

# In-place Occlusion-Free Visualization of Spatio-temporal Information with Route-Zooming

Authors: Guodao Sun, Ronghua Liang, Huamin Qu and Yingcai Wu

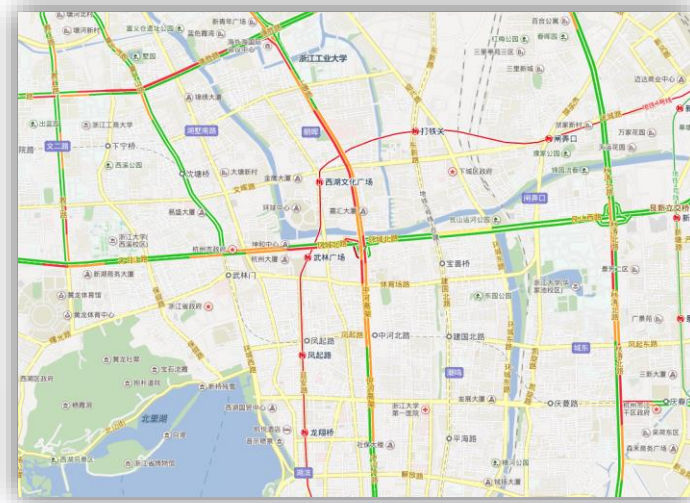
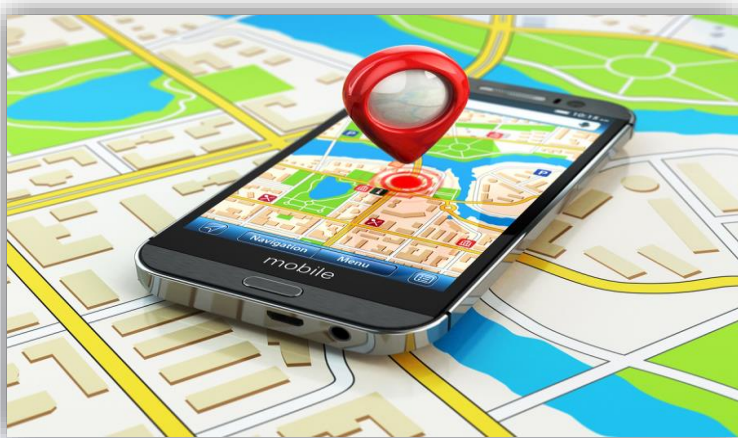
Presenter: Tan Tang



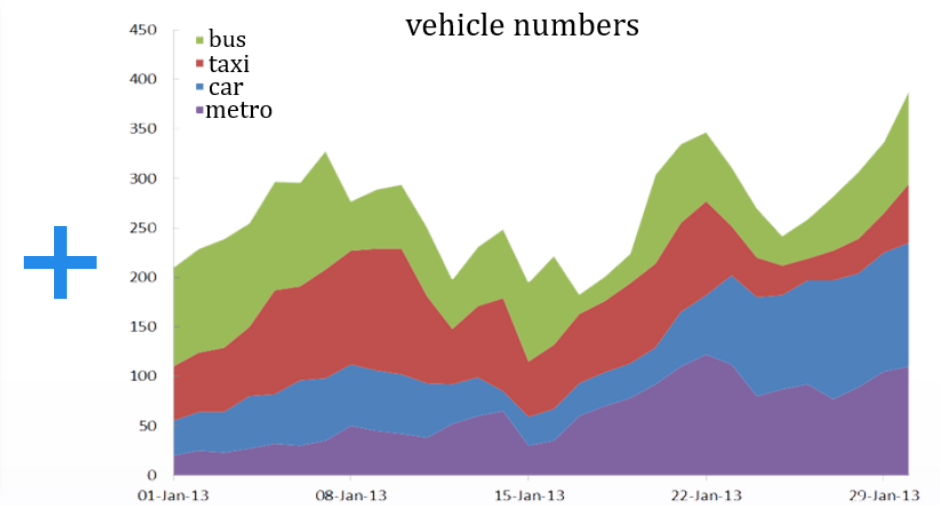
香港科技大學  
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UNIVERSITY OF SCIENCE  
AND TECHNOLOGY

