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FINDING A BETTER WAY

Processing of Eye Tracking Data from Naturalistic Driving Data

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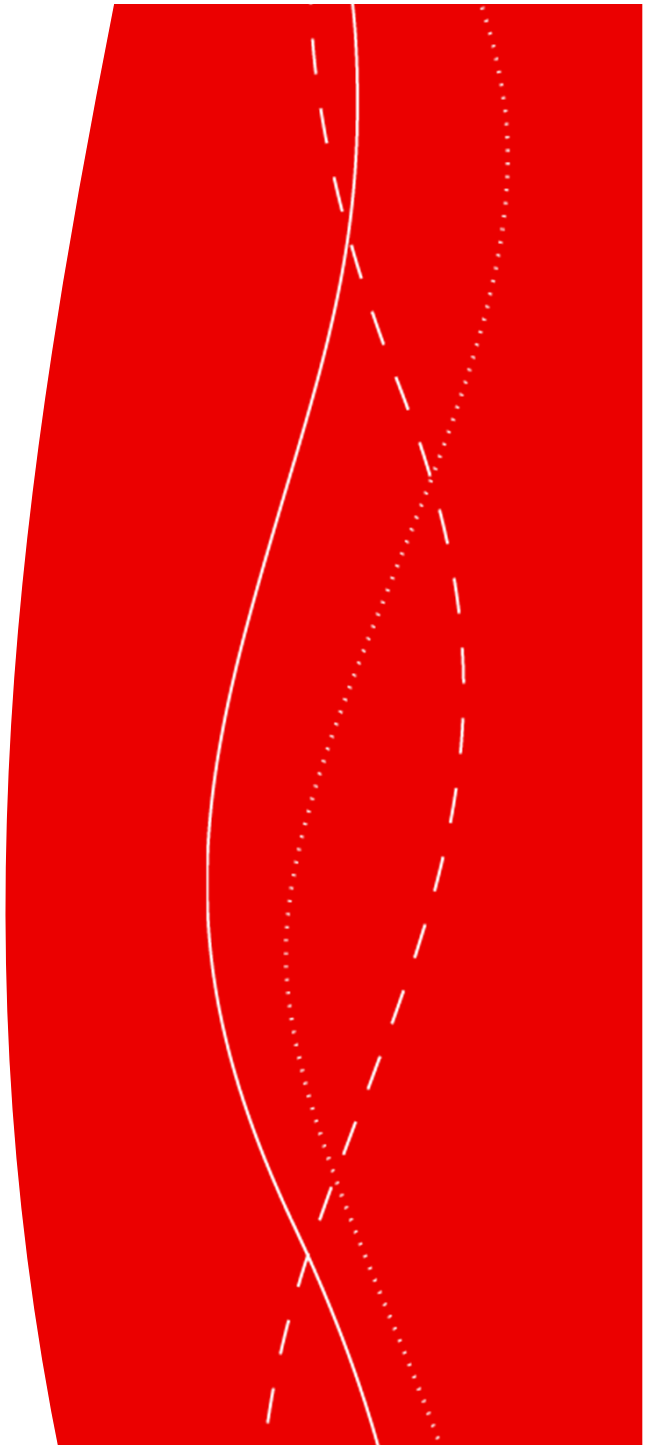
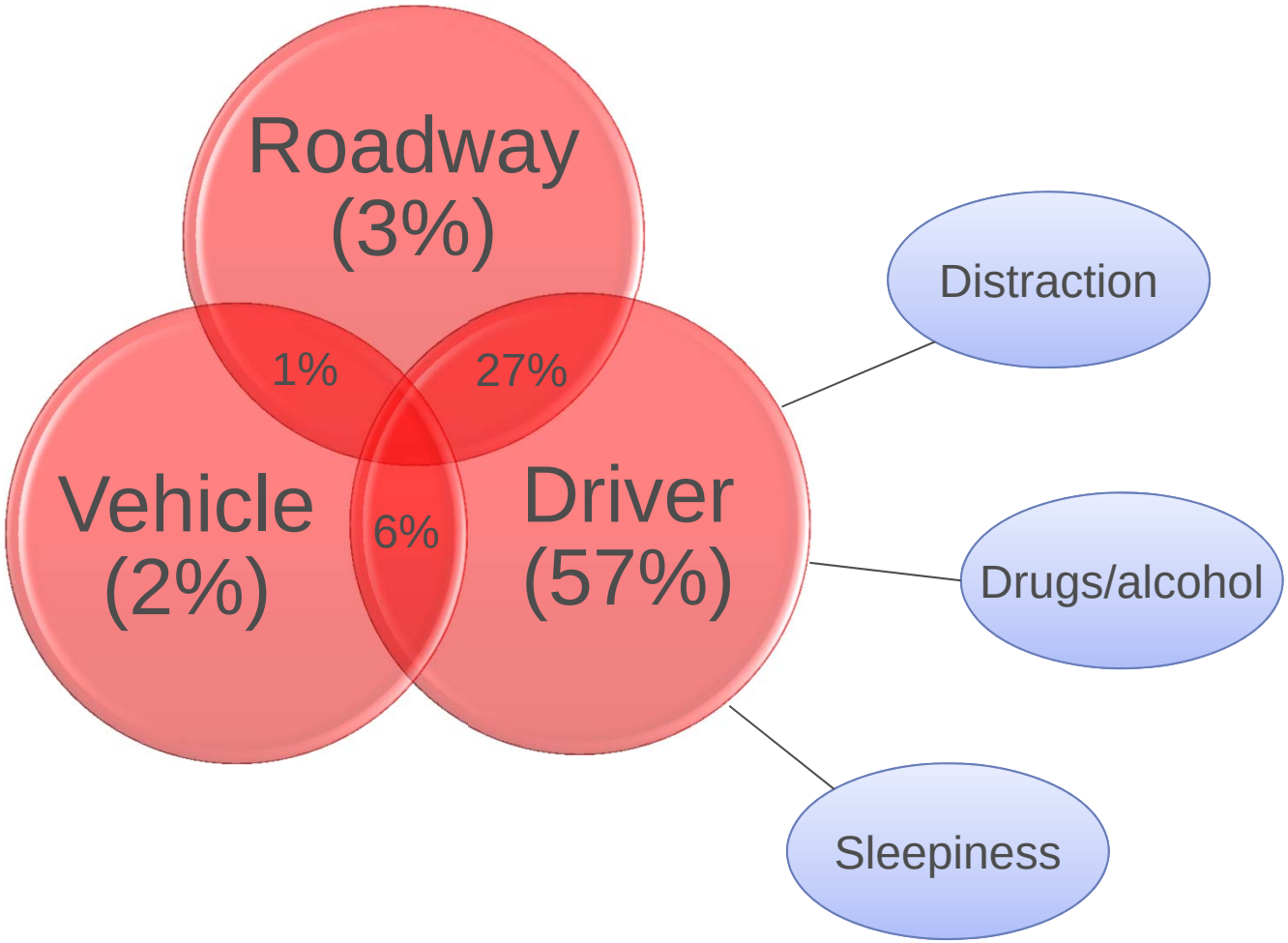


