

LENGTH BASED VEHICLE CLASSIFICATION FROM FREEWAY SINGLE LOOP DETECTORS

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Introduction

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- The lifespan of freeway depends on roadway usage, particularly by long vehicles
- Each state monitors usage via classification stations, e.g., Weight in Motion (WIM) and axle based
- The simplest classification stations use dual-loop detectors to measure vehicle length
- **This study seeks to use single-loop detectors to achieve length based classification performance comparable to dual loop detectors**

Loop based vehicle classification

- Dual loop based
Dual loop can measure speed and length

$$l = v \times on_time$$

Eq. 1

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- Single loop based

- Only capable of estimating speed
- Conventional speed estimation is noisy

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Eq. 1

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- **Our new technique promises much more accurate speed estimation enabling accurate length estimation via Eq. 1**

Speed estimation methods in this study

Conventional method

Conventionally,

$$\hat{V} = \frac{\hat{L}}{\textit{Mean on_time}}$$

Eq. 2

Where,

\hat{V} : estimated speed

\hat{L} : assumed average effective vehicle length
(set to a constant value, on the order of 20 ft)

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Eq. 2

Where,

\hat{V} : estimated speed

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The true average length, L , varies across samples depending on traffic, but is unobserved

Distribution method

- Key notes
 - Look at distribution of on-times in a given sample from a single loop detector

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- Estimate speed from mode on-times and deduce L for each mode

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 - Speed is similar across vehicles within a sample

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- Speed is similar across vehicles within a sample
- Distribution of on-time for a given sample usually follows a bimodal distribution

Distribution method

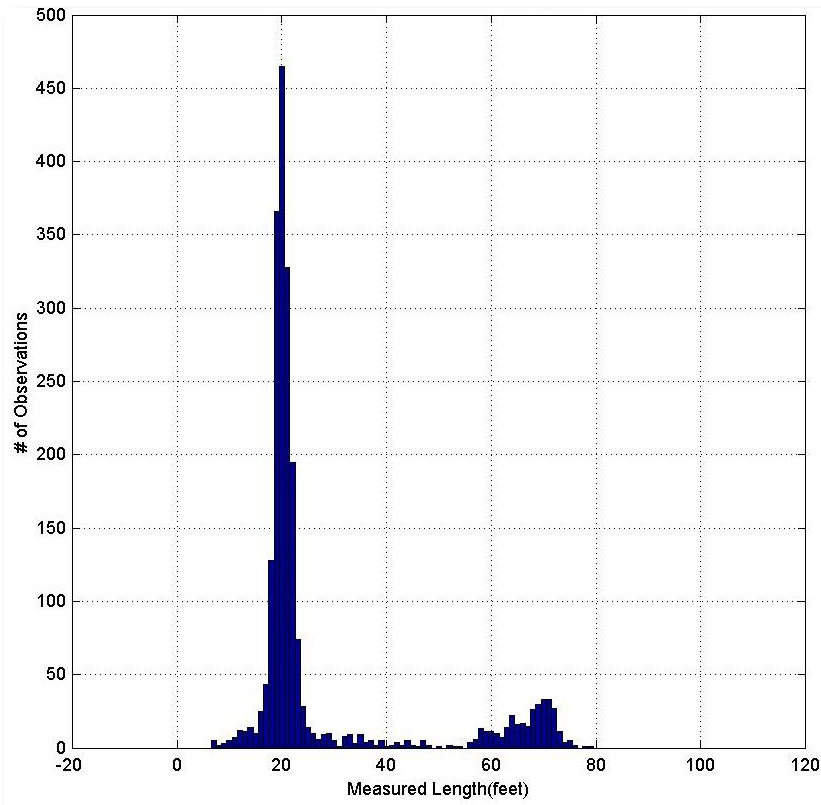
- Key notes

- Look at distribution of on-times in a given sample from a single loop detector
- Estimate speed from mode on-times and deduce L for each mode

- Two assumptions

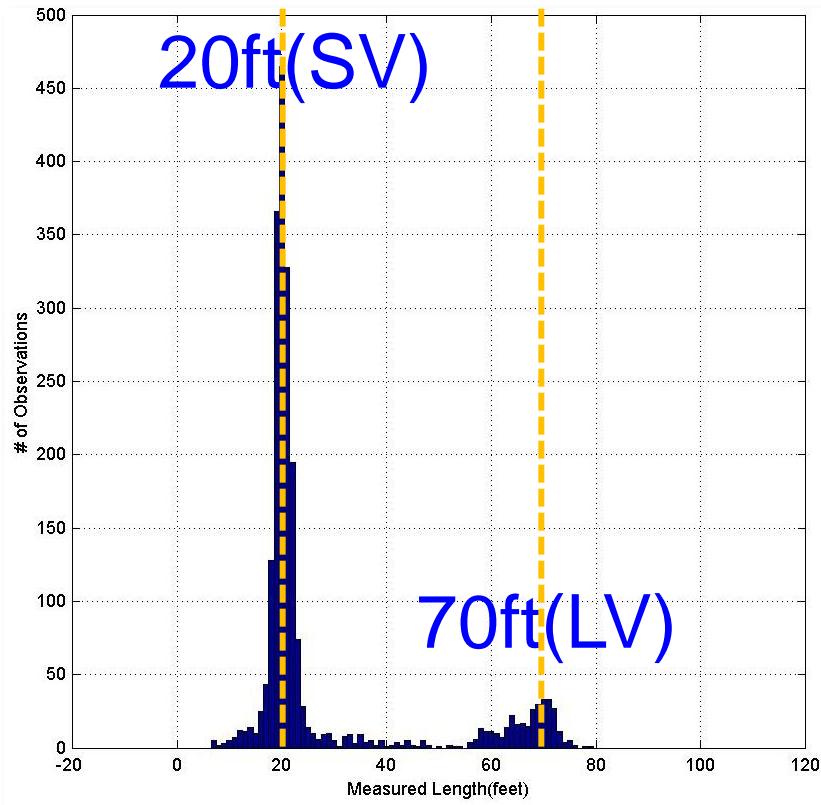
- Speed is similar across vehicles within a sample
- Distribution of on-time for a given sample usually follows a bimodal distribution **Why?**

