Network Science

Course Overview

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Lecturer

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lectures: mon 8:30-10:00 & tue 16:30-18:00 @ www.dei.unipd.it

office hours: contact me by email

In this course you'll meet

Lejla Dzanko

Prof. Caterina Suitner

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Prerequisites

Basic requirements (that you already satisfy)

Calculus and linear algebra

Familiarity with a programming language
(Python, R, MatLab, C, Java, etc.)

Probability theory / Statistics

Other useful knowledge

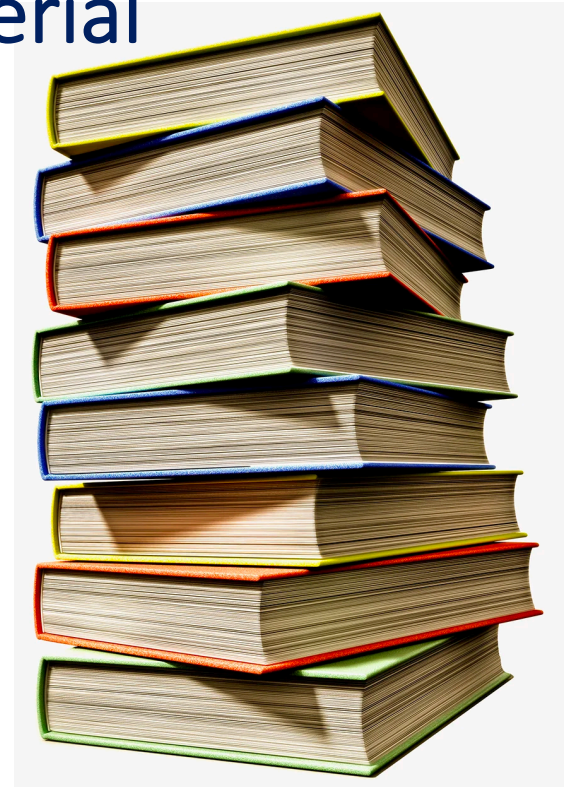Networking processes in economics, telecommunications, semantics, etc ...

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Textbooks ?

No textbook! 😊

Slides/videos & additional material available
  @ stem.elearning.unipd.it

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Project based exam

❑ **Project**
written report
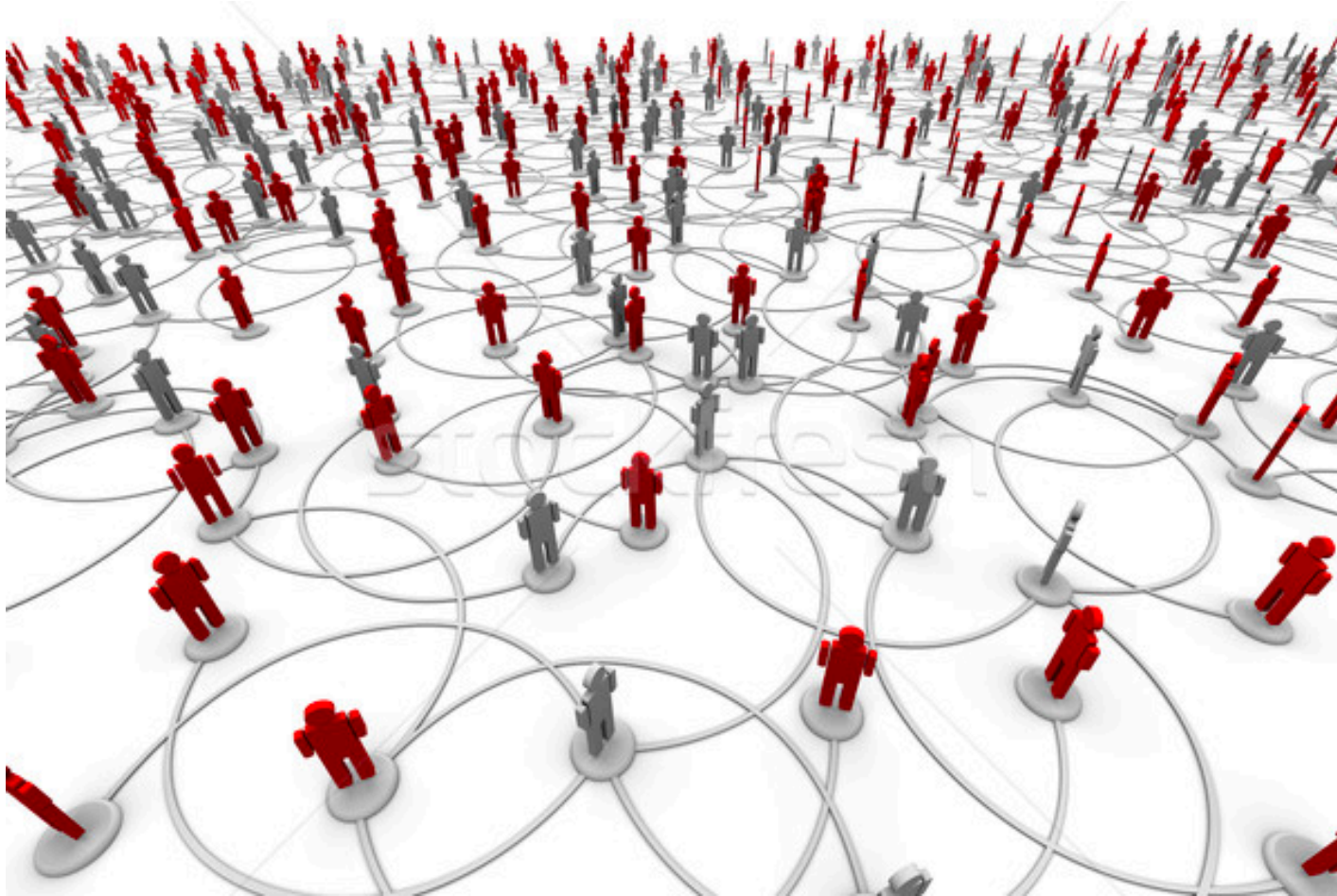extract network analytics using your
preferred programming language(s)

❑ **Oral presentation**
10 min presentation (slides)
5 min for questions

Final grade: 60% report, 40% presentation
+2 bonus (up to) if an interdisciplinary project (IP)

