

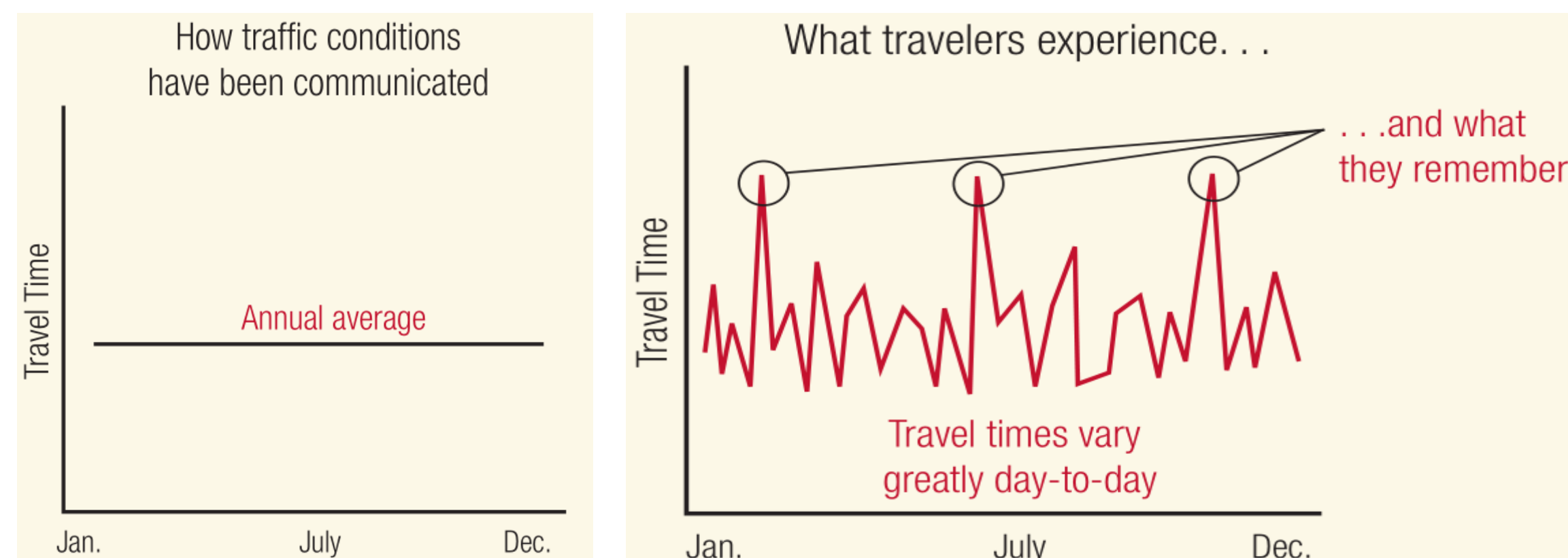


License Plate Recognition Technology's Potential Benefits to ITS: an 'Arterial Travel Time' Case Study

Roozbeh Rahmani Graduate Research Assistant, Carlos Sun Ph.D. P.E., J.D., Praveen Edara Ph.D. P.E., Henry Brown P.E., and Paige Martz Undergraduate Research Assistant
ZouTrans, University of Missouri-Columbia

Introduction

- Travel Time:
 - The most important performance measures
 - Not only average travel time, but more importantly, travel time reliability.



U.S. Federal Highway Administration (FHWA). 2006. Travel time reliability: Making it there on time, all the time, Federal Highway Administration, US Department of Transportation.

