# Telematics: Review and Applications in Freight Transportation

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# Transportation Data Visualization with a Focus on Freight: A Literature Review
--Manuscript Draft--

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| **Abstract:** | Road-based freight movements are a critical component of the supply chain and transportation networks, especially for the middle and last-mile distribution stages. With the drive to invest in big data collection capabilities, most of the collected freight movement data remains underutilized. To improve the efficiency and resiliency of the supply chain, it is essential to enhance the visibility of goods movements on road networks. This can be done by visualizing the different aspects of goods movement patterns using the data collected from telematics devices installed in commercial vehicles. Given the recent development in data visualization and collection technologies, there is a need to conduct a critical literature review in this nascent and increasingly important field of study to identify gaps in the literature and propose future research and policy directions. To this end, we provide in this paper a comprehensive literature review on this topic and analyze the previous research from different perspectives, such as data levels of abstraction and existing visualization techniques. In addition, we provide a taxonomy of freight transportation visualization according to the underlying analytic objective. Furthermore, we propose a decision support tool to aid freight data analysts in selecting the right visualization tools. Finally, we identify research gaps in the field of freight transportation visualization. |

# Telematics data visualization taxonomy

Introduction - telematics data

Level of abstraction

- Data aggregation
- Objectives

Visualization techniques

- Space
- Time
- Event

Conclusion - decision-maker analysis

# Developments in telematics


Advanced telematics devices


Telematics data precision

Real time exchange of data through internet

Cloud-based storage

# Significance of Data Visualization

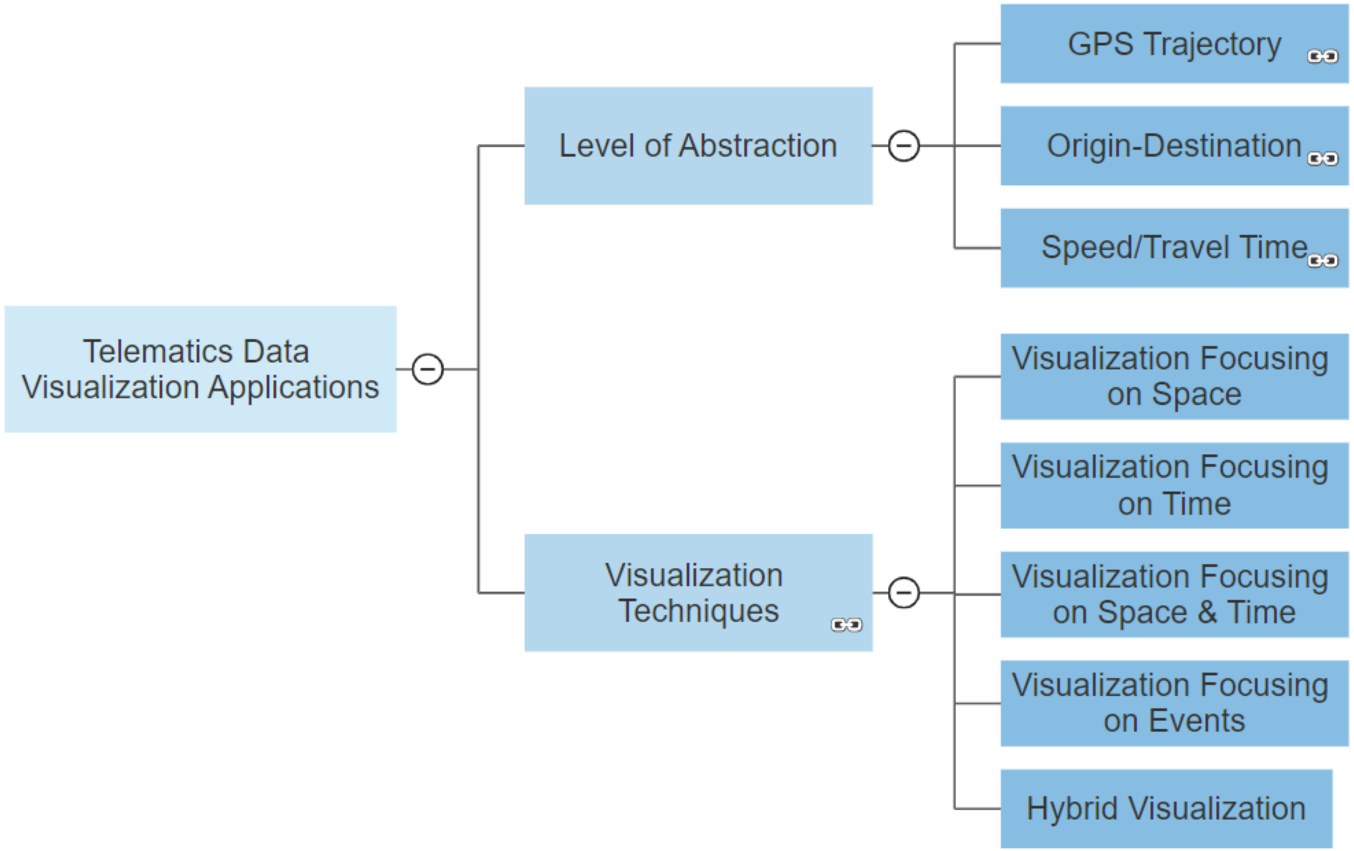
Human intelligence

+

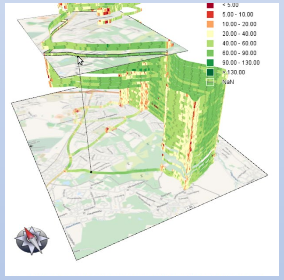
Computation & Analytics


Source: [Tesla AI Day]

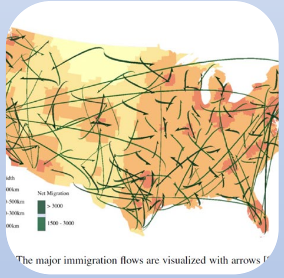
# Taxonomy For Telematics Data Visualization



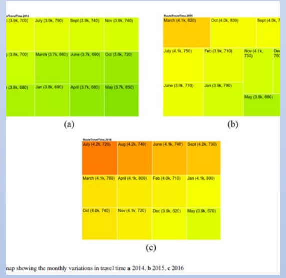
# Level of Abstraction



GPS Trajectory




Origin-Destination (OD)