Why we are here…



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Harry Lum & Jerry A. Reagan (Winter 1995).
Interactive Highway Safety Design Model: Accident Predictive Module.
Public Roads Magazine.

Measuring Driver Distraction

Exposure

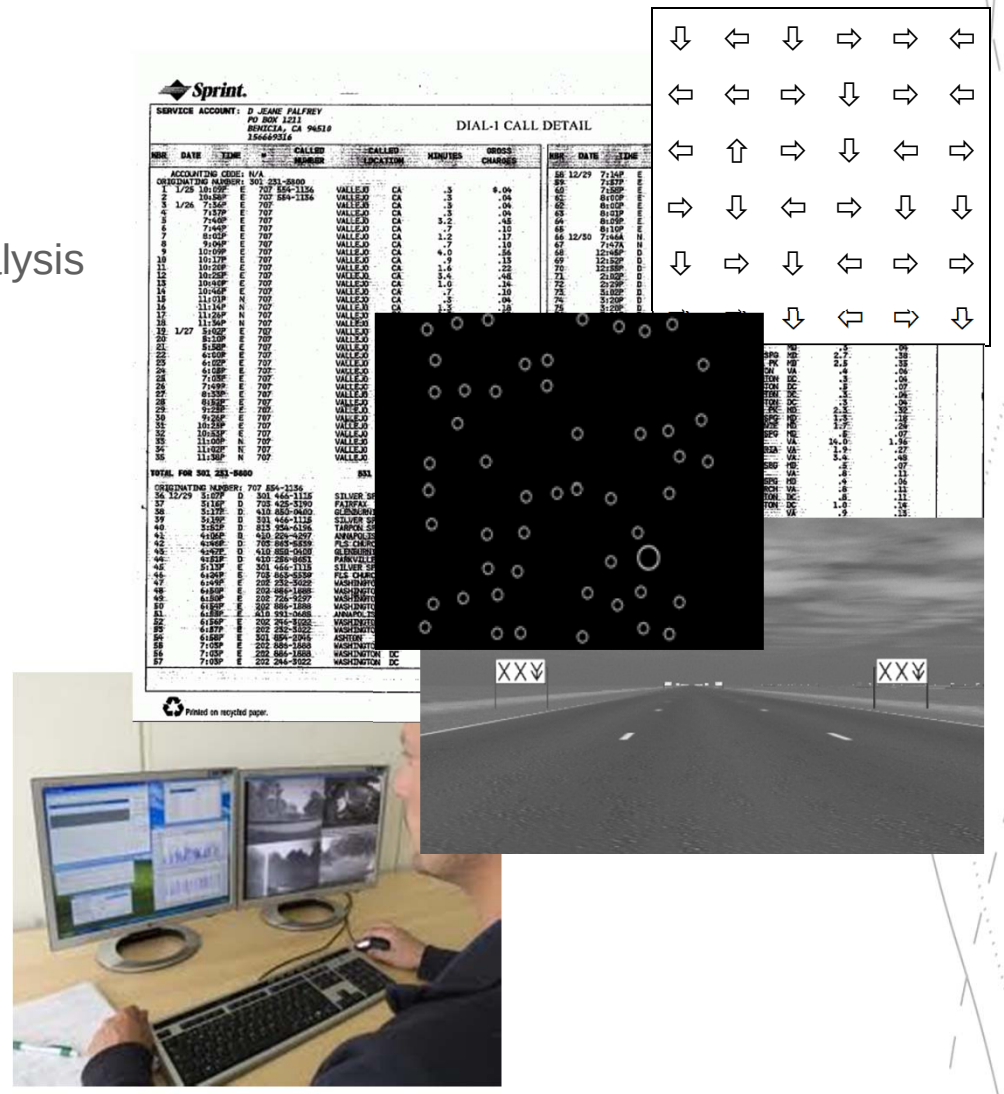
- Self-reported
- Phone activity records
- Roadside observations
- Instrumented vehicels + video analysis

Imposed measures

- Arrows task, SURT
- Lane change task
- Visual occlusion

Direct measures

- Driving and driver behaviour
- Visual behaviour



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Visual behaviour analysis of naturalistic data

- Too much video to look at!!
- Eye tracking is a necessary tool

- How well does eye tracking work in a field setting over an extended period of time?
- Can post-processing be used to improve the results?

- Data: the Sweden-Michigan Field Operational Test (SeMiFOT)
  - Six months of data with 44 unique drivers (>10000 trips)
  - 13 eye tracker equipped vehicles.
    - Two SmartEye Pro systems
    - Three SmartEye Antisleep systems
    - Eight Driver State Sensor systems

