VTTI
Driving Transportation with Technology

Driving Measures to Identify Driving Impairment

August 28, 2012

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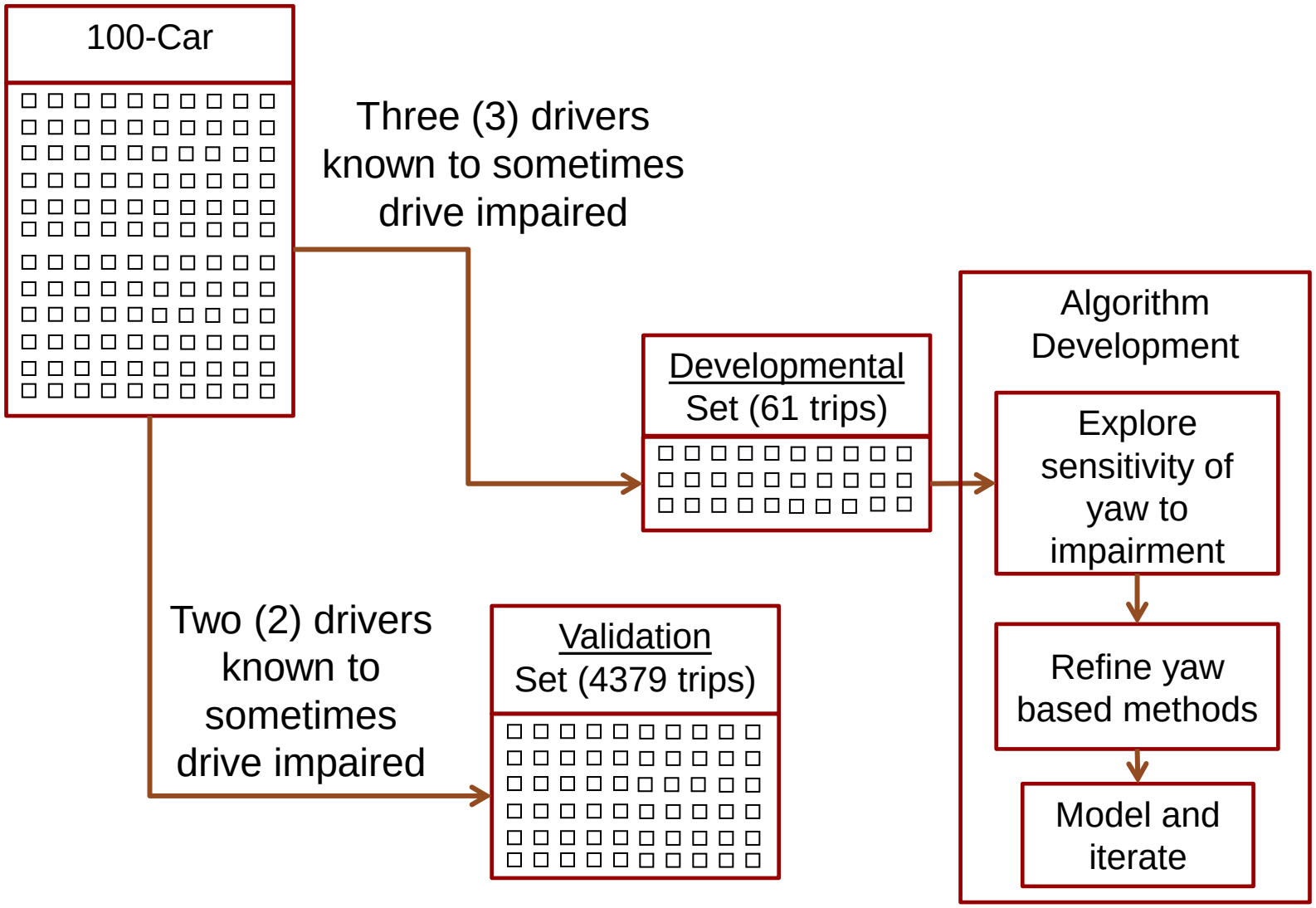
Objective

To develop an algorithm, of use in data mining and in real-time, to detect impaired driving.

Team and Status

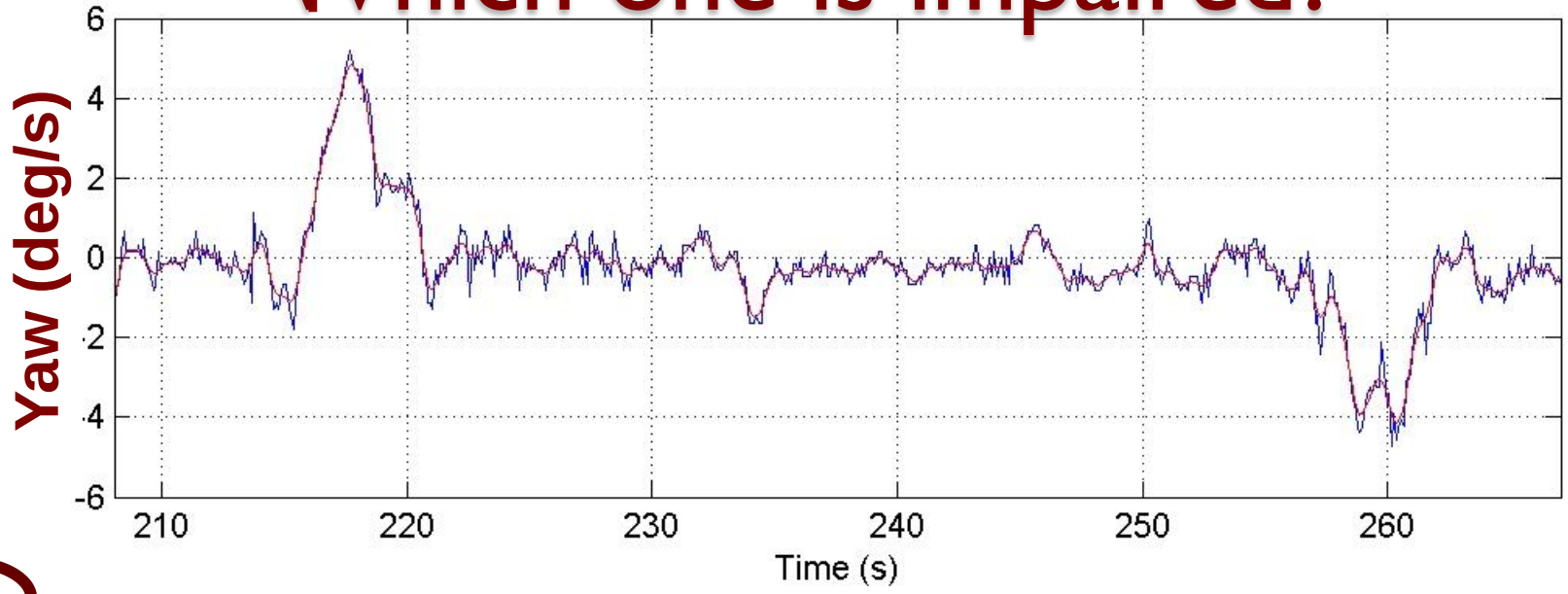
- This work was started under a gift from Nissan and continued under guided funding.
- Collaborative work with Hiroshi Tsuda, Jon Hankey, Tomohiro Yamamura, and Nobuyuki Kuge.
- Currently being reviewed for a possible patent (#12/767,385)