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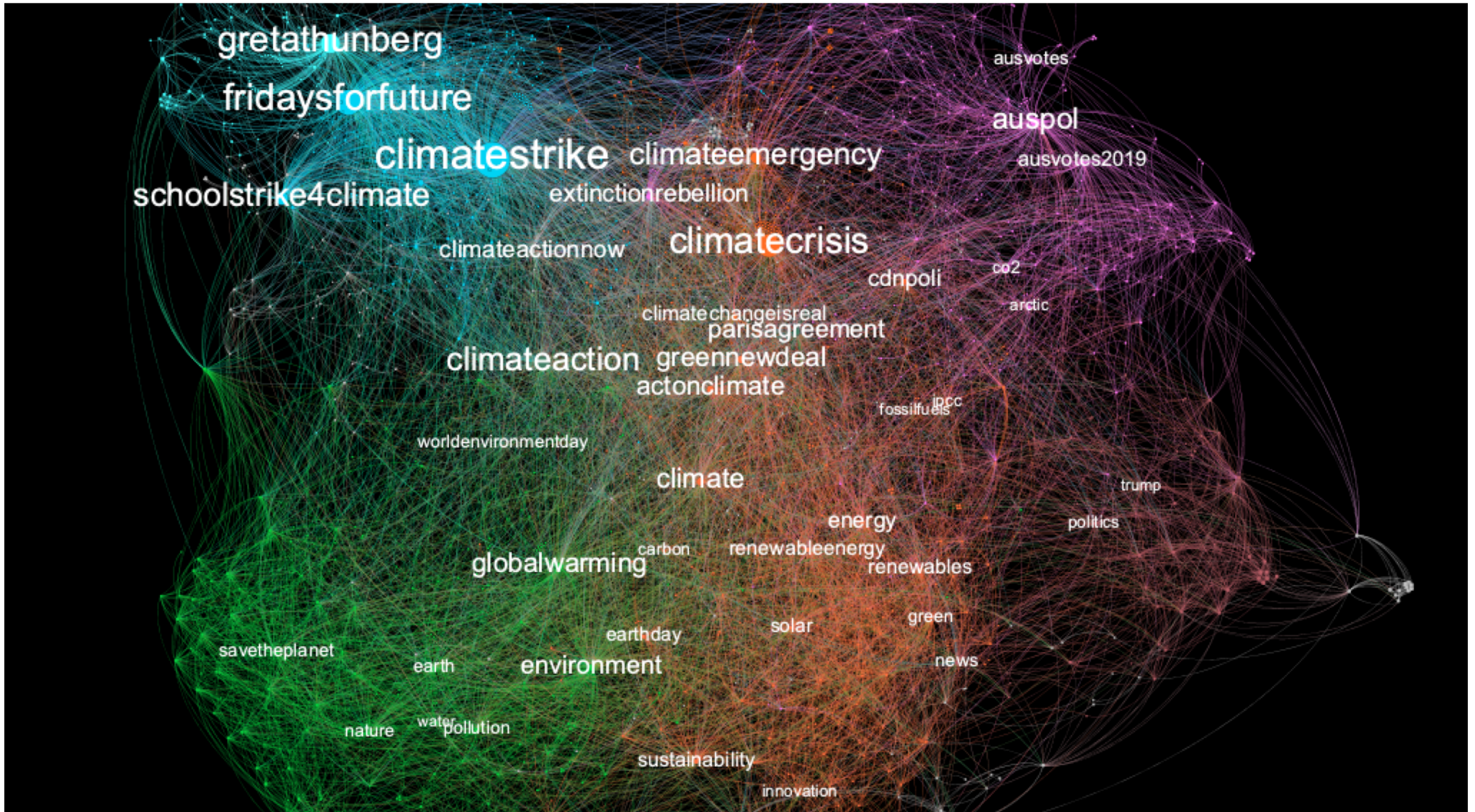# This course is about Networks

❑ Network = anything that interconnects
e.g., people sharing friendship in a social network platform
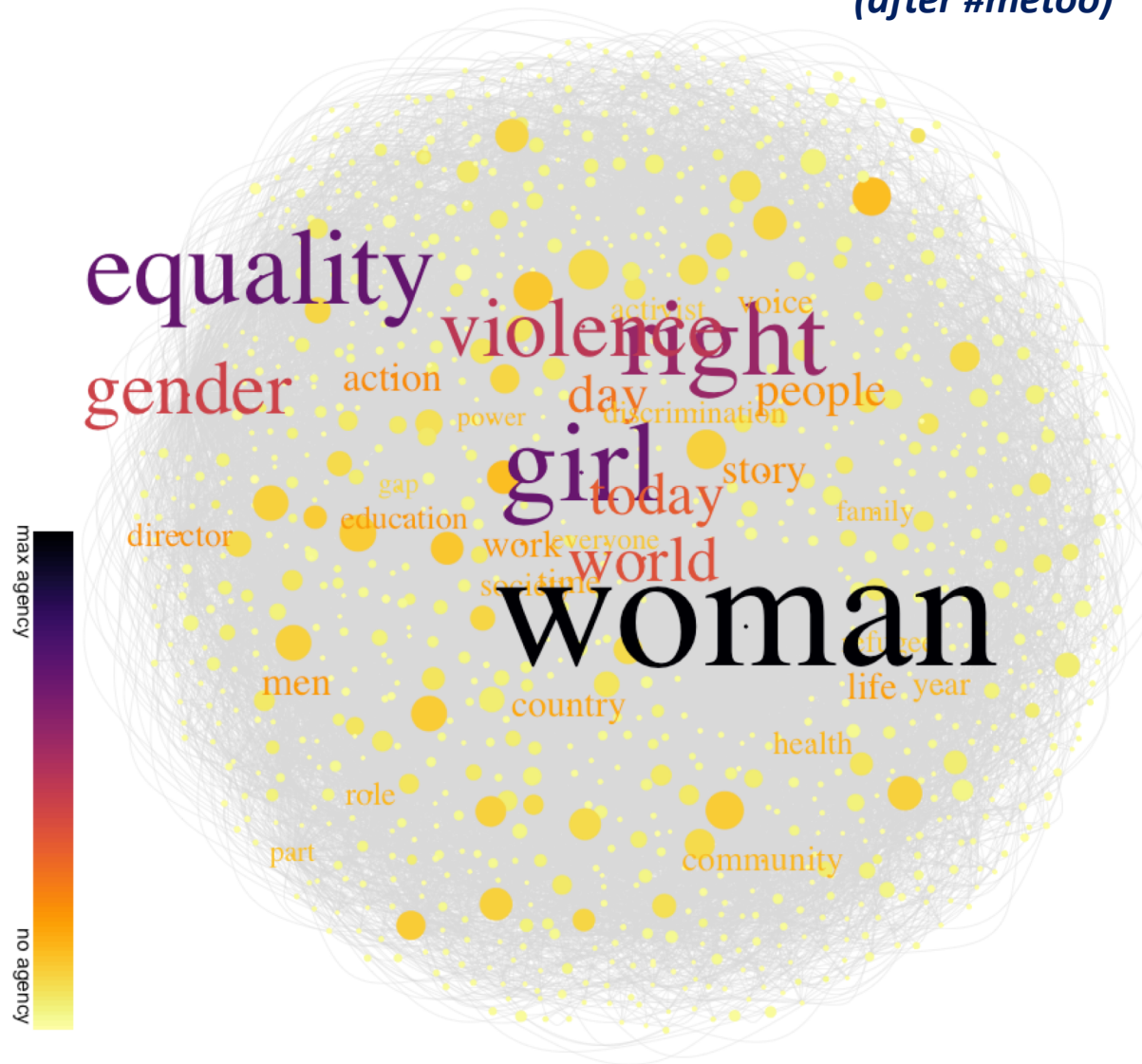
Network examples