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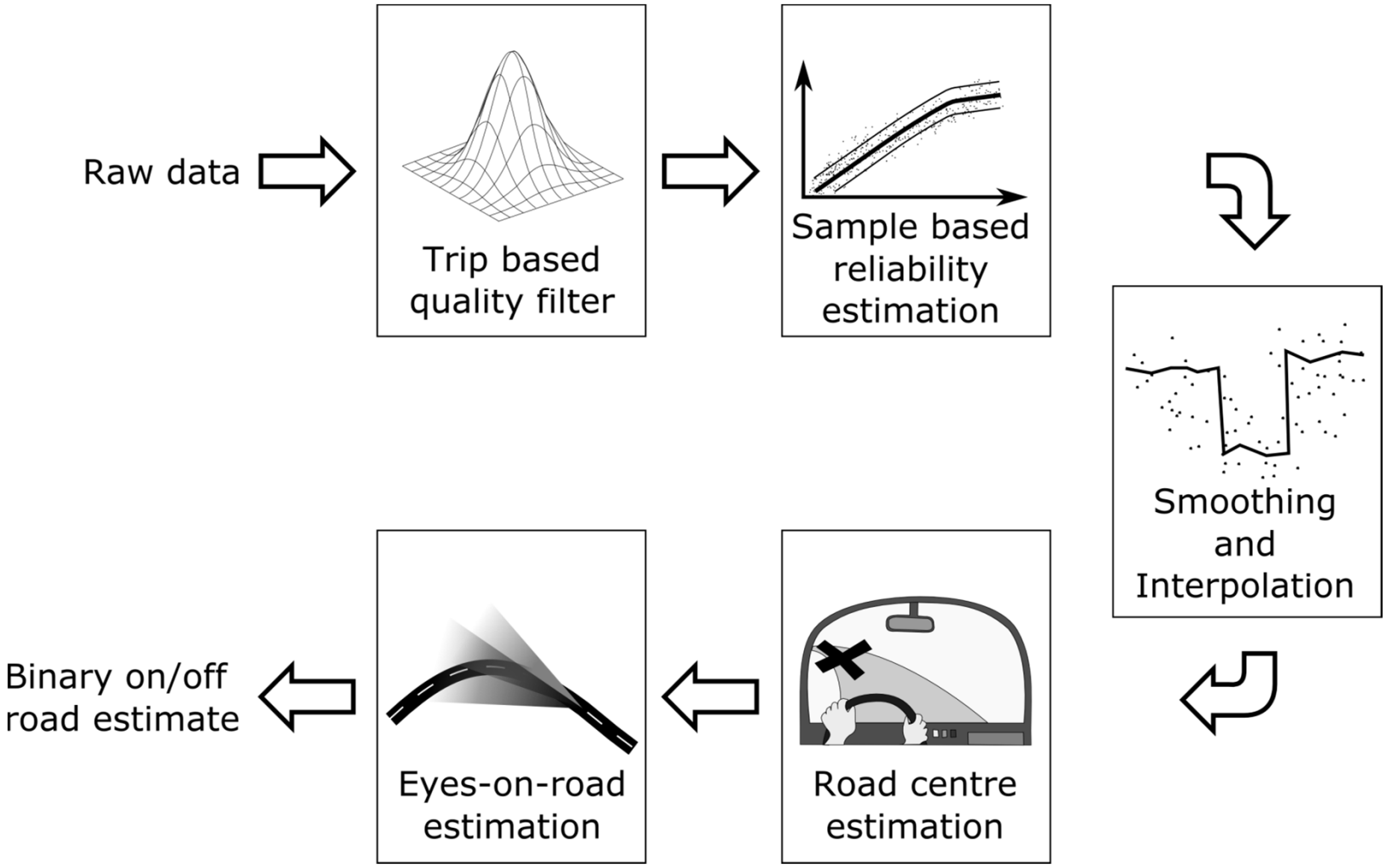
Processing Framework



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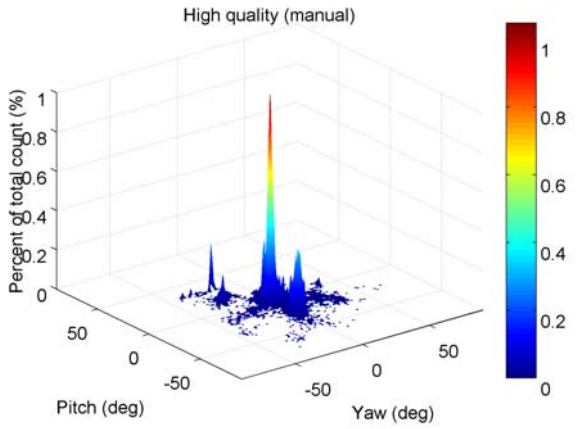
Trip based quality filter

- In a laboratory setting, accuracy and precision of about 1° is expected
- In a driving simulator with remote eye tracking, about 5° is feasible
- In naturalistic driving, worse performance is expected!
  - It becomes important to manage lost and erroneous tracking
  - The main objective of the trip based quality filter is to exclude trips where the tracking data have insufficient quality or where the percentage of lost tracking is large

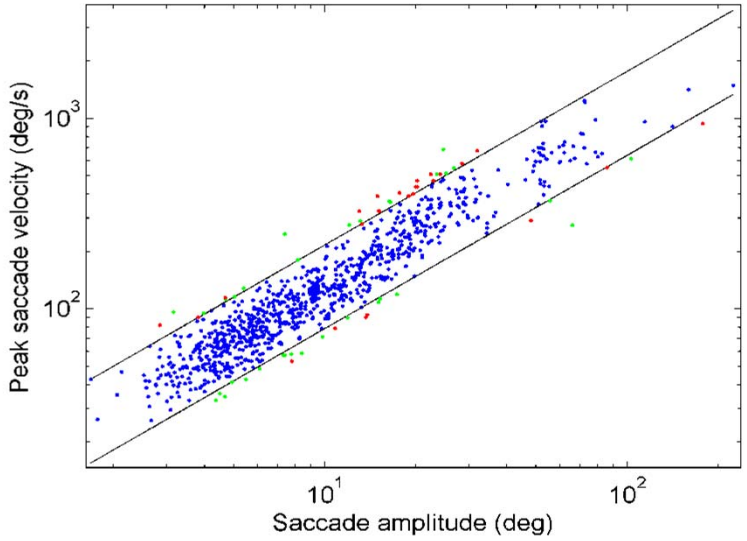
Quality Requirement	Thresholds
Percentage of available tracking	50%
Percent road centre (8°)	50%
Radius containing 80% of data	25°
SD radial gaze	15°
Min peak height	0.2



