

Visual Traffic Jam Analysis Based on Trajectory Data

Zuchao Wang, Min Lu, Xiaoru Yuan, Peking University
Junping Zhang, Fudan University
Huub van de Wetering, Technische Universiteit Eindhoven

Introduction

- Many cities are suffering from traffic jams



Beijing



Melbourne



Atlanta

Introduction

Real time road condition from Google Map

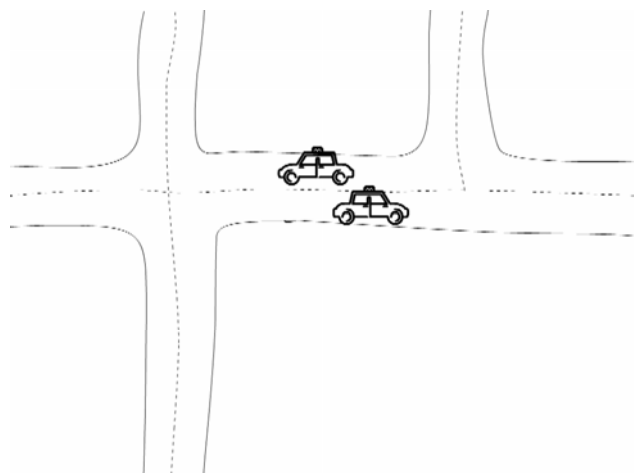
- Current traffic jam monitoring technologies



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Introduction

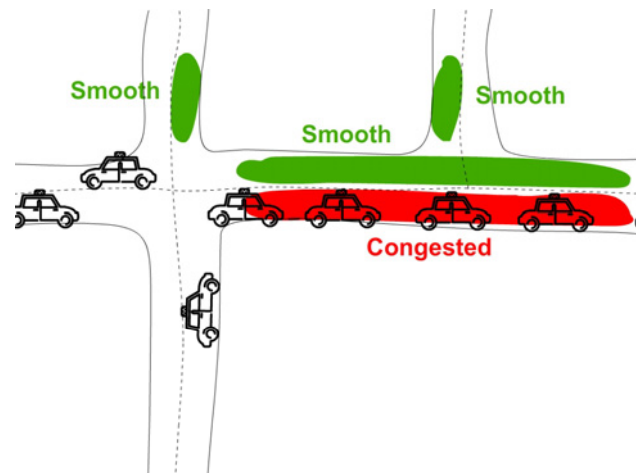
- Complexities of traffic jams
 - Road conditions change with time
 - Different roads have different congestion patterns
 - Congestions propagate along the road network



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Introduction

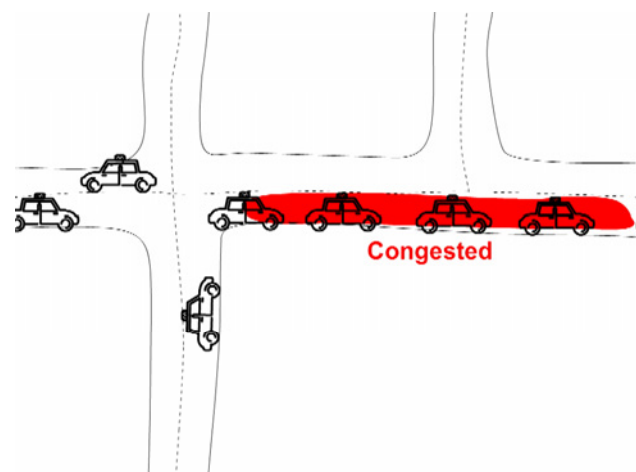
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Introduction

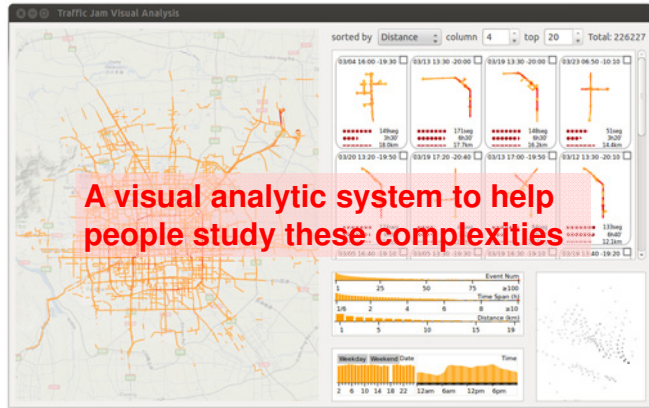
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Introduction

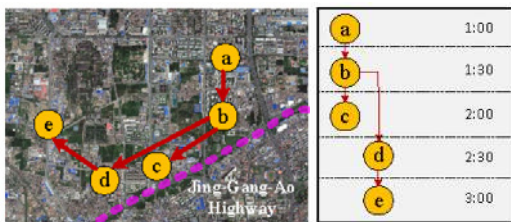
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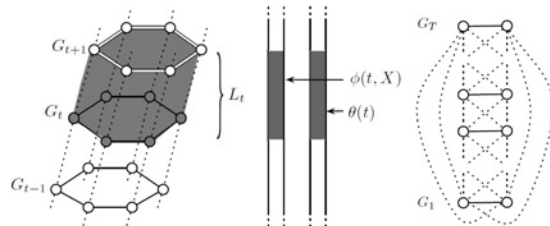
Related Work

- Traffic Modeling



Outlier tree
[Liu et al. 2011]

Study the propagation of traffic outlier events between regions



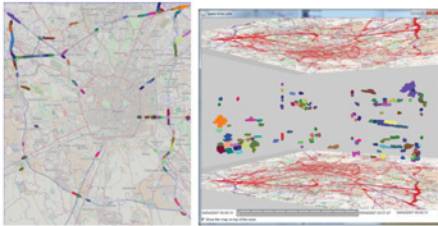
Probabilistic Graph Model
[Piatkowski et al. 2012]

powerful but complex

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Related Work

- Traffic Event Visualization



[Andrienko et al. 2011]