2019 hashtag network related to #climatechange (from Twitter, after #gretathunberg)
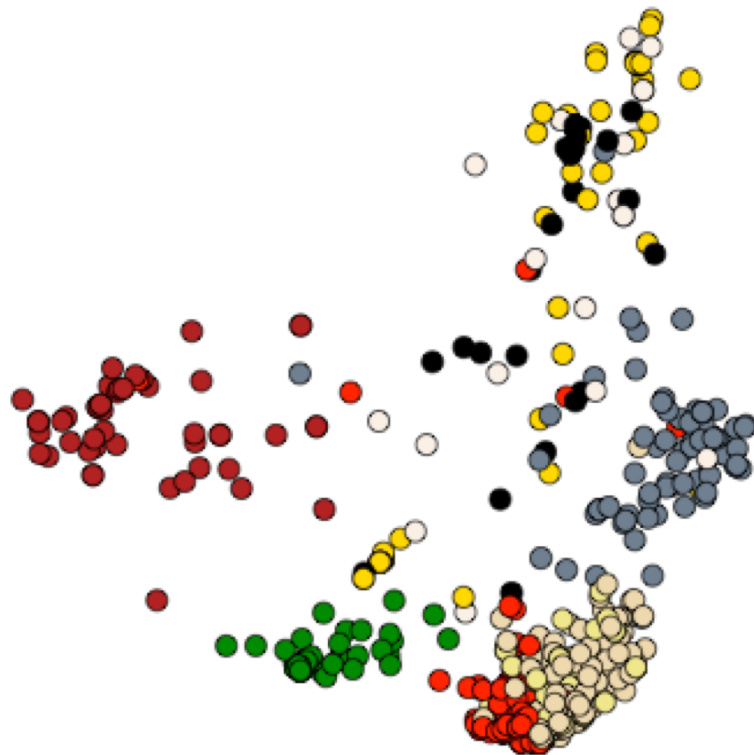
Network examples ... cont'd

2018 nouns network related to @UN_Women pages on Twitter
(after #metoo)

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Network examples ... cont'd

April-May 2016 political network (votes at the EU parliament)

