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IDENTIFYING RIDING PROFILES PARAMETERS FROM HIGH RESOLUTION NATURALISTIC RIDING DATA

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The question

- Is there a way to automatically detect riding situations (incidents) using solely data and without seeing the video?

  → *Automatic Riding Incident Detection*

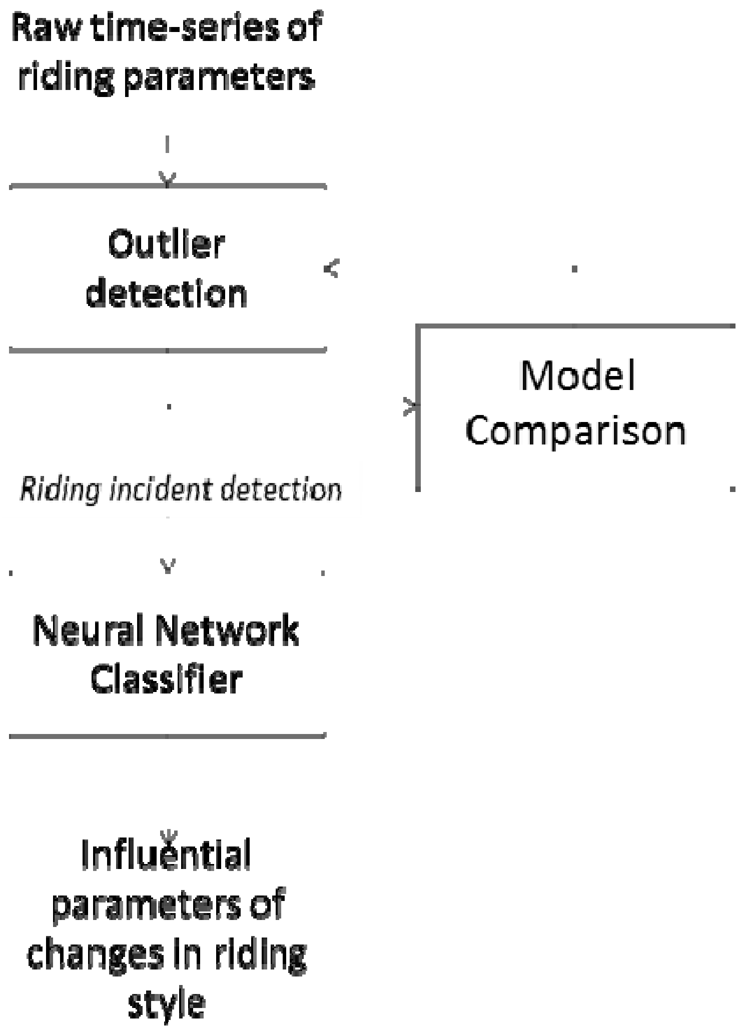
- Assumption
  - Each driver has a distinct behavior when reacting to internal/external stimuli that…
    - is reflected to the riding parameters (abrupt changes or deviation from the mean "typical" values)
    - may impose different riding profiles among riders

- Riding profiles define different boundaries of risky behavior.

The Scope

- Identify incidents based exclusively on high resolution naturalistic riding data without observing the videos.
  - distinguish between regular and irregular riding behavior.
  - artificial intelligence techniques to construct a regressor and uncover the influence of riding profile parameters.

The Methodology



Methodology

- Identify Incidents
  - High-resolution data (multivariate or not) often contain outliers

1. Jointly consider 100Hz riding parameters time series
2. detect the deviations from the mean behavior (Outliers)
3. nominate the occurrence of a deviation as the beginning of an incident.

Methodology

- an outlier is defined as an observation for a specific time interval that the rider for some reason drastically alters its riding behavior due to and external or internal stimulus.

- Mahalanobis distance: $d_i = \sqrt{(x_i - \hat{\mu}) S^{-1} (x_i - \hat{\mu})}$, $\hat{\mu}$ and S^{-1} are the sample mean and covariance matrix respectively

- At a significance level α, a determination as to whether a new observation can be considered as outlier or not can be made based on the following formula:

$$d_i \leq \left[p(n-l)(n+l) / n(n-p) \right] F_{p,n-p}$$

Methodology

- Neural Networks Classifier
  - a generalization of a single-layer Perceptron because it encompass a hidden layer consisting of a set of processing units
  - each layer consists of a set of processing units (neurons) that receive inputs and transfer them to the next layer through a set of connections (synapses).
  - Each connection possesses certain strength, the synaptic weight.
  - There are no connections between the units of the same layer.
  - In the input layer no kind of processing is performed.
  - The output: $y_k = f_k\left(a_k + \sum_{jk} w_{jk} f_i\left(a_k + \sum_{ij} w_{ij} x_i\right)\right)$

Naturalistic riding study

- Instrumented motorbike
  - BMW F650 Funduro
  - 12 important signals
  - Video installation was used to capture the frontal environment (required a minimum 90° field of view) and the rider’s face.
  - 100Hz signals’ data resolution, 10Hz video resolution and GPS position which can be sampled at 1Hz

Naturalistic riding study

- The route
  - rural two-way roads
  - shoulder width less than 1.2m
  - rolling terrain and high curvatures
  - mixed traffic conditions
  - not equally distributed traffic across the two directions
  - a significant number of uncontrolled access points
  - several zones where passing is permitted
  - daylight with good visibility and fine weather conditions