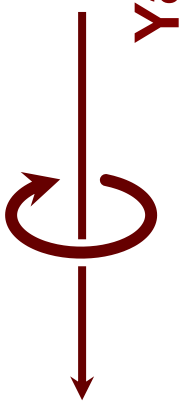


100-Car Naturalistic Data (Dingus et al., 2006)

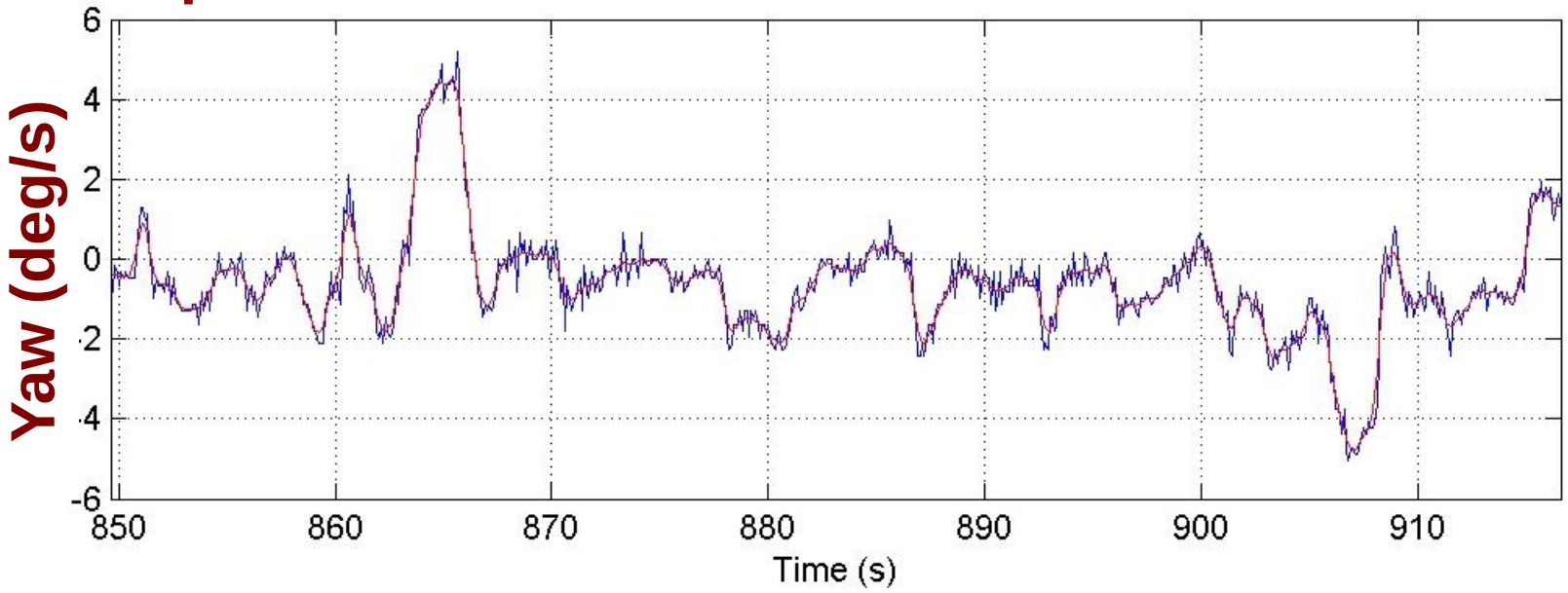
Which one is impaired?