- Travel Time Estimation vs. Measurement:
 - Estimation:** Averages speeds and transform to *average link travel time*.
 - Inaccurate for congested traffic
 - Not considering signal control delays
 - Measurement:** Tempo-spatial vehicle tracking, *actual travel time*, also *Origin Destination* studies
- Vehicle Tracking/Re-identification Devices:
 - On-Board-Unit:
 - GPS, Bluetooth, cellphone, toll tag reader (<30%)
 - No On-Board-Unit:
 - Inductive/Magnetic Signatures, License Plate Tracking (~100%)

LPR vs. other Vehicle Re-identification ITS Technologies

- Bluetooth, GPS, Cellphone, Toll Tag Identification
 - Good travel time estimators
 - Market penetration:
 - Bluetooth/GPS 5%
 - cellphone optimistically 30%
 - Toll Tag Identification System limited to the toll roads only
- Inductive Loop Detector and Magnetic sensor signatures
 - No board unit, high market penetration
 - Re-identification rate about 30-50%
 - Re-identification rate drastically decreases by increasing detectors distance (<1-1.5 mi)
 - Useless for OD studies**
- License Plate Recognition
 - High market penetration (~100%)
 - required by law to have a visible license plate
 - High re-identification accuracy (>90%)
 - Perfect for Dynamic OD studies**
 - Plates are identical
 - Accuracy is not sensitive to detectors distance
 - OD studies are the most expensive surveys

LPR's Potentials

- Parking Spaces Management and Toll Collection
- Actual Travel Time Measurement
 - tempo-spatial vehicles re-identification
 - LPR considers the control delays
- Real Time Signal Coordination
 - Individuals' **actual travel time**, instead of **average**
- Dynamic Origin-Destination Trip Matrix Estimation
 - In contrast to other methods, LPR's accuracy, barely sensitive to distance.
 - Higher market penetration
 - Larger successful re-identification rate
 - The most expensive study
- Incident Detection
 - Drastic increases in travel time incident
 - Flexibility of manual video monitoring to find incident
- Route Choice Determination
 - Different path travel times (Fig1) for each OD useful to:
 - Inform drivers about the shortest path
 - Dynamic traffic assignment.

