

# 05-1 Time

Monday, May 1, 2023 4:56 PM

# Time I

Sungahn Ko

HAIv

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## Disclaimer

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- Slides in this course courtesy of
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  - Dr. Yun Jang (Sejong Univ.)
  - Dr. Ross Maciejewski (ASU)
  - Dr. Niklas Elmquist (UMD)
  - Dr. David Ebert (Purdue)

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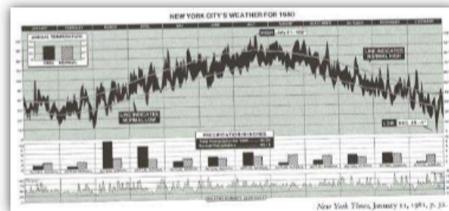
## The Eyes Have It: Temporal Data

- 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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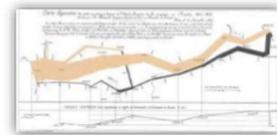
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Edward Tufte



*"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*



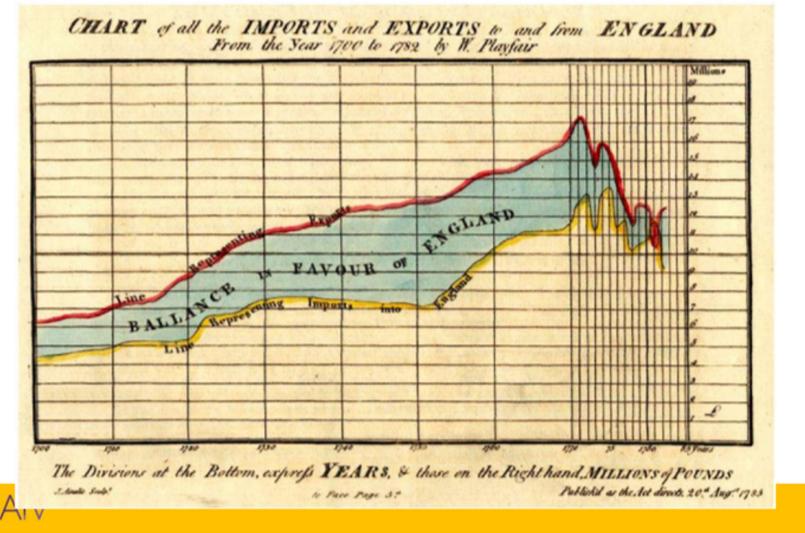
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[Playfair, 1785]

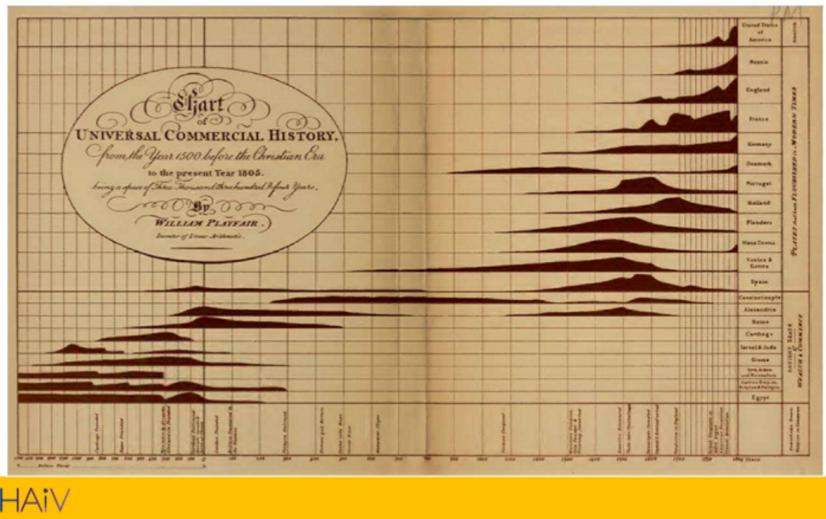
## Example: William Playfair (1759-1823)



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[Playfair, 1805]

## Example: William Playfair (1759-1823)



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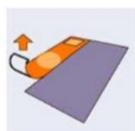
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## Example: Google Finance



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1. Rip off the wrist band along the perforation.



