

05-1 Time

Monday, May 1, 2023 4:56 PM

Time I

Sungahn Ko

HAIv

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- Slides in this course courtesy of
 - Dr. Abish Malik (Purdue)
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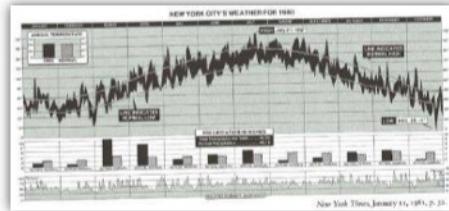
The Eyes Have It: Temporal Data

- Shneiderman 1996:
 - Timelines are widely used
 - **Examples:** medical records, project management, or historical presentations
 - **Data type separate from 1-dimensional data**
 - Distinction from 1D data
 - Items have a start and finish time
 - Items may overlap
 - **Frequent tasks**
 - Finding events before, after, or during period or moment
 - Basic tasks

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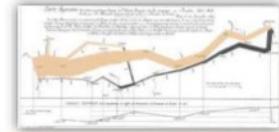
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Edward Tufte



"A random sample of 4,000 graphics drawn from 15 of the world's newspapers and magazines found that more than 75% of all the graphics published were time-series."

- *The Visual Display of Quantitative Information*



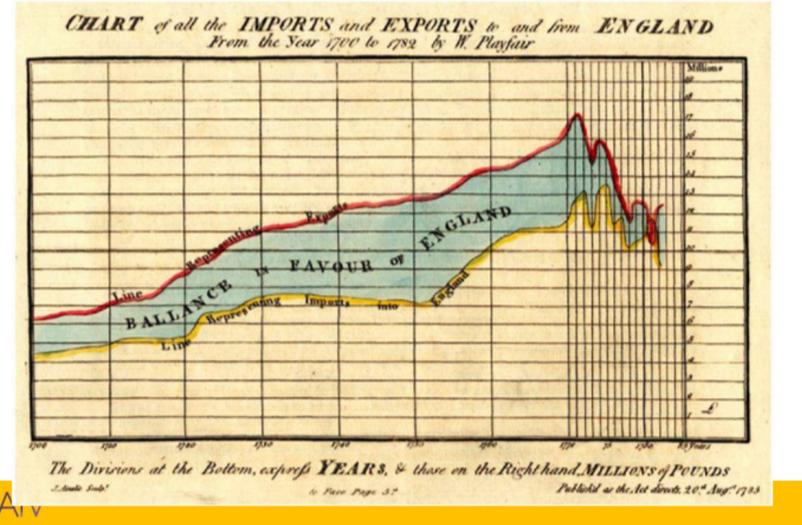
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[Playfair, 1785]

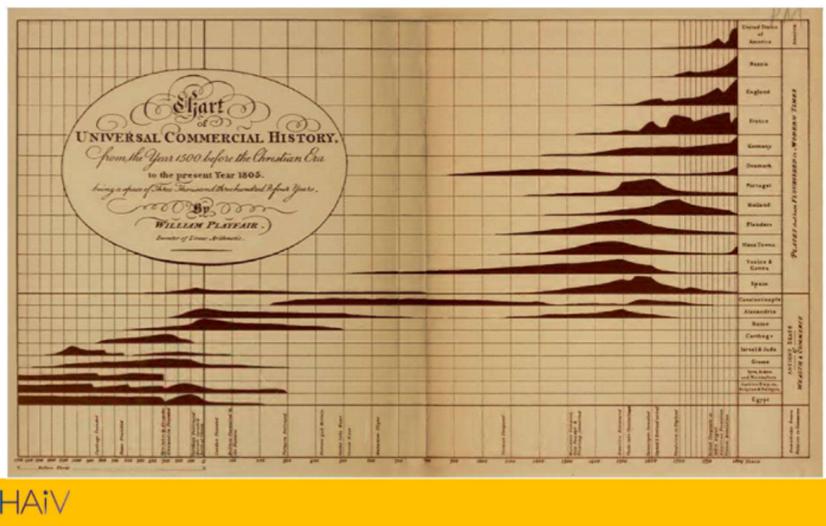
Example: William Playfair (1759-1823)



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[Playfair, 1805]

Example: William Playfair (1759-1823)

