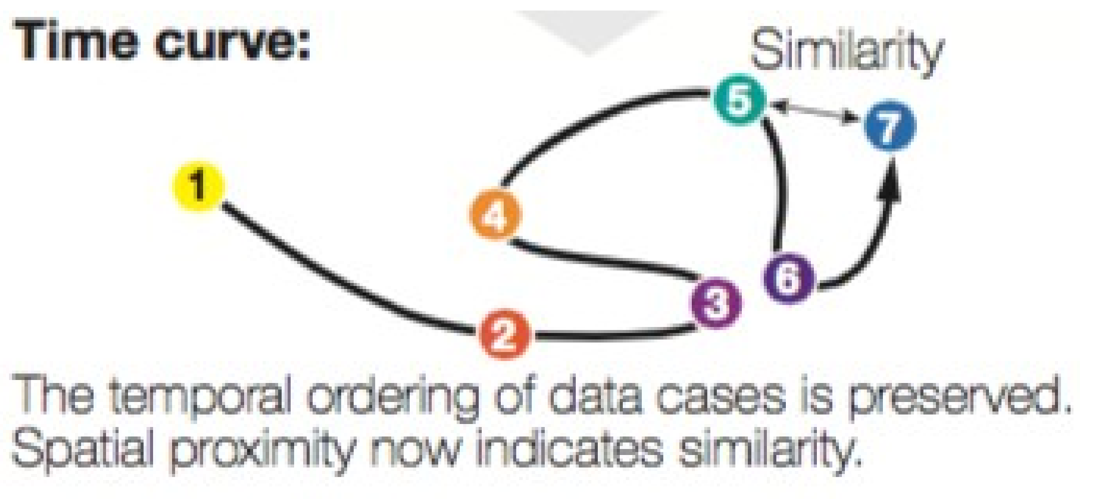
Time Curves: Folding Time to Visualize Patterns of Temporal Evolution in Data

Benjamin Bach, Conglei Shi, Nicolas Heulot, Tara Madhyastha

Tom Grabowski, Pierre Dragicevic

Microsoft Research-Inria Joint Centre, IBM Watson Research Centre

IRT SystemX, University of Washington



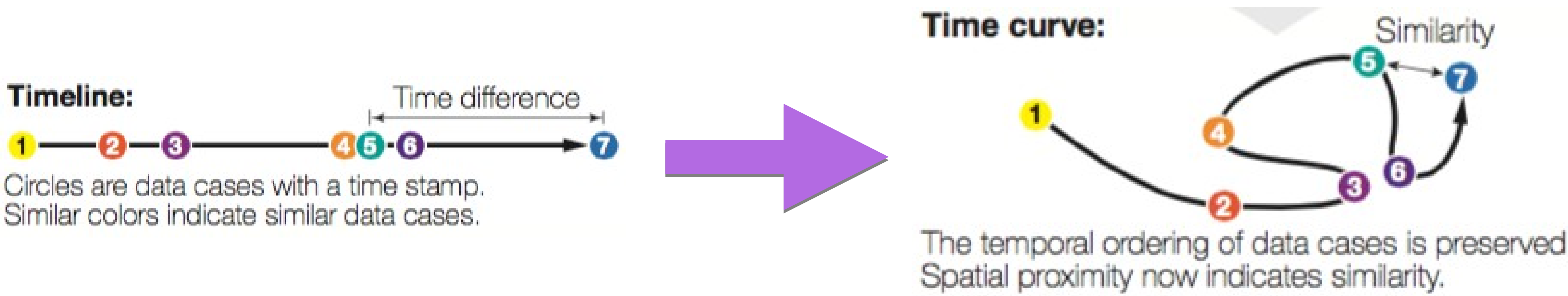
From TVCG 2015

Present 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

Outline

What

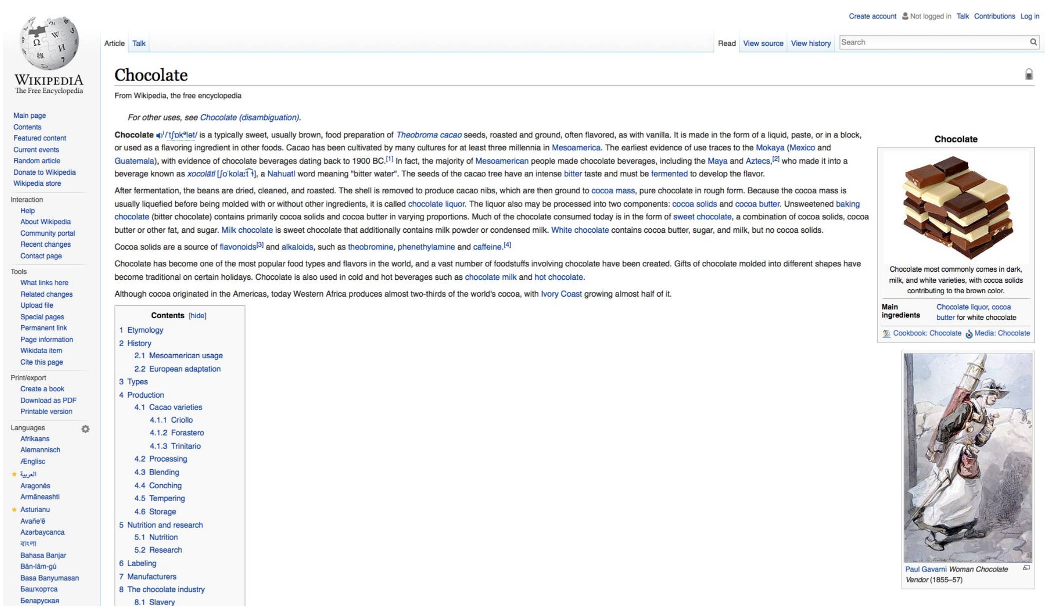