Distribution method



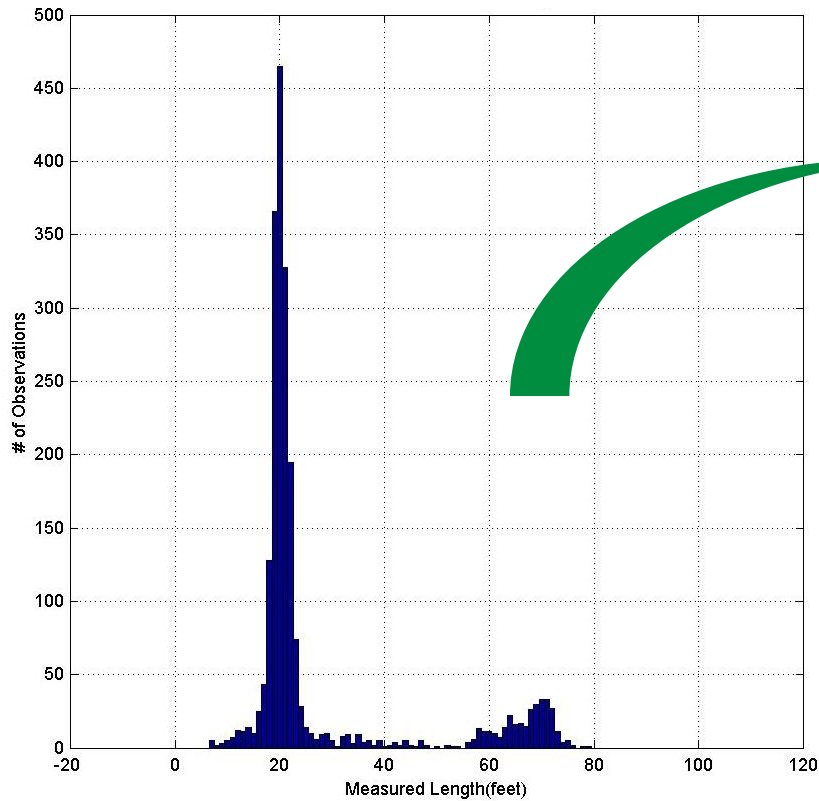
Distribution of measured length

Distribution method



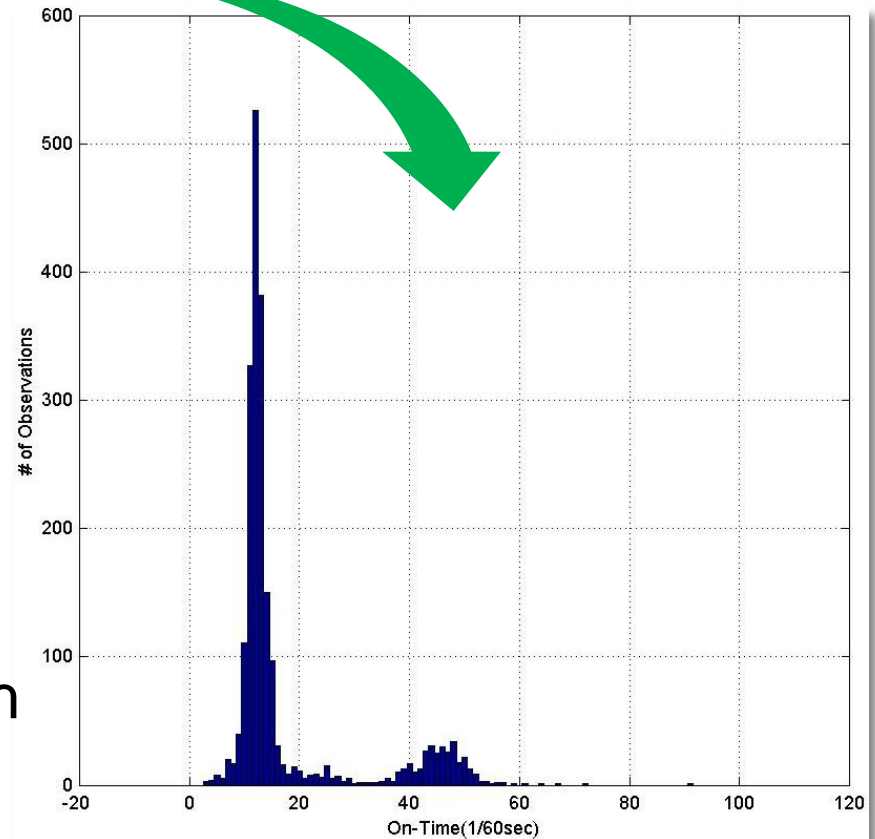
Distribution of measured length

Distribution method



Distribution of measured length

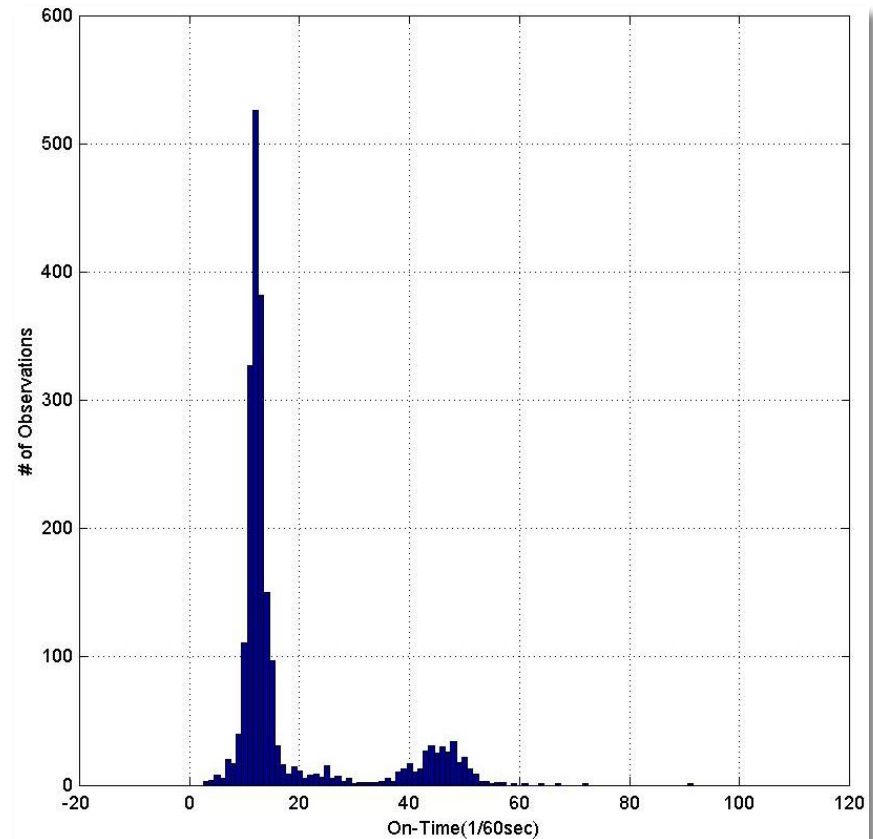
Assuming speed is roughly similar within the sample



Distribution of on-time

Distribution method

Now unobserved L can be deduced for each mode on-time



Distribution of on-time

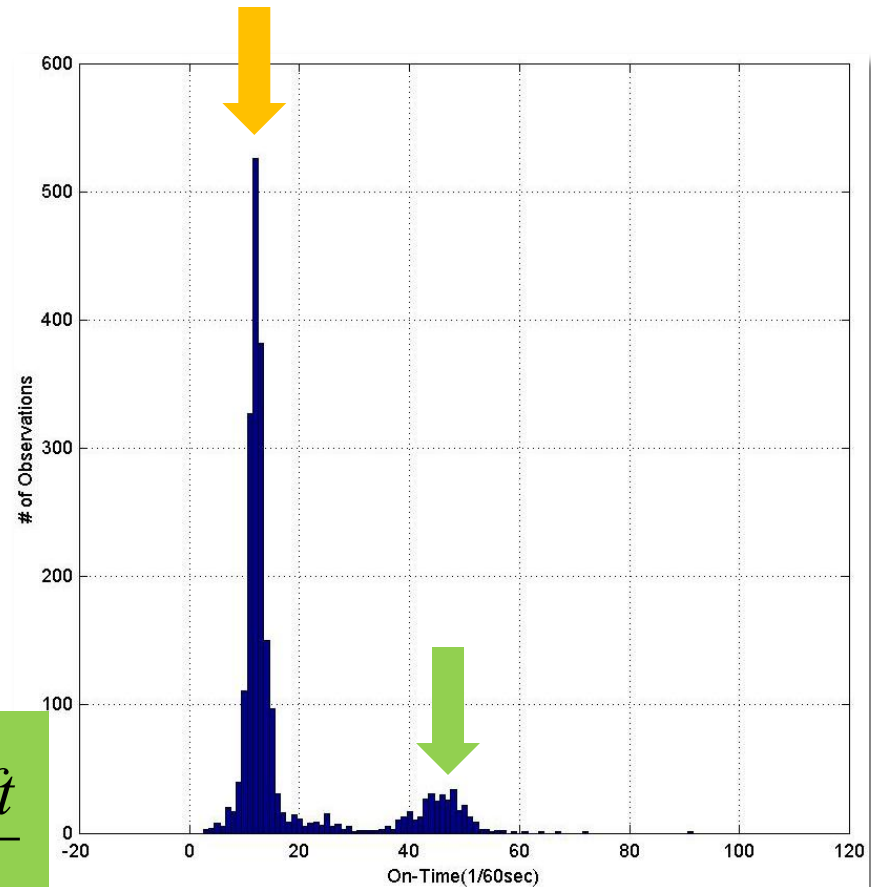
Distribution method

Now unobserved L can be deduced for each mode on-time

In which case speed is estimated from the L s and two modes

$$\hat{V}_{SV} = \frac{\hat{L}_{SV}}{on_{SV}} = \frac{20 \text{ ft}}{on_{SV}}$$

$$\hat{V}_{LV} = \frac{\hat{L}_{LV}}{on_{LV}} = \frac{70 \text{ ft}}{on_{LV}}$$



Distribution of on-time

Distribution method

- When the distribution of on-time is unimodal

Attempt to establish whether the mode corresponds to SV or LV

Distribution method

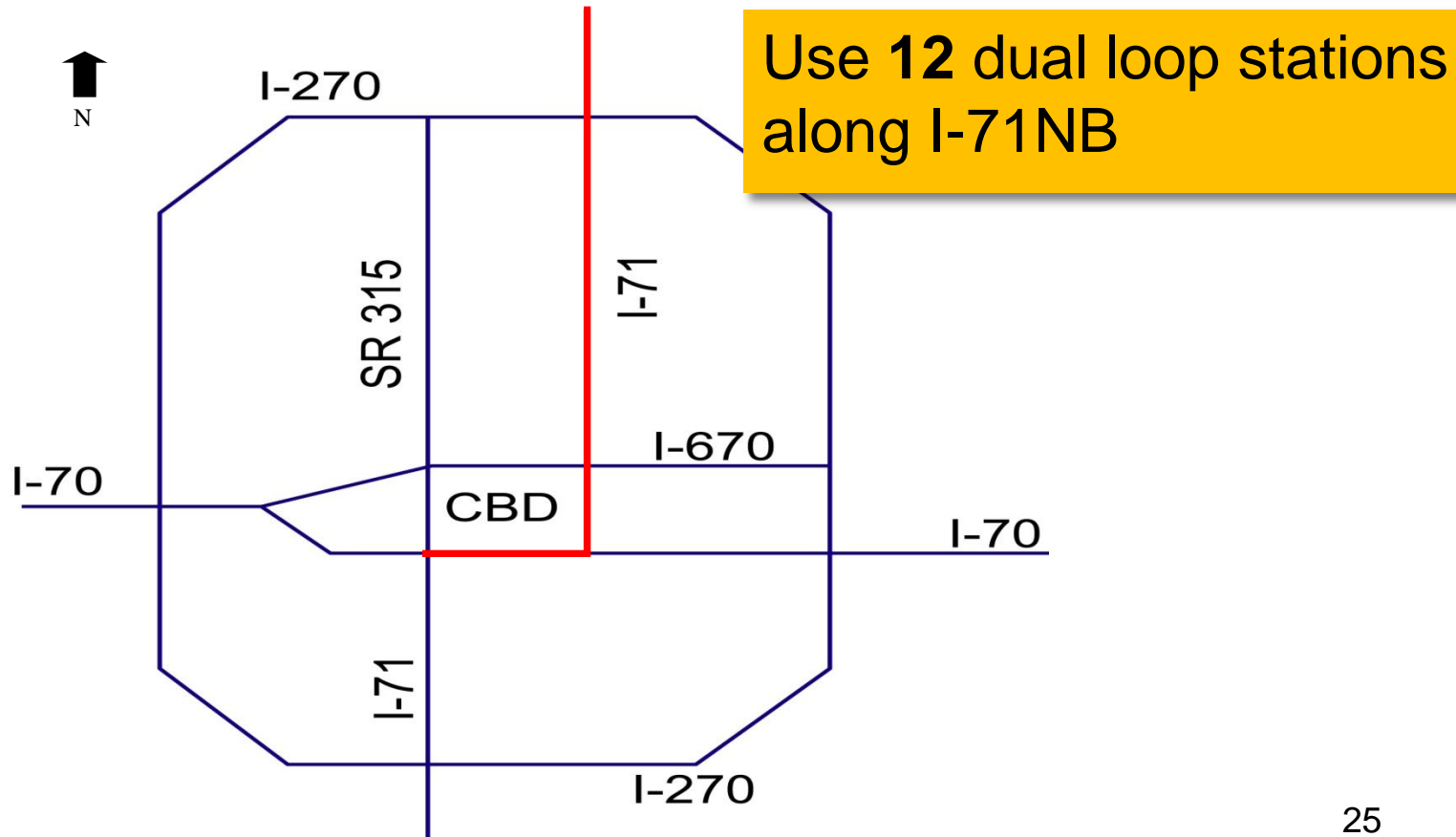
- When the distribution of on-time is unimodal
 - Attempt to establish whether the mode corresponds to SV or LV
- If the distribution is neither bimodal nor unimodal
 - The second shortest on-time measurement within each sample is taken and assumed to come from a passenger vehicle (SV)

