



2025.1

Algo. & Data Structure II

DCA3702

Prof. Ivanovitch Silva

Prazo Para Conclusão (em semestres): Mínimo: 5 Médio: 10 Máximo: 14

Optativas

Complementares

1º Nível

2º Nível

3º Nível

4º Nível

5º Nível

6º Nível

7º Nível

8º Nível

9º Nível

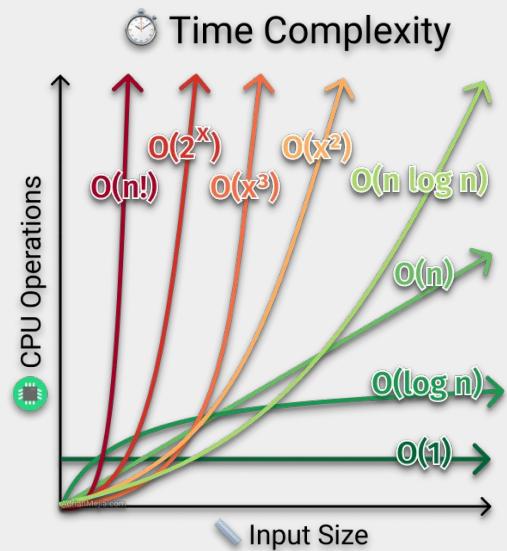
10º Nível

7º NÍVEL

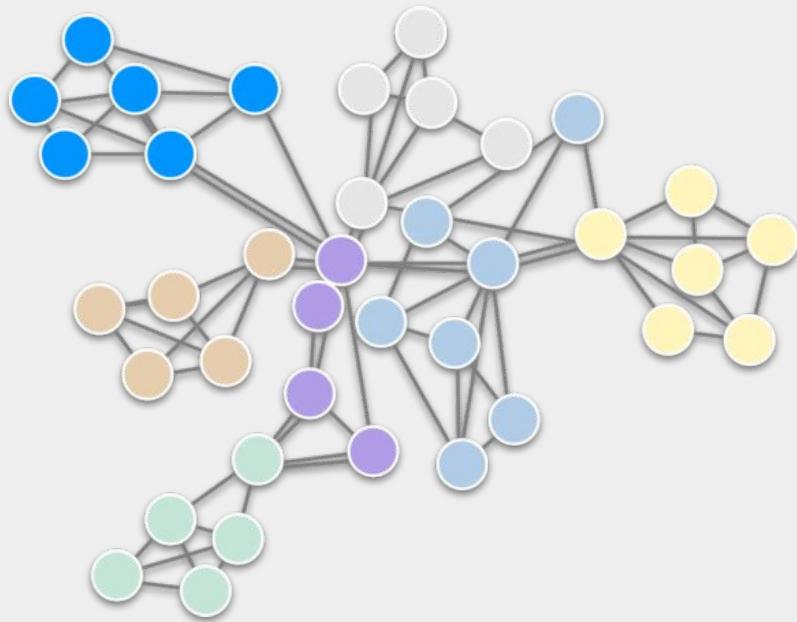
| | | |
|---|-------------|--|
| DCA3701 - PROJETO DE SISTEMAS DE CONTROLE - 90h | Obrigatória | |
| DCA3702 - ALGORITMOS E ESTRUTURAS DE DADOS II - 60h | Obrigatória | |
| DCA3703 - PROGRAMAÇÃO PARALELA - 45h | Obrigatória | |
| DCA3704 - SISTEMAS DISTRIBUÍDOS - 45h | Obrigatória | |
| DCA3705 - AUTÔMATOS E LINGUAGENS FORMAIS - 60h | Obrigatória | |
| DCA3706 - SISTEMAS EMBARCADOS - 60h | Obrigatória | |

Carga Horária Total: 360h

Course Outline



Algorithm Complexity



Graph

Training compute (FLOPs) of milestone Machine Learning systems over time

$n = 121$

<https://arxiv.org/pdf/2202.05924.pdf>

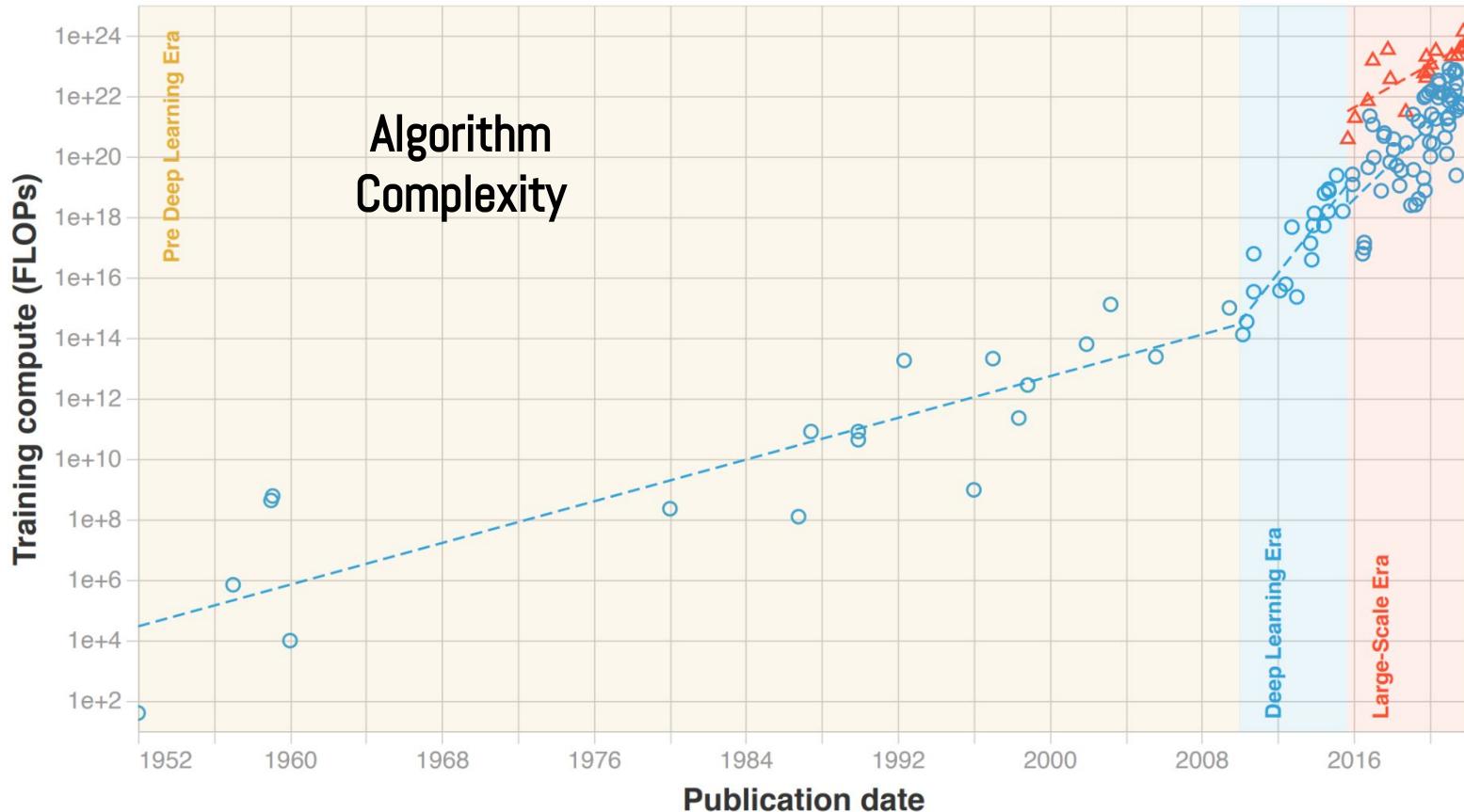
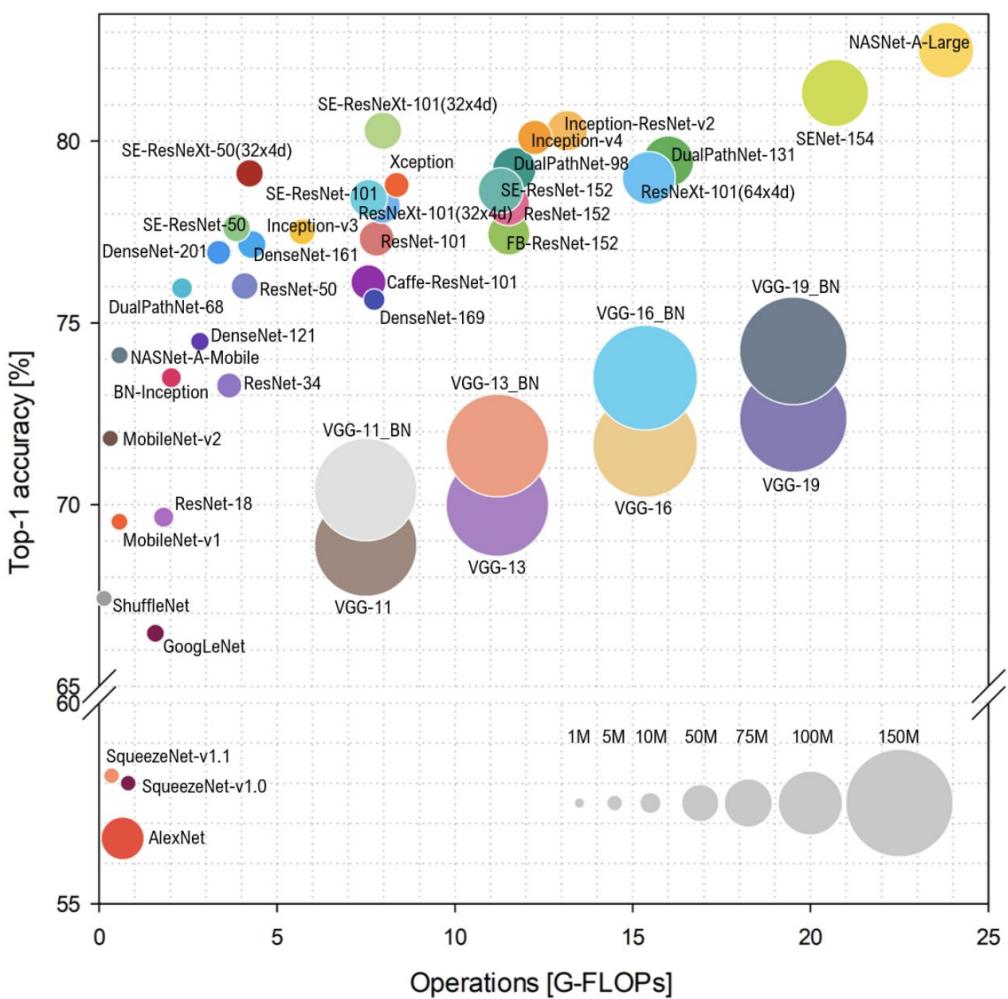


Figure 1: Trends in $n = 121$ milestone ML models between 1952 and 2022. We distinguish three eras. Notice the change of slope circa 2010, matching the advent of Deep Learning; and the emergence of a new large-scale trend in late 2015.

