# IMAGE DRIVEN GPS TRACE ANALYSIS FOR ROAD MAP INFERENCE

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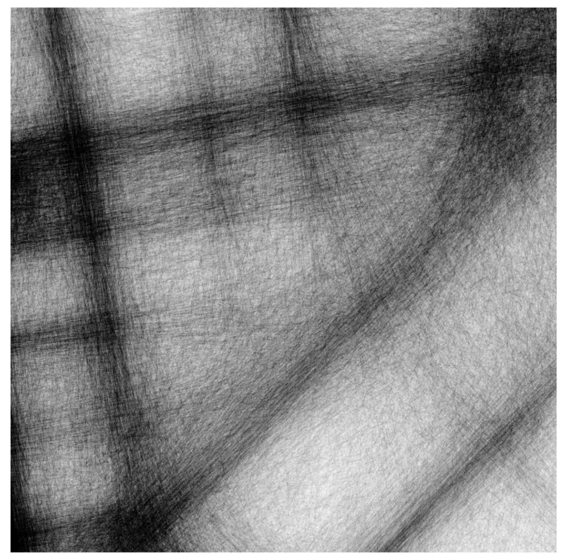
## INTRODUCTION



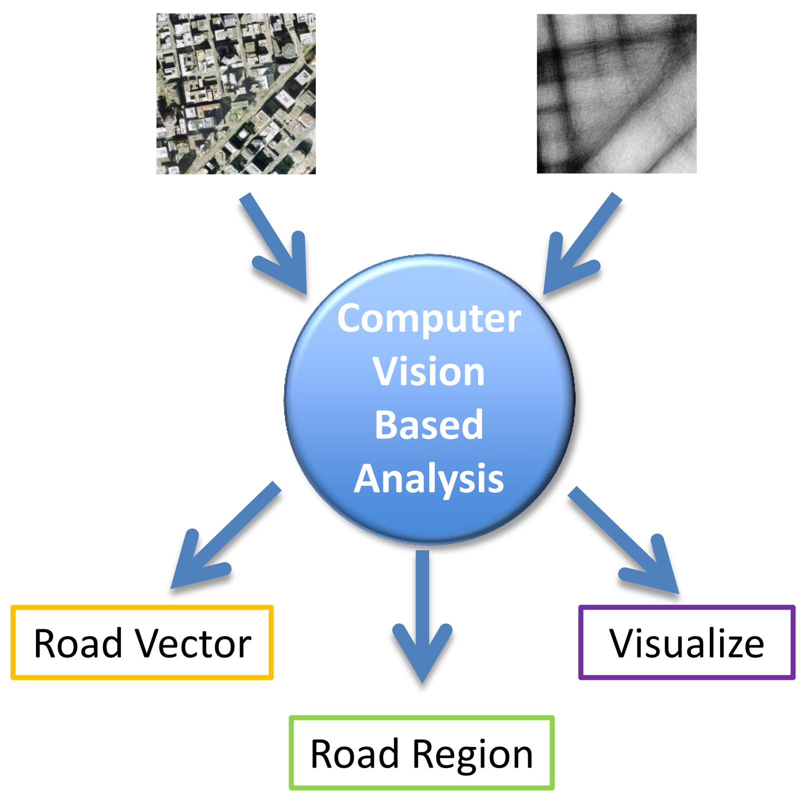
Raw GPS traces

Filtered trace data

- *Large-scale GPS trace data often noisy* - severe signal interference (from tall buildings, trees, cables, etc.), low data collection frequency (recorded every minute) to limit energy consumption and bandwidth, disparity in trace data (more data on freeway compared to residential area)
- Develop computer vision techniques to integrate image data into GPS trace analysis. Noisy traces can be significantly reduced, which leads to accurate map inference and road region extraction

## COMPUTER VISION SOLUTION

- Previous works relied on pruning and refinement of trace data based on density estimates, map matching, and trajectory analysis
- We use the aerial imagery covering the locations actually spanned by the trace data

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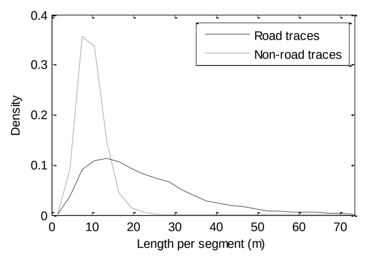
## COMPUTER VISION ANALYSIS FOR GPS TRACE SIGNAL EXTRACTION

