# Interactive Parallel-Coordinates

## A Bridge between Probabilistic and Deterministic

Ming HU, AESO

2022 CIGRE CANADA CONFERENCE & EXPOSITION

# Background

The power system has evolved over past few decades towards more decentralization, more integration of variable renewable sources and distributed energy sources. These trends bring more variability and uncertainty for system operation and planning, that deserves more focus and shift towards using probabilistic methods in power system reliability assessment

However, due to being highly abstract and computationally demanding, probabilistic methods are still facing challenges in full implementation. Even the pioneering specialists believe that "it is quite likely that deterministic approaches will continue to be used widely in practice. In this case, **a bridge between the two approaches** (probabilistic and deterministic) may be a valuable way forward."[2]

# Deterministic v/s Probabilistic in Concept

| | Deterministic | Probabilistic |
|---|---|---|
| Scope | Microscopic, Micro-states | Macroscopic, Macro-state |
| Focus | Individual state performance<br>With clearly defined credible condition(s): system peak, min wind … | Overall system behavior<br>LOLP, ENS … |
| Reality or abstraction | Reality details | Abstraction |
| Practice context | Simulation (more reality) | Statistical, Monte-Carlo simulation |
| Reality or abstraction | Operation (Operational) | Planning (strategical) |
| Limitation | Limited number of scenario(s) | Simplification |
| Perspective | Bottom-up | Top-down |
| Thinking orientation | T-domain (as in practice) | F-domain (pattern in long-term planning horizon) |

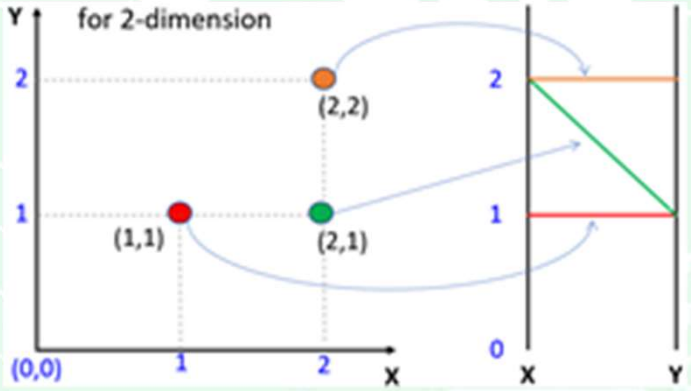
# Parallel Coordinates History (Wikipedia) & Concept)

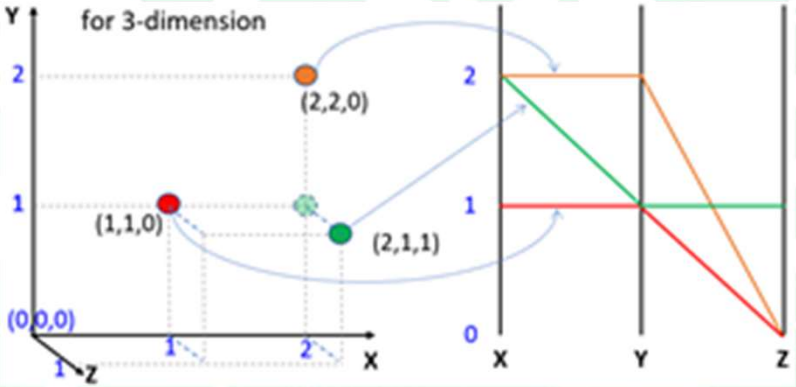
Parallel Coordinates are a common way of visualizing high-dimensional geometry and analyzing multivariate data.