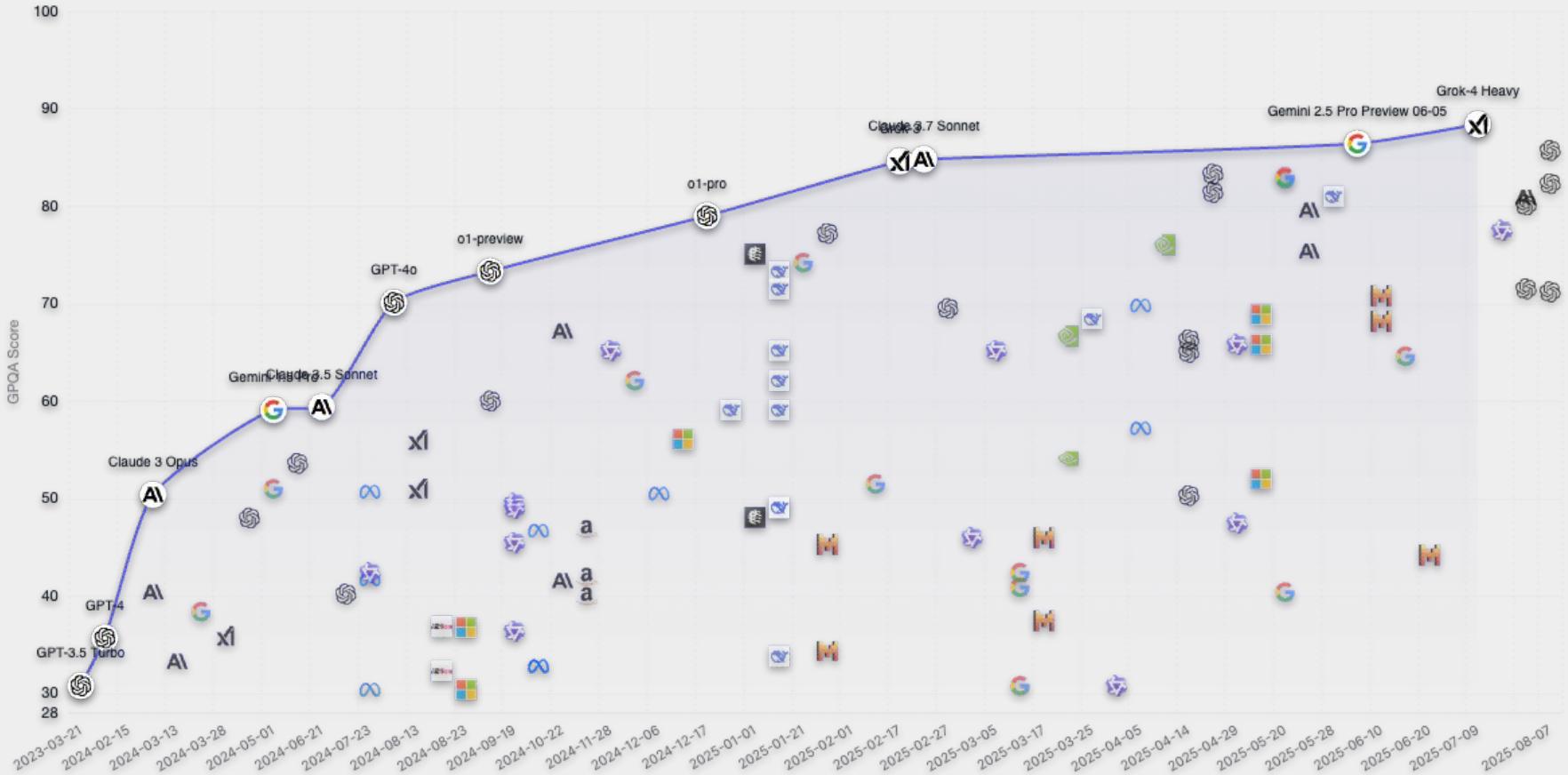
Algorithm Complexity



ML Model Evolution ImageNet

Source: S. Bianco, R. Cadene, L. Celona, and P. Napoletano, "Benchmark analysis of representative deep neural network architectures". IEEE Access, vol. 6, 2018.

LLM Leaderboard





mlco2 / codecarbon

Q Type / to search



Code

Issues 87

Pull requests 23

Discussions

Actions

Projects

Security

Insights



codecarbon

Public

Sponsor

Watch 21

Fork 197

Starred 1.3k

master

148 Branches

48 Tags

Go to file

Add file

Code

 inimaz Merge pull request #795 from mlco2/fix/auth-context-get-one-pr... 4987537 · 2 weeks ago 1,992 Commits

 .conda Add 3.13 in variants.yaml 5 months ago

 .github ci: deploy app from ci (#772) 2 months ago

 act API for codecarbon (#145) 4 years ago

 carbonserver Merge branch 'master' into fix/auth-context-get-one-proj... 2 weeks ago

 codecarbon fix: minor change in log that says where the codecarbon o... 2 weeks ago

 dashboard feat(core): ✨ allows picking up API endpoint from conf fil... 10 months ago

 deploy fix(deploy) fix typo (#698) 5 months ago

 docker Remove tox and makefile mentions 11 months ago

 docs chore: bump version (#765) 2 months ago

 examples Fix/fix prod api (#748) 3 months ago

 requirements Bump deps 2 months ago

 tests Fix empty country 2 months ago

About

Track emissions from Compute and recommend ways to reduce their impact on the environment.

