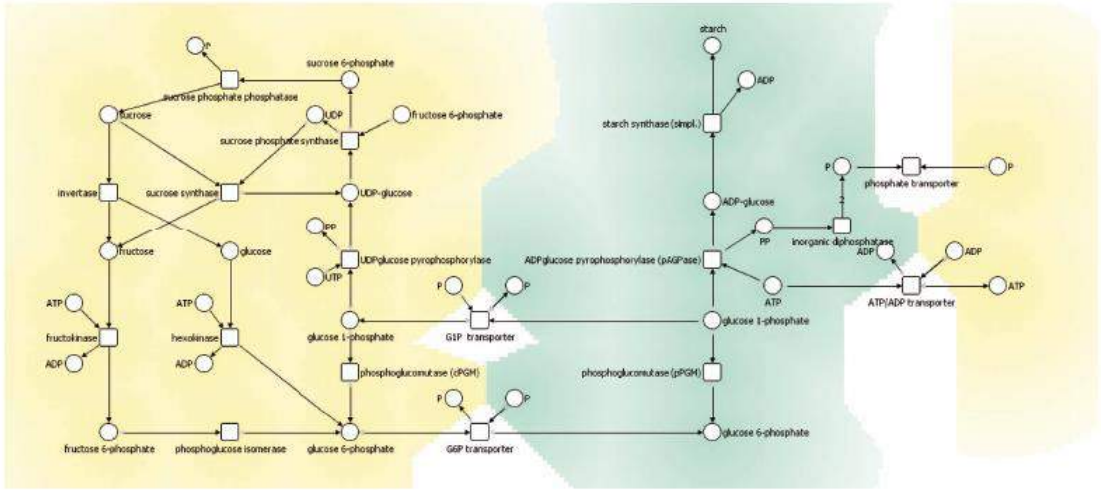
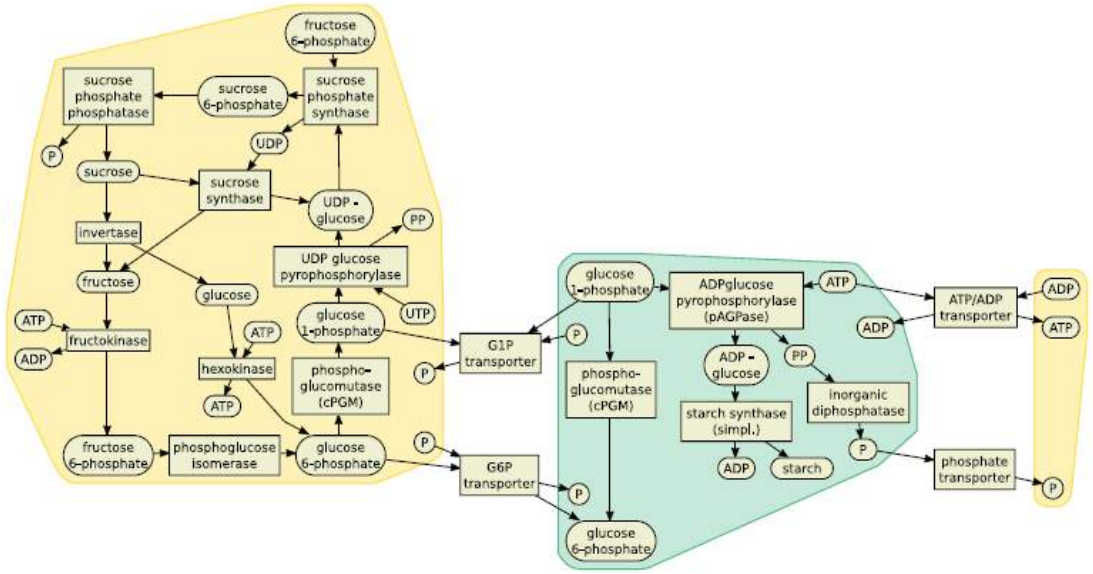



Hand drawn diagram




Constrained stress-majorization layout

# Part 1: Network Visualisation

Tim Dwyer
tim.dwyer@monash.edu
ialab.it.monash.edu/~dwyer/
Monash University, Australia
October 2019

MONASH University

# Panama Papers The Power Players

**King Salman bin Abdulaziz bin Abdulrahman Al Saud**
King of Saudi Arabia (2015-present); Crown Prince (2012-2015)

**Related countries**
Saudi Arabia

**Salman bin Abdulaziz bin Abdulrahman Al Saud became King of Saudi Arabia in January 2015, assuming the throne after the death of his brother King Abdullah. He previously served as defense minister and deputy prime minister and was the governor of Riyadh, the country's capital, from 1955 to 1960 and again from 1963 to 2011. He was named as heir to the throne in 2012.**

Embed

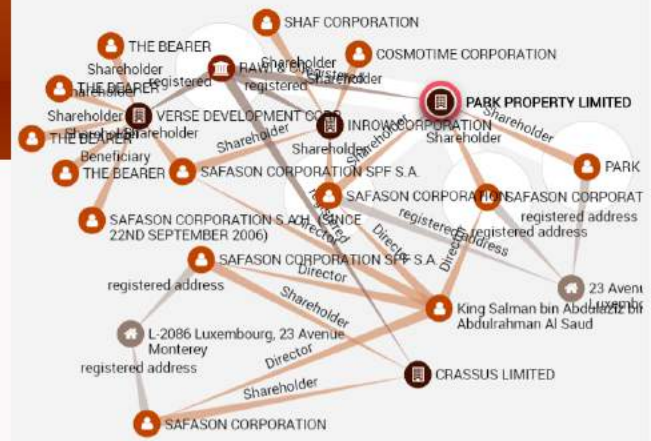
**Inside the Mossack Fonseca data »** British Virgin Island company used for mortgages on luxury homes in London and to hold yacht Read more...

Offshore glossary

Response

*King Salman did not respond to repeated requests made through the Saudi Embassy in the United States for comment.*

Explore the data: **King Salman bin Abdulaziz bin Abdulrahman Al Saud**




Category: Company, Officer, Address, Client
Category: Officer, Address, Company, Client
Type: Is officer of, Registered addr..., Registered

Linkurious

# Panama Papers The Power Players

**Malcolm Turnbull**
Prime Minister of Australia (2015 - present)

**Related countries**
Australia

**Malcolm Bligh Turnbull, a former journalist who made a fortune as a lawyer and merchant banker, entered politics in 2004. Before becoming Prime Minister in September 2015, Turnbull held several ministerial positions and led Australia's opposition party between September 2008 and December 2009.**

Embed

**Inside the Mossack Fonseca data »** Director of an offshore firm with interests in a company that planned to operate a mine in Russia

Turnbull was listed as a director of Star Technology Systems Limited, a British Virgin Islands company, in December 1993. The company, set up by Mossack Fonseca, was a subsidiary of Star Mining Corporation NL, an Australian-listed company of which Turnbull was a board member. Star Mining had planned to develop a Siberian gold mine as part of a joint venture, which later collapsed. Turnbull resigned as director of the BVI company in September 1995. One former director of Star Mining alleged that another director, now deceased, had paid Russian officials millions of dollars in bribes to secure Star Mining's mining rights.

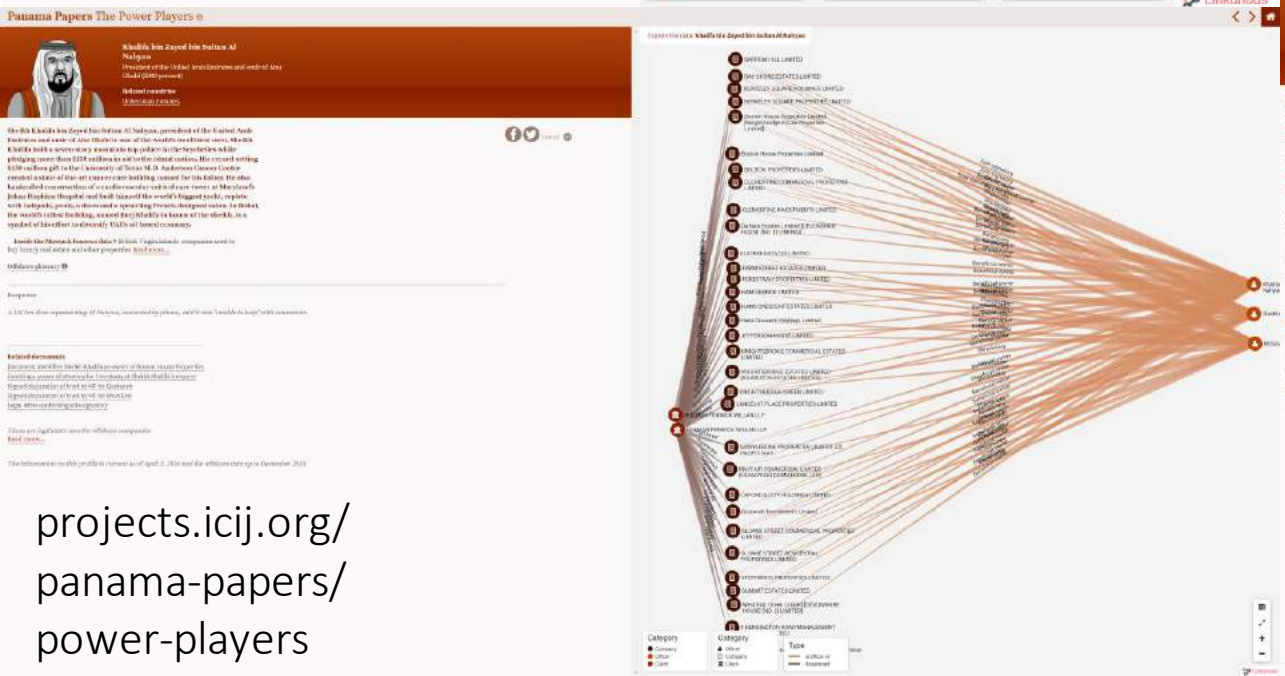
Offshore glossary

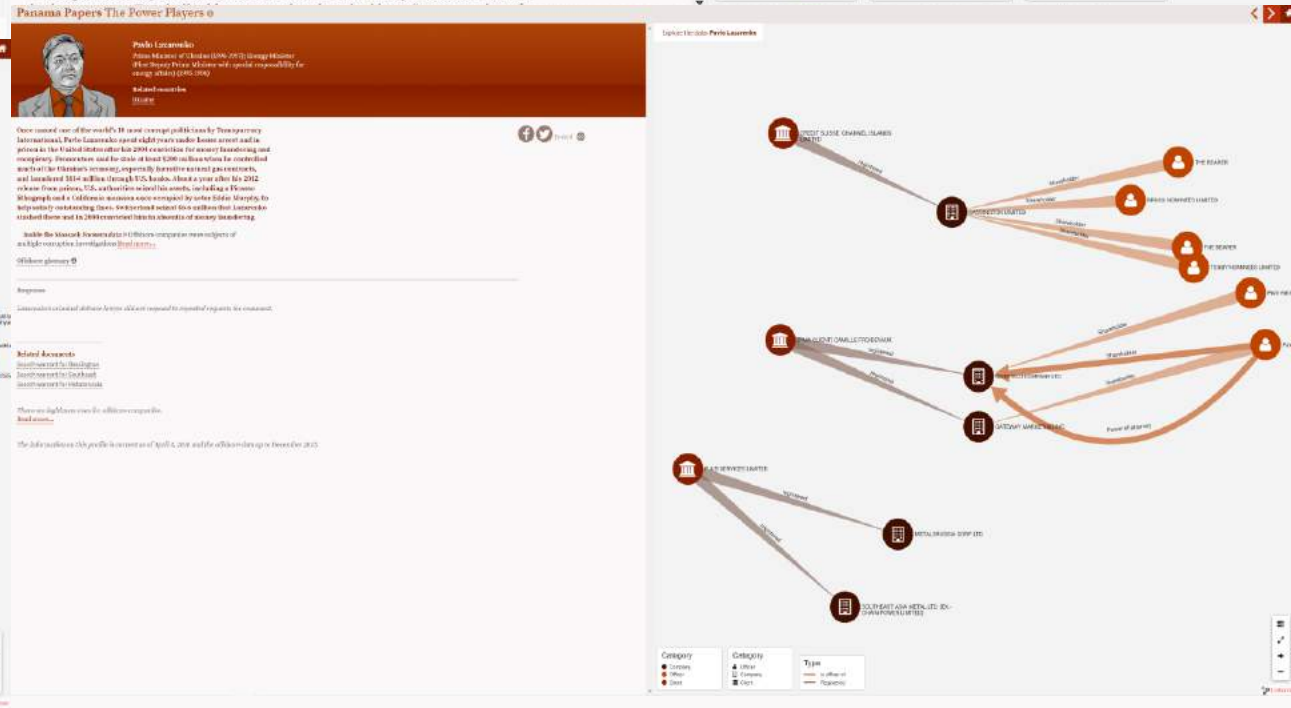
Response

*When questioned by the Australian Financial Review in May 2016 about his role*

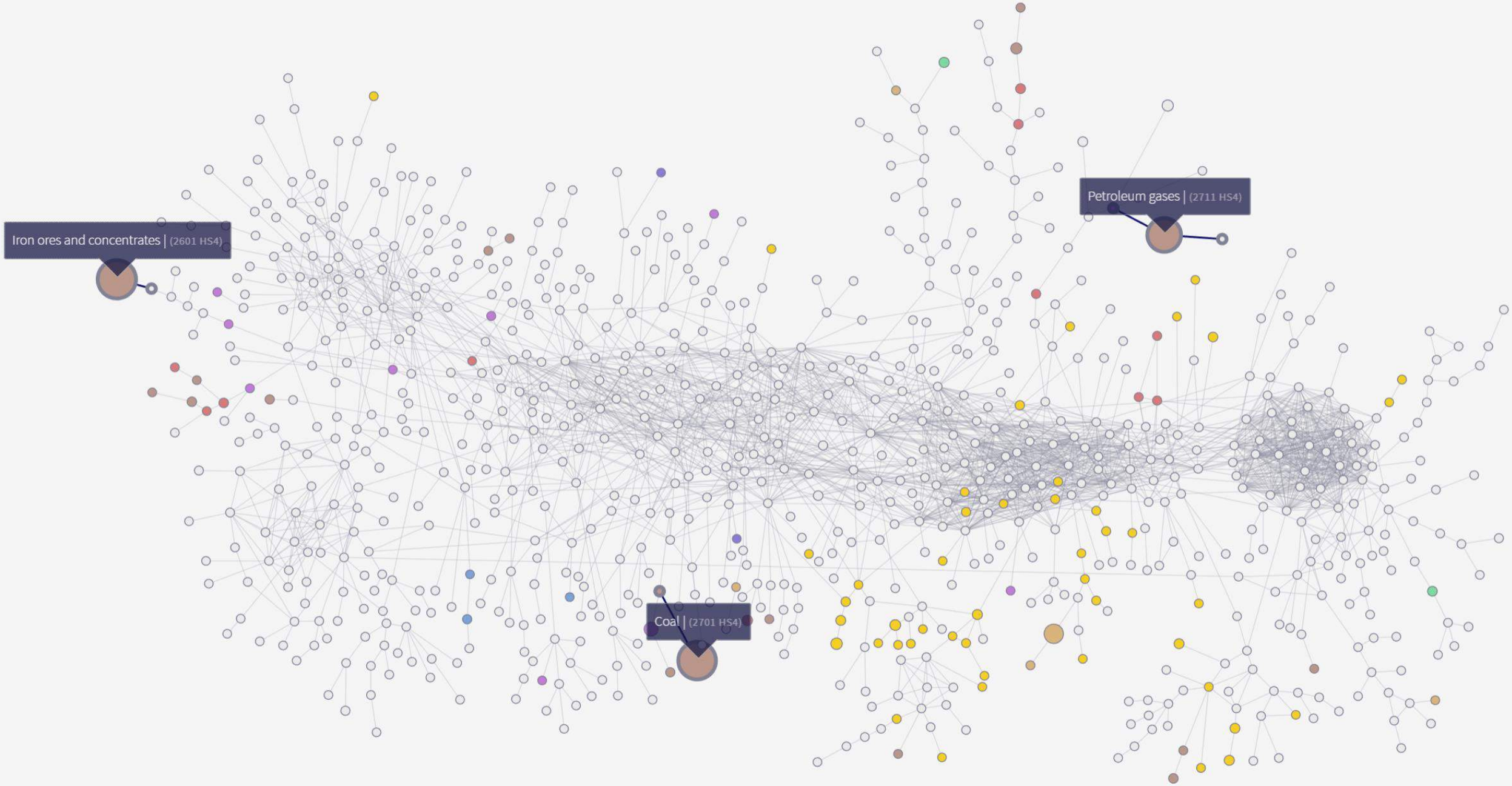
Explore the data: **Malcolm Turnbull**


Category: Company, Client
Category: Company, Client
Type: Registered

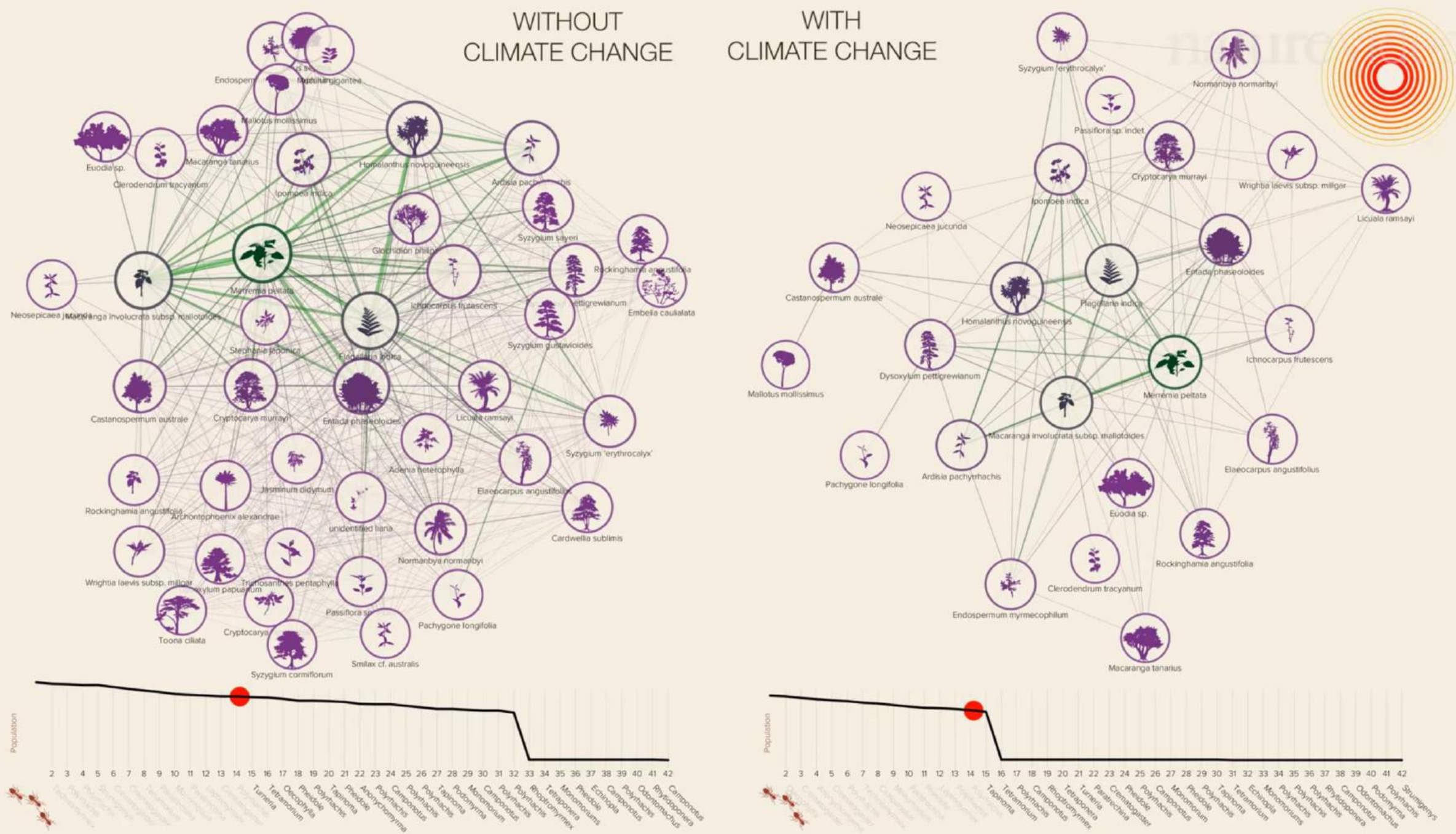




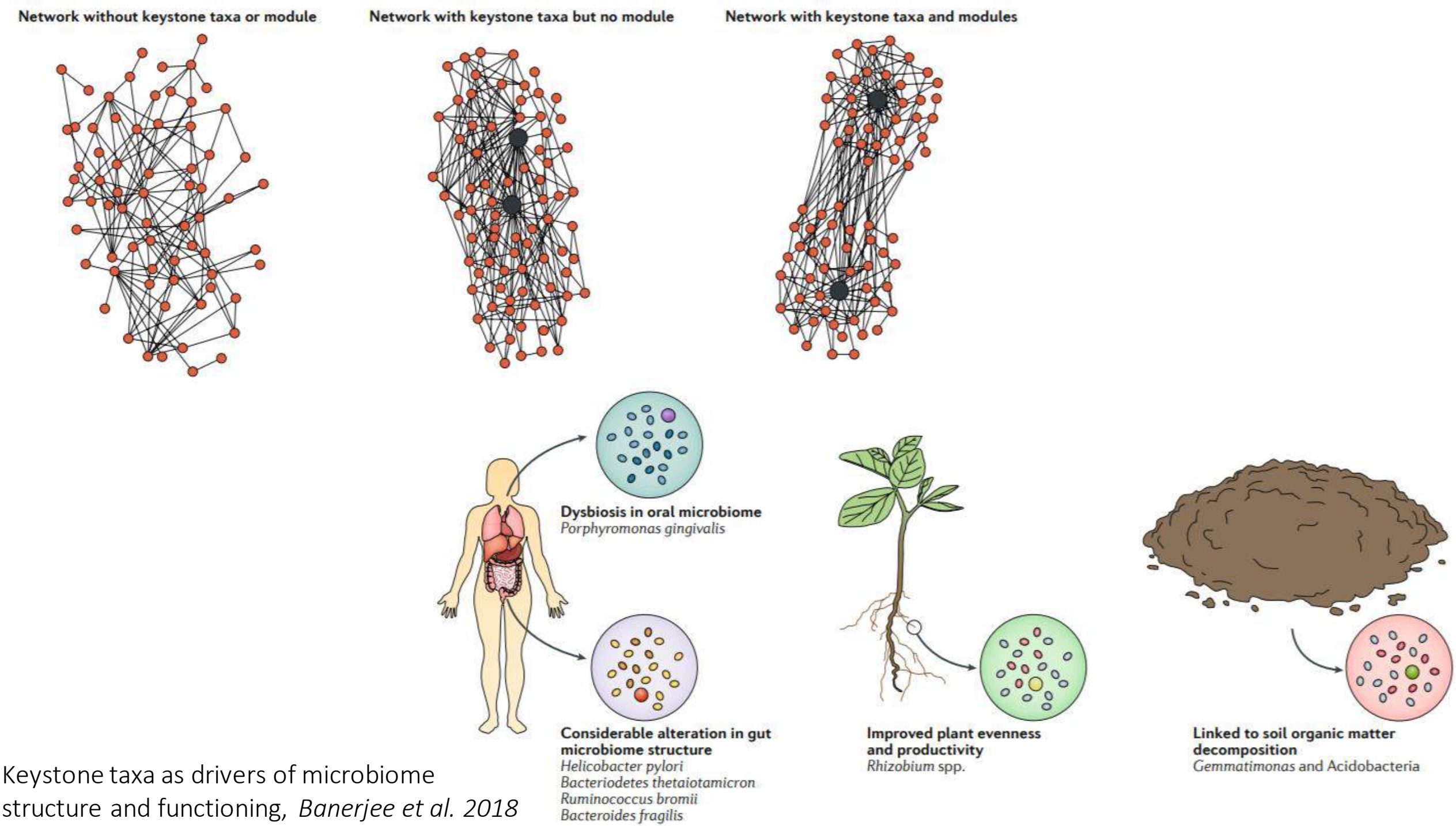
projects.icij.org/
panama-papers/
power-players




Atlas of economic complexity




Network Earth




Keystone taxa as drivers of microbiome structure and functioning, *Banerjee et al. 2018*

# Credits

Bongshin Lee
Microsoft Research

Vahan Yoghourdjian
General Assembly

Chunlei Chang

Karsten Klein
Uni Konstanz

Steve Kieffer

Yehuda Koren
Google

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Simon Fraser Uni

Michael Wybrow

George Robertson
Microsoft Research

Kun-Ting Chen

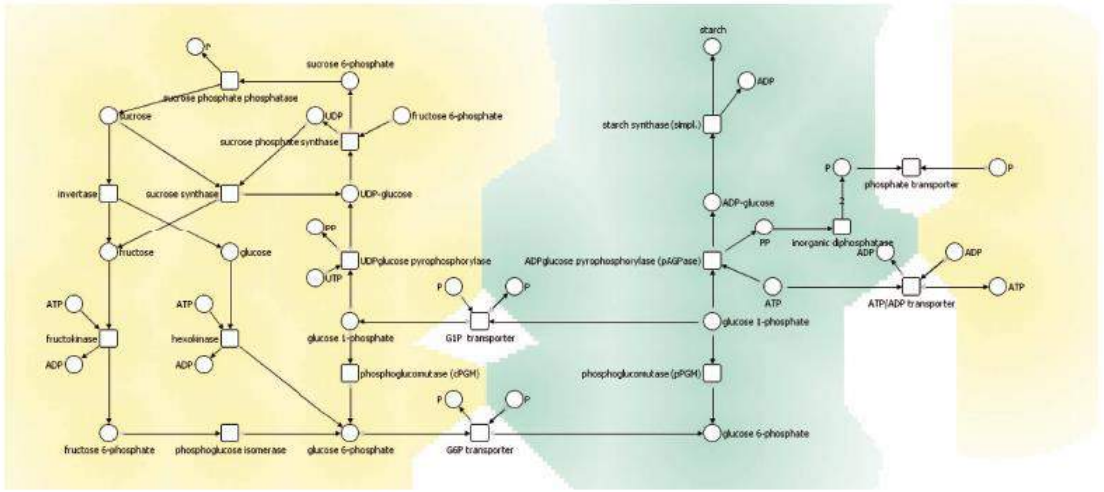
Graeme Gange

Peter Stuckey

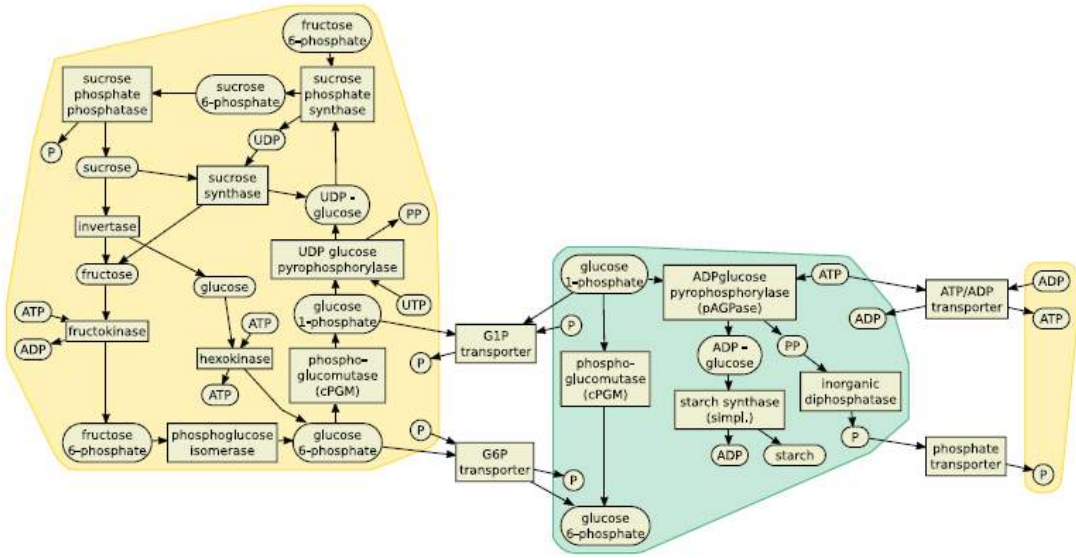
Kim Marriott

Yalong Yang, Harvard

Tim Dwyer, Yehuda Koren, and Kim Marriott.
"IPSep-CoLa: An incremental procedure for separation constraint layout of graphs."
*IEEE Transactions on Visualization and Computer Graphics* 12.5 (2006): 821-828.