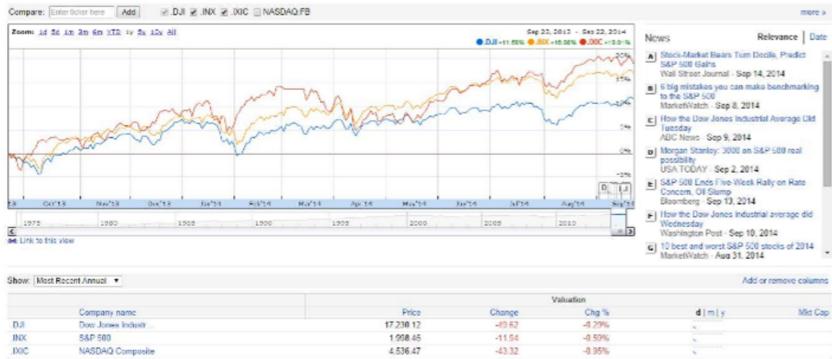


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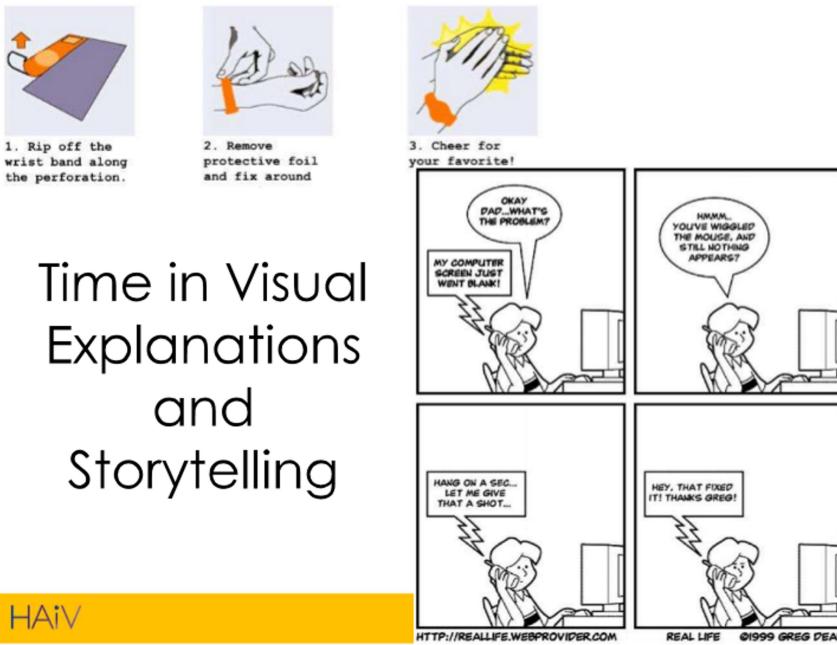
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Example: Google Finance



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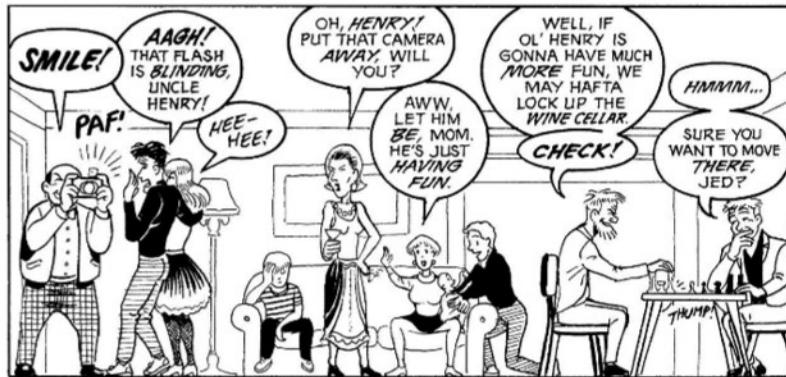


Time in Visual Explanations and Storytelling

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Time in Storytelling



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Temporal Data



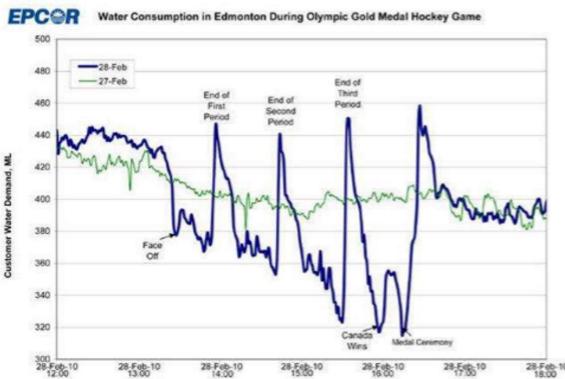
- Almost all data has a temporal component
 - Finance – stock prices, exchange rates, etc
 - Science – temperature, acidity, voltage, etc
 - Demographics – crime rate, education level, etc
- Goal:** temporal data analysis
 - Anomaly detection
 - Analysis (correlation + prediction)
 - Visualization for graphical representations
 - Interact/navigate/manipulate

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Classic Temporal Visualization

- Time on X-axis, value on Y-axis

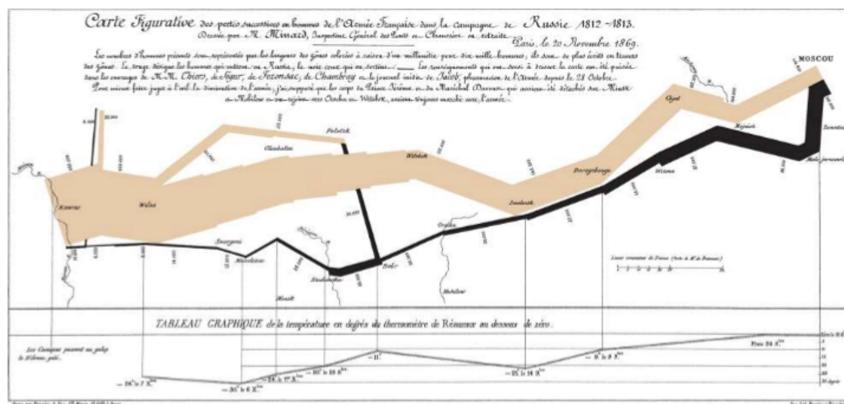


<http://chrisblattman.com/2010/03/08/graph-of-the-day-canadians-pee-between-periods/>