 mlco2.github.io/codecarbon

 Readme

 MIT license

 Activity

 Custom properties

 1.3k stars

 21 watching

 197 forks

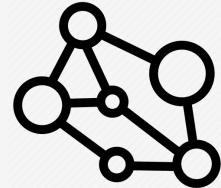
Report repository

Releases 45

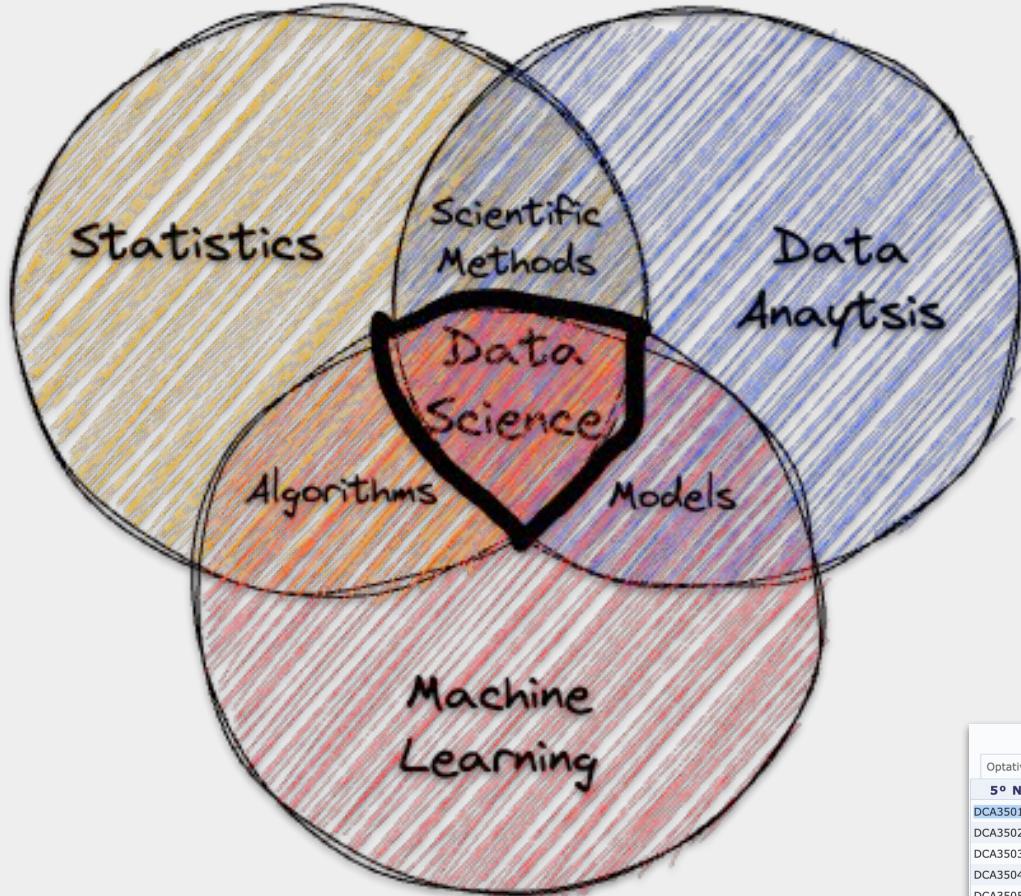
 v2.8.3 Latest
on Jan 19

+ 44 releases

Sponsor this project



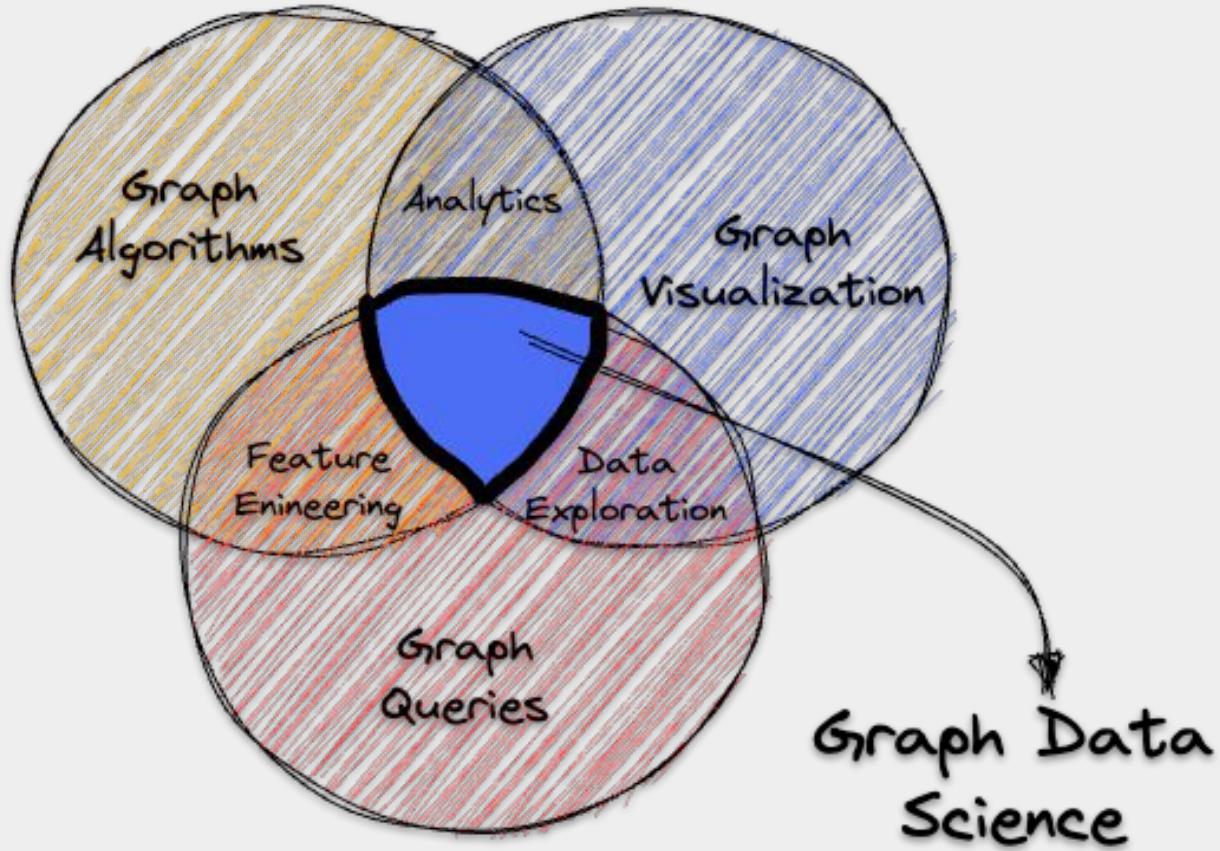
And about graph?
Where and how use them?



Data Science is an interdisciplinary field that uses scientific methods, processes, algorithms and systems to extract knowledge and insights from structured and unstructured data.

Data Scientists use data to answer questions.

| Prazo Para Conclusão (em semestres): Mínimo: 5 Médio: 10 Máximo: 14 | | | | | | | | | | | |
|---|----------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| Optativas | Complementares | 1º Nível | 2º Nível | 3º Nível | 4º Nível | 5º Nível | 6º Nível | 7º Nível | 8º Nível | 9º Nível | 10º Nível |
| 5º NÍVEL | | | | | | | | | | | |
| DCA3501 - CIÊNCIA DE DADOS - 60h | Obrigatória | | | | | | | | | | |
| DCA3502 - SINAIS E SISTEMAS - 60h | Obrigatória | | | | | | | | | | |
| DCA3503 - ALGORITMOS E ESTRUTURAS DE DADOS I - 60h | Obrigatória | | | | | | | | | | |
| DCA3504 - OTIMIZAÇÃO DE SISTEMAS - 60h | Obrigatória | | | | | | | | | | |
| DCA3505 - SISTEMAS OPERACIONAIS - 60h | Obrigatória | | | | | | | | | | |
| DCA3506 - ELETRÔNICA - 75h | Obrigatória | | | | | | | | | | |
| Carga Horária Total: 375h | Obrigatória | | | | | | | | | | |



Graph Data Science is a science-driven approach to gain knowledge from the relationships and structures in data, typically to power predictions.

Data Scientists use relationships to answer questions.



What is a Digital Twin anyway? Deriving the definition for the built environment from over 15,000 scientific publications

Mahmoud Abdelrahman ^a, Edgardo Macatulad ^{a,b}, Binyu Lei ^a, Matias Quintana ^c, Clayton Miller ^d, Filip Biljecki ^{a,e}*,

^a Department of Architecture, National University of Singapore, 4 Architecture Drive, Singapore, 117566, Singapore

^b Department of Geodetic Engineering, University of the Philippines, Diliman, Quezon City, 1101, Philippines

^c Future Cities Lab Global Programme, Singapore-ETH Centre, CREATE campus, #06-01 CREATE Tower, Singapore, 138602, Singapore

^d Department of the Built Environment, National University of Singapore, 4 Architecture Drive, Singapore, 117566, Singapore

^e Department of Real Estate, National University of Singapore, 15 Kent Ridge Dr, Singapore, 119245, Singapore

ARTICLE INFO

ABSTRACT

The concept of Digital Twins (DT) has attained within the built environment. However, consensus remains out of reach. The lack their conceptualization and implementation practitioners.

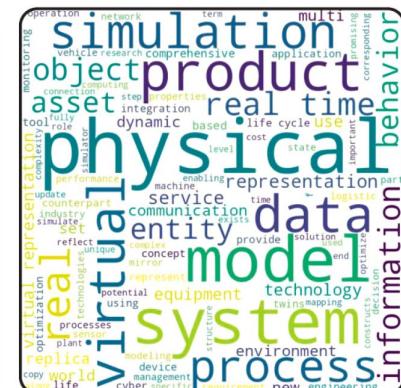
We employed Natural Language Processing (NLP) of DTs from a corpus of more than compares these findings with insights from concurrence on the components that comprise domains, contrasting them with those that define twin definitions over time and across different perspectives. We extracted the main component analysis. Subsequently, we identified components to assess the significance of each component.

Our analysis identified key components based on application domains, such as components reveal two major groups of DTs. Contrary to decision support (LTDs) DTs. Contrary to AI/ML, real-time capabilities, and bi-directional built environment. We derived two definitions. Both definitions have a must-have component such as prediction, AI, and bi-directional components.

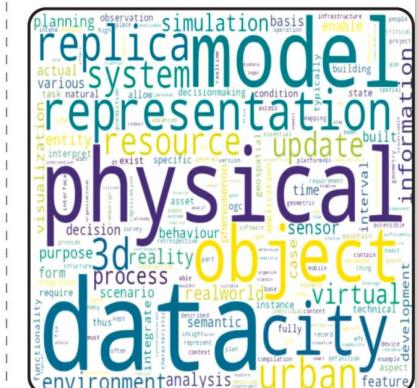
One of the key findings is that the definition highlighting the need for ongoing revision address this, we introduce a novel, reproducible current definitions in response to technol-

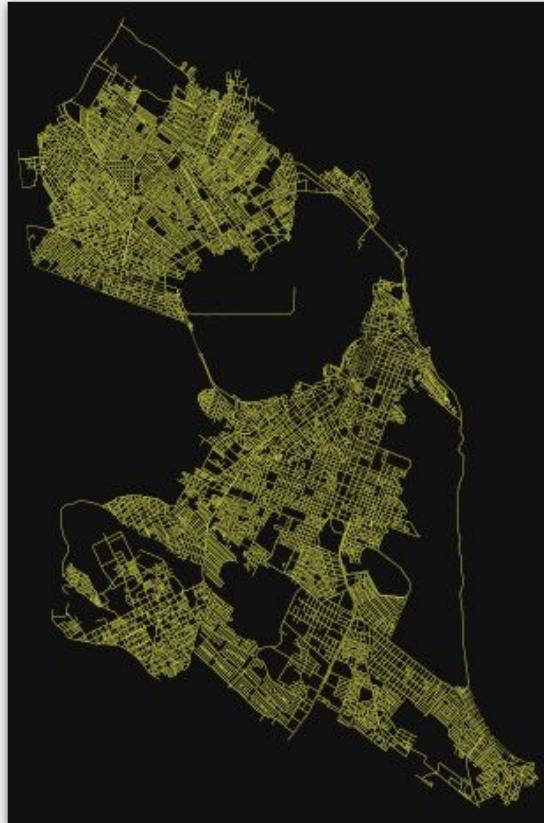
Data Science (DS) vs Graph Data Science (GDS)