Hand drawn diagram

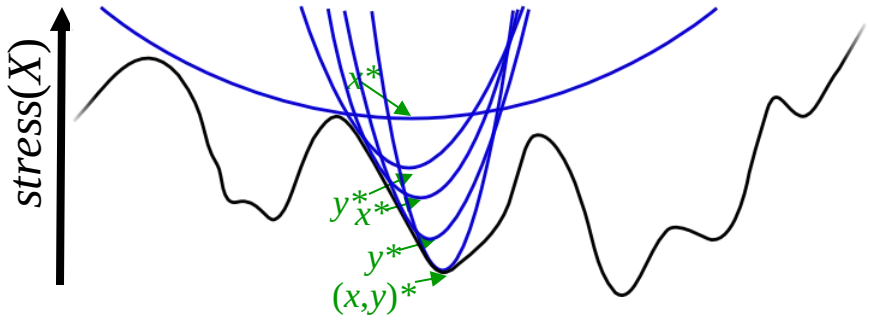


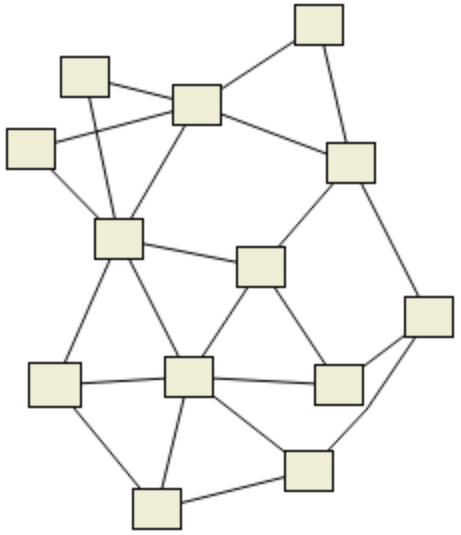

Constrained stress-majorization layout

# Stress majorization

$$\mathbf{stress}(x, y) = \sum_{i<j} w_{ij} \left( \|(x_i, y_i) - (x_j, y_j)\| - d_{ij} \right)^2$$

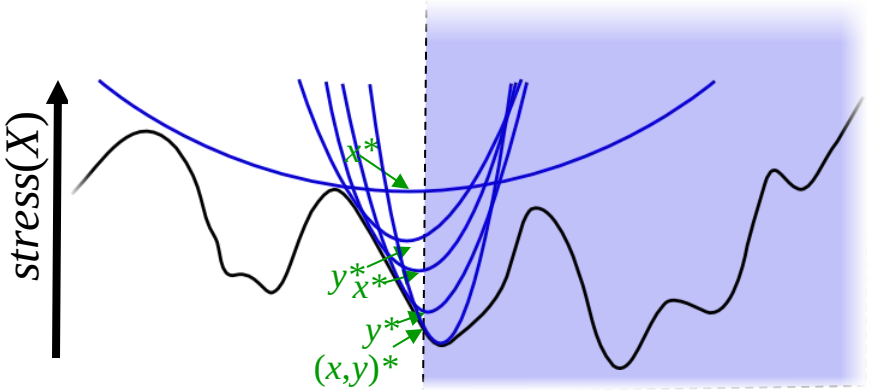
$$f(x) = \frac{1}{2} x' Q x + b'_{x,y} x \qquad f(y) = \frac{1}{2} y' Q y + b'_{y,x} y$$



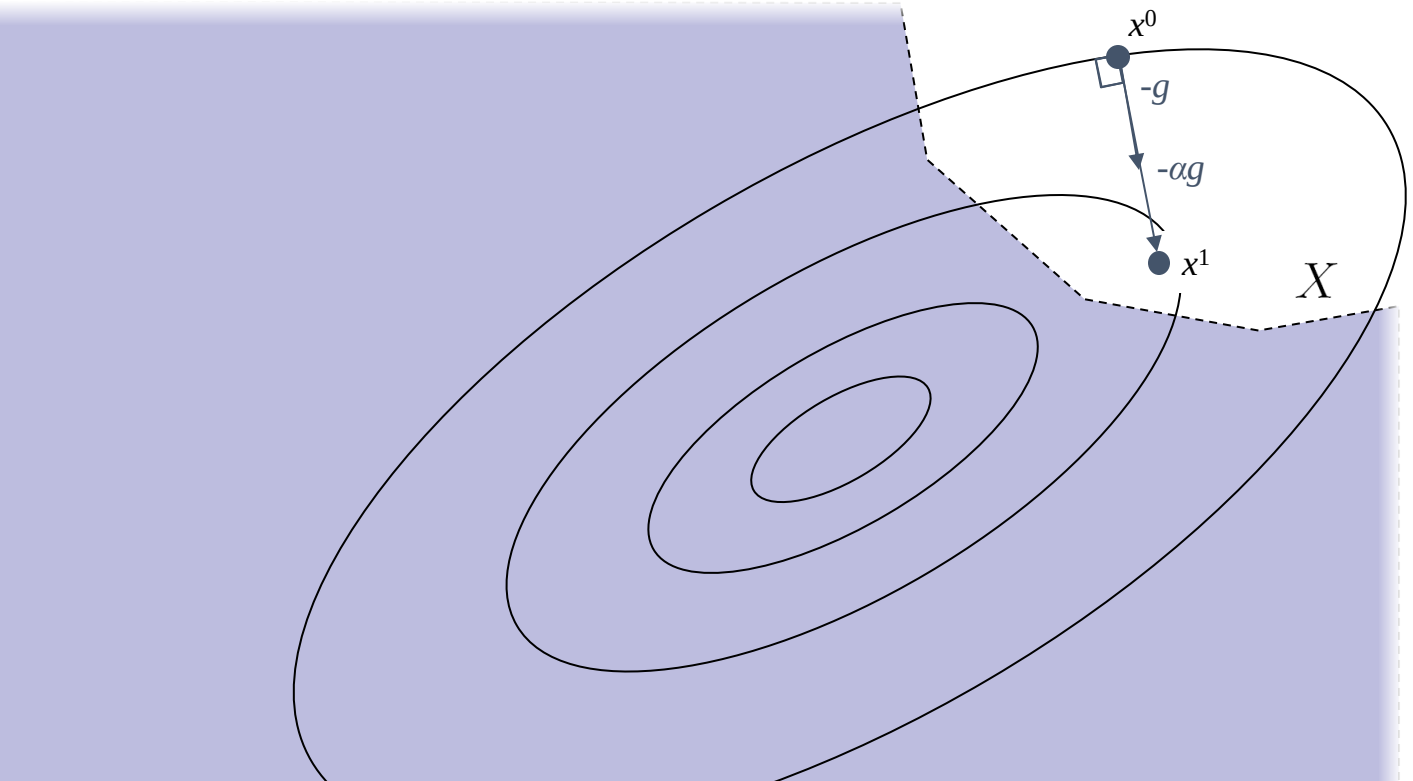
# Constrained stress majorization

- Instead of solving unconstrained quadratic forms we solve subject to separation constraints
- i.e. Quadratic Programming



# Gradient projection

$$\begin{aligned}&\text{minimize } \tfrac{1}{2}x'Qx + b'x\\&\text{subj. to: } x \in X\end{aligned}$$

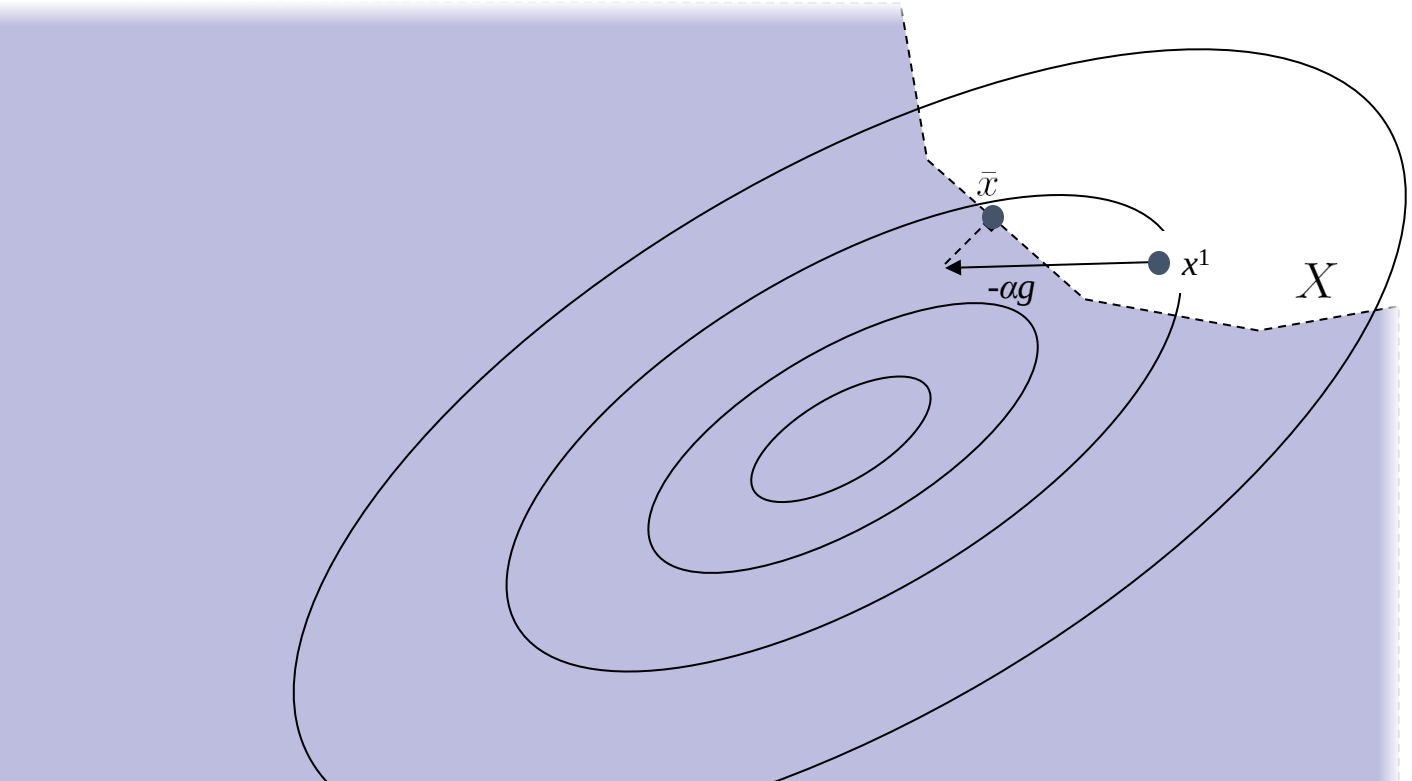


# Gradient projection

minimize $\frac{1}{2}x'Qx + b'x$
subj. to: $x \in X$

$$\nabla f(x^k) = g = Qx^k + b$$

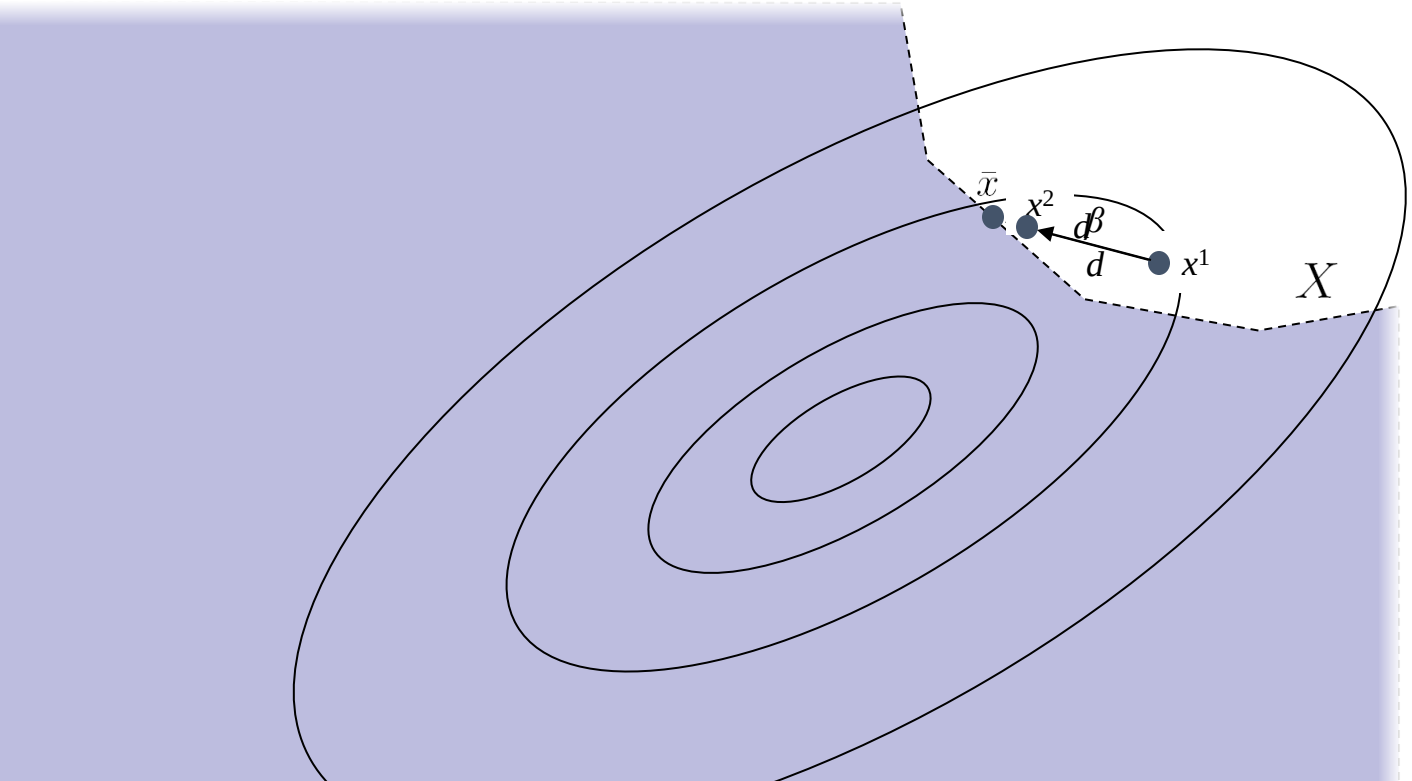
$$\alpha = \frac{g'g}{g'Qg}$$



# Gradient projection

$$\text{minimize } \tfrac{1}{2}x'Qx + b'x$$
$$\text{subj. to: } x \in X$$

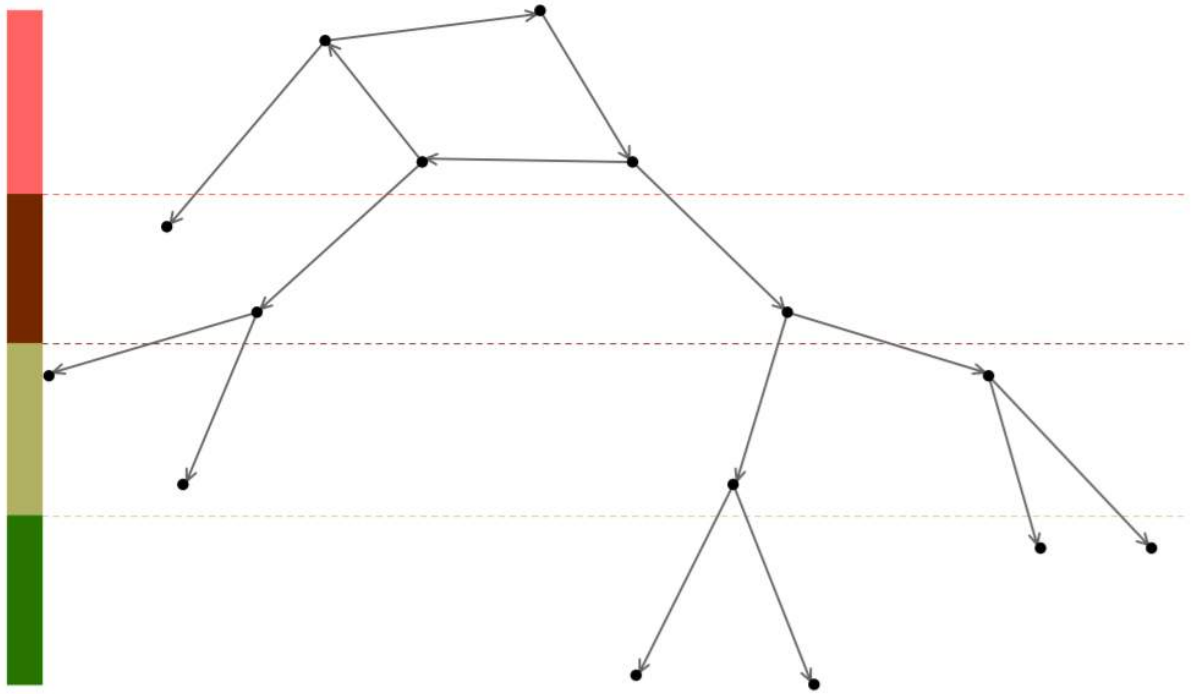
$$\begin{aligned}
\nabla f(x^k) = g &= Qx^k + b \\
\alpha &= \frac{g'g}{g'Qg} \\
\bar{x} &= \mathbf{project}(x^k - \alpha g) \\
d &= x^k - \bar{x}
\end{aligned}$$

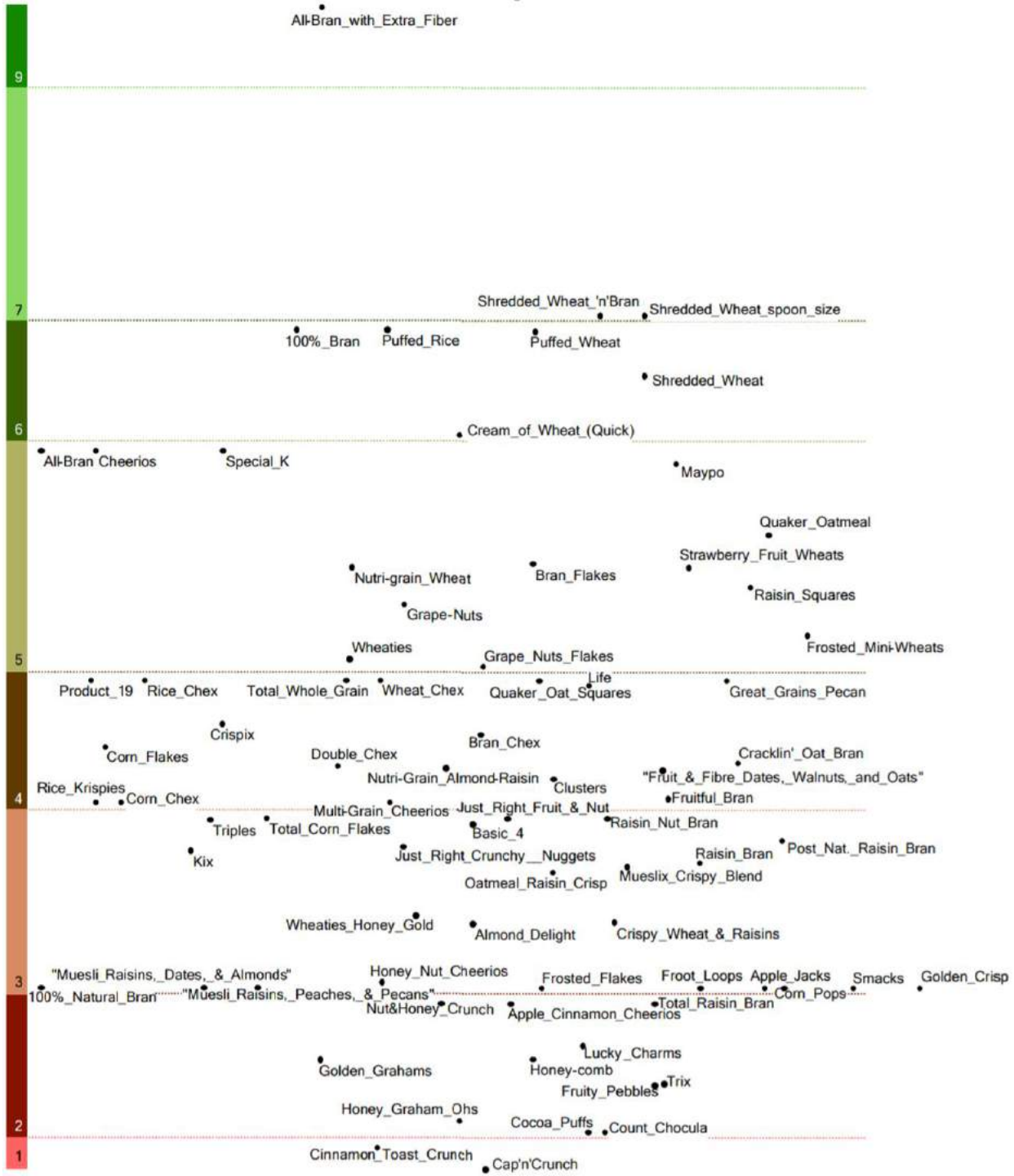


# Gradient projection

$$\text{minimize } \tfrac{1}{2}x'Qx + b'x$$
$$\text{subj. to: } x \in X$$


$$\begin{aligned}
\nabla f(x^k) = g &= Qx^k + b \\
\alpha &= \frac{g'g}{g'Qg} \\
\bar{x} &= \mathbf{project}(x^k - \alpha g) \\
d &= x^k - \bar{x} \\
\beta &= \min\left(\frac{g'd}{g'Qg}, 1\right) \\
x^{k+1} &= x^k + \beta d
\end{aligned}$$



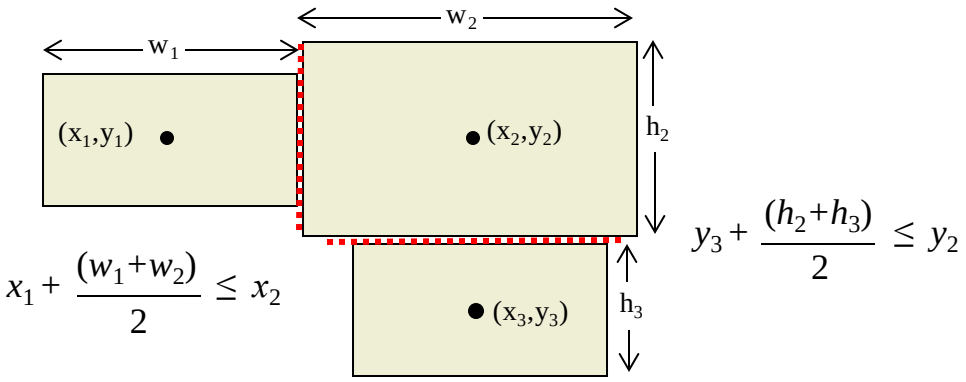


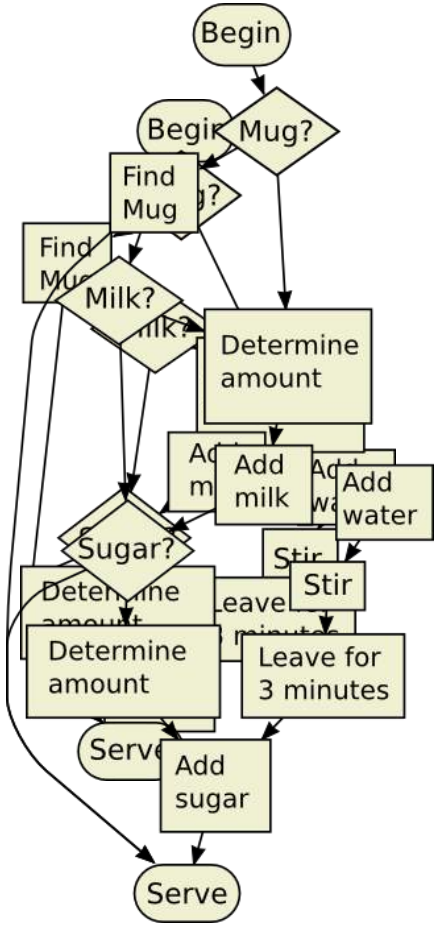

Tim Dwyer, Yehuda Koren
IEEE Symposium on Information Visualization, 2005.
INFOVIS 2005, 65-72

