SC4024/CZ4124
Data Visualization

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CCDS, Nanyang Technological University

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Chapter 9.2
Time-series Data Visualization

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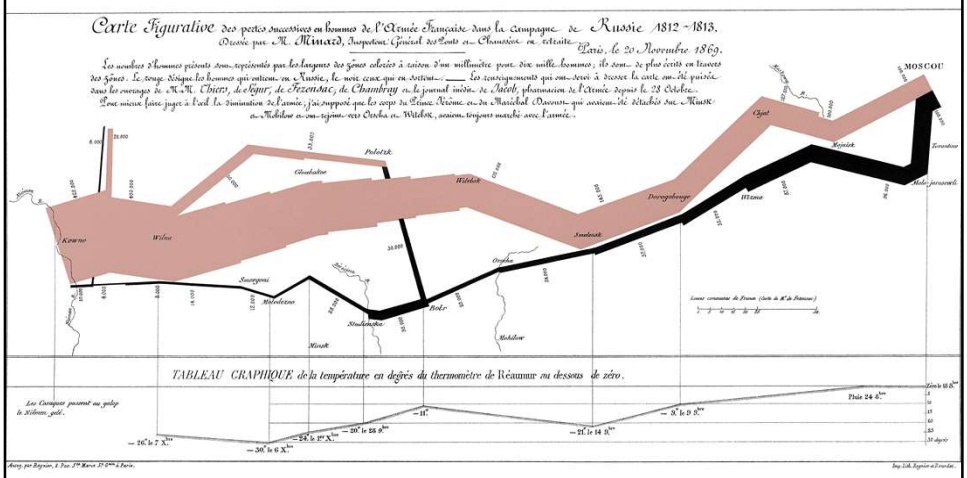
A Famous Example: Napoleon's Retreat from Moscow



Charles Minard's 1869 chart showing the number of men in Napoleon's 1812 Russian campaign army, their movements, as well as the temperature they encountered on the return path.

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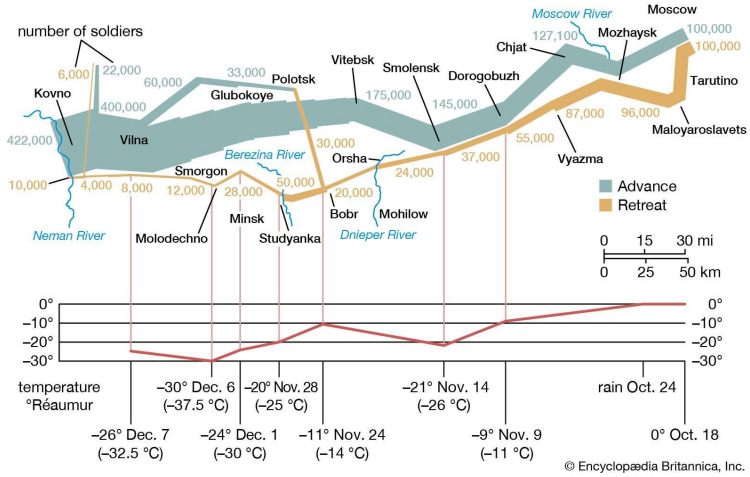
A Famous Example: Napoleon's Retreat from Moscow

Based on Charles Minard's graph of Napoleon's Russian campaign of 1812.



Charles Minard's 1869 chart showing the number of men in Napoleon's 1812 Russian campaign army, their movements, as well as the temperature they encountered on the return path.

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Outline

- Time-series data
- Time representation
- Time-series patterns
- Time-series data visualization with special requirements
- Interactive techniques for time-series data visualization

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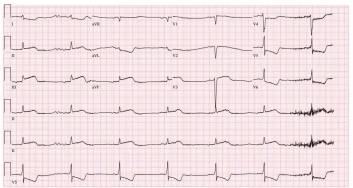
Time-series Data

- Time series data, also referred to as time-stamped data, is a sequence of data points indexed in time order.
- Examples
  - Stock price
  - Temperature
  - Economic indicators
  - Patient health evolution metrics (e.g., ECG data)
  - Sensor data



Large volume, high dimensional, multivariate, widely used

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Time Representation

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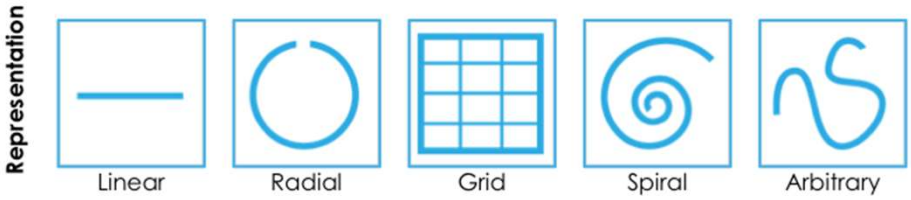
- Taxonomy

There are mainly five categories of time representations used in time-series data visualizations:



Brehmer, Matthew, et al. "Timelines revisited: A design space and considerations for expressive storytelling." TVCG 23.9 (2016): 2151-2164