Definitions Dataset



Delphi Survey Dataset

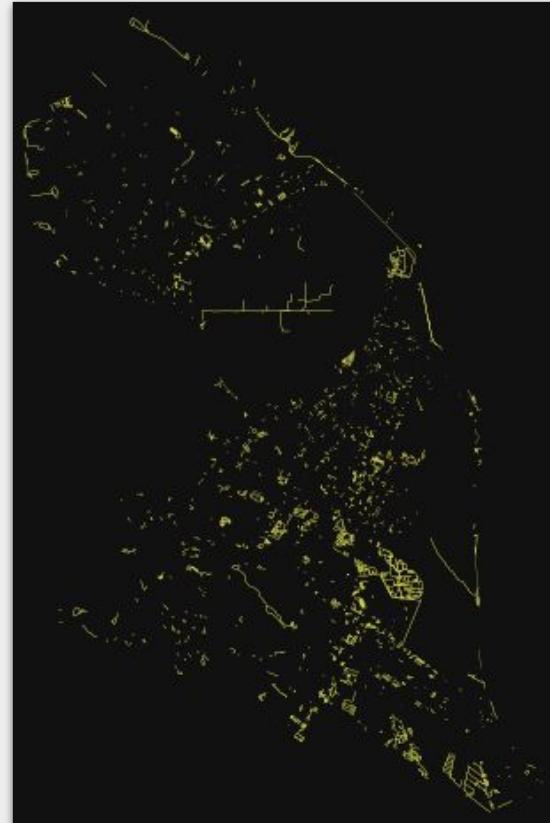




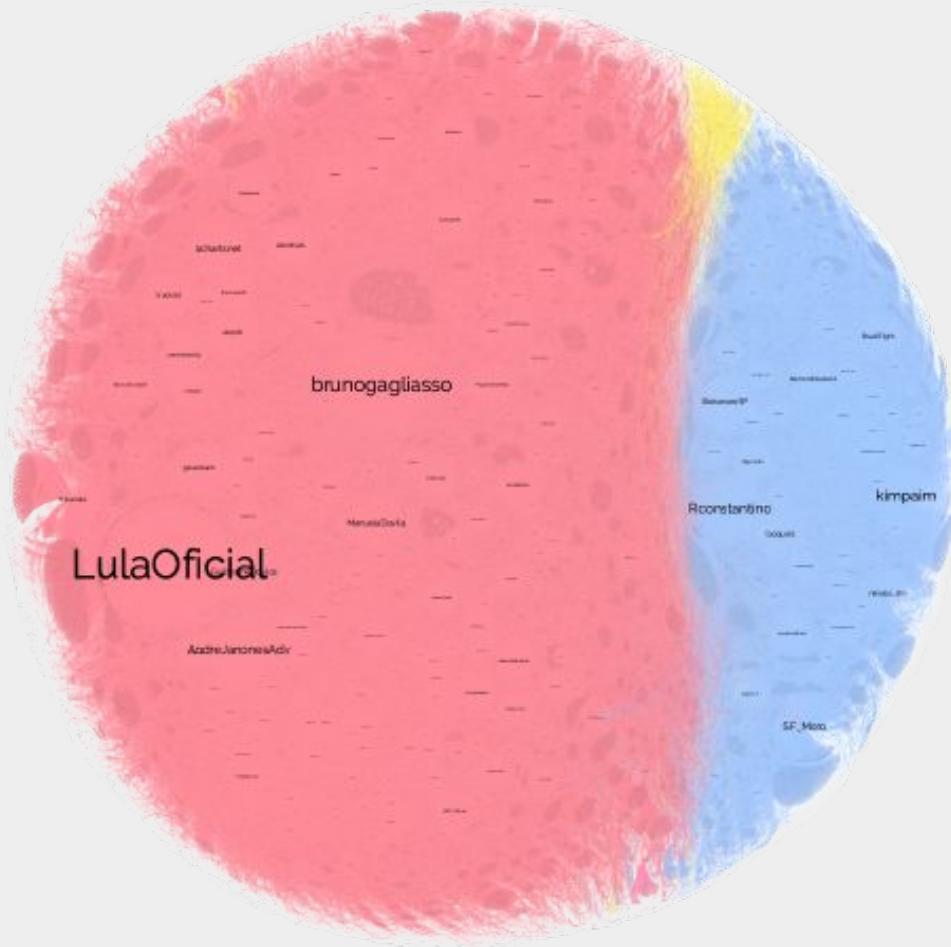
Drive



Bike

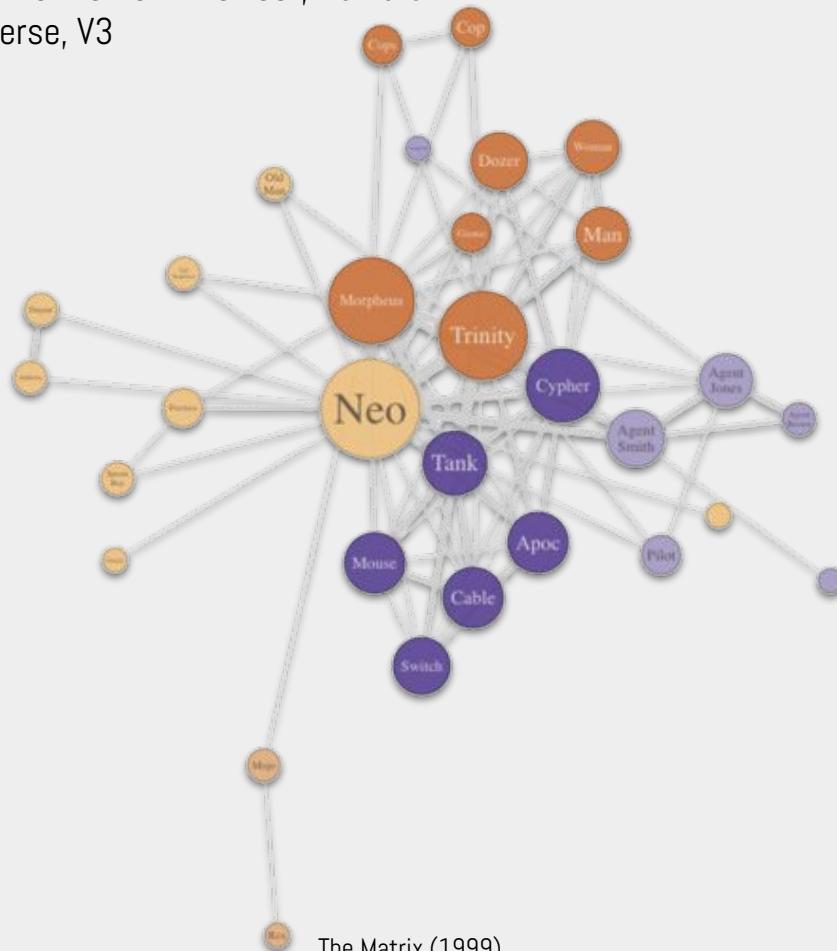


Bike - Drive

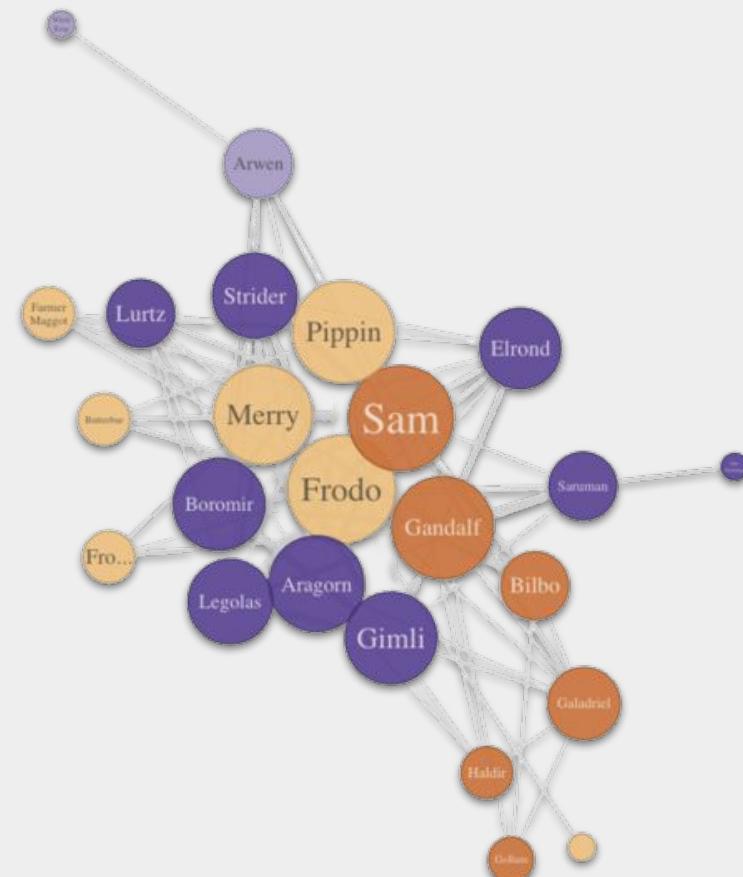


Visualizing Elections Feedback

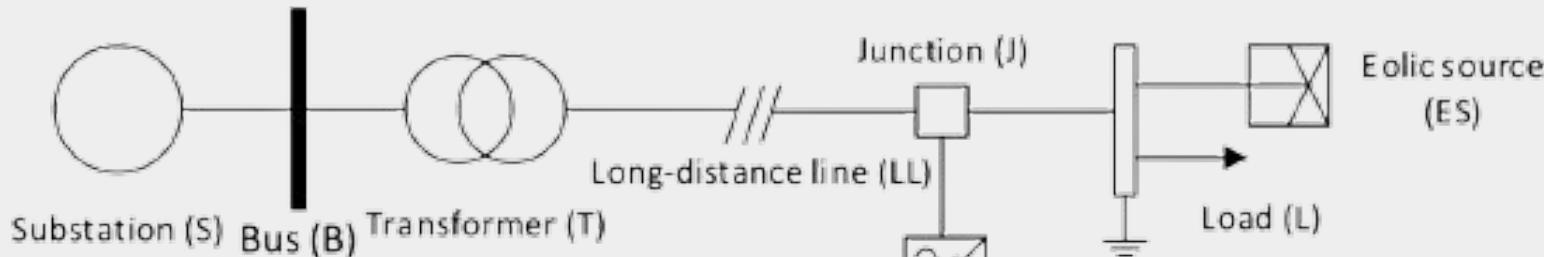
Clustering
Community Detection
Mention network