Fast node overlap removal
T Dwyer, K Marriott, PJ Stuckey
International Symposium on Graph Drawing, 153-164, 2005

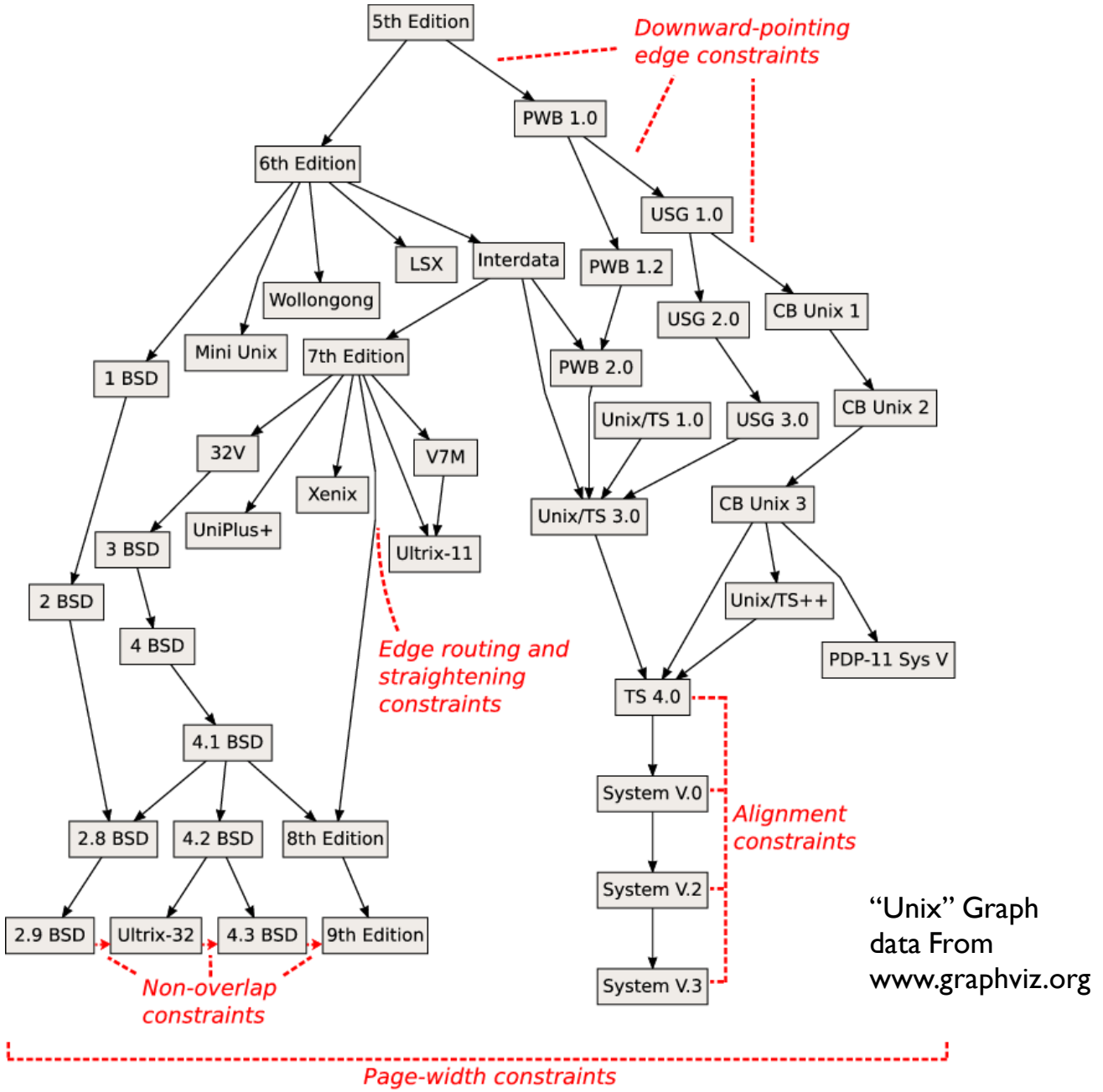
# Separation Constraints

$$x_1 + d \leq x_2$$
$$y_1 + d \leq y_2$$



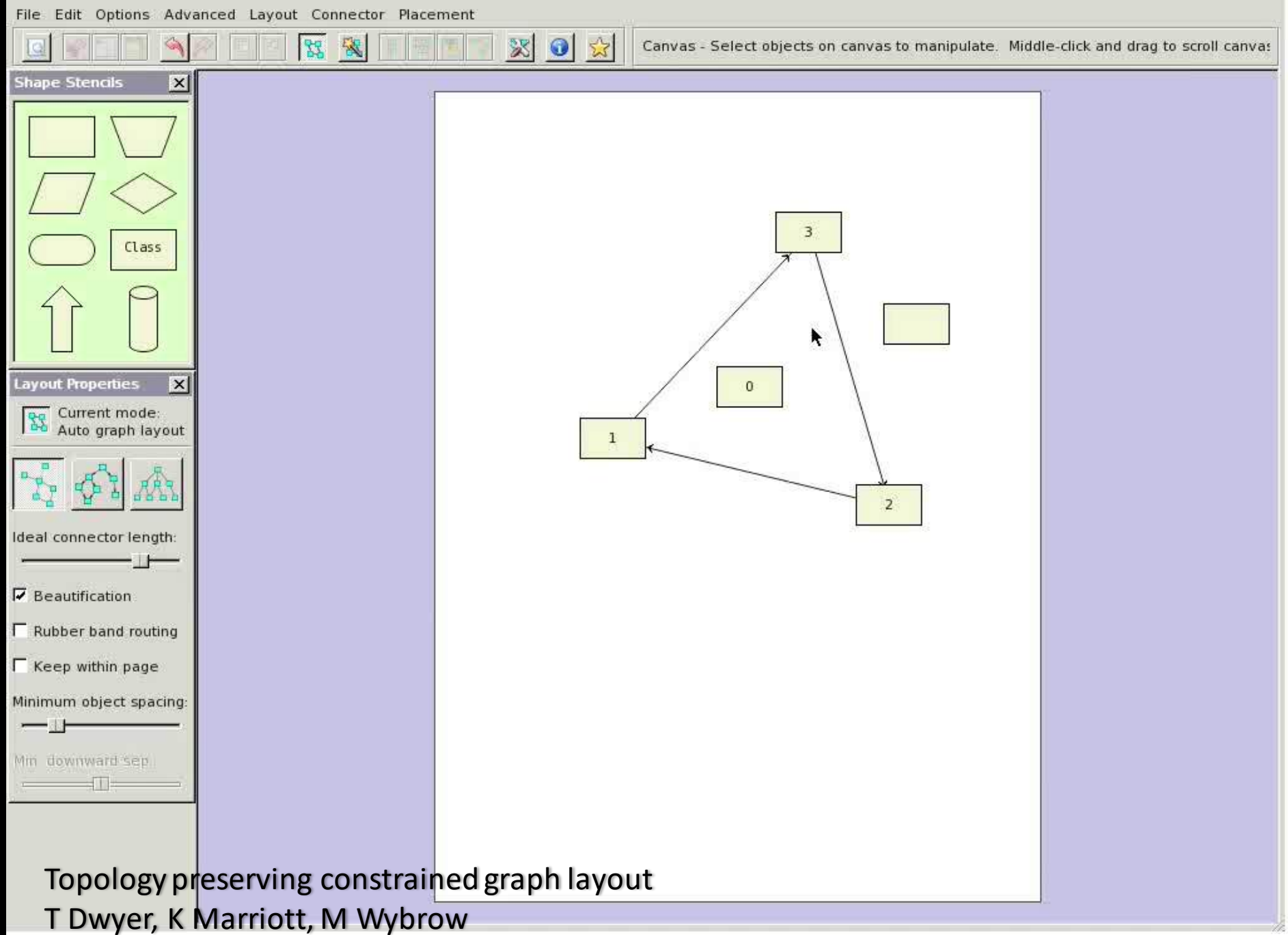



# IPSep-CoLa




"Unix" Graph data From www.graphviz.org


Tim Dwyer, Yehuda Koren, and Kim Marriott. "IPSep-CoLa: An incremental procedure for separation constraint layout of graphs." *IEEE Transactions on Visualization and Computer Graphics* 12.5 (2006): 821-828.

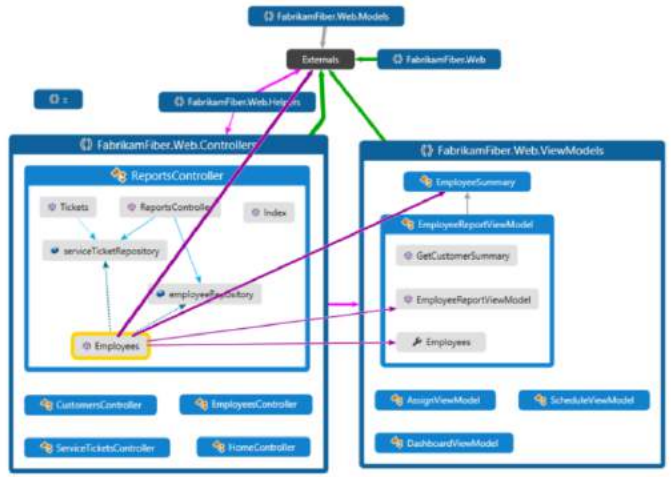



Topology preserving constrained graph layout
T Dwyer, K Marriott, M Wybrow
International Symposium on Graph Drawing, 230-241, 2008

# Map dependencies with code maps

05/16/2018 • 9 minutes to read • +4

You can visualize dependencies across your code by creating a code map. Code maps help you see how the code fits together without reading through files and lines of code.




To create and edit code maps, you need Visual Studio Enterprise edition. In Visual Studio Community and Professional editions, you can open diagrams that were generated in Enterprise edition, but you cannot edit them.

> ① **Note**
>
> Before you share maps created in Visual Studio Enterprise with others who use Visual Studio Professional, make sure that all the items on the map (such as hidden items, expanded groups, and cross-group links) are visible.

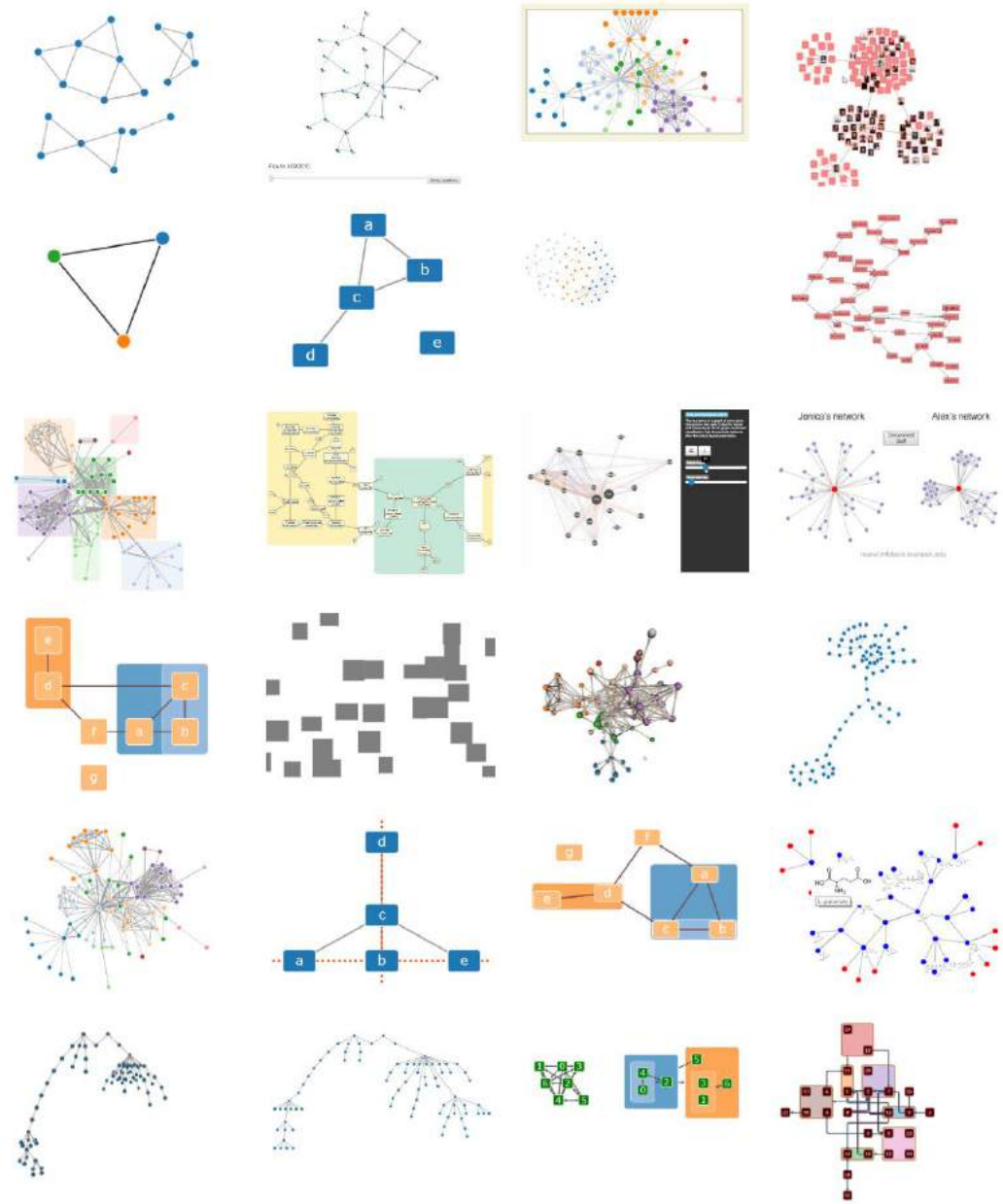
You can map dependencies for code in these languages:

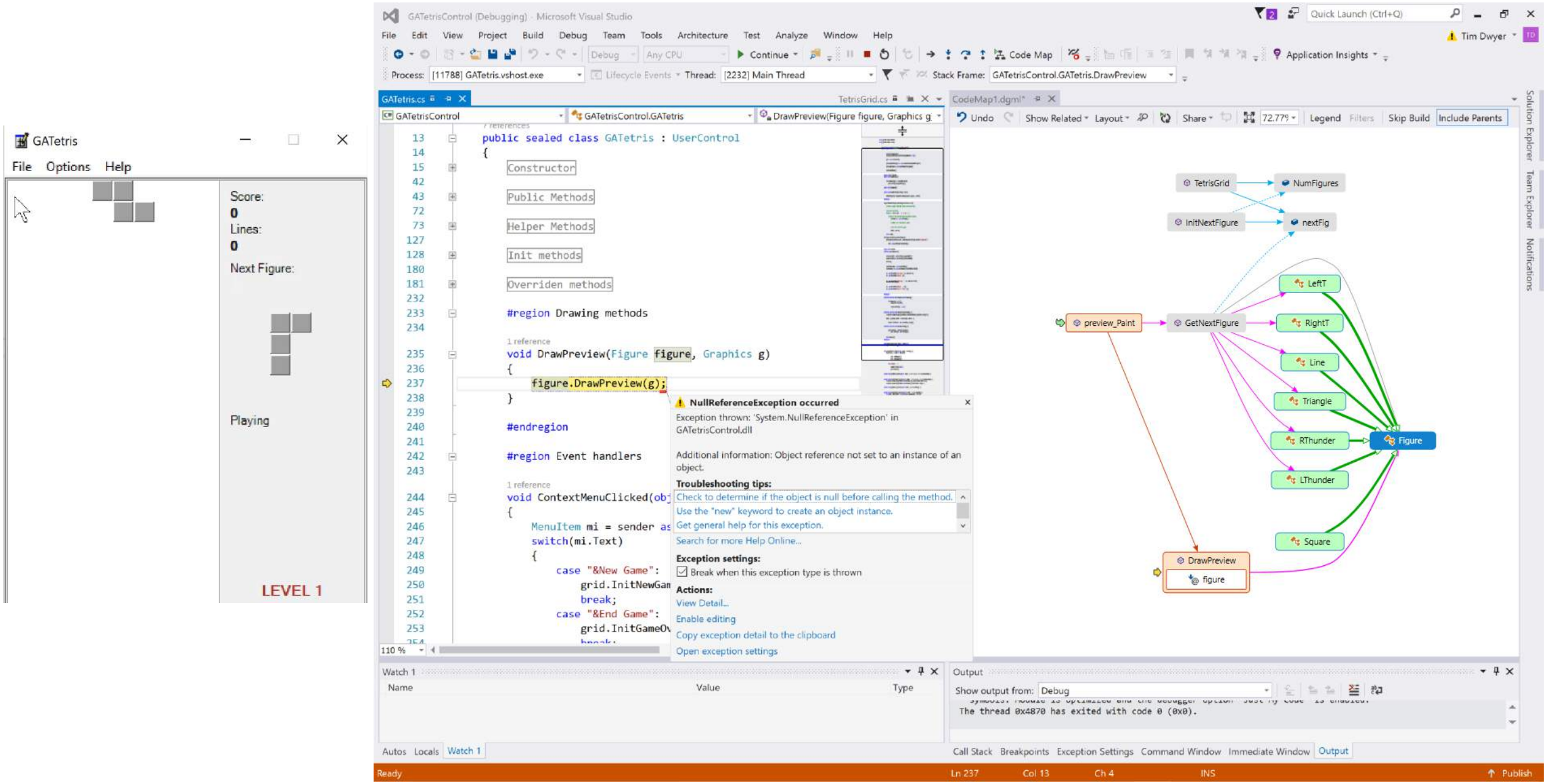
- Visual C# or Visual Basic in a solution or assemblies (*.dll* or *.exe*)
- Native or managed C or C++ code in Visual C++ projects, header files (*.h* or `#include`), or binaries
- X++ projects and assemblies made from .NET modules for Microsoft

# cola.js

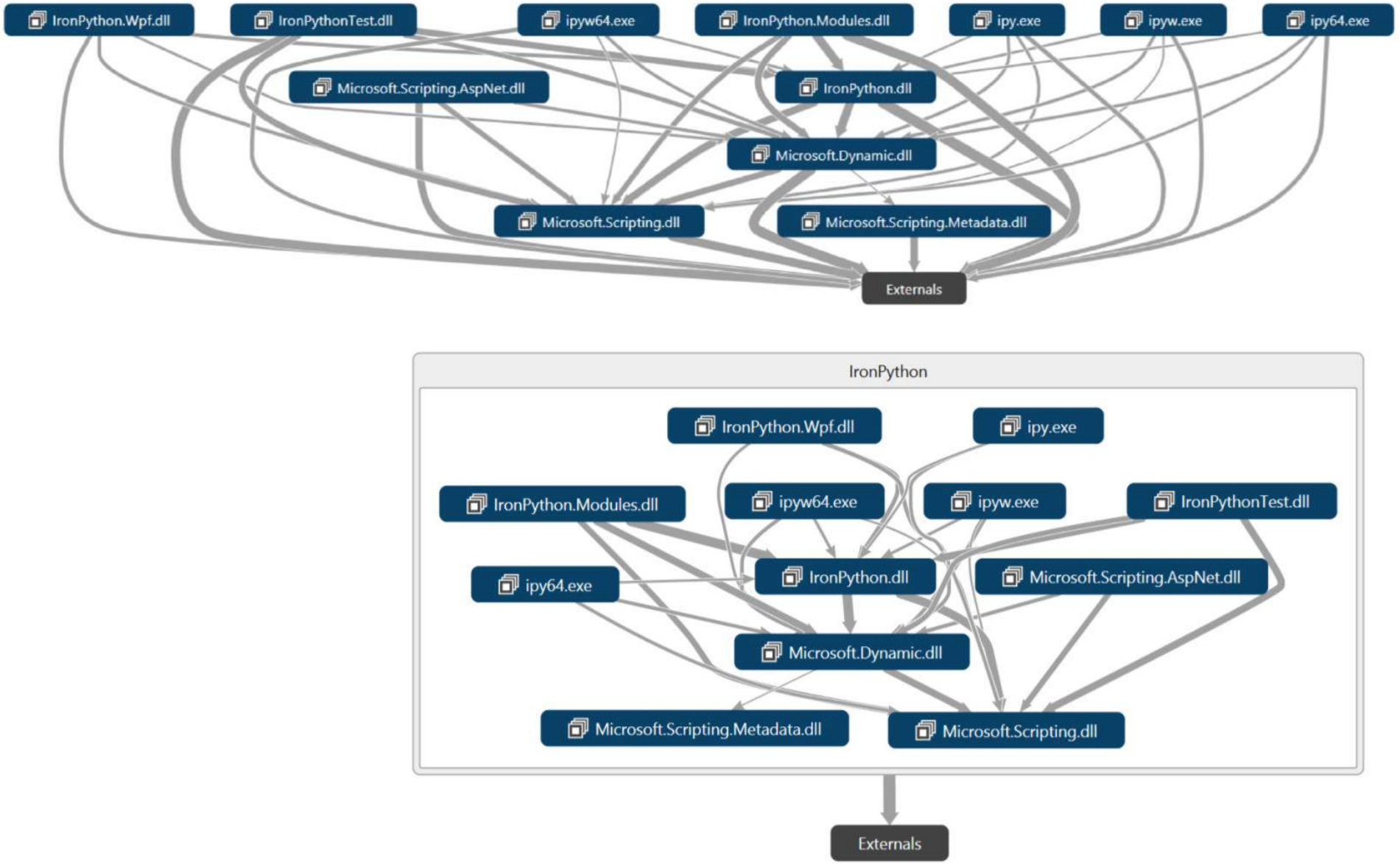
https://ialab.it.monash.edu/webcola

**Constraint-Based Layout in the Browser**

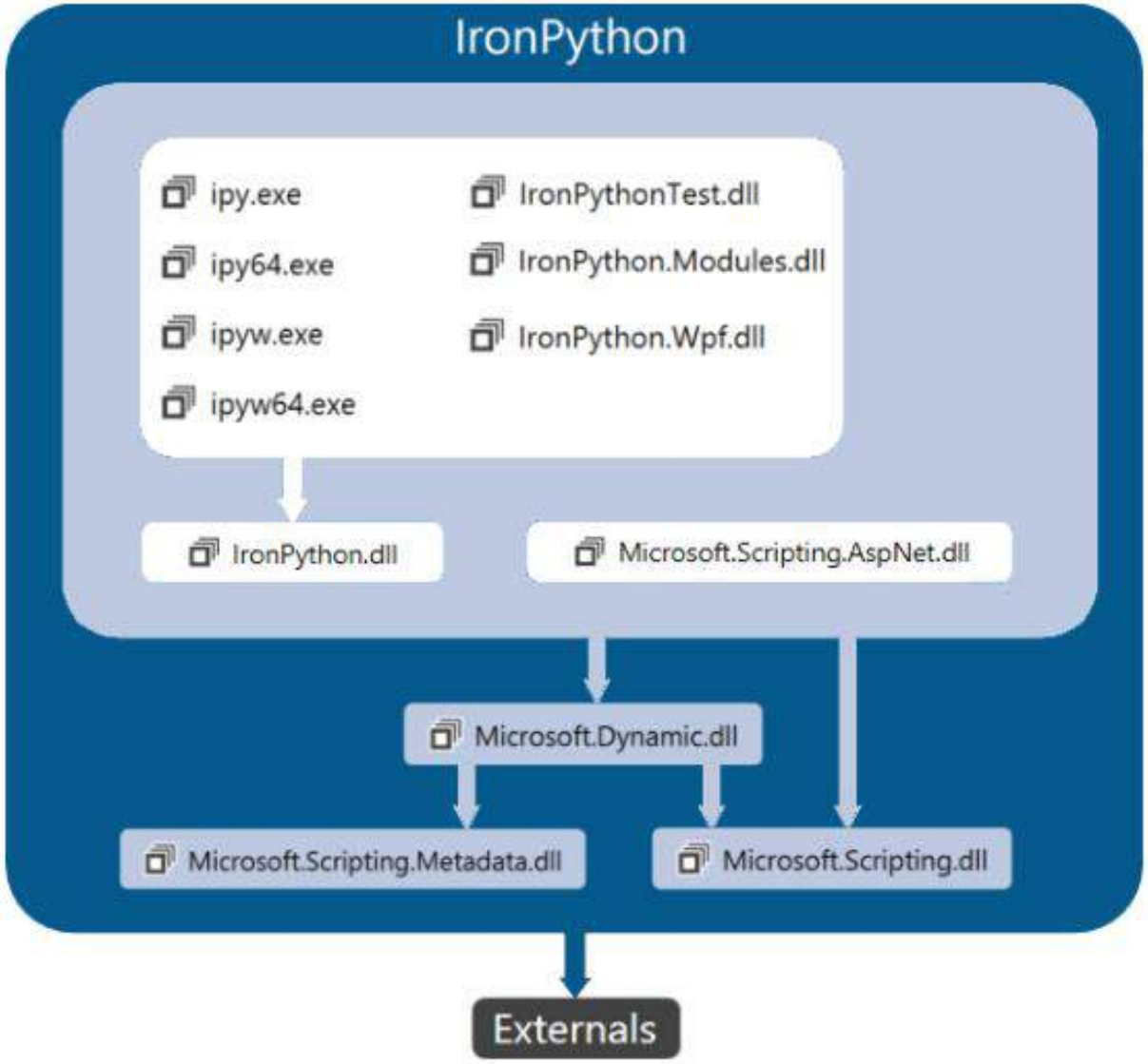




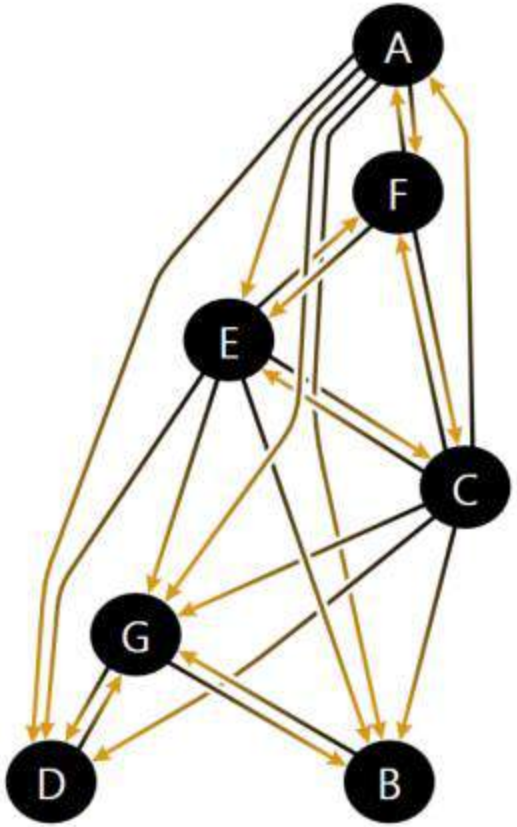

Tim Dwyer, *Network Visualization as a Higher-Order Visual Analysis Tool*
IEEE computer graphics and applications 36(6), pp. 78-85, 2016.