Why

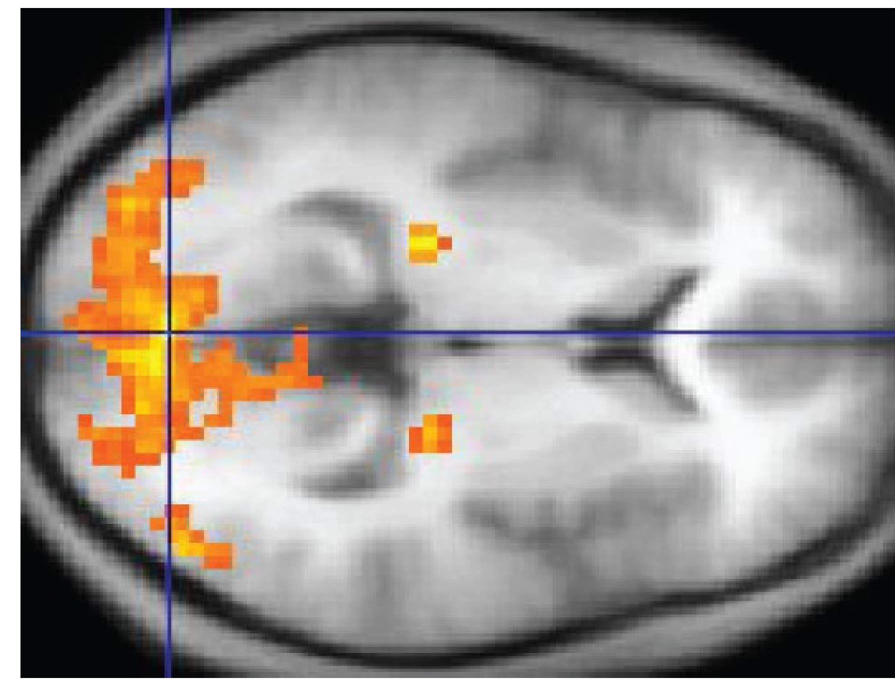
How

Validation

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]
],
```

Outline

What

Why

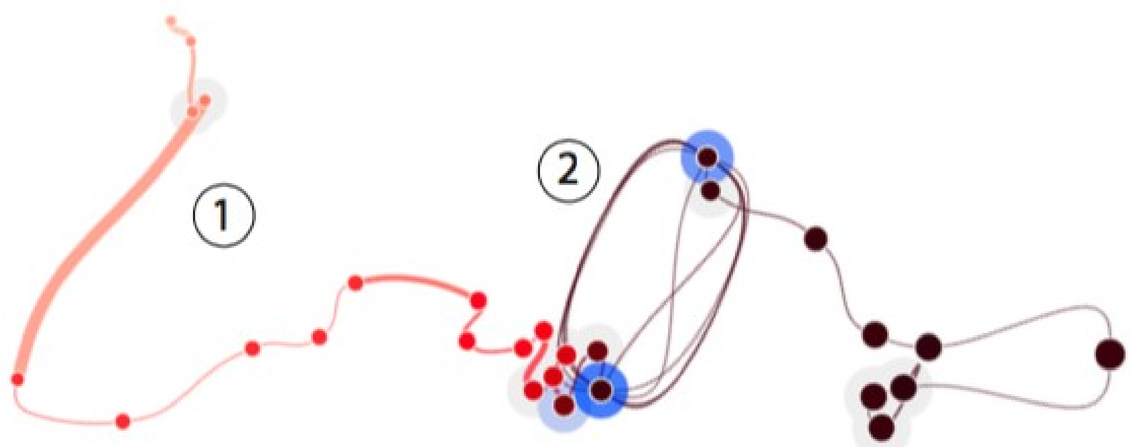
How

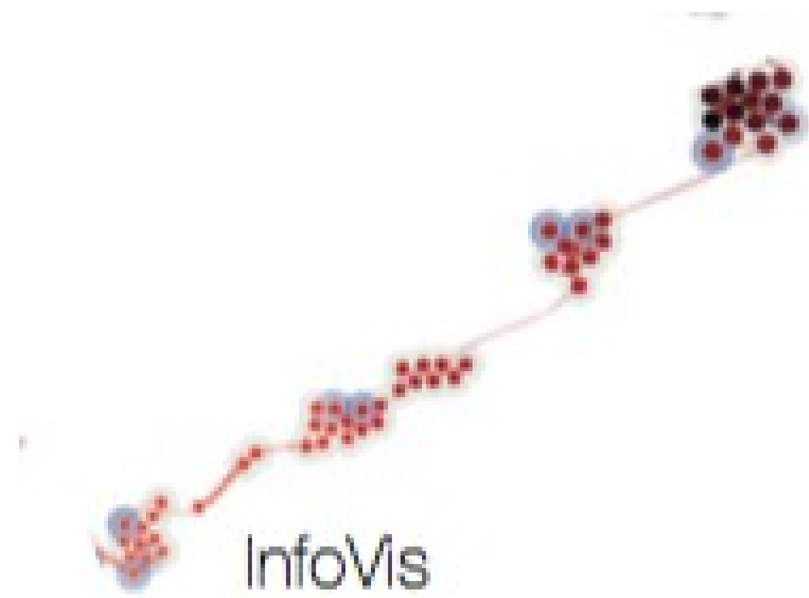
Validation

Why

Motivation: patterns can be of great interest to domain experts or general audience

Task: overview and identify patterns





Wiki article on Chocolate

Wiki article on InfoVis

Long progress at first, edit war in the middle.