2. Remove protective foil and fix around



3. Cheer for your favorite!



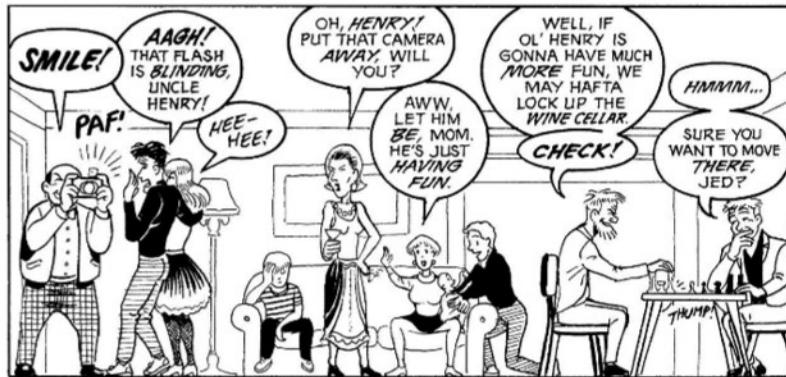
Time in Visual Explanations  
and Storytelling

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## Time in Storytelling



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## Temporal Data



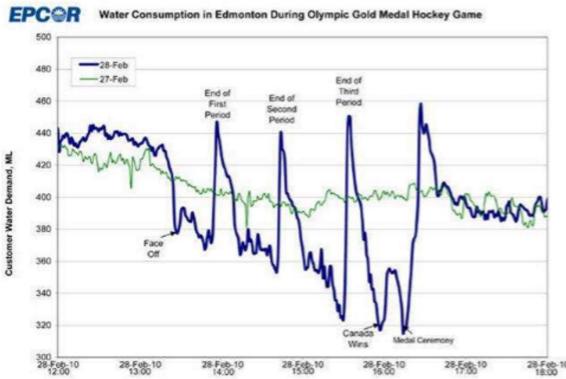
- Almost all data has a temporal component
  - Finance – stock prices, exchange rates, etc
  - Science – temperature, acidity, voltage, etc
  - Demographics – crime rate, education level, etc
- Goal: temporal data analysis
  - Anomaly detection
  - Analysis (correlation + prediction)
  - Visualization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

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## Classic Temporal Visualization

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

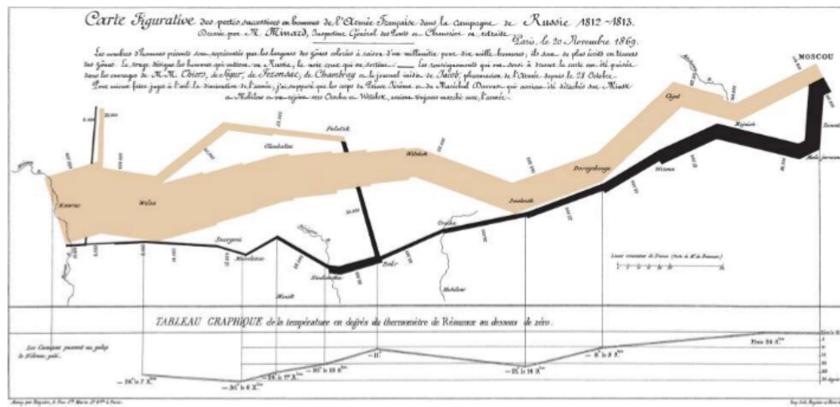


<http://chrisblattman.com/2010/03/08/graph-of-the-day-canadians-pee-between-periods/>

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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

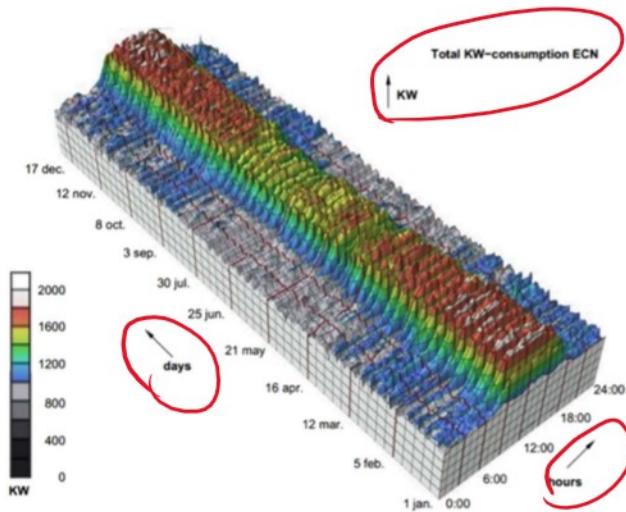
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Why is  
**temporal data analysis**  
difficult?