"invented" by Philbert Maurice d'Ocagne (fr) in 1885

first used by Henry Gannetts in 1880

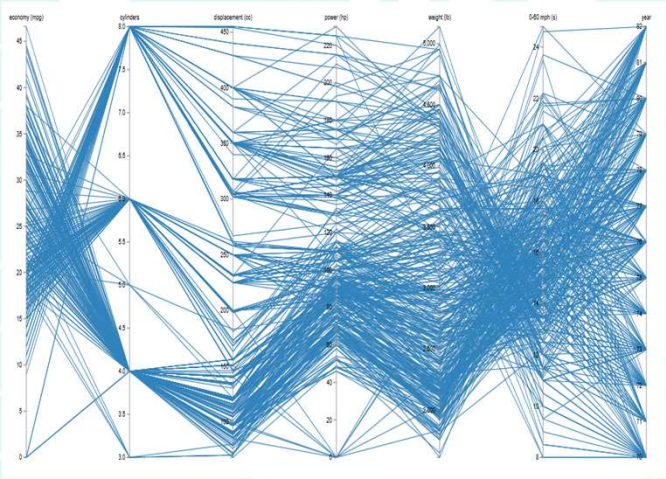
Organize multiple dimensions / coordinates in parallel (other than perpendicular – max out at 3 in physical space)



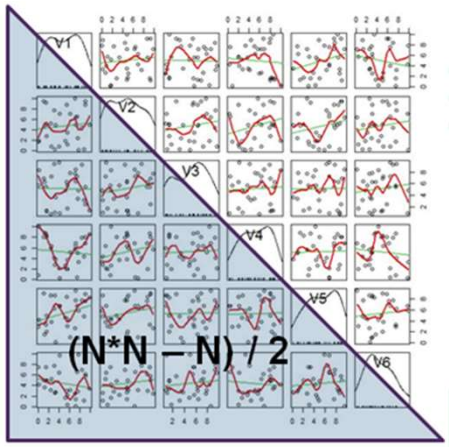
# Combined with Data Visualization Technique
## - to Enhance Parallel Thinking

Recent advancement of data interactive & visualization techniques (such as D3.js, web-based Data-Driven Document) make it more convenient and more powerful to enhance more efficient & transparent parallel thinking / analysis / communication



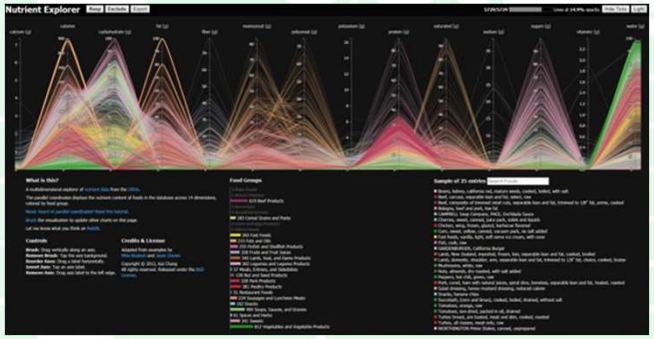
1 N-dimension PC chart ➔ N*(N-1)/2 scatter charts

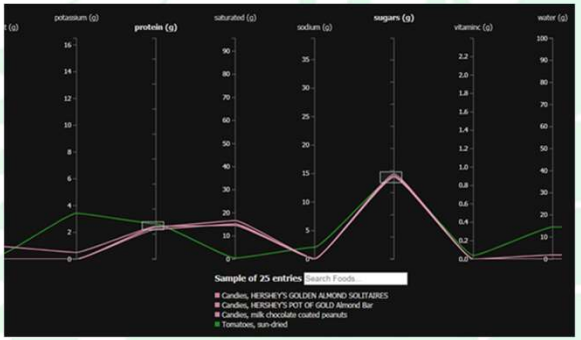
| Dimensions | Scatter $C_{(N,2)}$ |
|---|---|
| 5 | 10 |
| 10 | 45 |
| 20 | 190 |
| 30 | 435 |