Cluster, progress, cluster…

Outline

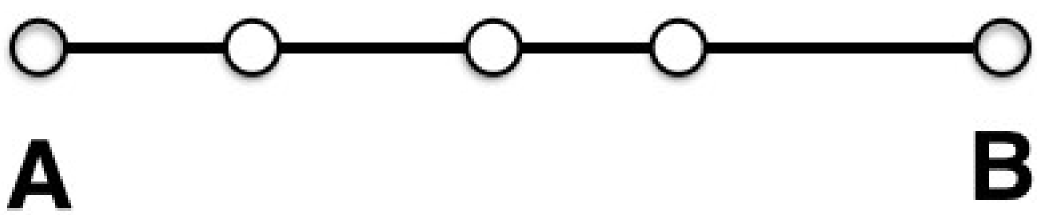
What

Why

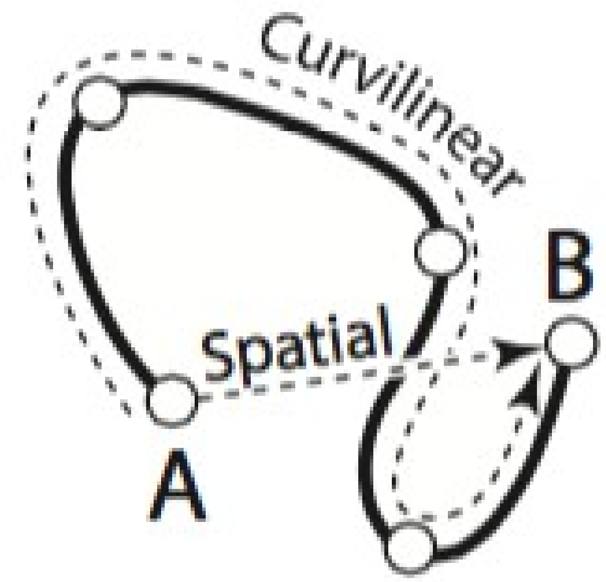
How

Validation

How (method)



Timeline



Time curve

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

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

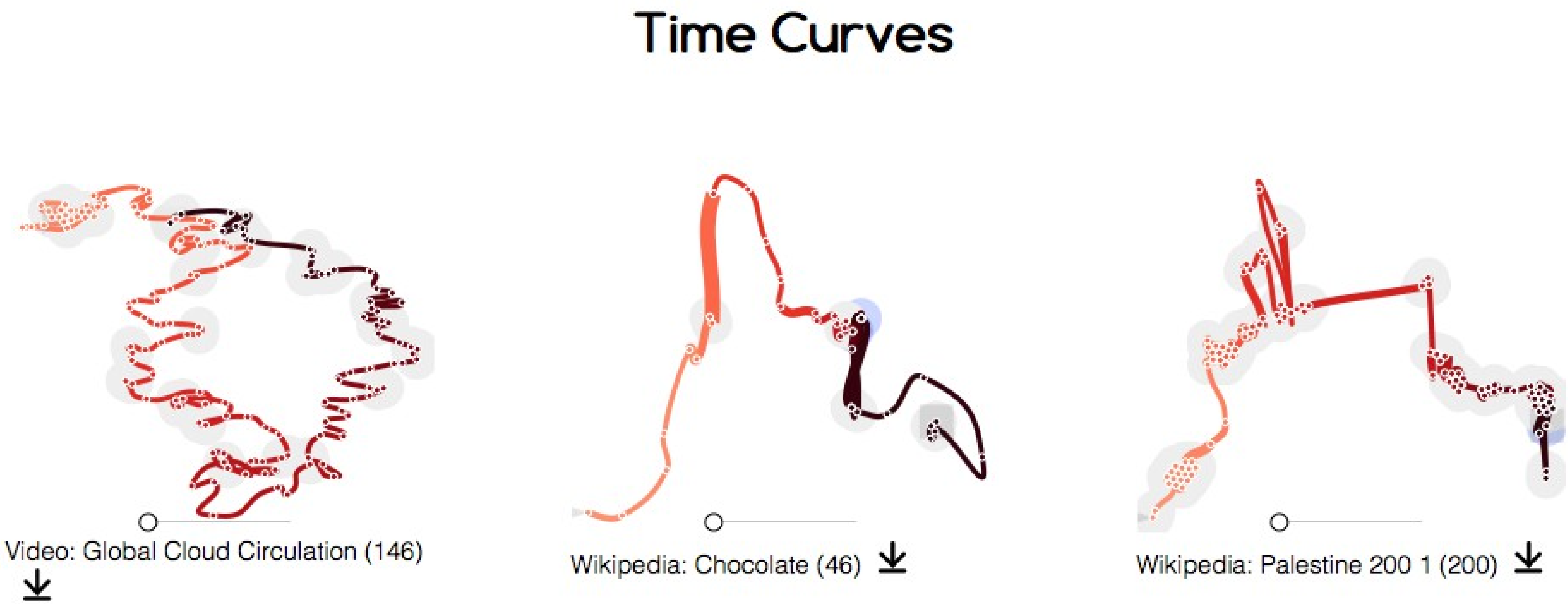
- A combination of other methods
- Sufficient for re-implementation

MDS: multipledimensional scaling

[46] Multidimensional scaling: I. Theory and method

Live demo

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



Outline

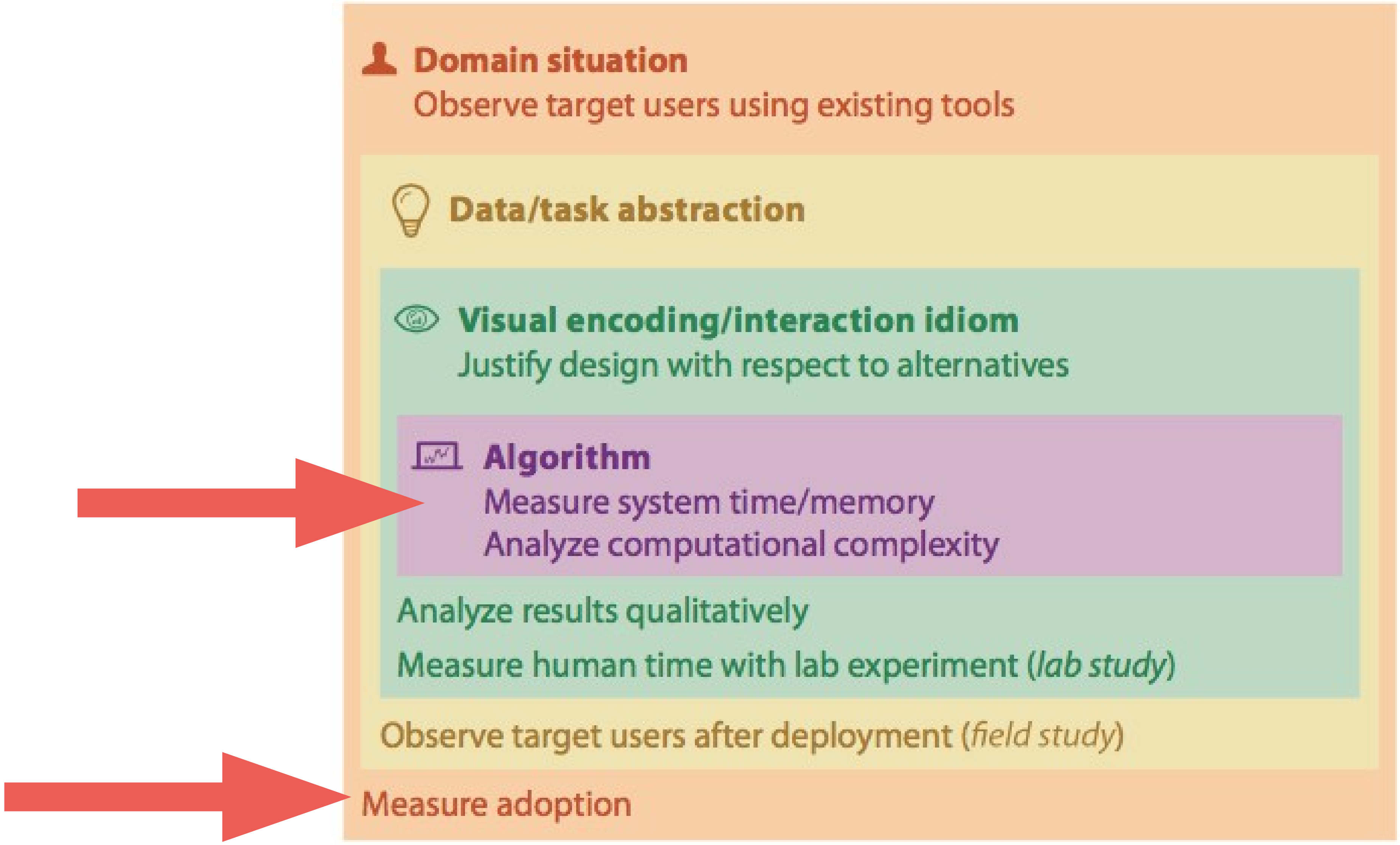
What

Why

How

Validation