spectral clustering layout

SimRank force directed layout

- GUE-NGL
- Greens-EFA
- S&D
- ALDE
- EPP
- ECR
- ENF
- EFDD
- NI

5star movement
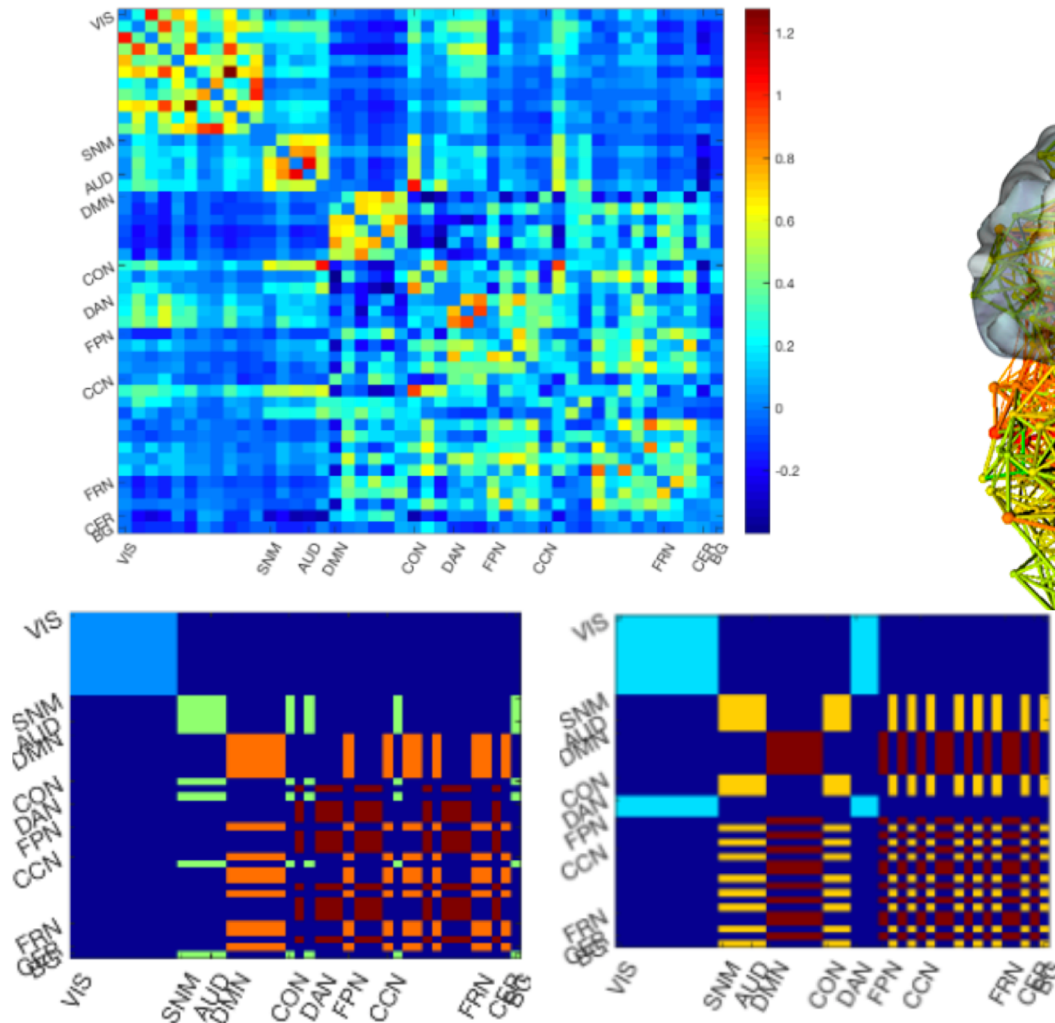
Neil Farage's UKIP

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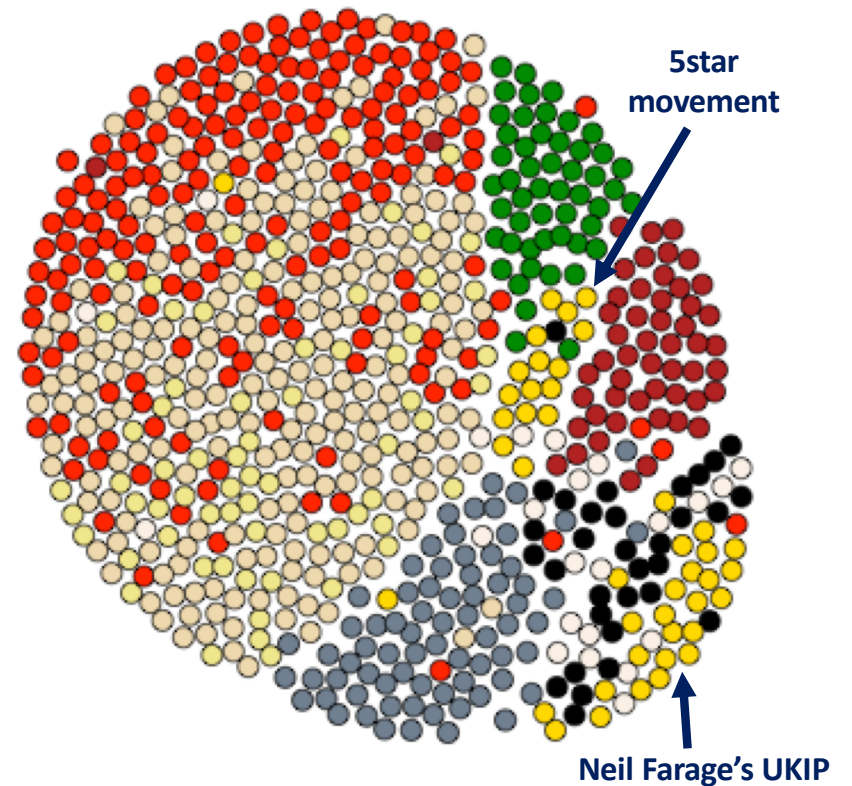
2007 food web (Core Sound, NC, USA after the shrimping season)
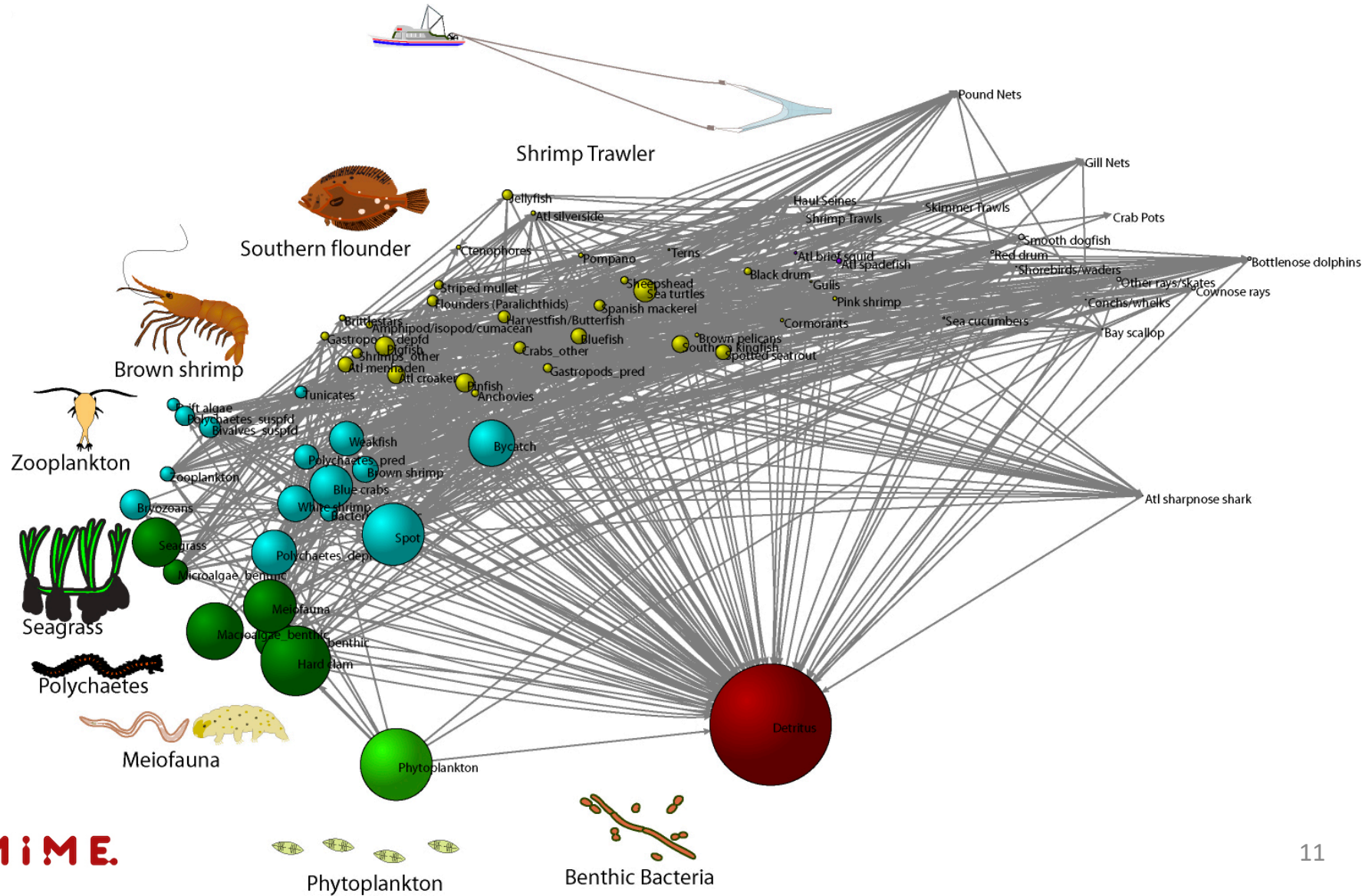
Network examples ... cont'd