Not Impaired

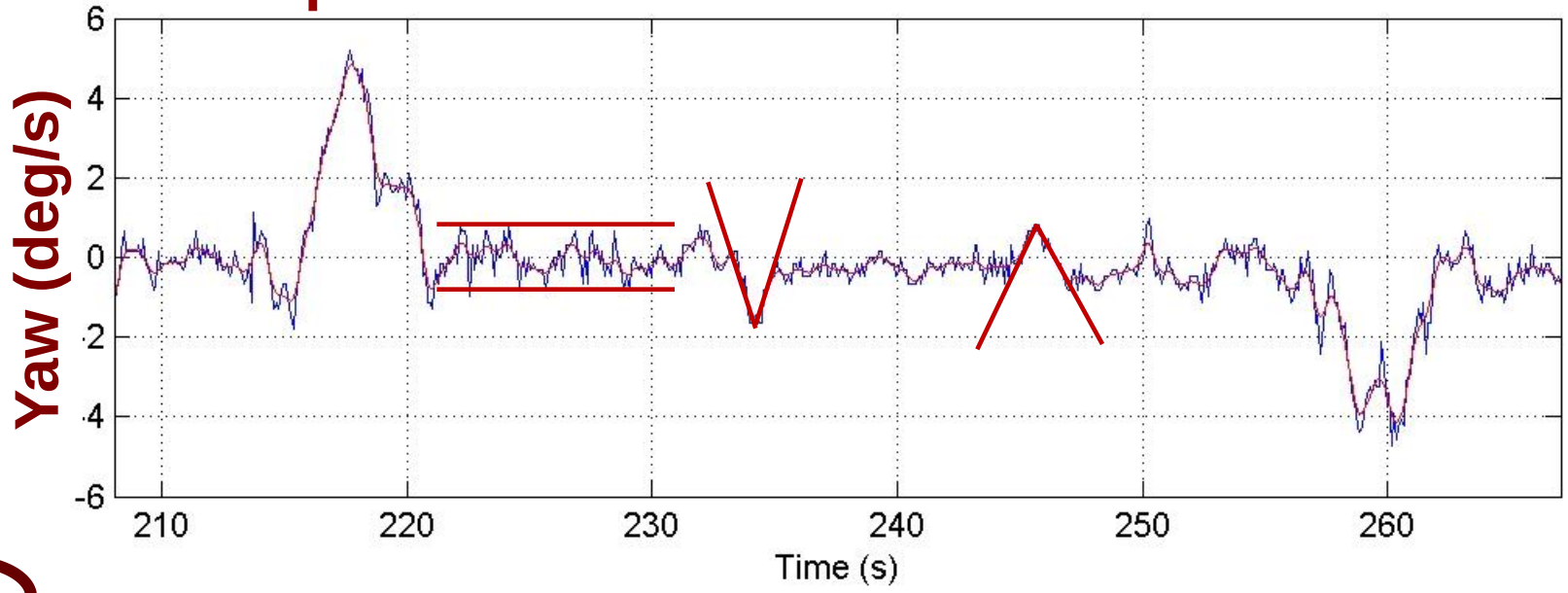


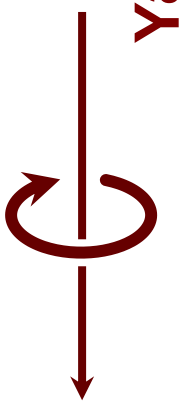


Impaired



Not Impaired





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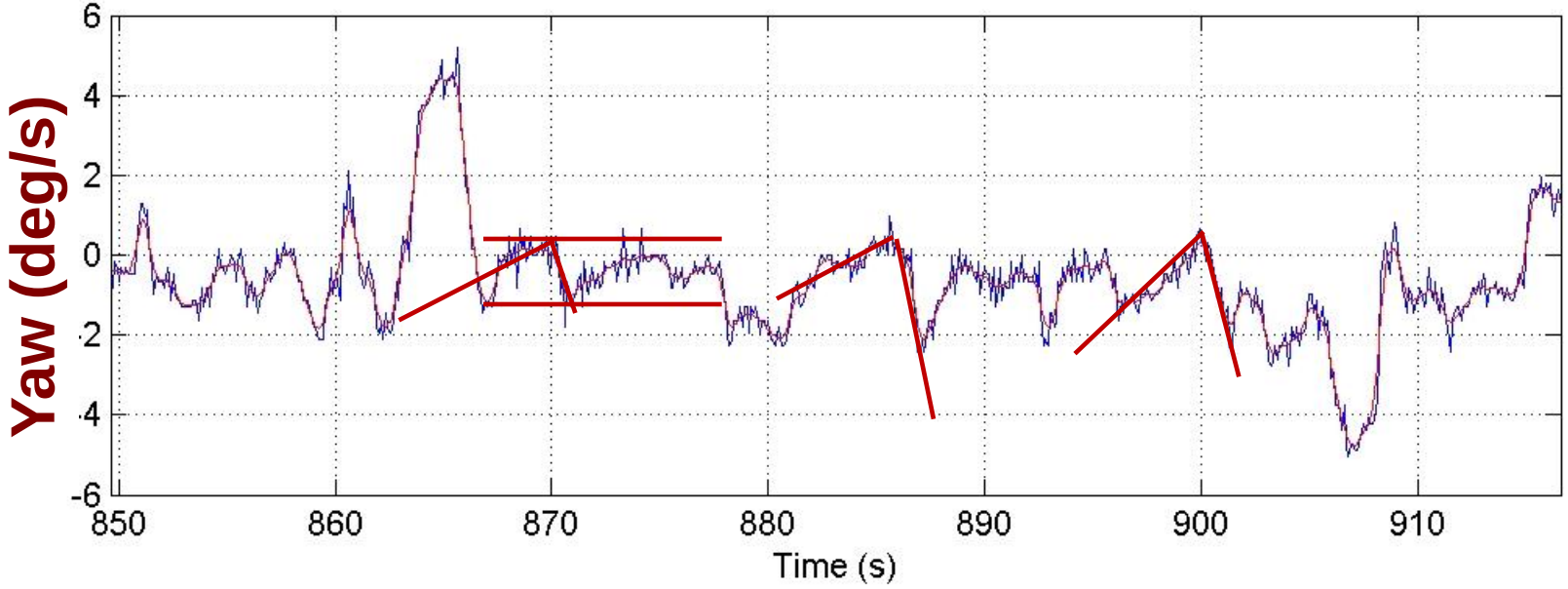
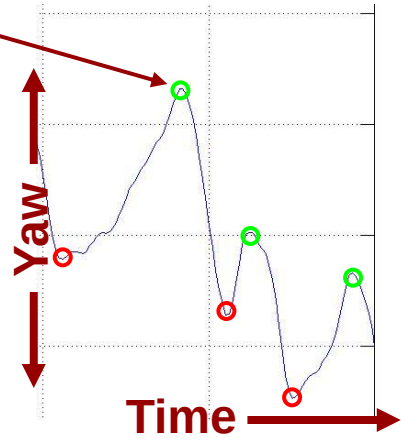
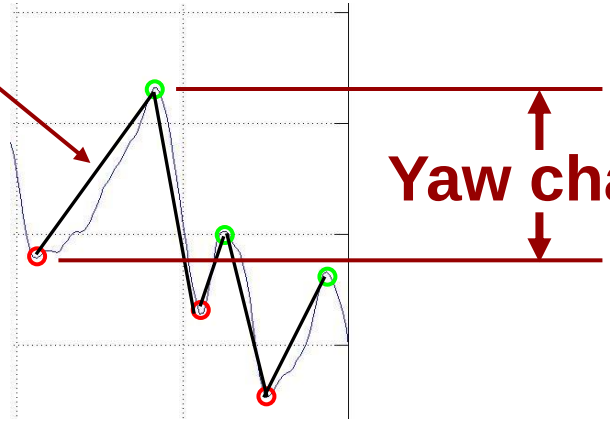