Evaluation in vehicle length

- Using dual loop detector data from I-71

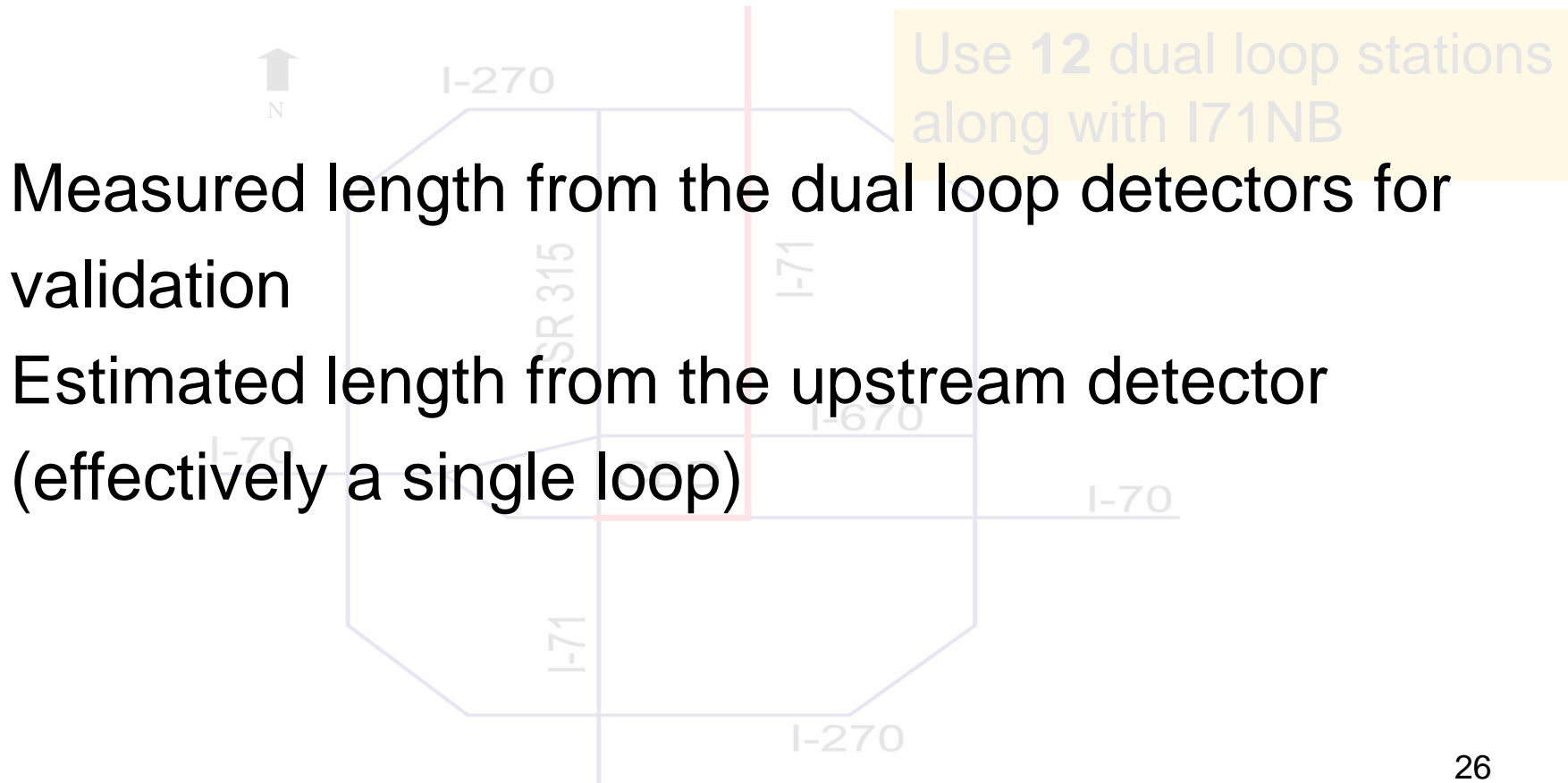
Analysis area

- Analysis area used in this study



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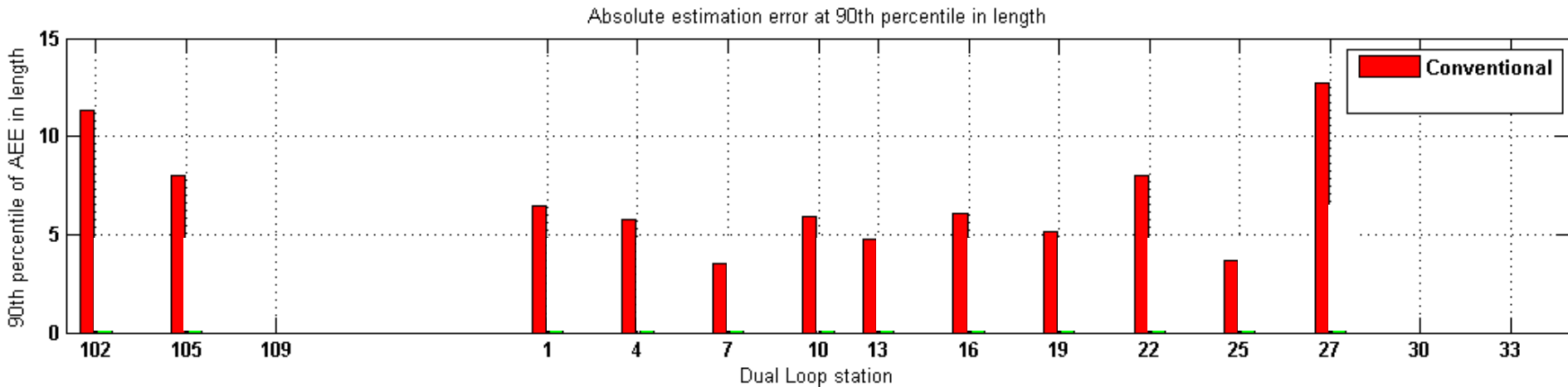


Measured length from the dual loop detectors for validation

Estimated length from the upstream detector (effectively a single loop)

Evaluation of speed and length estimation

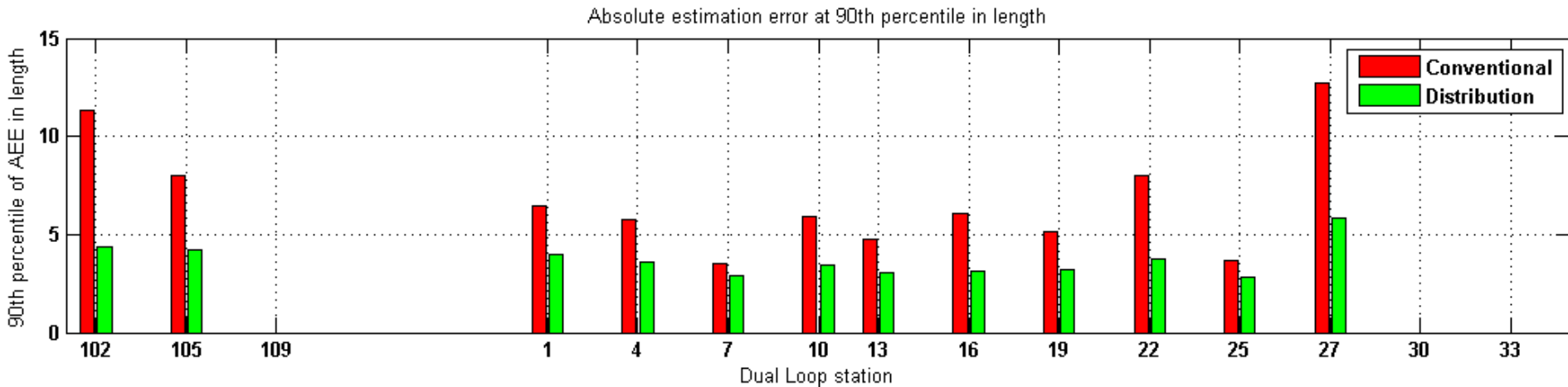
- Evaluation in length from empirical I-71 data



90th percentile of absolute estimation error in length
-Lane 3, a week of April 2005

Evaluation of speed and length estimation

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90th percentile of absolute estimation error in length
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Evaluation in length based vehicle classification

- Using dual loop detector data from I-71

Evaluation of length based vehicle classification

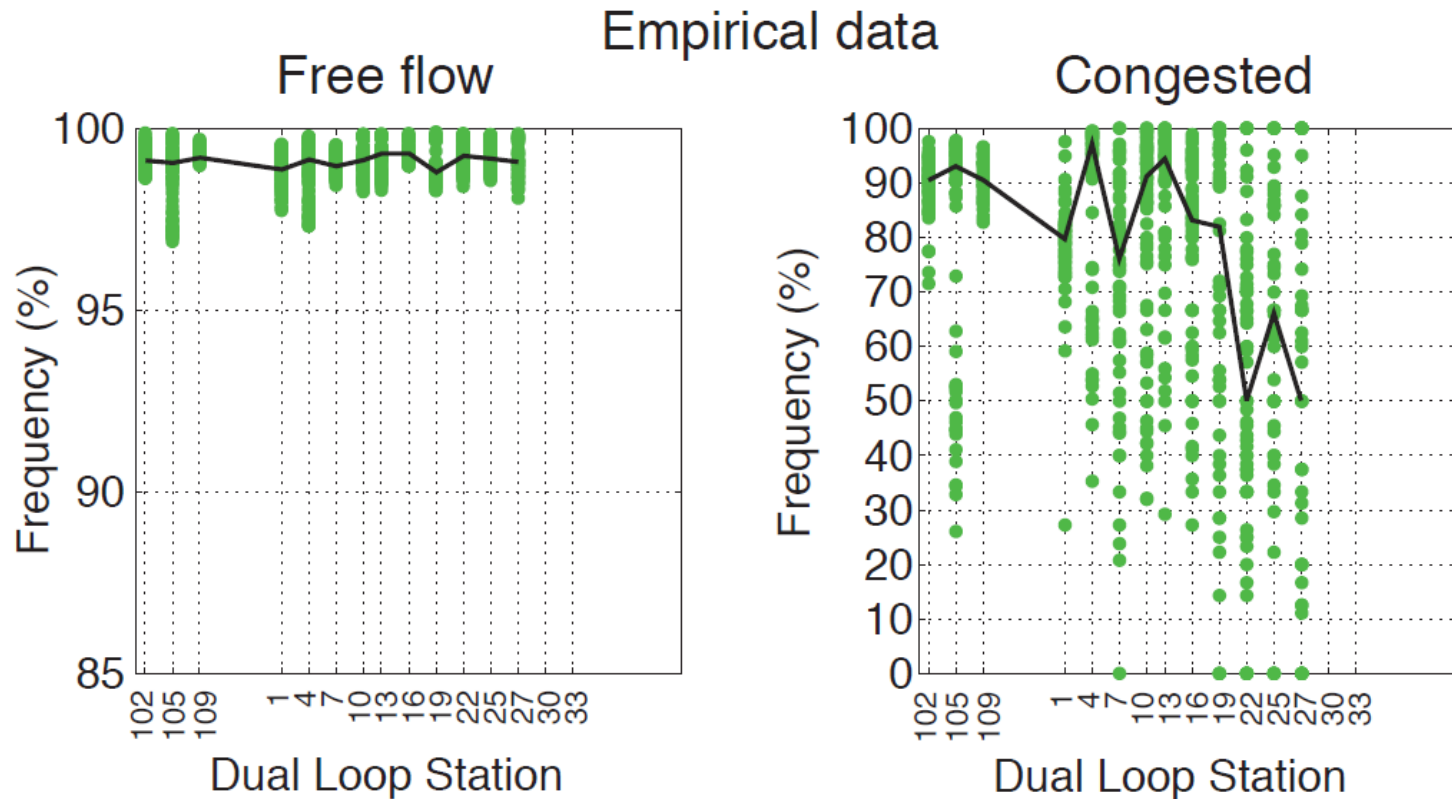
- Length based vehicle classification scheme
-