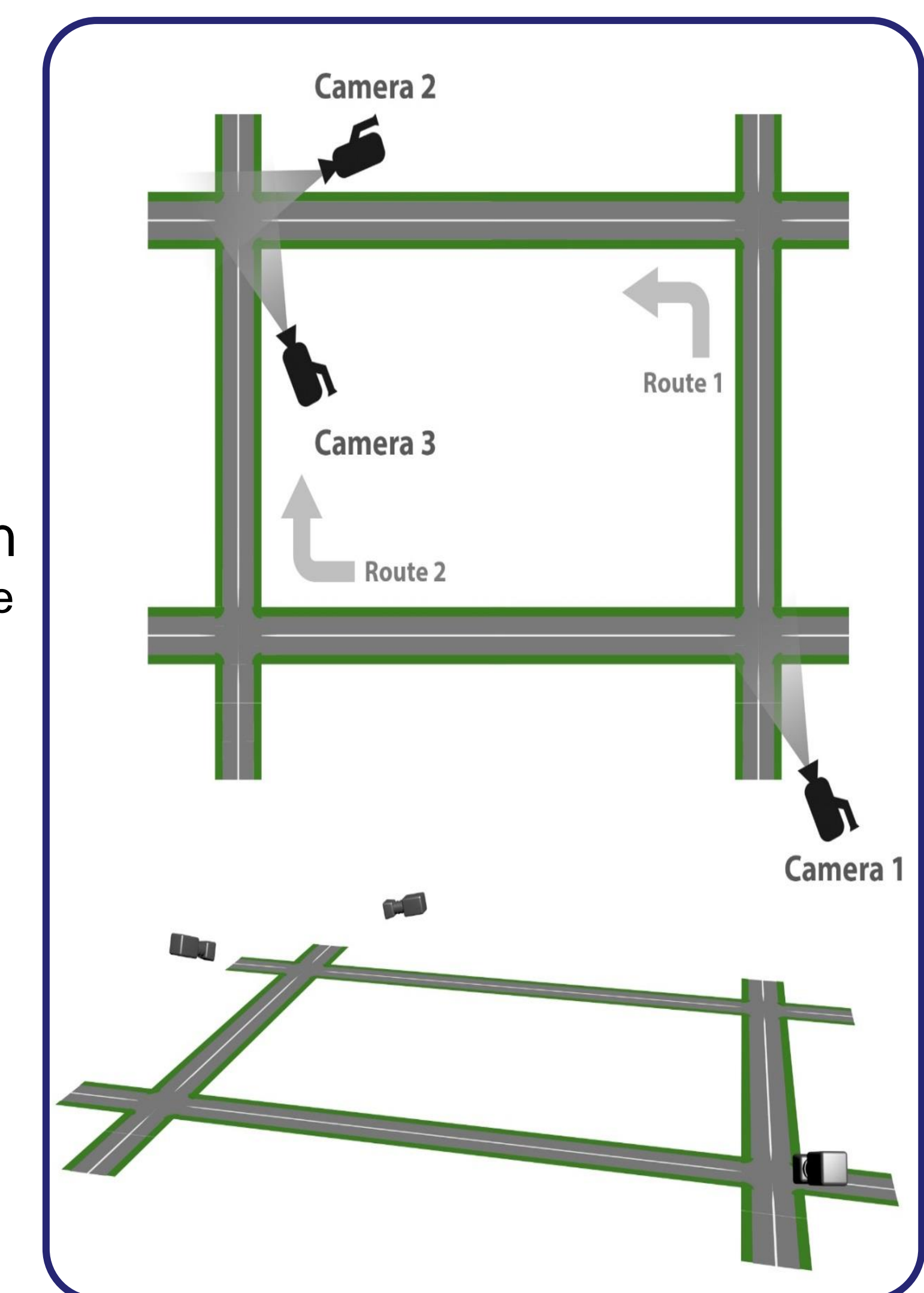


Figure 1. Route Choice Determination.

Case Study and Results

- Arterial Segment
 - 1 mile
 - five lane two-way
 - 4 signalized
 - 7 un-signalized (Fig 2)

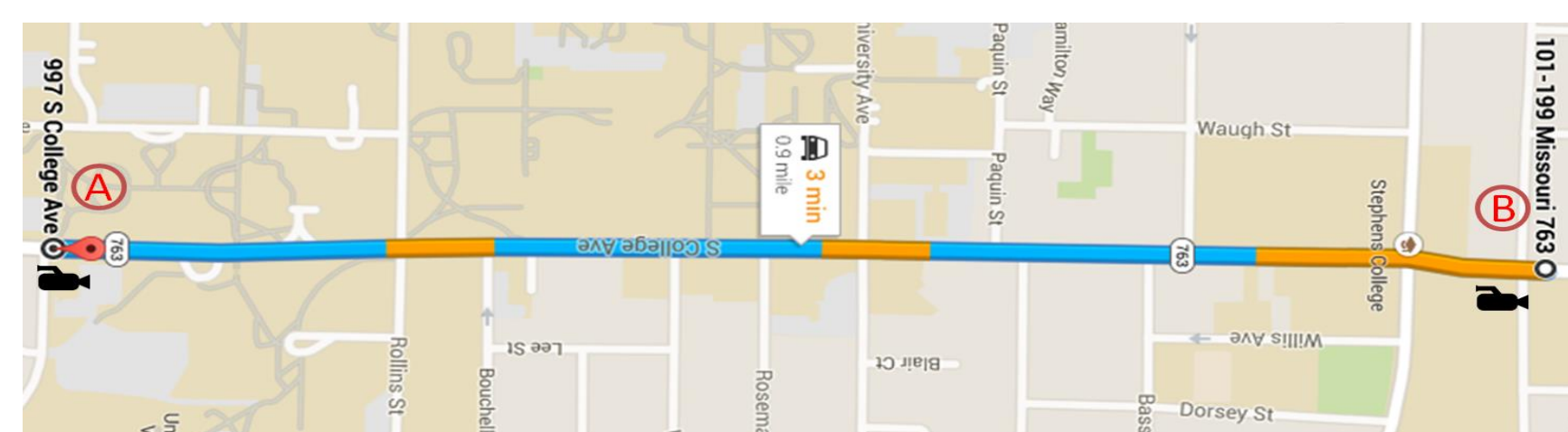


Figure 2. Arterial Segment

- Data Collection
 - Two Standard HD cameras
 - One hour at A and 67 minutes at B
 - Each camera covers two lane