# Urban Spatio-temporal Data

- Various sensors in cities have been producing massive spatio-temporal data



Vehicle trajectories

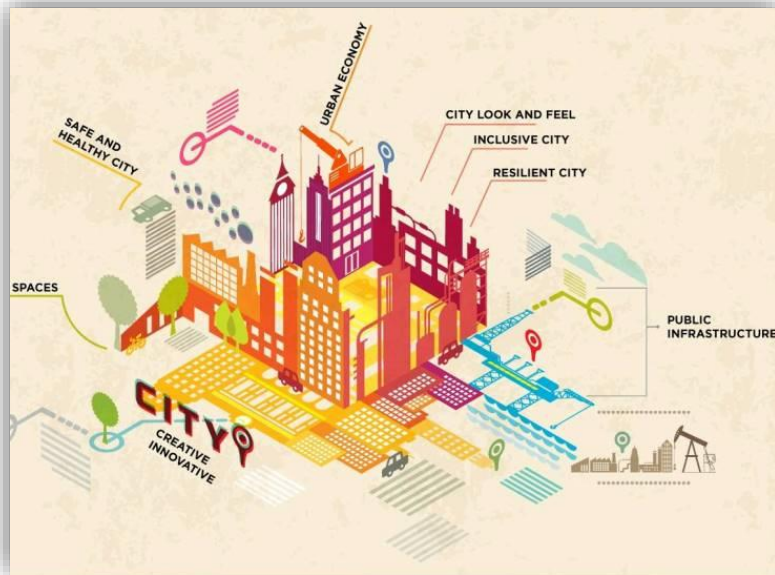


Traffic flow



# Treasures behind Spatio-temporal Data

- Spatio-temporal patterns are valuable for decision making and problem solving



Urban planning



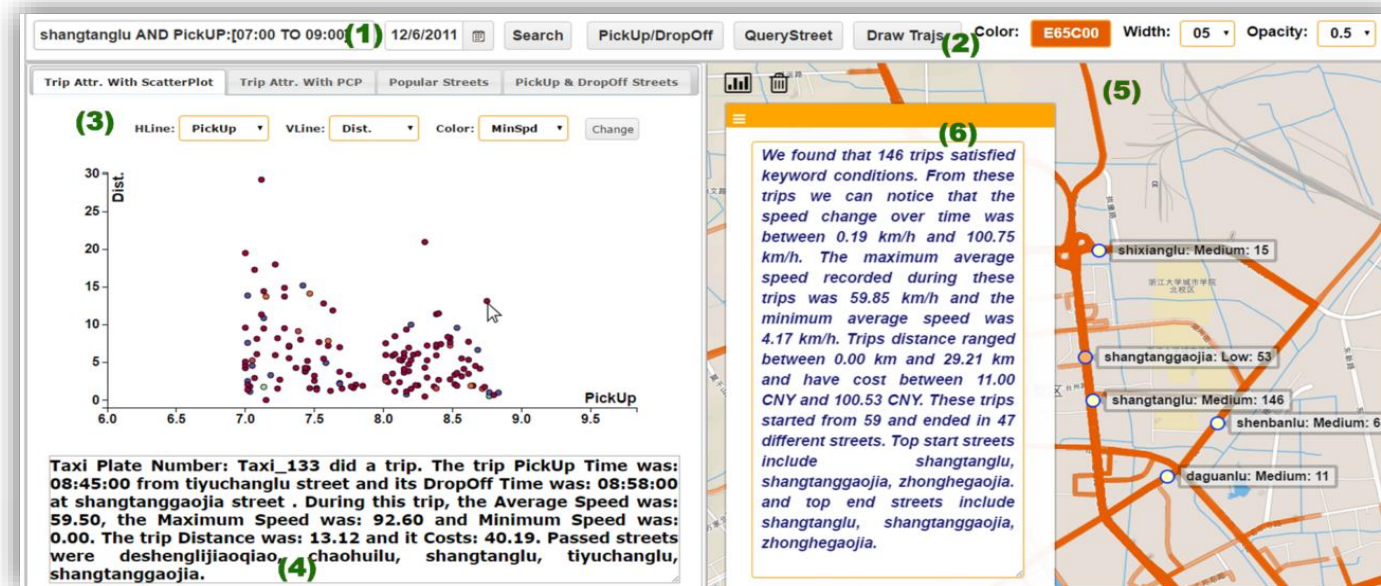
Management



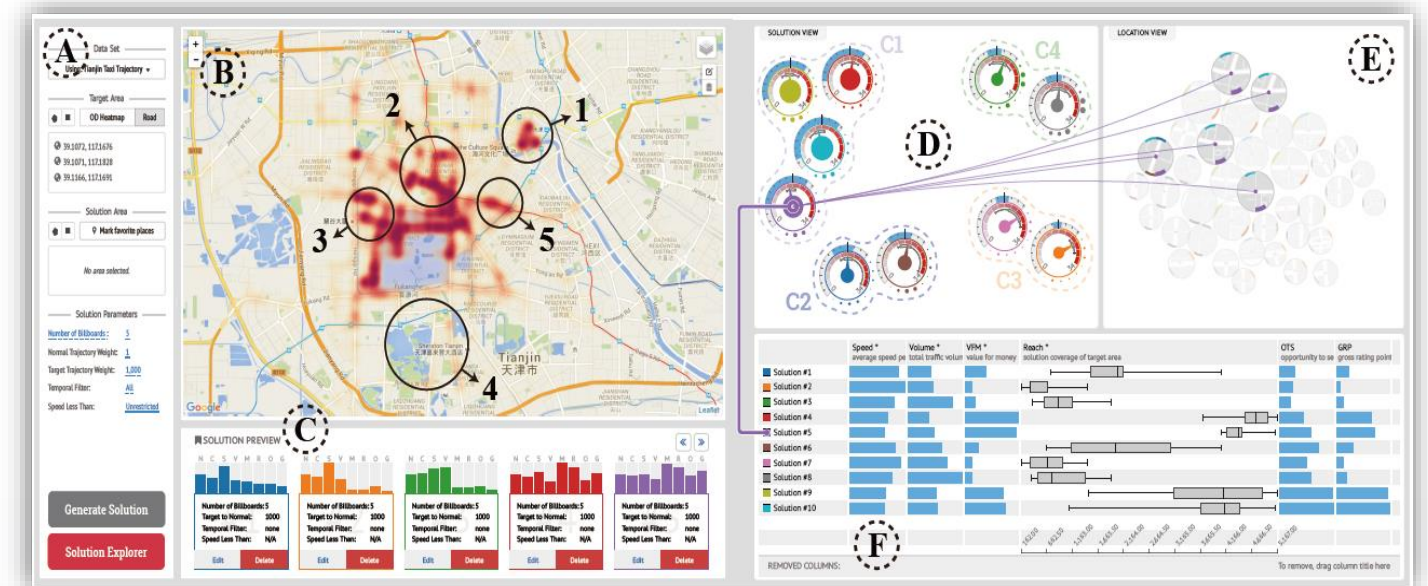
Transportation

# How to Understand Spatio-Temporal Data

- Proper visualizations are an important means for uncovering spatio-temporal patterns



AL-Dohuki et al. 2016

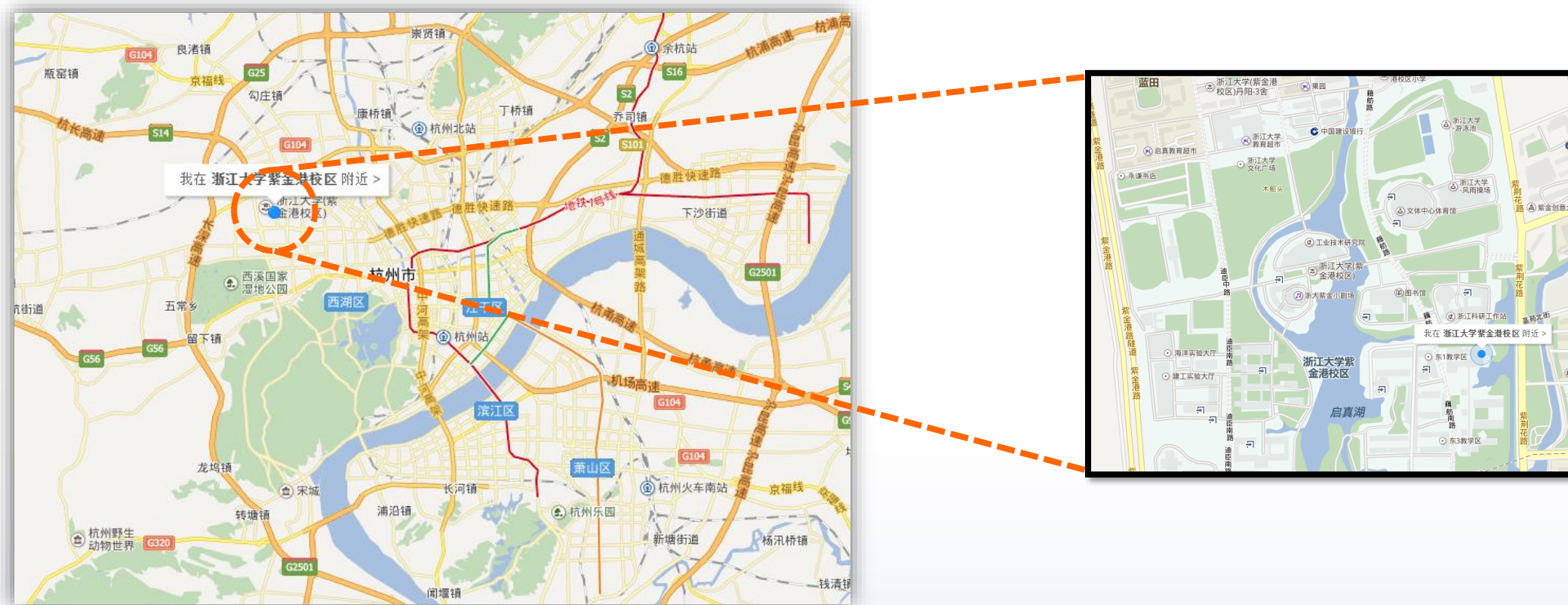


Liu et al. 2016



# Key Challenges(1/3)

- How to clearly perceive the information embedded on the narrow roads?
  - Conventional approaches zoom in the map at a very high level





## Key Challenges(2/3)

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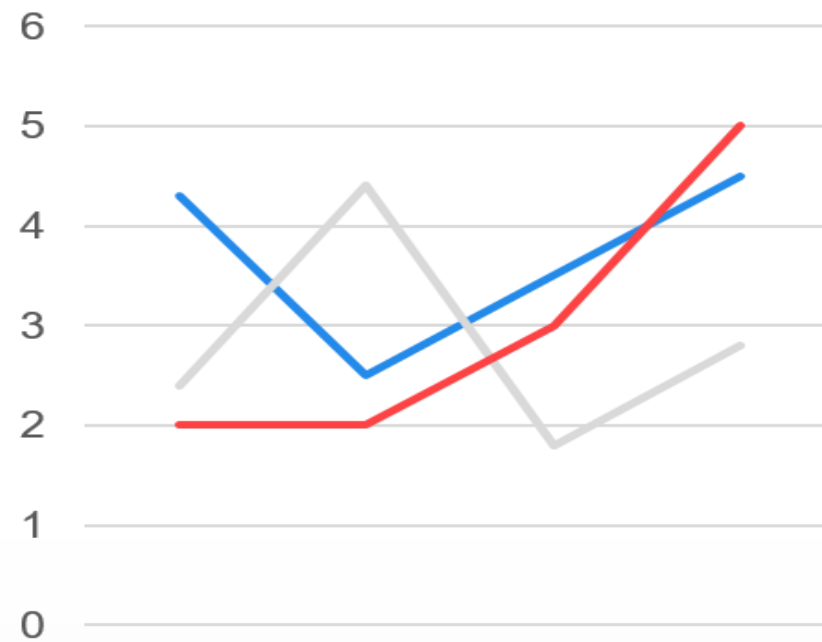
- How to encode the direction of time flow on a road when temporal information is embedded?
  - The arbitrary direction of roads makes it challenging to encode the time flow direction





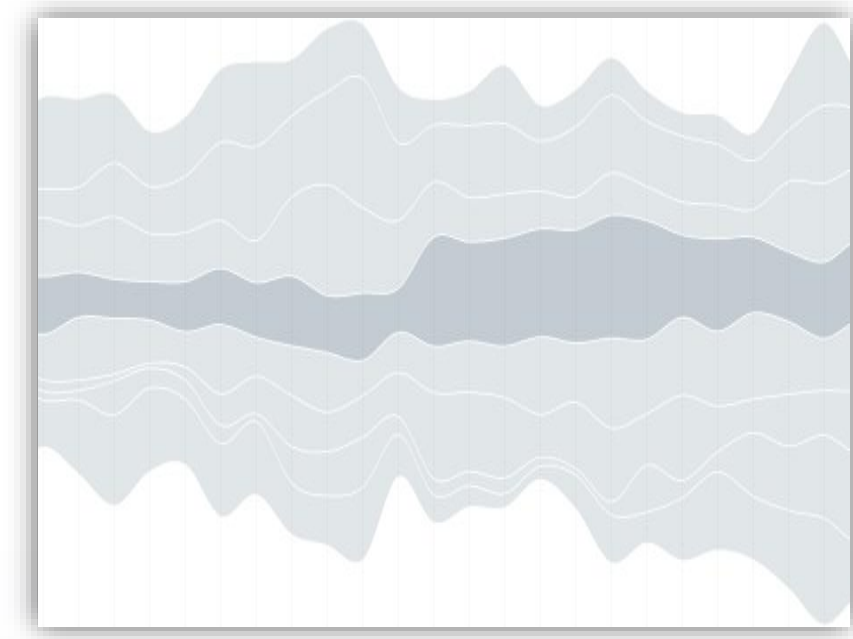
## Key Challenges(3/3)

- How to choose suitable visual representations to embed temporal information on the map?