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Linear Time

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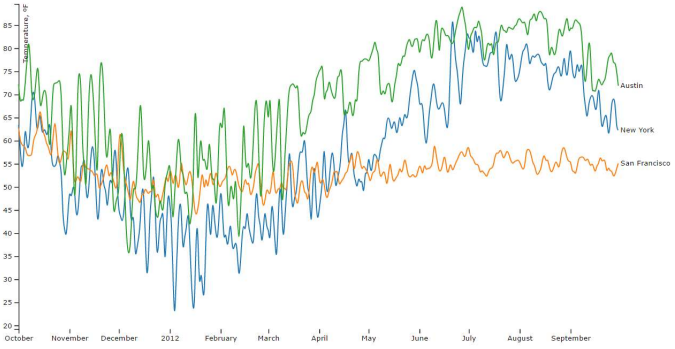
- Present time data as a 2D line graph
  - Time on x-axis
  - The other variable on y-axis
  - The most common way to represent a timeline



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Linear Time

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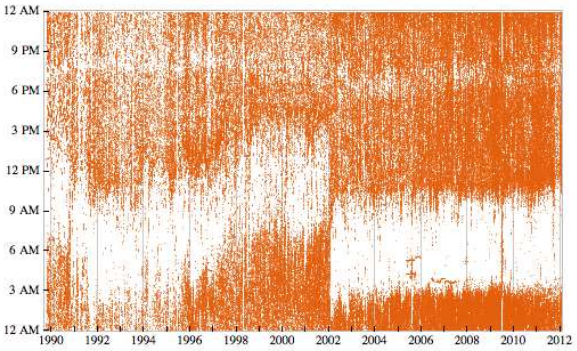
- Personal Data Visualization, *by* Stephen Wolfram
  - The x-axis and y-axis represent the year and daily timeslot respectively, and each dot represent an email
  - It shows the time of over 1 million emails since 1989



http://blog.stephenwolfram.com/2012/03/the-personal-analytics-of-my-life/

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Linear Time

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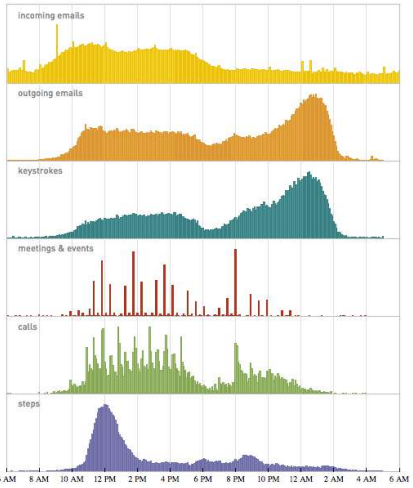
- Personal Data Visualization, *by* Stephen Wolfram

Visualization of other personal time-series data



http://blog.stephenwolfram.com/2012/03/the-personal-analytics-of-my-life/

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Radial Time

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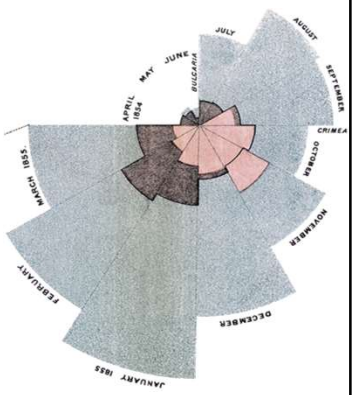
- Data distributed along the spiral
- It is appropriate for presenting the periodic nature of time, such as natural cycles of people, weather systems, etc.

Example: Nightingale Rose Charts:

- It shows the causes of mortality in the army in the East and was created by Florence Nightingale

- It indicates the annual rate of mortality per 1,000 in each month that occurred from preventable diseases (in blue), wounds (in red), and other causes (in **black**).



https://en.m.wikipedia.org/wiki/File:Nightingale-mortality.jpg

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Radial Time

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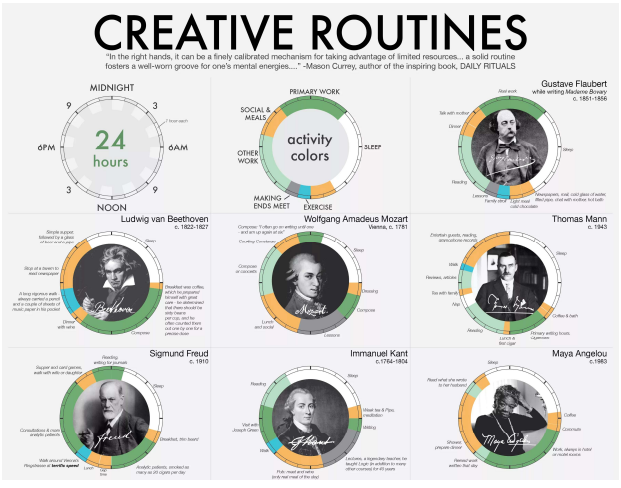
Example: Historic creative's daily routines



https://infowetrust.com/project/routines

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Grid Time

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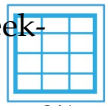
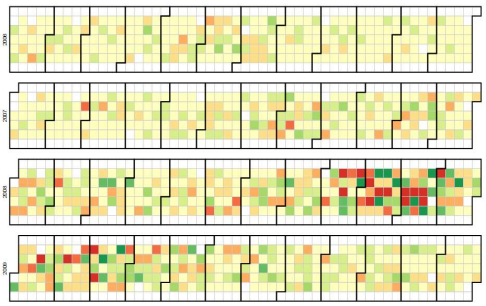


- Grid representations such as the standard Month-Week-Day calendar are ubiquitous.
- However, grid representations are only appropriate for timelines that reflect these granularities of time.