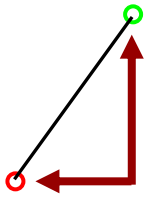
Impairment Model

1. Find local minimums and maximums



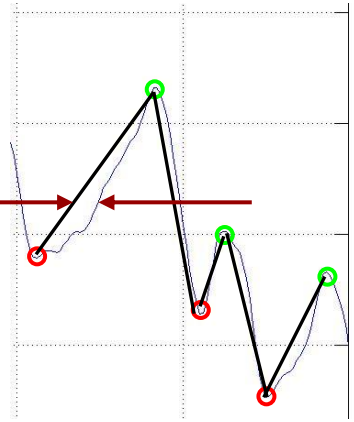
2. Connect with straight line





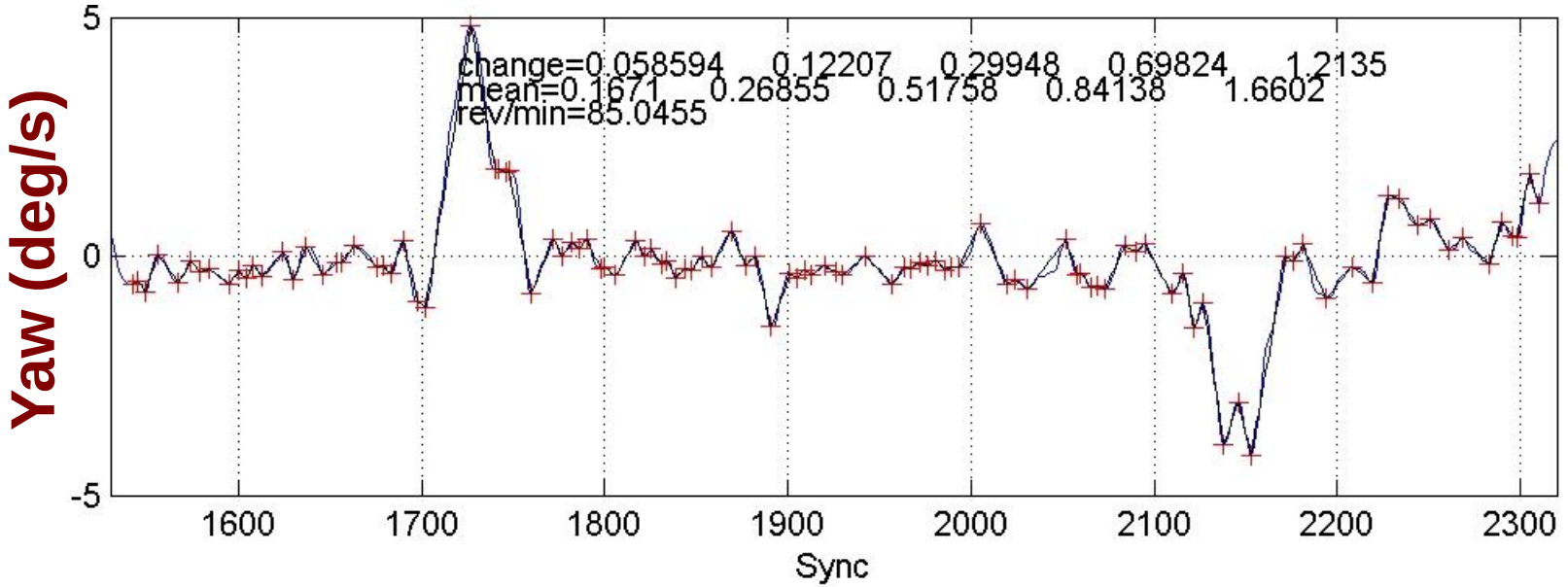
Rate of change

3. **Yaw deviation measured in time**

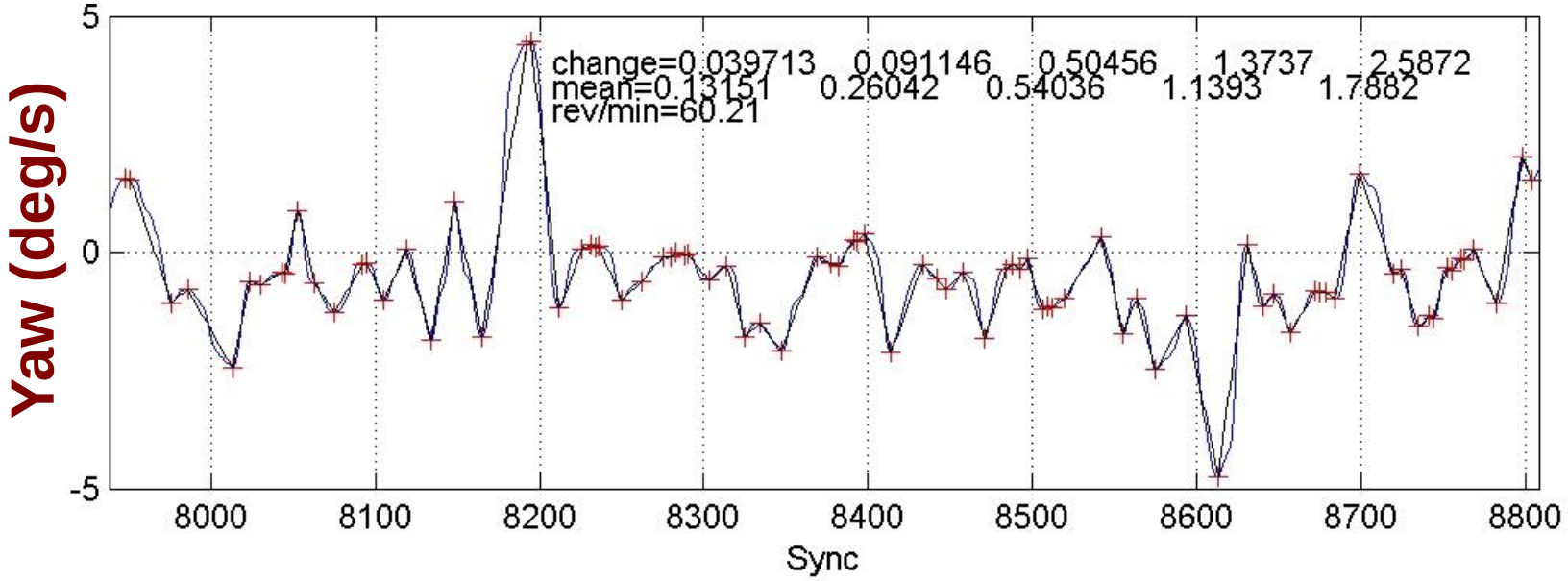


Creates a measure of the difference between actual and straight line yaw that is roughly a lag and lead