Class 1 $0 < \text{Effective Vehicle Length} \leq 28\text{ft}$

Class 2 $28\text{ft} < \text{Effective Vehicle Length} \leq 46\text{ft}$

Class 3 $\text{Effective Vehicle Length} > 46\text{ft}$

Evaluation of length based vehicle classification



% of correctly classified vehicles
-All lanes, April 2005

Evaluation of length based vehicle classification



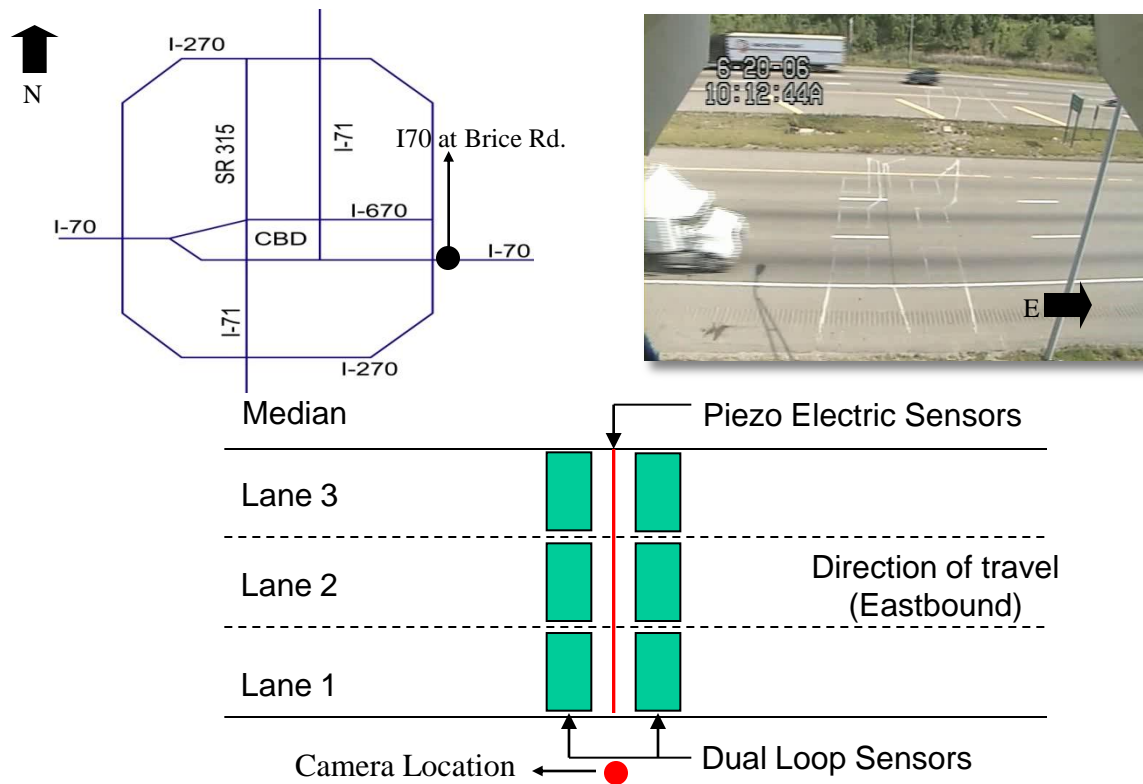
% of correctly classified vehicles
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Evaluation in length based vehicle classification

-Using video data from I-70 & I-71

Evaluation of length based vehicle classification

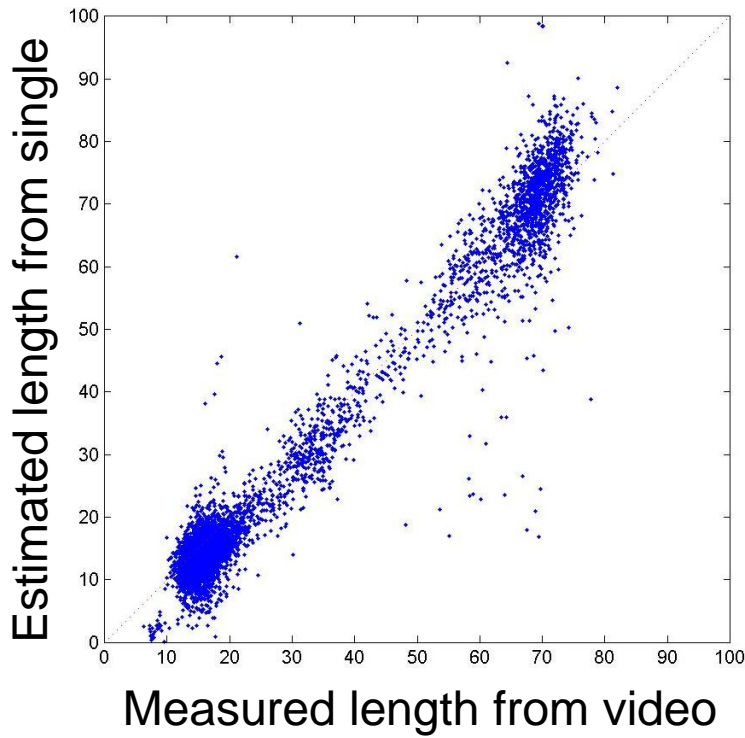
- Data collection from I-70E at Brice Rd.



Per vehicle data and video data from 10:12:44 to 14:00:01 on June 20, 2006 were used in this study