Line chart

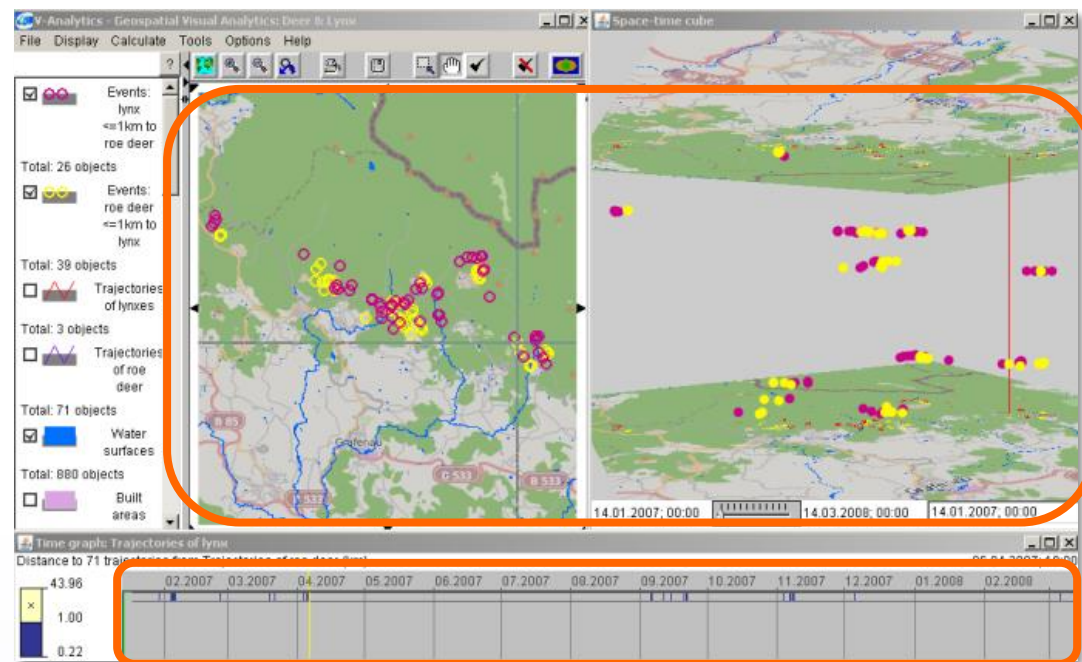
V.S



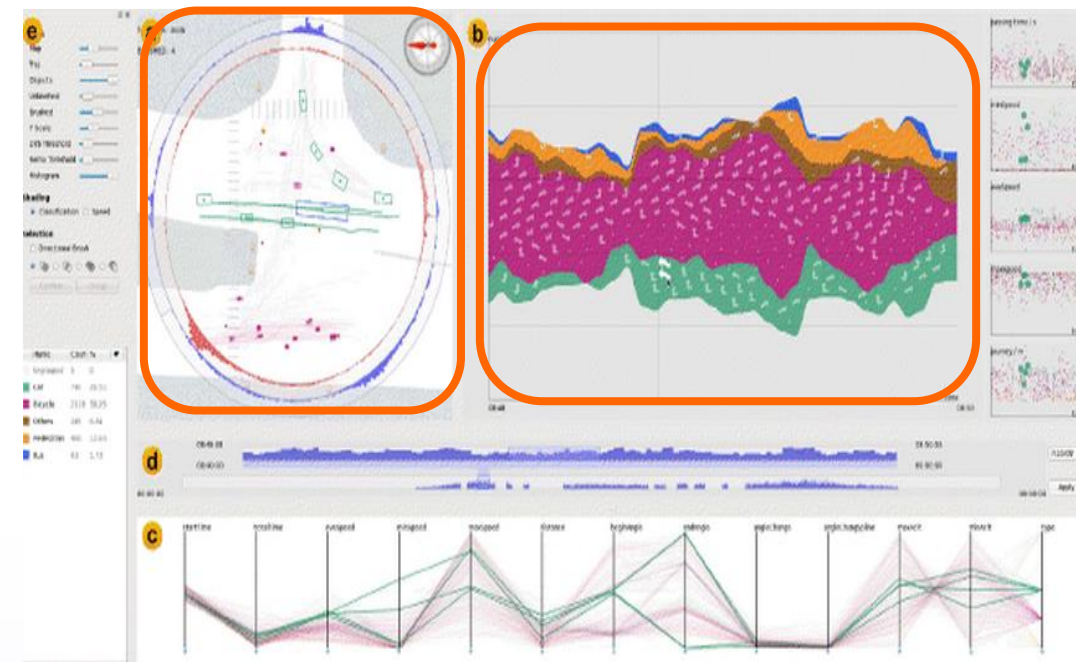
Stacked graph

# Visualizations of Spatio-Temporal Data

- The linked view systems make users endure memory burden when they switch between different views



Andrienko et al. 2011

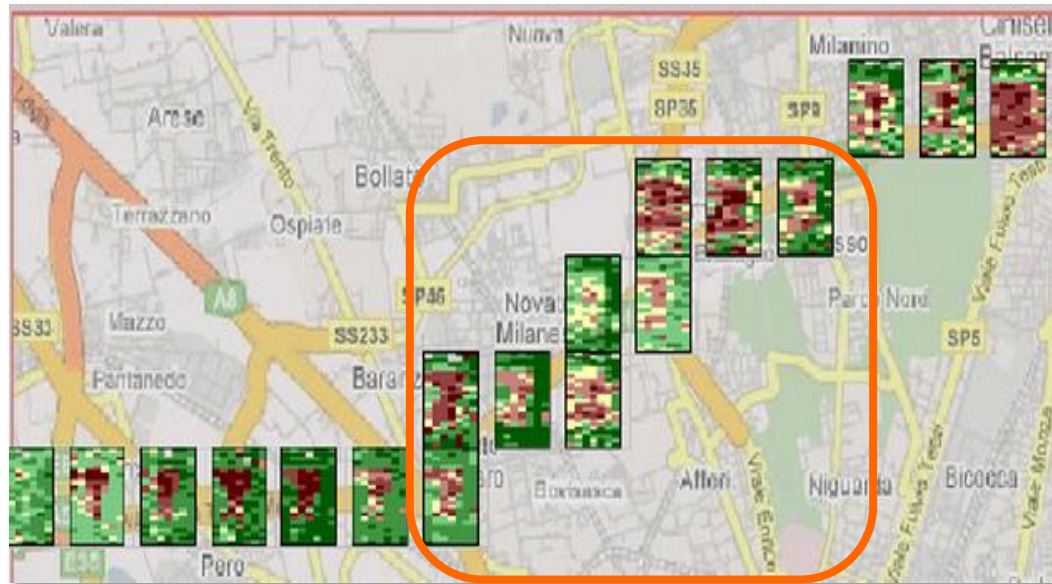


Guo et al. 2012

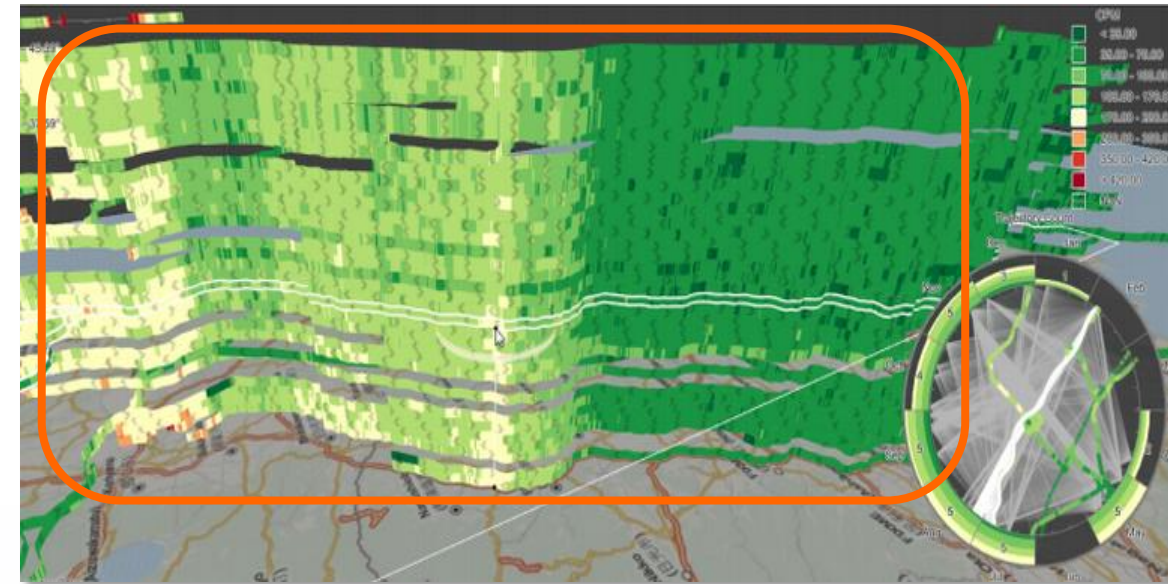


# Visualizations of Spatio-Temporal Data

- The Integrated view systems make users suffer from visual clutter when they are doing analytical tasks



Andrienko et al. 2012



Tominski et al. 2012



## Our method - Route Zooming

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# Analytical Tasks

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## Level-of-Detail Characterization

- Identify the trends and variations of attributes over different time periods in a large or local area



## Pattern Detection

- Identify & locate a specific pattern of attributes in its occurring spatial and temporal positions



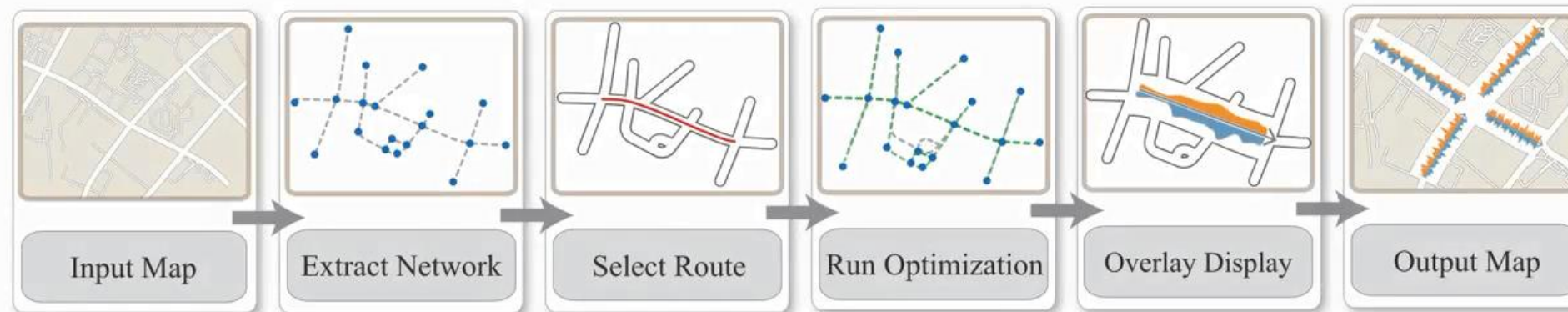
## Pattern Comparison

- Compare various patterns of attribute values across different time intervals and different spatial regions