Individual events extraction



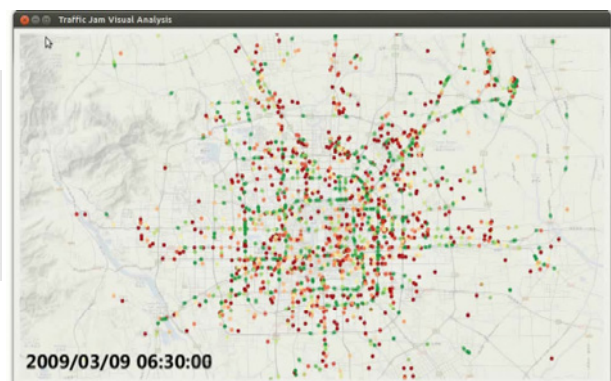
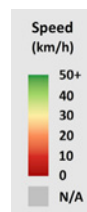
Incident Cluster Explorer
[Pack et al. 2011]

Individual events filtering

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Data Description

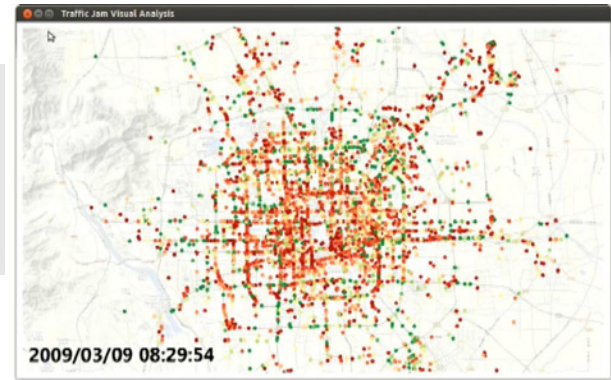
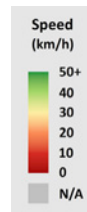
- Beijing taxi GPS data (from DataTang.com)
 - Size: 34.5 GB
 - #Taxi: 28,519
(7% of total traffic flow volume)
 - #Sampling point: 379,107,927
 - Time range: 24 days
(Mar.2nd~25th, 2009, missing 18th)
 - Sampling interval: 30 seconds
(60% data missing)



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 - Time range: 24 days
(Mar.2nd~25th, 2009, missing 18th)
 - Sampling interval: 30 seconds
(60% data missing)
- Beijing road network (from OpenStreetMap)
 - Size: 40.9 MB
 - 169,171 nodes and 35,422 ways



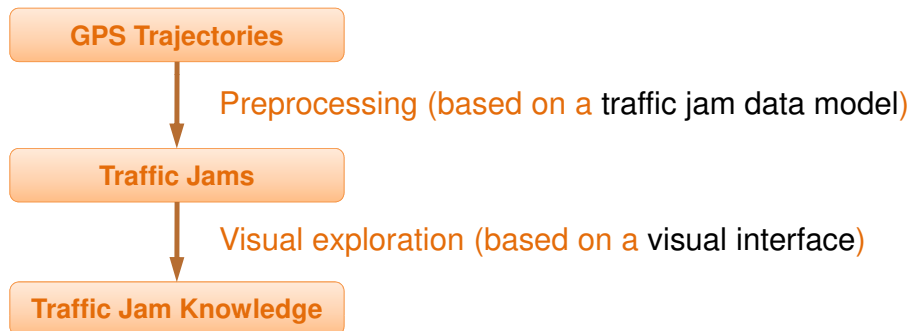
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Overview



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Overview



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Design Requirements

- Traffic jam data model

Complete

- Include location, time, speed

Structured

- Study propagations of traffic jams

Road Bound

- Traffic jams happen on roads

- Visual interface

Informative

- Show location, time, speed, propagation path

Multilevel

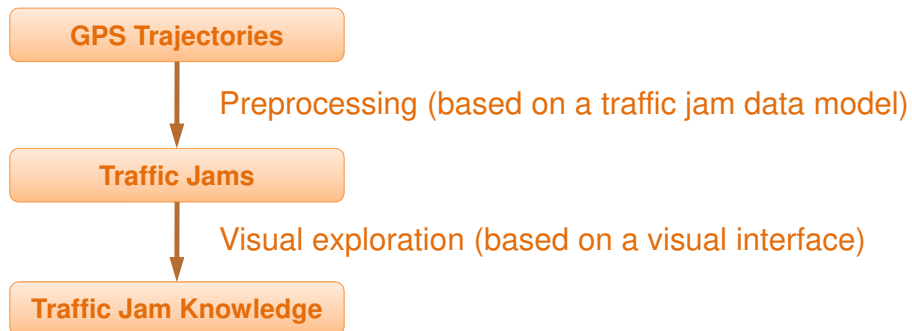
- Explore from city level to road segment level