Evaluation of length based vehicle classification

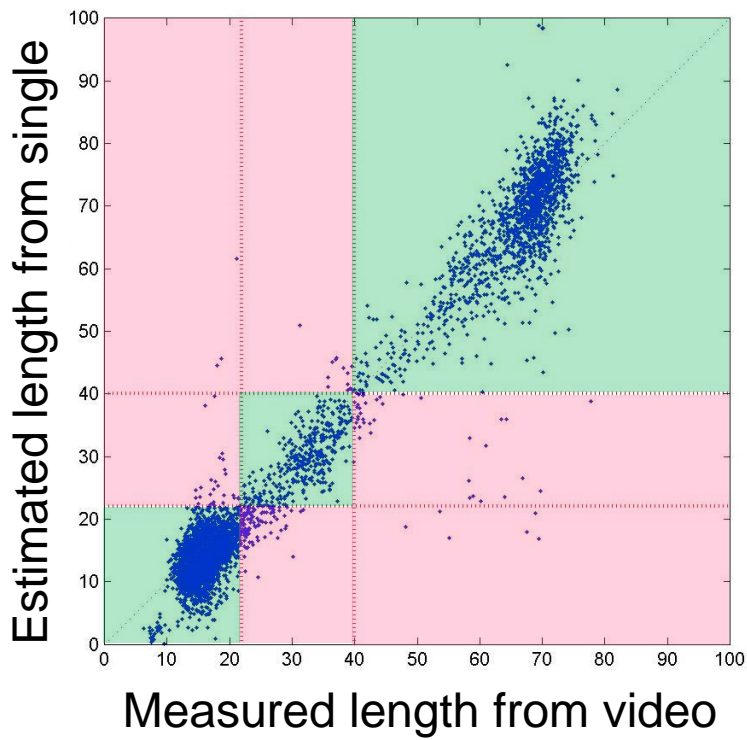
- Results from I-70



Single loop versus video

Evaluation of length based vehicle classification

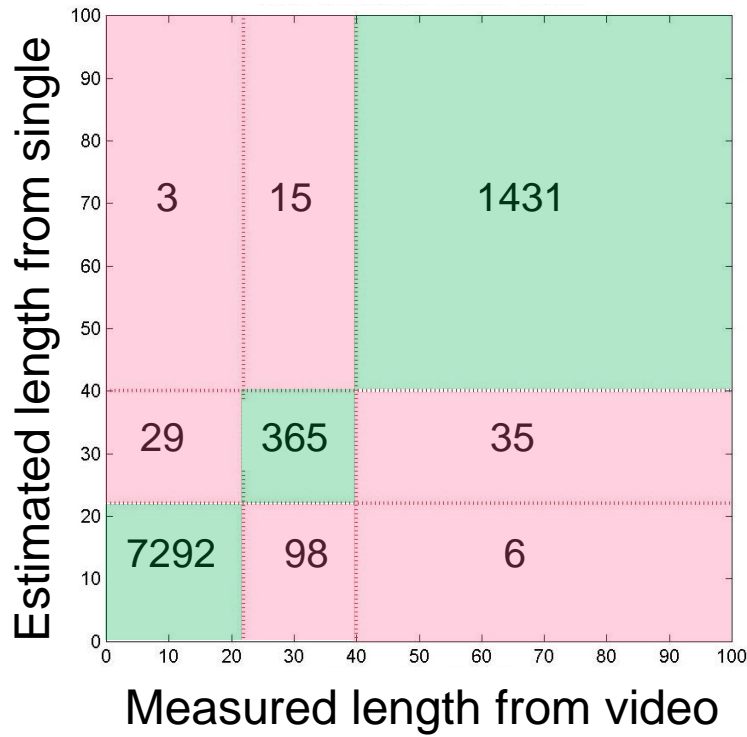
- Results from I-70



Single loop versus video

Evaluation of length based vehicle classification

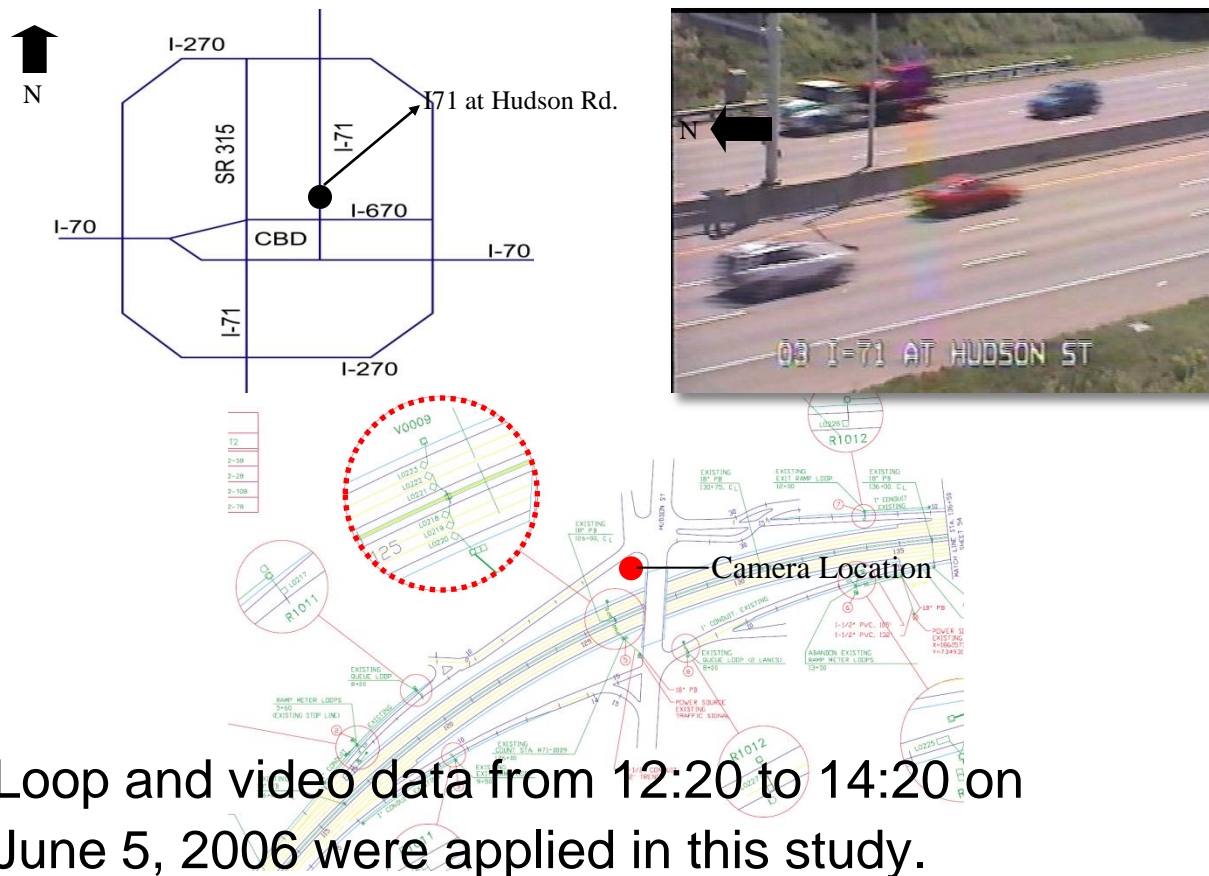
- Results from I-70



Single loop versus video

Evaluation of length based vehicle classification

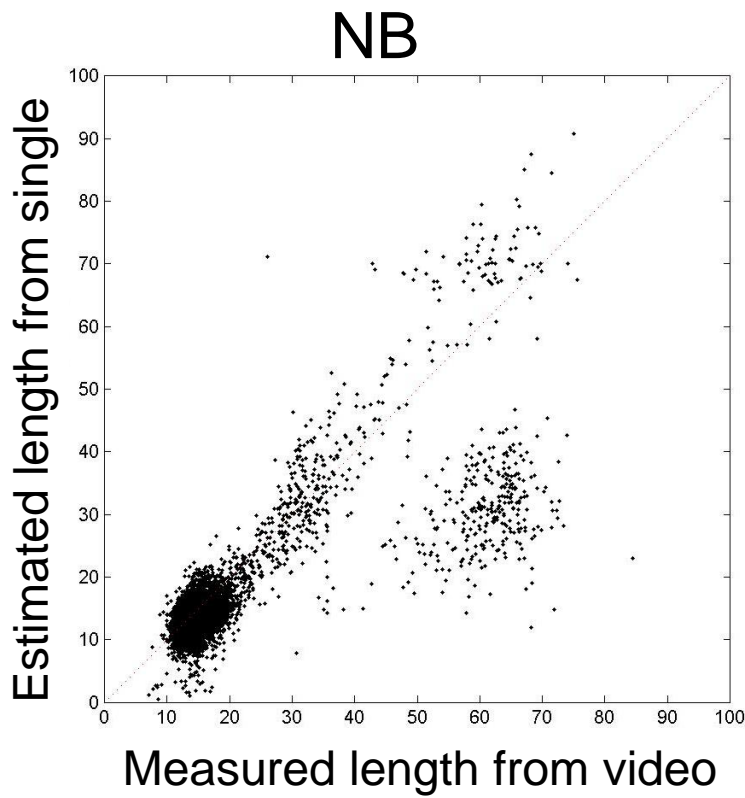
- Data collection from I-71 at Hudson Rd.



Loop and video data from 12:20 to 14:20 on June 5, 2006 were applied in this study.

Evaluation of length based vehicle classification

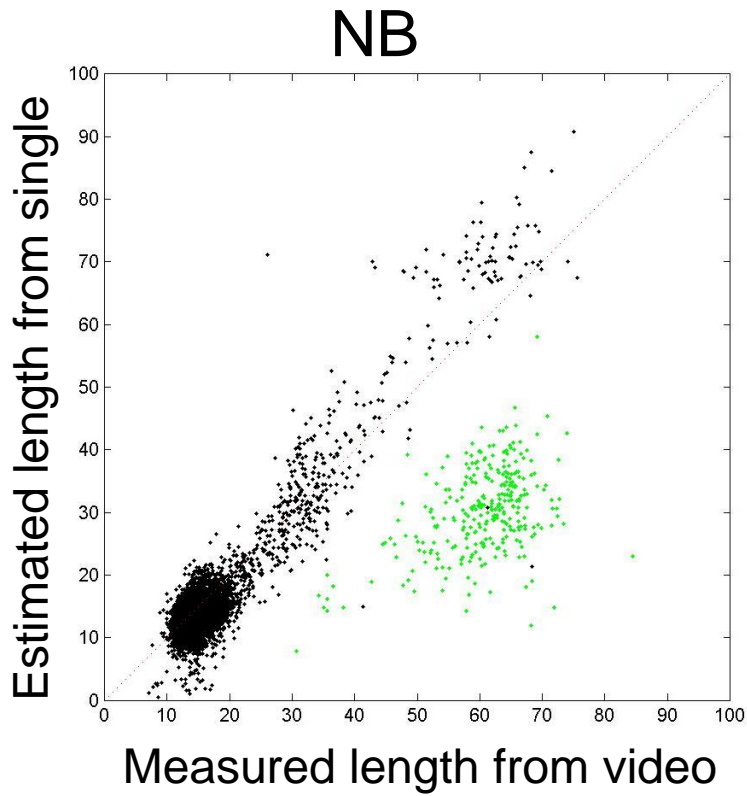
- Results from I-71



Single loop versus video

Evaluation of length based vehicle classification

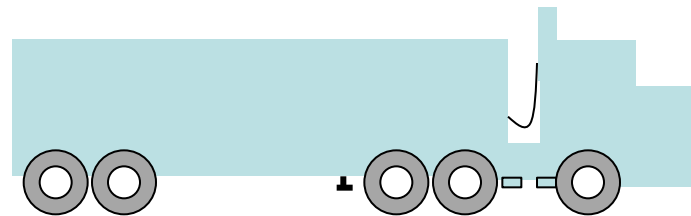
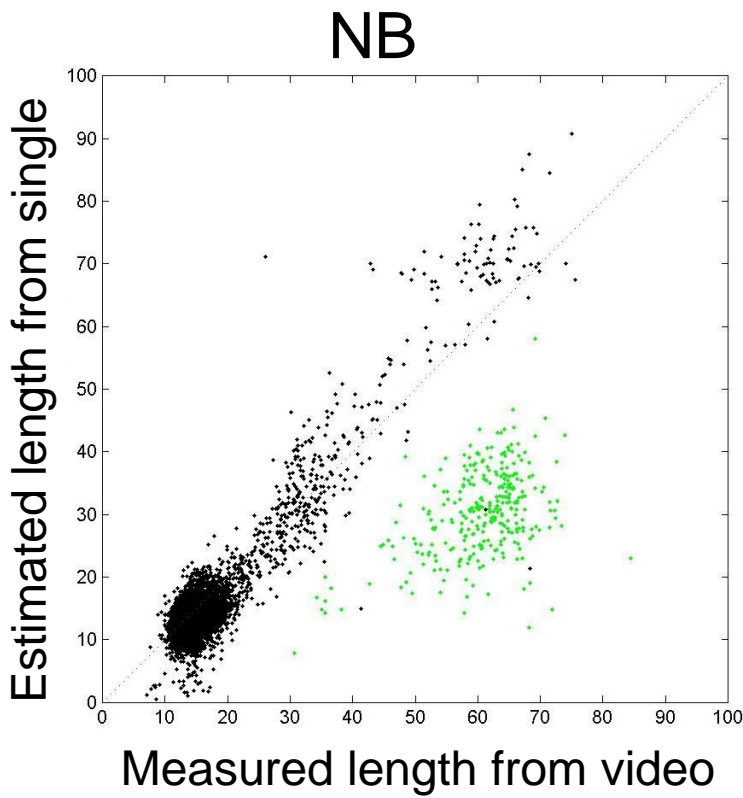
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Single loop versus video