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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

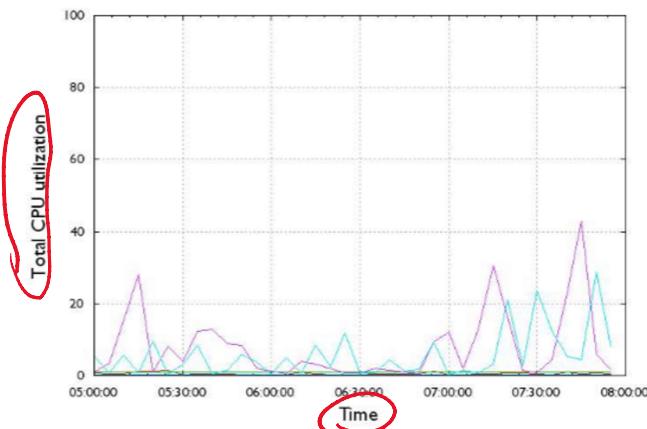
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[McLachlan, CHI 2008]

## Example: Monitoring Time Series

CPU utilization over time



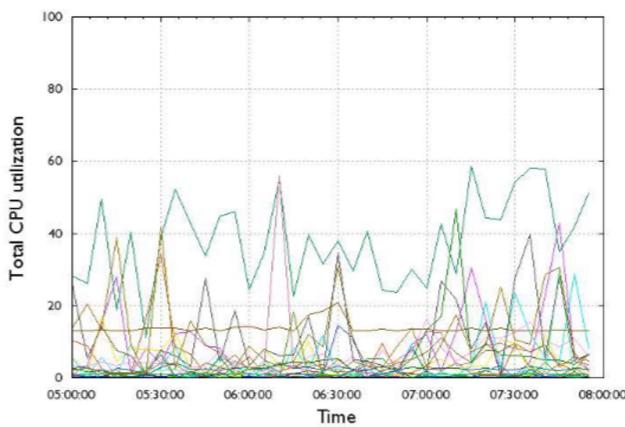
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[McLachlan, CHI 2008]

## Example: Monitoring Time Series

CPU utilization over time

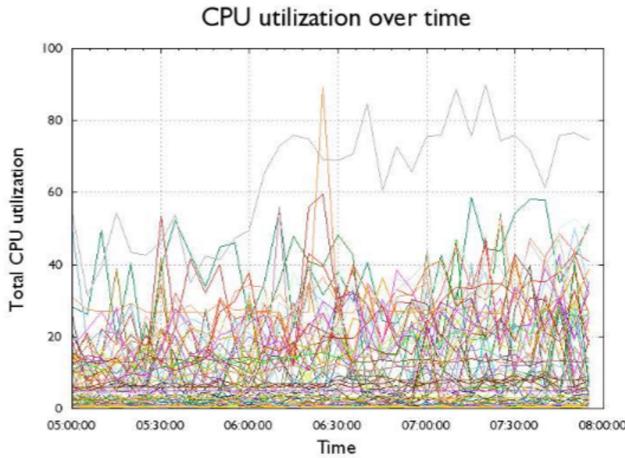


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[McLachlan, CHI 2008]

## Example: Monitoring Time Series

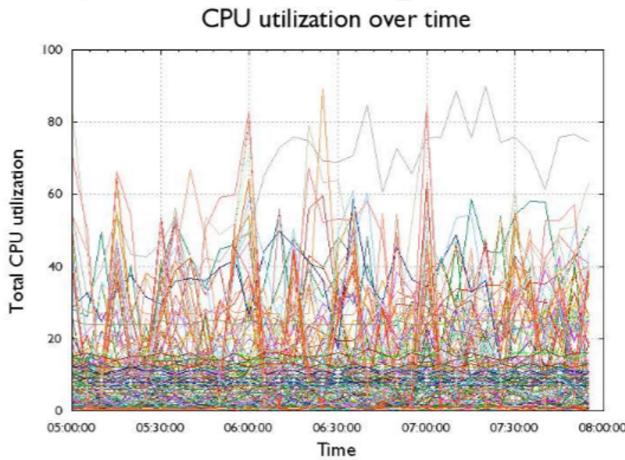


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[McLachlan, CHI 2008]

## Example: Monitoring Time Series



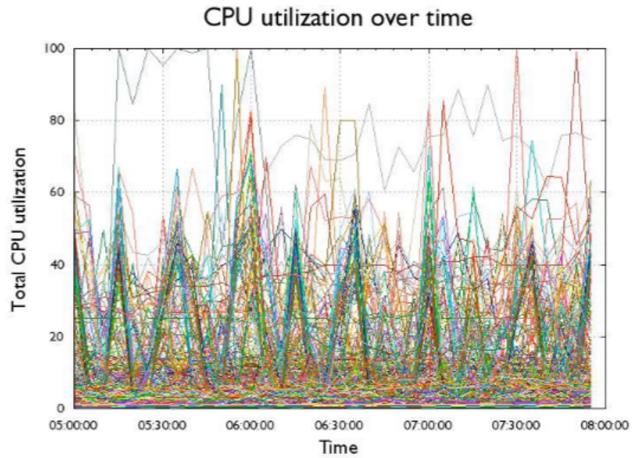
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[McLachlan, CHI 2008]