### FACTORIZATION BASED SEGMENTATION

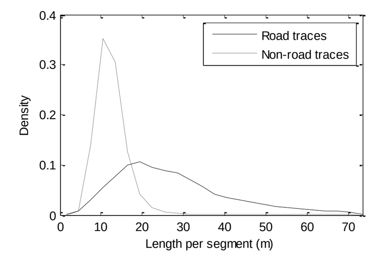
- A factorization based image model represented as:

$$Y = Z\beta + \varepsilon$$

- Segmentation algorithm factors feature matrix $Y$ into two matrices

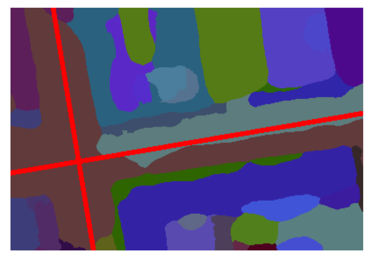



Mean shift




Factorization

High resolution aerial imagery

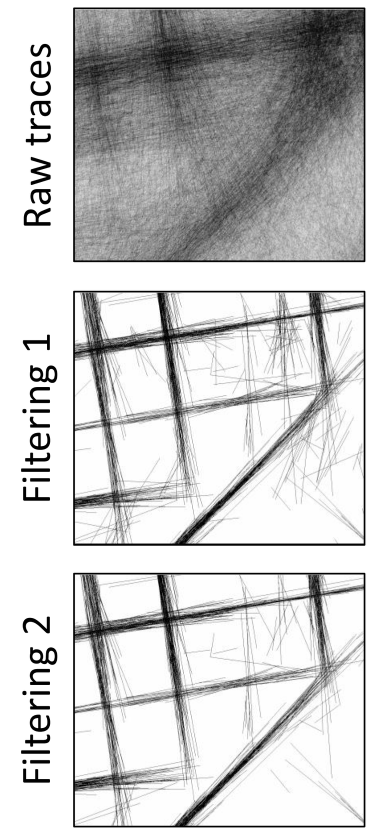


Segmentation output with road vector overlaid

Our main intuition is that since road regions tend to be grouped in segmentation, the number of segments spanned by road traces should be lower than those traces that lie on non-road regions