The brain network (functional connectivity network)

What is then network science?

Network science

From Wikipedia, the free encyclopedia

For other uses, see Network (disambiguation).

Network science is an academic field which studies complex networks such as telecommunication networks, computer networks, biological networks, cognitive and semantic networks, and social networks, considering distinct elements or actors represented by *nodes* (or *vertices*) and the connections between the elements or actors as *links* (or *edges*). The field draws on theories and methods including graph theory from mathematics, statistical mechanics from physics, data mining and information visualization from computer science, inferential modeling from statistics, and social structure from sociology. The United States National Research Council defines network science as "the study of network representations of physical, biological, and social phenomena leading to predictive models of these phenomena."[1]

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And how do we study networks?

With a holistic character

> (the whole is greater than the sum of its parts)

With mathematical rigour

The approach is

- empirical (driven by concrete data),
- precise (requires a proper formalism),
- interdisciplinary (can be applied to several fields), and
- challenging (in data size and in objectives)

And what do we study?
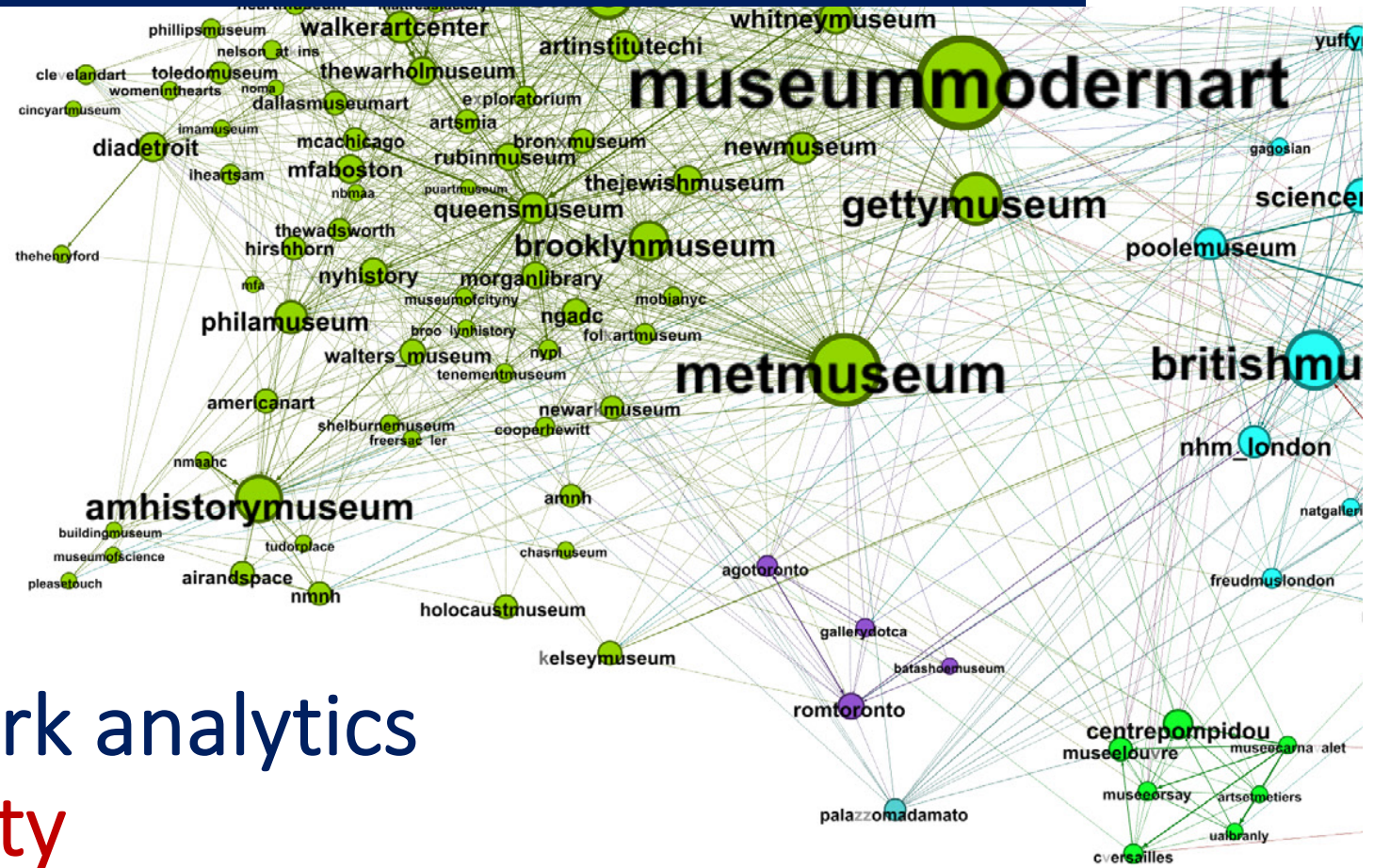
many network analytics
e.g., centrality

☐   degree, PageRank, HITS, betweenness, etc.