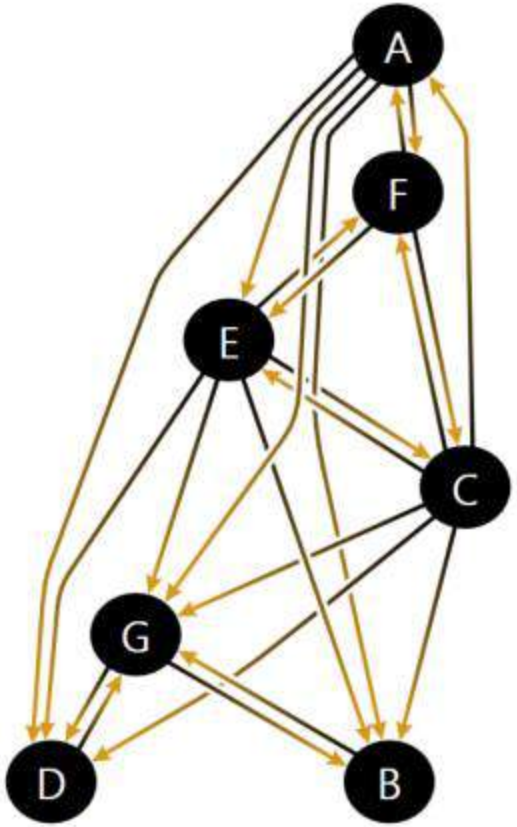

Dwyer, Tim, Nathalie Henry Riche, Kim Marriott, and Christopher Mears. "Edge compression techniques for visualization of dense directed graphs." *IEEE transactions on visualization and computer graphics* 19, no. 12 (2013): 2596-2605.

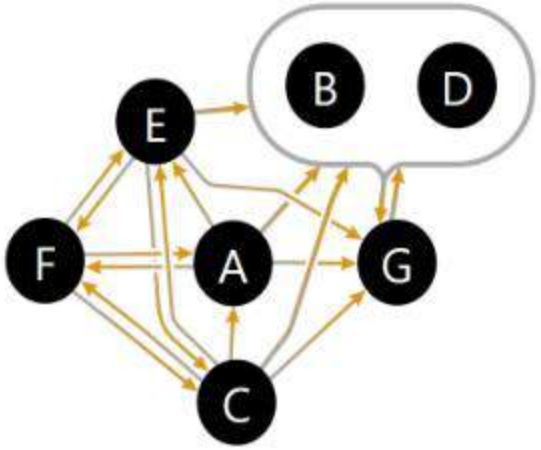



Dwyer, Tim, Nathalie Henry Riche, Kim Marriott, and Christopher Mears. "Edge compression techniques for visualization of dense directed graphs." *IEEE transactions on visualization and computer graphics* 19, no. 12 (2013): 2596-2605.

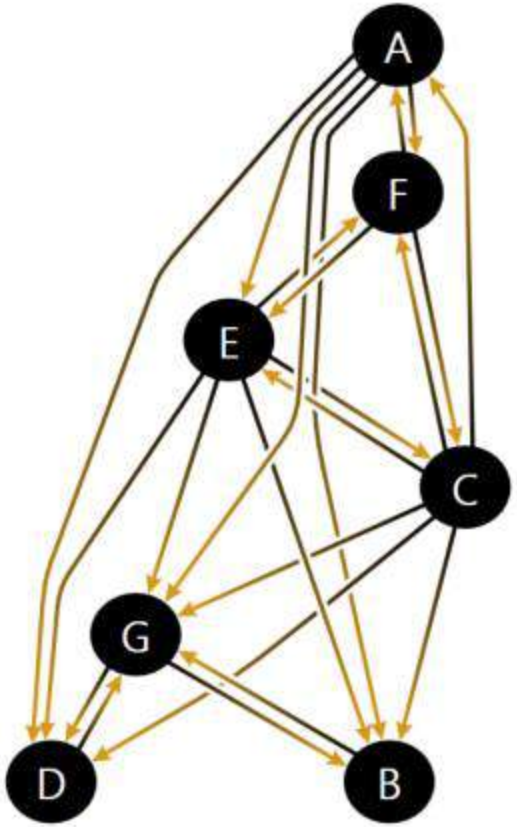


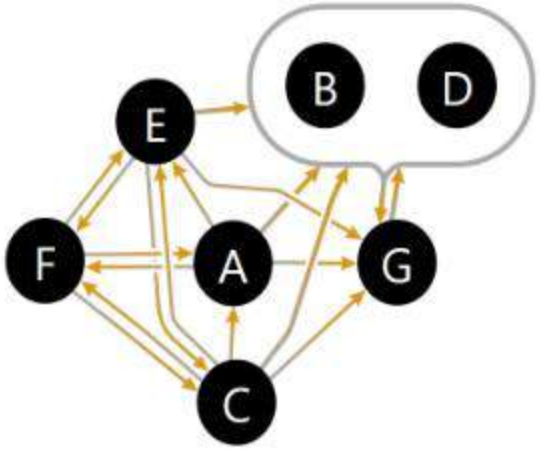

23 Edges

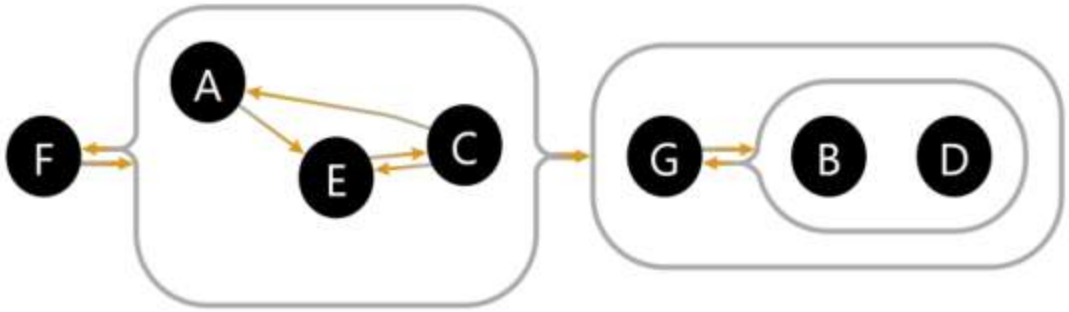


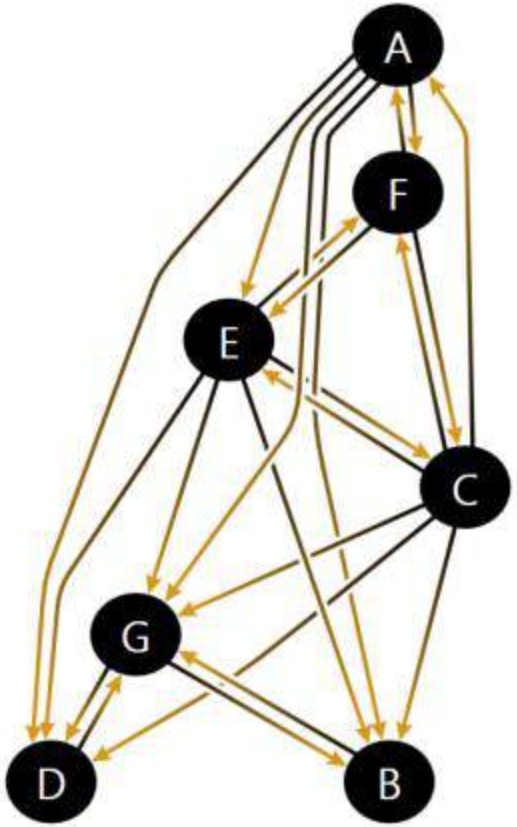

17 Edges

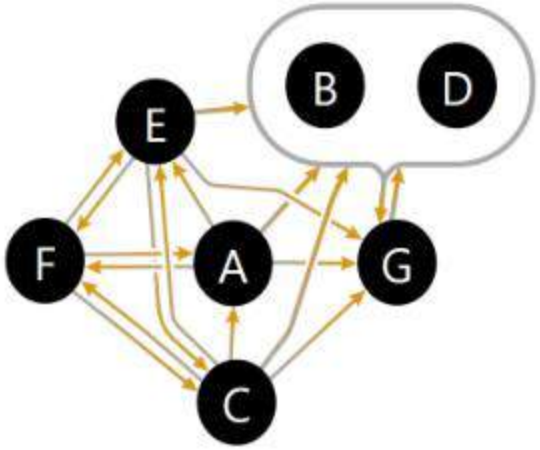


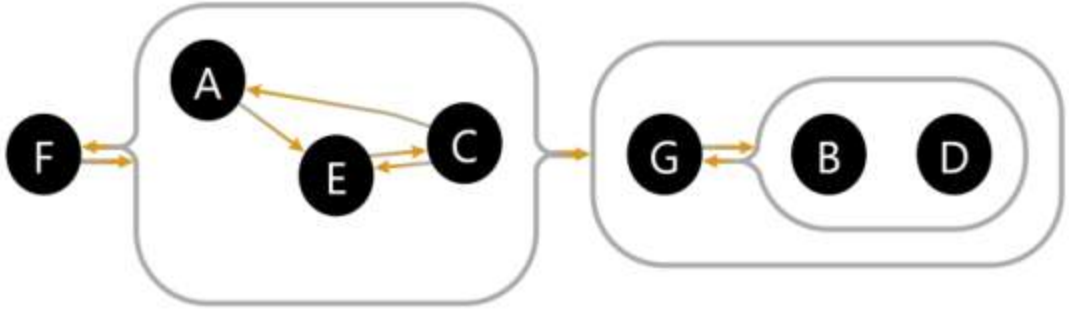



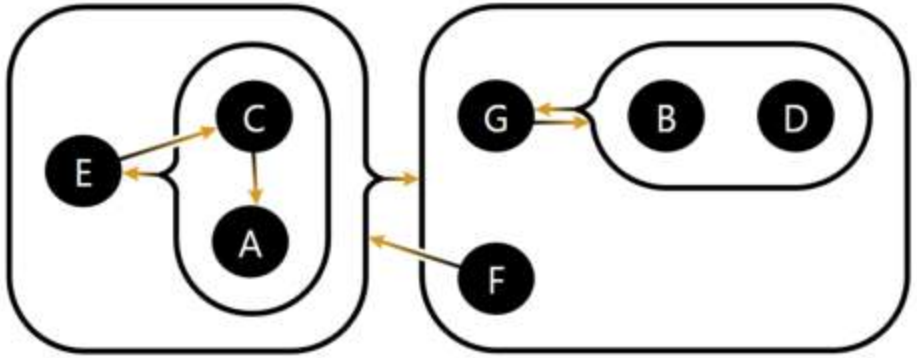




9 Edges

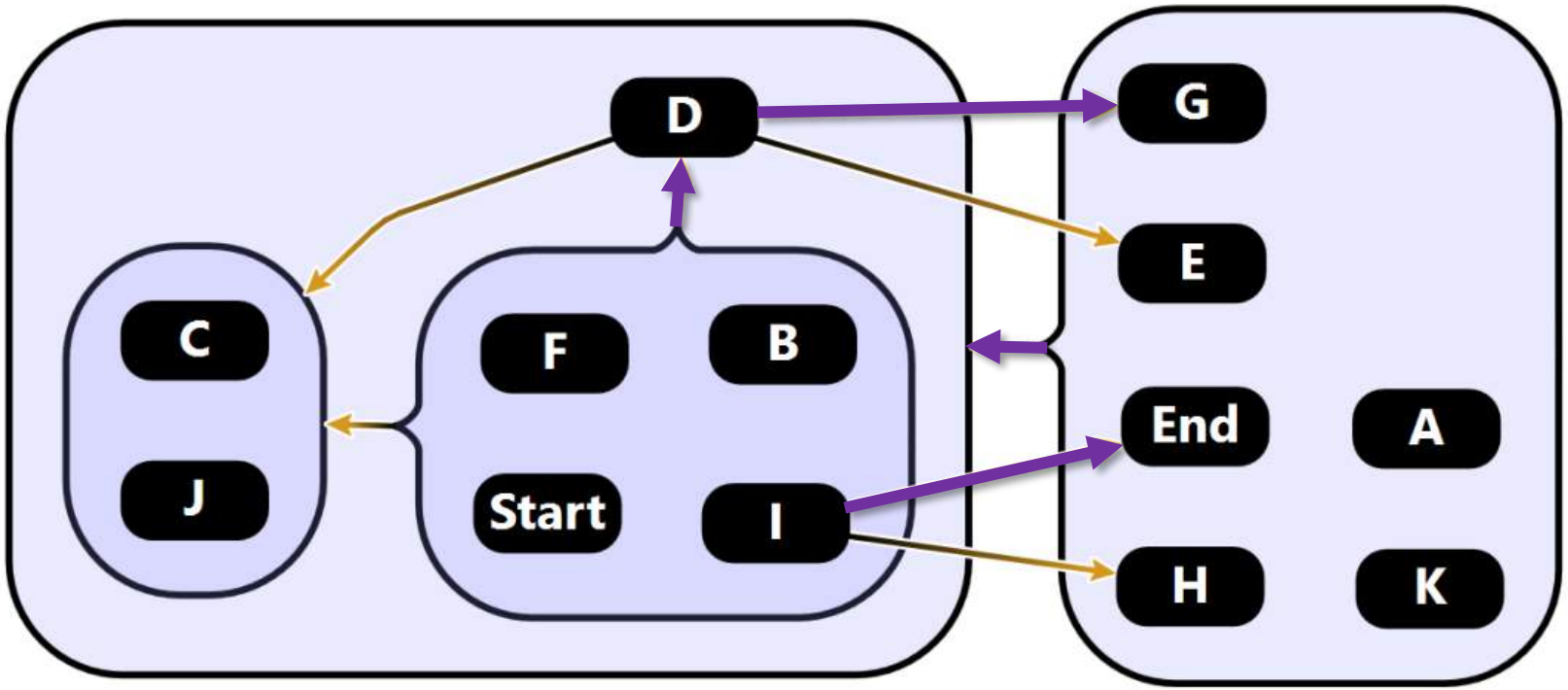



7 Edges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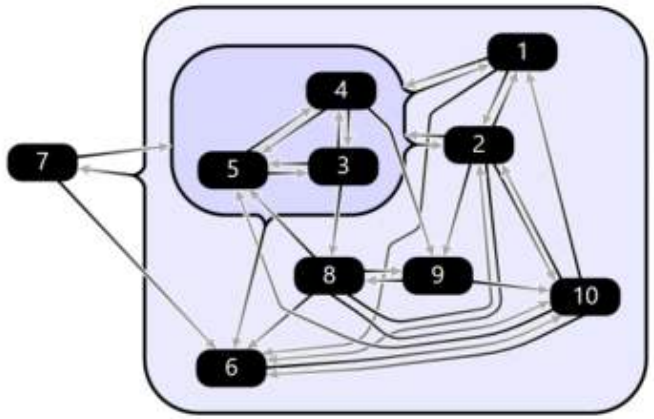
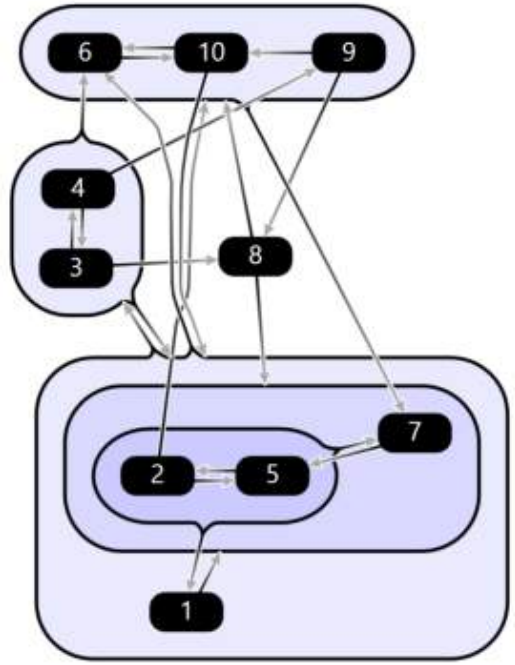
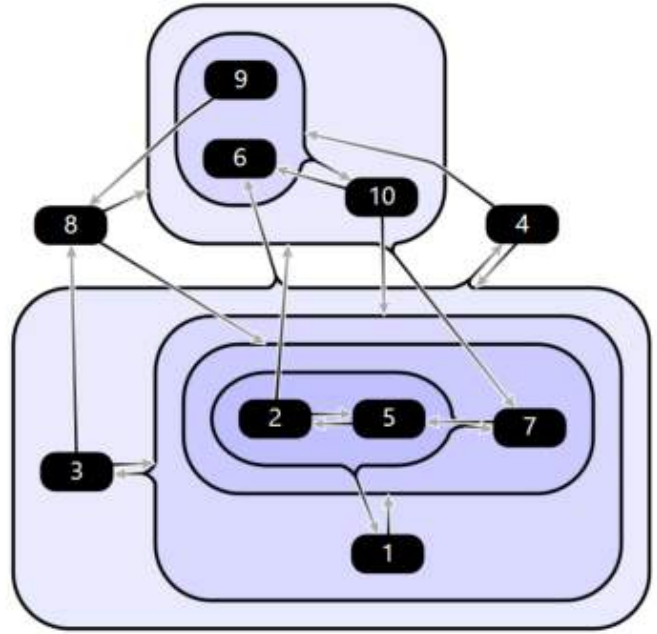