Validation

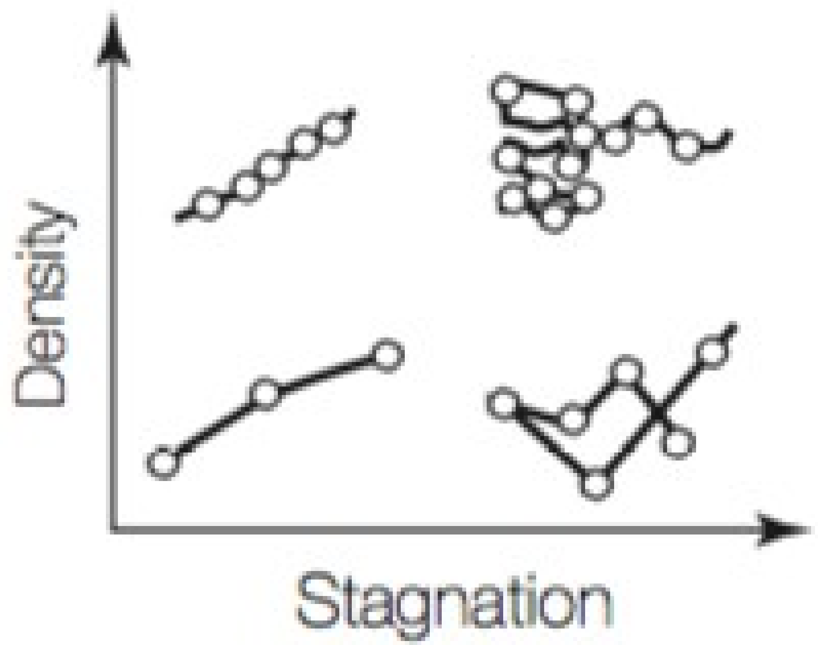


Domain situation
Observe target users using existing tools
Data/task abstraction
Visual encoding/interaction idiom
Justify design with respect to alternatives
Algorithm
Measure system time/memory
Analyze computational complexity
Analyze results qualitatively
Measure human time with lab experiment (lab study)
Observe target users after deployment (field study)
Measure adoption

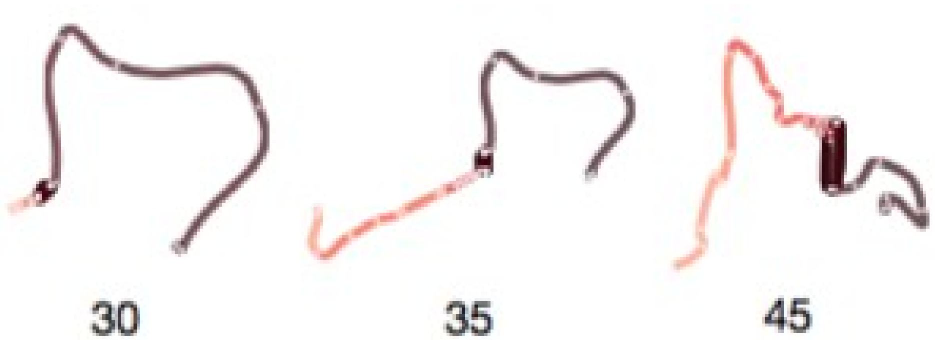
Validation (algorithm)

# 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.



Wikipedia Article *Chocolat*

Stability: shape is kept when adds new time points.