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Napoleon's March (Charles Minard)



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Temporal Analysis: Tasks

- ?? overview (multiple + long series)
 - ?? across + within time series
 - ?? temporal series
 - ?? patterns (cyclic or not)
 - ?? anomalies (outliers)
 - ?? cause and effect
 - ?? details about specific events
- Seeing
Comparing
Querying
Finding
Finding
Understanding
Seeing

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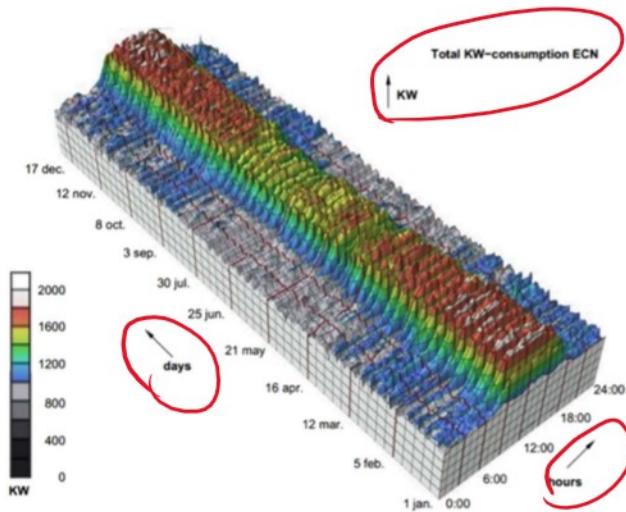
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Grand question
↳

Why is
temporal data analysis
difficult?

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Challenge 1: ?? Long Time Periods

- Many individual measurements
- Patterns often have different scale
 - Daily, weekly, monthly, yearly, etc
- Example:
 - 100 years of daily ocean temperature
 - 10 years of stock market data
 - 1 week of web server logs
- Solution: Compress (aggregate) time

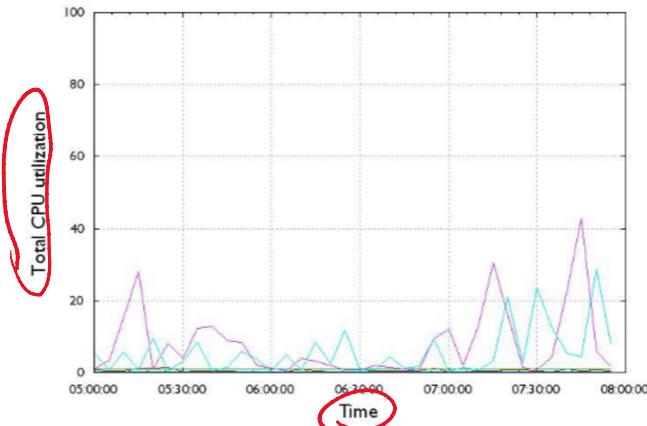
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[McLachlan, CHI 2008]

Example: Monitoring Time Series

CPU utilization over time



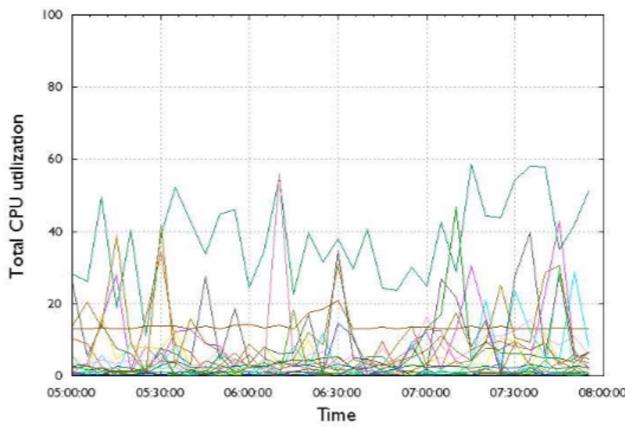
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[McLachlan, CHI 2008]

Example: Monitoring Time Series

CPU utilization over time

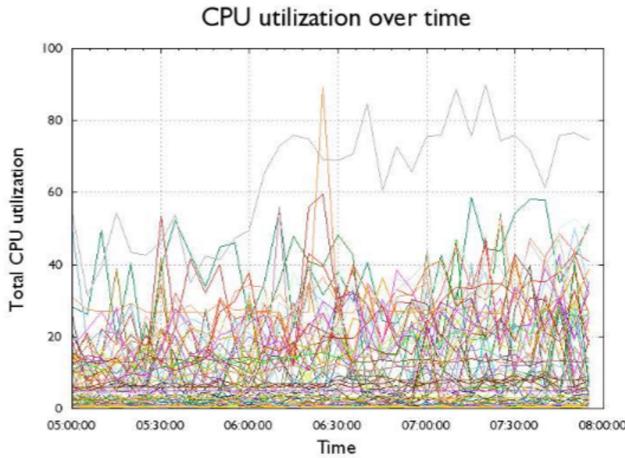


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[McLachlan, CHI 2008]