## Example: Monitoring Time Series

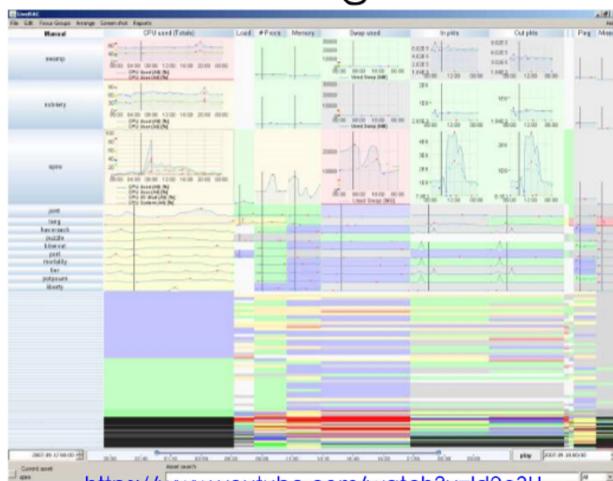


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[McLachlan, CHI 2008]

## 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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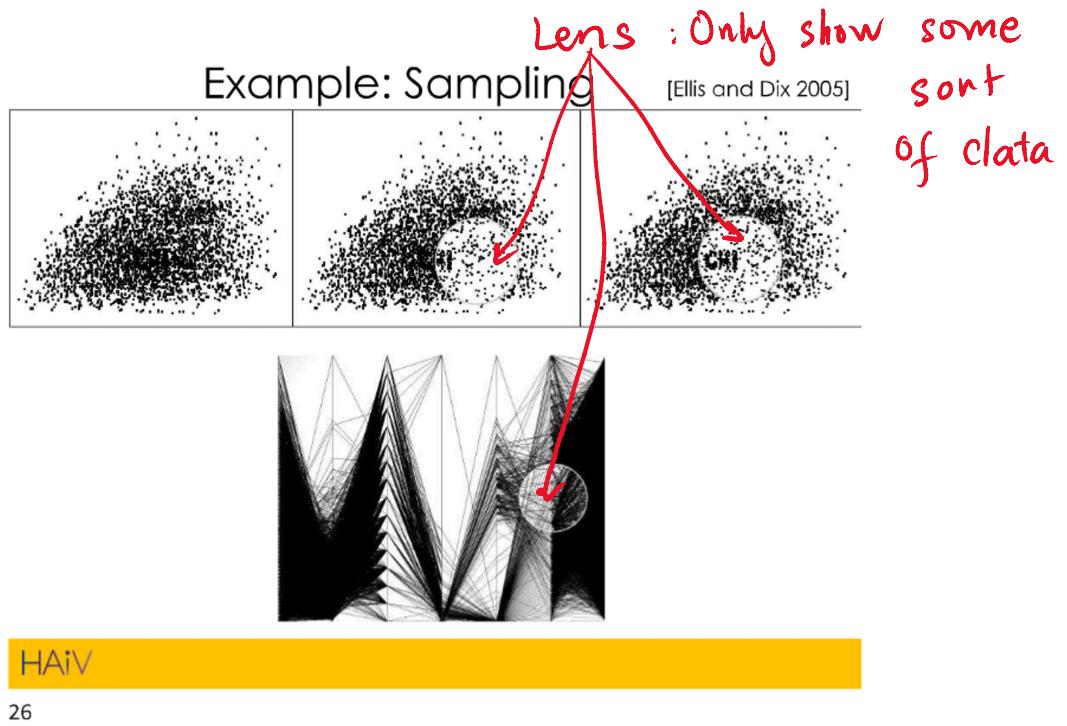
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## One solution Sampling

- 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?