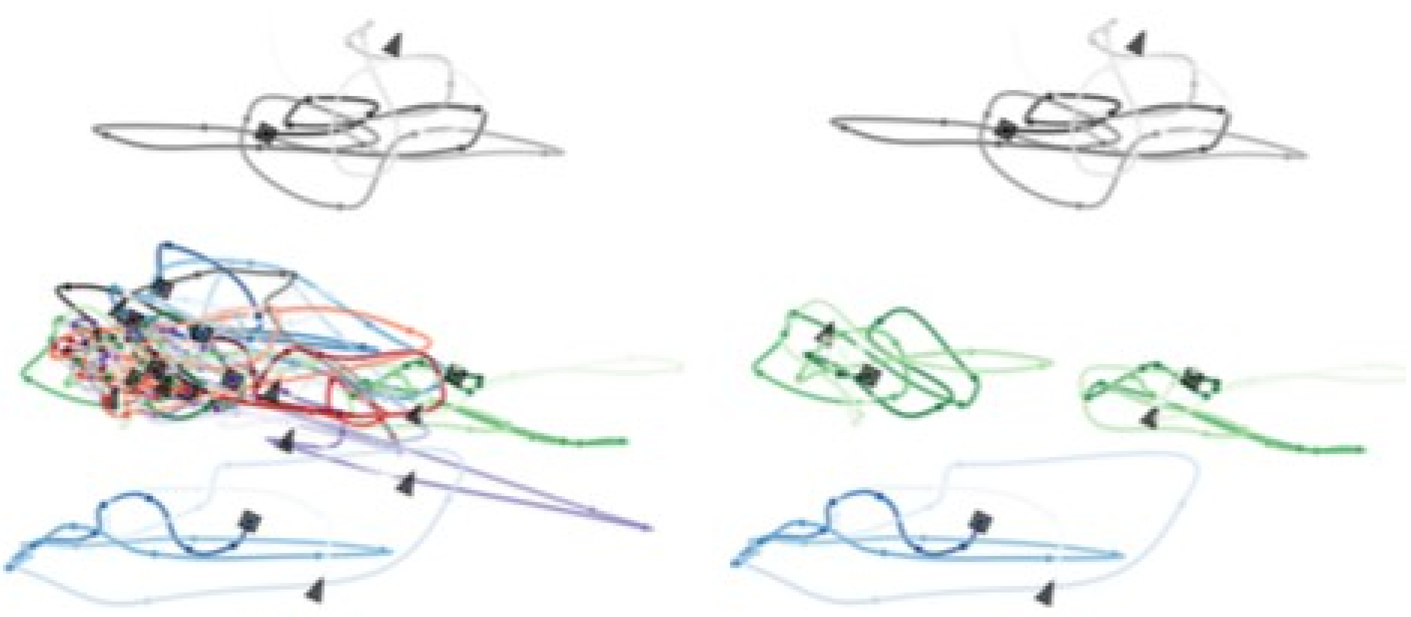
Validation (domain situation)

Informal user feedback

Users : one neuroscientist over two months

Task : identify/compare patterns in fMRI data

Result: encouraging feedback regarding the usability



(a) (b)

Pattern: meaningful difference between individuals in (b)

fMRI:functional magnetic resonance imaging

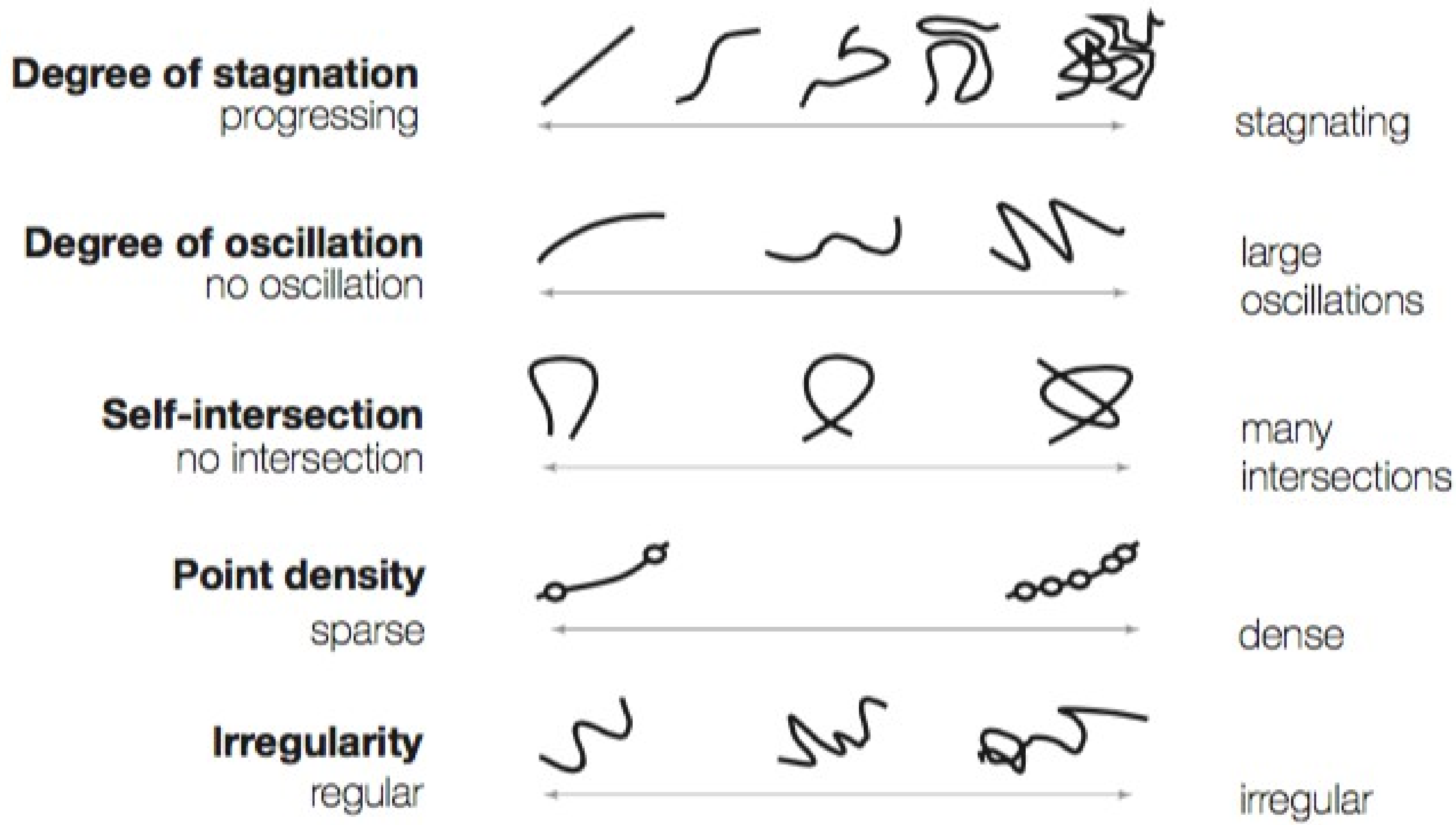
Time curves: summary

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

What else?