Google

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And what do we study? ... cont'd
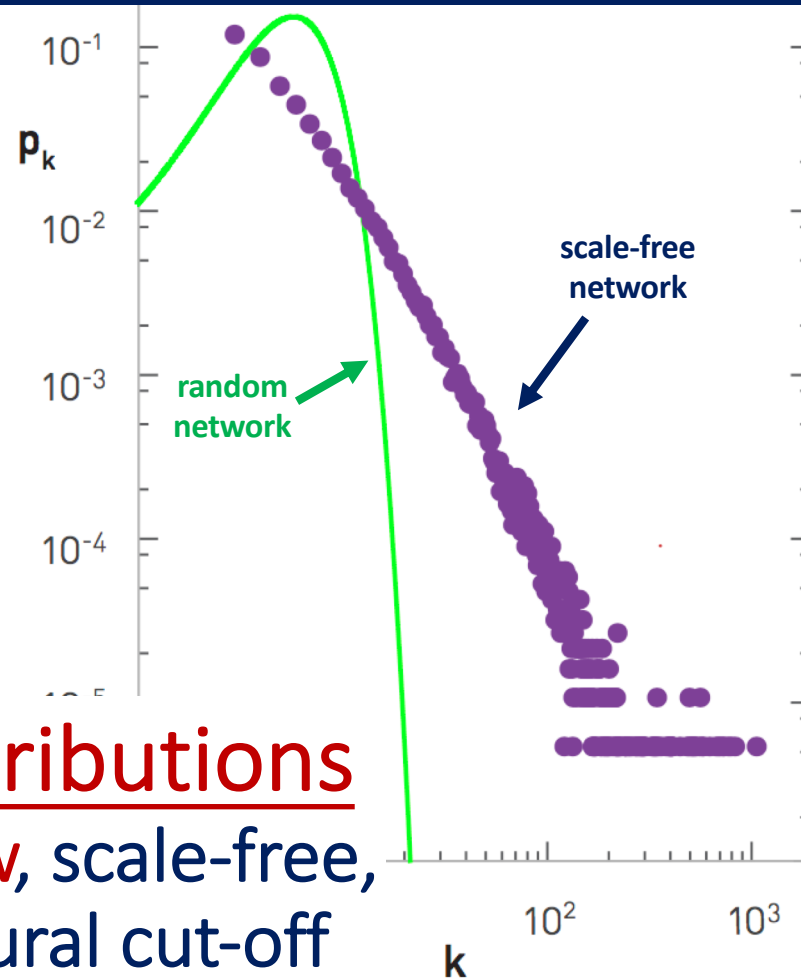
degree distributions
- [ ] power-law, scale-free, hubs, natural cut-off

(because networks are not organized at random)

network models
- [ ] preferential attachment, fitness, aging, accelerated growth

And what do we study? … cont'd
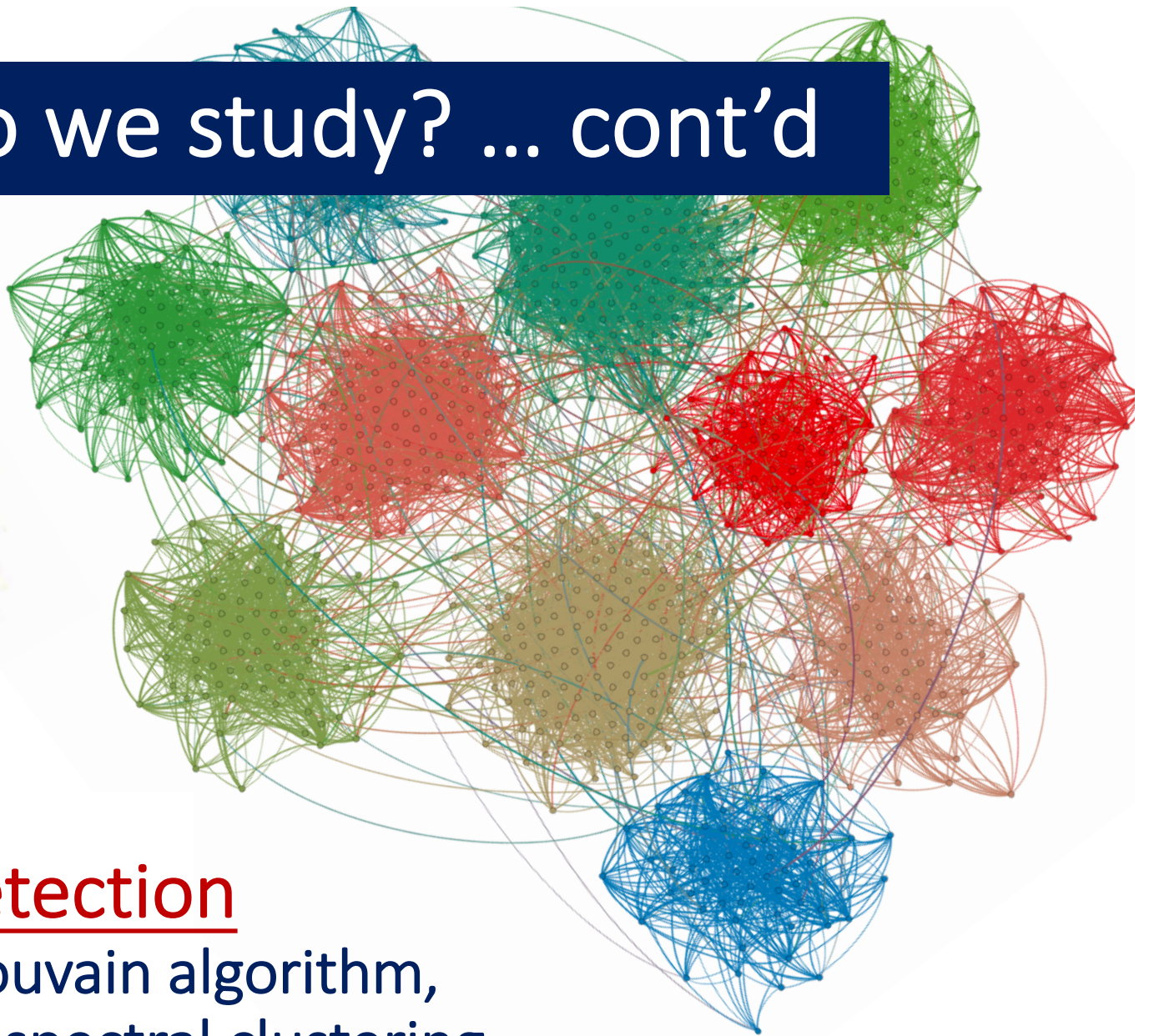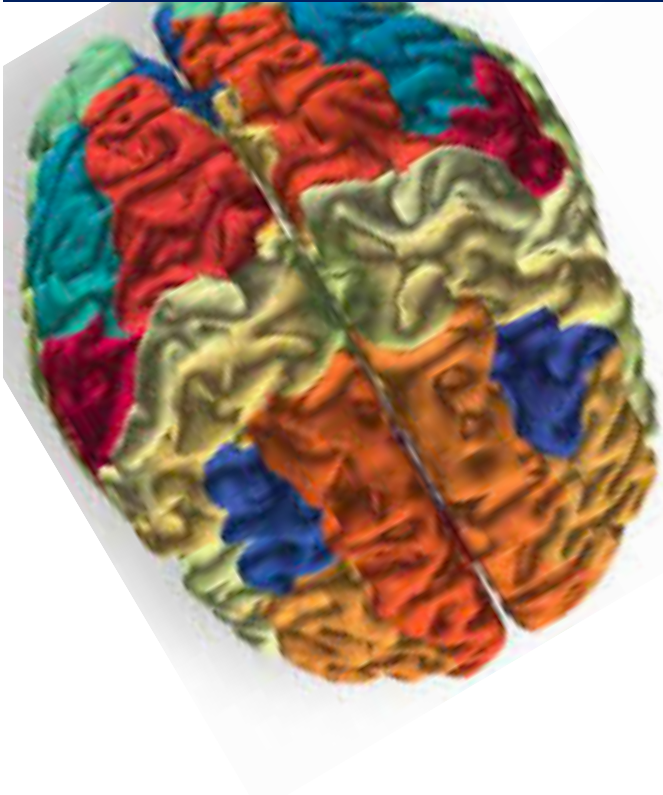
community detection
- ☐ modularity, Louvain algorithm, conductance, spectral clustering, overlapping communities