Reliability estimate

- A quality measure, based on image quality, is provided by the manufacturer.
- We have added rules based on physiological constraints.
  - If tracking is lost too frequently or for too long, the data is considered to be unreliable.
  - If the saccadic main sequence is violated, the data is considered to be unreliable.

$$v_{peak} = v_{\max}\left(1 - e^{-\frac{a}{C}}\right)$$



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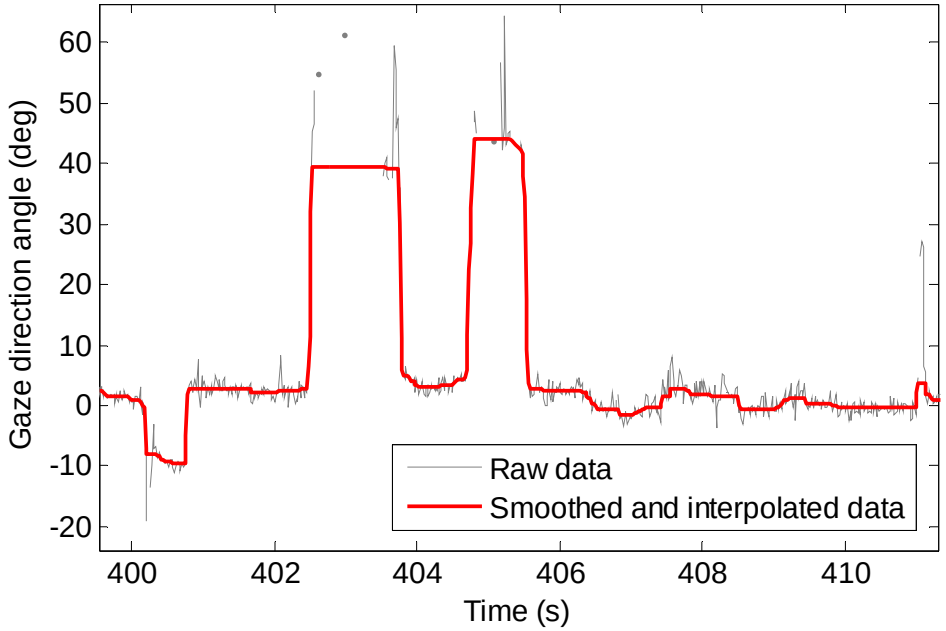
Smoothing and Interpolation

- Corrupted data are replaced by interpolation and uncorrupted data are smoothed.
- These two operations are achieved in a unified framework using quantile regression for gaze tracking data.
- Quantile regression has the advantage of being able to preserve jumps (saccades) as well as constant sequences (fixations).