Patterns and examples!

Geometric characteristics



No effective progress

Edit war in Wiki

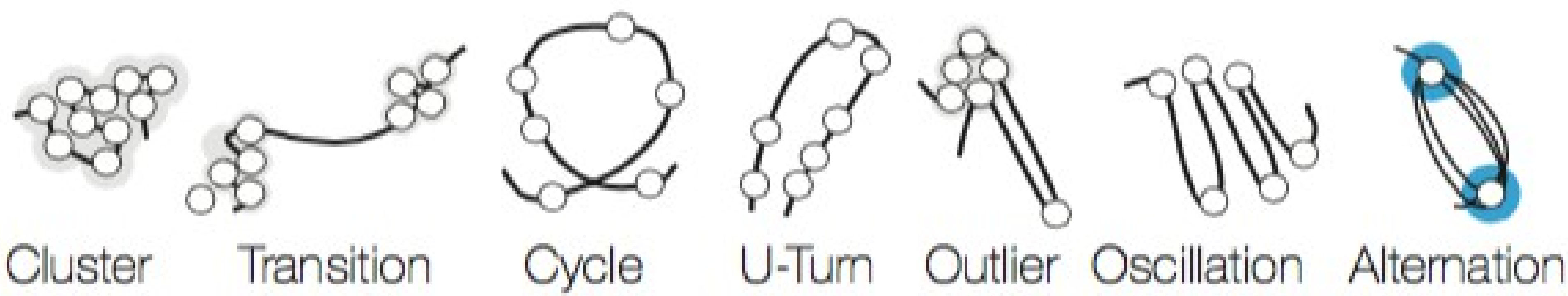
Ineffective reversal

Many small changes

Chaotic processes

Curves between two remote time points

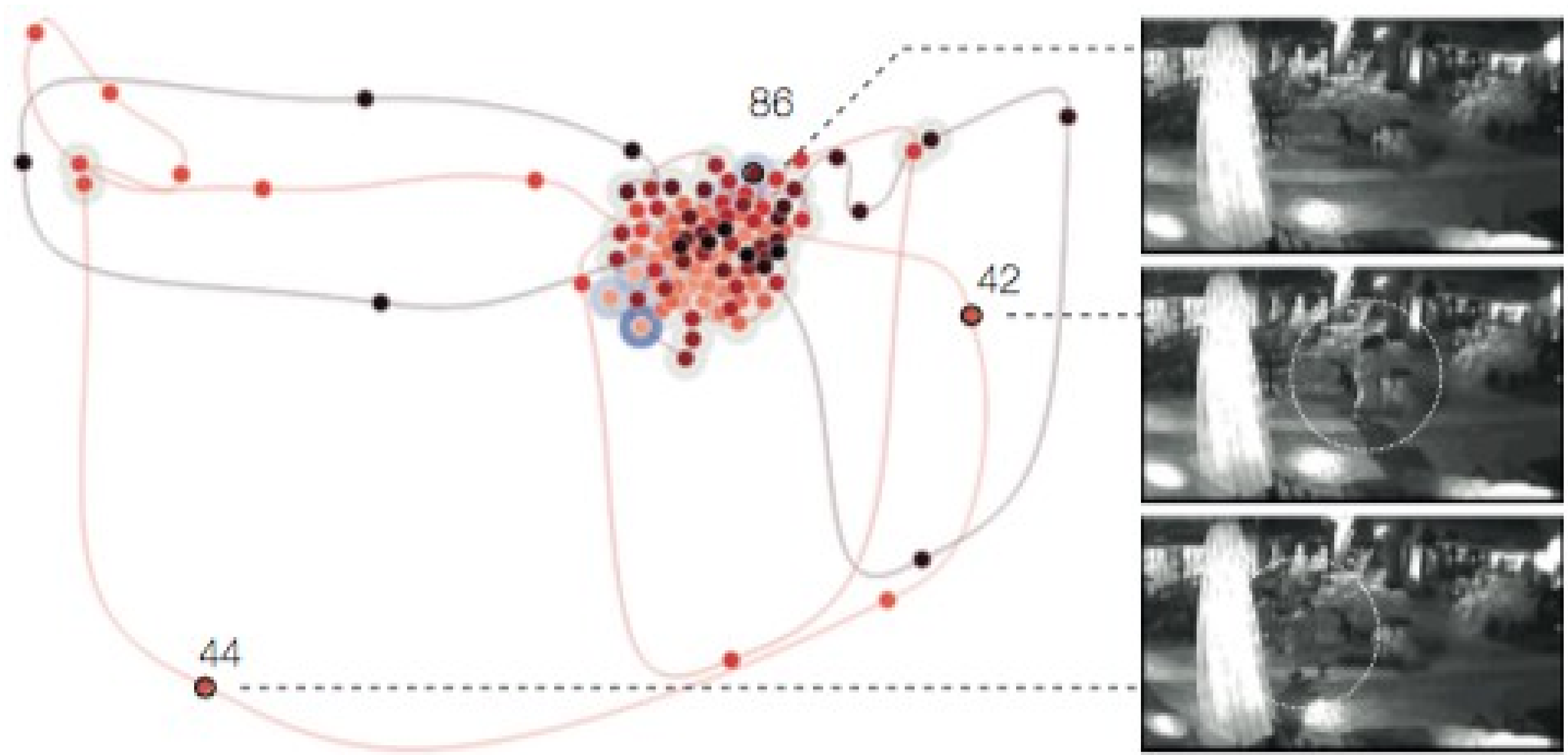
Patterns



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

Specific combination of geometric characteristics