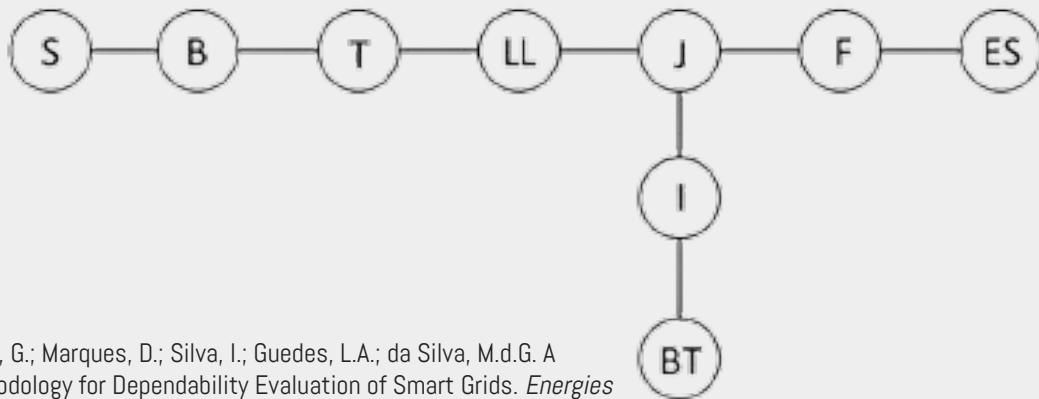
The Matrix (1999)



The Lord of the Rings: The Fellowship of the Ring (2001)

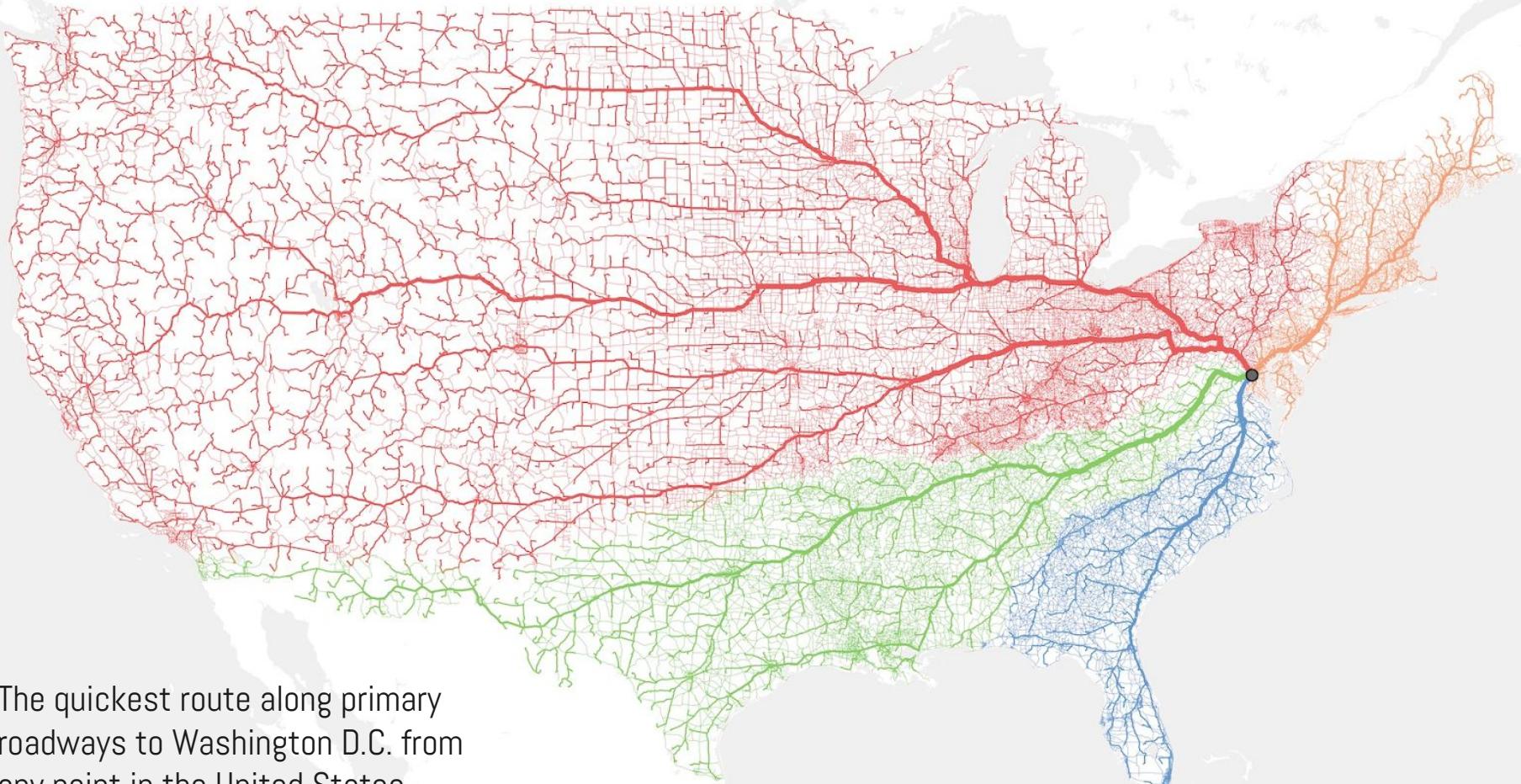


**One-line diagram
to Graph**

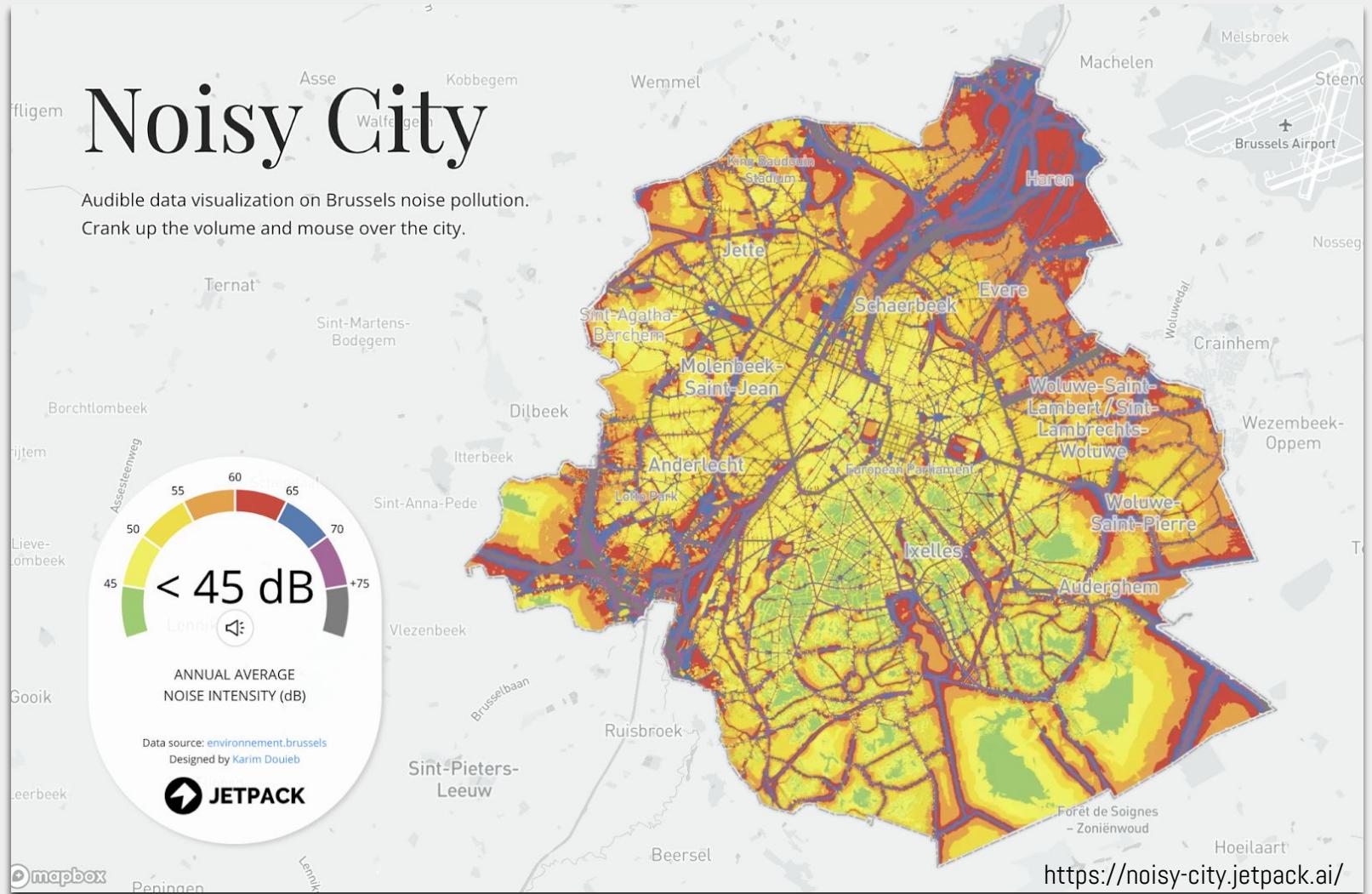
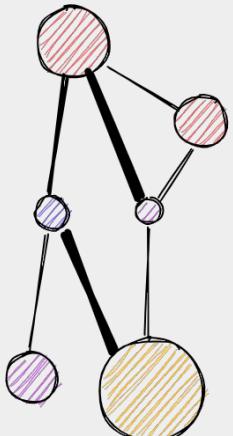