Example: Dow Jones stock price from 2006 to 2009



http://mbostock.github.io/d3/talk/20111018/calendar.html

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Grid Time

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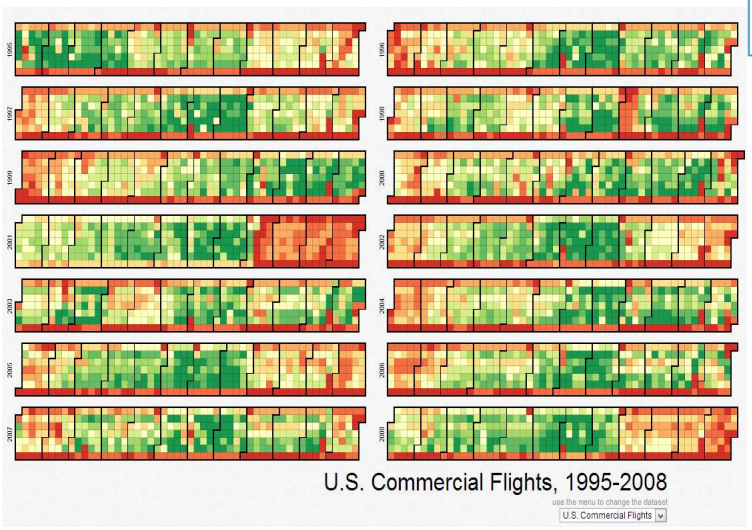
Example: US Commercial Flights



Source: http://mbostock.github.io/d3/talk/20111018/calendar.html

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Spiral Time

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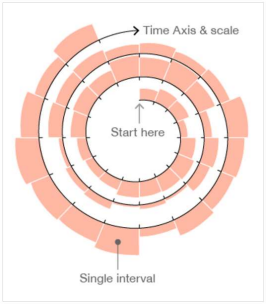
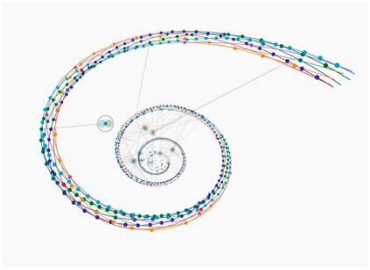
- Spiral representations are dense, space-filling shapes that radiate to or from a centre point.
- Spiral timelines are aesthetically appealing and appropriate for presenting many events within a single dense display

Example: Ross Spiral Curriculum





Ross spiral curriculum, 2015. https://spiral.ross.org/spiral

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Arbitrary Time

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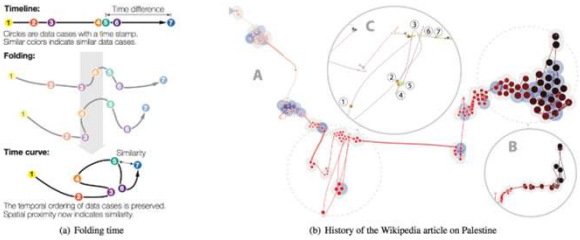
- Arbitrary timeline representations may appear visually similar to connected scatterplots and time curves
- Like spiral representations, arbitrary representations can be useful for presenting many events within a single dense display and improve the memorability of a time-series data

Example: Time Curves: Folding Time to Visualize Patterns of Temporal Evolution in Data



(a) Folding time (b) History of the Wikipedia article on Palestine

http://www.aviz.fr/~bbach/timecurves/

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Arbitrary Time

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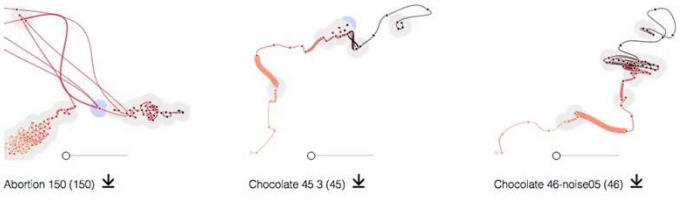
Demo Video of Time Curves