Surveillance video



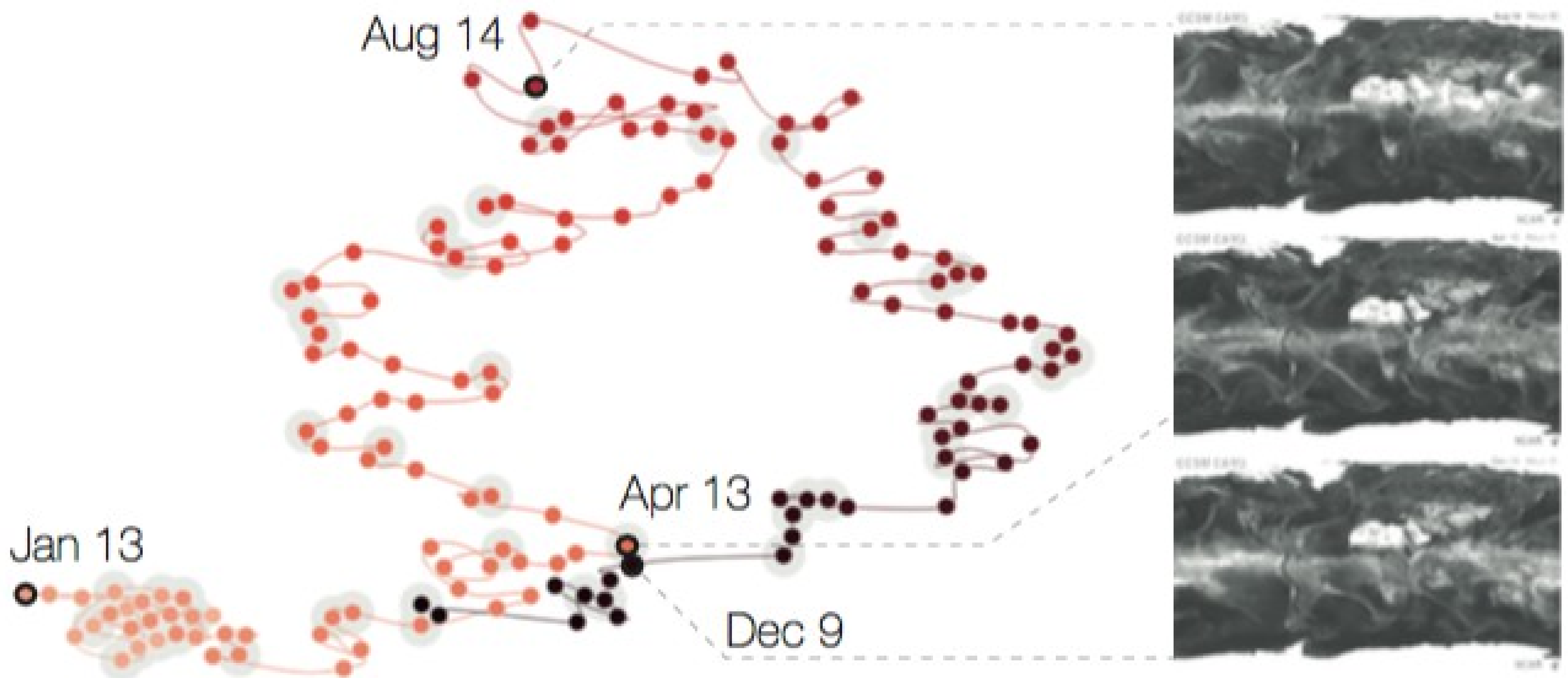
video

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

Patterns
Cluster: minor changes
Outliers: moving people

Video summarization, anomaly detection

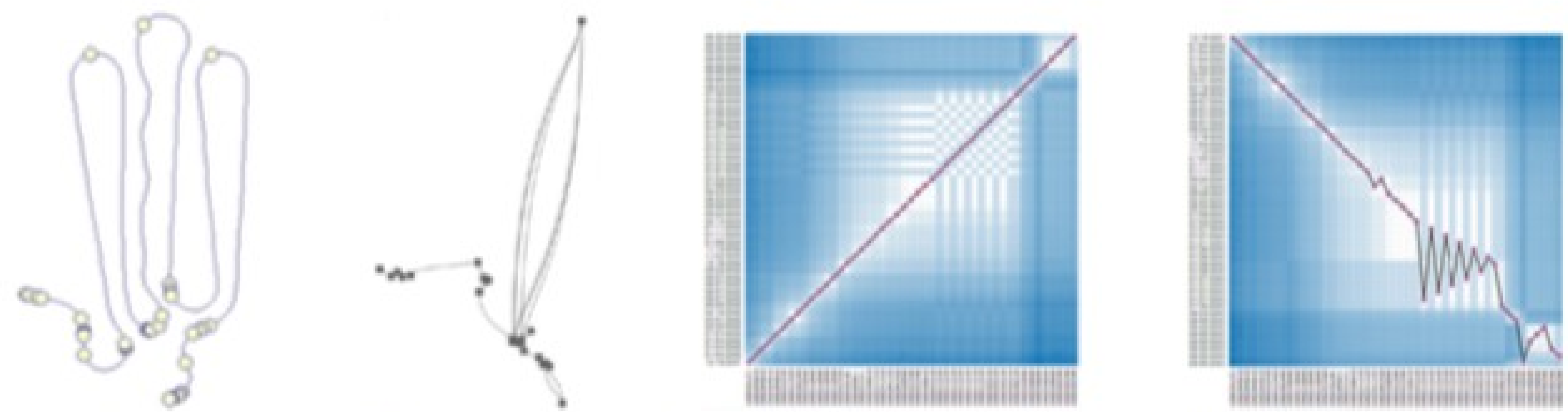
Cloud coverage and precipitation



Patterns:
Extremes: Jan & Aug
Dec goes to Apr