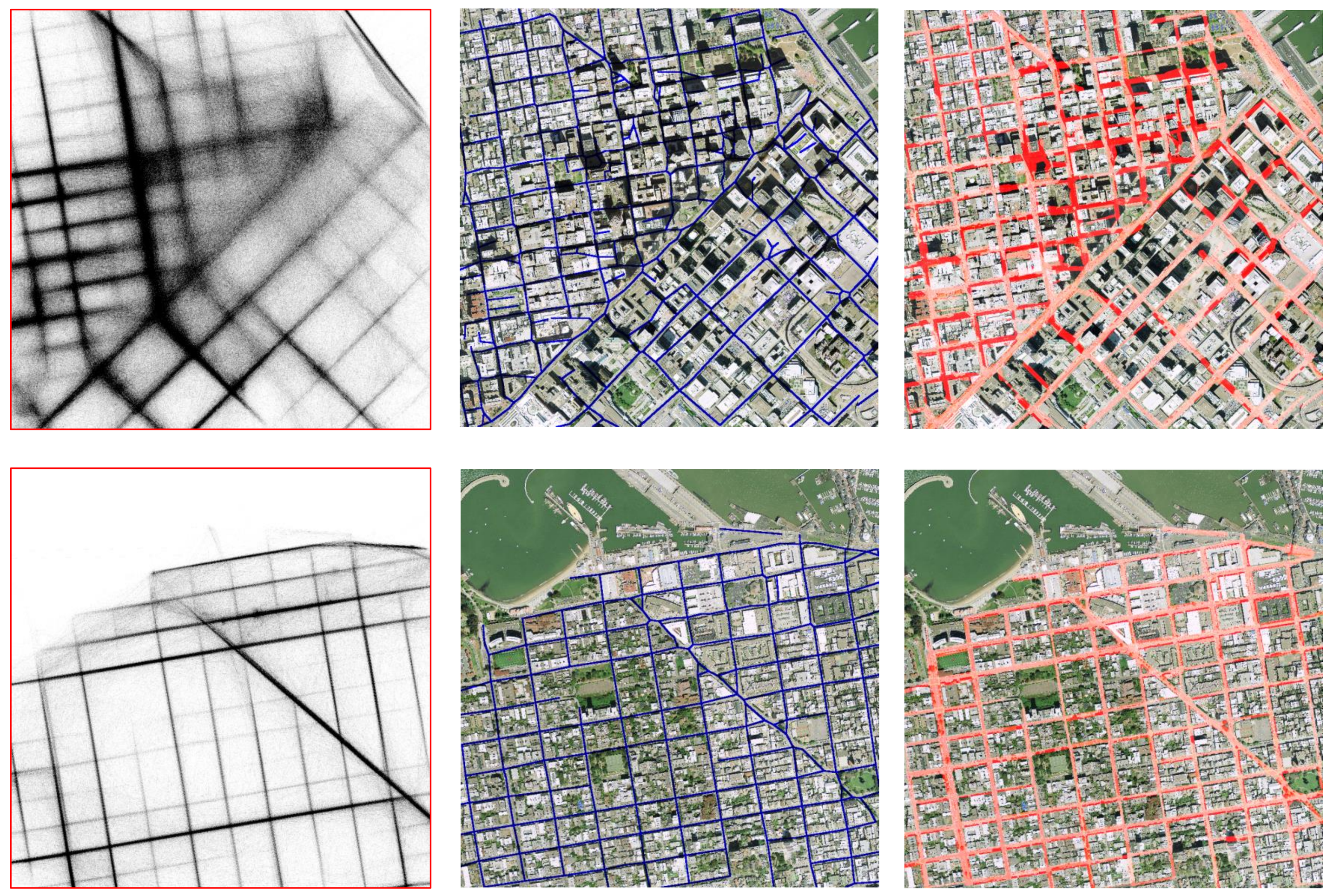
### STRUCTURE TENSOR ANALYSIS

- Most objects on and near a road (vegetation, pavement markings, vehicles, and buildings) spread along the road
- Shift the image patch containing a road and compute the pixel difference. The largest difference occurs when the shift is perpendicular to the road orientation
- Construct a structure tensor using the gradients within the patch. Obtain the shift vector from eigenvectors. Compare the shift vector with trace orientation.