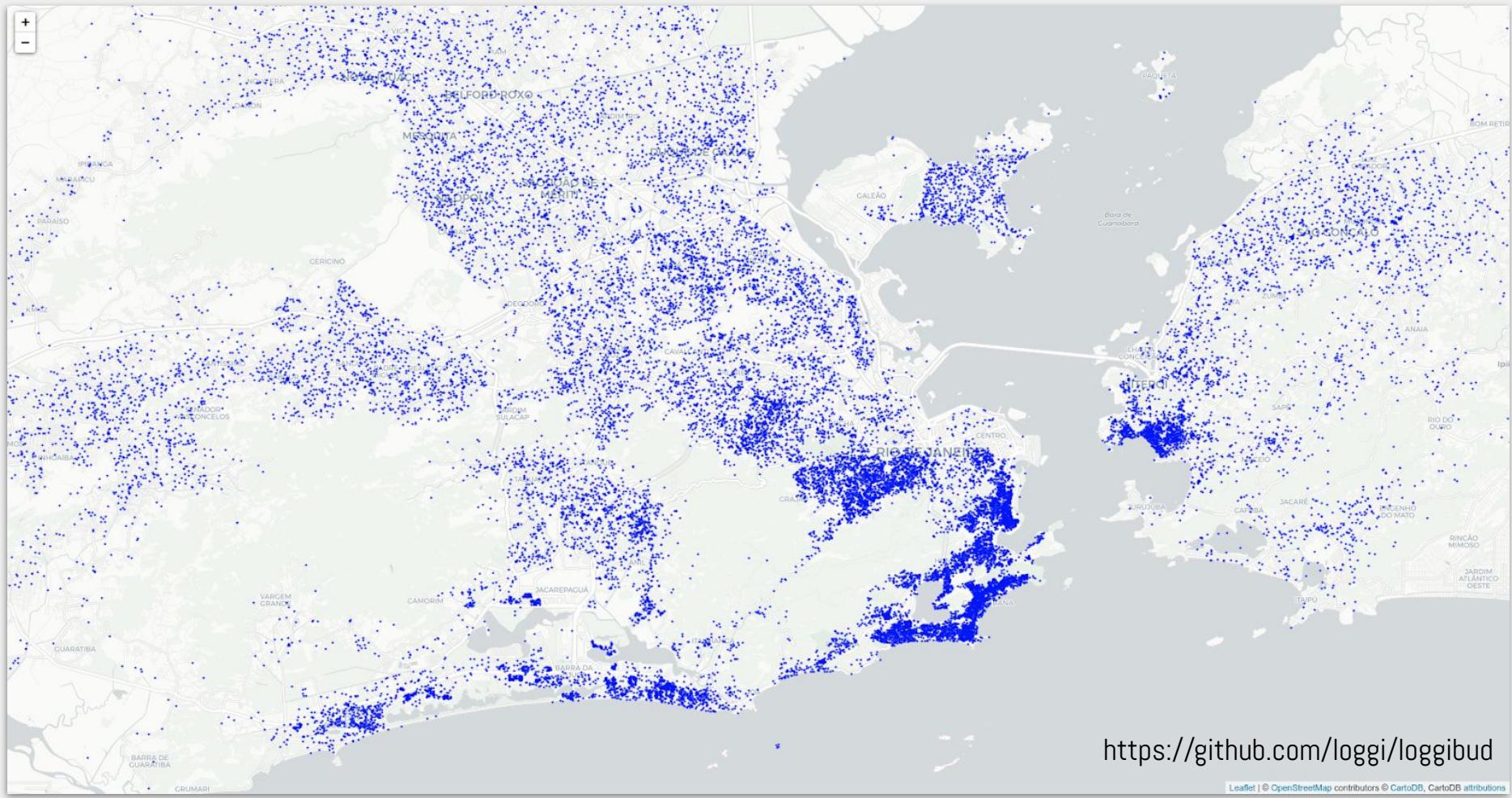
Adjacency Matrix

| | S | B | T | LL | J | I | BT | F | ES |
|----|---|---|---|----|---|---|----|---|----|
| S | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| B | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| T | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| LL | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| J | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| I | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| BT | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| F | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| ES | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

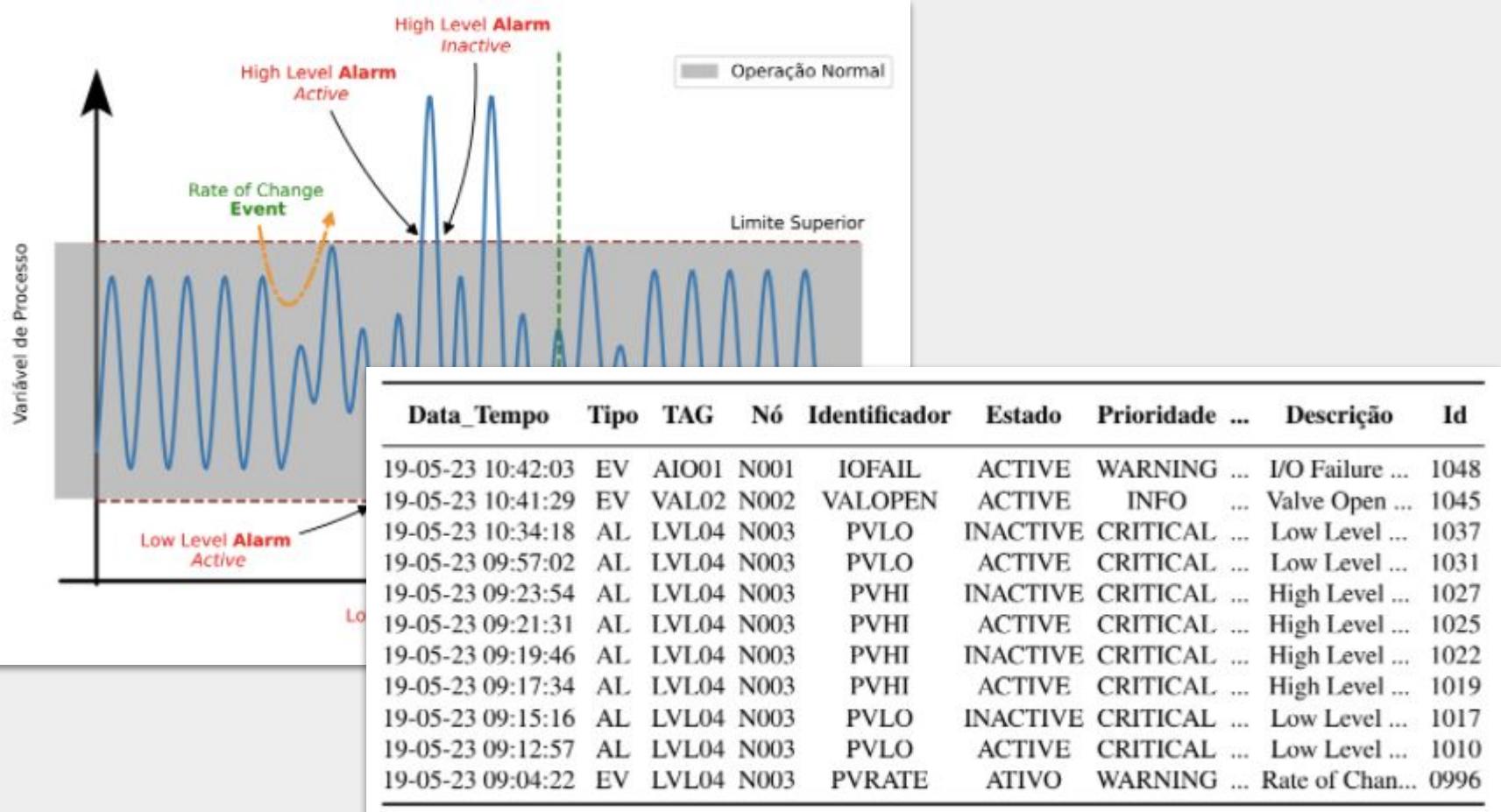


The quickest route along primary
roadways to Washington D.C. from
any point in the United States