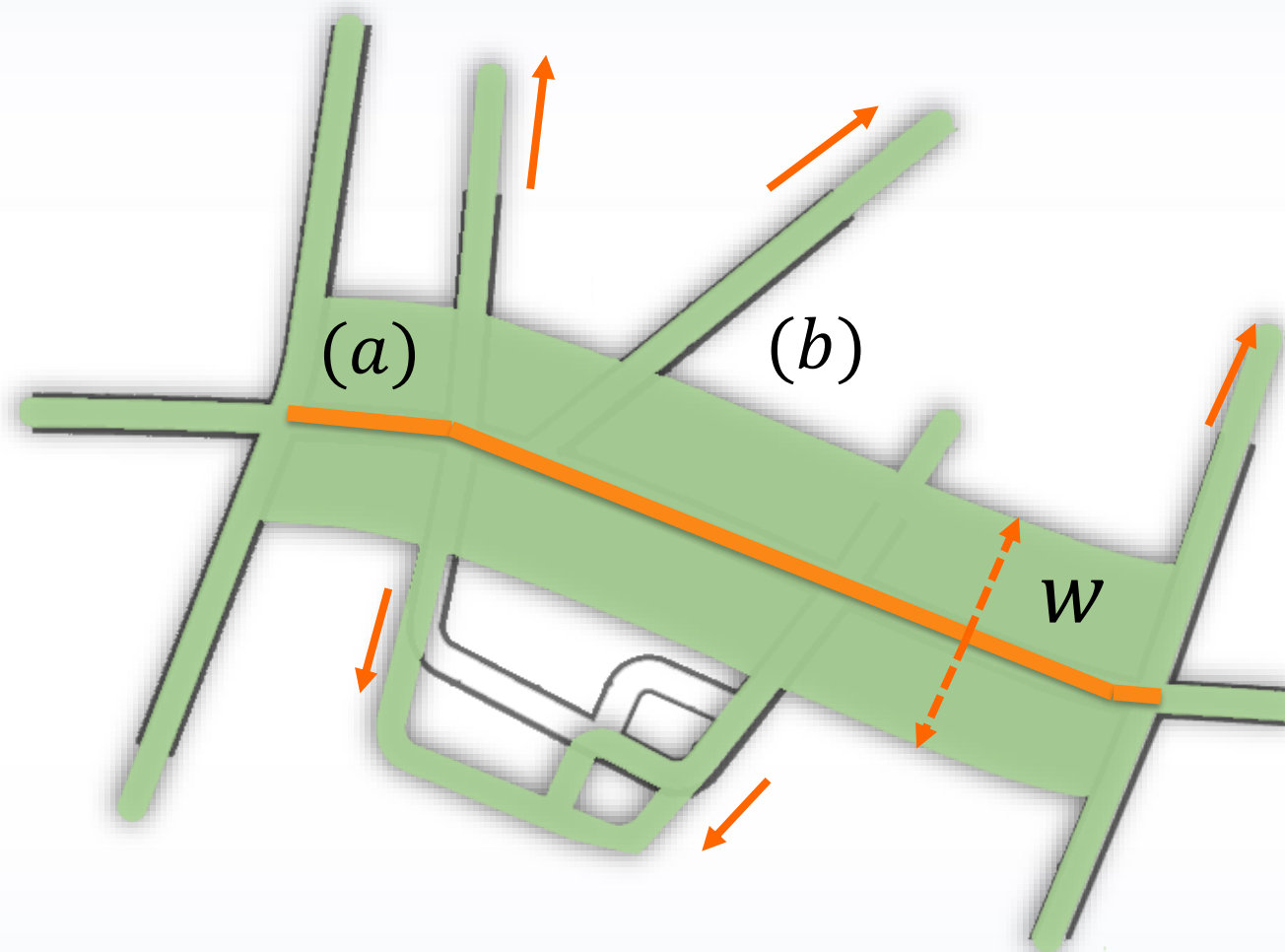


# Our Algorithm Pipeline

## System Overview

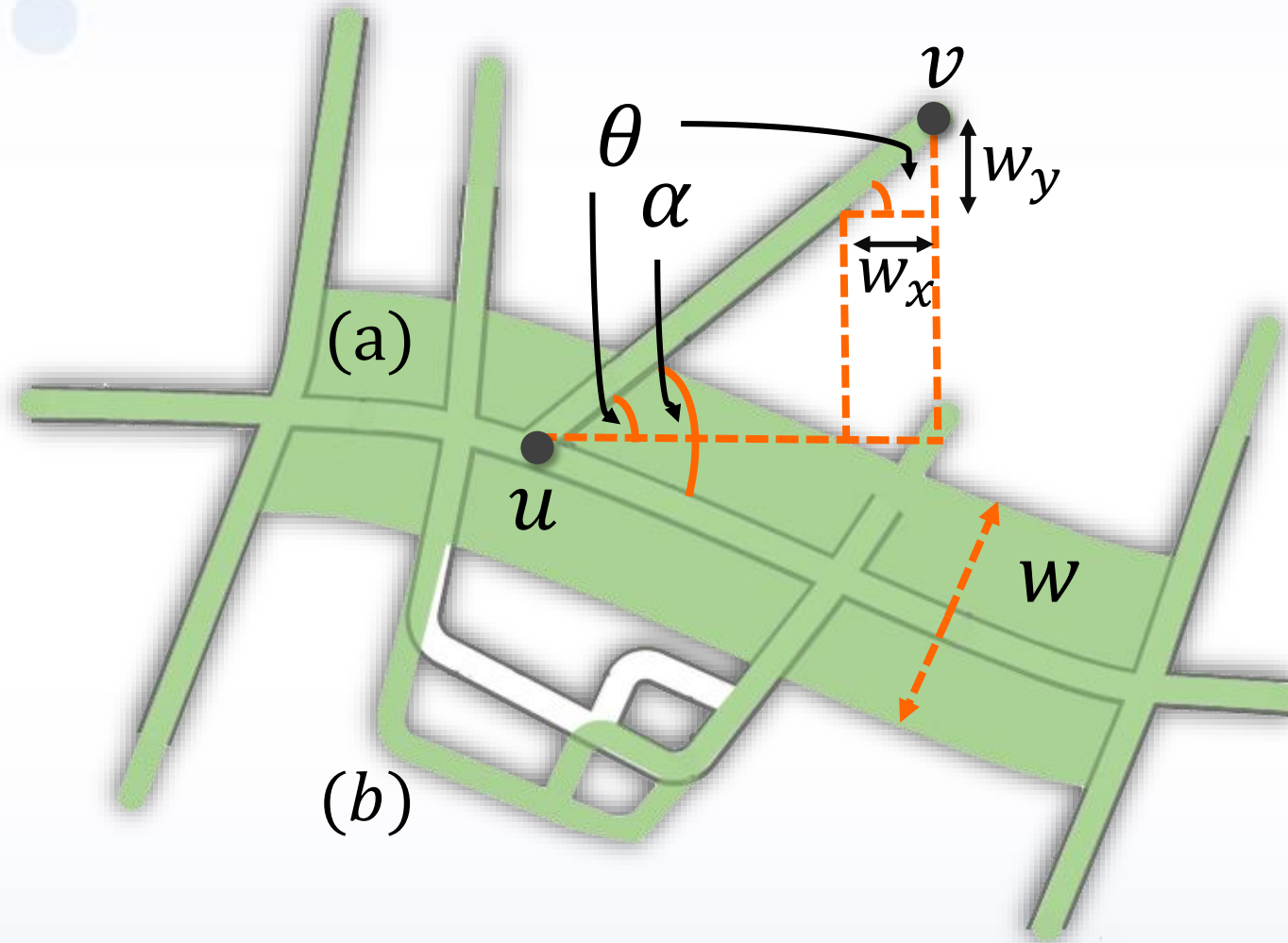


# Route Zooming – Unfolded



- (a) The route to be broadened is called the focus road
- (b) Other routes are called context road

# Route Zooming – Unfolded



Translation of context roads:

$$w_x = \frac{w}{2\sin(\alpha)} \cos(\theta), w_y = \frac{w}{2\sin(\alpha)} \sin(\theta)$$