- Ground Truth
 - 781 vehicles, A
 - 725 vehicles, B
 - 206 vehicles passed both A and B

- Re-identification Accuracy:
 - 188 correct out of 206 (**91.3%**)
 - 9 by matching texts on vehicles
 - 5 wrong matches (**2.4% error**)

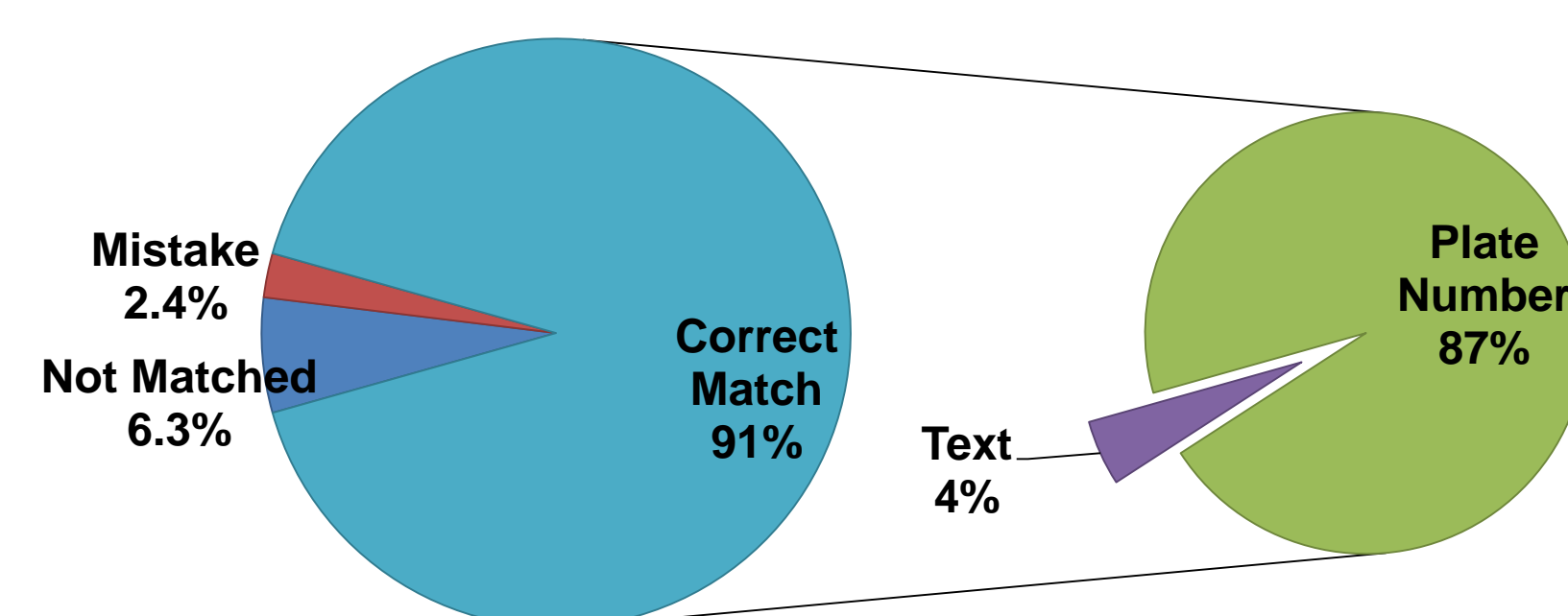


Figure 3. LPR Re-identification Accuracy

- Arterial Travel Time
 - Negative travel times, first passed B then A (Fig 4)
 - Extremely large positive, intermediate stops
 - Extracting Outliers, using Tukey Filter (Fig 5)