Filter Enabled

- Select and study a subset of propagations

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Overview

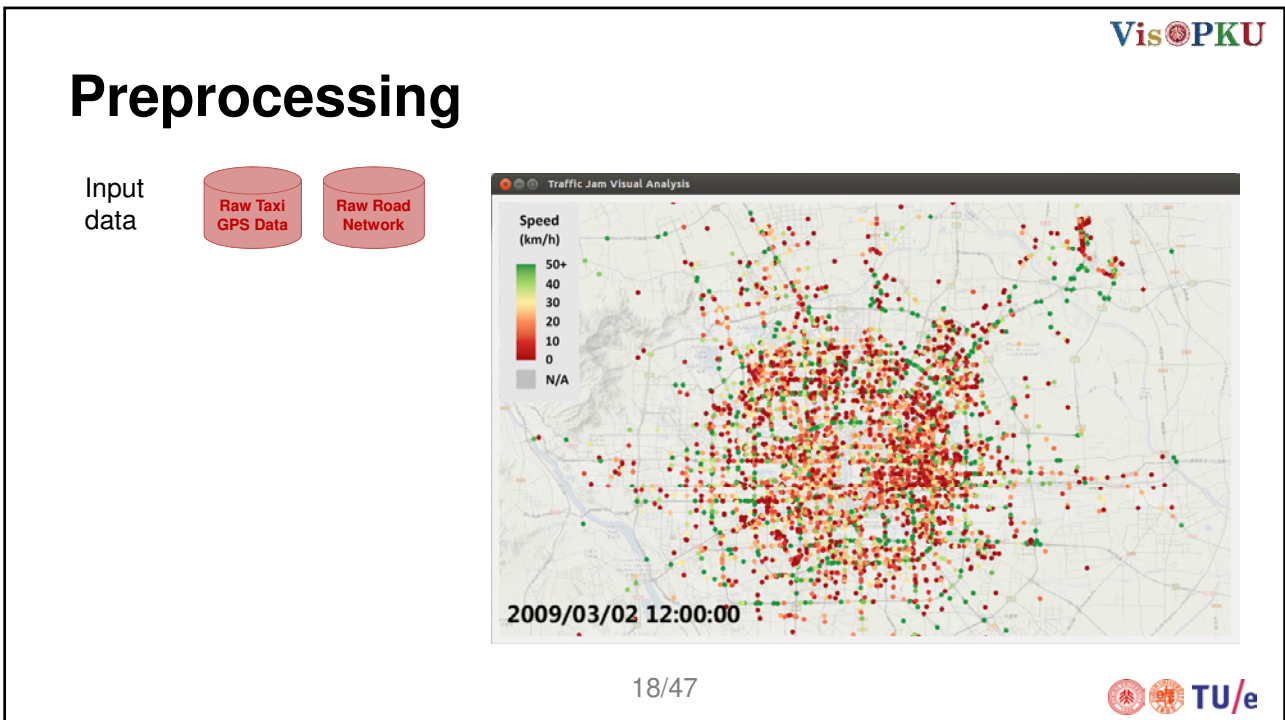
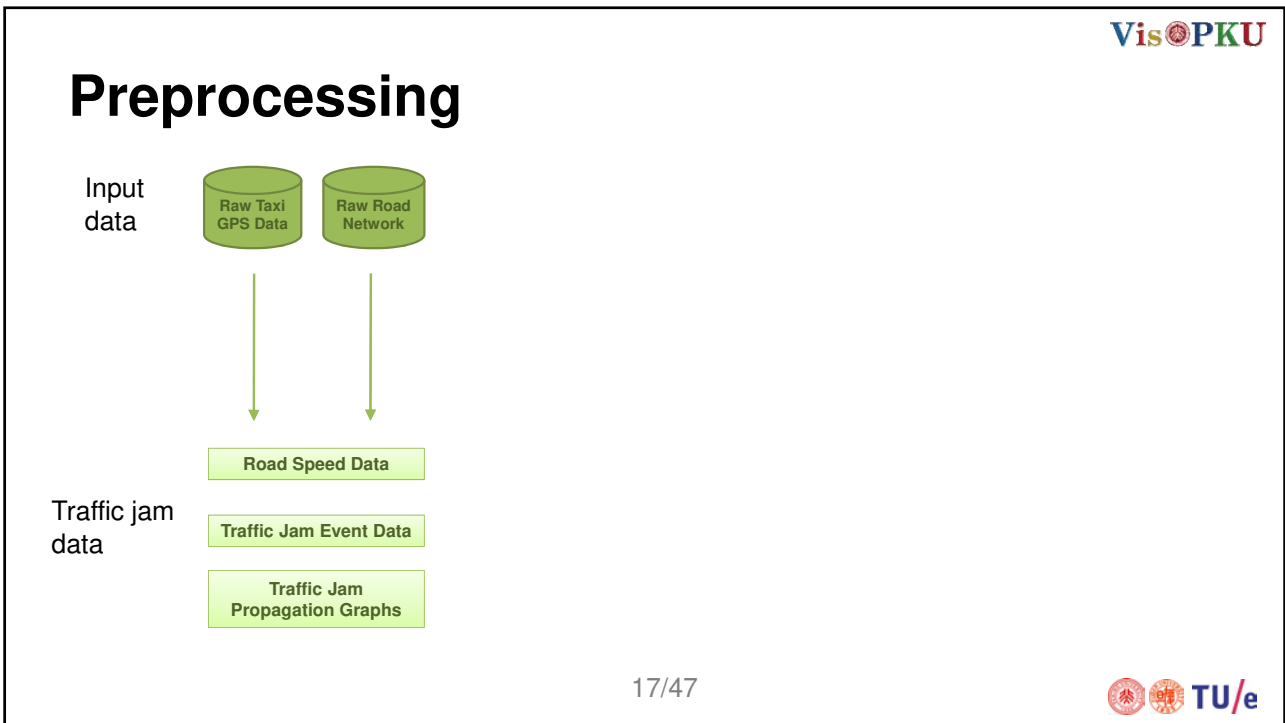


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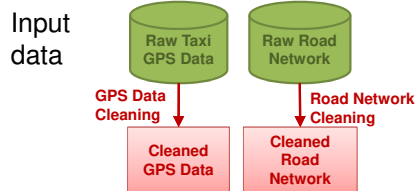
Overview



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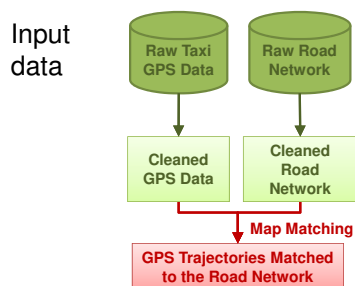