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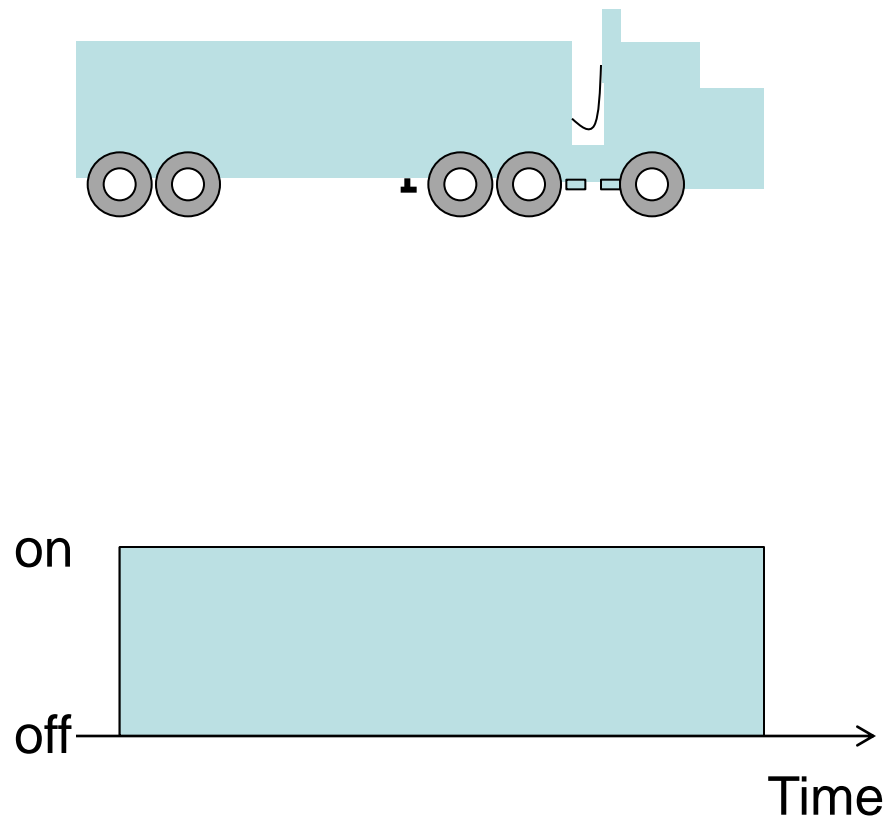
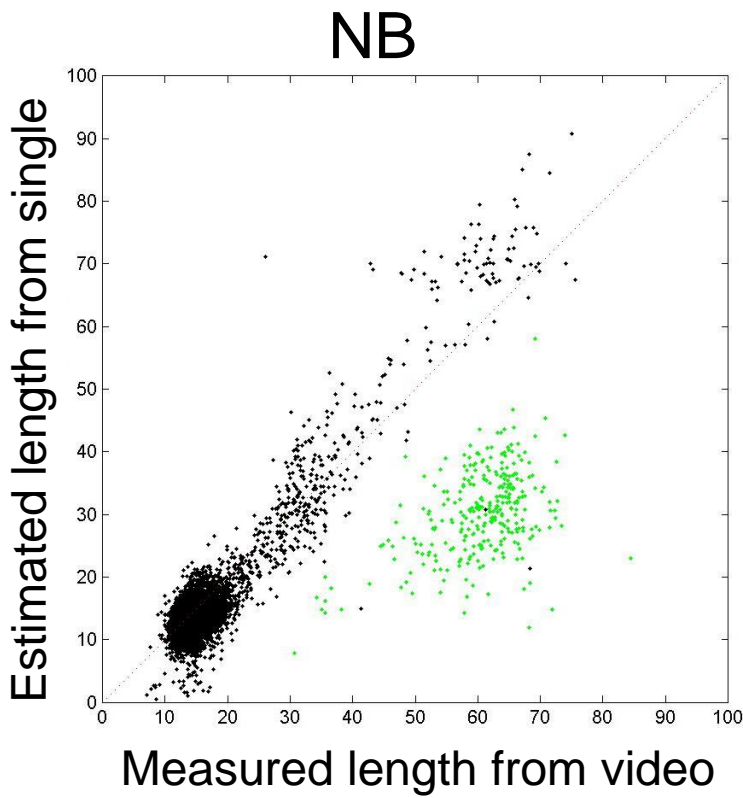
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Single loop versus video