# Applications in Action – Interactive Demo

Example of Food Nutrient Explorer http://bl.ocks.org/syntagmatic/raw/3150059/

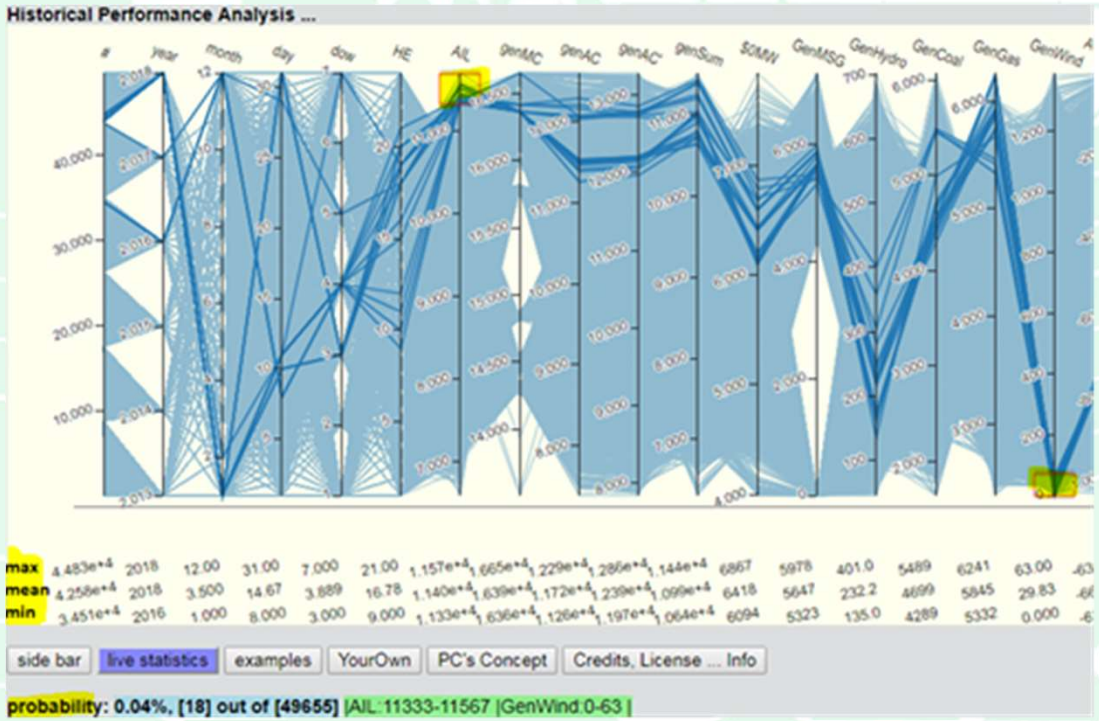



Examples for Power System Performance

- Historical performance analysis
- Future Performance assessment (forecast analysis)