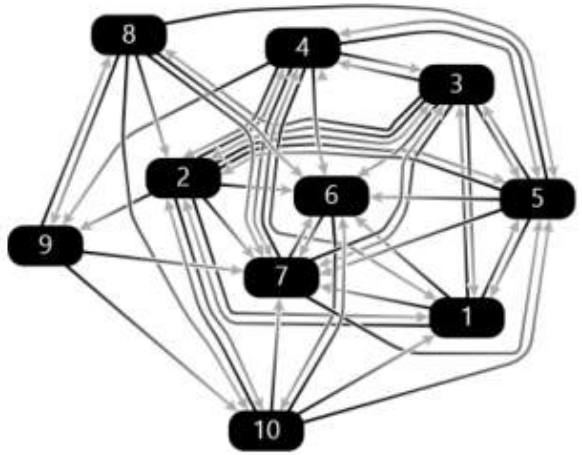

(a) Optimal crossing-weight=2000



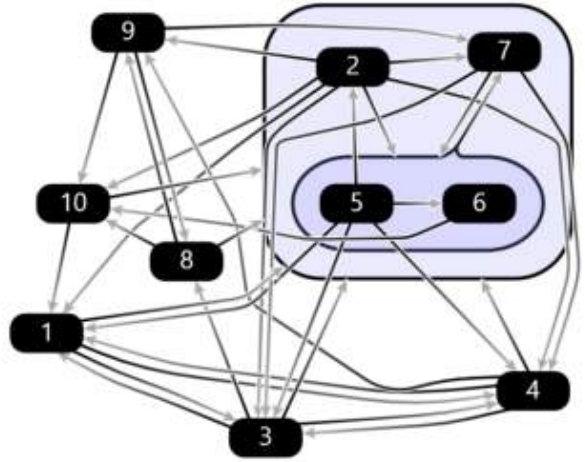

(b) Optimal crossing-weight=1000



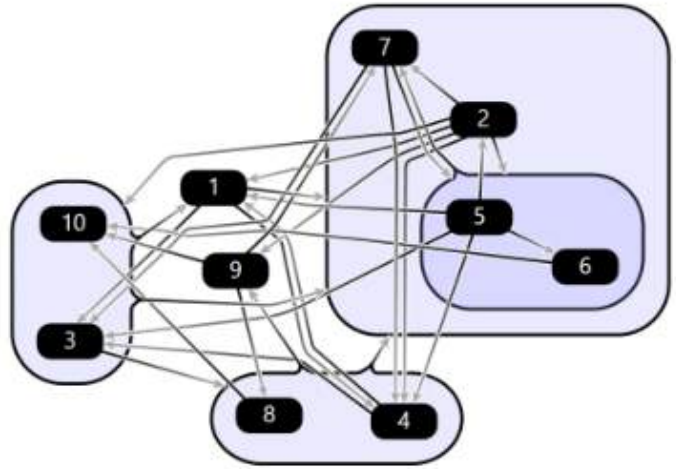

(c) Optimal crossing-weight=1




(d) Heuristic crossing-weight=2000



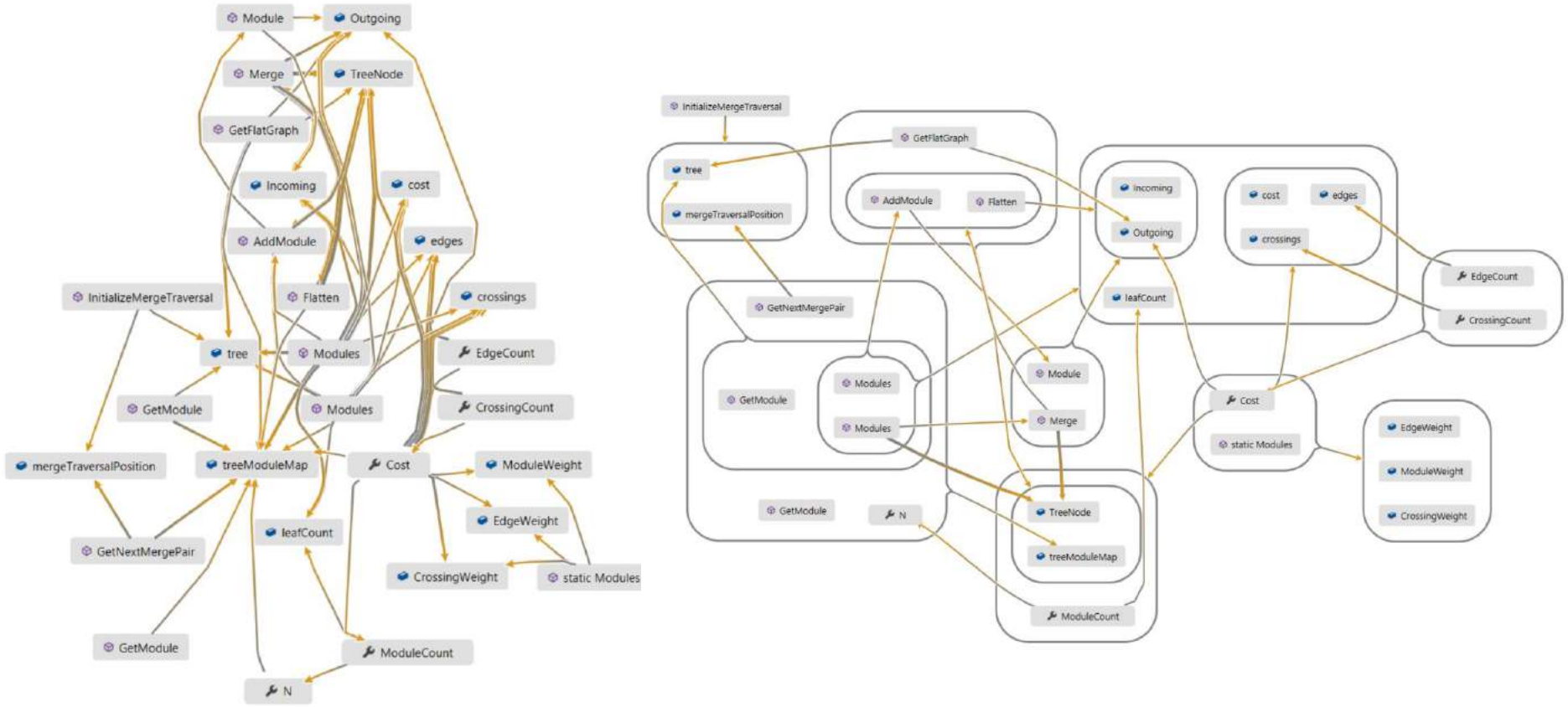

(e) Heuristic crossing-weight=1000

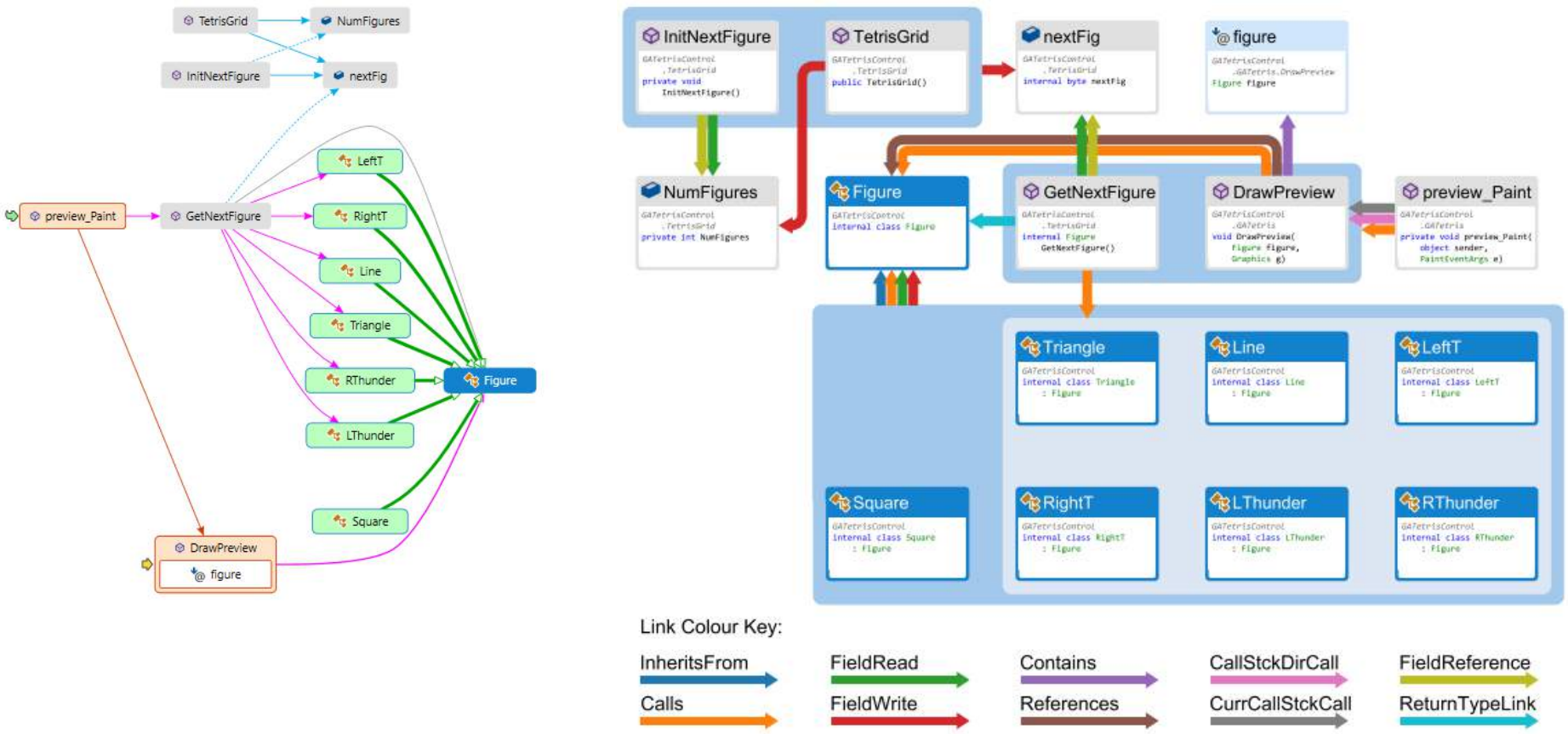



(f) Heuristic crossing-weight=1

*Improved Optimal and Approximate Power Graph Compression for Clearer Visualisation of Dense Graphs*

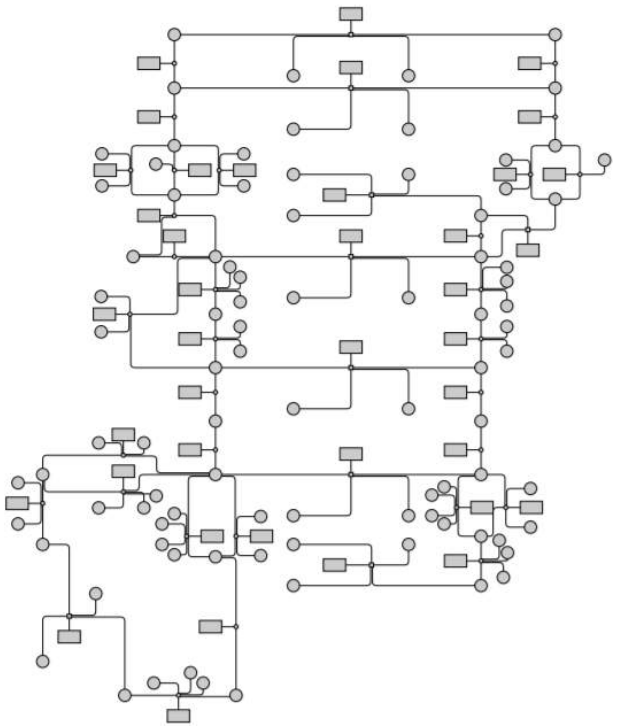
T Dwyer, C Mears, K Morgan, T Niven, K Marriott, M Wallace Pacific Visualization Symposium (PacificVis), 2014 IEEE, 105-112

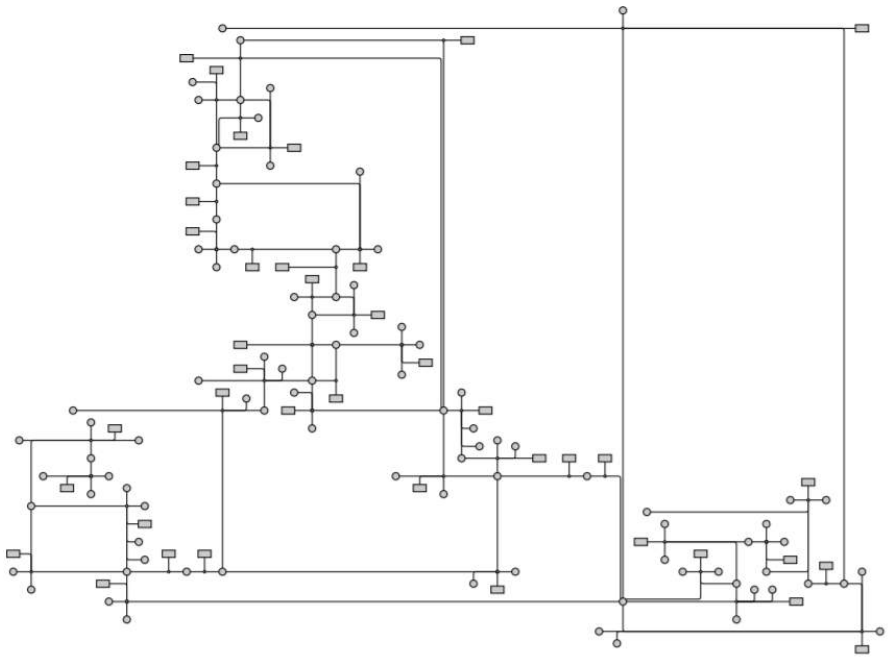


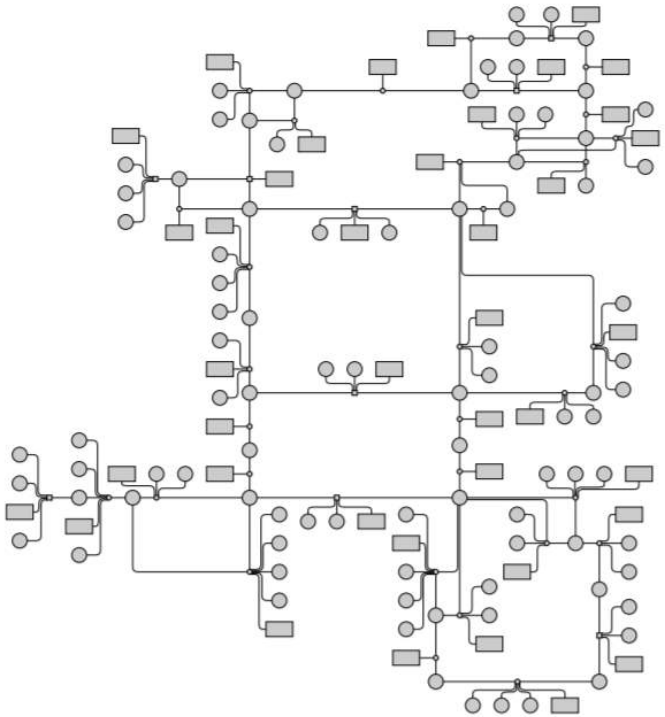



Yoghourdjian, V., Dwyer, T., Gange, G., Kieffer, S., Klein, K., & Marriott, K.
*High-quality ultra-compact grid layout of grouped networks.*
IEEE Transactions on Visualization and Computer Graphics, 22(1), 339-348. 2015

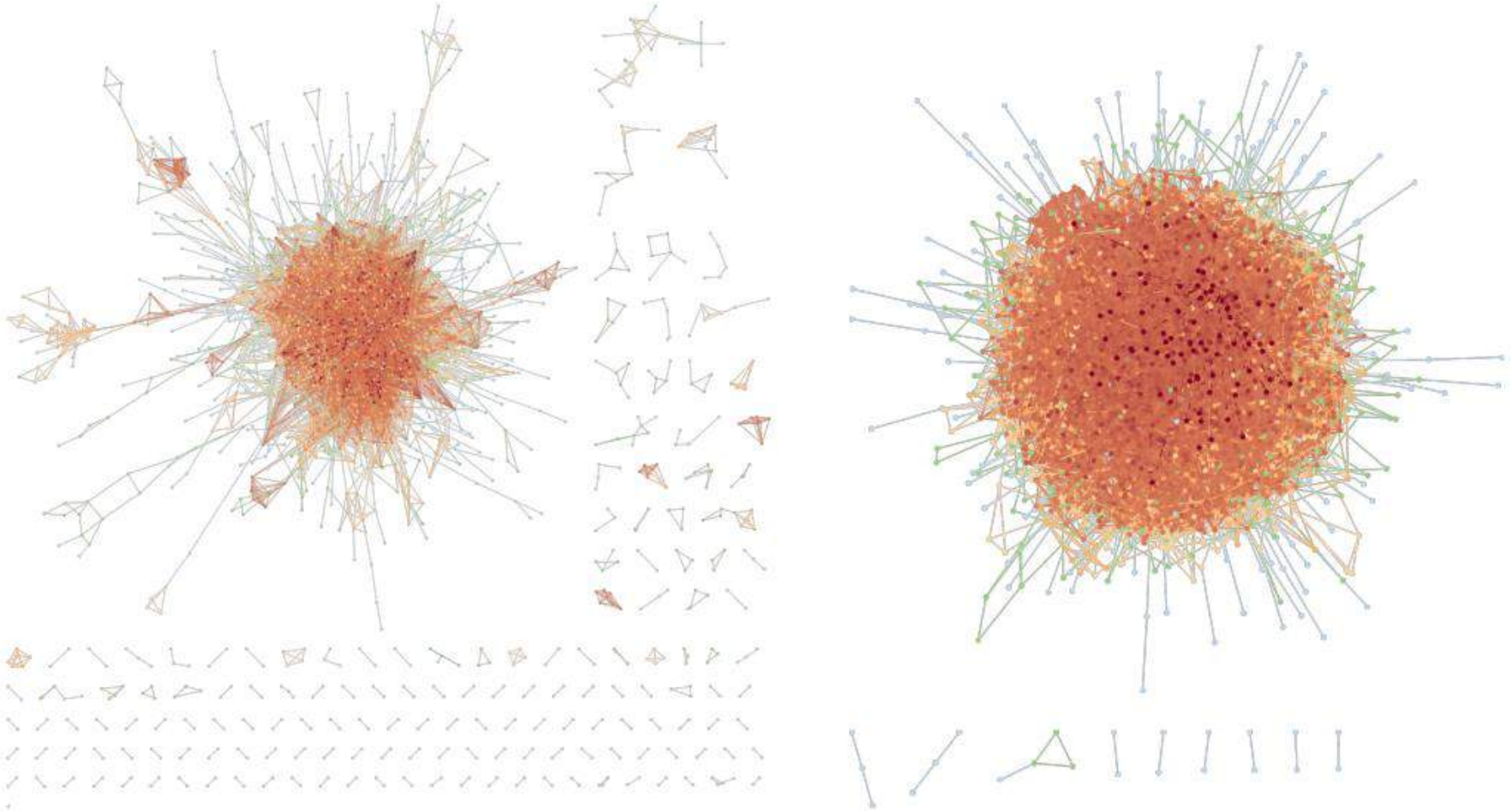
Kieffer, S., Dwyer, T., Marriott, K., & Wybrow, M.
Hola: Human-like orthogonal network layout.
*IEEE transactions on visualization and computer graphics*, *22*(1), 349-358. 2015







Vahan Yoghourdjian, Tim Dwyer, Karsten Klein, Kim Marriott, and Michael Wybrow
*Graph Thumbnails: Identifying and Comparing Multiple Graphs at a Glance*
*IEEE Transactions on Visualization and Computer Graphics, 2018*



E. coli PPI

Vahan Yoghourdjian, Tim Dwyer, Karsten Klein, Kim Marriott, and Michael Wybrow
*Graph Thumbnails: Identifying and Comparing Multiple Graphs at a Glance*
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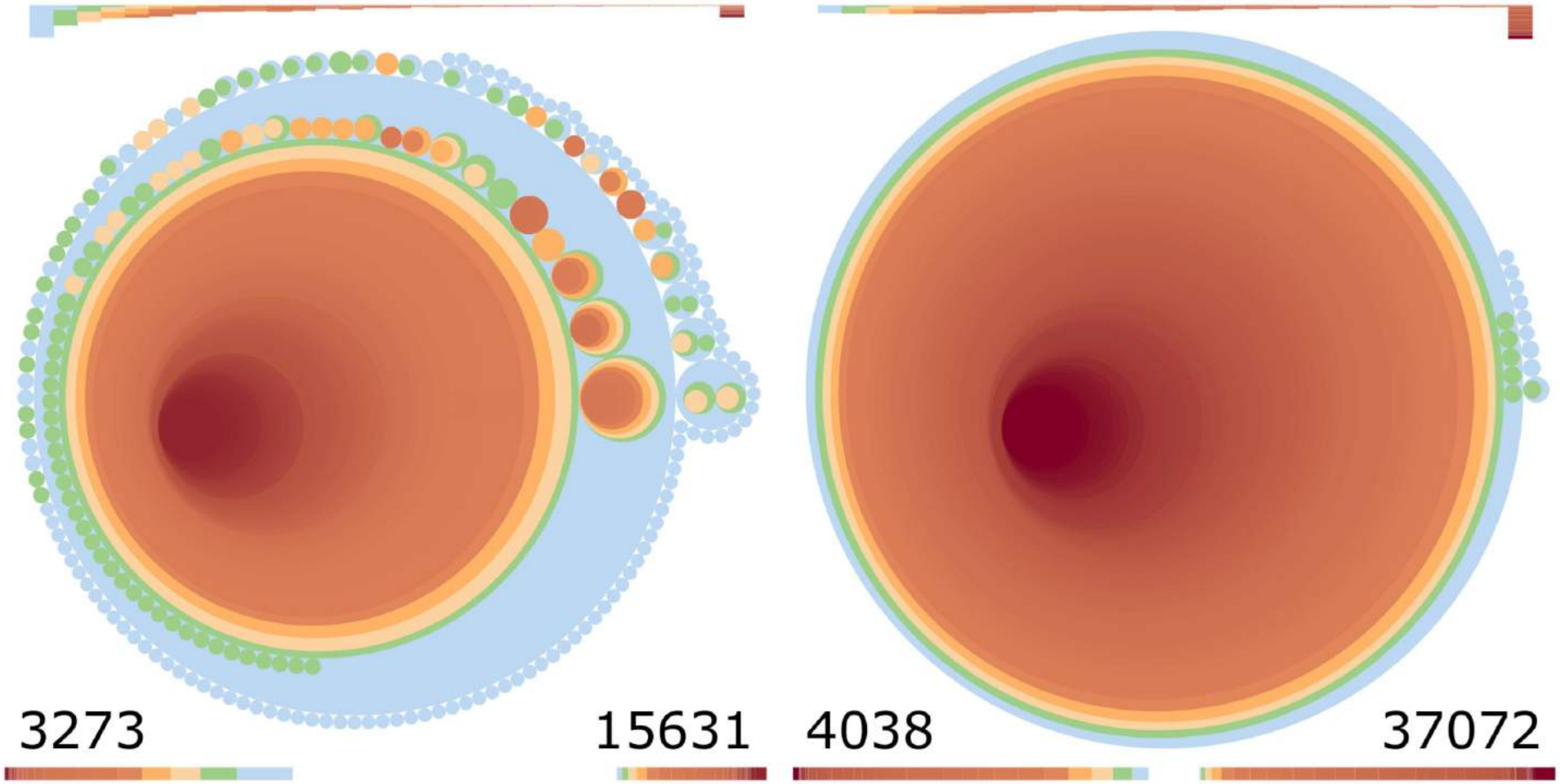


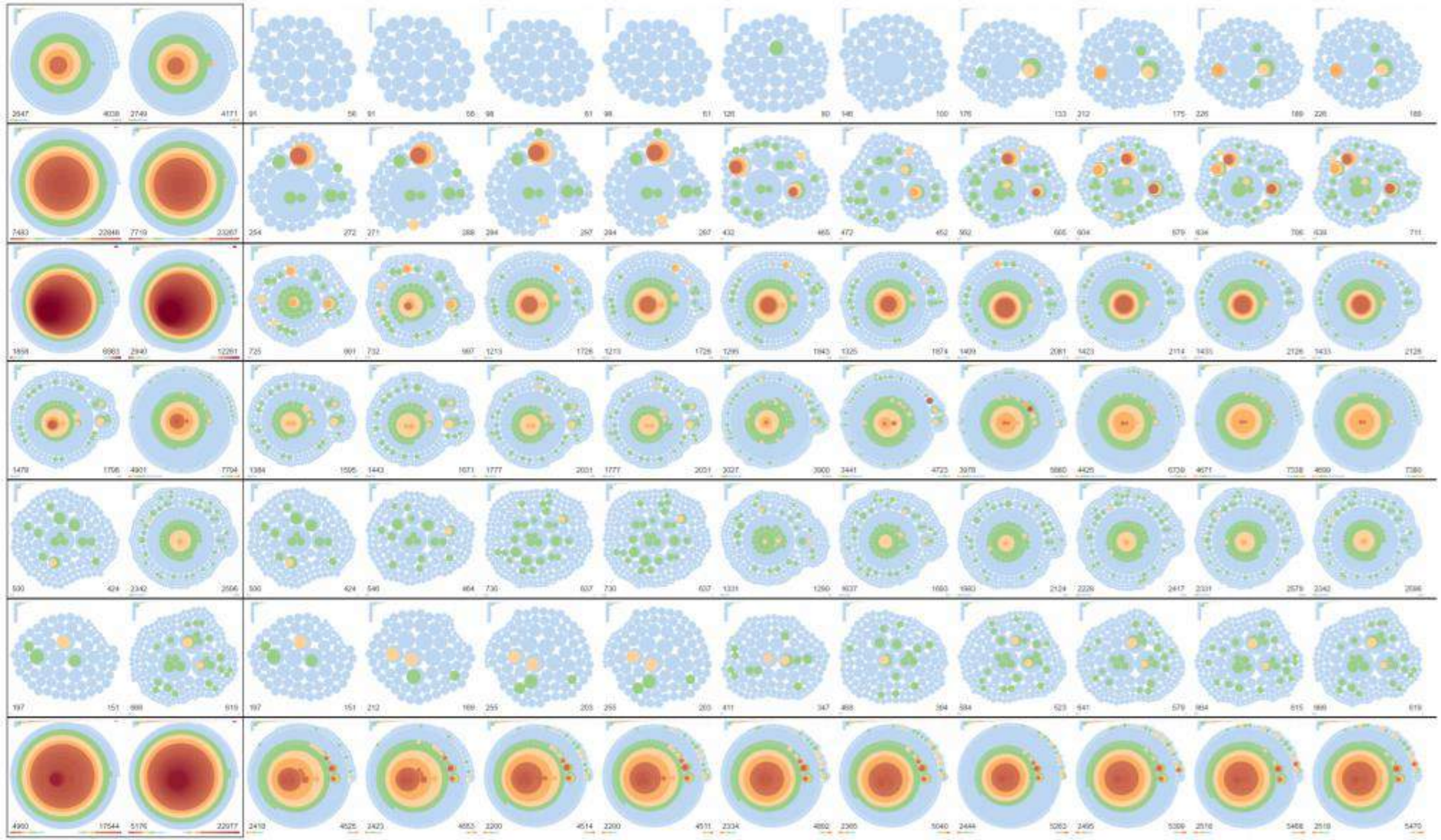


Fig. 14. Evolution of DIP database structure for seven organisms (*C. elegans*, *D. melanogaster*, *E. coli*, *H. sapiens*, *M. musculus*, *R. norvegicus*, *S. cerevisiae*), each row shows data for one organism (from top to bottom in the listed order). The two leftmost columns show the full DIP dataset for the years 2008 and 2017, respectively. The remaining columns show the high-confidence core dataset (the most reliable subset of the interactions) for the years 2008–2017 (Note that at the time of retrieval the full and the core data set for mouse and rat were the same for the years 2008 and 2017, while the sizes given on the DIP web page differed).