Speed/Travel Time

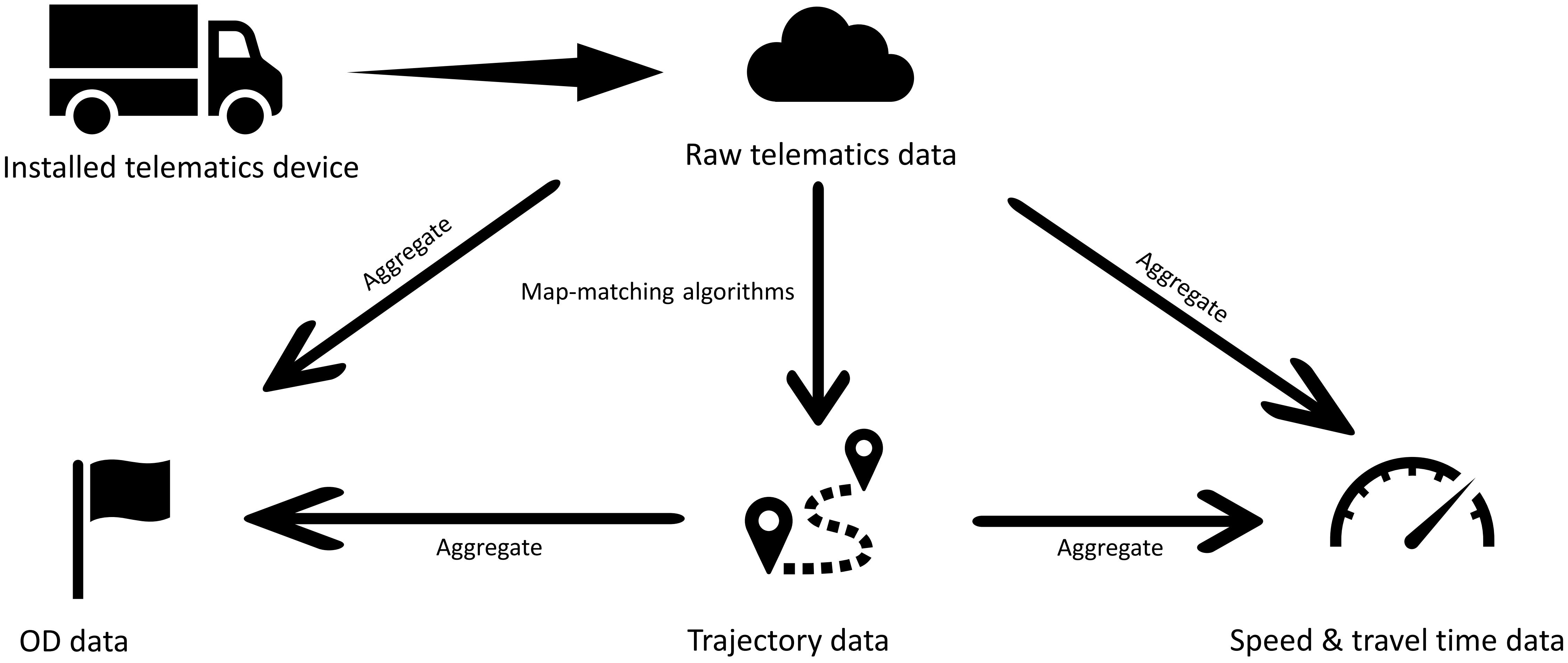
# Raw Telematic Data

**Table 1** Sample of reduced raw data obtained from the GPS devices

| Device ID | Latitude | Longitude | Reporting time |
|---|---|---|---|
| 45214[illegible] | 13.08826 | 80.28201 | 07:29:35 |
| 4521[illegible] | 13.0882 | 80.28197 | 07:29:40 |
| 45214[illegible] | 13.08809 | 80.28165 | 07:29:45 |
| 452149[illegible] | 13.08787 | 80.28145 | 07:29:50 |
| 452149[illegible] | 13.08751 | 80.28136 | 07:29:55 |
| 452149[illegible] | 13.08711 | 80.28126 | 07:30:00 |
| 452149[illegible] | 13.08674 | 80.28117 | 07:30:05 |
| 45214[illegible] | 13.08645 | 80.28108 | 07:30:10 |

Source: Gracious, R., Kumar, B. A., & Vanajakshi, L. (2020). Characterizing bus travel time using advanced data visualization techniques

# Data Aggregation



# Objectives – Trajectory

Traffic Jam

Trajectory Clustering