Example: Monitoring Time Series

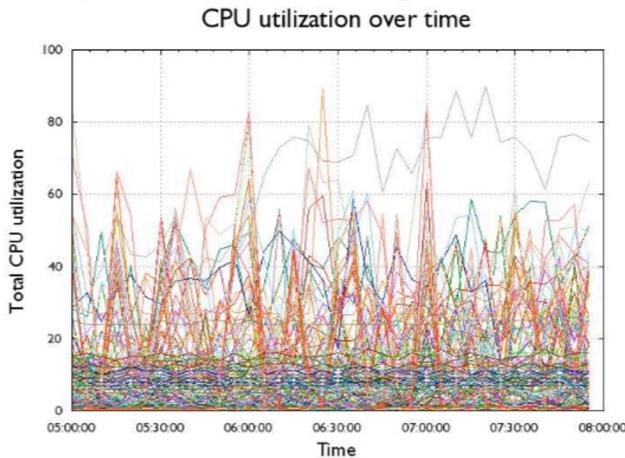


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[McLachlan, CHI 2008]

Example: Monitoring Time Series



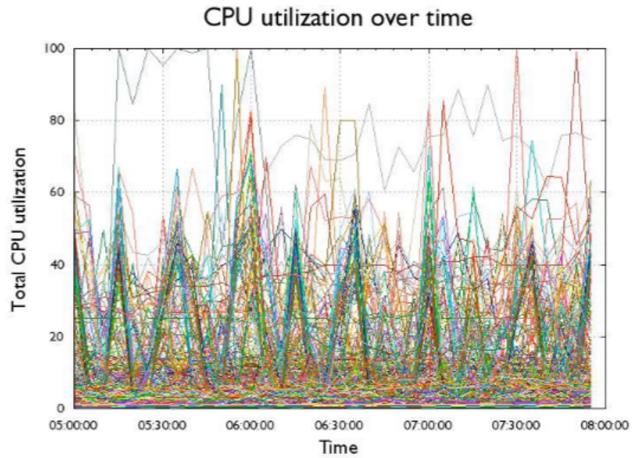
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[McLachlan, CHI 2008]

Example: Monitoring Time Series

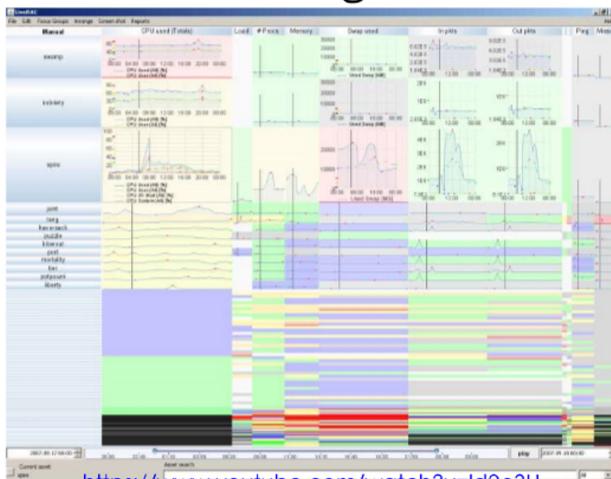


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[McLachlan, CHI 2008]

LiveRac: Monitoring Time Series



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<https://www.youtube.com/watch?v=ld0c3HOVskw>

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Many Series

Challenge 2: ??

- Multiple concurrent time series
- Or: long period organized into cycles
 - Hourly, daily, weekly, monthly, yearly, etc
- Example:
 - Multiple stocks
 - Ocean temperatures in different places
 - CPU utilization
- Solution: Multiple visualizations, aggregate series

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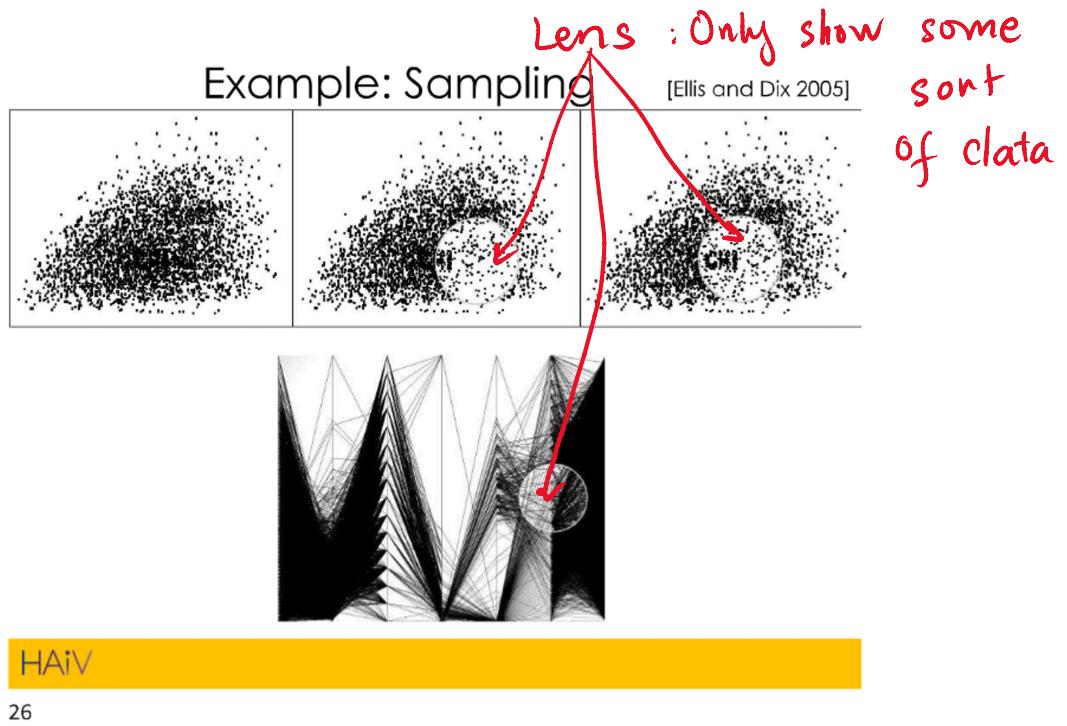
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One solution Sampling