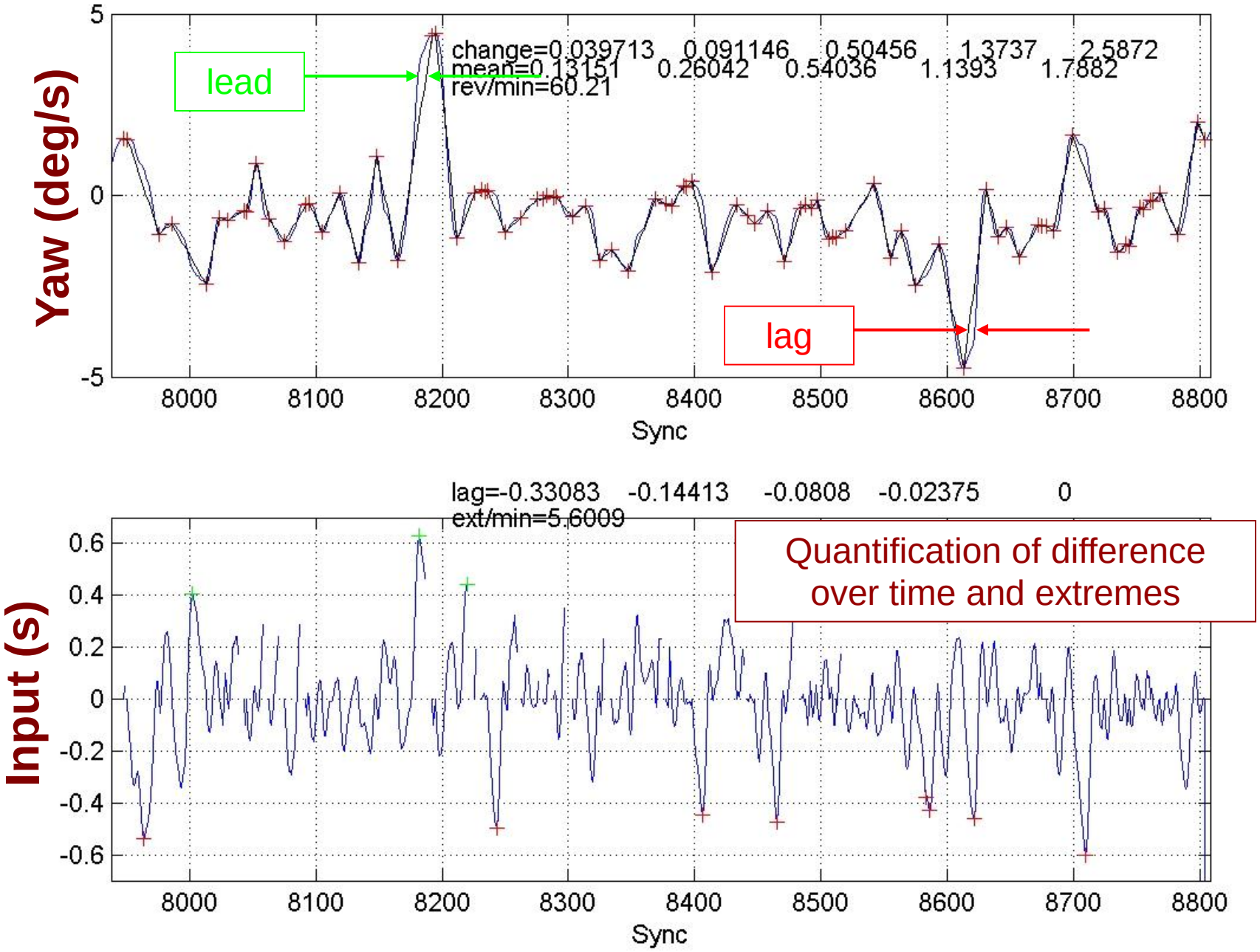
Not Impaired



Impaired

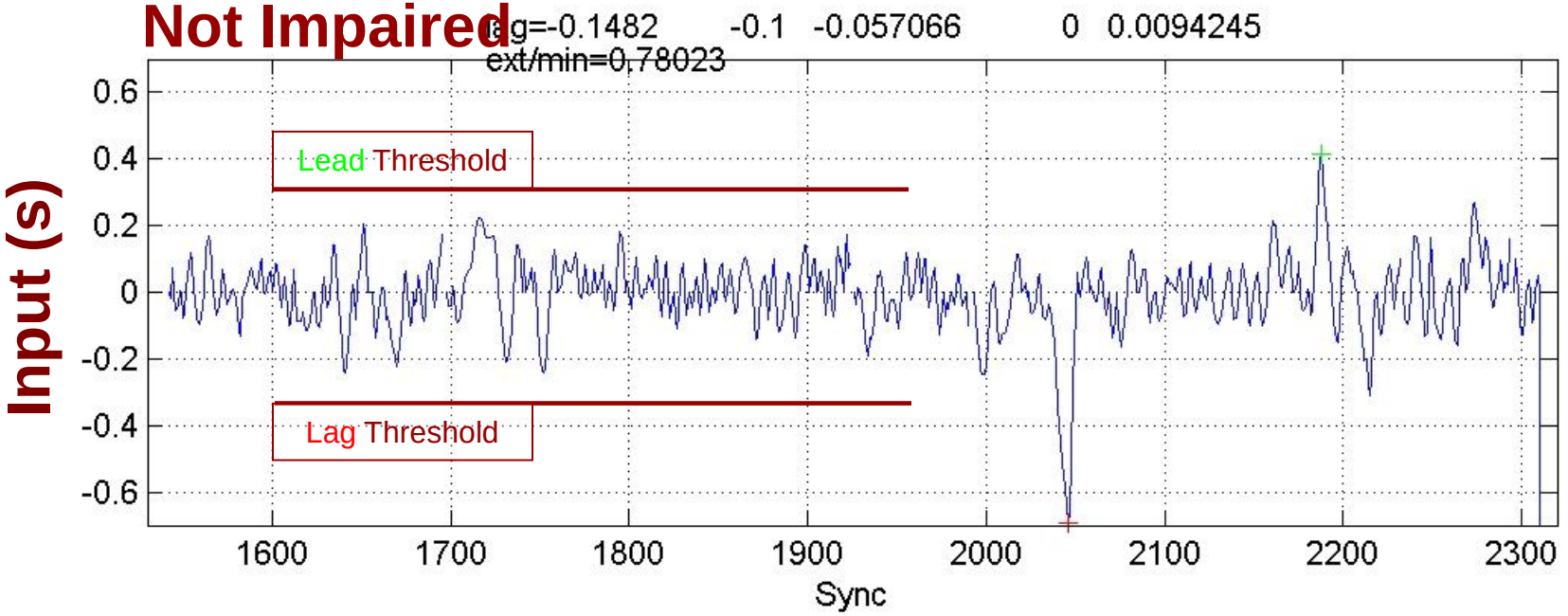


Impaired



Quantification of difference over time and extremes

Not Impaired