Monitor Large-scale Trajectory Data

Visualization of transportation patterns

Multiple Route Choices

# Objectives – Origin and destination

- Mass Rapid Transit Monitoring
- Travel-to-work Flow
- Immigration/Goods Flow
- Exploration of Urban Function
- Traffic Dynamic Exploration

# Objectives – Speed & Travel Time

Characterizing Movers' Travel Time

Co-Occurrence Pattern

Bottleneck Analysis

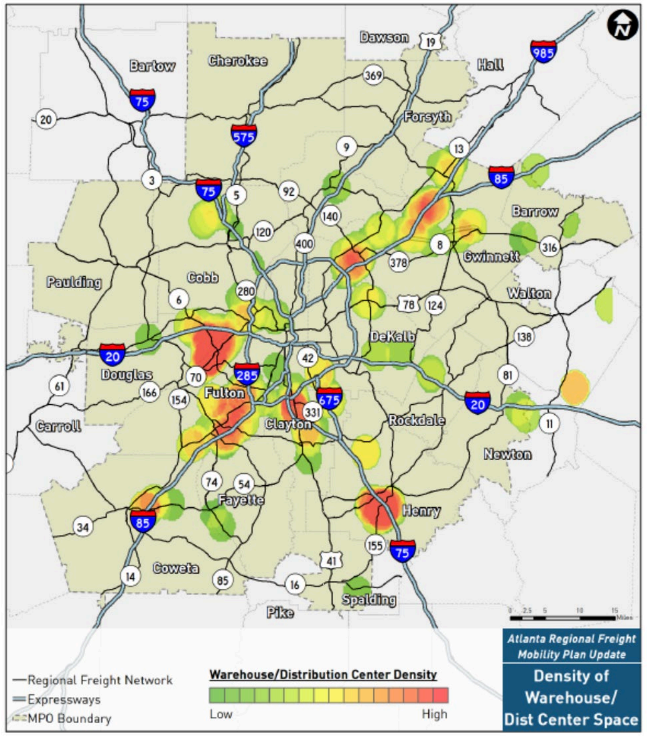
# Visualization Techniques

SPACE

TIME

EVENTS

# Visualization focusing on space




Source: Georgia Power Company. Consultant analysis


Fig. 6. Visualization of hot spots in a city through the heatmap technique [75]. The red regions represent high volume of traffic, whereas the blue regions indicate low volume of traffic.

Source: Chen, W., Guo, F., & Wang, F.-Y. (2015). A survey of Traffic Data Visualization.