Original coordinates of node  $u$ :  $(x_u, y_u)$

New coordinates of node  $u$ :  $(x'_u, y'_u)$

## ■ Focus Road Deformation

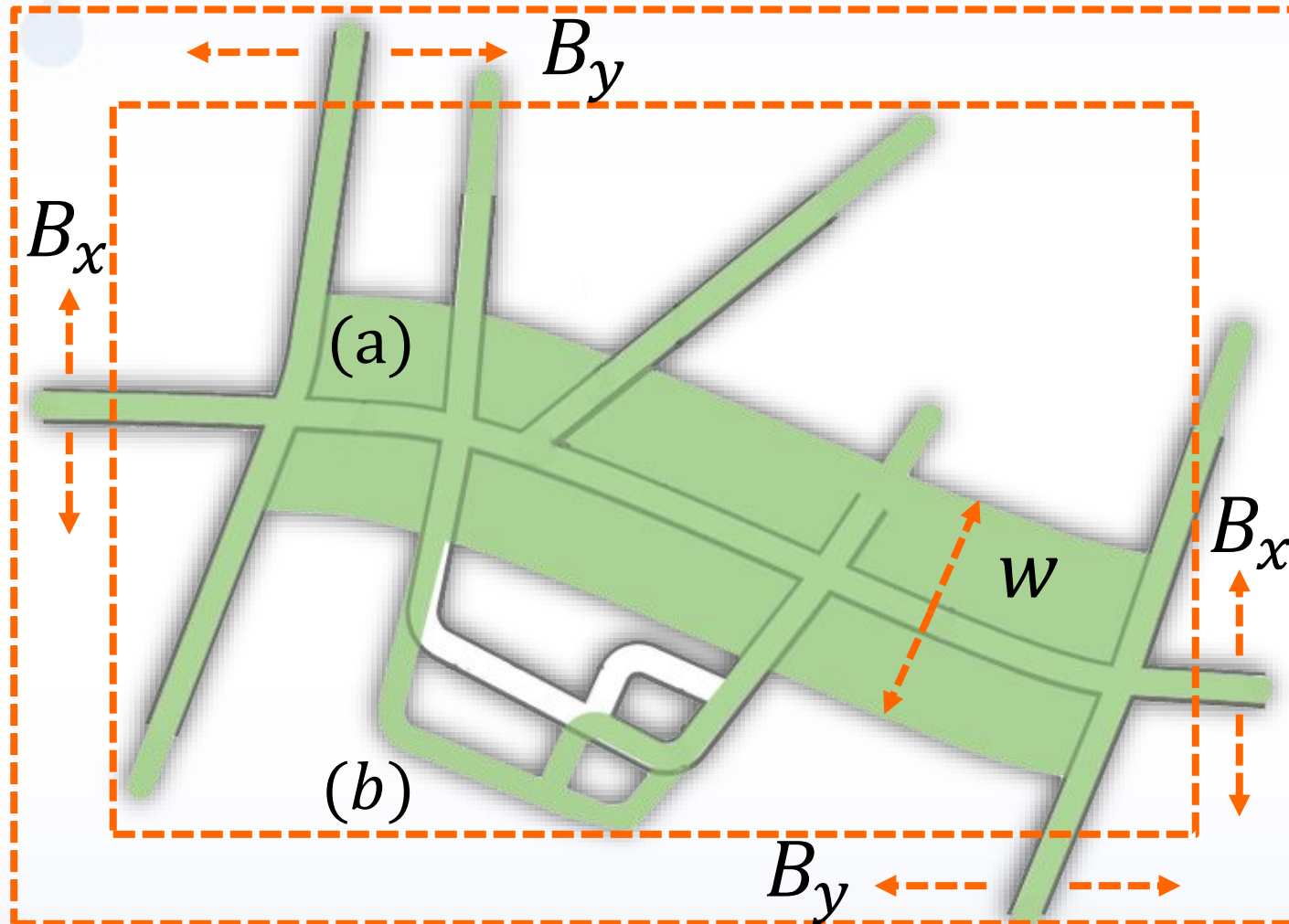
$$D_{Focus} = |(x'_u - x'_v) - (x_u - x_v) - w_x|^2 + |(y'_u - y'_v) - (y_u - y_v) - w_y|^2$$

## ■ Preferred Position

$$D_{Preferred} = |x'_u - x_u|^2 + |y'_u - y_u|^2$$



# Route Zooming – Unfolded



All nodes should be within a bounding box( $B_x, B_y$ )

## Context Road Deformation

$$D_{Context} = (|(x'_u - x'_v) - (x_u - x_v)|^2 + |(y'_u - y'_v) - (y_u - y_v)|^2) / Dist(u, v)$$

## Road Bending

$$D_{Focus} = |atan2(y'_u - y'_v, x'_u - x'_v) - atan2(y_u - y_v, x_u - x_v)|^2$$

## Node Translation

$$D_{Bx} = |x'_u - x_u|^2, D_{By} = |y'_u - y_u|^2$$

# Route Zooming – Solving

- We define **an energy function** using a weighted summarization of above items
  - $D = \omega_f D_{Focus} + \omega_c D_{Context} + \omega_s D_{Bending} + \omega_b D_{Bx} + \omega_b D_{By} + \omega_p D_{Preferred}$
- This optimization problem can be solved by a **typical least squares** algorithm
  - $x' = (A^T A)^{-1} A^T b$

$\min_x D$



$a_{i1}$	$a_{i2}$	...		

Coefficient Matrix  $A$

$\times$

$x_1$
$\vdots$

New Position  $x'$

$=$

$b_1$
$\vdots$

Constant Vector  $b$

# Route Zooming – Handle Road Intersection

- We insert virtual roads between focus roads and intersected context roads

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## Algorithm 1 Handling Road Intersection

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**Input:** A deformed road network,  $n = 0.5$