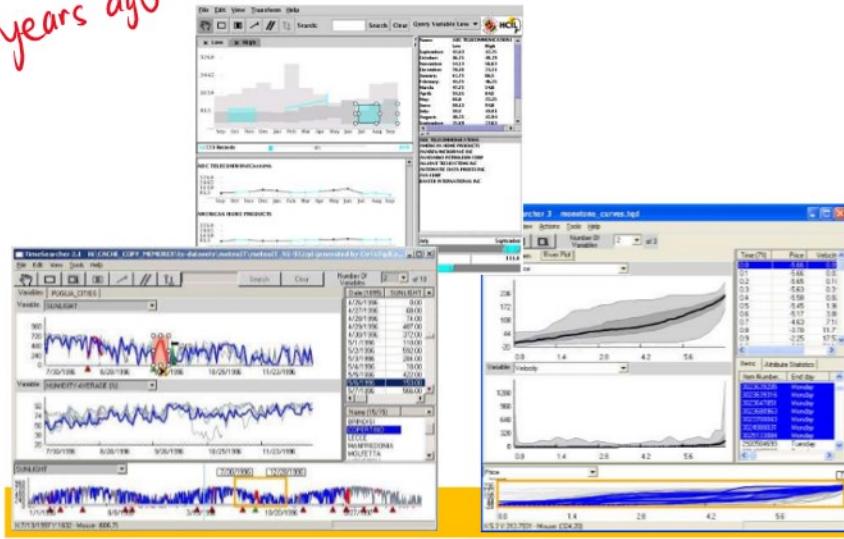
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[HCIL, 2001-2007]

## Calendars: TimeSearcher 1+2+3

*20 years ago*

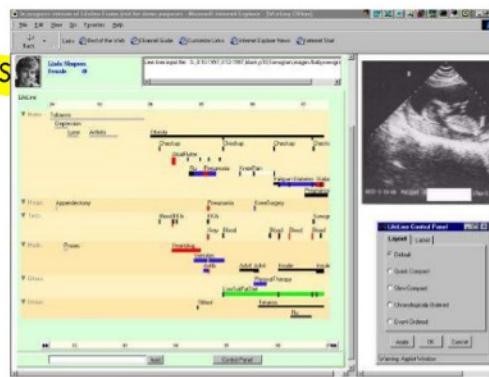


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[Plaisant et al. 1996]

## 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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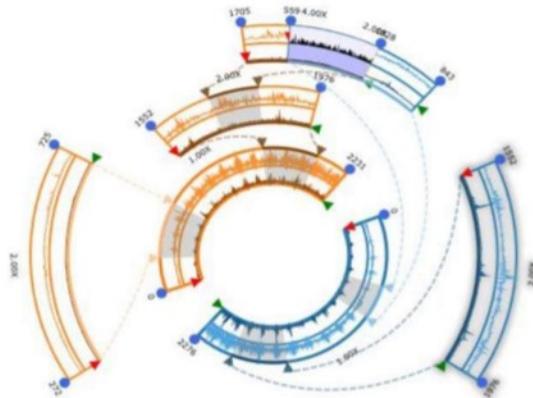
## Visual Compression

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

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[Zhao, 2011] KronoMiner

Video!

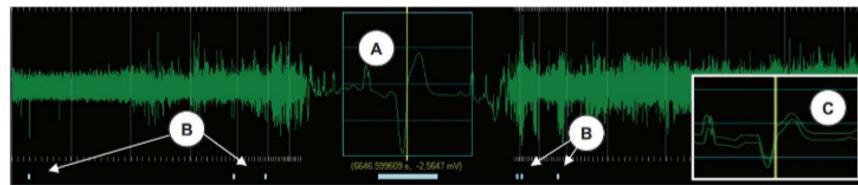
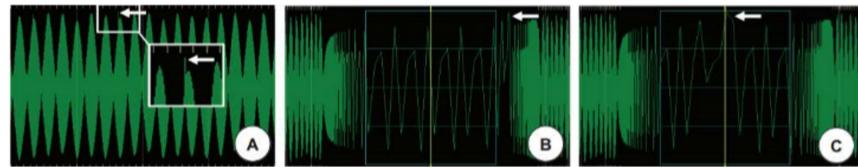