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

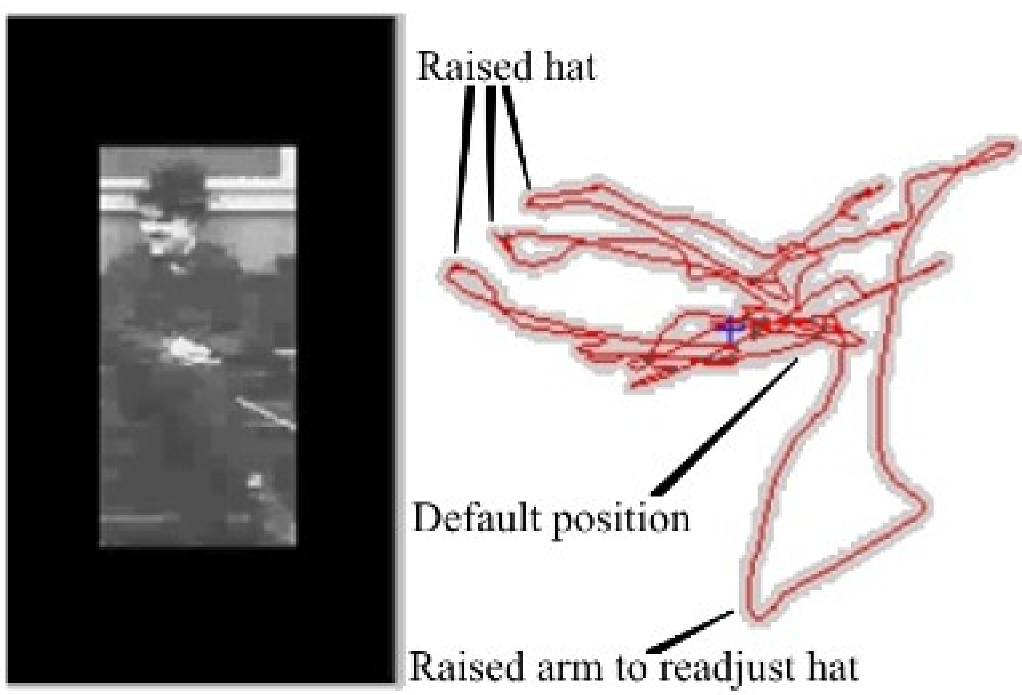


(a) Prototype #1 (b) Proto. #2 (c) Distance matrix in Proto. #3 (d) time ordering on x axis, Proto. #3

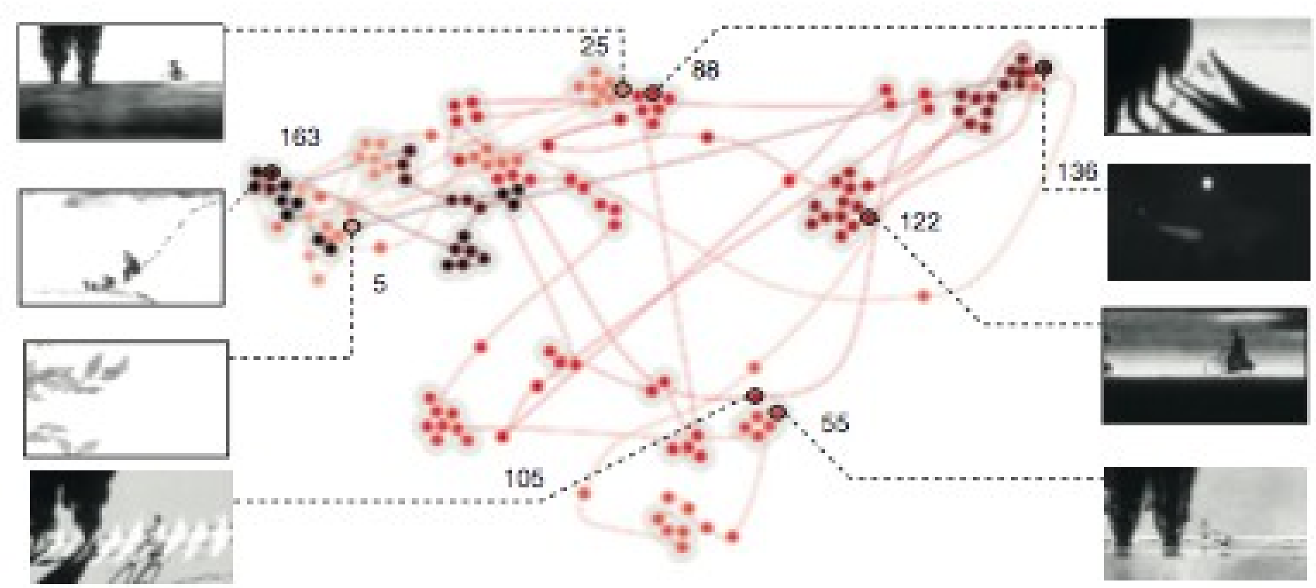
Useful in other domains such software engineering management, law making study…

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

Thanks!

Q&A