# Interactive Demo
## for Historical System Performance

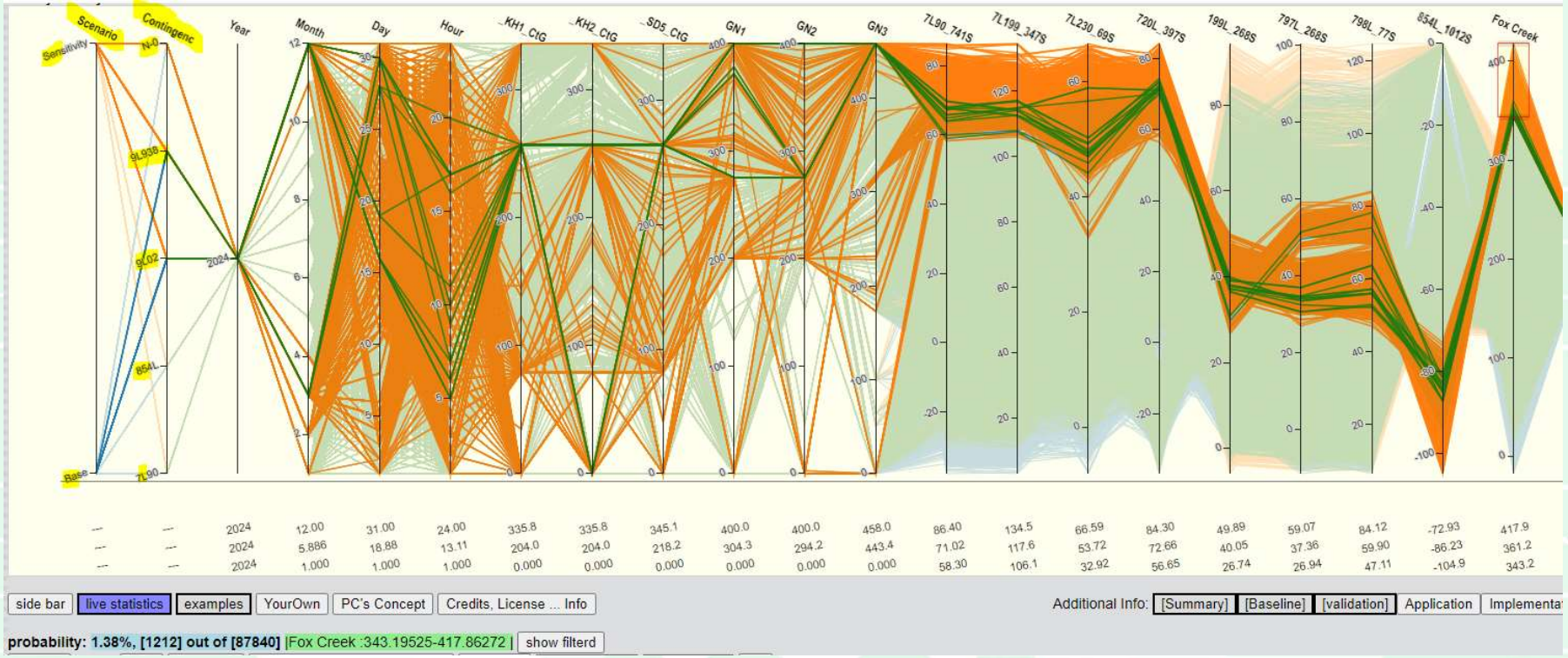



To investigate and have better understanding

- condition outliers and risk level
- condition correlation / pattern

To make representative & credible study conditions / assumptions

# **Interactive Demo**
## for Future Performance Assessment



# Discussion

## Applicable through the whole analysis process

- Start with scoping & assumptions: based on better understanding of historical situation / performance
- Analysis: reveal / find patterns and outliers … debugging & making sense of analysis / simulation results
- End with efficient, transparent and defendable results **communication** to facilitate / engage **common understanding** and solution

## Implementation

- Identify all key factors (coordinates) of your analysis (problem)
- Collect & prepare the data as a multi-column CSV file
- Share your interactive dashboard through a web-link and web-browser (Chrome, Firefox, Edge or IE later version)
- Customize / enhance

# Conclusion

- Promote & coordinate & enhance the capability of Parallel & Cross thinking, robust reasoning and clear communication
  - Enhance analysis / thinking capability Wider & Deeper at the same time
- Enable Bi-Directional thinking:
  - Details-Focus without losing / sacrificing overall big picture (context, background, inter-relations …)
  - Strategy-Focus without losing practice details and reality
- Bridge the gaps between the Bottom-Up (practicing details) and Top-Down (drive decision-making)
  - **Probabilistic v/s Deterministic planning**
  - system overall metrics (highly-aggregated / abstracted / summarized) v/s practice details (time-sequential) in reality

# Thank You


[1] Wikipedia, Parallel coordinates [online] https://en.wikipedia.org/wiki/Parallel_coordinates

[2] R. Allan, R. Billinton, Probabilistic assessment of power systems. IEEE PROCEEDINGS OF THE IEEE, VOL. 88, NO. 2, FEBRUARY 2000 https://ieeexplore.ieee.org/document/823995

[3] M. Schilling, J. Souza, M. Filho, Power System Probabilistic Reliability Assessment: Current Procedures in Brazil, IEEE TRANSACTIONS ON POWER SYSTEMS, VOL. 23, NO. 3, AUGUST 2008

[4] Wikipedia, Statistical physics [online] https://en.wikipedia.org/wiki/Statistical_physics

[5] K. Zhang, Nutrient Explorer [online] http://bl.ocks.org/syntagmatic/raw/3150059/

[6] K. Zhang, A visual toolkit for multidimensional detectives [online] https://syntagmatic.github.io/parallel-coordinates/

[7] Mike Bostock, Data-Driven Documents [online], https://d3js.org/