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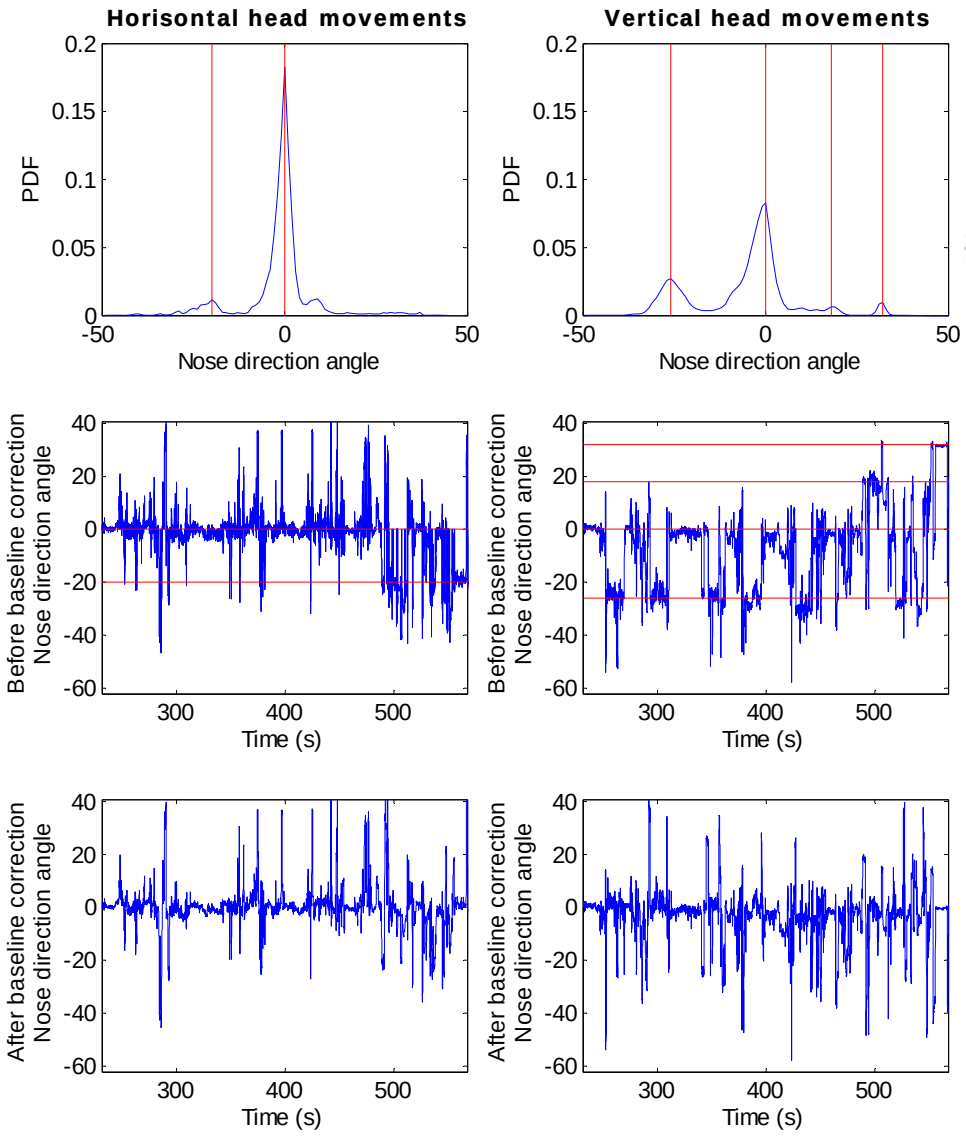
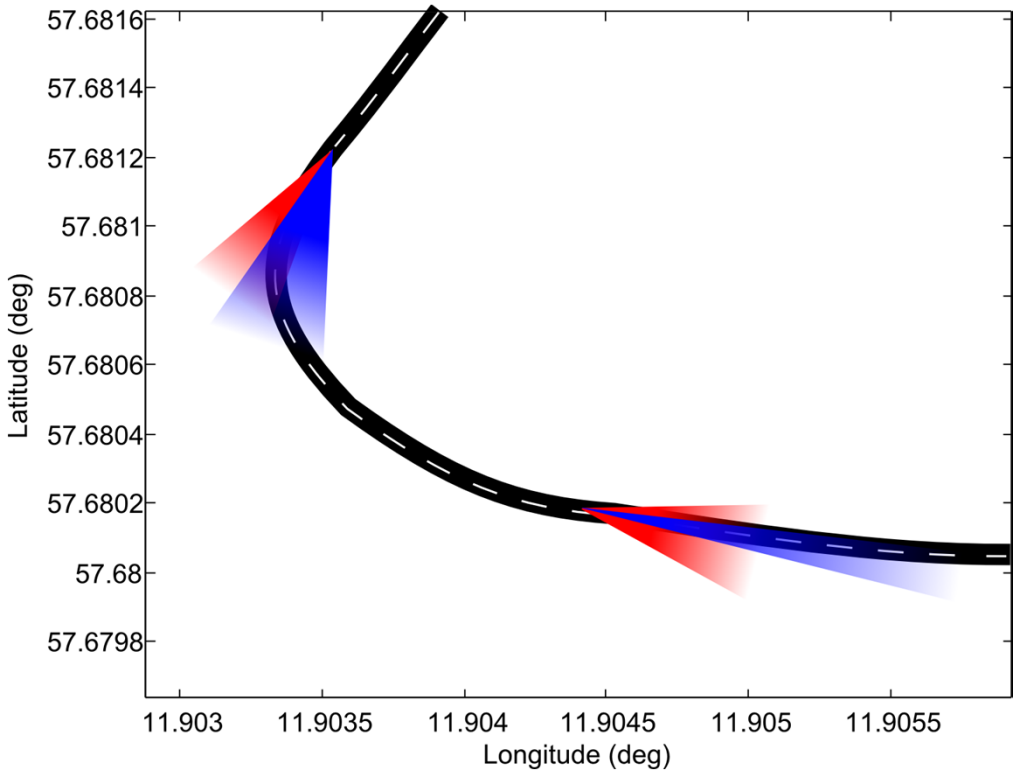
Road centre estimation