- Sometimes not necessary to analyze entire dataset
 - Interested in general trend
 - Avoid summarizing entire data
- Sampling: take subset at random and average

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Vis for Multiple Time-Series

- Video editing metaphor
 - Timeline
 - Parallel time-series
- No distortion
- Easy overview
- How to zoom?

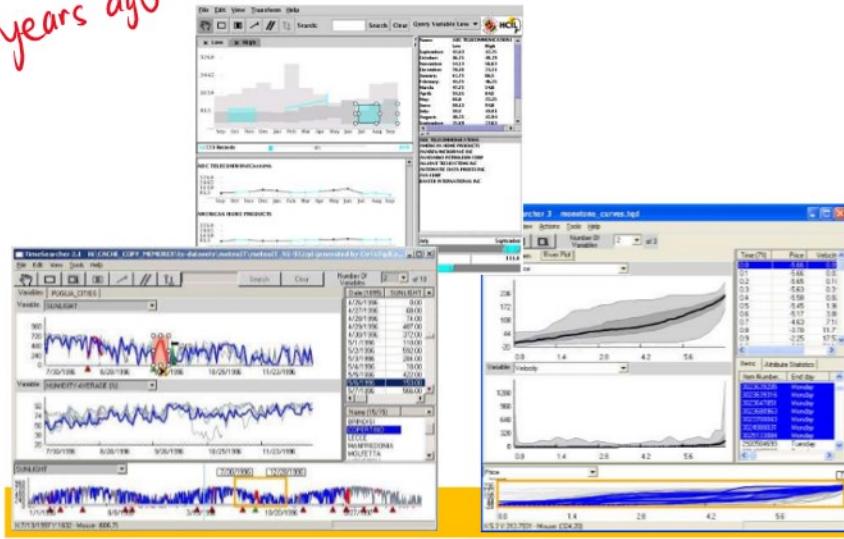
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[HCIL, 2001-2007]

Calendars: TimeSearcher 1+2+3

20 years ago

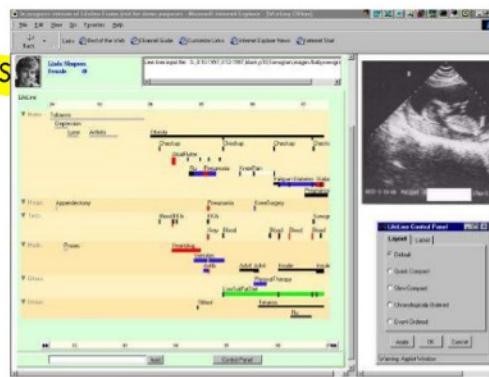


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[Plaisant et al., 1996]

LifeLines

- Personal data over time
- Medical records
- Details on demand
- Color coding & line thickness
- Benefits:
 - Trends
 - Anomalies
 - Overview
- Challenges: Scalability, multiple records?



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Visual Compression

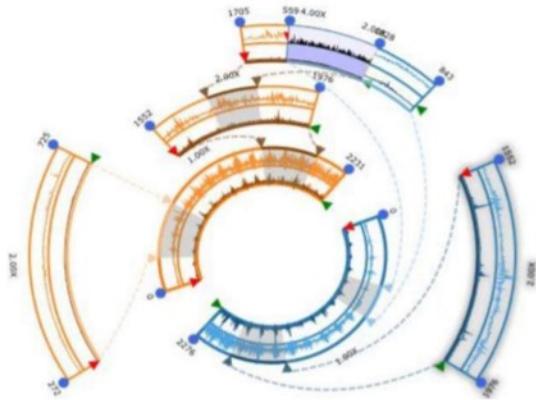
- Stretch and shrink space to make space
 - Allow for many datasets
 - Examples
 - KronoMiner
 - [Kincaid, 2010]
 - Horizon graphs

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[Zhao, 2011]

KronoMiner



A blue rectangular button with the word "Video!" written in white, tilted at an angle.