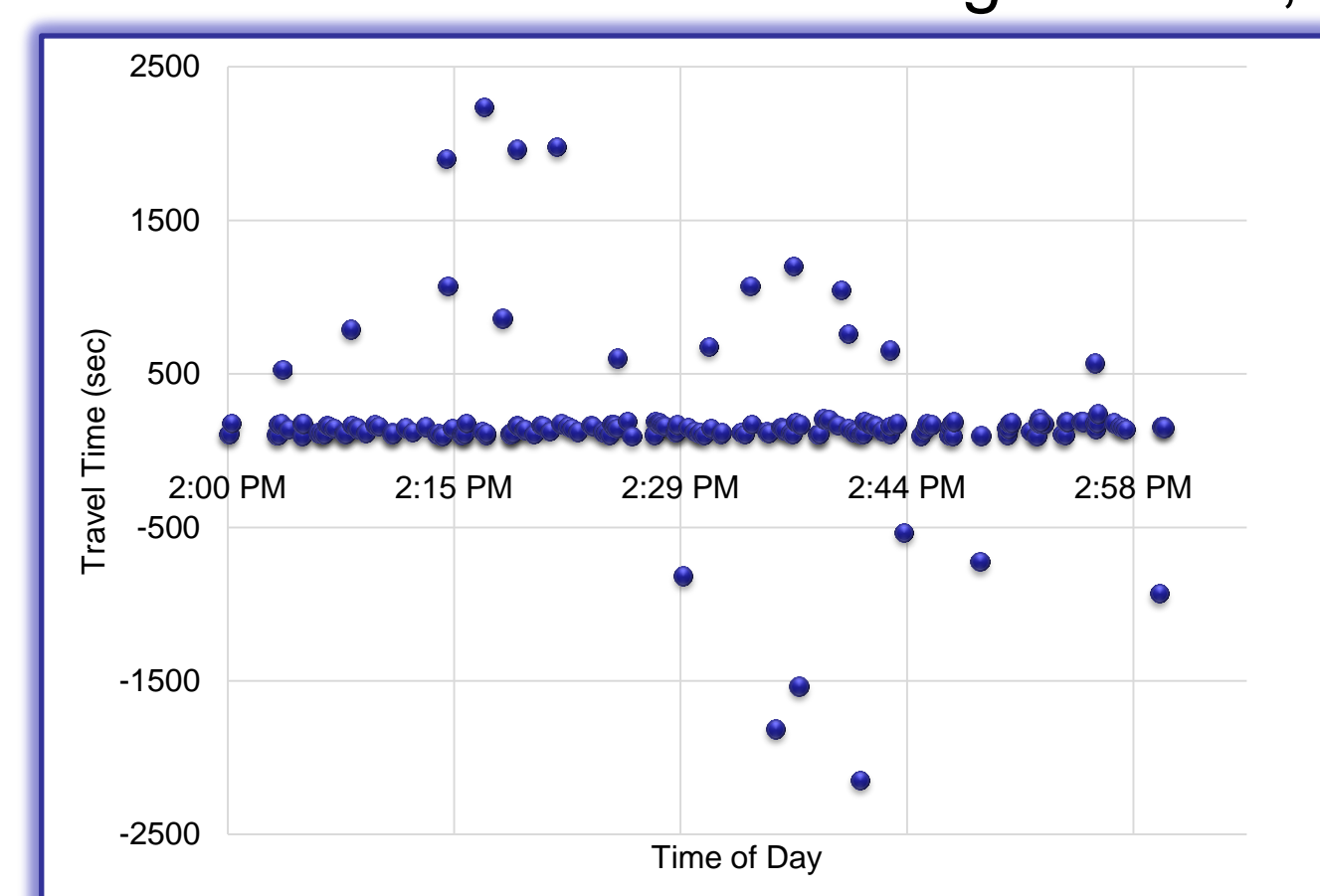


Figure 4. Individual's Travel Times.