# Visualization focusing on space – OD

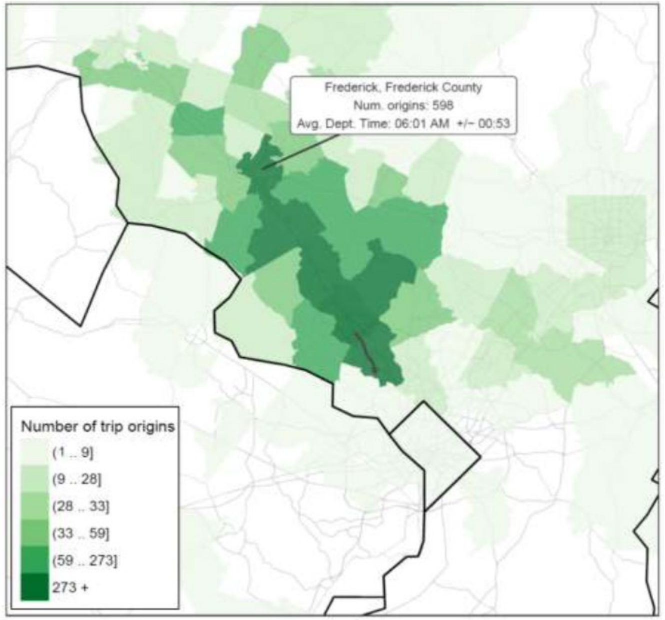



**Figure 5. Sub-County Level Origins**

Source: Petrone, A., & Franz, M. L. (2018). Probe vehicle based trajectory data visualization and applications.

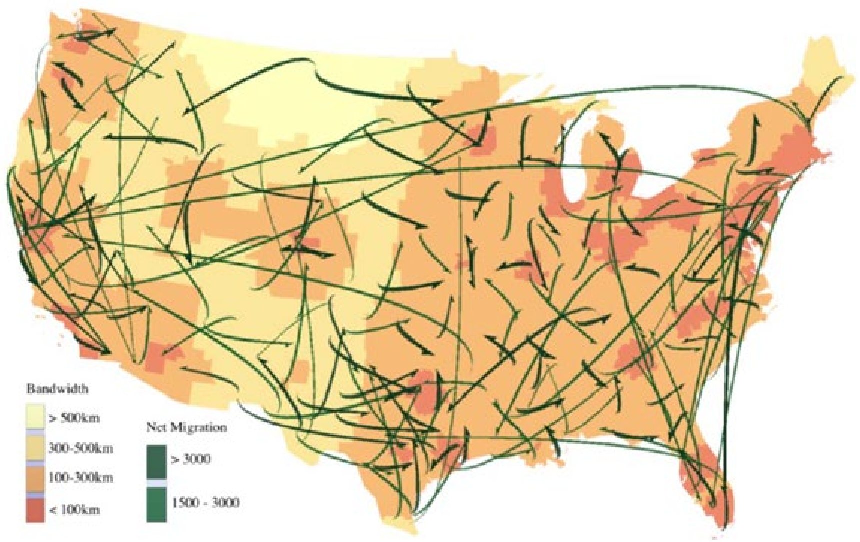



Fig. 9. The major immigration flows are visualized with arrows [82].

Source: Chen, W., Guo, F., & Wang, F.-Y. (2015). A survey of Traffic Data Visualization.

# Visualization focusing on time

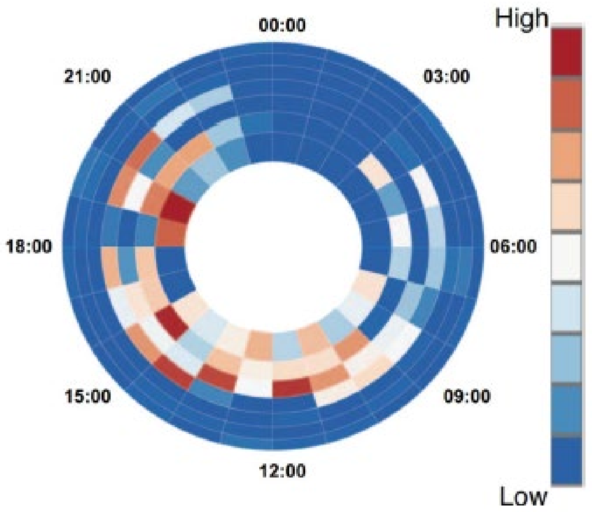



Fig. 3. Visualizing periodic time in radial layout [11]. Time in a day is shown on the circular axis and each ring represents a day. The sector color represents a selected traffic quantity with the color map shown on the right.

Source: Chen, W., Guo, F., & Wang, F.-Y. (2015). A survey of Traffic Data Visualization.


**Fig. 7.** Traffic congestion analysis. The average speed is within 20 km/h from Qingjiang East Road to Chengwen Elevated Road (a) while more than 60 km/h after Chengwen Elevated Road (b).

Source: Jin, S., Tao, Y., Yan, Y., Xu, J., & Lin, H. (2019). Visual analytics of taxi trajectory data via topical sub-trajectories.