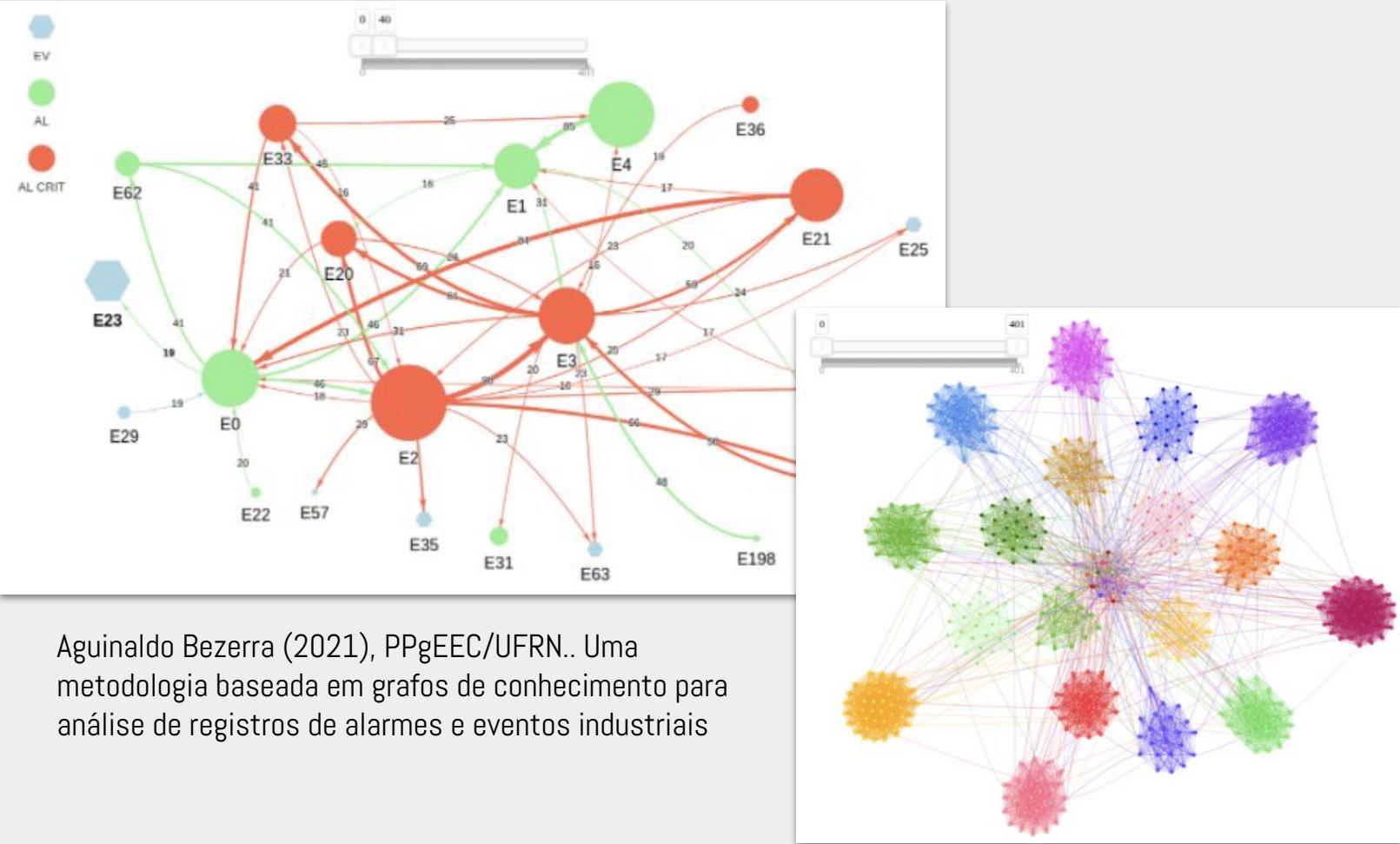




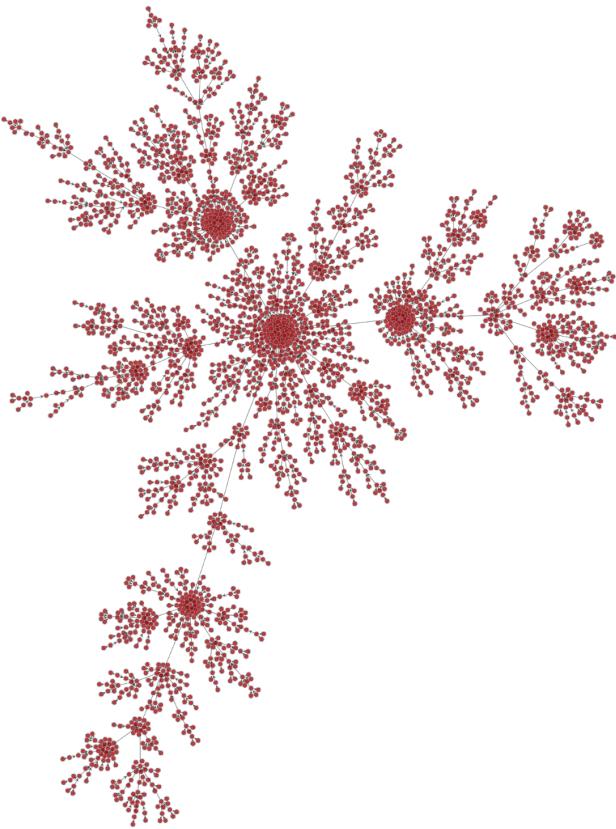
<https://github.com/loggi/loggibud>



Aguinaldo Bezerra (2021), PPgEEC/UFRN. Uma metodologia baseada em grafos de conhecimento para análise de registros de alarmes e eventos industriais

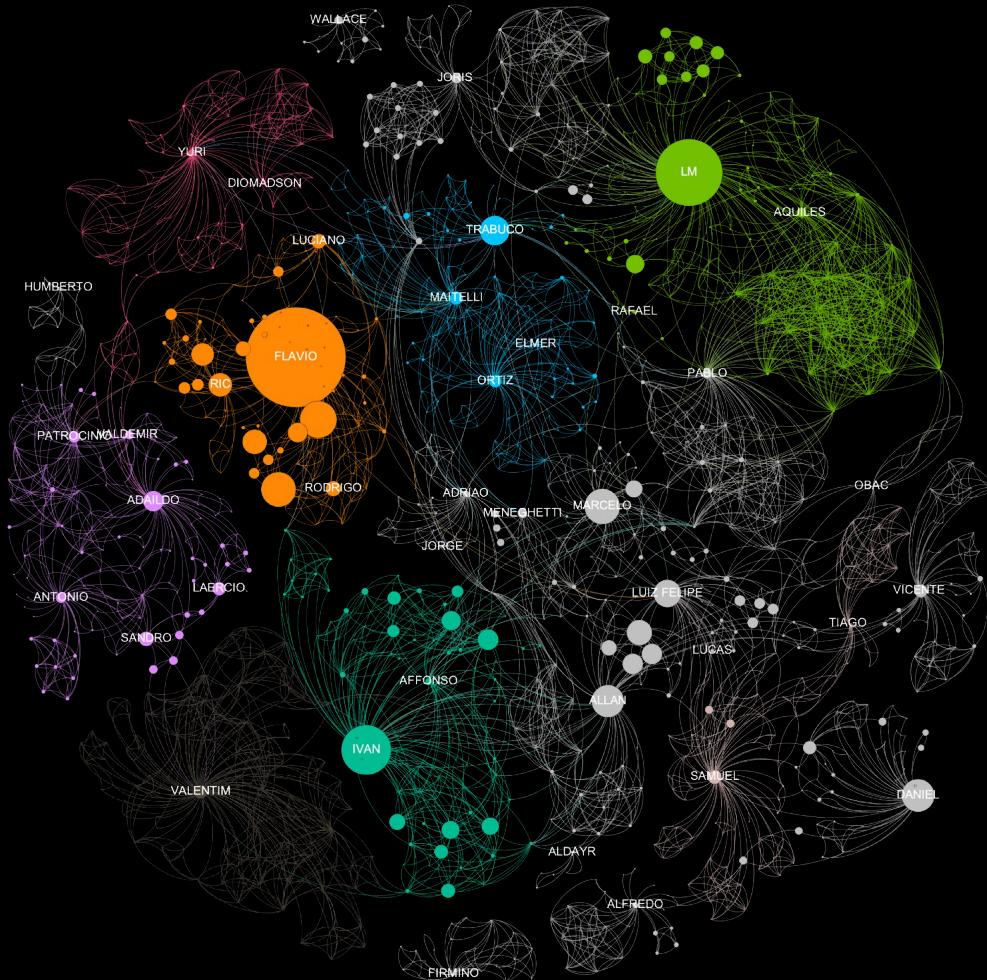


Aguinaldo Bezerra (2021), PPgEEC/UFRN.. Uma metodologia baseada em grafos de conhecimento para análise de registros de alarmes e eventos industriais



Descreva em detalhes todos os ingredientes desse prato.

Este prato parece ser composto por **camarões** empanados com uma crosta crocante, possivelmente feita com **farinha panko**, sementes de **gergelim** ou **quinoa**. Eles são servidos sobre um molho agridoce vermelho-escuro, provavelmente à base de frutas ou mel. Ao centro, há um risoto cremoso, possivelmente preparado com **arroz arbóreo** ou carnaroli, enriquecido com pequenos cubos de legumes como abobrinha e finalizado com lâminas crocantes de amêndoas torradas. A decoração inclui um ramo fresco de **alecrim**. Ao lado, há também um molho adicional avermelhado, que pode ser o mesmo molho que decora o prato. O prato está apresentado sobre folhas decorativas verdes, destacando a apresentação elegante e tropical.