Preprocessing



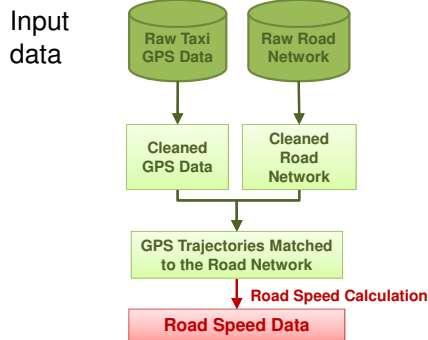
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Preprocessing

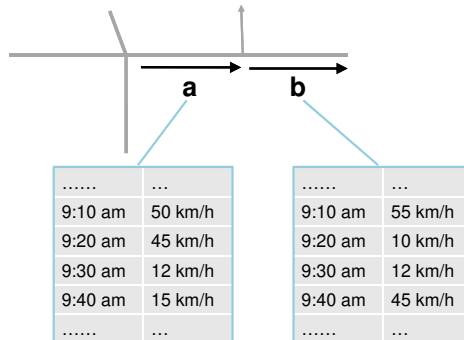


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Preprocessing

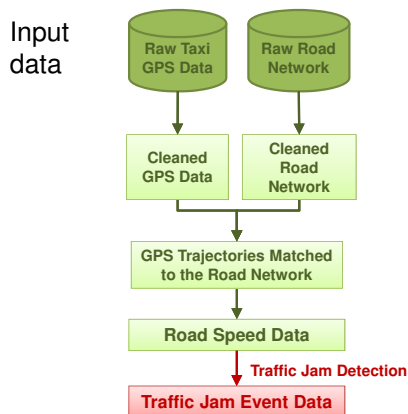


Road speed: for each road at each time bin (10 min)

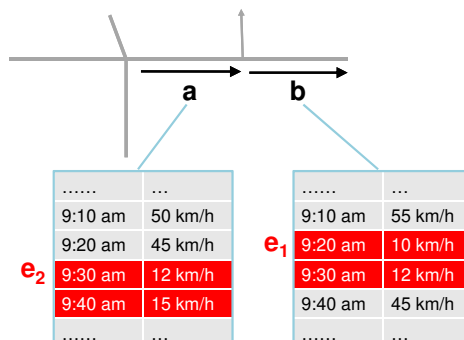


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Preprocessing

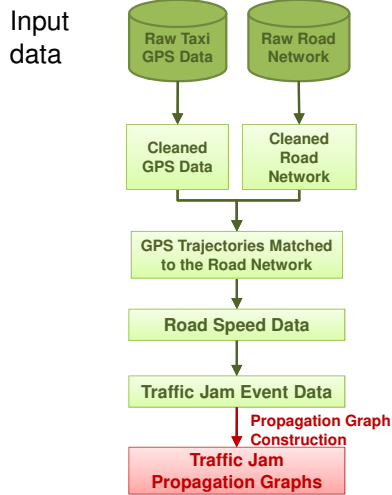


Traffic jam events: road, start/end time bin

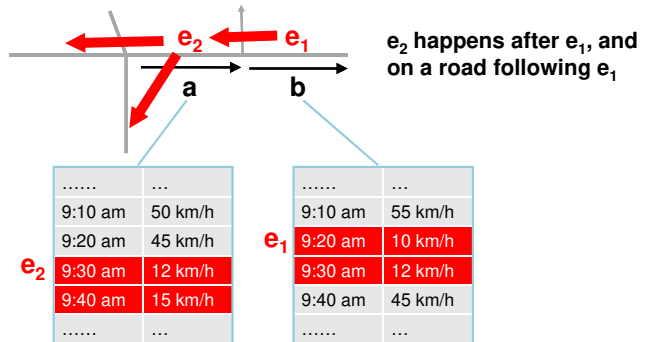


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Preprocessing

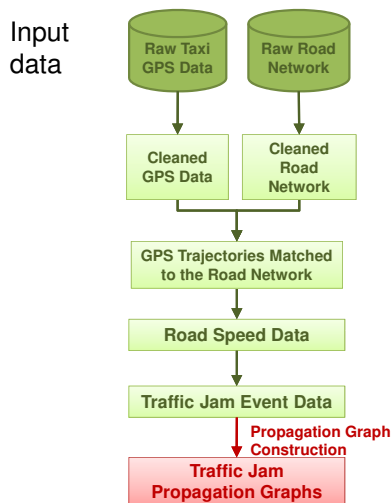


Defining propagation based on spatial/temporal relationship:

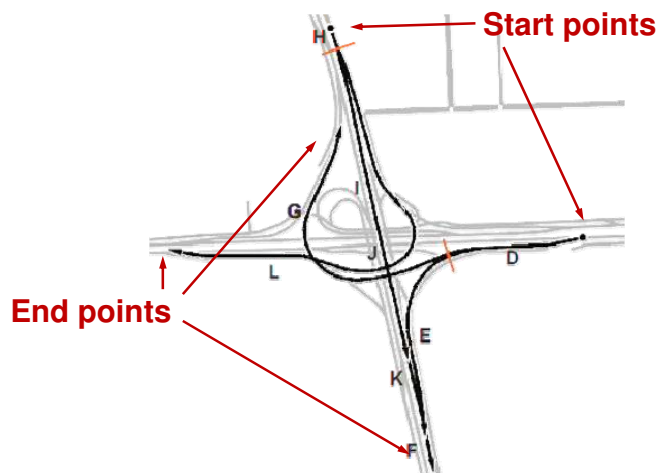


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Preprocessing



A real propagation graph:




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VisOPKU

Preprocessing

Input data




Raw Taxi GPS Data




Raw Road Network

↓ ↓




Road Speed Data

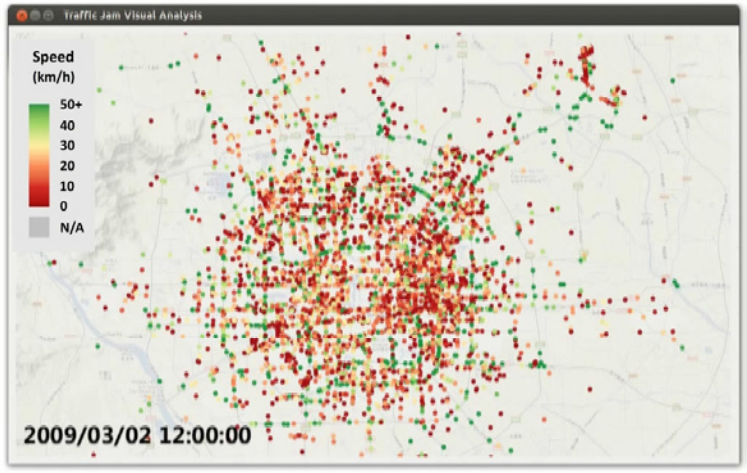


Traffic Jam Event Data

↓




Traffic Jam Propagation Graphs



Input Taxi GPS Trajectories

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VisOPKU


Visual Interface

Three levels of exploration


Traffic jam data




Road Speed Data



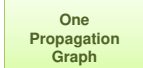
Traffic Jam Event Data



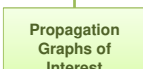
Traffic Jam Propagation Graphs



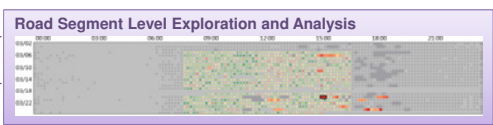
Road of Interest




One Propagation Graph



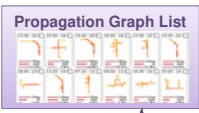
Propagation Graphs of Interest



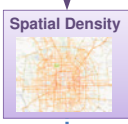
Road Segment Level Exploration and Analysis



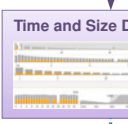
Propagation Graph Level Exploration



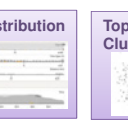
Propagation Graph List




Spatial Density



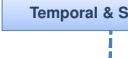
Time and Size Distribution



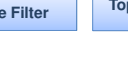
Topological Clustering



Spatial Filter




Temporal & Size Filter



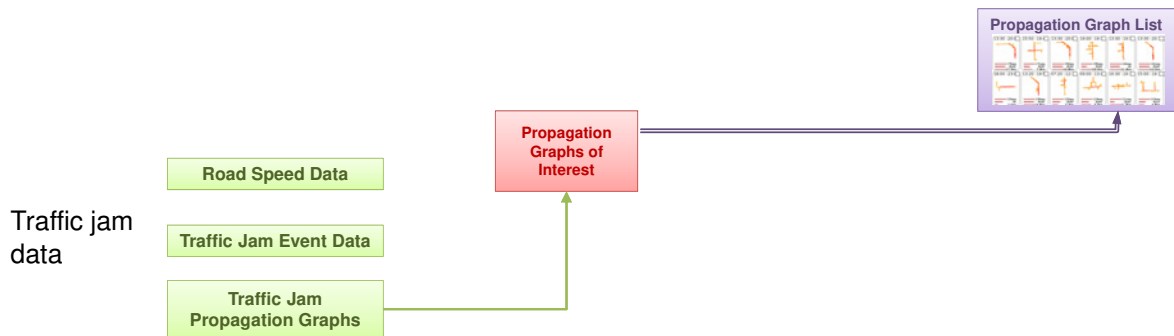
Topological Filter

Dynamic Query

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Visual Interface: City Level



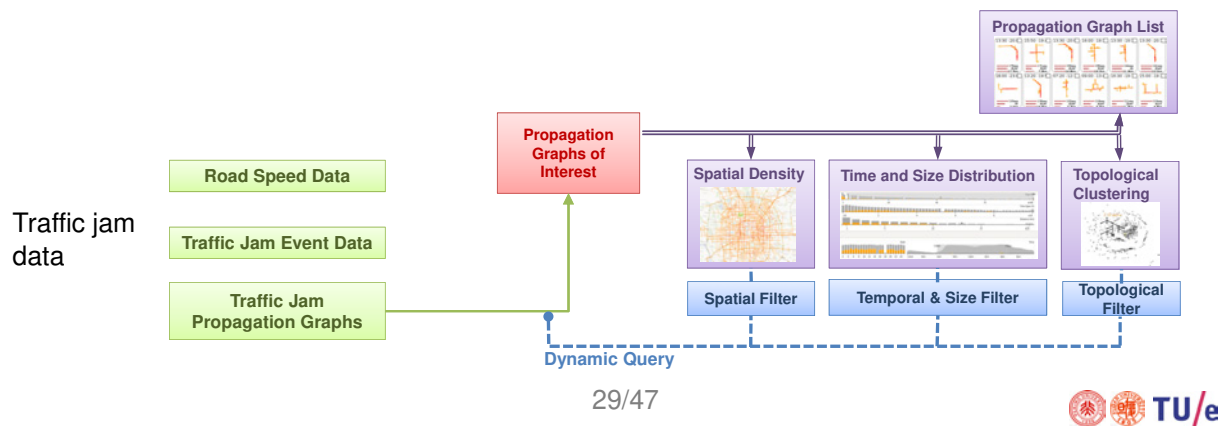
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Visual Interface: City Level

- Graph list view: show propagation graphs as icons

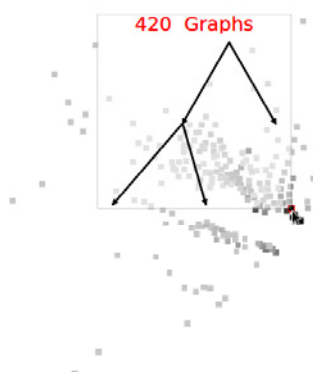
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Visual Interface: City Level