# Visualization focusing on events

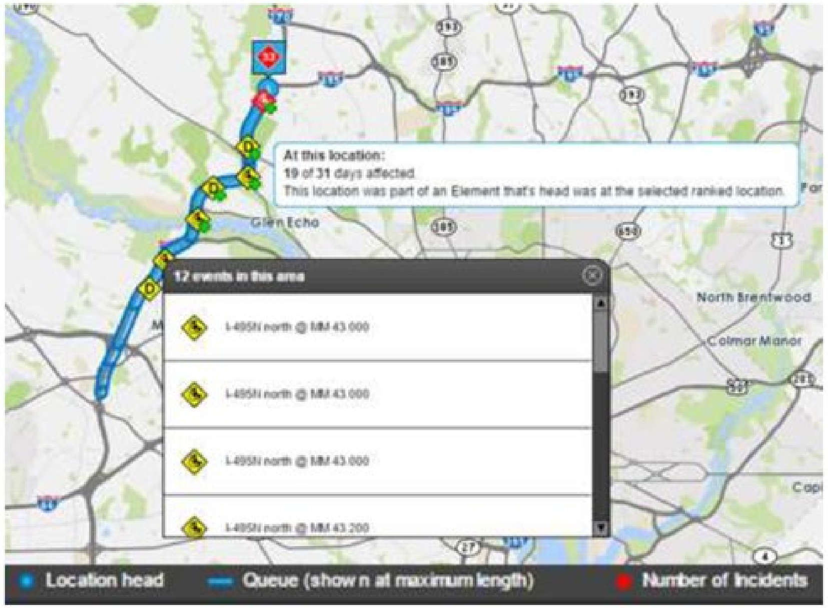



**Figure 6. Bottleneck Map**

Source: Franz, M. L., Pack, M. L., Lund, D., & Plaisant, C. (2017). Visualization tools for traffic bottleneck analysis.

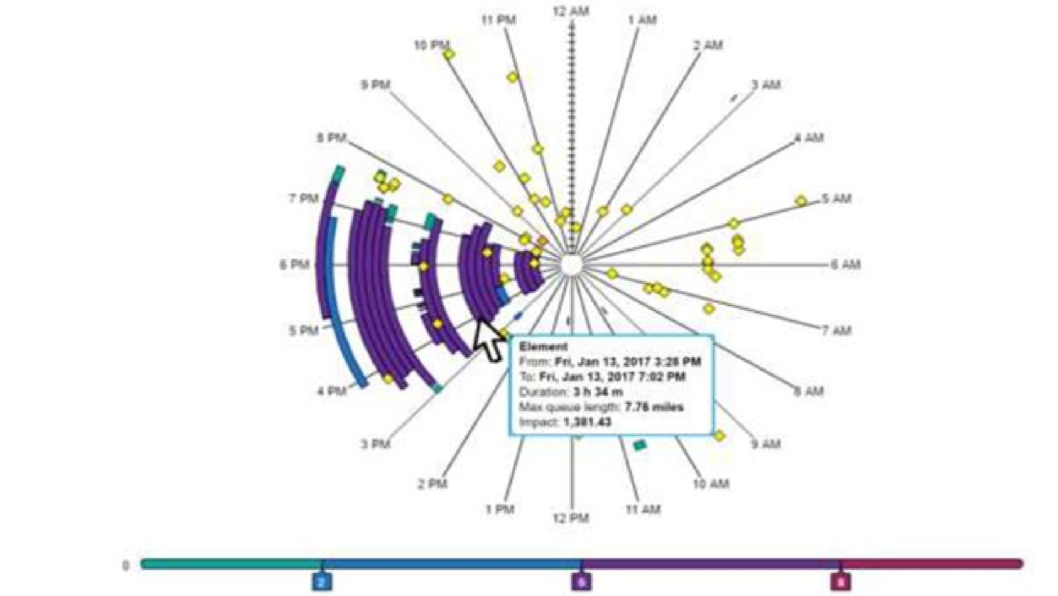



**Figure 8. Time Spiral**

Source: Franz, M. L., Pack, M. L., Lund, D., & Plaisant, C. (2017). Visualization tools for traffic bottleneck analysis.