TimeCurves: Folding Time to Visualize Patterns of Evolution in Temporal Data



Benjamin Bach, Conglei Shi, Nicolas Heulot, Tara Madhyasta, Tom Grabowski, Pierre Dragicevic

www.aviz.fr/~bbach/timecurves

Music (c) by Louisiana Five
http://www.aviz.fr/~bbach/timecurves/

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Arbitrary Time

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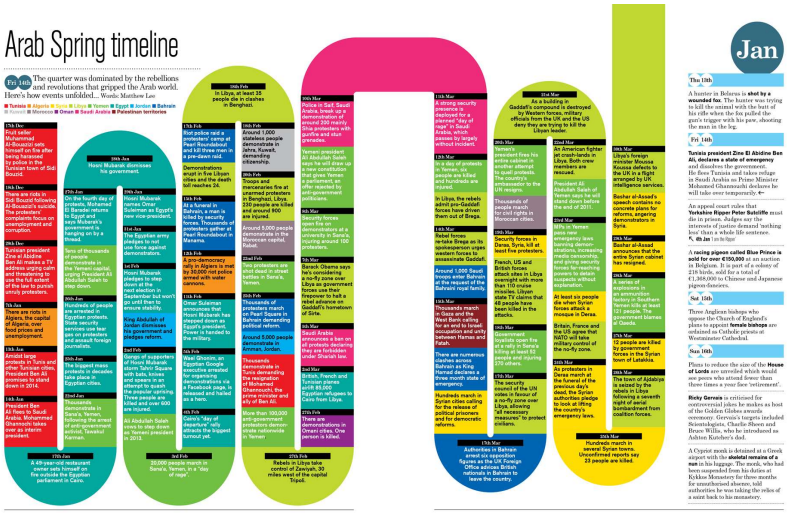
Example: Arab Spring Timeline



https://www.slow-journalism.com/infographics/society/arab-spring-timeline

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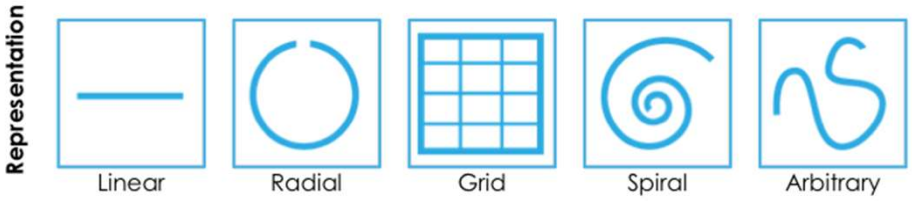
Time Representation

- Taxonomy



- Among the above four types, linear time representation is more popular

Brehmer, Matthew, et al. "Timelines revisited: A design space and considerations for expressive storytelling." TVCG 23.9 (2016): 2151-2164.

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What will you learn from this lesson?

- Time-series data
- Time representation
- Time-series data patterns
- Time-series data visualization with special requirements
- Interactive techniques for time-series data visualization

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Time-series data patterns

- Trend
- Rate of change
- Co-variation
- Cycles
- Exceptions

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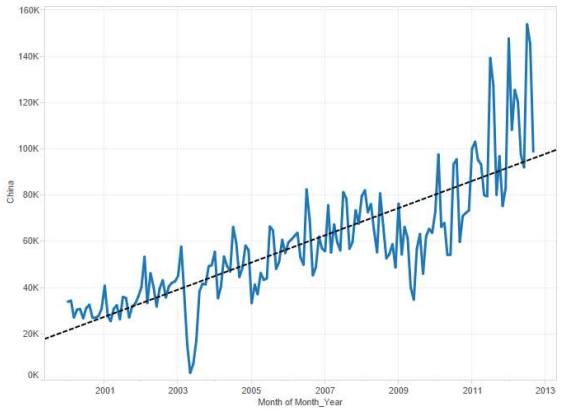
Time-series Patterns: Trend

- The overall or general direction of change in a series of time-series values is called the trend, which is often displayed in a graph as a trend line.



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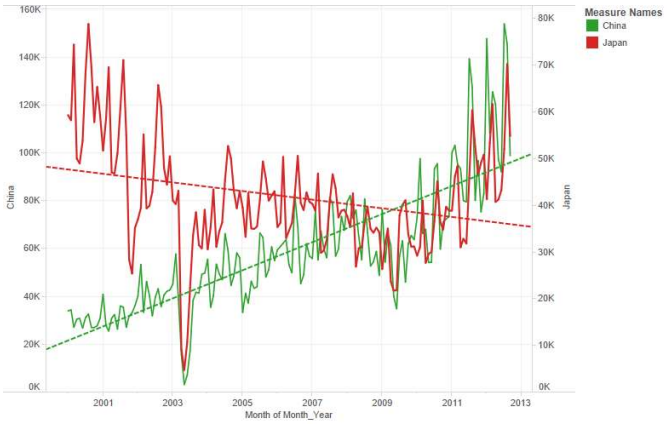
Time-series Patterns: Trend

- Example: Visitors from China is in increasing trend and visitor from Japan is in decreasing trend



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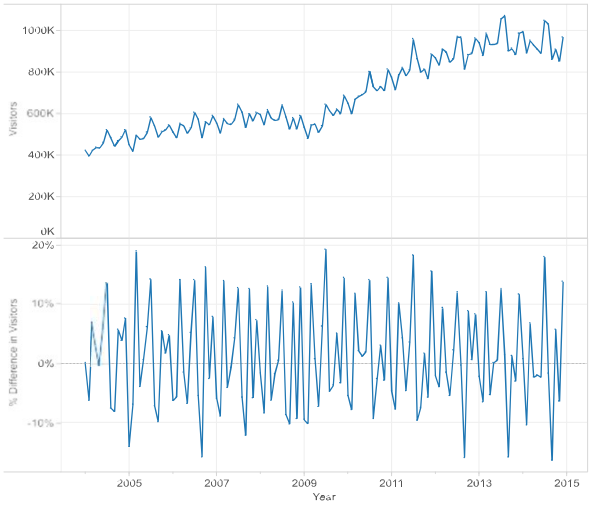
Time-series Patterns: Rate of change

- The percentage difference between one value to the next value.