Visual Interface: City Level

- Graph projection view: topological aggregation



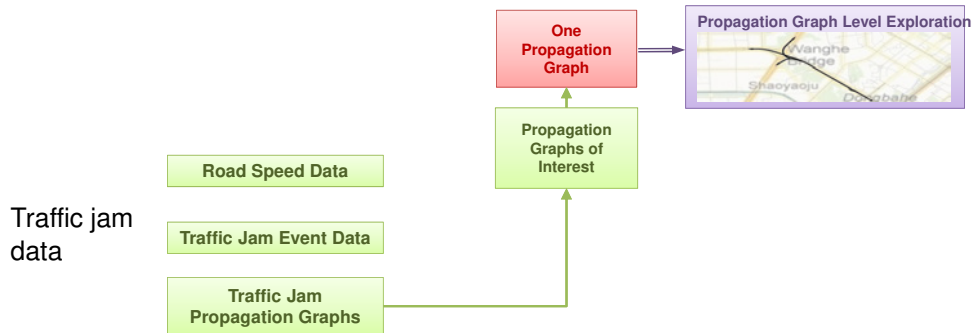
All propagation graphs are grouped

Each group is represented by a point

Graphs in the same group have similar topologies

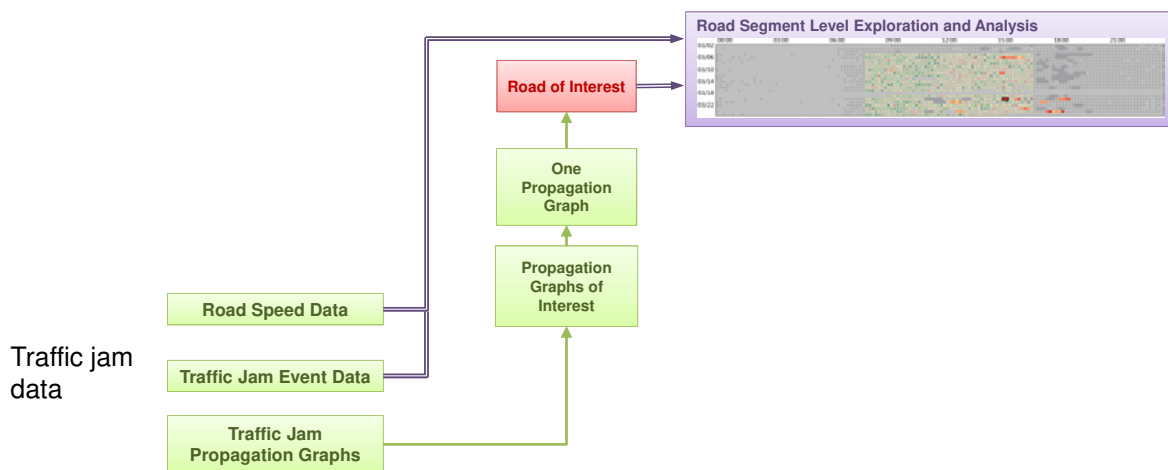
Distance between points represent the topological distance between graph groups

Visual Interface: Single Propagation Level



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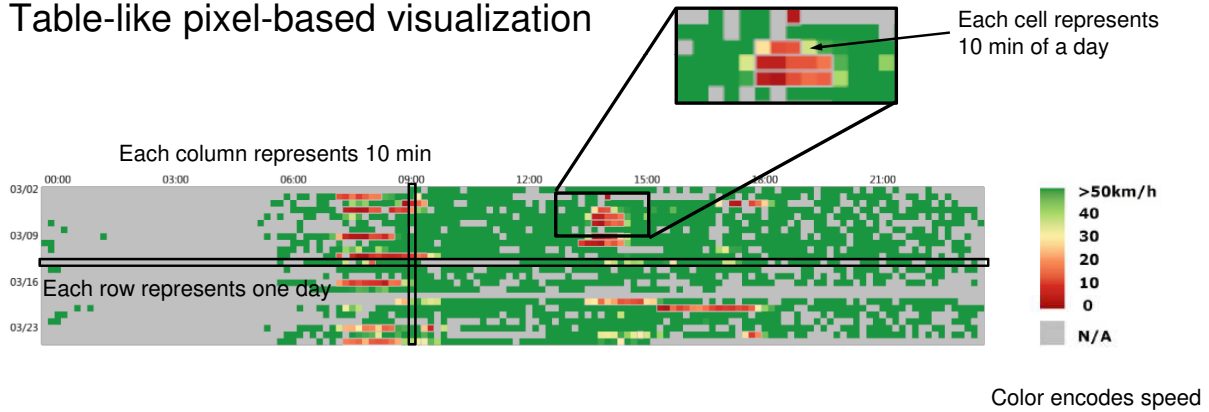
Visual Interface: Single Road Level



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Visual Interface: Single Road Level

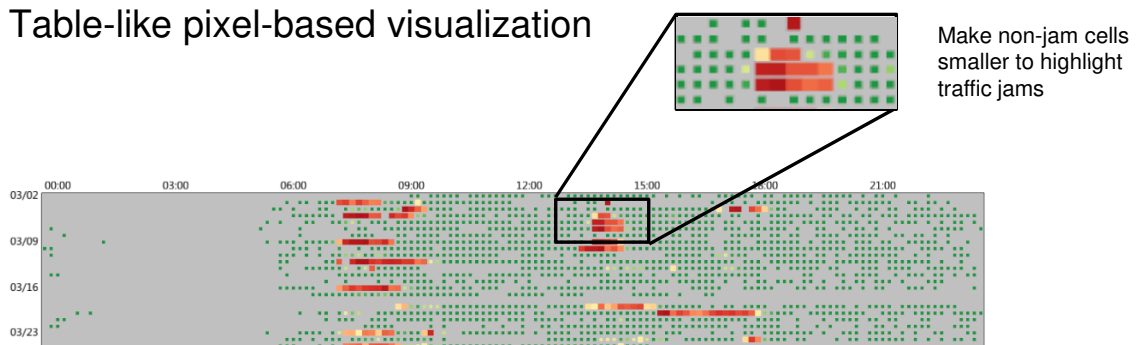
- Table-like pixel-based visualization



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Visual Interface: Single Road Level