HAiV <https://www.youtube.com/watch?v=U0IN7vfrxi0>

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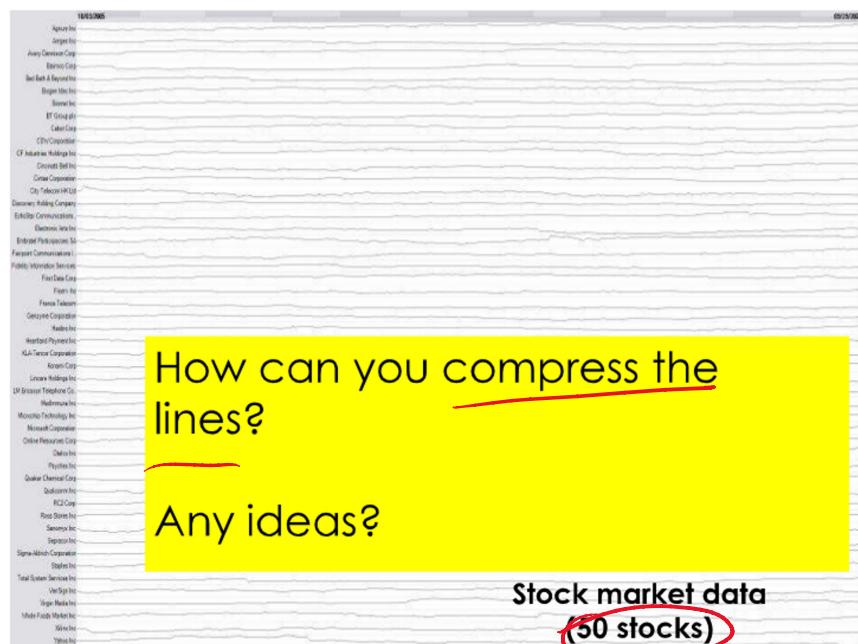
[Kincaid, 2010]

## Focus+Context for Time Series



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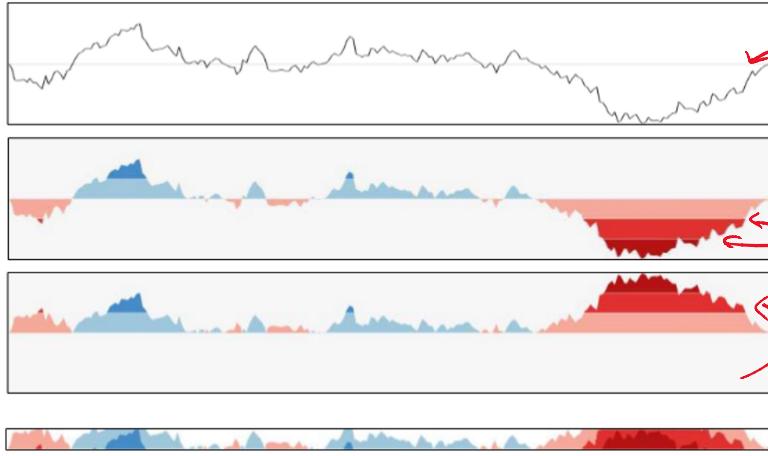
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[Panopticon]

[Feb 2008]

## Horizon Graphs



cut line

assign color : { red : below  
blue : above }

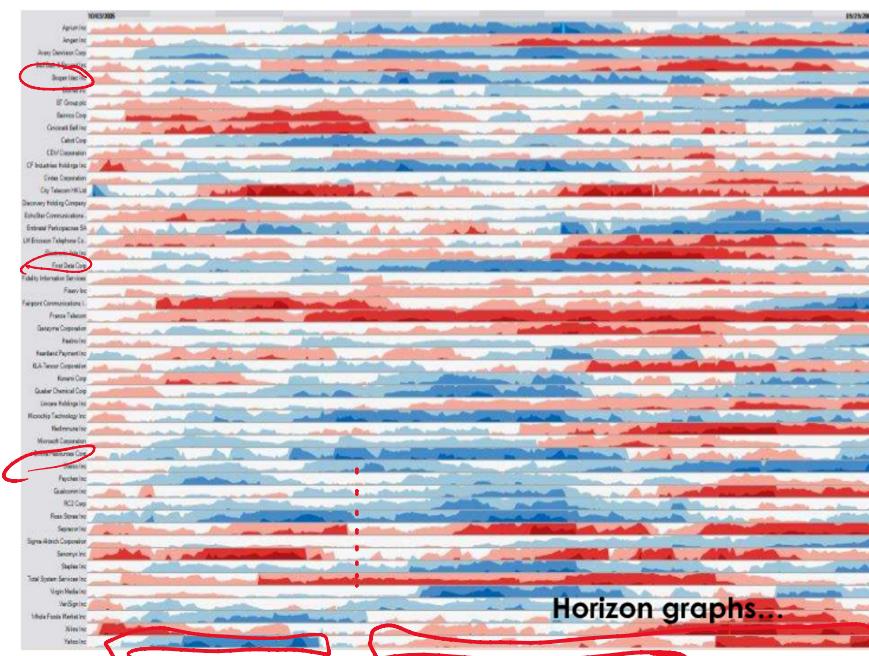
cut line

Fold it .

Merge it .