# Visualization focusing on space & time

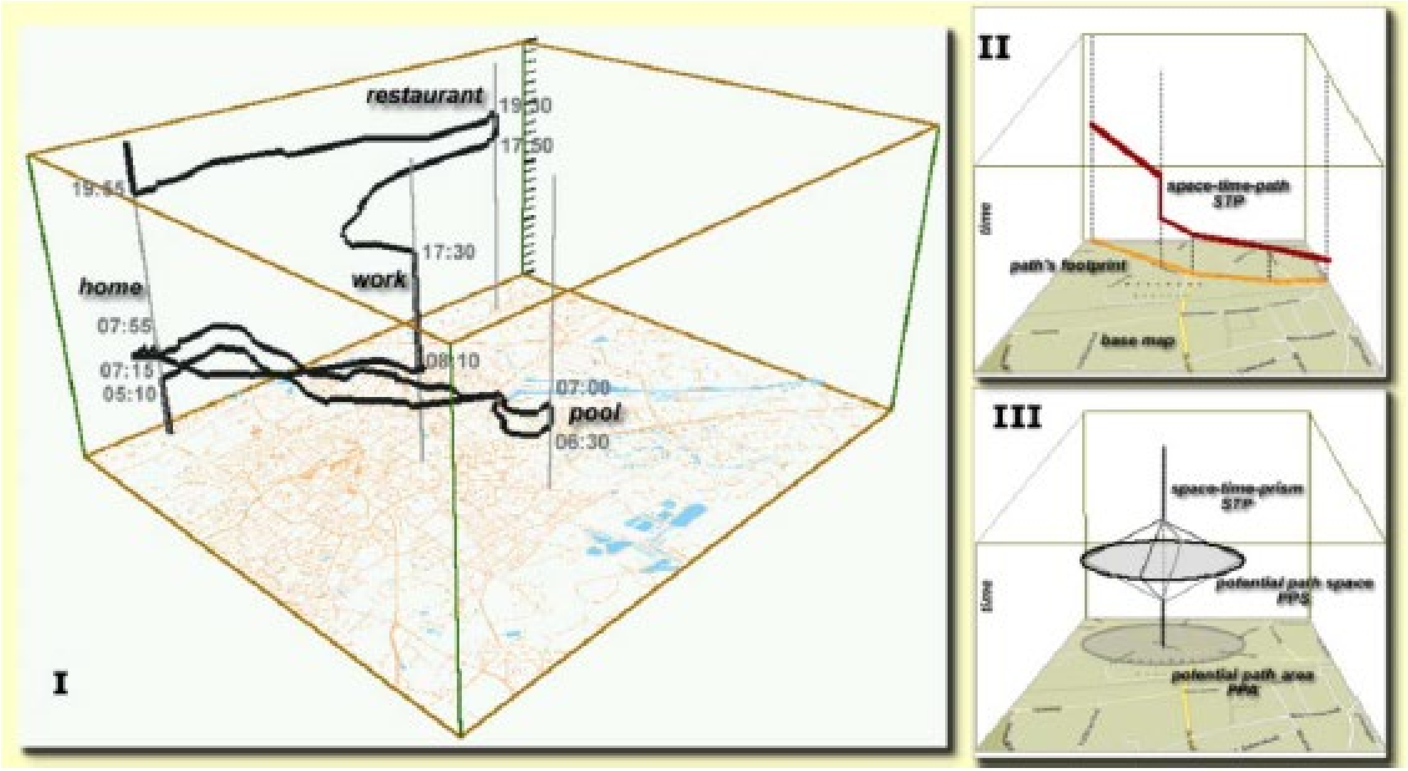



Fig. 12. Space-time-cube: both spatial information and temporal information are visualized in a cube [84]. The $X$-axis and $Y$-axis represent spatial information, whereas the $Z$-axis represents temporal information.

Source: Chen, W., Guo, F., & Wang, F.-Y. (2015). A survey of Traffic Data Visualization.

# Visualization focusing on spatial – temporal events

Figure 4

Results of the stop analysis using Flower charts show different patterns of spatiotemporal distribution of stop events.

Source: Bak, P., Ship, H. J., Yaeli, A., Nardi, Y., Packer, E., Saadoun, G., Bnayahu, J., & Peterfreund, L. (2015). Visual analytics for movement behavior in traffic and Transportation.