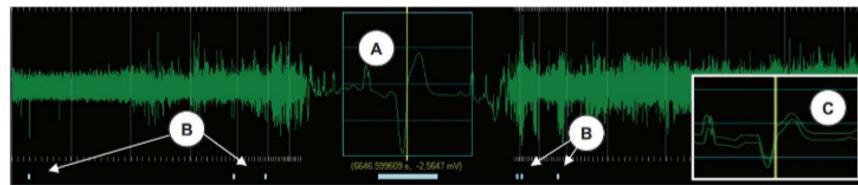
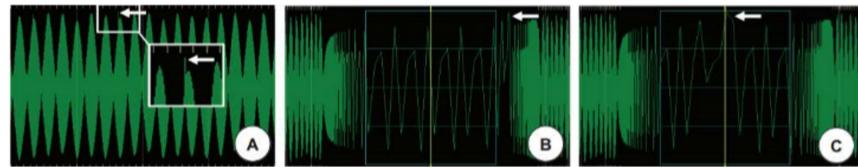
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<https://www.youtube.com/watch?v=U0IN7vfrxi0>

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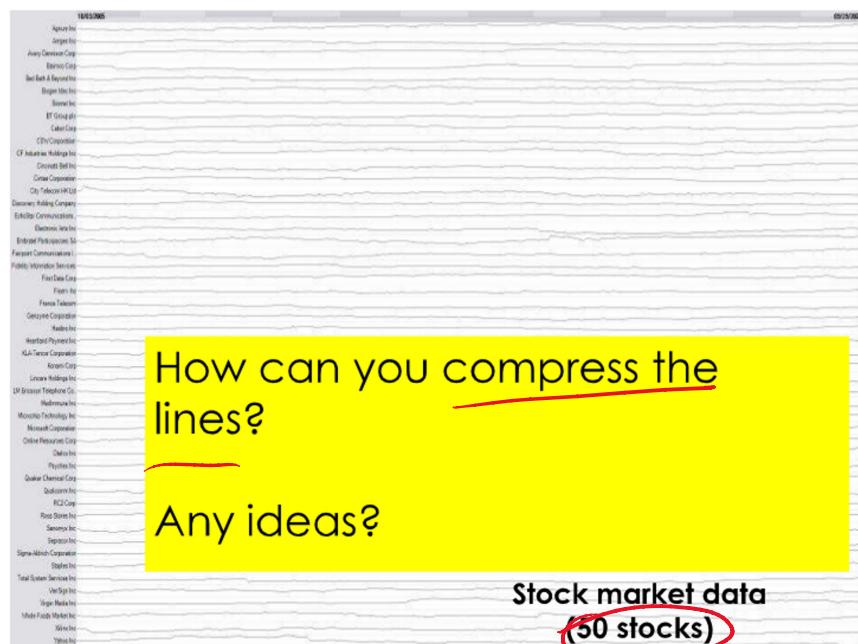
[Kincaid, 2010]

Focus+Context for Time Series



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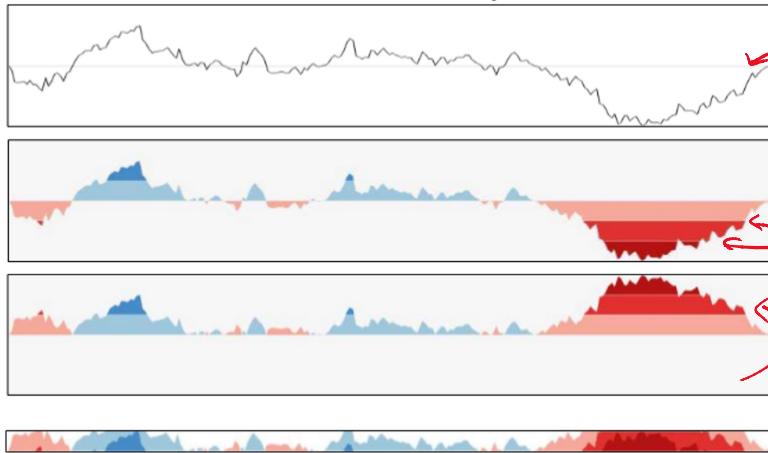
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[Panopticon]
[Fev 2008]

Motivation: Save space in vis design.

Horizon Graphs



assign color : { red : below
blue : above }

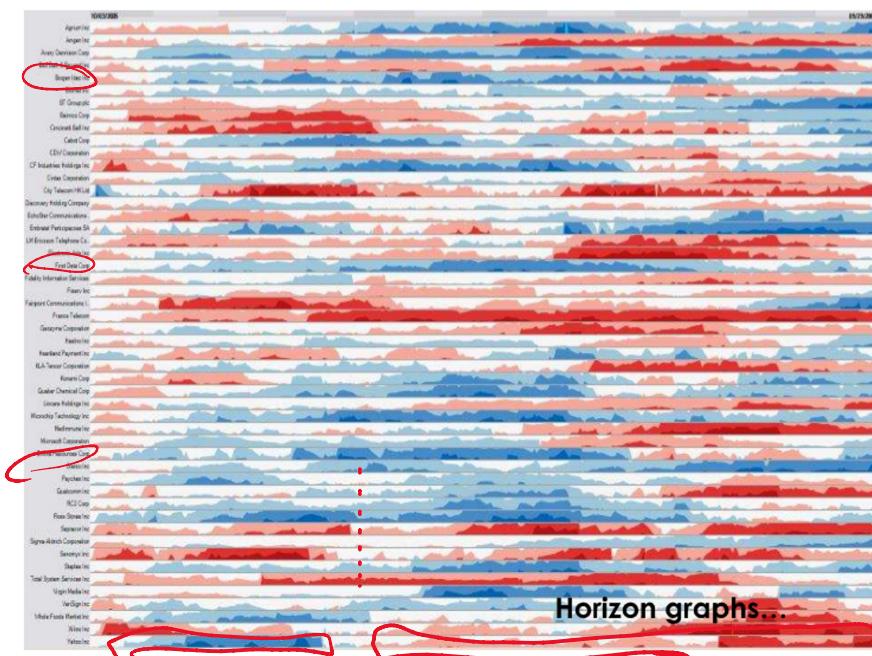
cut line

Fold it .