**Output:** A road network without road intersection

**while** road intersection exists **do**

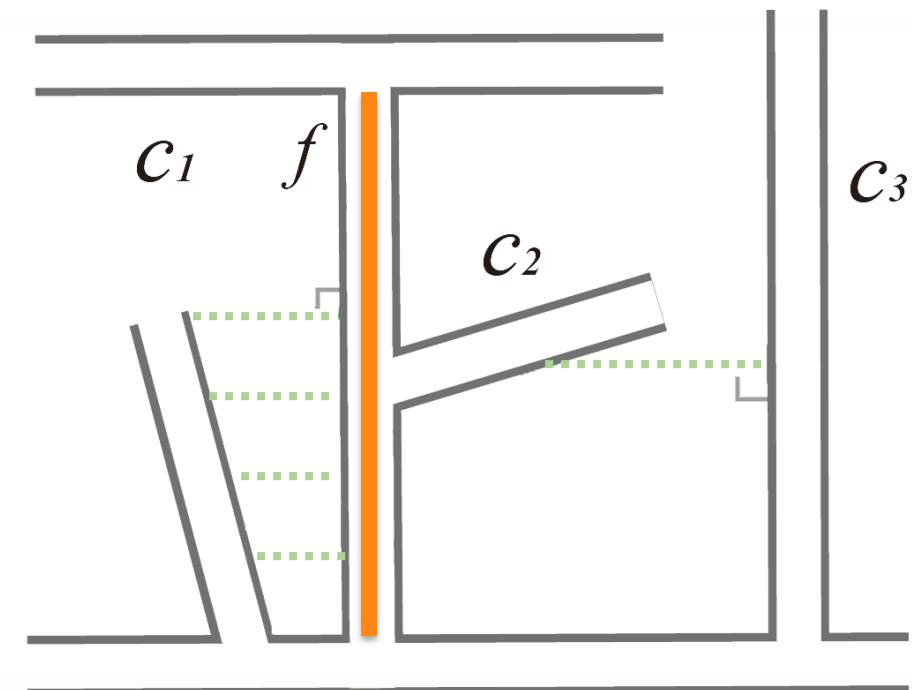
$n = n * 2$

    insert  $n$  virtual roads

    run *route-zooming* algorithm

**end while**

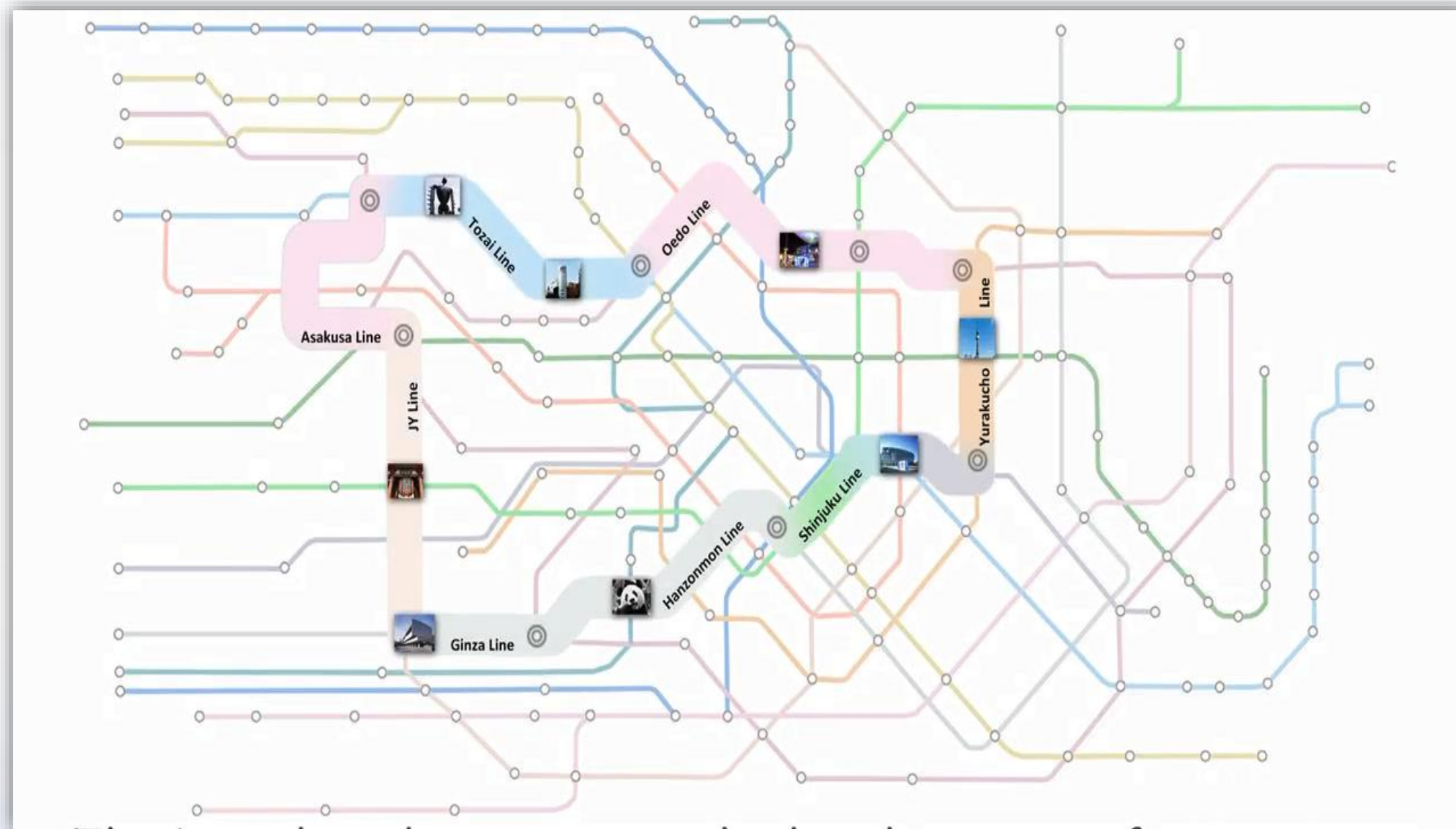
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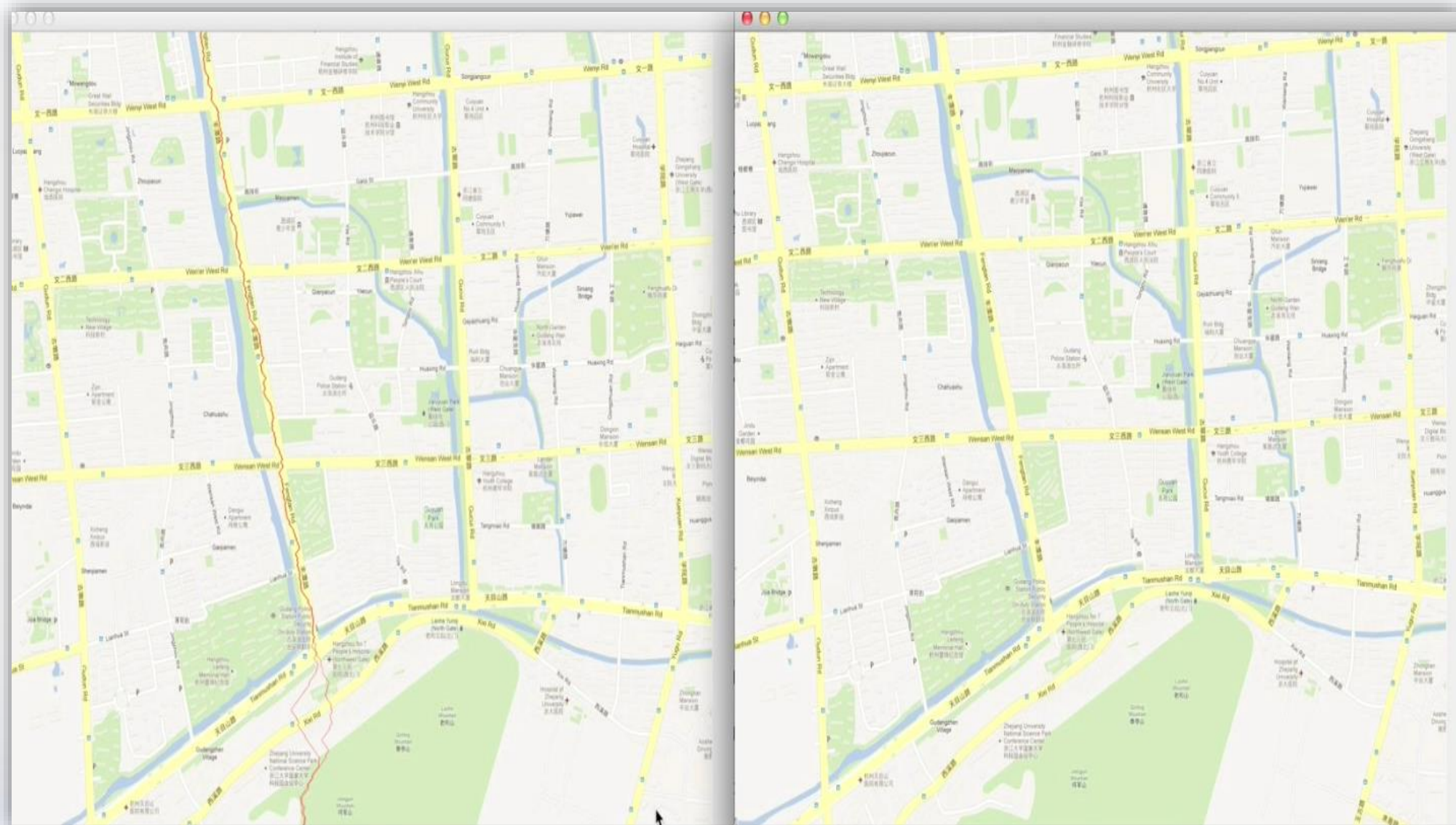
Insert Virtual Roads Iteratively