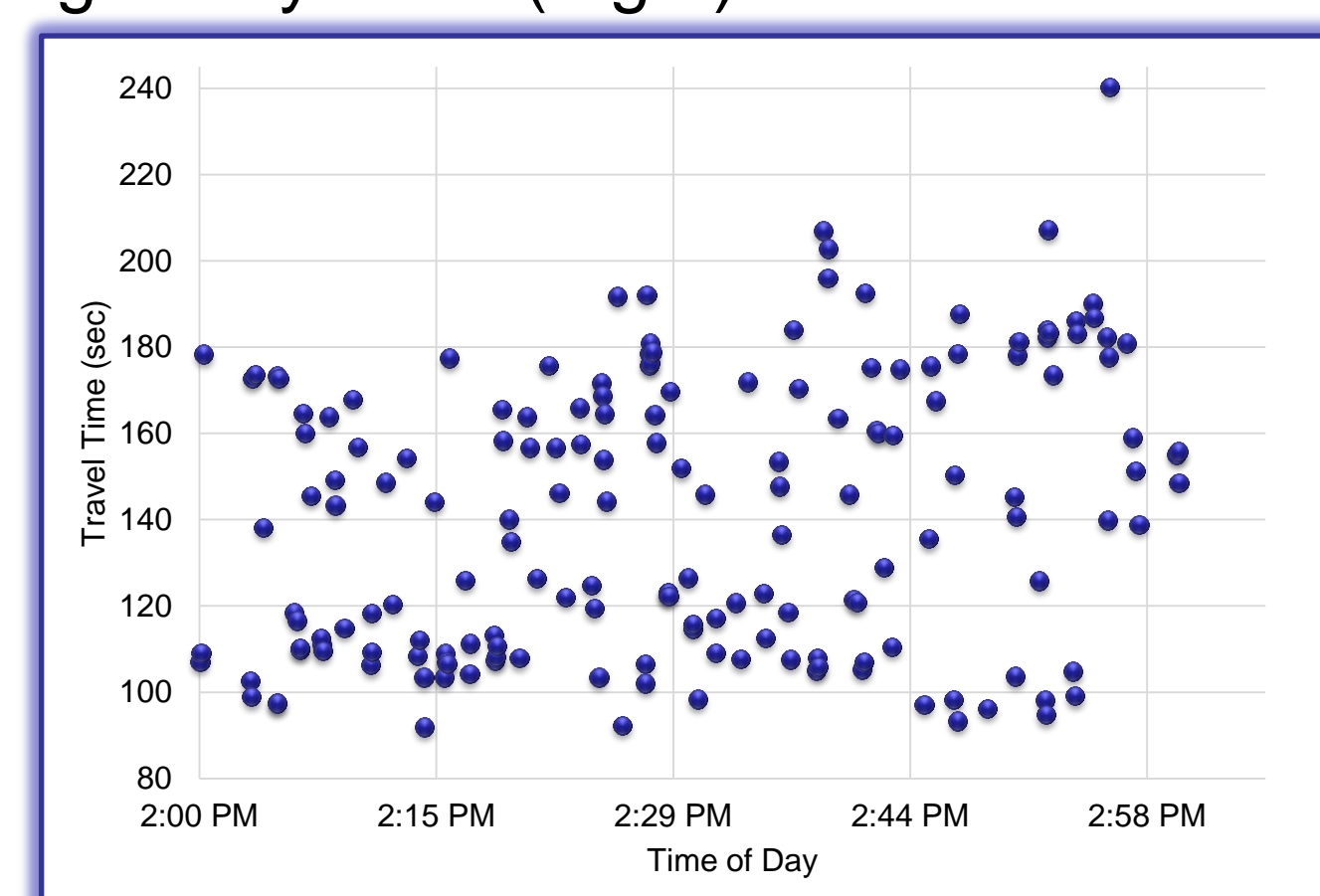


Figure 5. Final Individual's Travel Times.