Merge it .

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[Elmqvist, CHI 2008]

Multi-Focus Interaction

- Guaranteed views of multiple focus points
- Context visibility
- Intervening context awareness
- Distance awareness



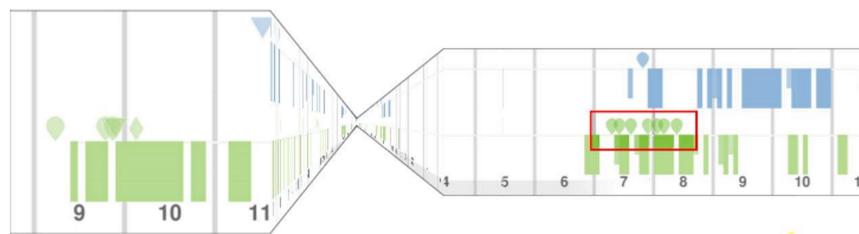
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[Elmqvist, TVCG 2009]

Multi-Focus Interaction for Temporal Data

- Use multi-focus interaction for long periods
- Compare within time series
- Problems:
 - Folds consume space

<https://www.youtube.com/watch?v=l1KiO1iZ1Dl>



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[Javed 2010]

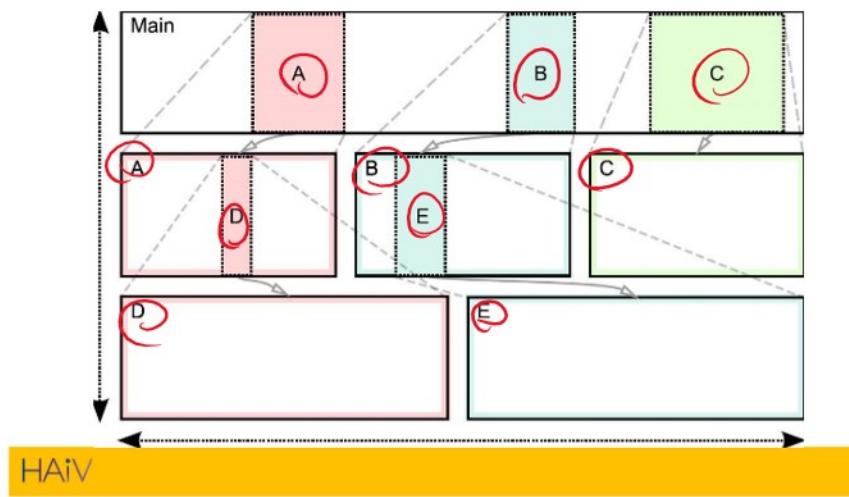
When?
What?
Why
useful?

Stack Zooming

- **Stack zooming:** separate focus and overview
 - Defined for 1D visual spaces
 - Create stack (hierarchy) of focus points
 - Focus areas placed adjacent to context
 - Small multiples [Tufte 1983]
 - Also allow comparison across multiple time series
- Fulfils multi-focus interaction requirements

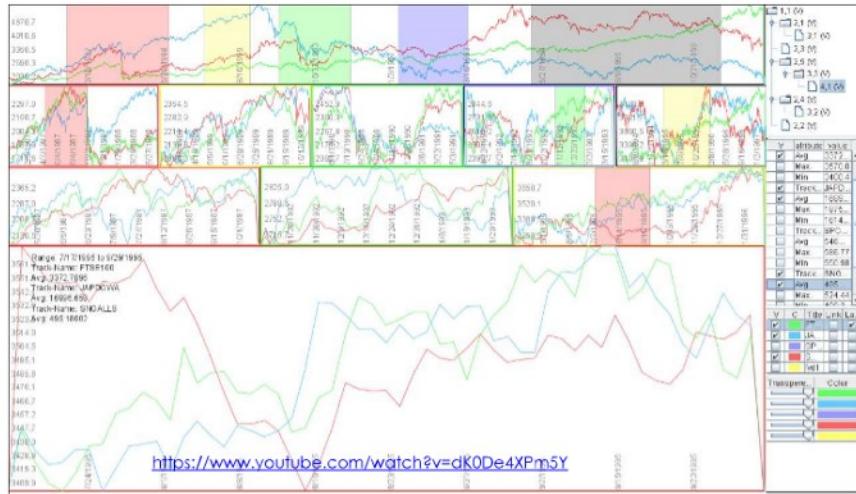


Stack Zooming: Basic Design



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Stack Zooming: Screenshot



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[van Wijk and van Selow 1999]

Temporal Clustering

- **Idea:** use cluster analysis (CA) to aggregate time-series into groups
 - Abstract the data
 - Detect seasonal patterns
- **Approach:**
 - Group similar temporal patterns
 - Show weekly and daily summary