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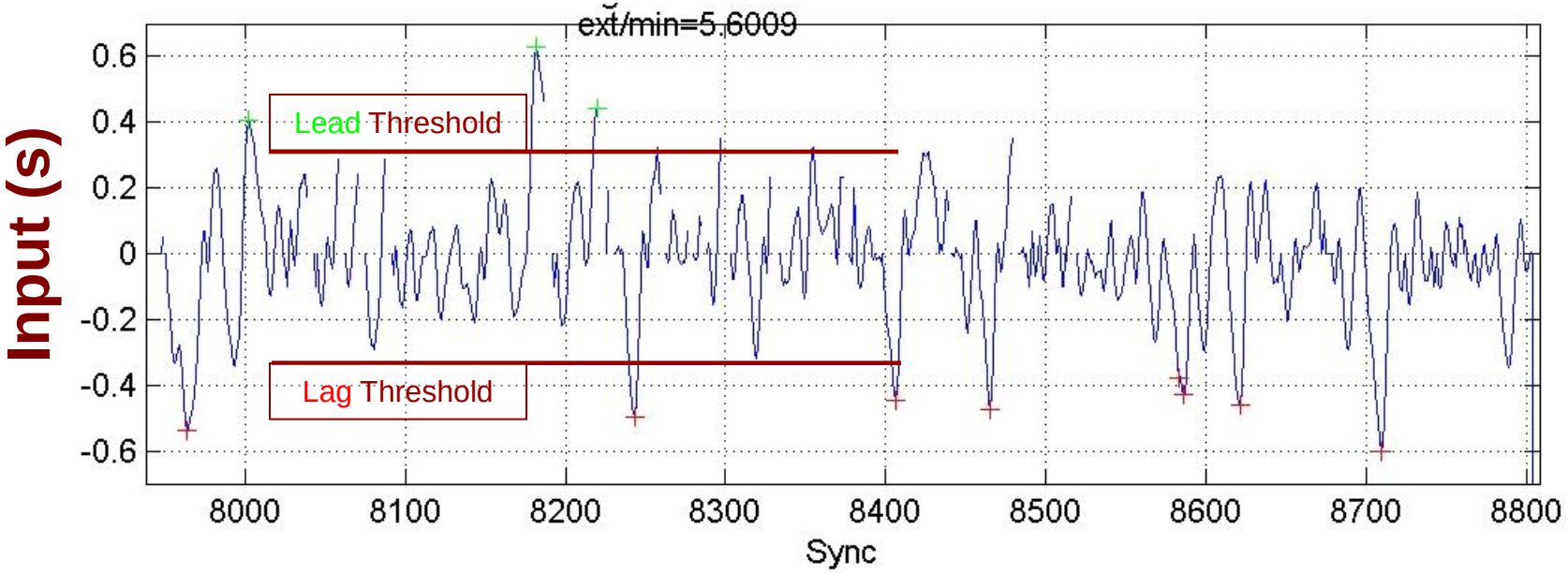
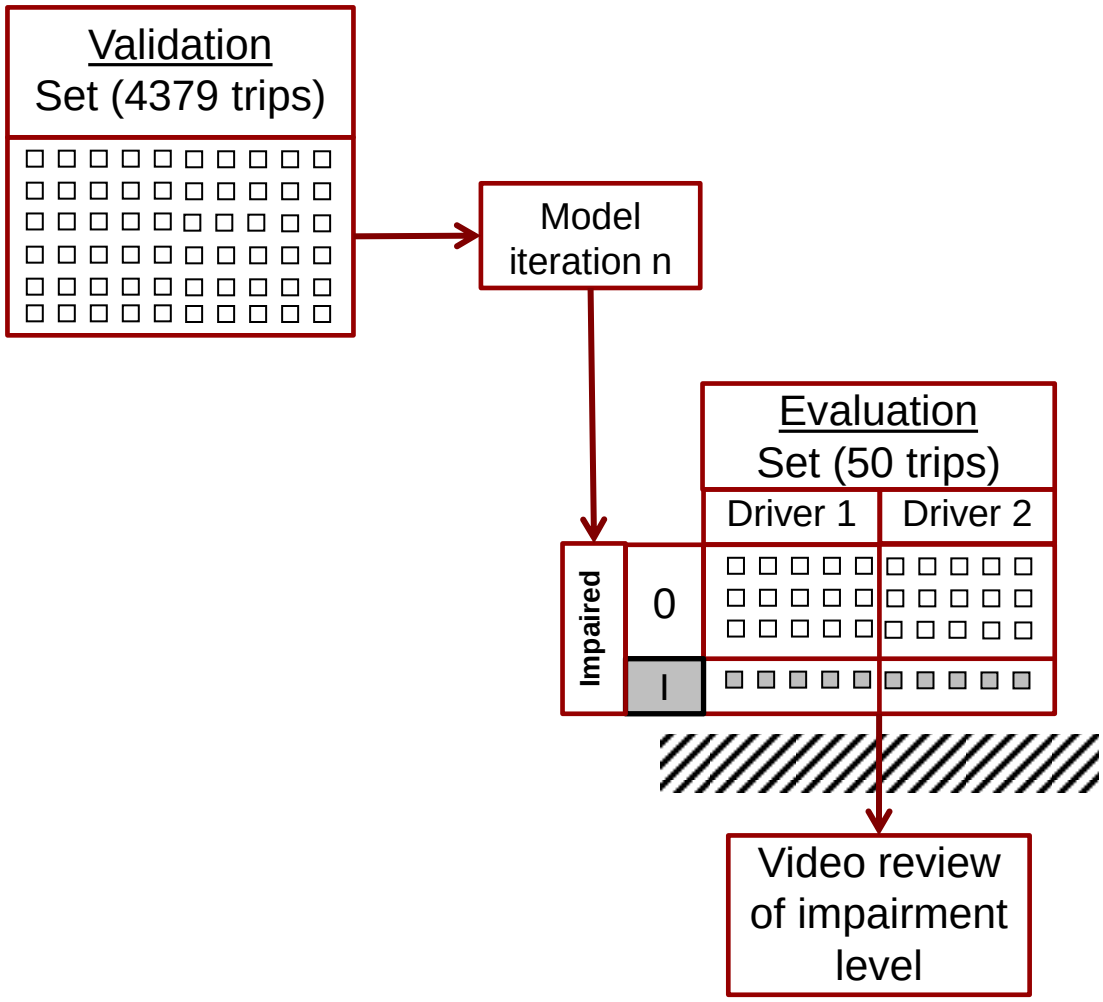
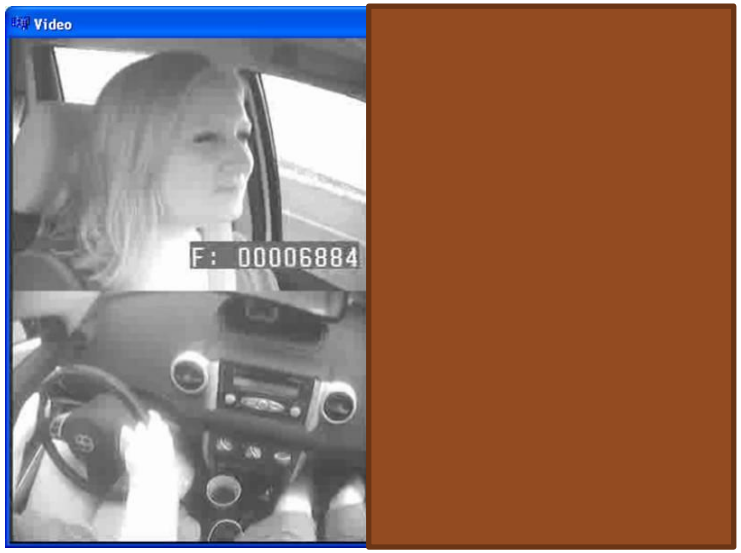