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Horizon graphs...

[Elmqvist, CHI 2008]

## Multi-Focus Interaction

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



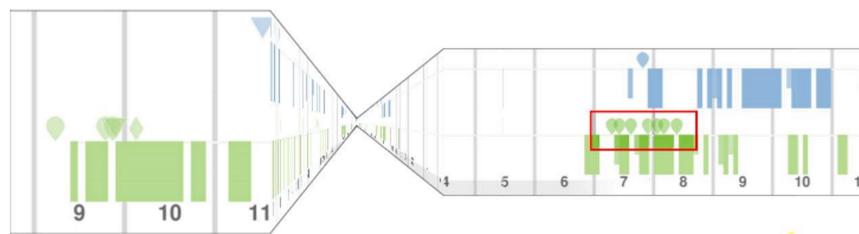
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[Elmqvist, TVCG 2009]

## 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=l1KiO1iZ1DI>



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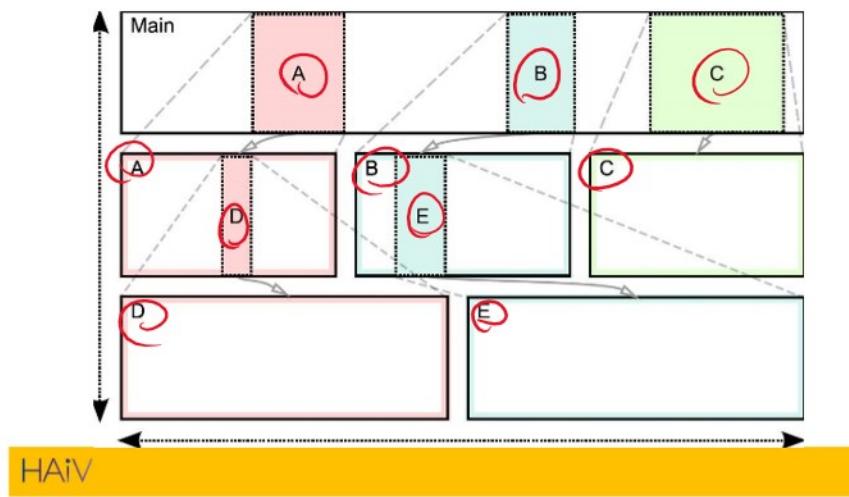
[Javed 2010]

## 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

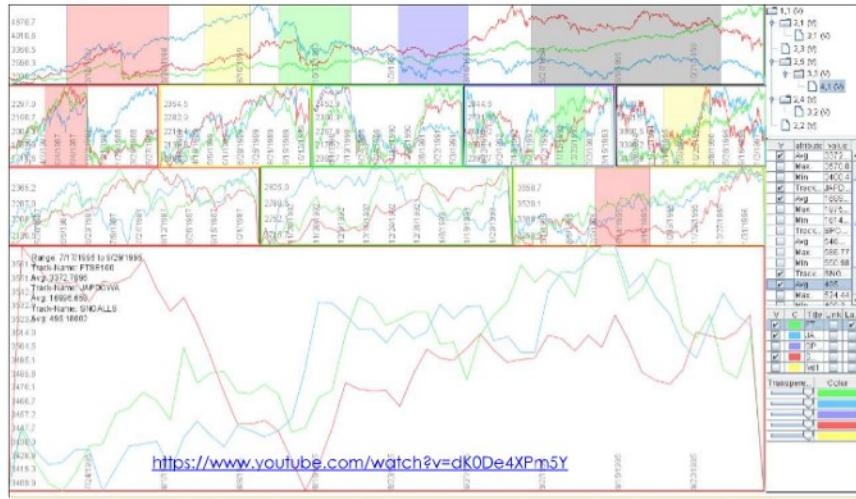


## Stack Zooming: Basic Design



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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