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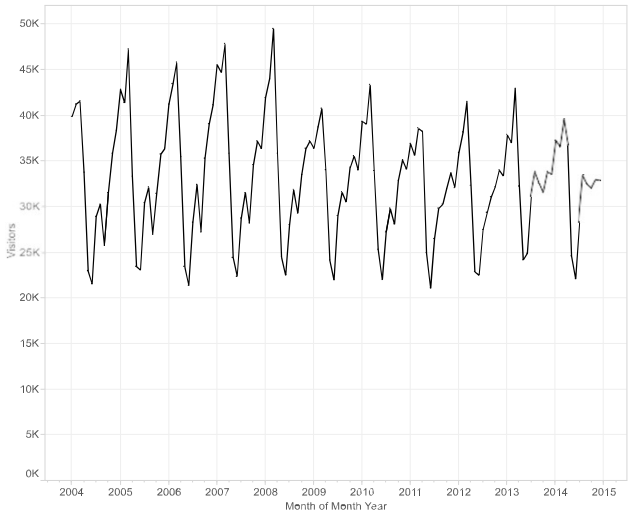
Time-series Patterns: Cycles

- Cycles are patterns that repeat at regular intervals.



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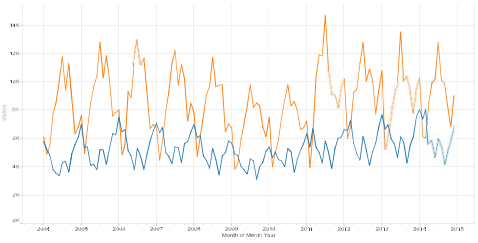
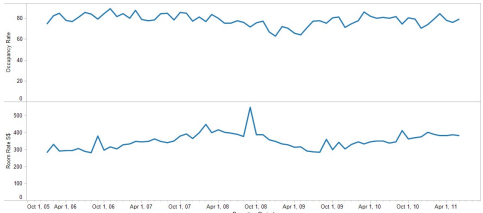
Time-series Patterns: Co-variation

- When two time series relate to one another so that changes in one are reflected as changes in the other, either immediately or later.

With Co-variation





Without Co-variation

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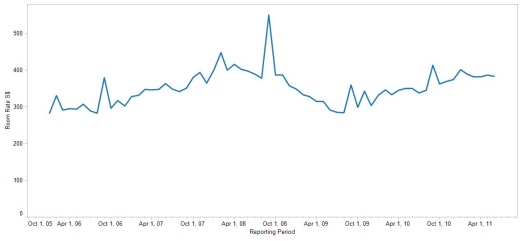
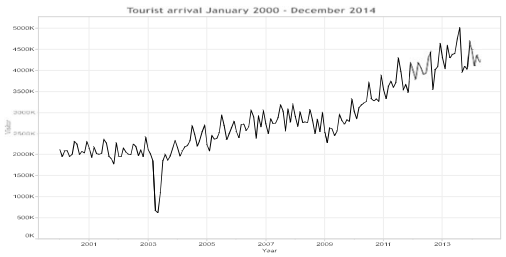
Time-series Patterns: Exceptions

- Values that fall outside the norm.





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What will you learn from this lesson?

- Time-series data
- Time representation
- Time-series data patterns
- Time-series data visualization with special requirements
- Interactive techniques for time-series data visualization

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Massive Time-series Data

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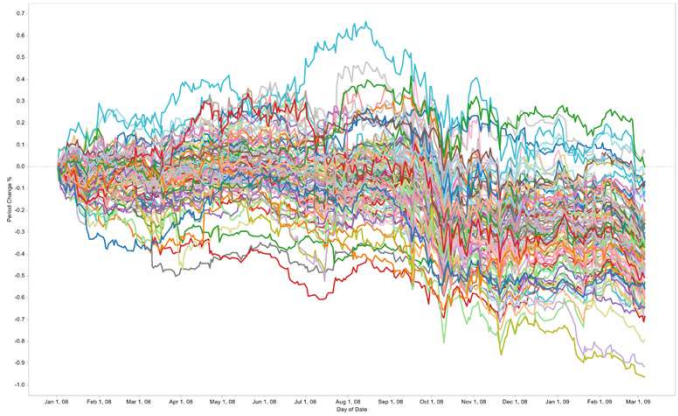
- Classic line chart