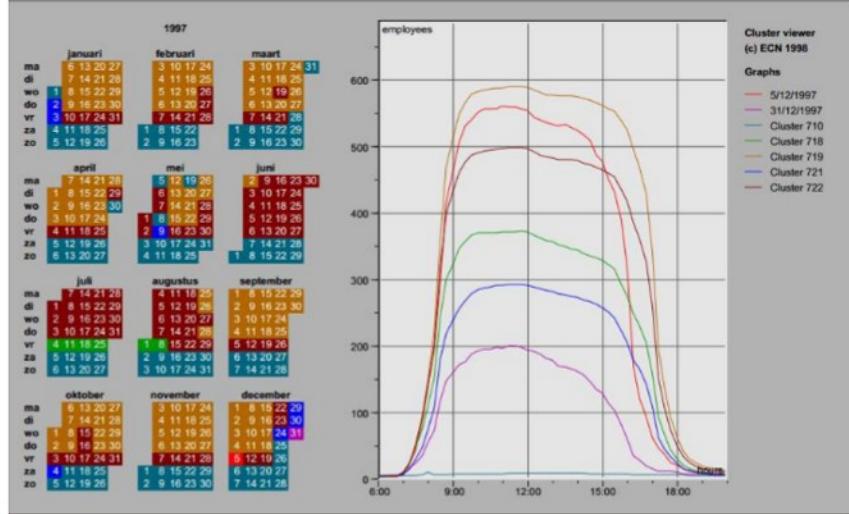
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[van Wijk and van Selow 1999]

Calendar-View of Clusters



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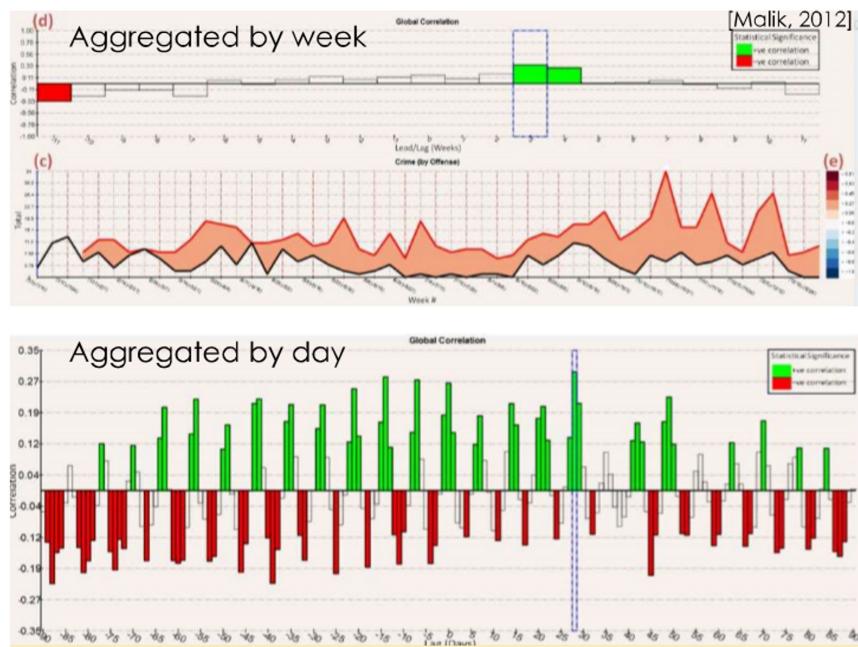
[Malik, 2012]

Temporal Correlation

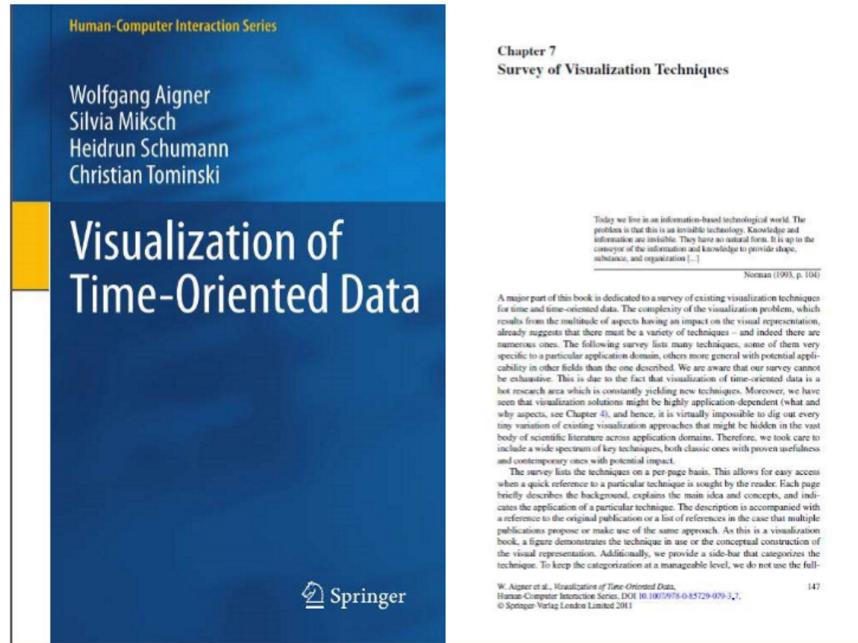
- **Idea:** Interactively explore spatio-temporal correlations
 - Detect periodical patterns
 - Explore causal/predictive links
- **Approach:**
 - Use lead/lag analysis; correlogram plots
 - Different temporal aggregation levels

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