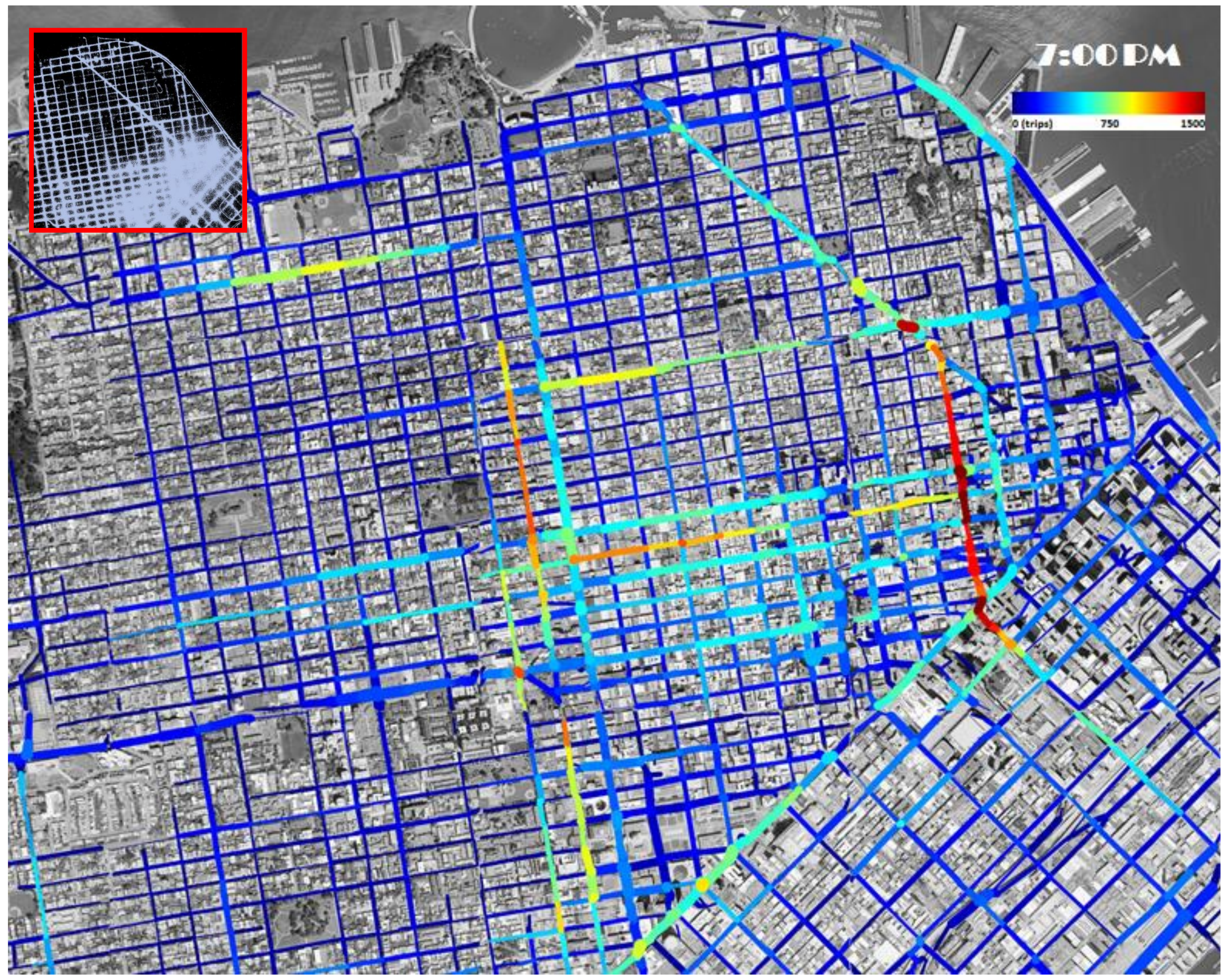



## RESULTS

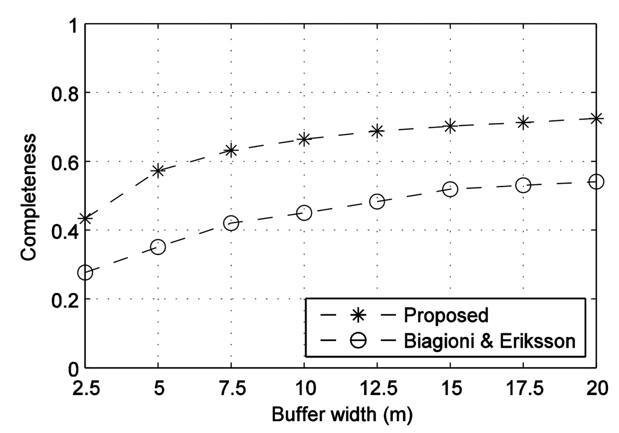
### ROAD VECTOR DATA AND ROAD SEGMENTATION

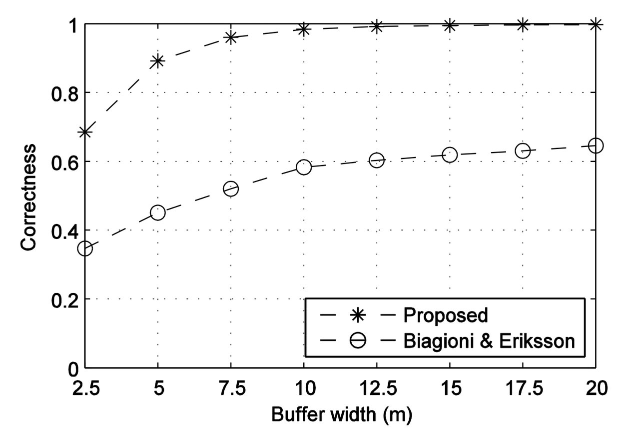


### MORE THAN 500 TAXI, ONE MONTH DATA




### COMPARISON




Biagioni and Eriksson. Map inference in the face of noise and disparity. In ACM SIGSPATIAL GIS, 2012.

### CONCLUSION

- Applying computer vision techniques to GPS trace data analysis can produce effective and robust solution.
- Work can be extended for vision based aerial scene understanding solutions.