  - When there are massive time-series data, serious visual clutters will occur



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Massive Time-series Data

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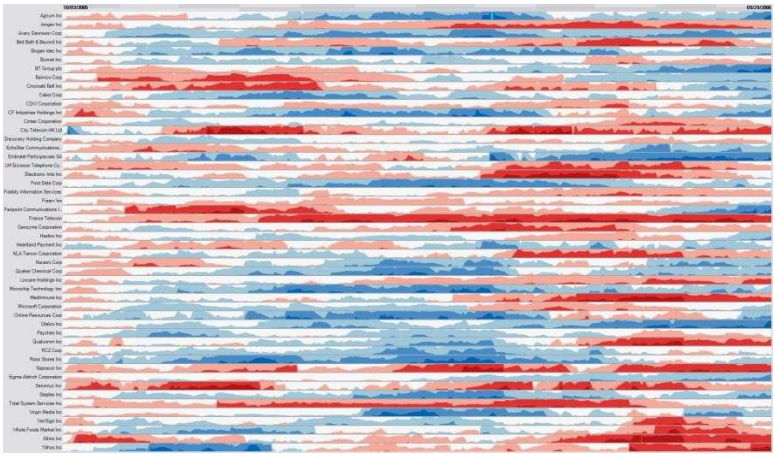
- Horizon graph is designed to mitigate the visual clutter issues when there are massive time-series data



https://www.perceptualedge.com/blog/?p=390

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Massive Time-series Data

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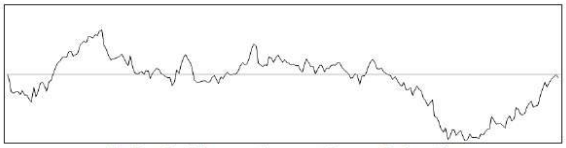
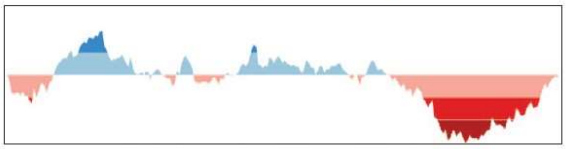
- The Basic Construct of a Horizon Graph



(a) Standard line graph centered around a baseline.



(b) Color (blue is positive, red is negative) and layering.

(c) Mirroring around the baseline.

(d) Wrapping bands into a single space.

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Distribution Over Time

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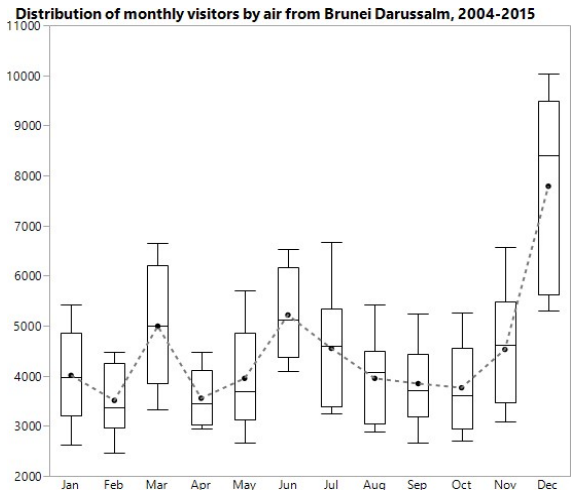
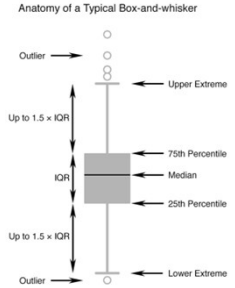
- Possible Visualization: Boxplots with a trend line





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Distribution Over Time

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- Possible Visualization: Candlestick Charts

Source: https://patternswizard.com/how-to-read-stock-charts/

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Distribution Over Time

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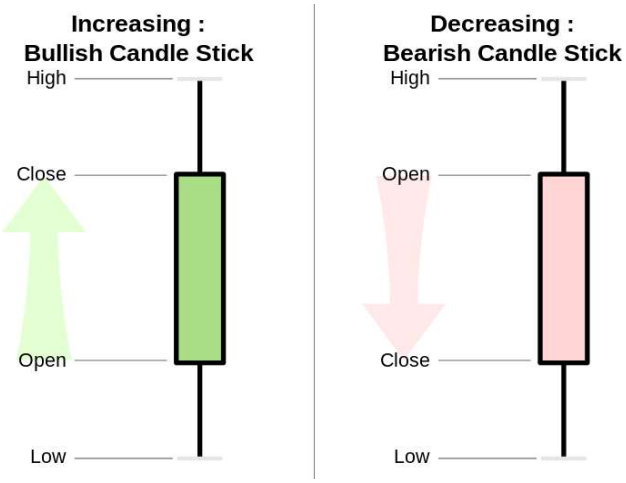
- Interpreting Candlestick Chart



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Distribution Over Time

- Candlestick in D3.js

Source: https://observablehq.com/@d3/candlestick-chart/2

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Part-Whole Relationships

- To show values that combine to form a whole comparison to one another and the whole change through time

Region	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
East	64,162	70,172	93,657	55,056	63,631	53,040	51,974	63,272	54,110	112,284	69,697	27,437
Central	125,392	80,851	87,645	52,996	107,159	80,349	19,907	70,431	92,568	72,961	49,881	85,084
West	67,364	63,742	83,856	92,412	120,284	116,618	66,692	49,671	92,920	65,971	31,516	99,000
South	94,572	63,234	79,491	68,963	65,868	56,659	97,101	126,879	73,240	102,589	73,044	177,943
Total	$351,490	$277,998	$344,649	$269,425	$356,942	$306,666	$235,674	$310,254	$312,839	$353,805	$224,139	$389,465