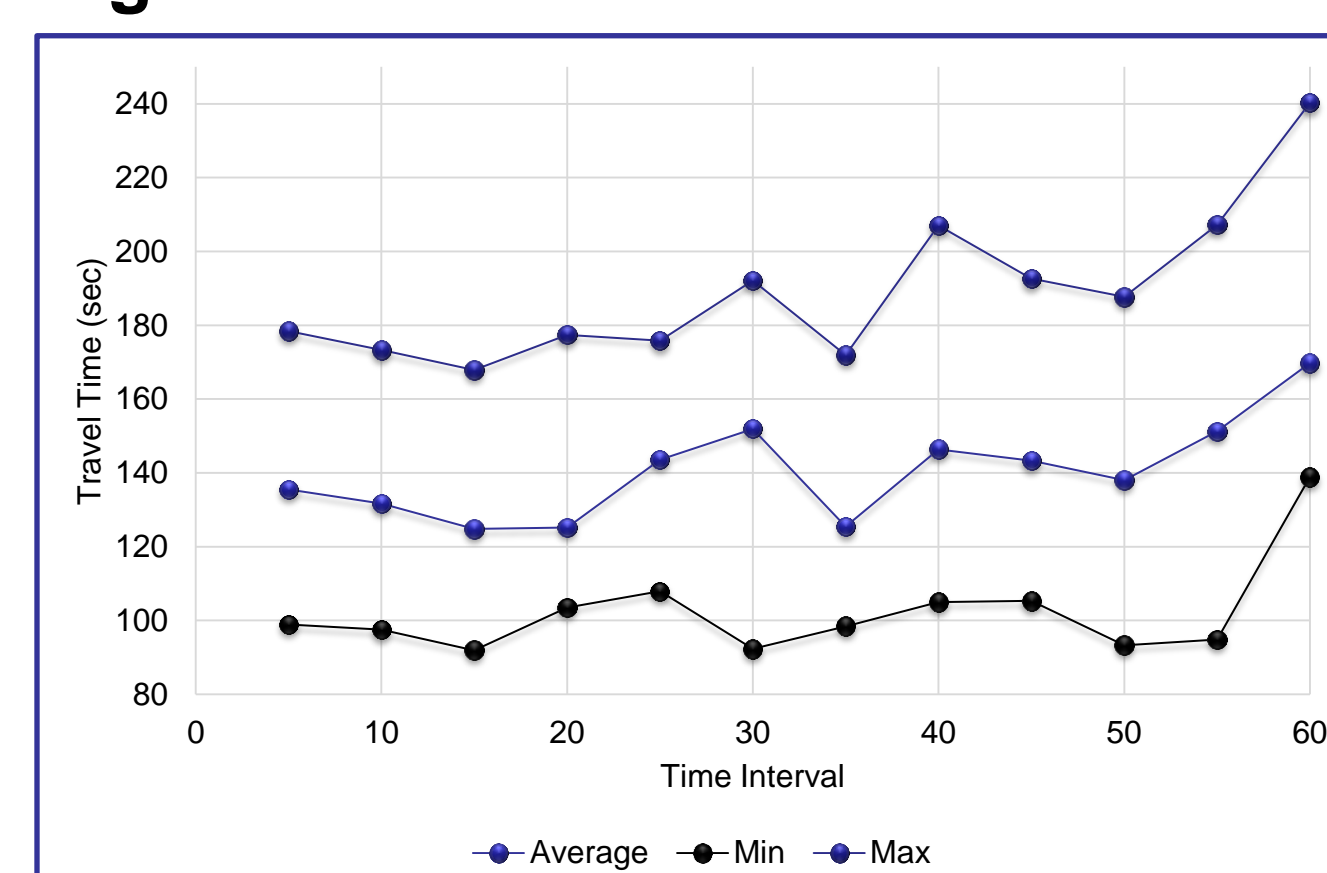


Figure 6. Average, Minimum and Maximum Travel Times in 5 minutes intervals

- Reading the texts on vehicles' body as plate number
 - Benefit : Larger re-identification rate.
 - Drawback: duplicates. Solution is filtering out repetitive travel times with same captured times.



Figure 7. Example of Texts on a Bus Body (Vision Components, ANPR Demo Software).

Summary

- Market penetration
 - ~100%
 - All vehicles are required by law to have
- Accuracy
 - 91.3%** re-identification, using two HD cameras
 - Other LPR studies mostly less than **60%**
 - References: 10-20% (1), 18% (2), 35% (3), 50% (4), 60% (5), 65% (6).
- LPR Applications
 - Travel Time Measurement instead of Estimation
 - The segment travel time could be improve up to 40 seconds (**30% improvement**)
 - Accuracy is not sensitive to distance
 - Perfect for OD studies (Most expensive surveys in transportation)

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