Cognitive Scalability of Network Visualisation

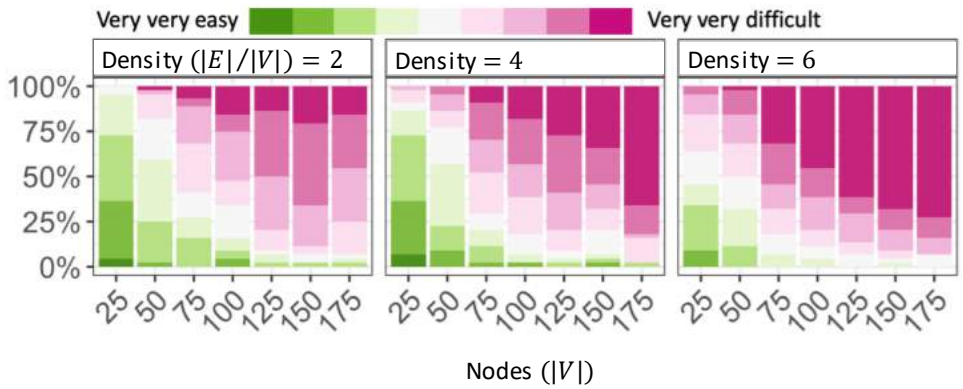
Vahan Yoghourdjian, Yalong Yang, Lee Lawrence, Michael Wybrow, Tim Dwyer, Kim Marriott

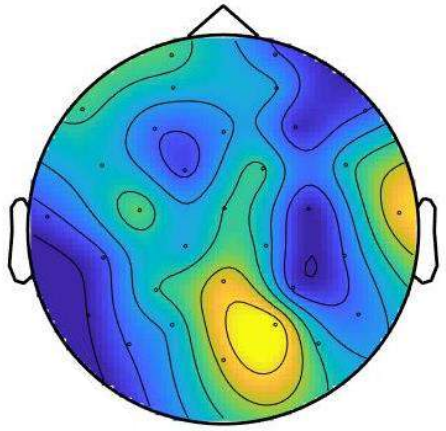
Hardness model

*Graph size*

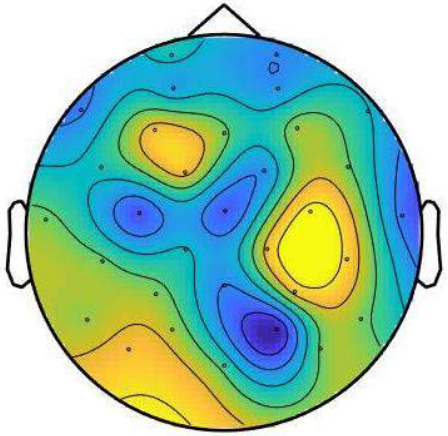
*Local measures*

*Clutter (crossings)*

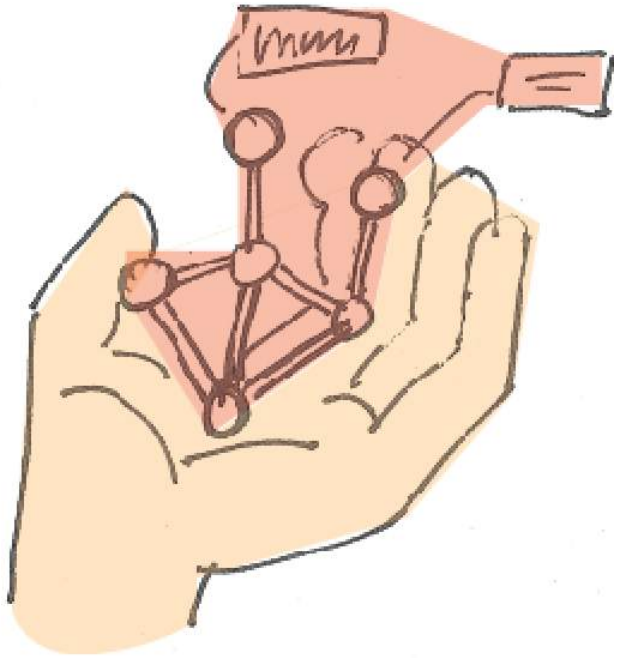


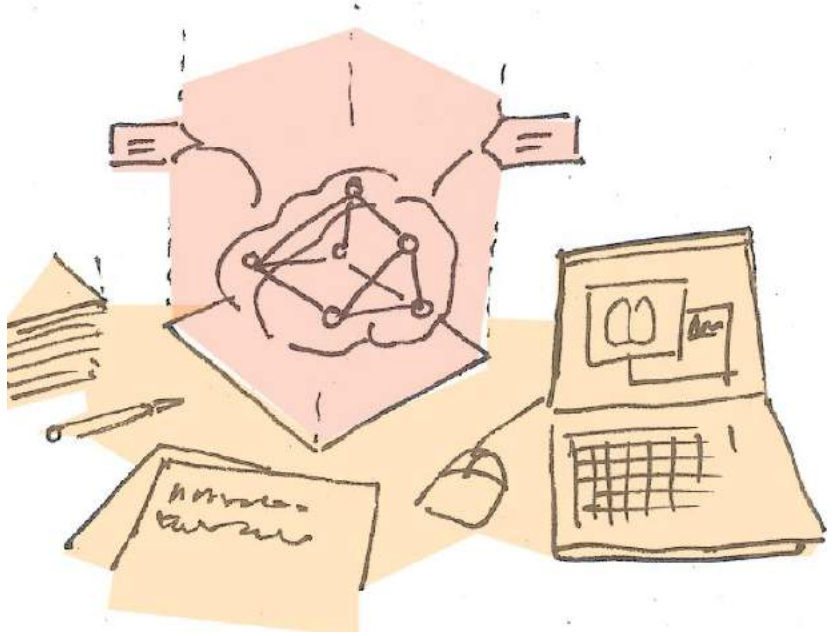



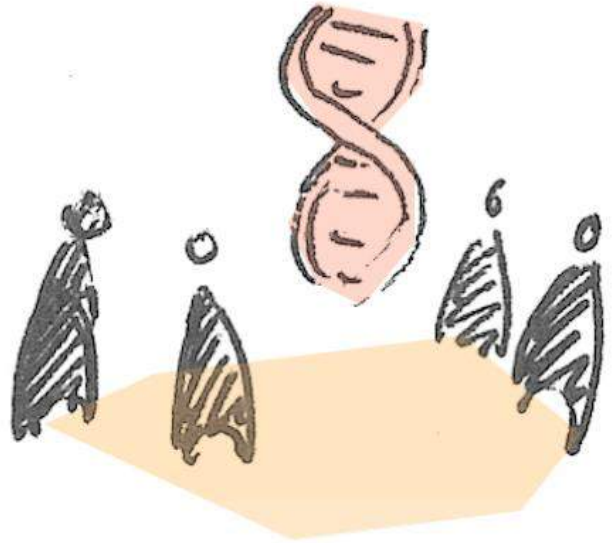
Easy



Hard







# Part 2: Immersive Analytics

Interactive data analysis using the surfaces and spaces around us

MONASH University

# Credits

Maxime Cordeil

Tobias Czauderna

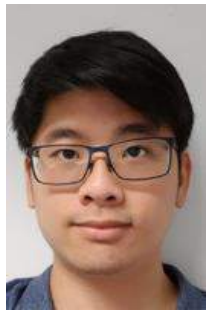
Peter Hoghton

Sarah Goodwin

Kim Marriott

Andrea Batch
Uni Maryland

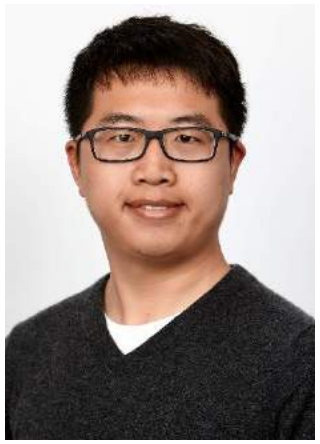
Barrett Ens



Benjamin Lee

Falk Schreiber

Matthias Klapperstueck



Yalong Yang

Bernie Jenny

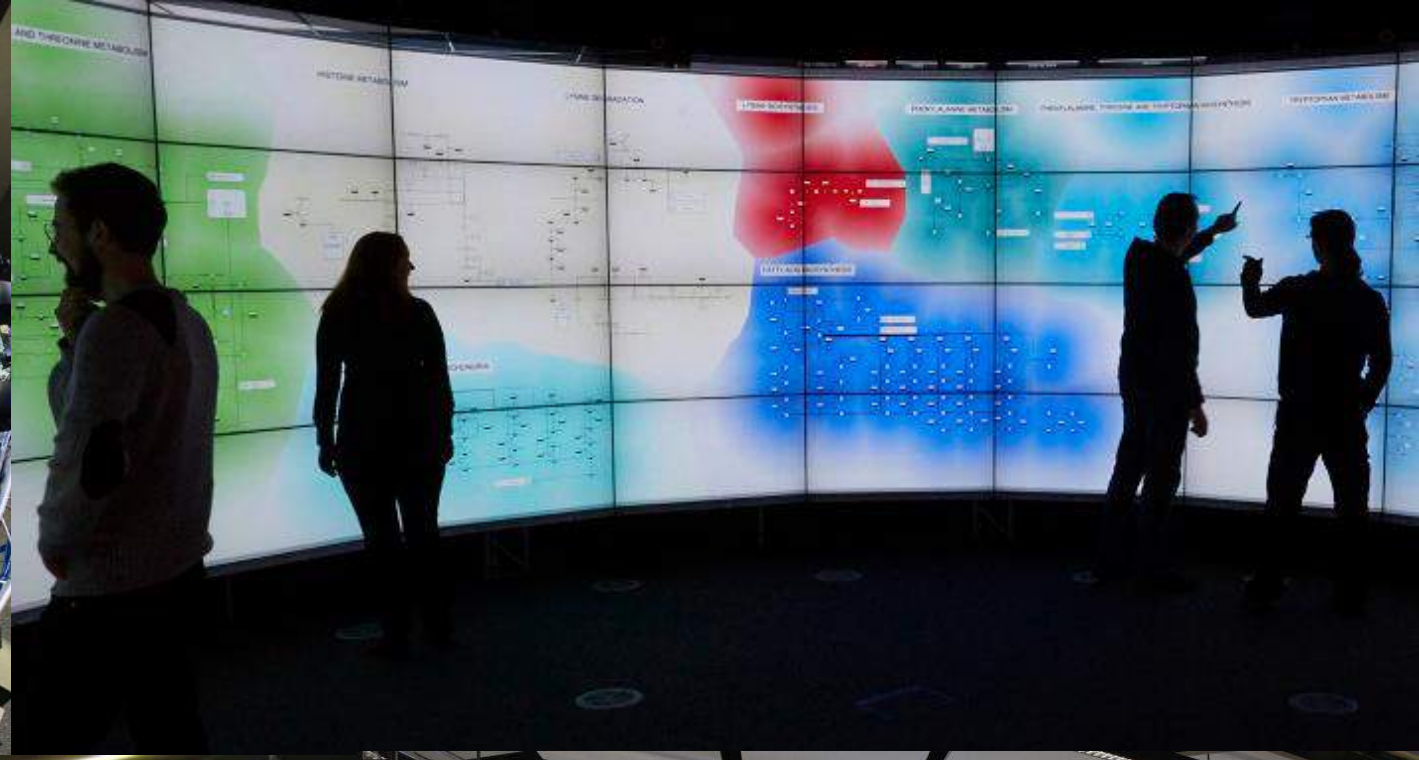
Benjamin Bach

Bruce Thomas
UniSA

Andrew Cunningham
UniSA

Niklas Elmqvist
Uni Maryland

MONASH
University




MONASH
ENERGY MATERIALS
AND SYSTEMS
INSTITUTE (MEMSI)
MONASH

Immersive Analytics Goals:

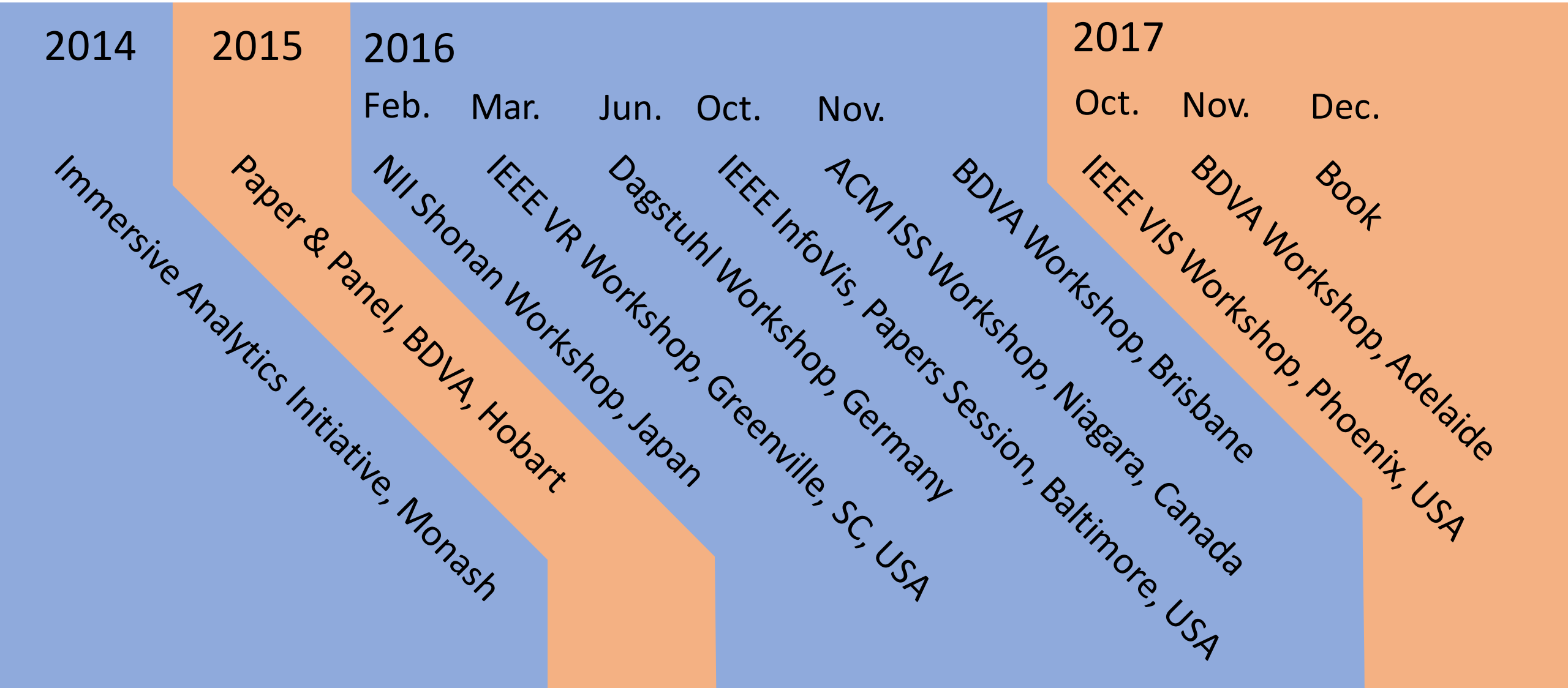
to remove barriers between people, their data and the tools they use for analysis

to support data understanding and decision making everywhere and by everyone

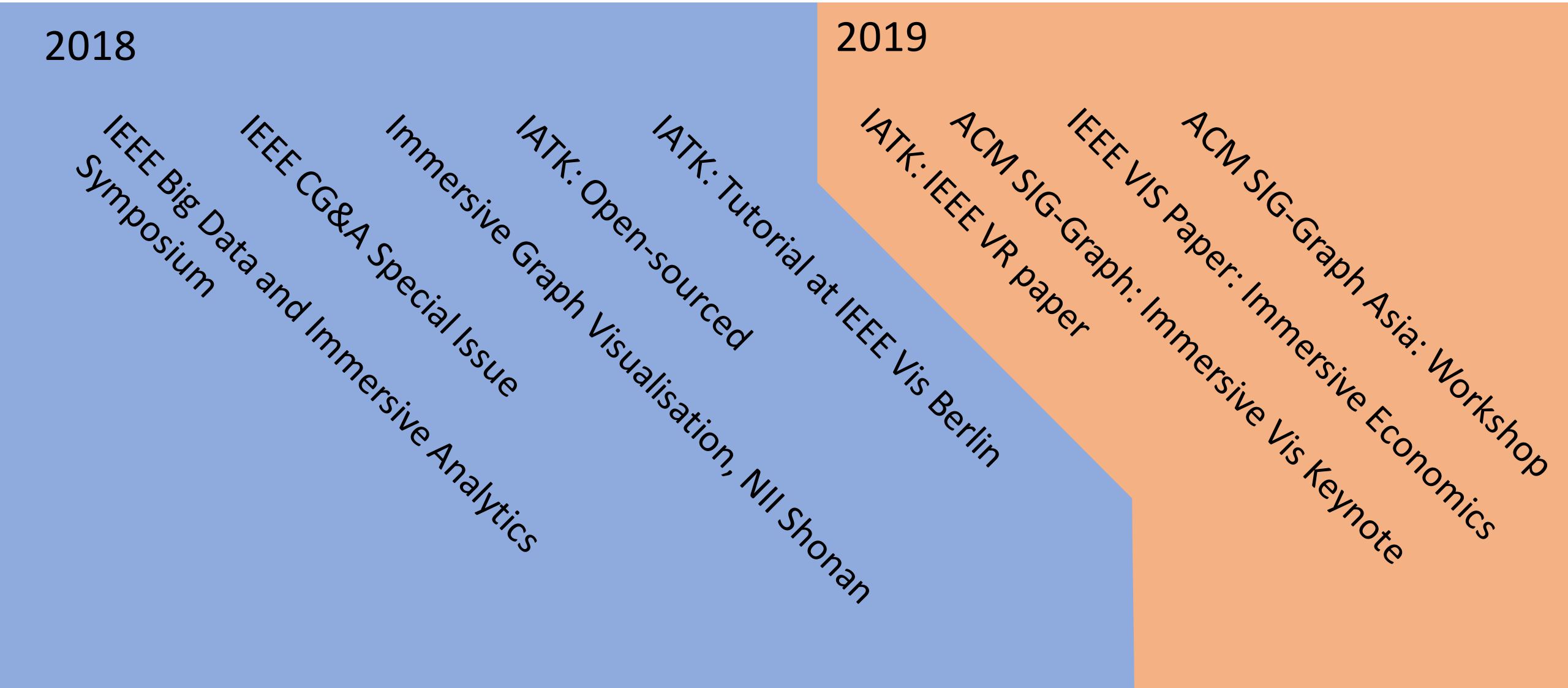
to make embodied tools that are intuitive, engaging,
and make the best possible use of all sensory channels.


Immersive Analytics is the use of engaging, embodied analysis tools to support data understanding and decision making.

# Immersive Analytics Timeline

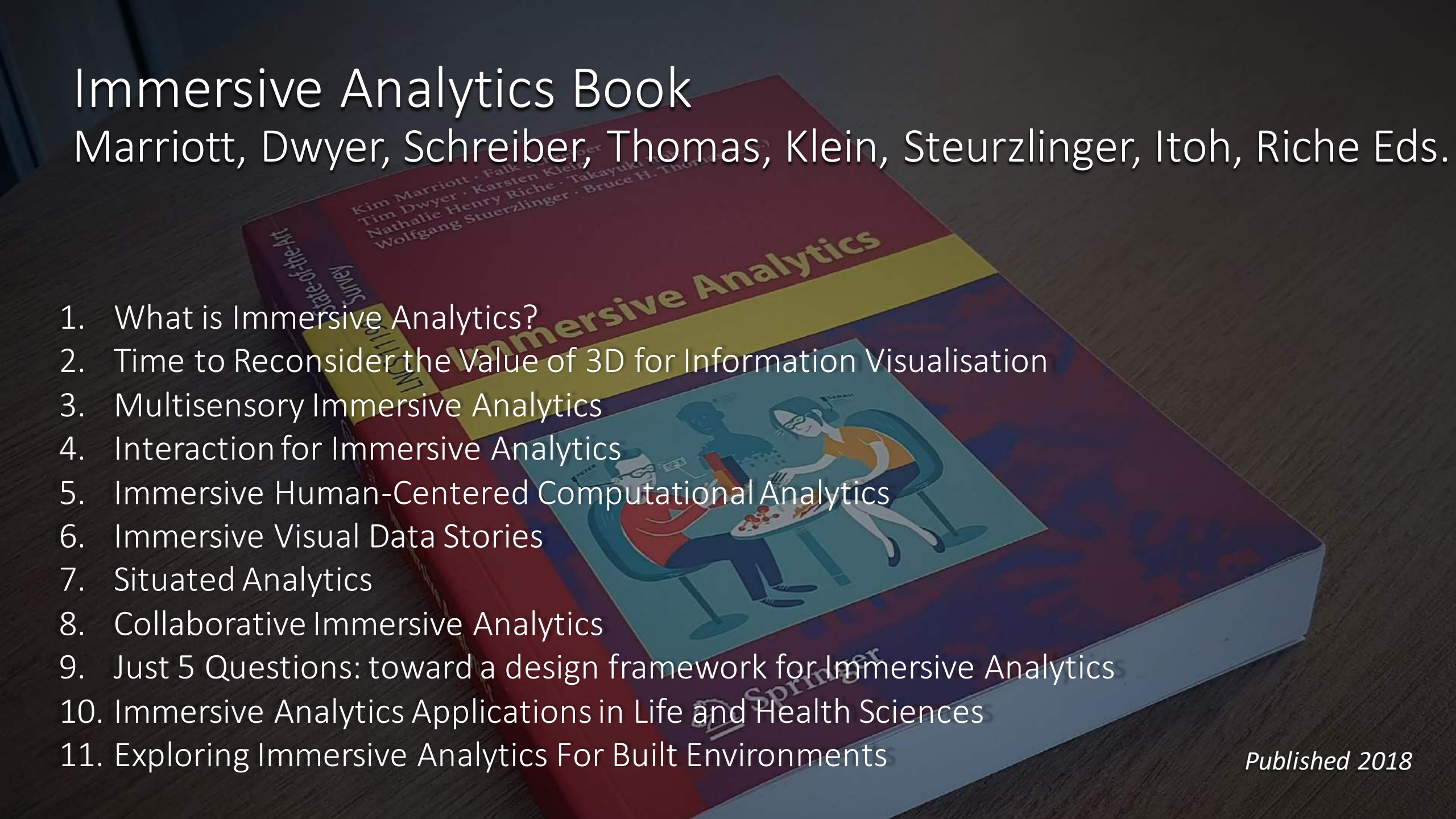


# Immersive Analytics Timeline



# Immersive Analytics Book

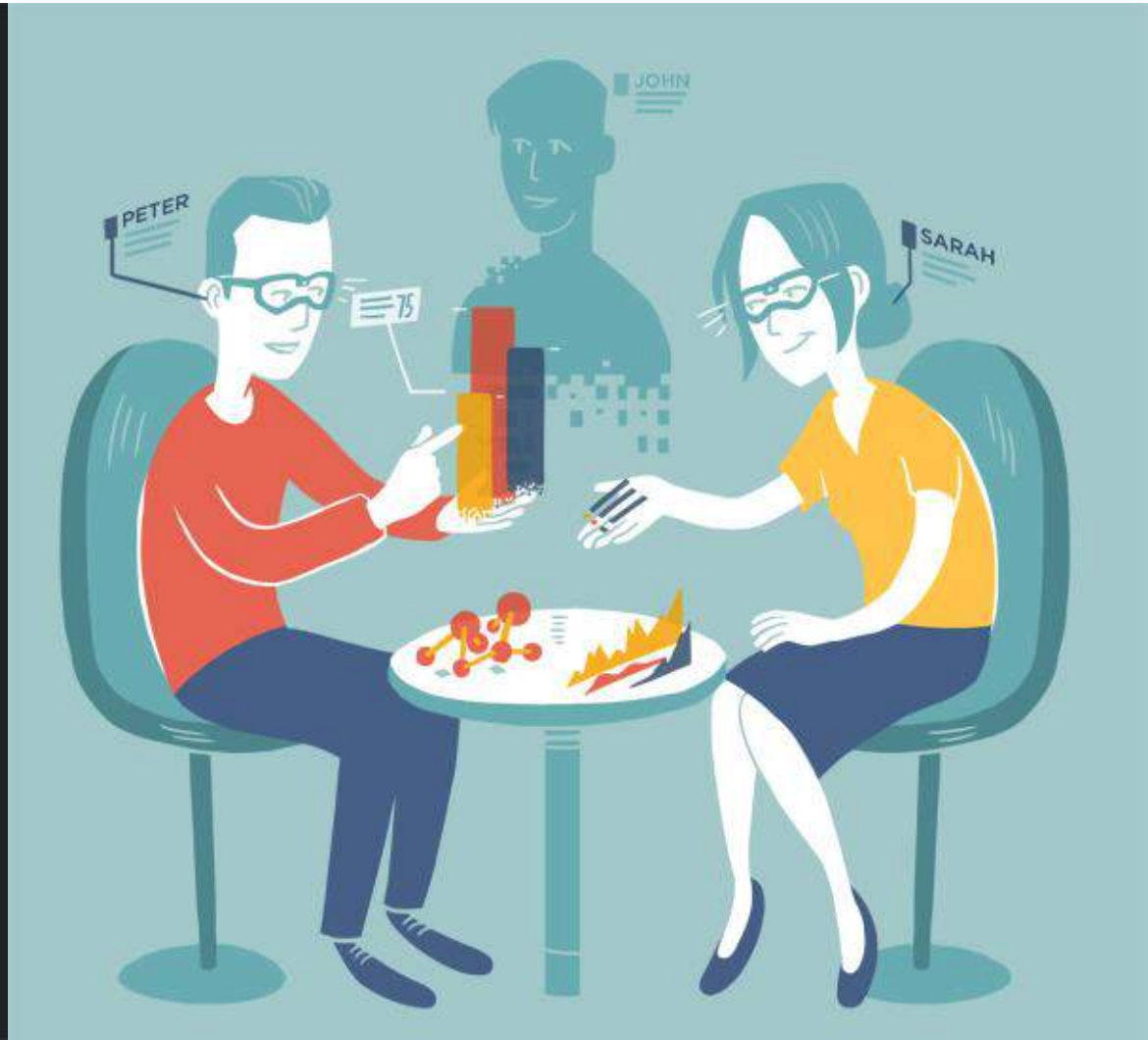
## Marriott, Dwyer, Schreiber, Thomas, Klein, Steurzlinger, Itoh, Riche Eds.