Co-authorship Network PPgEEC 2017-2021

Edsger W. Dijkstra

co-authored 1 paper with

John R. Rice

co-authored 9 papers with

Dan C. Marinescu

co-authored 2 papers with

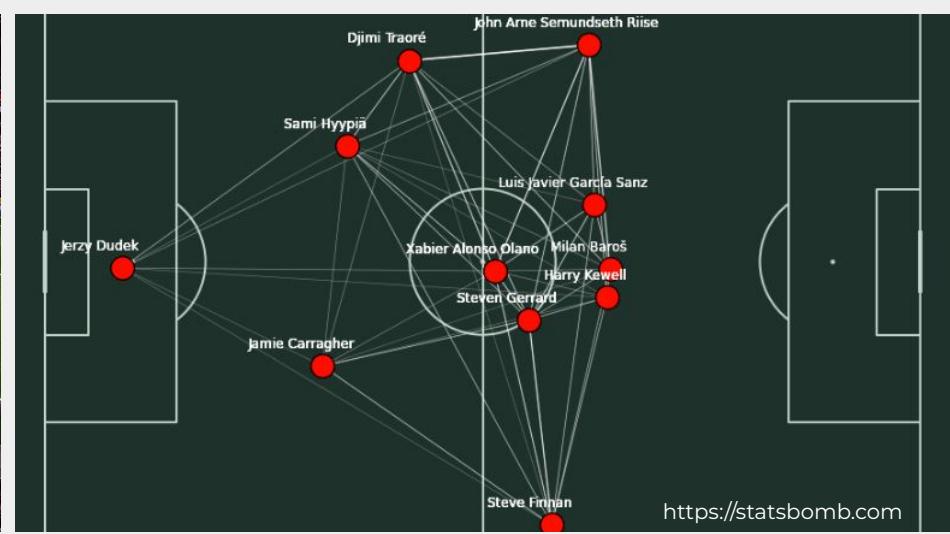
Theo Lynn

co-authored 7 papers with

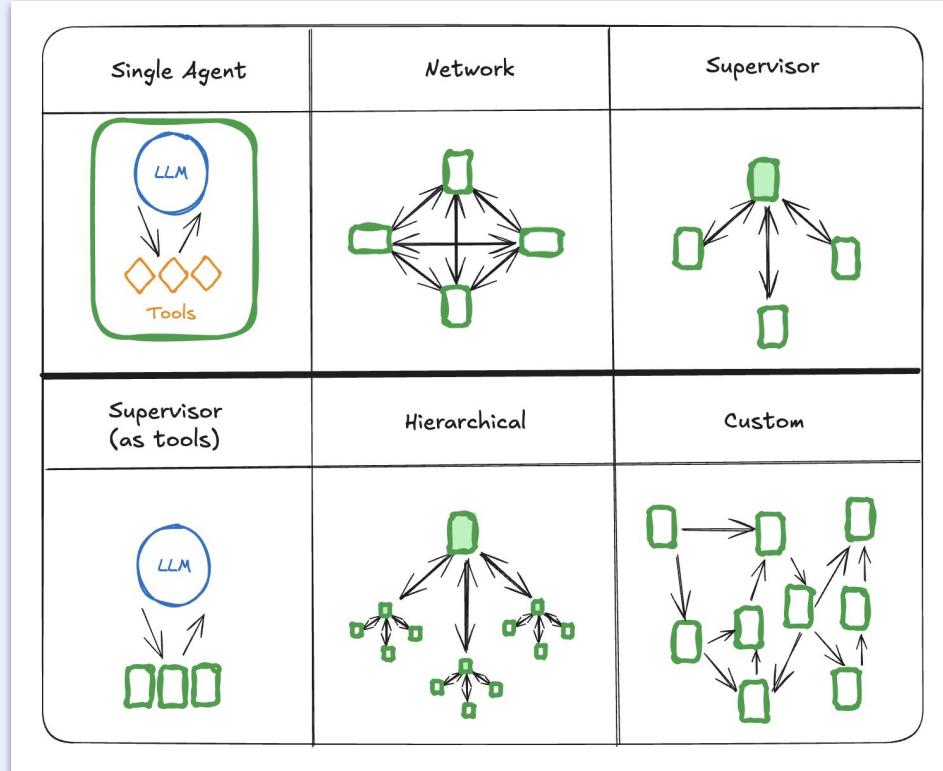
Ivanovitch Silva

distance = 4

<https://www.csauthors.net/distance/edsger-w-dijkstra/ivanovitch-silva>



Multi-Agents Architecture



| Agosto - 2025 | | | | | | |
|---------------|----|----|----|----|----|----|
| D | S | T | Q | Q | S | S |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 29 | 30 | 31 | | | | |

| Setembro - 2025 | | | | | | |
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| Outubro - 2025 | | | | | | |
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| D | S | T | Q | Q | S | S |
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| 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 | 30 | 31 | | | |

| Novembro - 2025 | | | | | | |
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| 23 | 24 | 25 | 26 | 27 | 28 | 29 |
| 30 | | | | | | |

| Dezembro - 2025 | | | | | | |
|-----------------|----|----|----|----|----|----|
| D | S | T | Q | Q | S | S |
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| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 29 | 30 | 31 | | | | |

Week 01

11/08 and 13/08 - Planning

Week 02

18/08 - Course Presentation

20/08 - Network Elements I (Networkx)

Week 03

25/08 - Network Elements II (Networkx)

27/08 - Homophily and Assortativity (Networkx)

Week 04

01/09 - Paths, Distance, and Walks (Networkx)

03/09 - [Project #01] - Description

Week 05

08/09 - [Project #01] doing

10/09 - [Project #01] doing

Week 06

15/09 - [Project #01] doing

17/09 - [Project #01] doing

Week 06

22/09 - [Project #01] Pitch Presentation (10min) + Peer Q&A + Report

24/09 - [Project #01] Pitch Presentation (10min) + Peer Q&A + Report

Unit 01

11/08 to 24/09

| Agosto - 2025 | | | | | | |
|---------------|----|----|----|----|----|----|
| D | S | T | Q | Q | S | S |
| 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 31 | | | | | | |

| Setembro - 2025 | | | | | | |
|-----------------|----|----|----|----|----|----|
| D | S | T | Q | Q | S | S |
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| 14 | 15 | 16 | 17 | 18 | 19 | 20 |
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| Outubro - 2025 | | | | | | |
|----------------|----|----|----|----|----|----|
| D | S | T | Q | Q | S | S |
| | 1 | 2 | 3 | 4 | | |
| 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 2 | 13 | 14 | 15 | 16 | 17 | 18 |
| 9 | 20 | 21 | 22 | 23 | 24 | 25 |
| 6 | 27 | 28 | 29 | 30 | 31 | |

| Novembro - 2025 | | | | | | |
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| Dezembro - 2025 | | | | | | |
|-----------------|----|----|----|----|----|----|
| D | S | T | Q | Q | S | S |
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| 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 | 30 | 31 | | | |

Week 08

29/09 - Shortest path algorithm (Dijkstra)

01/10 - Shortest path algorithm (Dijkstra + Min-Heap)

Unit 02

29/09 to 05/11

Week 09

06/10 - Shortest path algorithm (Bellman-Ford)

08/10 - Shortest path algorithm (A*)

Week 10

13/10 - Minimum spanning tree (Kruskal)

15/10 - Minimum spanning tree (Prim)

Week 11

20/10 - [Project #02] - Description

22/10 - [Project #02] - Doing

Week 12

27/10 - **no class**

29/10 - [Project #02] doing

Week 13

03/11 - [Project #02] Pitch Presentation (10min) + Peer Q&A + Report

05/11 - [Project #02] Pitch Presentation (10min) + Peer Q&A + Report

| Agosto - 2025 | | | | | | |
|---------------|----|----|----|----|----|----|
| D | S | T | Q | Q | S | S |
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| 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
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| Setembro - 2025 | | | | | | |
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| D | S | T | Q | Q | S | S |
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| 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 | 30 | | | | |

| Outubro - 2025 | | | | | | |
|----------------|----|----|----|----|----|----|
| D | S | T | Q | Q | S | S |
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| 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 26 | 27 | 28 | 29 | 30 | 31 | |

| Novembro - 2025 | | | | | | |
|-----------------|----|----|----|----|----|----|
| D | S | T | Q | Q | S | S |
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| 2 | 3 | 4 | 5 | 6 | 7 | 8 |
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| 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| 23 | 24 | 25 | 26 | 27 | 28 | 29 |
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| Dezembro - 2025 | | | | | | |
|-----------------|----|----|----|----|----|----|
| D | S | T | Q | Q | S | S |
| 1 | 2 | 3 | 4 | 5 | 6 | |
| 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 | 30 | 31 | | | |

Week 14

10/11 - Key Centrality Metrics

12/11 - Core Decomposition

Unit 03

Week 15

17/11 - Case study (wikipedia) + Advanced Visualization (Gephi)

19/11 - NLP and Network

10/11 to 17/12

Week 16

24/11 - [Project #03] Description

26/11 - [Project #03] Doing

Week 17

01/12 - [Project #03] Follow-up

03/12 - [Project #03] Doing

Week 18

08/12 - [Project #03] Pitch Presentation (10min) + Peer Q&A + Report

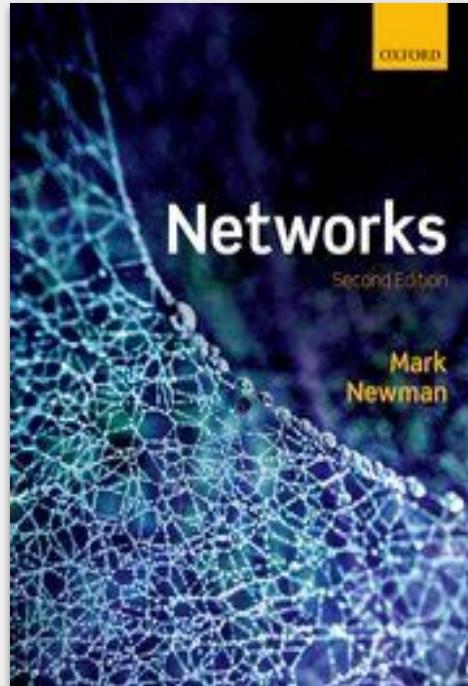
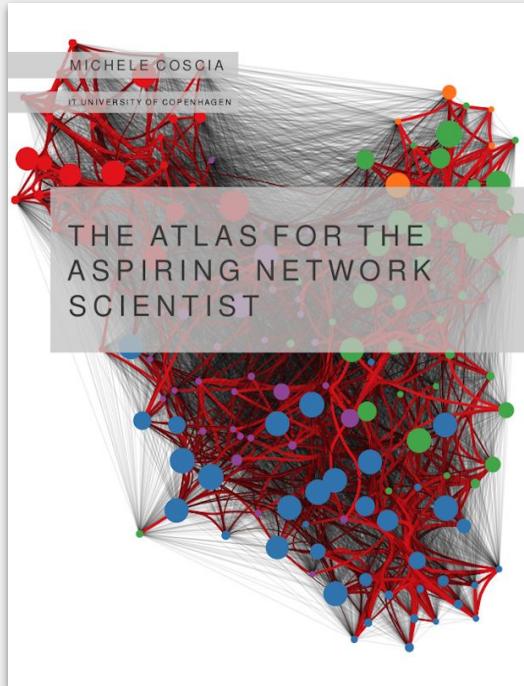
10/12 - [Project #03] Pitch Presentation (10min) + Peer Q&A + Report

Week 19

15/12 - no class

17/12 - Final exam

References



Clone me!!!!

<https://github.com/ivanovitchm/datastructure>