# Route Zooming - Illustration



# Technique Comparison – Seam Carving



Sun et al. PacificVis 2014



# Technique Comparison – Seam Carving



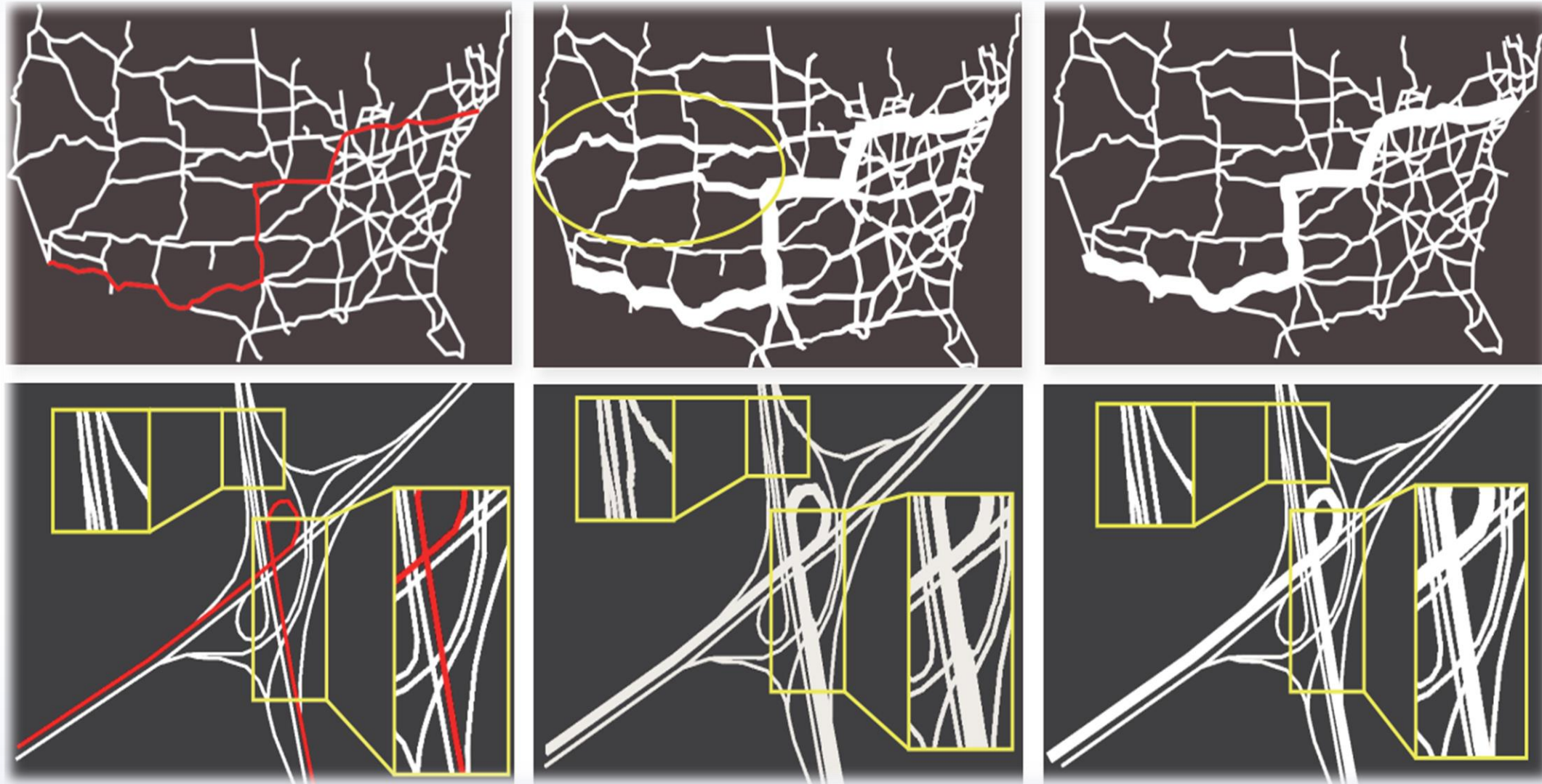
Selected Route

Seam Carving

Route Zooming



# Technique Comparison – Seam Carving



Selected Route

Seam Carving

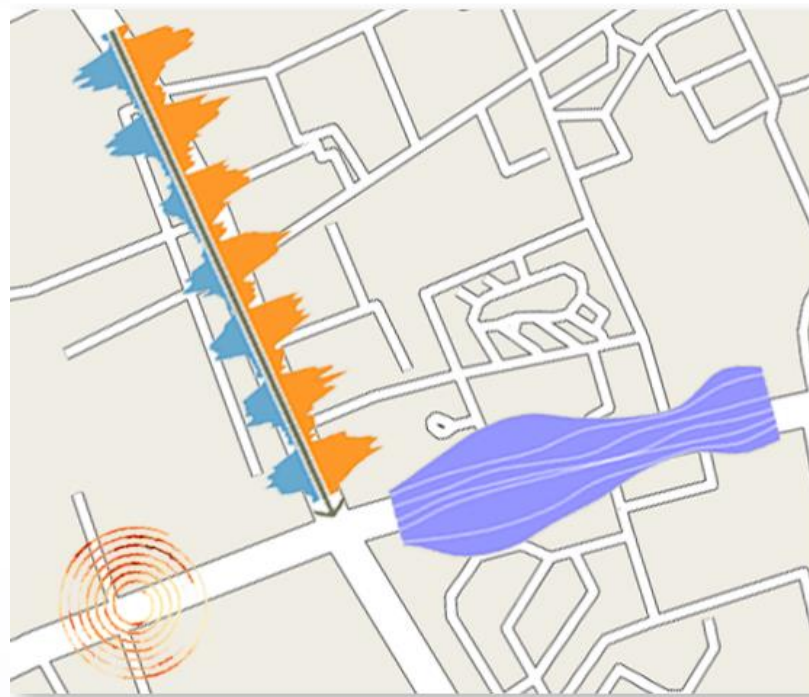
Route Zooming

# Visual Design – Timeline Visualization

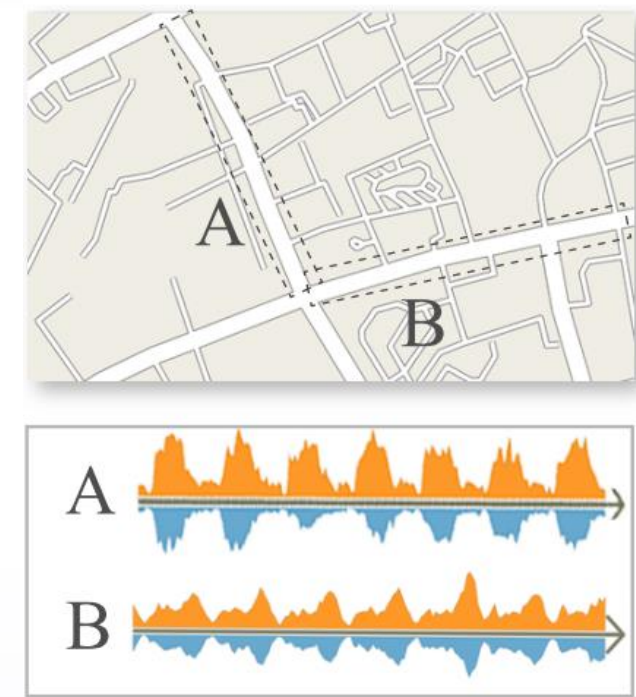
- We can embed temporal information on the broadened road



Embedded View



Integrated View

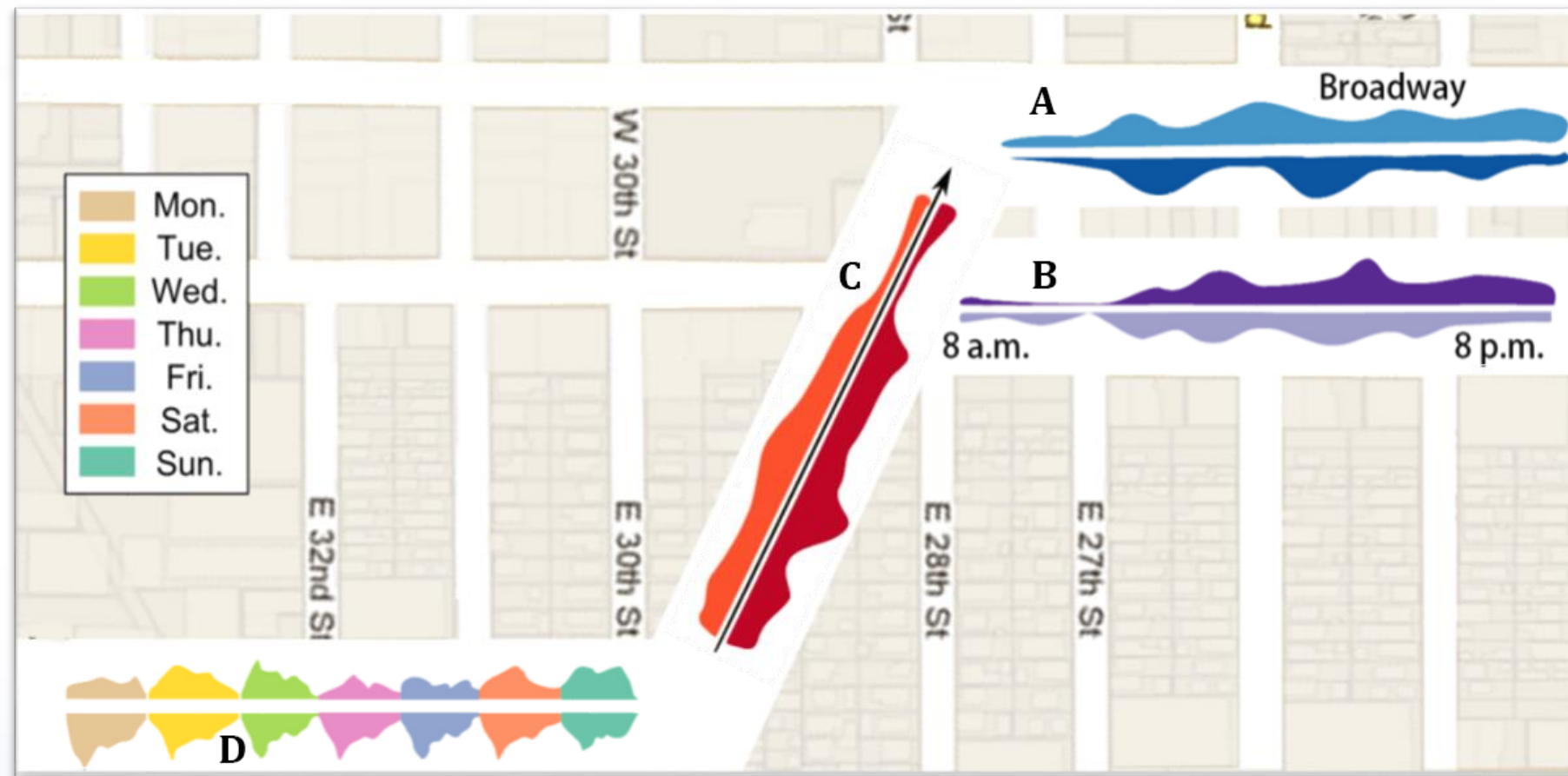


Linked View



# Visual Design – Time Direction

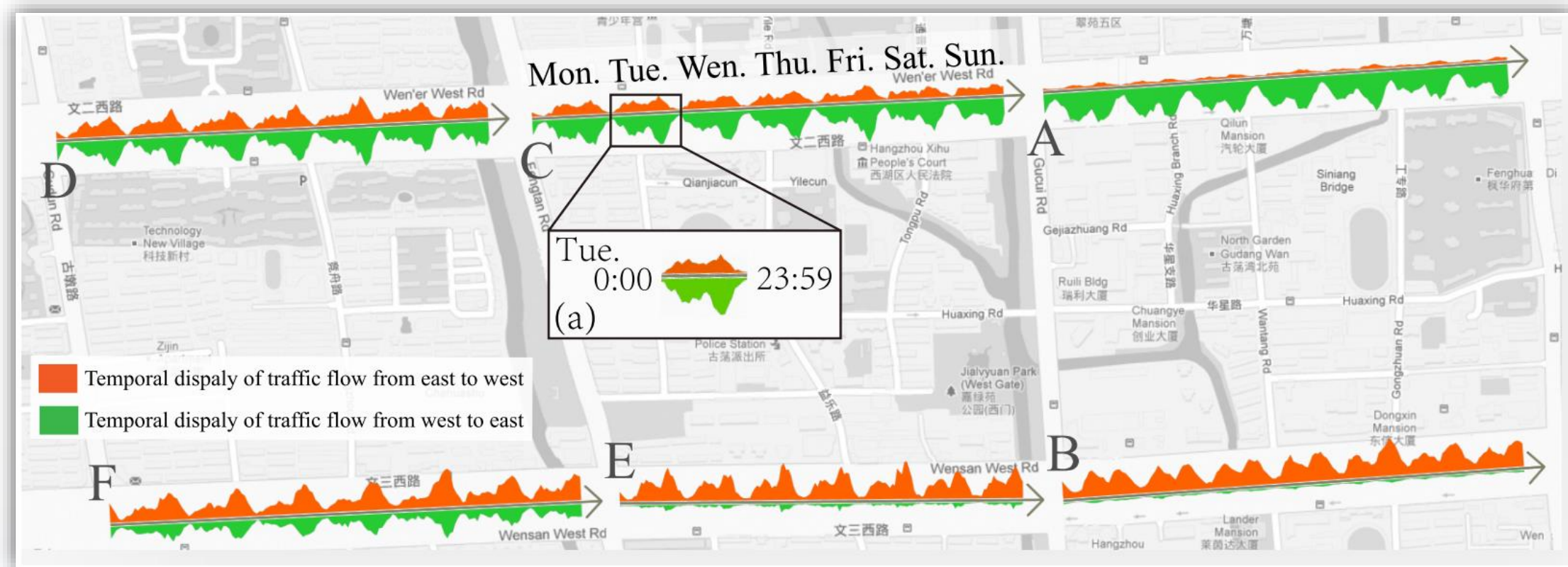
- We introduce various methods to indicate the direction of time flow