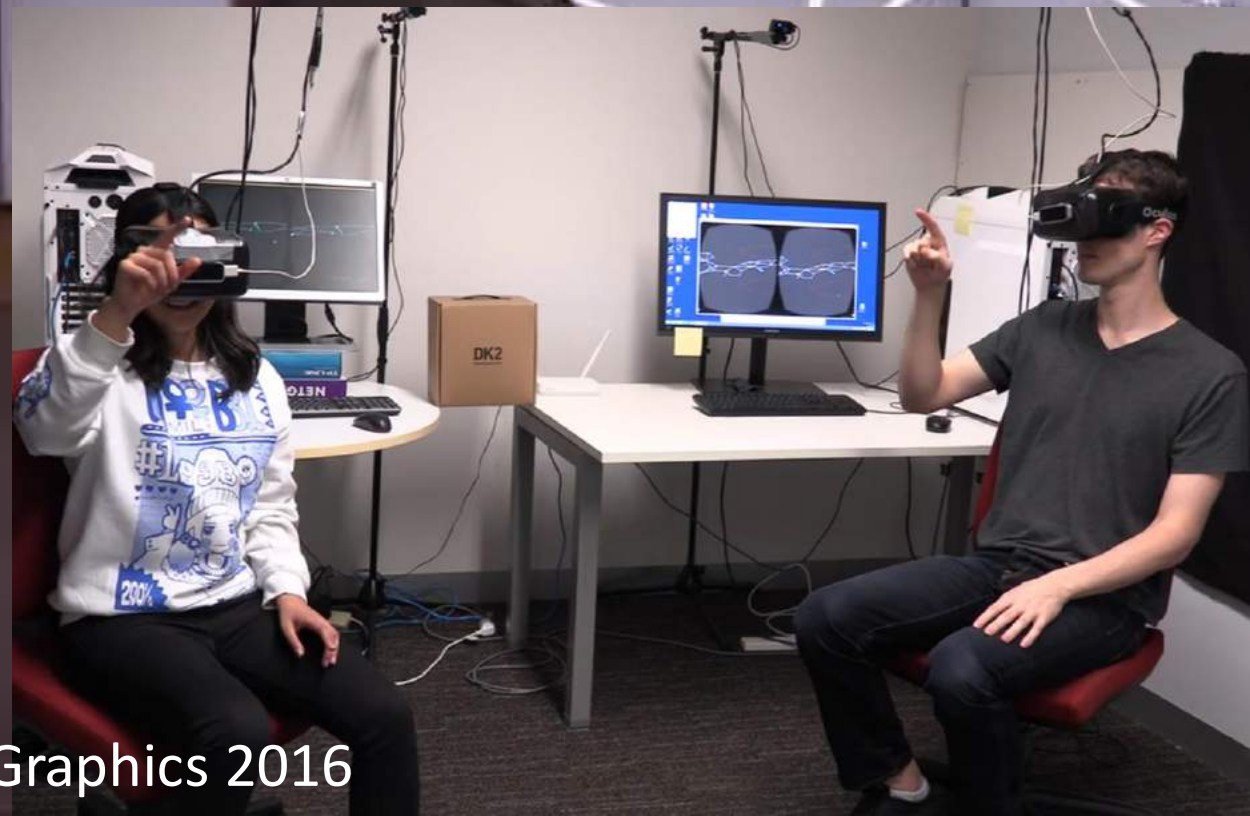

1. What is Immersive Analytics?
2. Time to Reconsider the Value of 3D for Information Visualisation
3. Multisensory Immersive Analytics
4. Interaction for Immersive Analytics
5. Immersive Human-Centered Computational Analytics
6. Immersive Visual Data Stories
7. Situated Analytics
8. Collaborative Immersive Analytics
9. Just 5 Questions: toward a design framework for Immersive Analytics
10. Immersive Analytics Applications in Life and Health Sciences
11. Exploring Immersive Analytics For Built Environments

*Published 2018*

# Immersive Analytics Research at Monash



# Immersive Collaborative Analysis of Network Connectivity: CAVE-style or Head-Mounted Display?

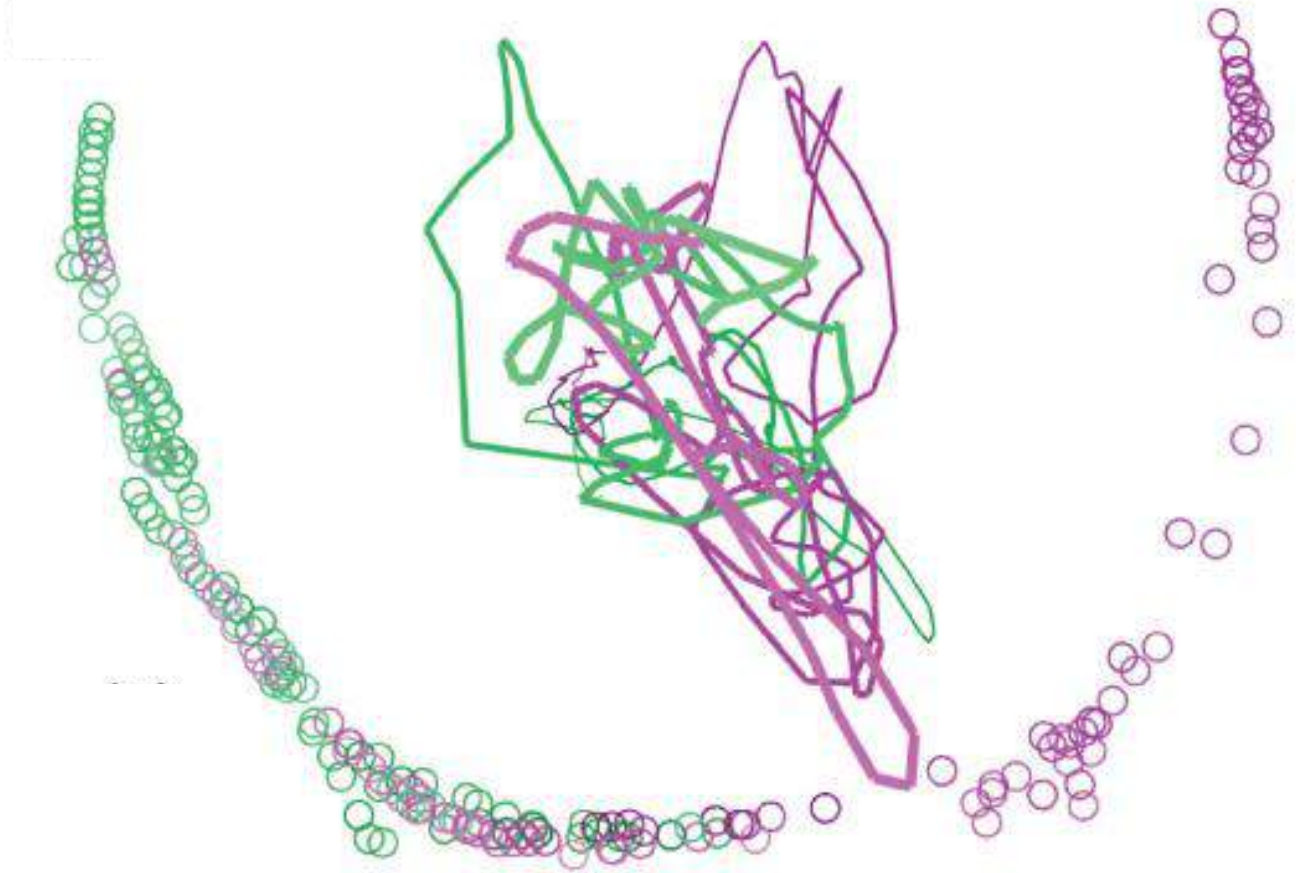


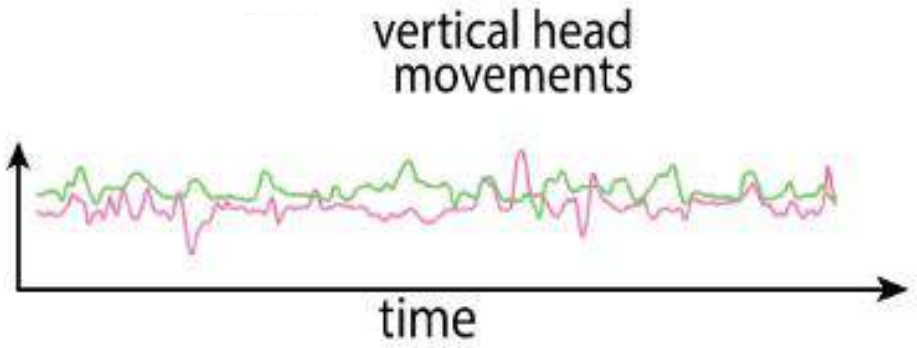

Cordeil, Dwyer, Klein, Laha, Marriott, Thomas

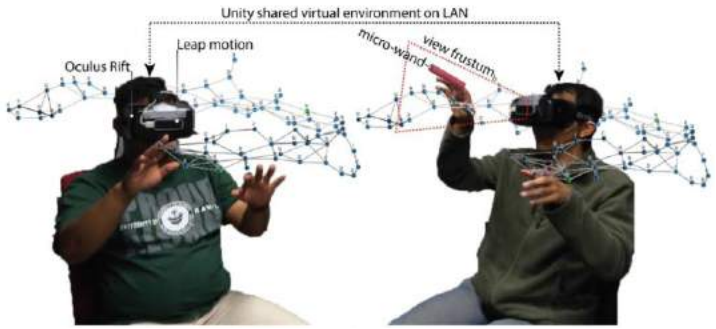
IEEE Transactions on Visualization and Computer Graphics 2016

# **Collaboration:** Positions and movements

HMDs records

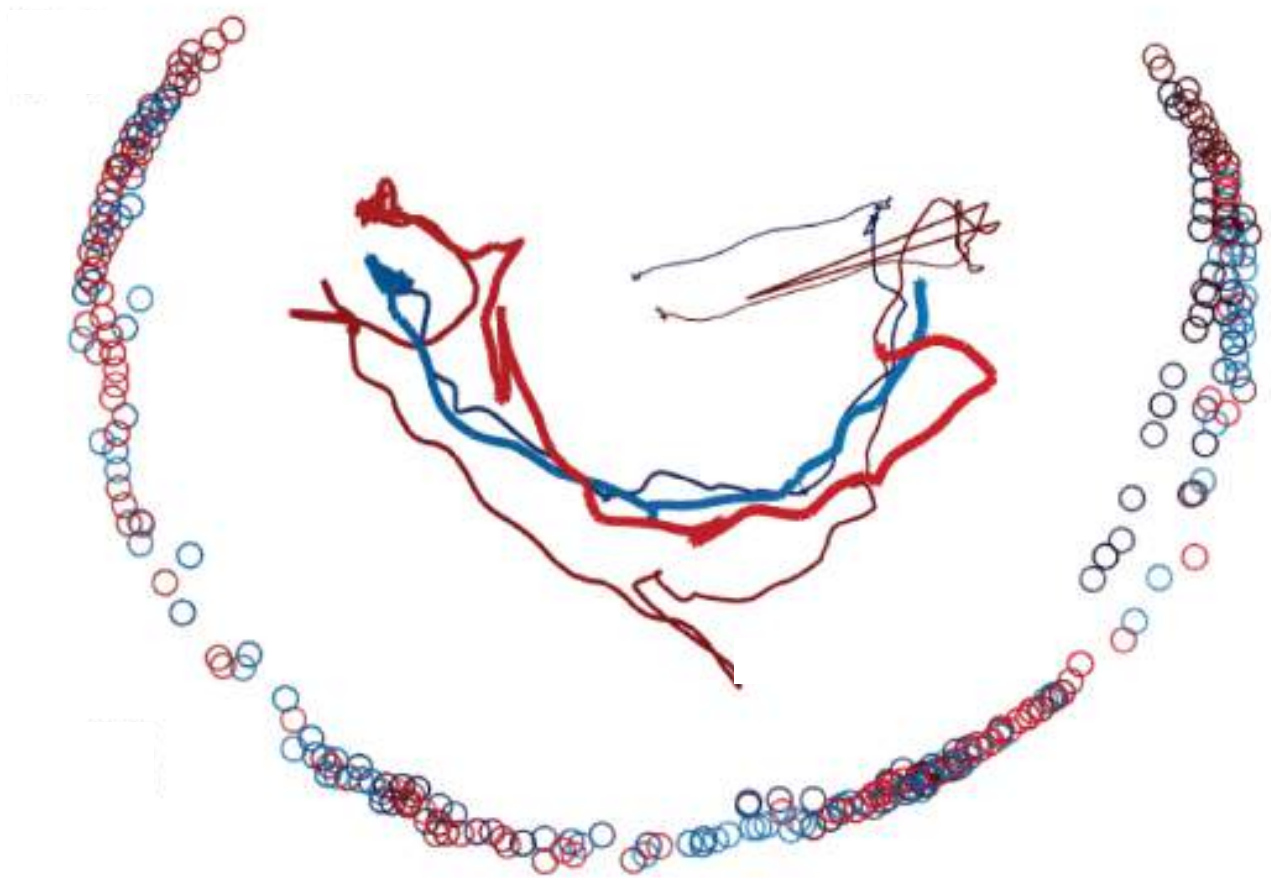


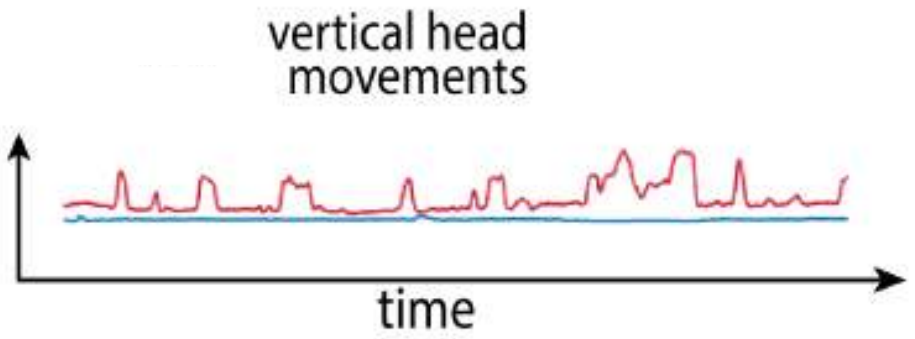


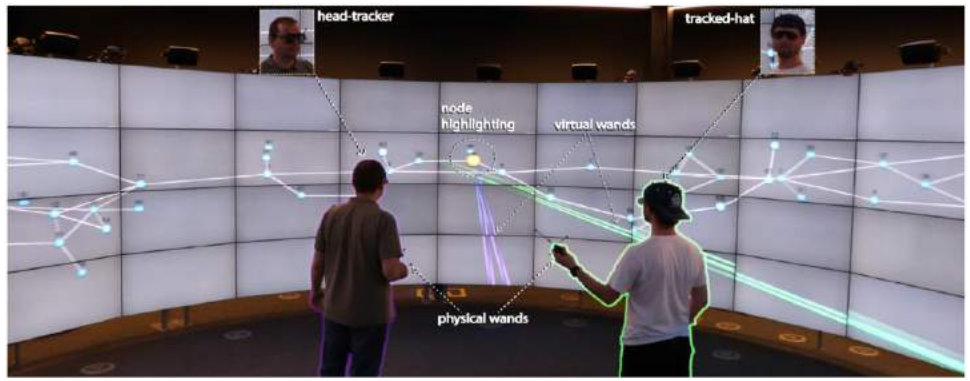



# **Collaboration:** Positions and movements

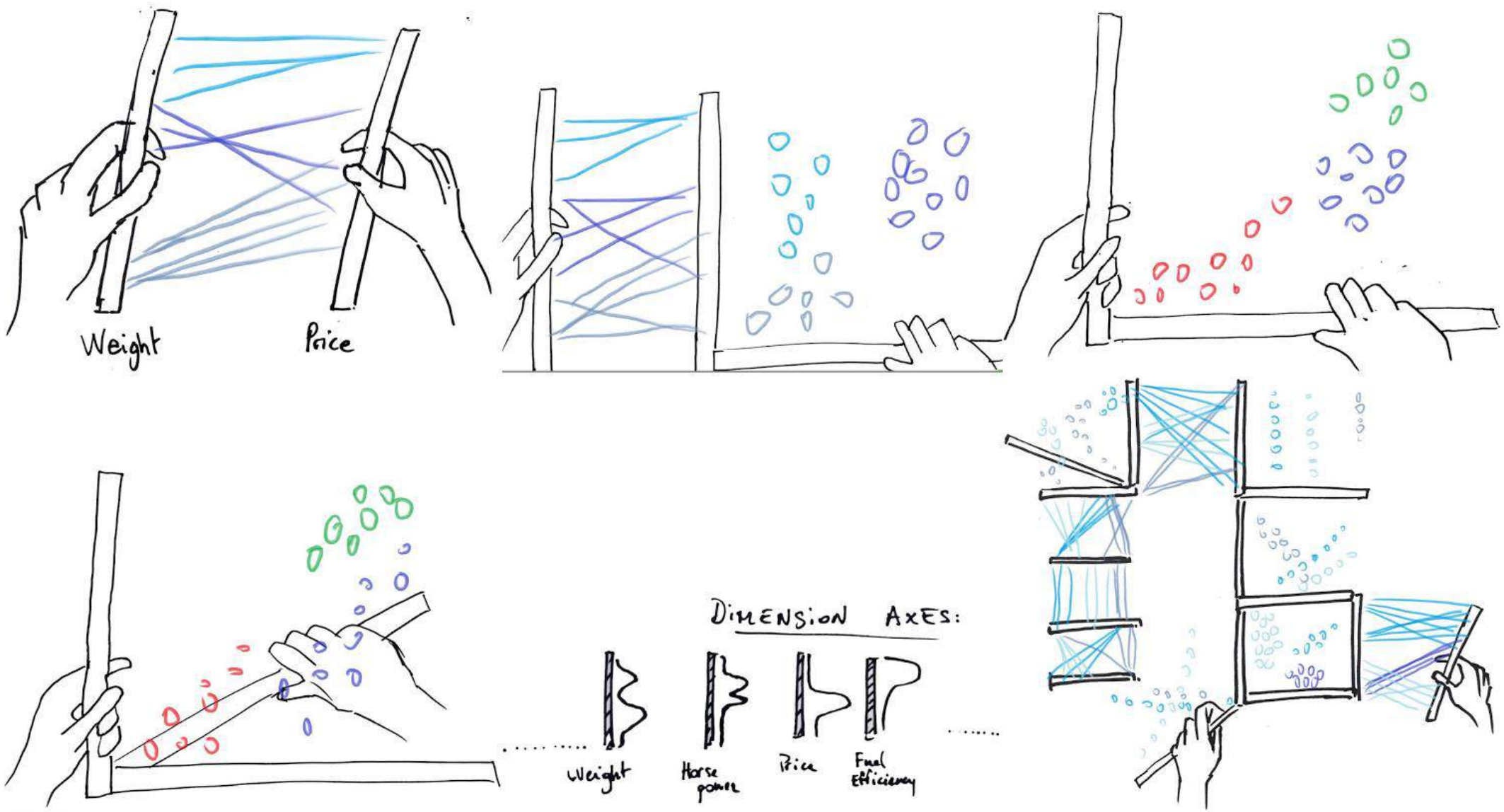
CAVE2 records



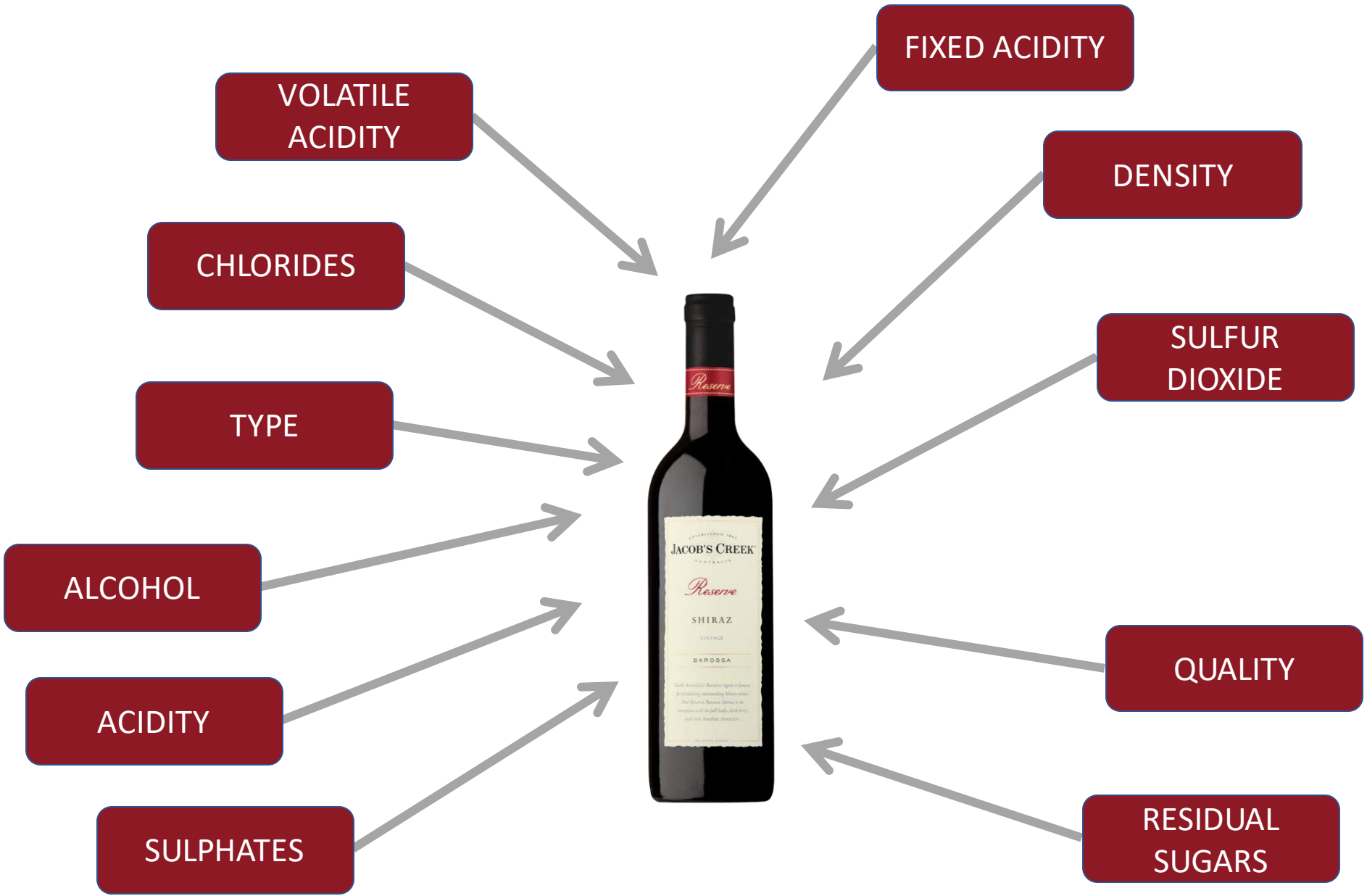


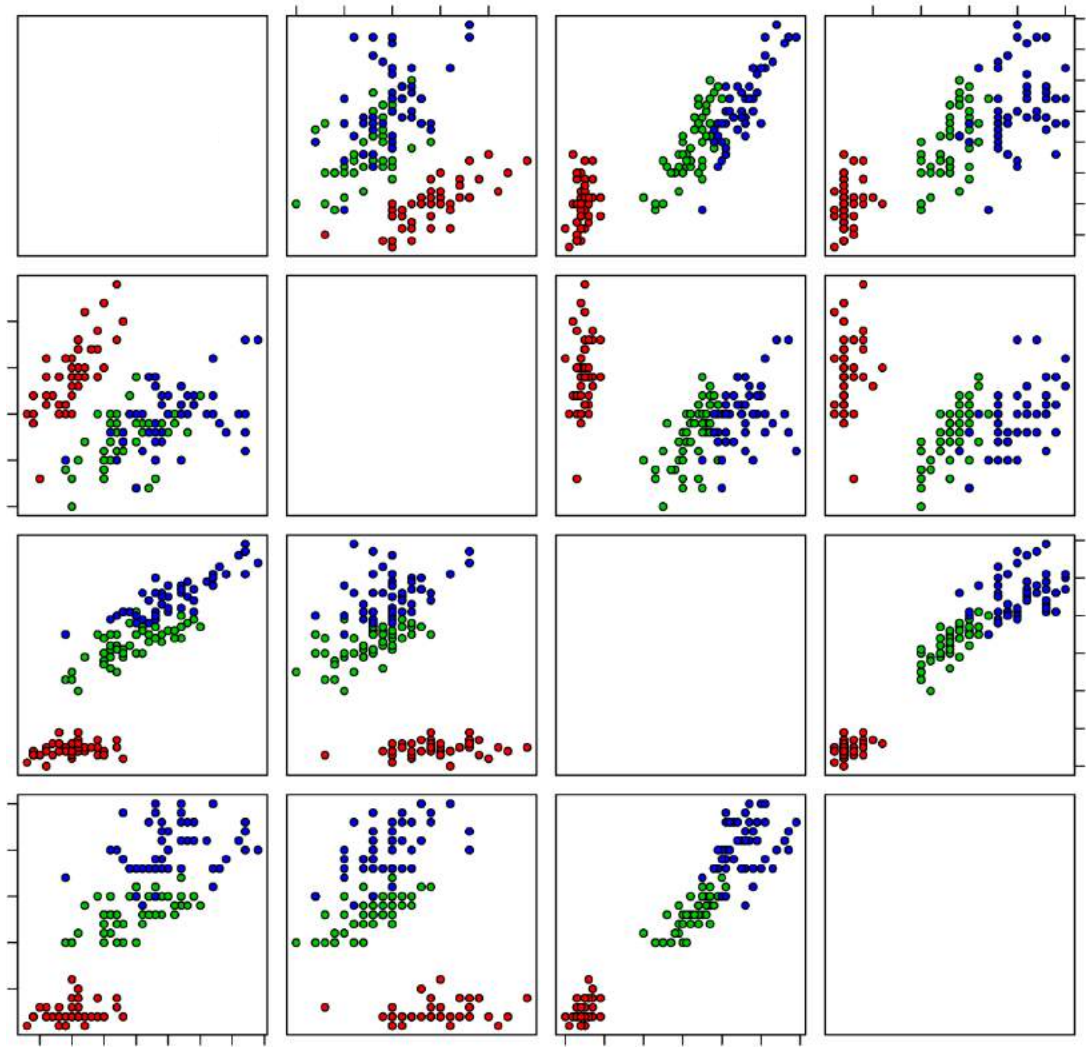
ImAxes: Immersive axes as embodied affordances for interactive multivariate data visualisation.
Cordeil, M., Cunningham, A., Dwyer, T., Thomas, B. H., & Marriott, K.
In *Proc. ACM Symp. on User Interface Software and Technology* (pp. 71-83). ACM UIST 2017