Evaluation of length based vehicle classification

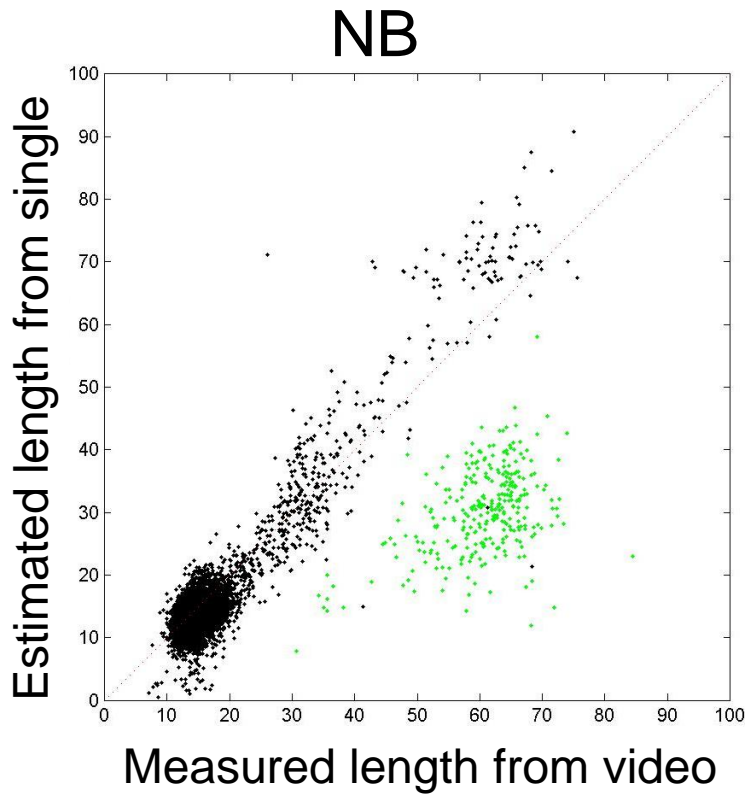
- Results from I-71



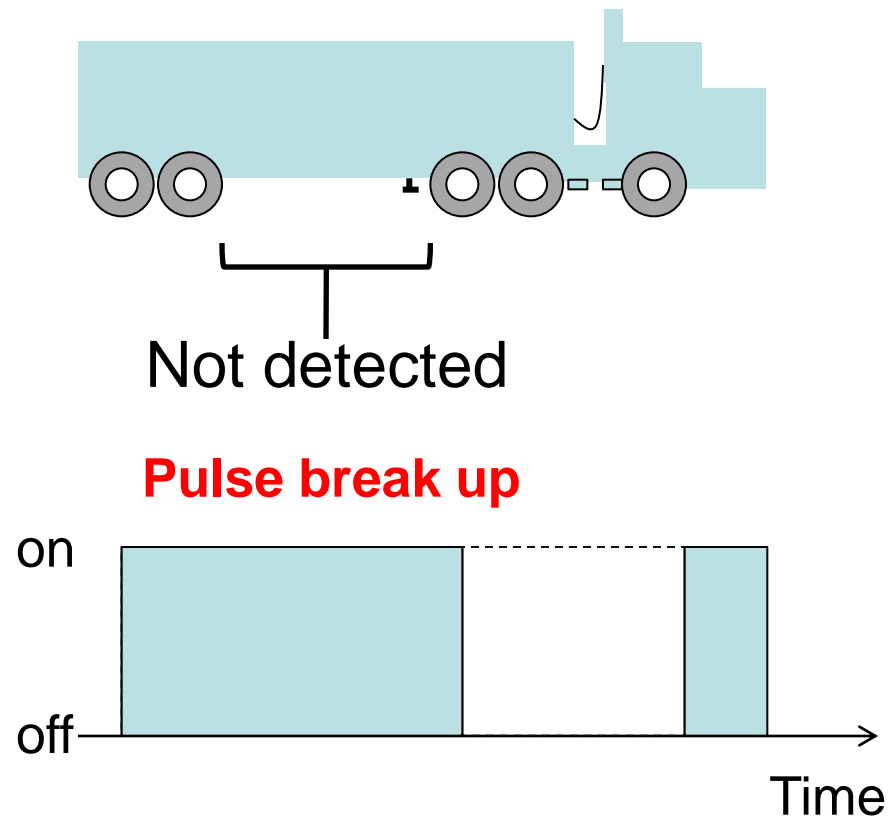
Single loop versus video

Evaluation of length based vehicle classification

- Results from I-71

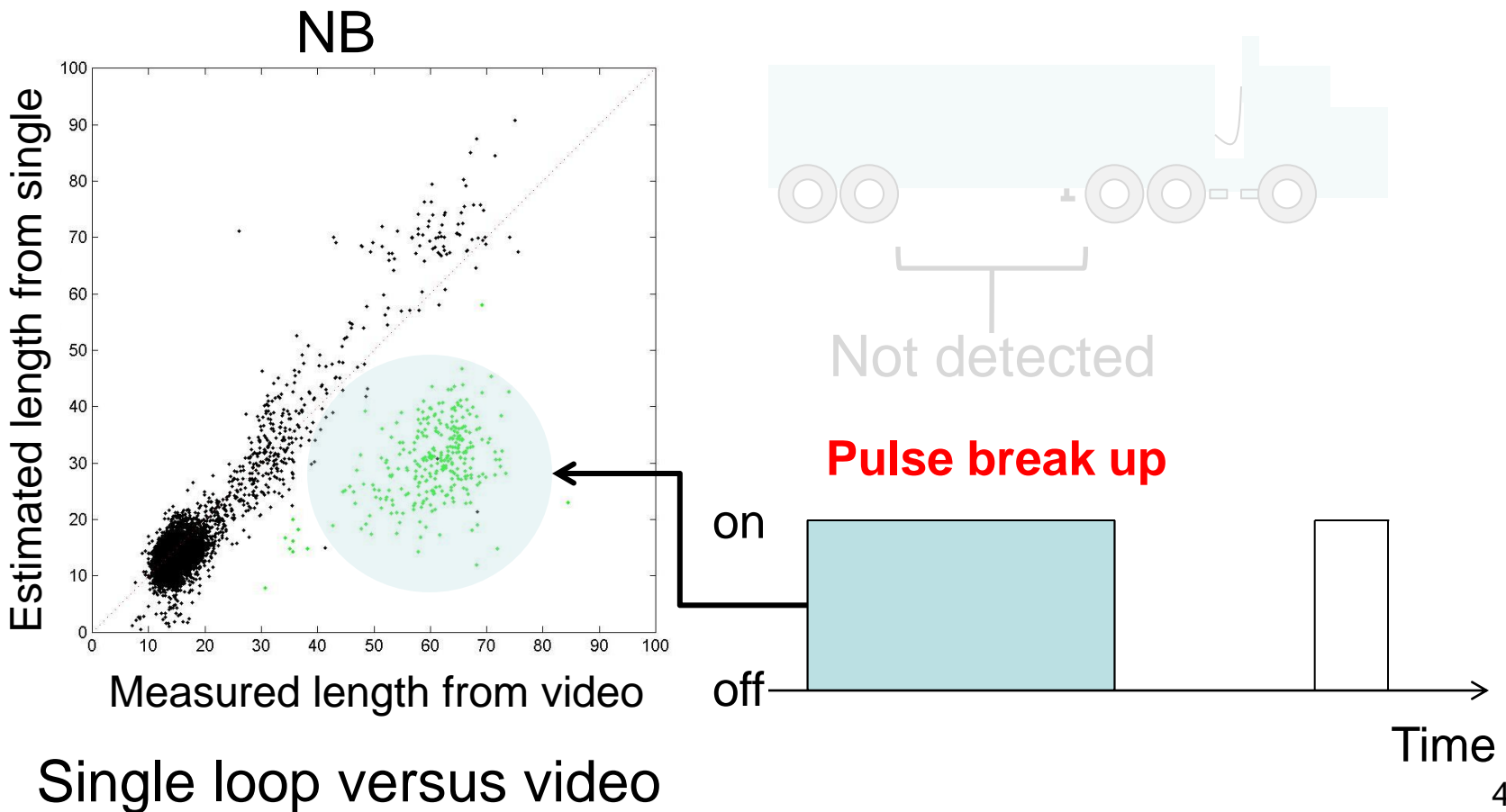


Single loop versus video



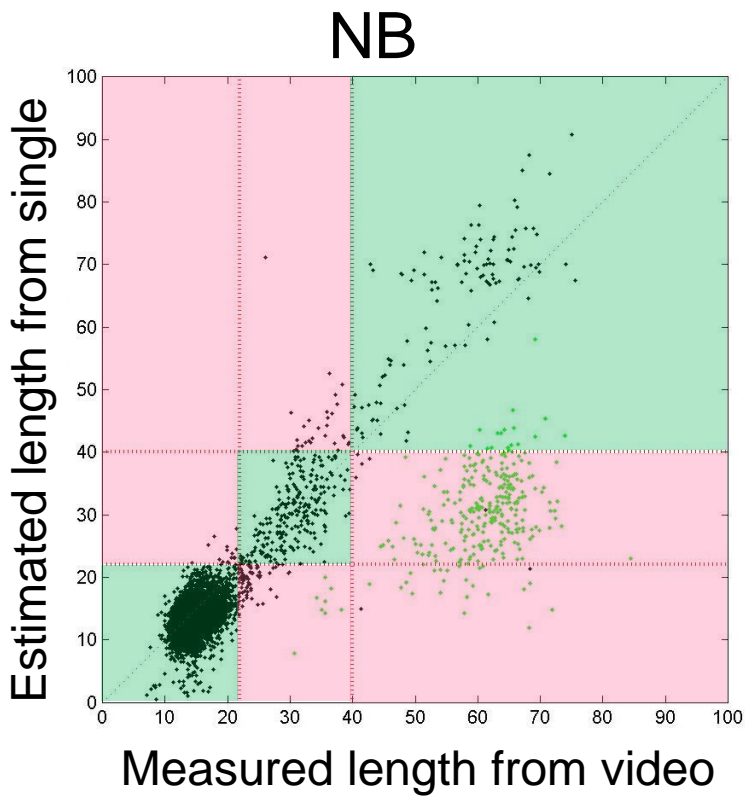
Evaluation of length based vehicle classification

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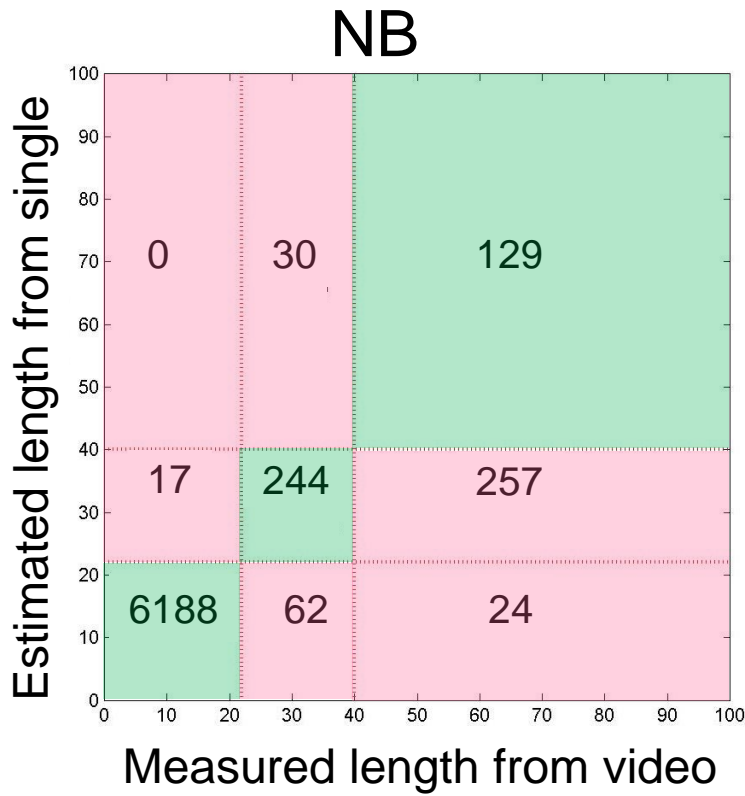
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Single loop versus video

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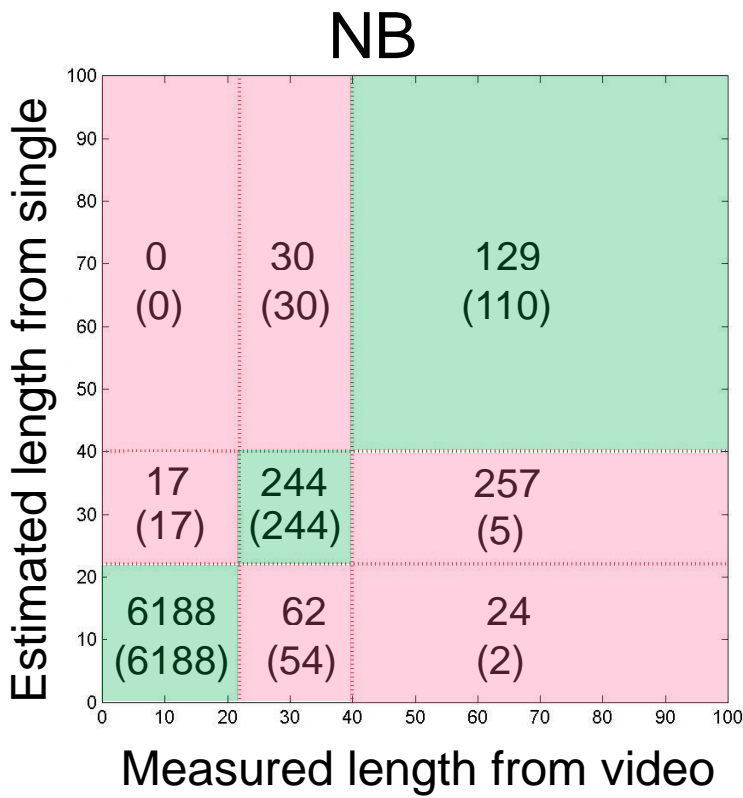
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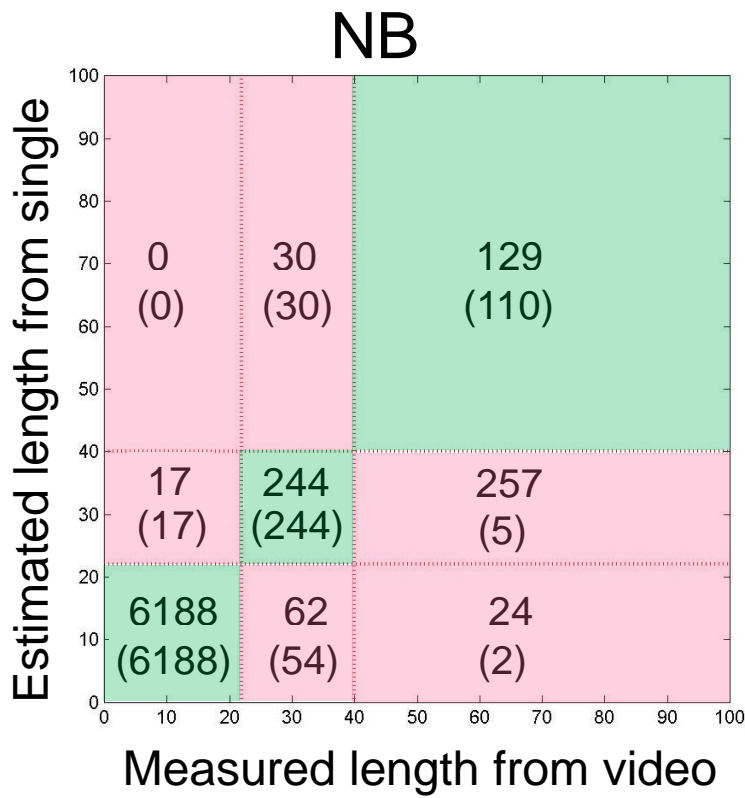


- Before and (after) removing pulse break ups
- We now have tools to automatically detect these errors