Validation
Set (4379 trips)
Model
iteration n
Evaluation
Set (50 trips)
Driver 1
Driver 2
Impaired
0
I
Video review
of impairment
level

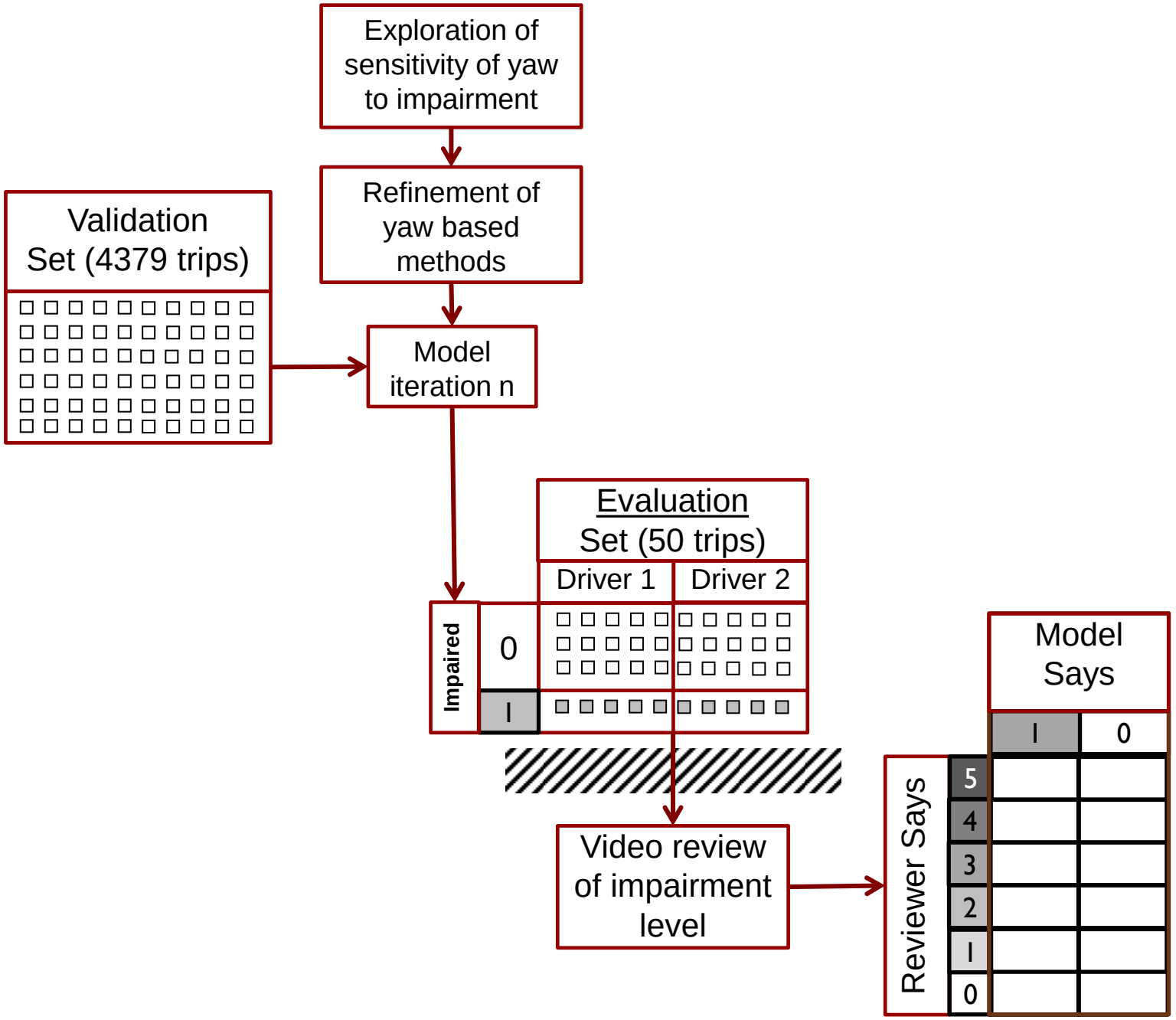
Video Review

- Expert reviewer
- Evaluation set – 50 trips selected by the algorithm. 19 unimpaired and 6 impaired.
- Randomized
- Only interior views were used to evaluate impairment
- Symptoms reviewed (43) related to:
  - Eyes
  - Mouth
  - Face
  - Hands
  - Body
  - Head
  - Demeanor
  - Miscellaneous



Video Review Ratings

- Confidence rating
  1. I don't believe the driver is impaired
  2. May or may not be impaired
  3. I believe the driver is impaired
- Level of impairment
  0. Not Impaired
  1. Somewhat impaired
  2. -
  3. Moderately impaired
  4. -
  5. Severely impaired