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Part-Whole Relationships

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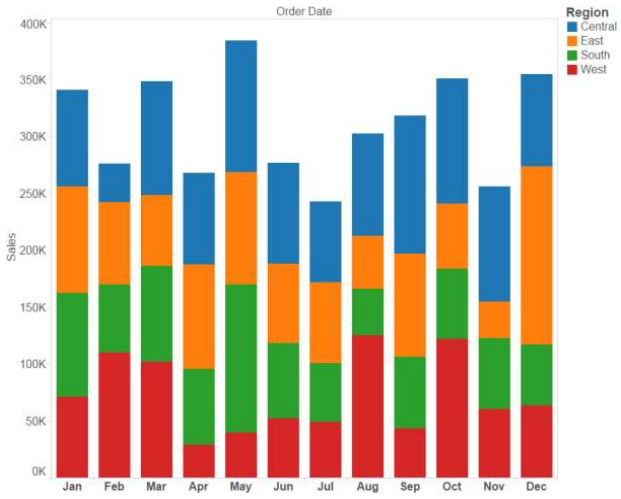
- Possible Visualization: stacked bar chart



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Part-Whole Relationships

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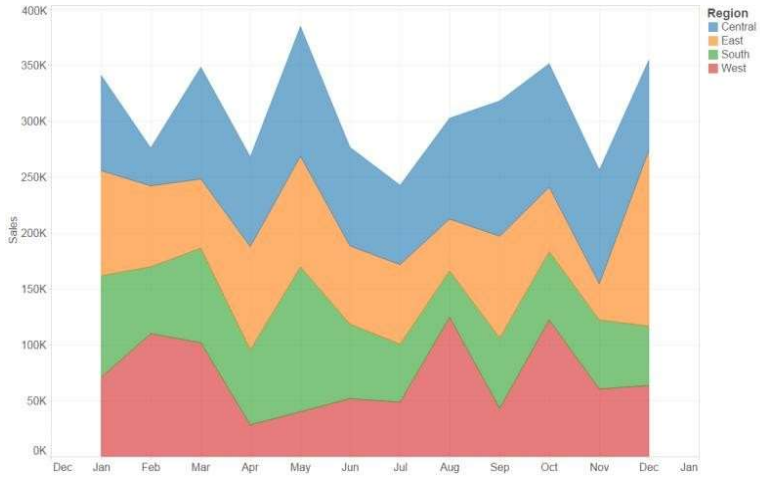
- Possible Visualization: Stacked area chart



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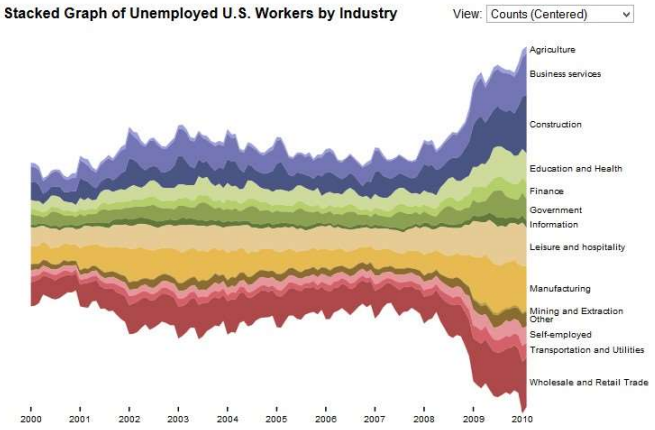
Part-Whole Relationships

- Possible Visualization: Stream Graph (Stacked Graph)



https://homes.cs.washington.edu/~jheer/files/zoo/ex/time/stack.html
https://www.d3-graph-gallery.com/streamgraph

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What will you learn from this lesson?

- Time-series data
- Time representation
- Time-series data patterns
- Time-series data visualization with special requirements
- Interactive techniques for time-series data visualization

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Interactivity

- Select: mark something as interesting
- Explore: show me something else
- Reconfigure: show me a different arrangement
- Encode: show me a different representation
- Abstract/Elaborate: show me more or less details
- Filter: show me something conditionally
- Connect: show me related items

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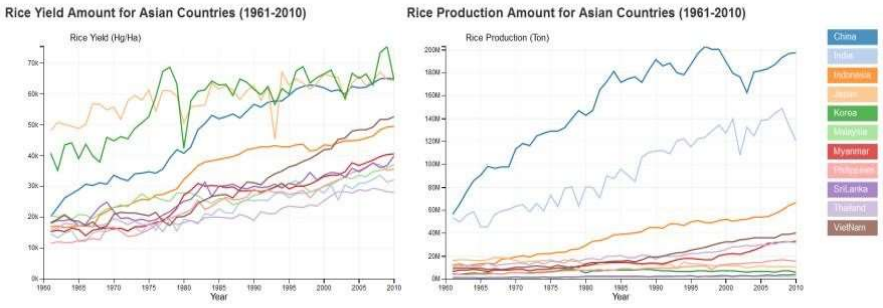
Interactive Line Graph