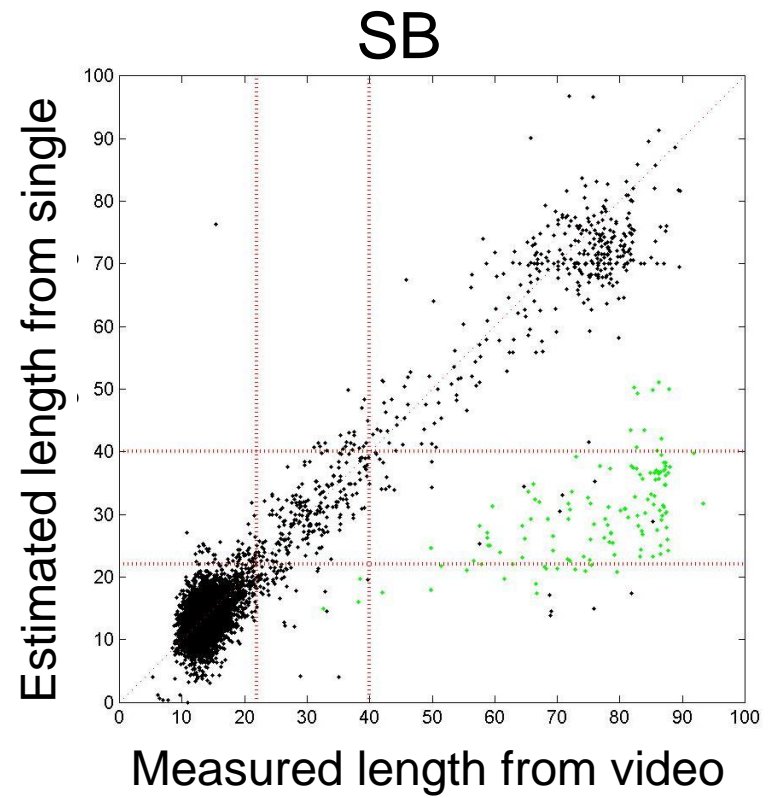
Single loop versus video

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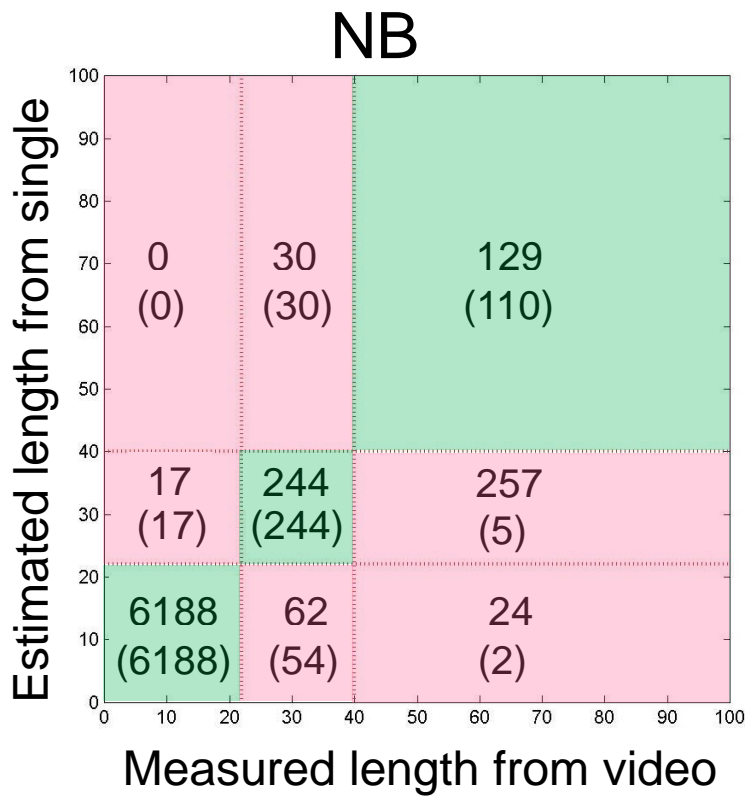
Single loop versus video



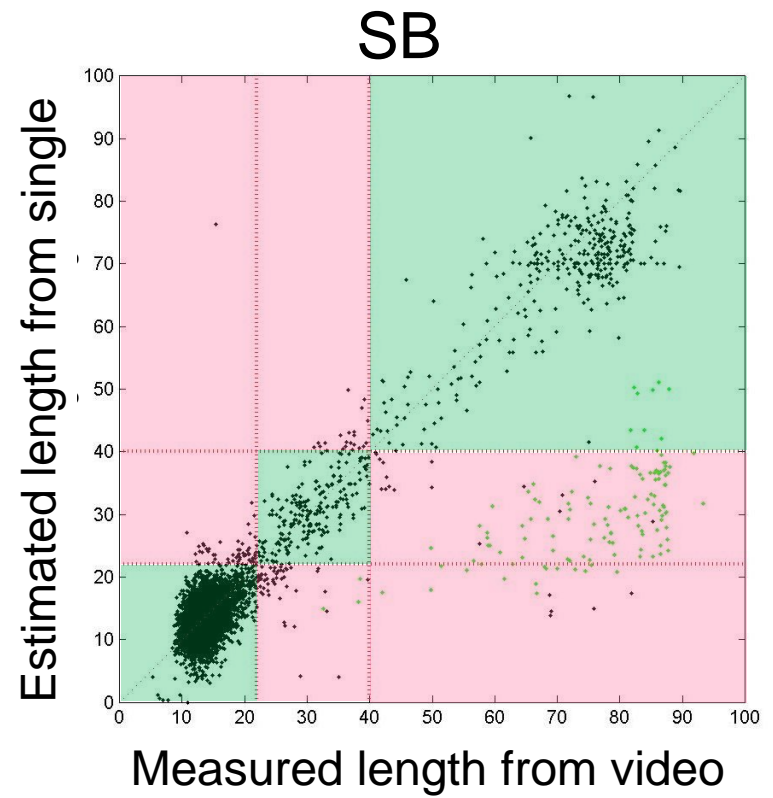
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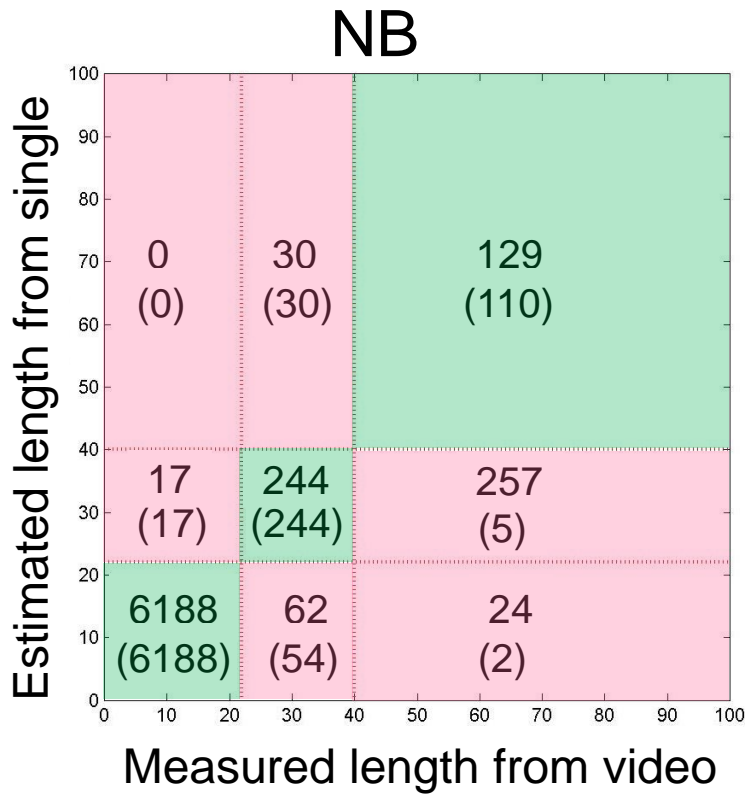
Single loop versus video



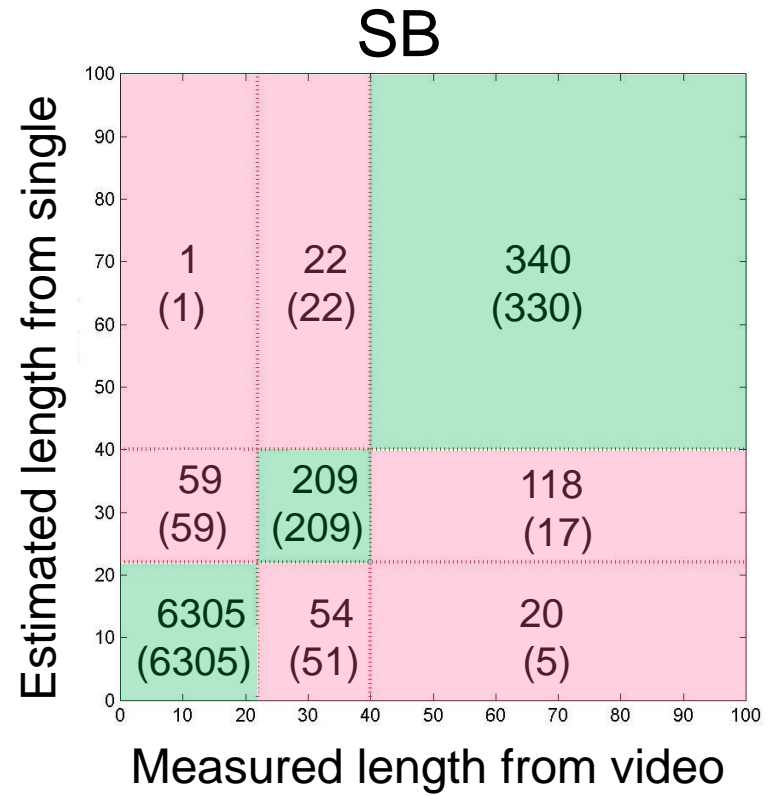
Single loop versus video

Evaluation of length based vehicle classification

- Results from I-71



Single loop versus video



Single loop versus video

Evaluation of length based vehicle classification

- Summary of vehicle classification results

Loop detector classification vs. video

	Single loop detectors		
	I70 at Brice	I71 at Hudson NB	I71 at Hudson SB
Class1	99.6%		
Class 2	76.4 %		
Class 3	97.2 %		

Evaluation of length based vehicle classification

- Summary of vehicle classification results

Loop detector classification vs. video

	Single loop detectors		
	I70 at Brice	I71 at Hudson NB	I71 at Hudson SB
Class1	99.6%	99.7%	99.1%
Class 2	76.4 %	74.4%	74.1%
Class 3	97.2 %	94.0%	93.8%

Excluding I-71 pulse break ups

Evaluation of length based vehicle classification

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Loop detector classification vs. video

	Single loop detectors			Dual loop det.
	I70 at Brice	I71 at Hudson NB	I71 at Hudson SB	I70 at Brice
Class1	99.6%	99.7%	99.1%	97.9%
Class 2	76.4 %	74.4%	74.1%	79.9%
Class 3	97.2 %	94.0%	93.8%	97.6%

Excluding I-71 pulse break ups

Conclusions

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- The developed method produces single loop classification performance comparable to dual loop based classification
- Problems arise from pulse breakup
Identifying pulse break-up can improve vehicle classification accuracy

Questions ?