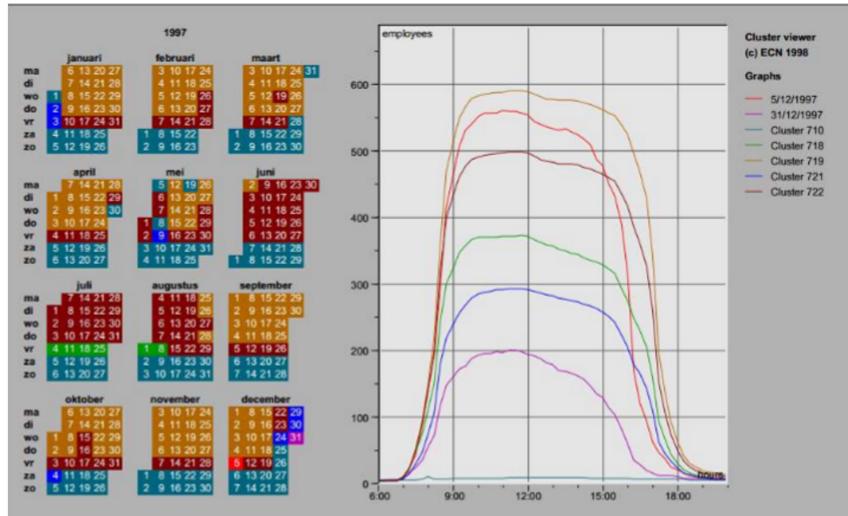
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[van Wijk and van Selow 1999]

## Calendar-View of Clusters



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[Malik, 2012]

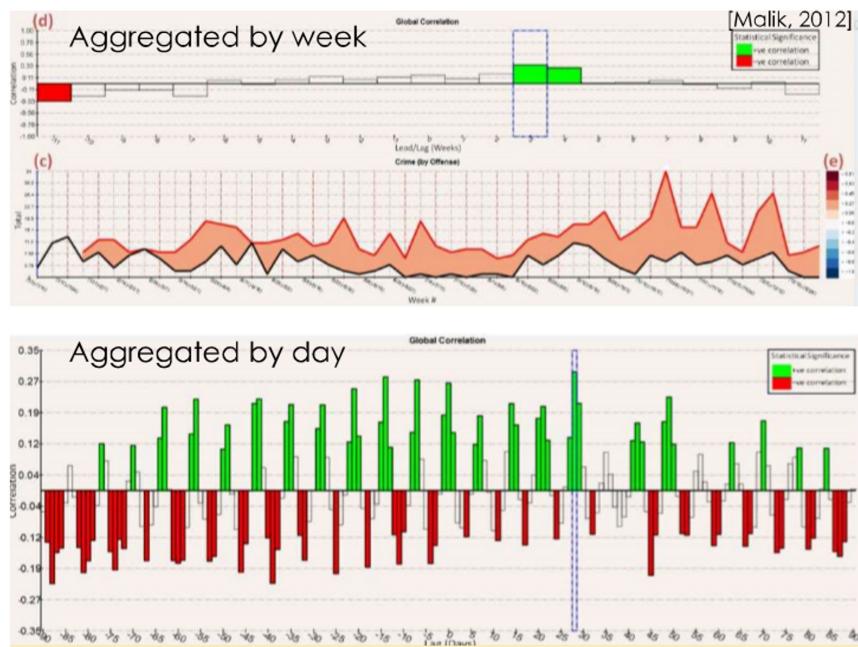
## Temporal Correlation

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

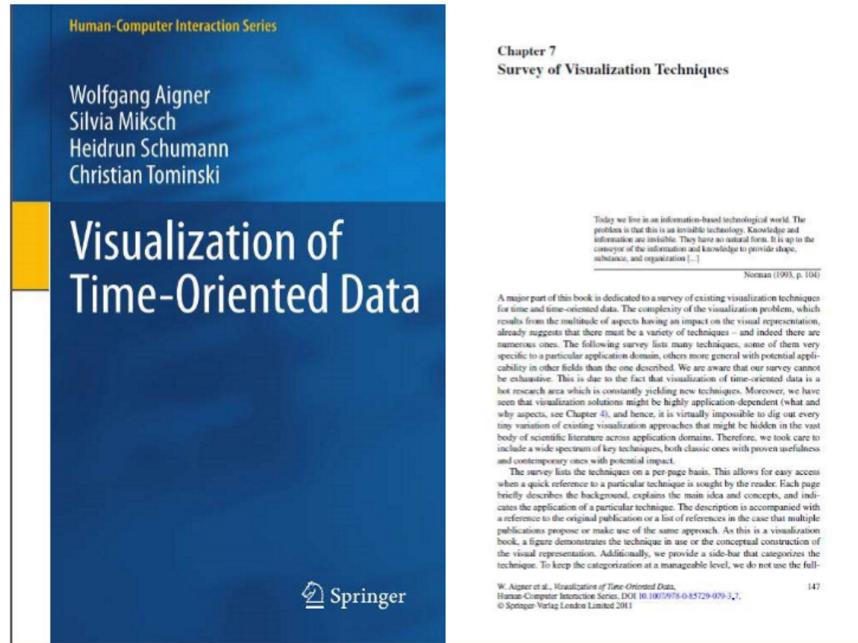
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