Exploration of sensitivity of yaw to impairment
Refinement of yaw based methods
Validation Set (4379 trips)
Model iteration n
Evaluation Set (50 trips)
Driver 1
Driver 2
Impaired
0
I
Video review of impairment level
Reviewer Says
Model Says
I
0
5
4
3
2
I
0

Model 1 Evaluation

Reviewer Says \ Model Says	Impaired	Not Impaired
Impaired	Hit	Miss
Not Impaired	False Alert	Correct Rejection

		Impairment Rating	Model Says: Impaired, Driver 1	Model Says: Impaired, Driver 2	Model Says: Not impaired, Driver 1	Model Says: Not impaired, Driver 2
Reviewer Says	5	Severely Impaired	2	1	2	0
	4		0	2	4	5
	3	Moderately Impaired	0	1	1	4
	2		0	0	1	7
	1	Somewhat Impaired	3	0	1	1
	0	Not Impaired	1	2	10	2

0.26	Sensitivity	Method finds x% of true events
0.80	Specificity	x% correct saying something is not of interest

0.75	0.32
Positive Predictive	Negative Predictive
Strength of confirming a true indication	Strength of confirming a false indication

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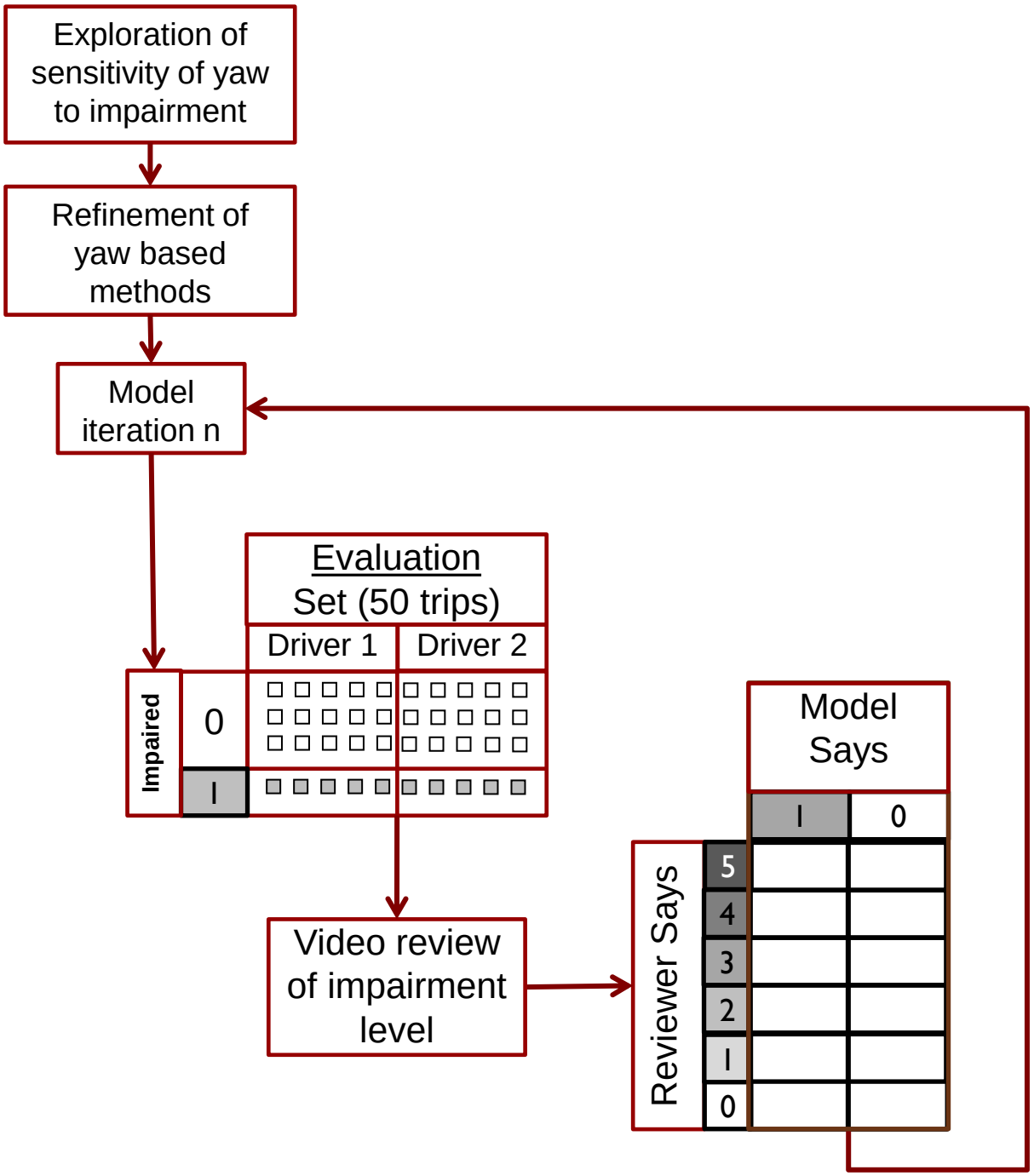
Exploration of sensitivity of yaw to impairment
Refinement of yaw based methods
Model iteration n
Evaluation Set (50 trips)
Driver 1
Driver 2
Impaired
0
I
Video review of impairment level
Reviewer Says
Model Says
I
0
5
4
3
2
I
0

Model 2 Evaluation

Reviewer Says	Model Says: Impaired	Model Says: Not Impaired
Impaired	Hit	Miss
Not Impaired	False Alert	Correct Rejection

		Model Says: Impaired		Model Says: Not impaired				
Reviewer Says	Impairment Rating	Driver 1	Driver 2	Driver 1	Driver 2			
5	Severely Impaired	3	1	1	0	0.31	Sensitivity	Method finds x% of true events
4		1	1	3	6			
3	Moderately Impaired	0	1	1	4			
2		0	0	1	7			
1	Somewhat Impaired	4	0	0	1			
0	Not Impaired	1	0	10	4	0.93	Specificity	x% correct saying something is not of interest
		0.92		0.37				
		Positive Predictive		Negative Predictive				
		Strength of confirming a true indication		Strength of confirming a false indication				

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Observations

- Vehicle measures are a convenient and valuable source of data for identifying impairment.
- Naturalistic data are messy, but real. This keeps algorithm development and testing honest.

Not Impaired