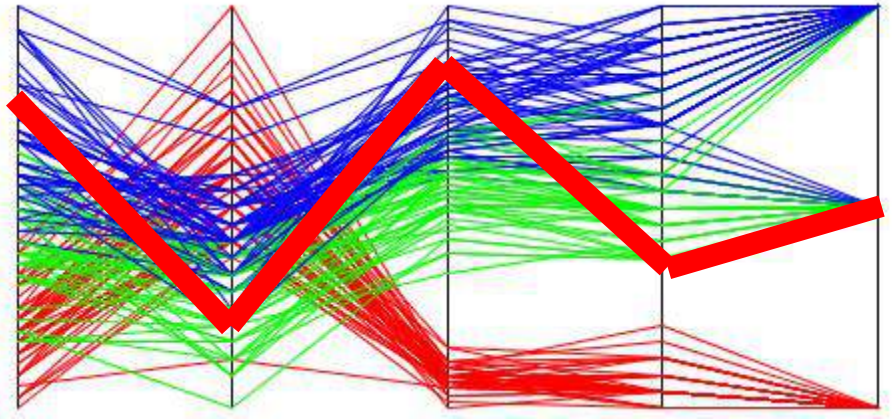
# Multidimensional data



| | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | fixed acidity | volatile acidity | citric acid | residual sugar | chlorides | free sulfur dioxide | total sulfur dioxide | density | pH | sulphates | alcohol | quality | Type |
| 2 | 7 | 0.27 | 0.36 | 20.7 | 0.045 | 45 | 170 | 1.001 | 3 | 0.45 | 8.8 | 6 | White |
| 3 | 6.3 | 0.3 | 0.34 | 1.6 | 0.049 | 14 | 132 | 0.994 | 3.3 | 0.49 | 9.5 | 6 | White |
| 4 | 8.1 | 0.28 | 0.4 | 6.9 | 0.05 | 30 | 97 | 0.9951 | 3.26 | 0.44 | 10.1 | 6 | White |
| 5 | 7.2 | 0.23 | 0.32 | 8.5 | 0.058 | 47 | 186 | 0.9956 | 3.19 | 0.4 | 9.9 | 6 | White |
| 6 | 7.2 | 0.23 | 0.32 | 8.5 | 0.058 | 47 | 186 | 0.9956 | 3.19 | 0.4 | 9.9 | 6 | White |
| 7 | 8.1 | 0.28 | 0.4 | 6.9 | 0.05 | 30 | 97 | 0.9951 | 3.26 | 0.44 | 10.1 | 6 | White |
| 8 | 6.2 | 0.32 | 0.16 | 7 | 0.045 | 30 | 136 | 0.9949 | 3.18 | 0.47 | 9.6 | 6 | White |
| 9 | 7 | 0.27 | 0.36 | 20.7 | 0.045 | 45 | 170 | 1.001 | 3 | 0.45 | 8.8 | 6 | White |
| 10 | 6.3 | 0.3 | 0.34 | 1.6 | 0.049 | 14 | 132 | 0.994 | 3.3 | 0.49 | 9.5 | 6 | White |
| 11 | 8.1 | 0.22 | 0.43 | 1.5 | 0.044 | 28 | 129 | 0.9938 | 3.22 | 0.45 | 11 | 6 | White |
| 12 | 8.1 | 0.27 | 0.41 | 1.45 | 0.033 | 11 | 63 | 0.9908 | 2.99 | 0.56 | 12 | 5 | White |
| 13 | 8.6 | 0.23 | 0.4 | 4.2 | 0.035 | 17 | 109 | 0.9947 | 3.14 | 0.53 | 9.7 | 5 | White |
| 14 | 7.9 | 0.18 | 0.37 | 1.2 | 0.04 | 16 | 75 | 0.992 | 3.18 | 0.63 | 10.8 | 5 | White |
| 15 | 6.6 | 0.16 | 0.4 | 1.5 | 0.044 | 48 | 143 | 0.9912 | 3.54 | 0.52 | 12.4 | 7 | White |
| 16 | 8.3 | 0.42 | 0.62 | 19.25 | 0.04 | 41 | 172 | 1.0002 | 2.98 | 0.67 | 9.7 | 5 | White |
| 17 | 6.6 | 0.17 | 0.38 | 1.5 | 0.032 | 28 | 112 | 0.9914 | 3.25 | 0.55 | 11.4 | 7 | White |
| 18 | 6.3 | 0.48 | 0.04 | 1.1 | 0.046 | 30 | 99 | 0.9928 | 3.24 | 0.36 | 9.6 | 6 | White |
| 19 | 6.2 | 0.66 | 0.48 | 1.2 | 0.029 | 29 | 75 | 0.9892 | 3.33 | 0.39 | 12.8 | 8 | White |
| 20 | 7.4 | 0.34 | 0.42 | 1.1 | 0.033 | 17 | 171 | 0.9917 | 3.12 | 0.53 | 11.3 | 6 | White |
| 21 | 6.5 | 0.31 | 0.14 | 7.5 | 0.044 | 34 | 133 | 0.9955 | 3.22 | 0.5 | 9.5 | 5 | White |
| 22 | 6.2 | 0.66 | 0.48 | 1.2 | 0.029 | 29 | 75 | 0.9892 | 3.33 | 0.39 | 12.8 | 8 | White |
| 23 | 6.4 | 0.31 | 0.38 | 2.9 | 0.038 | 19 | 102 | 0.9912 | 3.17 | 0.35 | 11 | 7 | White |
| 24 | 6.8 | 0.26 | 0.42 | 1.7 | 0.049 | 41 | 122 | 0.993 | 3.47 | 0.48 | 10.5 | 8 | White |
| 25 | 7.6 | 0.67 | 0.14 | 1.5 | 0.074 | 25 | 168 | 0.9937 | 3.05 | 0.51 | 9.3 | 5 | White |
| 26 | 6.6 | 0.27 | 0.41 | 1.3 | 0.052 | 16 | 142 | 0.9951 | 3.42 | 0.47 | 10 | 6 | White |
| 27 | 7 | 0.25 | 0.32 | 9 | 0.046 | 56 | 245 | 0.9955 | 3.25 | 0.5 | 10.4 | 6 | White |
| 28 | 6.9 | 0.24 | 0.35 | 1 | 0.052 | 35 | 146 | 0.993 | 3.45 | 0.44 | 10 | 6 | White |
| 29 | 7 | 0.28 | 0.39 | 8.7 | 0.051 | 32 | 141 | 0.9961 | 3.38 | 0.53 | 10.5 | 6 | White |
| 30 | 7.4 | 0.27 | 0.48 | 1.1 | 0.047 | 17 | 132 | 0.9914 | 3.19 | 0.49 | 11.6 | 6 | White |
| 31 | 7.2 | 0.32 | 0.36 | 2 | 0.033 | 37 | 114 | 0.9906 | 3.1 | 0.71 | 12.3 | 7 | White |
| 32 | 8.5 | 0.24 | 0.39 | 10.4 | 0.044 | 20 | 142 | 0.9974 | 3.2 | 0.53 | 10 | 6 | White |
| 33 | 8.3 | 0.14 | 0.34 | 1.1 | 0.042 | 7 | 47 | 0.9934 | 3.47 | 0.4 | 10.2 | 6 | White |
| 34 | 7.4 | 0.25 | 0.36 | 2.05 | 0.05 | 31 | 100 | 0.992 | 3.19 | 0.44 | 10.8 | 6 | White |
| 35 | 6.2 | 0.12 | 0.34 | 1.5 | 0.045 | 43 | 117 | 0.9939 | 3.42 | 0.51 | 9 | 6 | White |
| 36 | 5.8 | 0.27 | 0.2 | 14.95 | 0.044 | 22 | 179 | 0.9962 | 3.37 | 0.37 | 10.2 | 5 | White |
| 37 | 7.3 | 0.28 | 0.43 | 1.7 | 0.08 | 21 | 123 | 0.9905 | 3.19 | 0.42 | 12.8 | 5 | White |
| 38 | 6.5 | 0.39 | 0.23 | 5.4 | 0.051 | 25 | 149 | 0.9934 | 3.24 | 0.35 | 10 | 5 | White |
| 39 | 7 | 0.33 | 0.32 | 1.2 | 0.053 | 38 | 138 | 0.9906 | 3.13 | 0.28 | 11.2 | 6 | White |
| 40 | 7.3 | 0.24 | 0.39 | 17.95 | 0.057 | 45 | 149 | 0.9999 | 3.21 | 0.36 | 8.6 | 5 | White |
| 41 | 7.3 | 0.24 | 0.39 | 17.95 | 0.057 | 45 | 149 | 0.9999 | 3.21 | 0.36 | 8.6 | 5 | White |
| 42 | 6.7 | 0.23 | 0.39 | 2.5 | 0.172 | 63 | 158 | 0.9937 | 3.11 | 0.36 | 9.4 | 6 | White |
| 43 | 6.7 | 0.24 | 0.39 | 2.9 | 0.173 | 63 | 157 | 0.9937 | 3.1 | 0.34 | 9.4 | 6 | White |
| 44 | 7 | 0.31 | 0.26 | 7.4 | 0.069 | 28 | 160 | 0.9954 | 3.13 | 0.46 | 9.8 | 6 | White |
| 45 | 6.6 | 0.24 | 0.27 | 1.4 | 0.057 | 33 | 152 | 0.9934 | 3.22 | 0.56 | 9.5 | 6 | White |
| 46 | 6.7 | 0.23 | 0.26 | 1.4 | 0.06 | 33 | 154 | 0.9934 | 3.24 | 0.56 | 9.5 | 6 | White |
| 47 | 7.4 | 0.18 | 0.31 | 1.4 | 0.058 | 38 | 167 | 0.9931 | 3.16 | 0.53 | 10 | 7 | White |
| 48 | 6.2 | 0.45 | 0.26 | 4.4 | 0.063 | 63 | 206 | 0.994 | 3.27 | 0.52 | 9.8 | 4 | White |
| 49 | 6.2 | 0.46 | 0.25 | 4.4 | 0.066 | 62 | 207 | 0.9939 | 3.25 | 0.52 | 9.8 | 5 | White |
| 50 | 7 | 0.31 | 0.26 | 7.4 | 0.069 | 28 | 160 | 0.9954 | 3.13 | 0.46 | 9.8 | 6 | White |
| 51 | 6.9 | 0.19 | 0.35 | 5 | 0.067 | 32 | 150 | 0.995 | 3.36 | 0.48 | 9.8 | 5 | White |
| 52 | 7.2 | 0.19 | 0.31 | 1.6 | 0.062 | 31 | 173 | 0.9917 | 3.35 | 0.44 | 11.7 | 6 | White |
| 53 | 6.6 | 0.25 | 0.29 | 1.1 | 0.068 | 39 | 124 | 0.9914 | 3.34 | 0.58 | 11 | 7 | White |
| 54 | 6.2 | 0.16 | 0.33 | 1.1 | 0.057 | 21 | 82 | 0.991 | 3.32 | 0.46 | 10.9 | 7 | White |
| 55 | 6.4 | 0.18 | 0.35 | 1 | 0.045 | 39 | 108 | 0.9911 | 3.31 | 0.35 | 10.9 | 6 | White |
| 56 | 6.8 | 0.2 | 0.59 | 0.9 | 0.147 | 38 | 132 | 0.993 | 3.05 | 0.38 | 9.1 | 6 | White |
| 57 | 6.9 | 0.25 | 0.35 | 1.3 | 0.039 | 29 | 191 | 0.9908 | 3.13 | 0.52 | 11 | 6 | White |
| 58 | 7.2 | 0.21 | 0.34 | 11.9 | 0.043 | 37 | 213 | 0.9962 | 3.09 | 0.5 | 9.6 | 6 | White |
| 59 | 6 | 0.19 | 0.26 | 12.4 | 0.048 | 50 | 147 | 0.9972 | 3.3 | 0.36 | 8.9 | 6 | White |

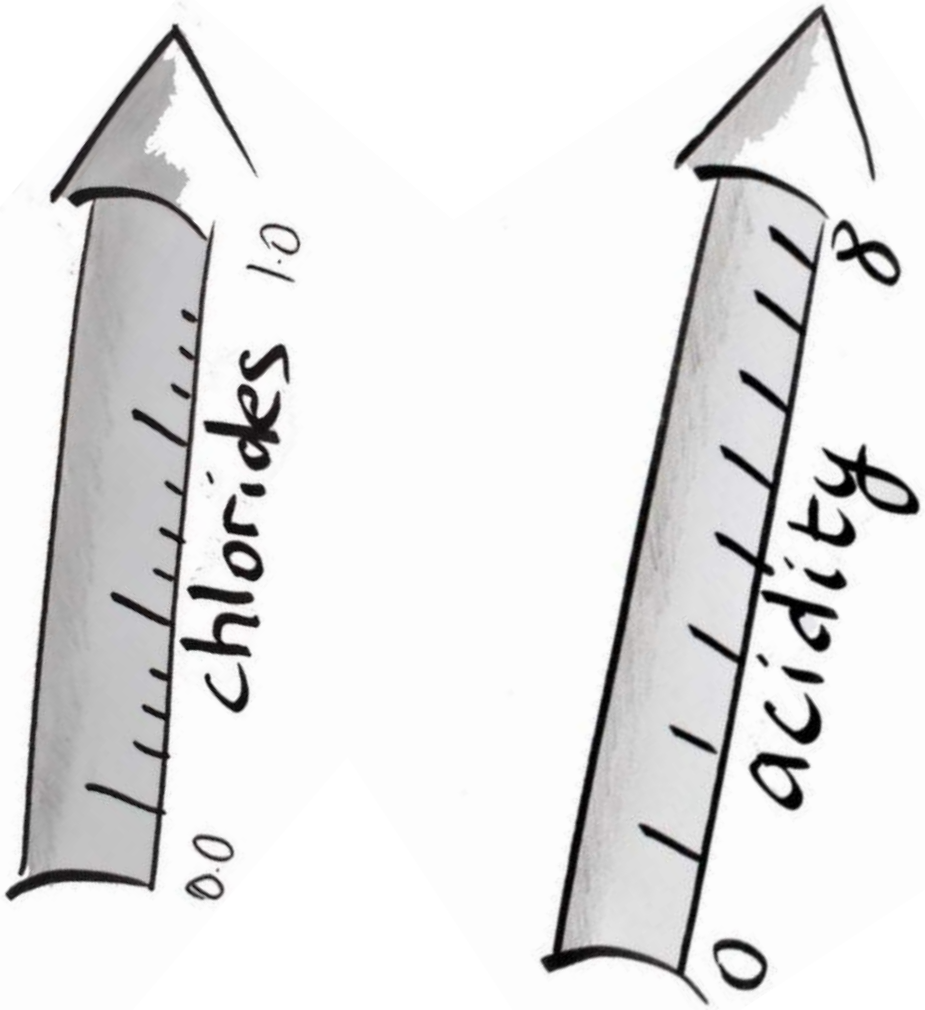


Scatterplot Matrix



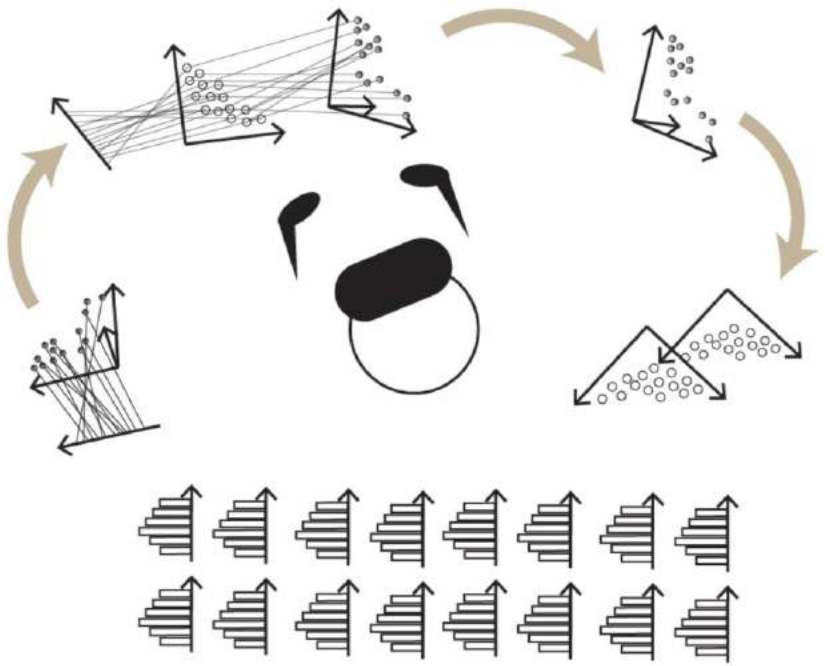
Parallel coordinates

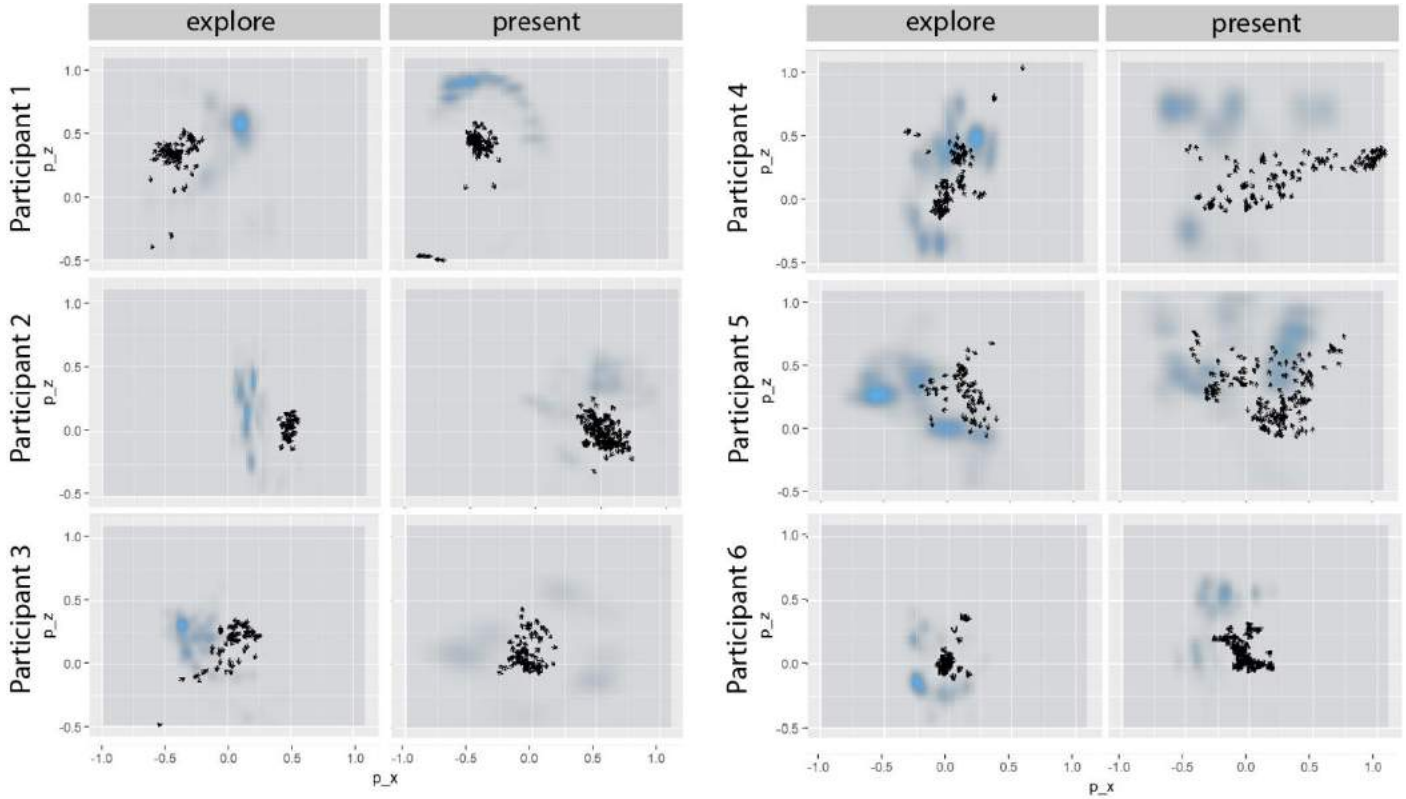
# Axes as embodied* affordances**

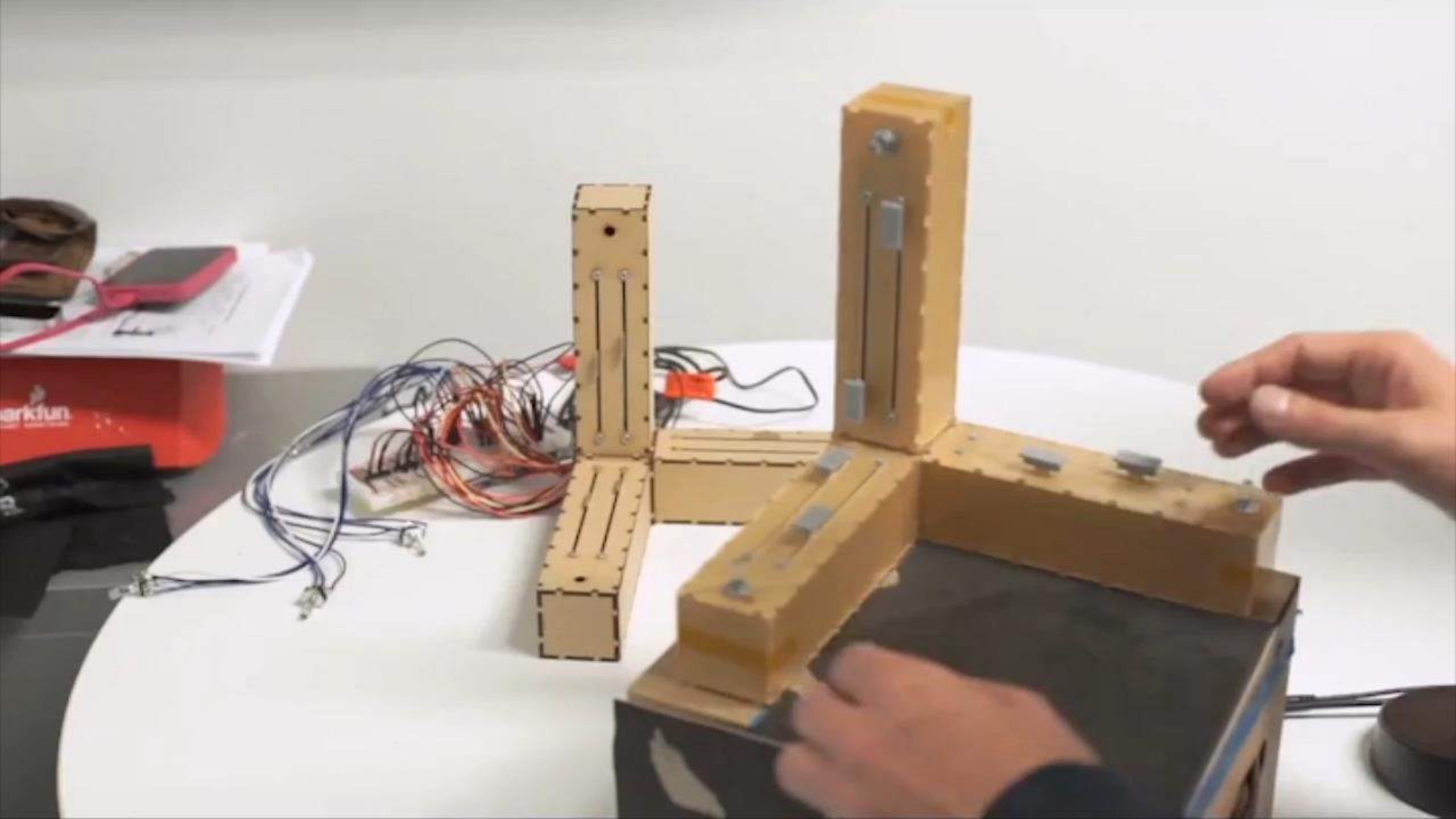



* Dourish, P. (2004)
** DA Norman (2002)

There Is No Spoon: Evaluating Performance, Space Use, and Presence with Expert Domain Users in Immersive Analytics.
Batch A, Cunningham A, Cordeil M, Elmqvist N, Dwyer T, Thomas BH, Marriott K.
*IEEE Transactions on Visualization and Computer Graphics, 2019*



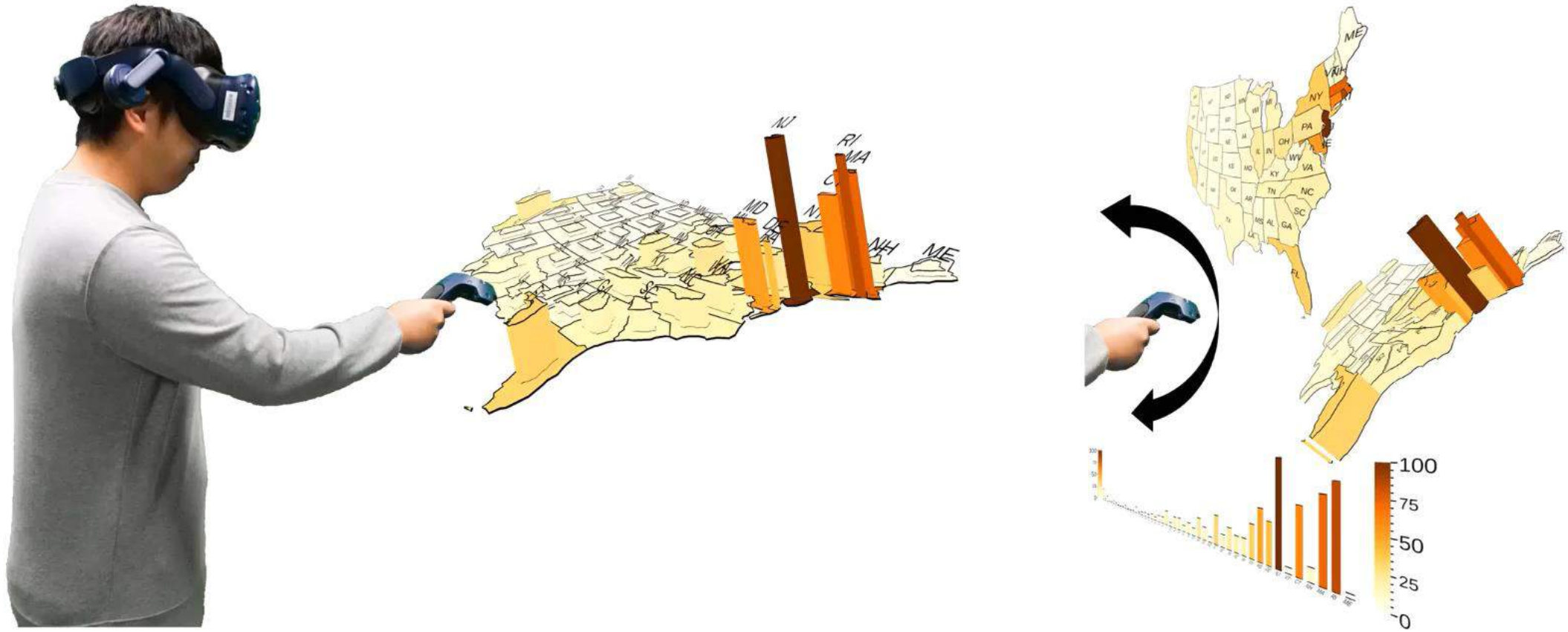




# Shared Surfaces and Spaces: Collaborative Data Visualisation in a Co-located Immersive Environment

Benjamin Lee, Maxime Cordeil, Arnaud Prouzeau,
Bernhard Jenny, and Tim Dwyer

Accompanying Video
IEEE VIS 2019




# Tilt Map: Interactive Transitions Between 2D Choropleth Map, 3D Prism Map and Bar Chart in Immersive Environments

# In-Situ Mixed Reality Data Visualisation