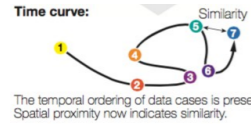


# Time Curves: Folding Time to Visualize Patterns of Temporal Evolution in Data

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From TVCG 2015  
Presented by Jianhui (Jimmy) Chen  
CPSC 547 InfoVis

## Overview

Data: 7 versions of a Wiki article  
Task: explore document history



Pattern: after 4, 5, the article comes back to 3 at 6  
Encoding channels: shape, colour

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## Outline

- What
- Why
- How
- Validation

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## What

General temporal data:



Wiki articles      Videos      fMRI

Data abstraction: distance matrix

```
"distancematrix": [
  [0, 0.7, 0.3],
  [0.7, 0, 0.5],
  [0.3, 0.5, 0]
],
```

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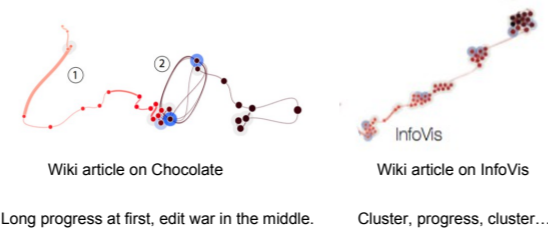
## Outline

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## Why

Motivation: patterns can be of great interest to domain experts or general audience  
Task: overview and identify patterns



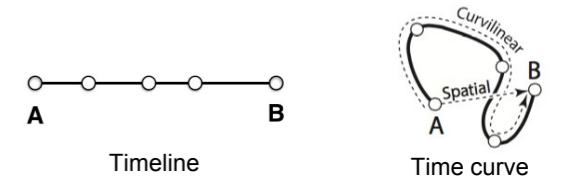
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## Outline

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## How (method)



Information encoding      TL    TC  
Rank distance: how far in time      Y    Y  
Curvilinear distance: cumulated changes      Y    Y+  
Spatial distance: effective changes      N    Y

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## How (implementation)

Distance matrices: number of characters inserted or deleted, Euclidean distance, ...  
Time points positions: "classical" MDS method (not clearly defined) [46]  
Curves: Bézier curve  
Overlap removal: a simple iterative approach (not clearly defined)  
Rotating curves: time goes from left to right

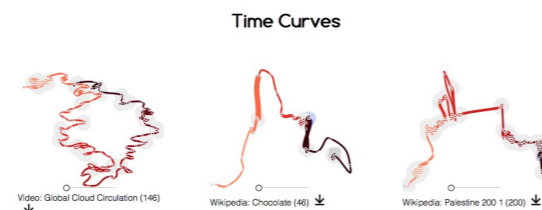
- A combination of other methods
- Sufficient for re-implementation

MDS: multidimensional scaling  
[46] Multidimensional scaling: I. Theory and method

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## Live demo

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



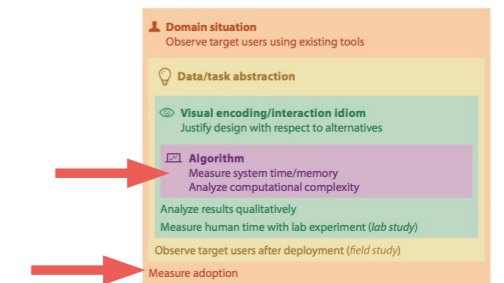
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## Outline

- What
- Why
- How
- Validation

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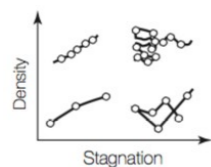
## Validation



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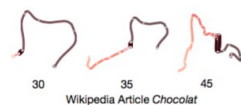
## Validation (algorithm)

# time points	time (sec)
50	9
100	20
500	500



Computational Complexity  $O(N^3)$

Perceptual scalability: depends on data complexity and and down-sampling method.