- When using remote eye tracking in vehicles, the world outside the car is unknown.
- The most frequent gaze location is often used as “straight ahead”.
- In naturalistic data, an adaptive road centre is necessary.
- Detect peaks in 1D PDFs
- Assign each sample to the most likely peak, but avoid frequent mode shifting.



Eyes-off-road determination

- Eyes-off-road is defined as gaze directions more than 10° away from the road centre point.
- Hysteresis with an inner radius of 7° is used.
- GPS data is used so that the driver is always allowed to look at the forward roadway.



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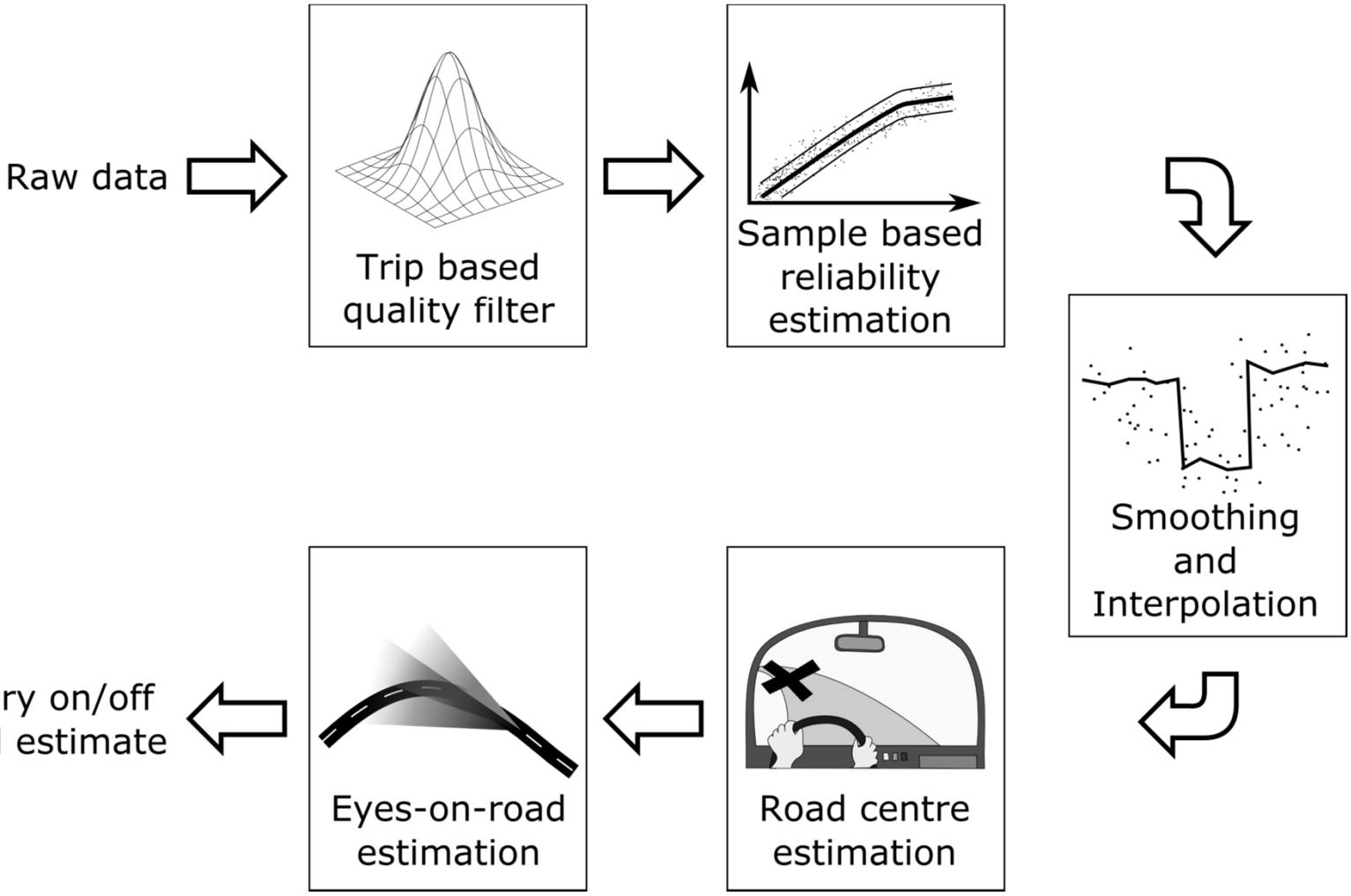
Recapitulating the Processing Framework