And what do we study? ... cont'd
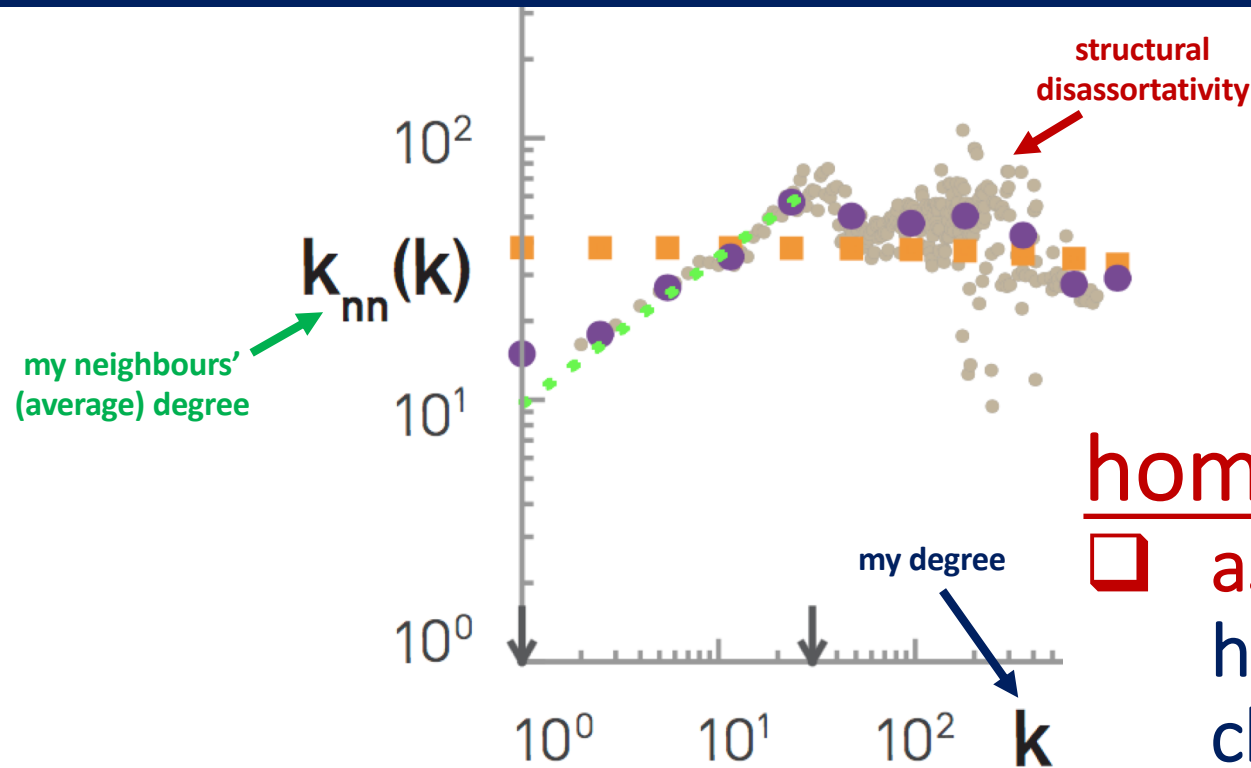
homophily
- ❑ assortativity (degree homophily), echo chambers, polarization

robustness
- ❑ how robust is a network to node removal?

link prediction
- ❑ which is the next link to activate?