(1) Road Names (2) Text (3) Visual Symbols (4) Colors

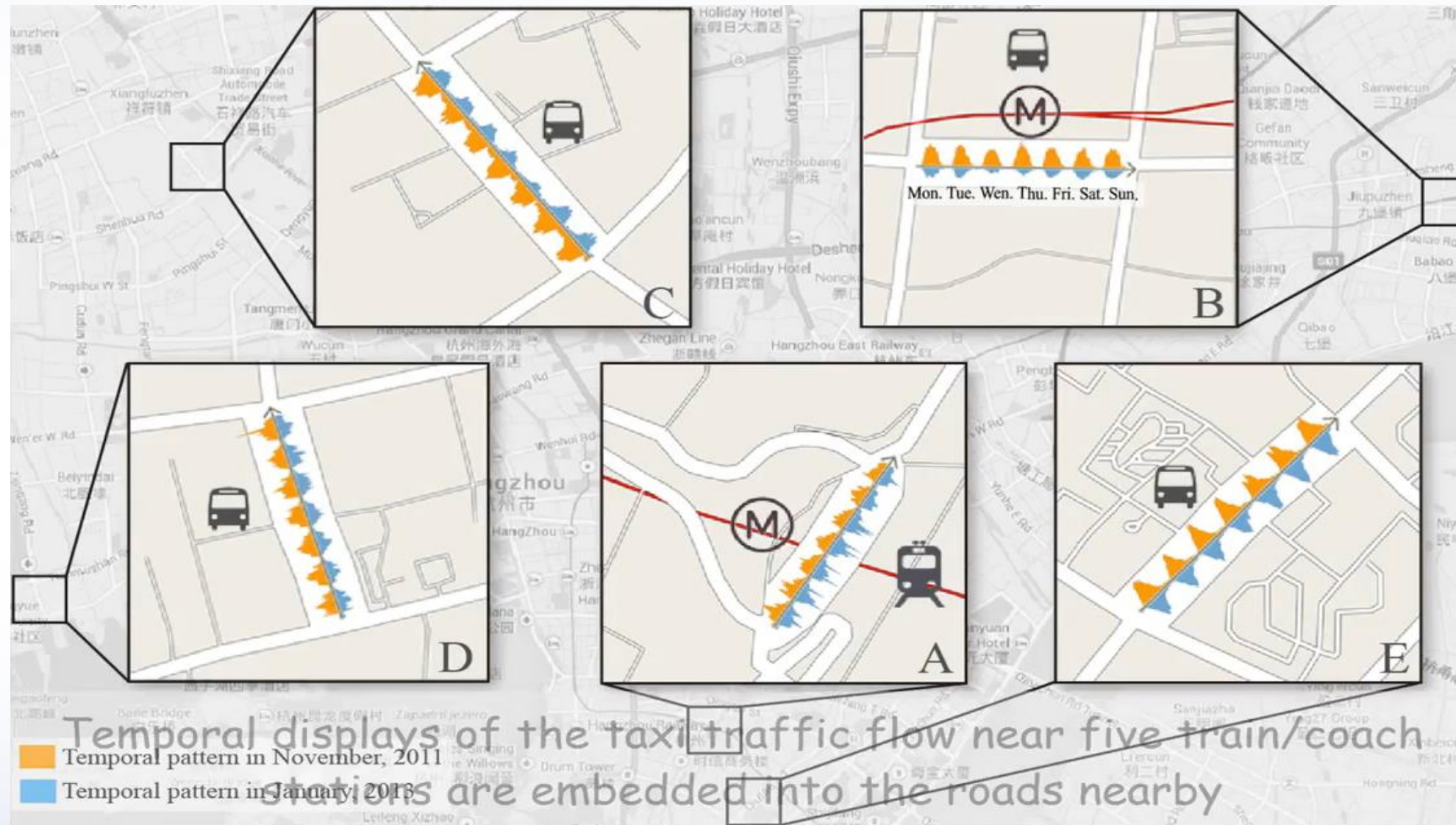


- Our system allows quick detection and easy comparison of interesting patterns



A clear pattern of traffic imbalance is observed by comparing the green and the red parts (A, B)

# Case Study II – Close Inspection of Local Regions





# Discussions

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- Overlaying temporal displays on roads of **unusual shapes** may lead to distortions
- Overlaying temporal displays on roads of **different lengths** is a non-trivial problem
- Broadening a certain road to a large degree may exceed the screen **resolution boundary**



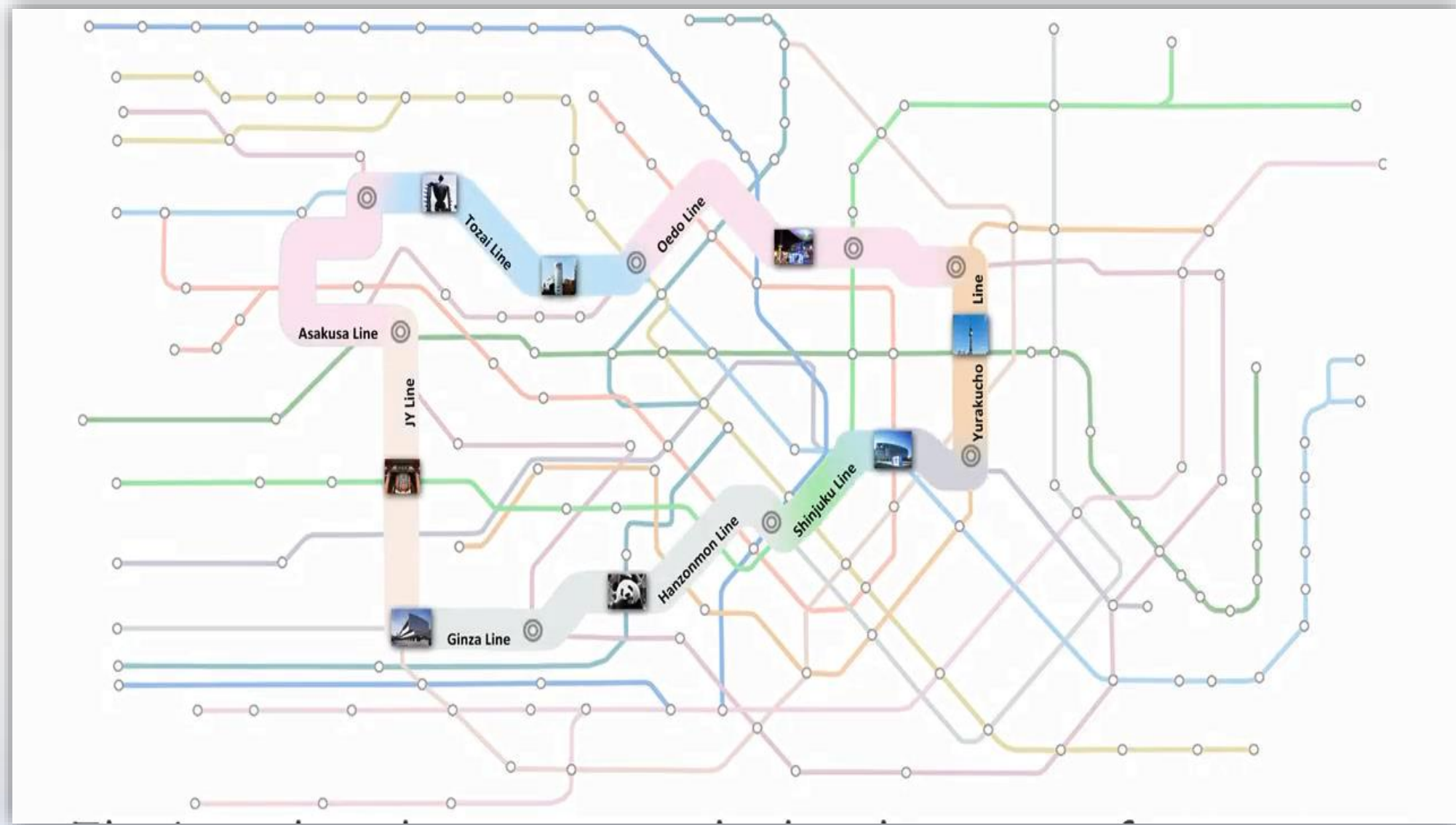
# Future Works

- Systematic and quantitative **evaluations** on our route-zooming algorithm
- User centered **experiments** of different temporal visualizations





# Q&A





# **Thanks for Your Attention**

Email: [guodao@zjut.edu.cn](mailto:guodao@zjut.edu.cn)