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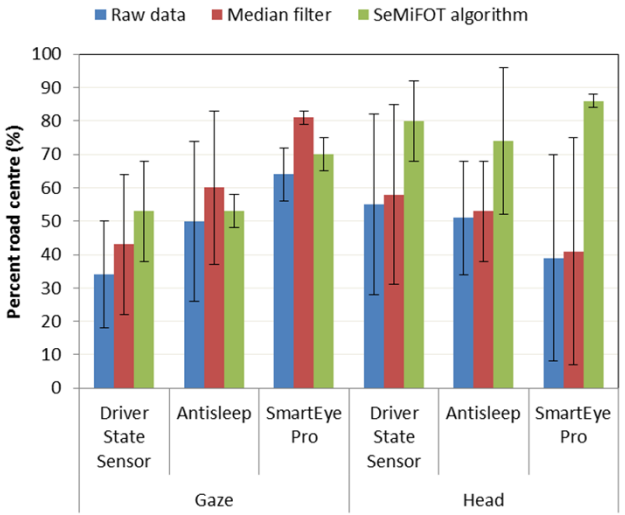
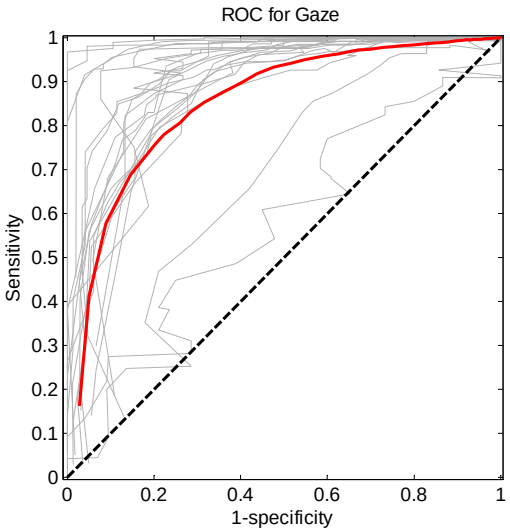
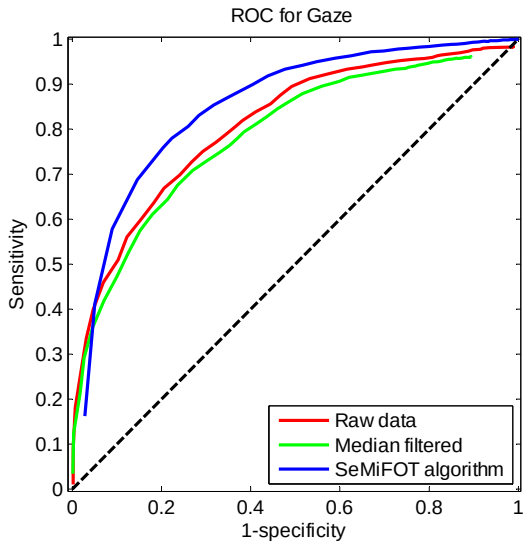
Summary of Results

Quality Requirement	No. of trips		No. of drivers	
	Head	Gaze	Head	Gaze
Entire database	10035	10035	44	44
Entire tracking database	4794	4794	35	35
After excluding trips without tracking	4220	4220	35	35
After excluding short trips and velocity<50km/h	1147	1147	35	35
After automatic trip based quality filtering	669	363	30	23







Summary and conclusions

- Field use of eye tracking systems is cumbersome and deteriorated quality should be expected.
- It is important to know when the data is reliable and also to repair and enhance available data when possible.
- By adding advanced data processing and signal enhancement techniques the performance was increased with approximately 10%.

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Thank you for listening!

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