- Example: Filtering



Link: http://tinyurl.com/ntfqocw

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Animation: Visualizing the Change Over Time

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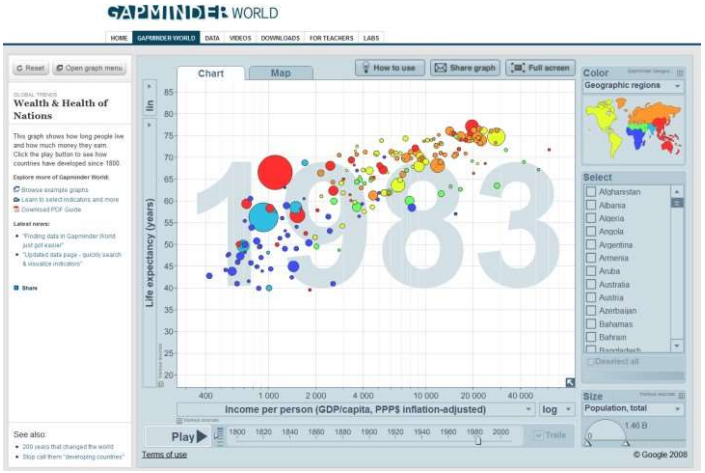
- Example: Animated bubble plot



Source: https://www.gapminder.org/tools/#$chart-type=bubbles&url=v1

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More Research on Time-series Data Visualization

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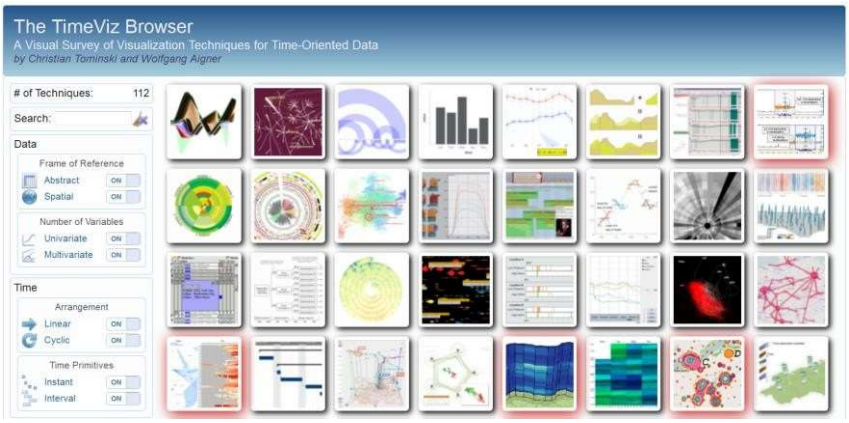

Source: http://survey.timeviz.net/

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Summary

- Time representation
  Linear, radial, grid, spiral, arbitrary
- Time-series data patterns
  Trend, rate of change, co-variation, cycles, exceptions
- Interactive techniques for time-series data visualization

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Questions?

Thank You!

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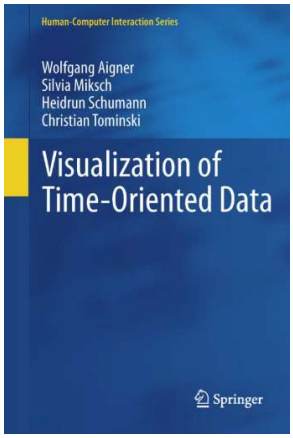
Visualization of Time-Oriented Data

Aigner, W., Miksch, S., Schumann, H., Tominski, C.Springer



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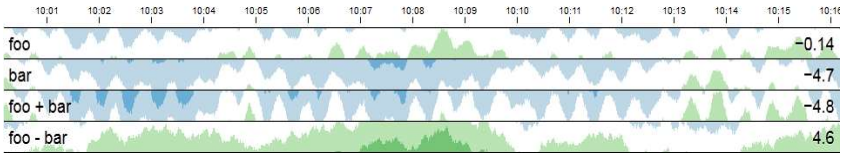
Visualizing the Change Over Time

- Animation + Interactivity: Horizon Graph using d3.js

Cubism.js

Time Series Visualization

https://square.github.io/cubism/



Tutorial: http://bost.ocks.org/mike/cubism/intro/#0

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- Slopegraphs in Tableau (http://dataremixed.com/2013/12/slopegraphs-in-_tableau/)

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  - Time on the Horizon (http://www.perceptualedge.com/articles/visual_business_intelligence/time_on_the_horizon.pdf)
  - Horizon Graphs Revisited (http://www.perceptualedge.com/blog/?p=390)
  - Sizing the Horizon: The Effects of Chart Size and Layering on the Graphical Perception of Time Series Visualizations (http://vis.stanford.edu/files/2009-TimeSeries-CHI.pdf)
  - Interactive Horizon Graphs (http://hal.archives-ouvertes.fr/docs/00/78/13/90/PDF/IHG.pdf)
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