- Table-like pixel-based visualization

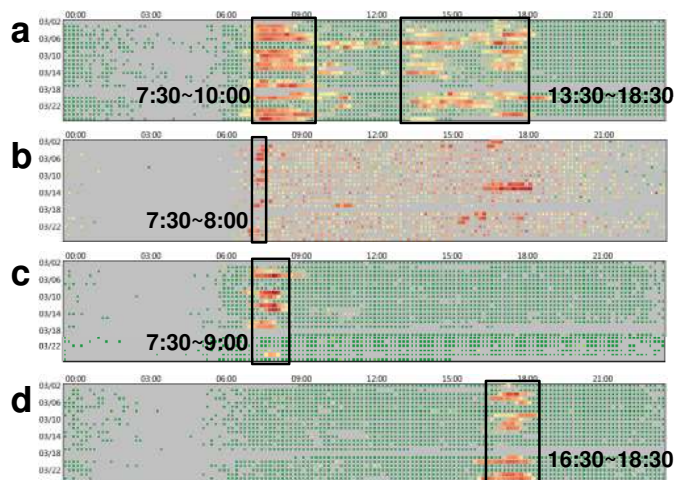


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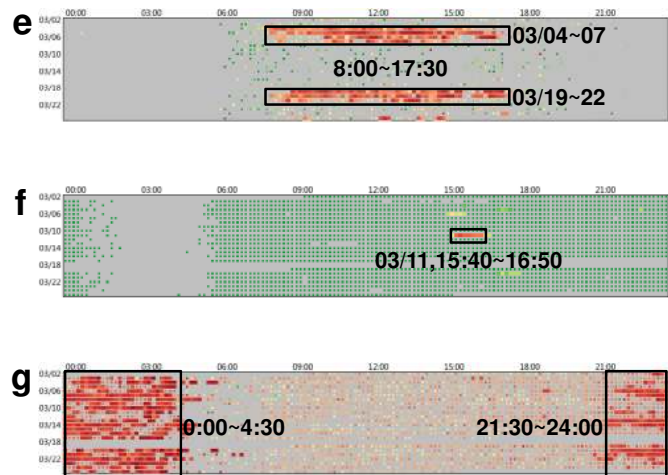
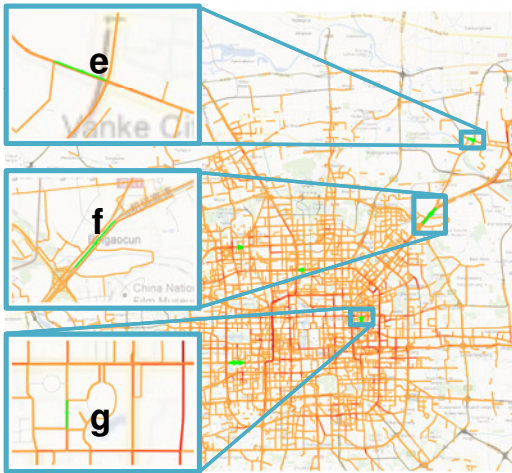
Case Studies

- Road level exploration
- Propagation graph exploration
- Propagation trend exploration

Case Study: Road Level Exploration



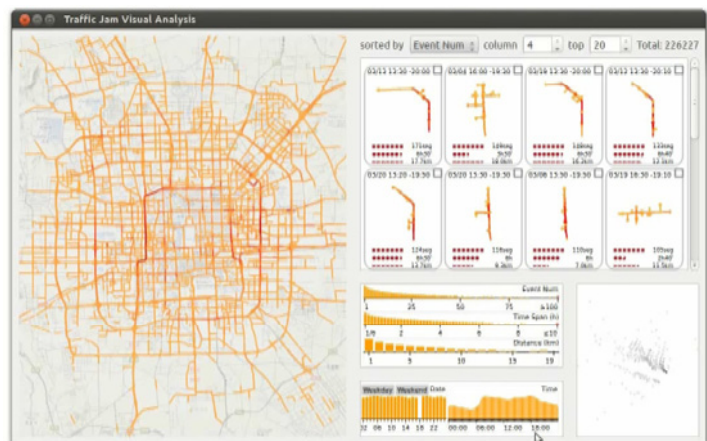
Case Study: Road Level Exploration



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Case Study: Propagation Graph Exploration

- Filter propagation graphs
- Observe propagation path
- Check road speed
- Check propagation time
- Watch animation

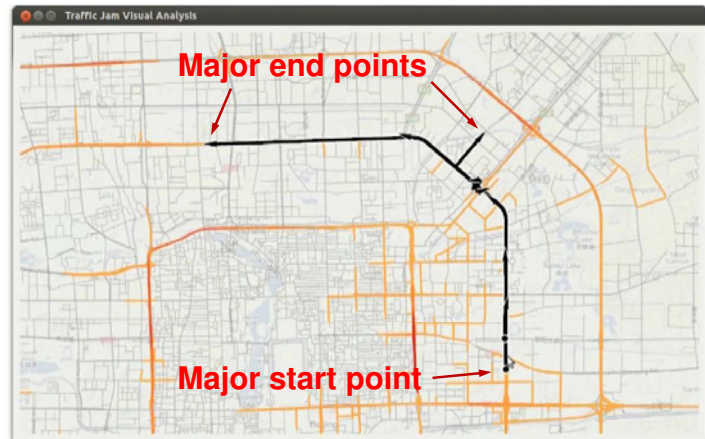


Temporal Filtering

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Case Study: Propagation Graph Exploration