# Hybrid Visualizations

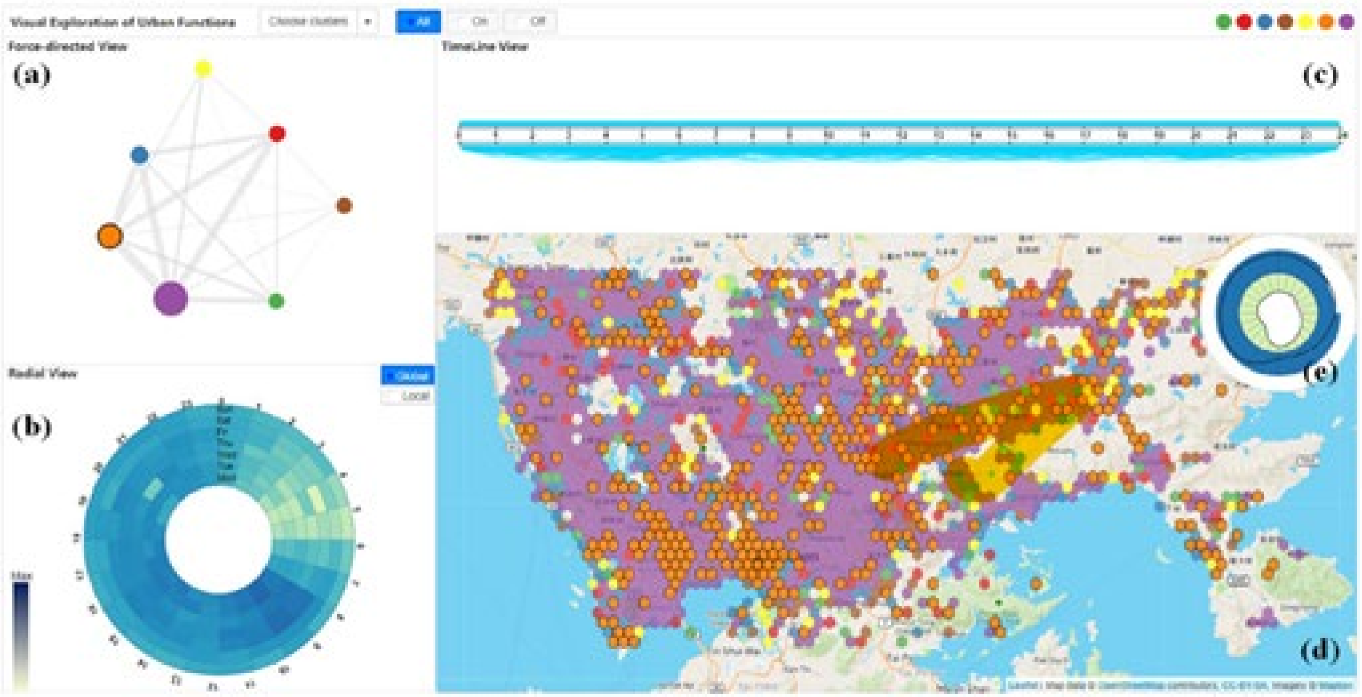
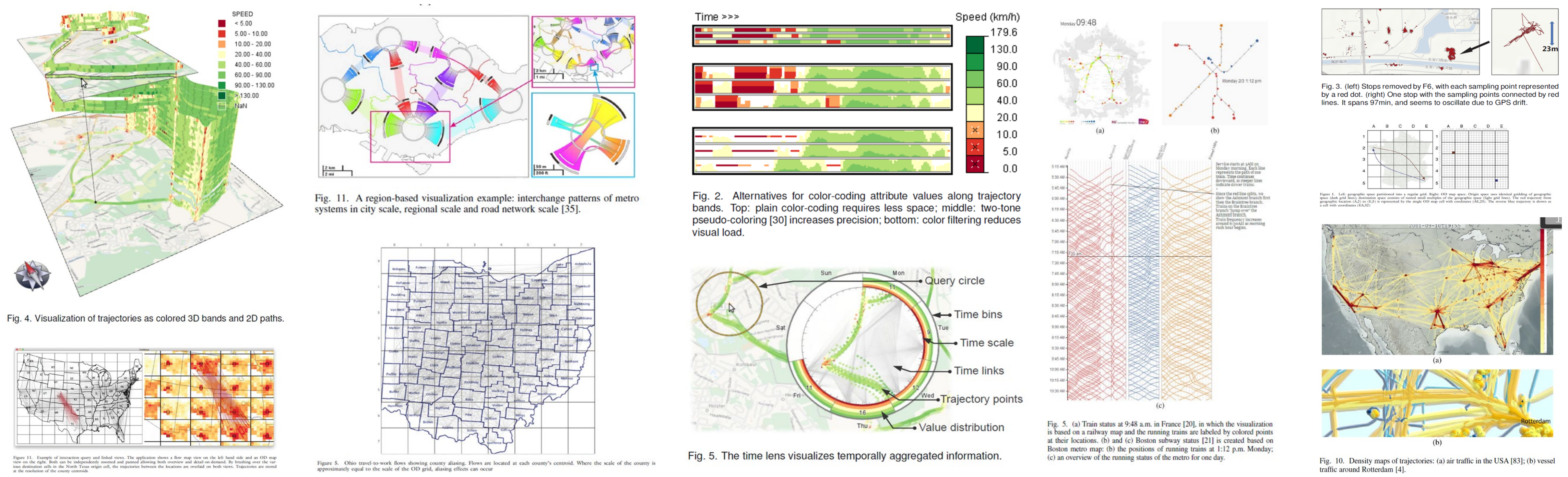