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Origin of network science

❑ **Many ideas around for a while**
  graph theory (Euler 1735)
  ecological networks (Elton 1927)
  social networks (Moreno 1934)
  economic networks (Leontief 1941)
  Internet (Cerf and Kahn 1973)

❑ **Effort to finding a common language only started around the 2000s**
  convergence of disciplines
  availability of data collections and archives
  the Internet itself as an instrument to gain access to big data

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What about the project ?

choose your dataset (possibly create your own dataset)

apply the ideas learned during the course

show that you can do clever things

try extracting meaningful measures/analytics that describe an interesting aspect of your network

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What about interdisciplinary projects ?

in collaboration with the twin course of
<u>Social Network Analysis</u> @ Communication
Strategies

revise

SNA students suggest research questions

NS students conceive appropriate algorithmic
solutions
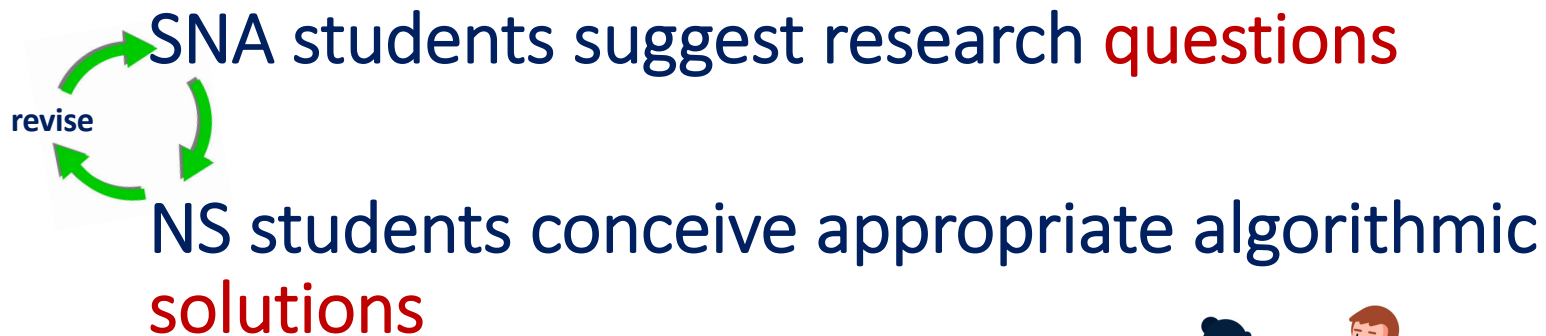
in brainstorming sessions
the instructor will help/give feedback ☺

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Interdisciplinary projects 2019

Interdisciplinary projects 2019

10:00 IP6 INSULTS AND HATE   networks from words in tweets

Salvatore Romano, Carlo Facchin, Enrico Lanza, Abanoub Gaber Aziz Saeed, Alberto Zancanaro

10:40 IP2 ITALIAN POLITICIANS AND IMMIGRATION

Giovanni Boato, Martina Eleno, Riccardo Pinton, Sarra Ben Mayassa, Salihi Memen,
Francesco Savio, Mario Serafin

11:20 IP7 NOODLES AND SPAGHETTI   networks from recipes, food colours

Diana Ching-Fang Tai, Elena Camuffo, Giovanni Colotti, Laura Crosara, Federico Fiorenzoli,
Daniele Lorenzi, Matteo Moro, Aniello Xie

14:20 IP8 VENETO DIALECT   network of social connections

Ainhoa Sotomayor Aranburu, Ane Arzallus Alonso, Stella Mariz Barafon, Bianca Rangel Campinho,
Fabio Cecchinato, Stefano Alberton

15:00 IP3 PRO-LIFE AND PRO-CHOICE   networks from words in tweets

Lara Schwarz, Leila Dzanko, Giulia Rizzoli, Sanja Miljanovic, Sara Shena

15:30 IP1 FREEDA NETWORK

Elena Faccio, Rachele Calamai, Damiano Clementel, Laura Iacovissi

16:00 IP5 GRETA EFFECT AND CLIMATE CHANGE

Riccardo Bergamasco, Francesca Civo, Martino De Nardi, Matteo Migliorini,
Domenico Solimini, Carlotta Segna

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Is IPs dirty work?

- ❑ scraping with APIs,
  downloading,
  PoS tagging,
  data storing,
  etc.

… but can get better if you use Phython, and, in any case,

- ❑ the reward is
  worth the effort

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Calendar (tentative)

OCTOBER 2022

SUN	MON	TUE	WED	THU	FRI	SAT
						1
2	3 (intro)	4 (intro)	5	6	7	8
9	10 (network models)	11 (network models)	12	13	14	15
16	17 (centrality)	18 (centrality)	19	20	21	22
23	24 (community detection)	25 (community detection)	26	27	28	29
30	X					

NOVEMBER 2022

SUN	MON	TUE	WED	THU	FRI	SAT
		X (homophily / polarization)	2	3	4	5
6	7 (homophily)	8 (polarization)	9	10	11	12
13	14 (IPs kickoff)	15	16	17	18	19
20	21 (Twitter labs)	22	23	24	25	26
27	28 (Twitter labs)	29 (layout)	30			

DECEMBER 2022

SUN	MON	TUE	WED	THU	FRI	SAT
				1	2	3
4	5 (Gephi lab)	6 (robustness)	7	8	9	10
11	12 (igraph lab)	13 (link prediction)	14	15	16	17
18	19	20 (seminar)	21	22	23	24
25	26	27	28	29	30	31

○ 2 x project discussion in Jan

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Exam sessions (starting dates)

- ❑ Feb 1, 2023 (Wed) - 9:00, Le
- ❑ IP day Feb 6, 2023 (Mon) - 9:00 - tbc
- ❑ Feb 21, 2023 (Tue) - 9:00, Le
- ❑ Jul 5, 2023 (Wed) - 9:00, Le
- ❑ Sep 11, 2023 (Tue) - 9:00, Ce

PS: You will be asked to enrol in
www.uniweb.unipd.it

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Useful books/material

❑ **A.L. Barabási, «Network science»**

http://barabasi.com/networksciencebook

(these slides = Ch.1 "Introduction")

❑ **J. Lescovec, «Machine learning with graphs»**
http://web.stanford.edu/class/cs224w

❑ **M. Newman, «Networks: an introduction»**
Oxford University Press, 2010

❑ **R. van der Hofstad, «Random graphs and complex networks»**
http://www.win.tue.nl/~rhofstad/NotesRGCN.html

Useful programming languages
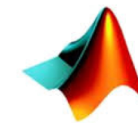
❑ **Python**

   very good at scraping data (e.g., via Twitter APIs), polishing data (POS tagger), plotting graphs, implementing algorithms

❑ **R**

   very good for memory storage, plotting graphs, implementing algorithms

❑ **MatLab**

   An alternative for algorithms and graph plotting

   University license available

   https://www.ict.unipd.it/servizi/servizi-utenti-istituzionali/contratti-software-e-licenze/matlab

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What about you?

Why did you pick the course?

Which is your background?

Do you know Python?

What do you expect from this course?

Do you have a laptop?

Are you interested in an interdisciplinary work?

Questions ?