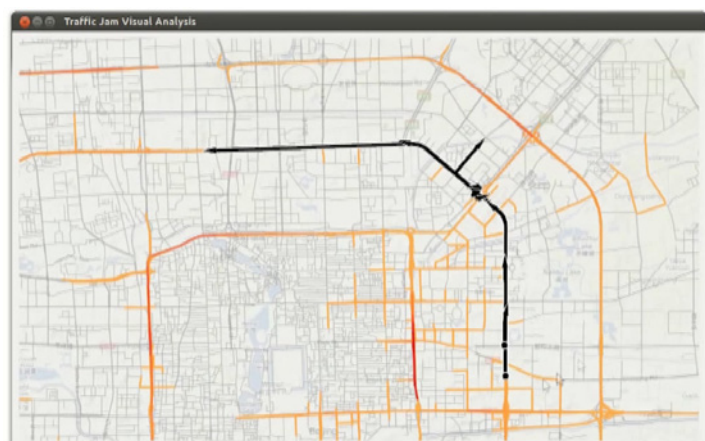
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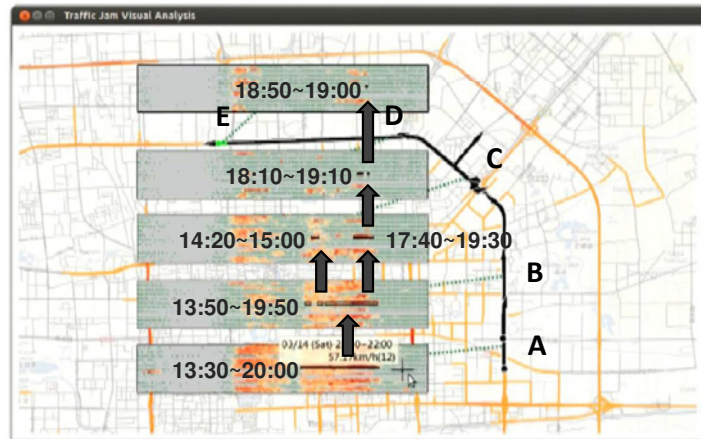
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Case Study: Propagation Graph Exploration

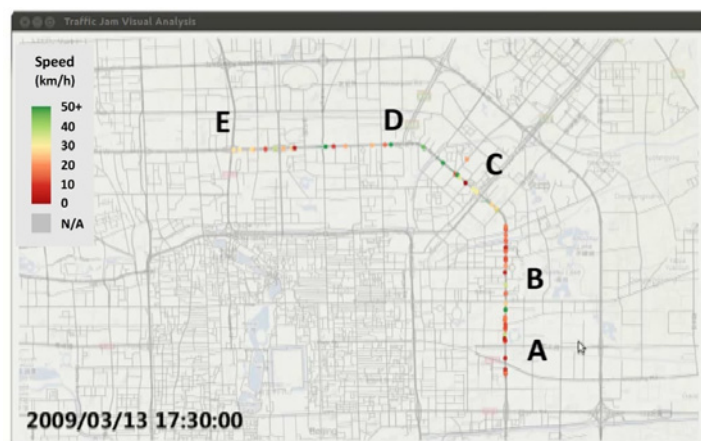
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Case Study: Propagation Graph Exploration

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Watching Taxi Trajectory Animation

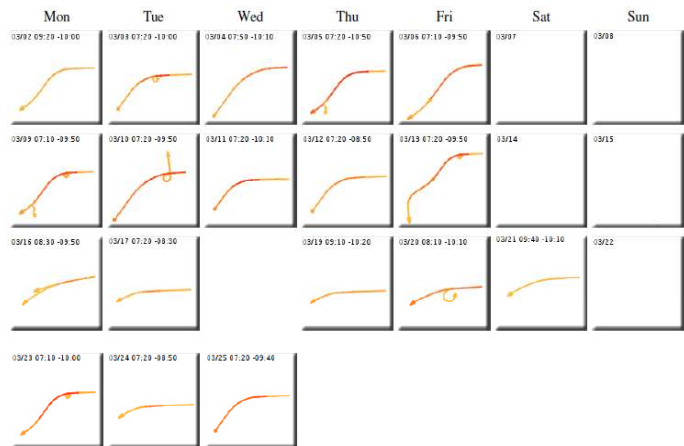
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Case Study: Propagation Trend Exploration

One fixed region



Different mornings



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Showing to the public



北京设计周
BEIJING DESIGN WEEK

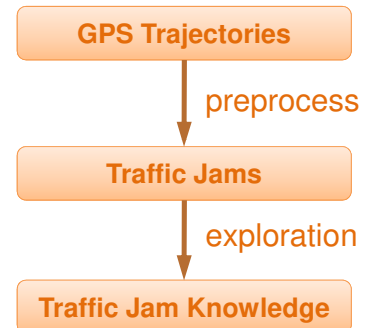
International Information Design Exhibition
09/26/2013~10/13/2013

Simplified version
Only road level exploration

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Conclusion

- A visual analytic system to study traffic jams
 - An automatic process to extract traffic jams from GPS trajectories
 - A visual interface to support multilevel exploration of traffic jams



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Future Work

- Improve the traffic jam data model (e.g. add prediction functions)
- Support more analysis task (e.g. spatial/temporal clustering)
- Try better visual design of propagation graphs
- Collaboration with the domain experts

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Acknowledgement

- Funding:
 - NSFC Project No. 61170204
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- Data:
 - Datatang.com
 - OpenStreetMap
- Anonymous reviewers for valuable comments

Our website:
<http://vis.pku.edu.cn/trajectoryvis>