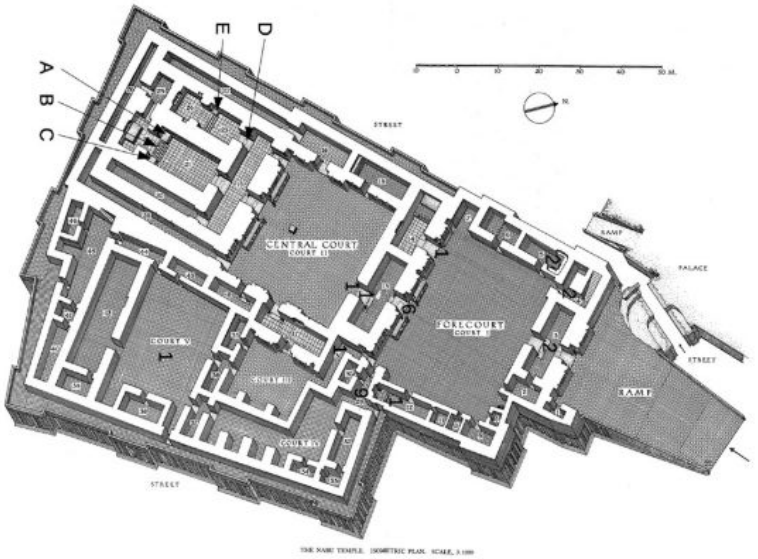


Figure 3.7: Plan of the Ezida temple in Dur-Šarruken, with the locations of inscribed elements (marked with letters A–E abandoned tablets (marked by numerals) added by the author. The bridge to the palace is to the northwest, tablet storage the west wall (5, 15), and the gods' cellas to the southwest (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",
    )
```