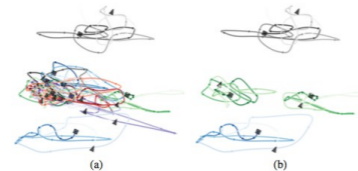


Stability: shape is kept when adds new time points.

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## Validation (domain situation)

Informal user feedback  
Users: one neuroscientist over two months  
Task: identify/compare patterns in fMRI data  
Result: encouraging feedback regarding the usability



Pattern: meaningful difference between individuals in (b)

fMRI: functional magnetic resonance imaging

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## Time curves: summary

What: Data	Time series: Wikipedia histories, videos and dynamic network
What: Derived	Pairwise distances
Why: Tasks	Reveal patterns in temporal datasets
How: Encode	Circles and dots: time stamp Curve: evolution Distance and colour: similarity
Scale	About 100 time points

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## What else?

Patterns and examples!

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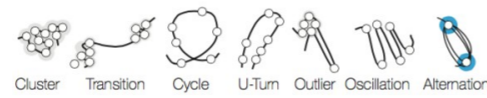
## Geometric characteristics

<b>Degree of stagnation</b> progressing		stagnating	No effective progress
<b>Degree of oscillation</b> no oscillation		large oscillations	Edit war in Wiki
<b>Self-intersection</b> no intersection		many intersections	Ineffective reversal
<b>Point density</b> sparse		dense	Many small changes
<b>Irregularity</b> regular		irregular	Chaotic processes

Curves between two remote time points

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## Patterns

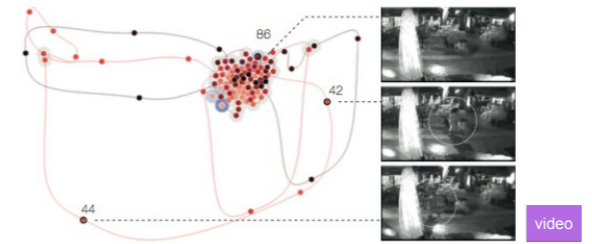


Cluster : minor revision  
 Transition: big progression  
 Cycle : back to previous point after a long progression  
 Outlier : large sudden changes

...  
 Specific combination of geometric characteristics

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## Surveillance video



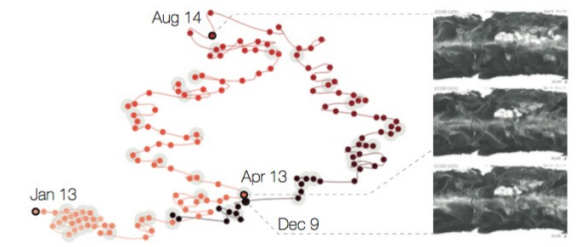
Derived data  
 Time stamp: one frame/second  
 Distance : normalized absolute pixel difference

Patterns  
 Cluster: minor changes  
 Outliers: moving people

Video summarization, anomaly detection

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## Cloud coverage and precipitation

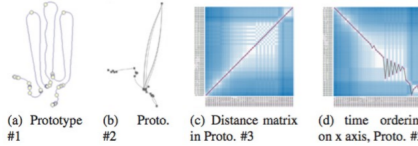


Patterns:  
 Extremes: Jan & Aug  
 Dec goes to Apr

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## Conclusion

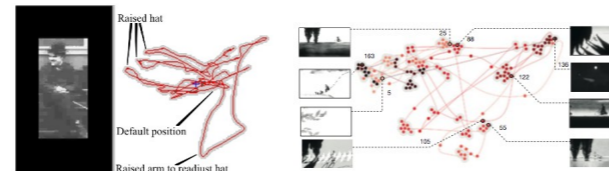
- A general approach for visualizing patterns of evolution in temporal data
- Demonstrated by lots of examples (solid work)
- Gives developing history of time curve method



Useful in other domains such software engineering management, law making study...

## Critiques

- No direct comparison with previous work
- Validation is insufficient



Video Interpretation from [37]

Animated movie example in the paper

[37] Image Spaces and Video Trajectories: Using Isomap to Explore Video Sequences

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**Thanks!**  
**Q&A**

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