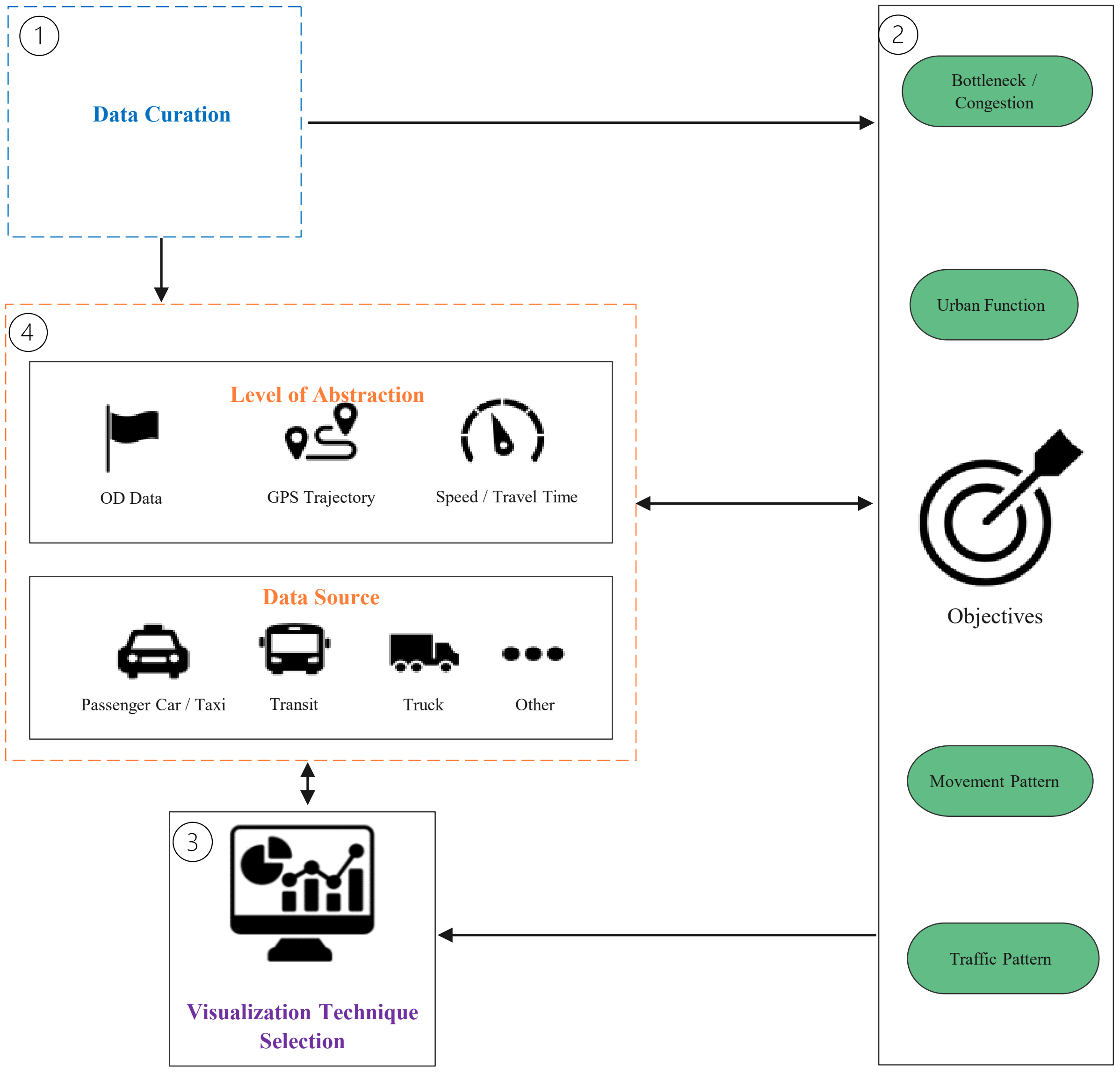

Fig. 1. Visualization for a spatio-temporal taxi OD dataset: (a) a force-directed view to present the correlation between functional areas. (b) a radial view to visualize traffic volume changes over time. (c) a timeline view to present the distribution of pick-up/drop-off and the travel time within or between functional areas. (d) a map view to present global urban functions, in which the temporal distribution of traffic flow volumes of a local area of interest can be checked by means of Glyph designed as shown in (e).

Source: Zhou, Z., Yu, J., Guo, Z., & Liu, Y. (2018). Visual exploration of urban functions via spatio-temporal taxi od data.




# There are many more visualizations for telematics

# Decision Support Tool



# Conclusion

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## Exploit Existing Techniques

## Hybrid Visualizations

## Data fusion


# Thank You

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