Naturalistic riding study

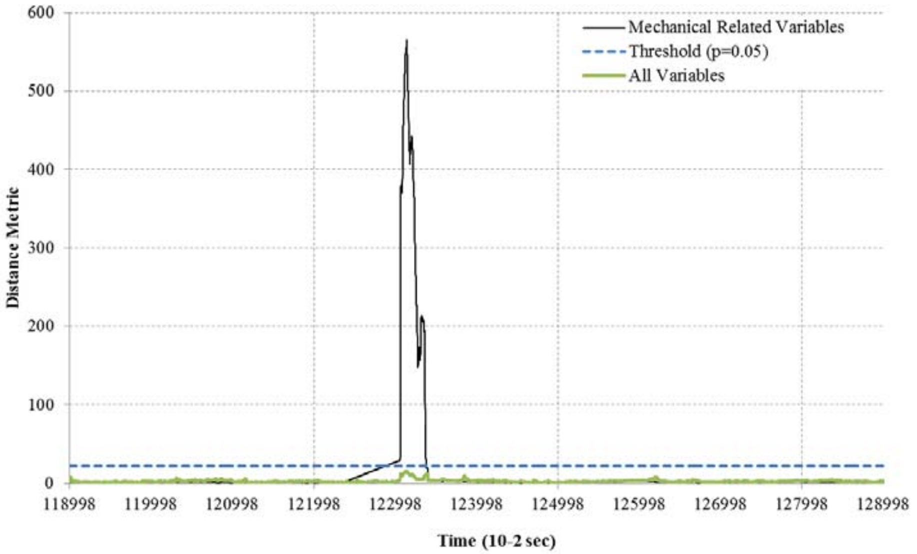
- The final dataset:
  - 56 trips of 20 minutes duration, meaning a set of time series of riding parameters with $6.72 \cdot 10^6$ data.

Monitored Basic Variables	Description
Longitudinal acceleration [g]	linear acceleration
Lateral acceleration [g]	
Vertical acceleration [g]	
speed [kph]	longitudinal speed
yaw rate [deg/s]	roll, yaw and pitch rates
pitch rate [deg/s]	
roll rate [deg/s]	
Throttle [%]	throttle position
Brake Rear [%]	brake pressure rear
Steering [%]	steering angle
Brake activity Front [0/100]	brake activation front
Brake activity Rear [0/100]	brake activation rear
Wheel Speed [km/h]	Speed of the rear wheel

Results

- Detecting Incidents
  - Three models are evaluated using different data:
    - Model 1: steering, throttle, brake activation and wheel speed.
    - Model 2: linear acceleration and speed.
    - Model 3: All available variables.

Distance metric time series of Model 1 and Model 3.
Any distance metric value above the 5% threshold value signifies an irregular behavior (outlier).



  - Model 1 is the optimum
  - Traffic related variables have been found less influential in detecting incidents.

Results

An example of detected incident using the proposed methodology (5 sec data, incident duration: ~ 1.5 sec)

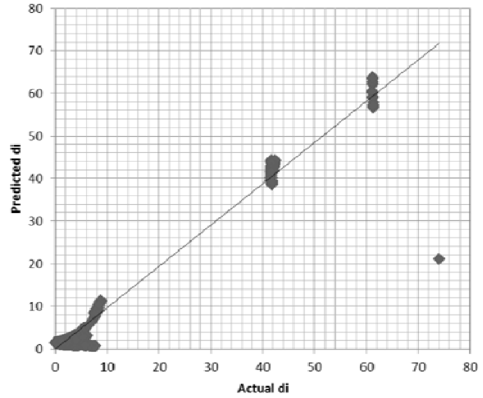
Results

- Examples the situations detected are:
  - Moped moving on the left to avoid fixed object,
  - Braking and moving on the right after having overtaken vehicles (vehicles are in front of the moped as well),
  - Overtaking more than one vehicle,
  - Moped moving to the left to avoid stationary object.

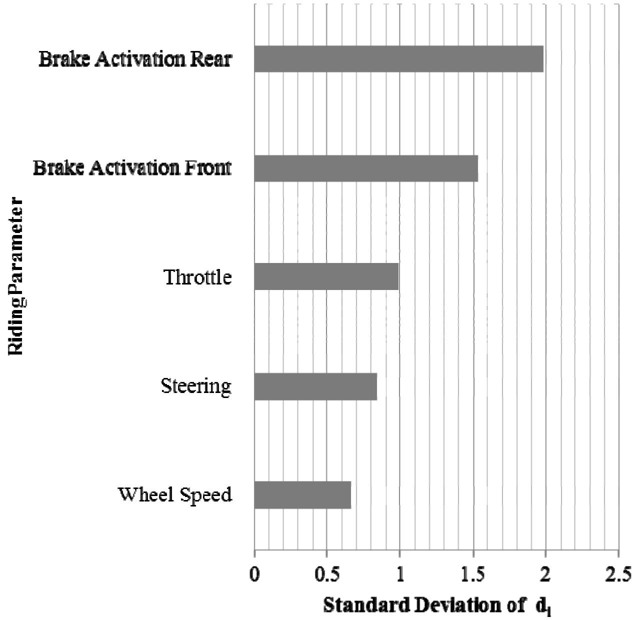
- These situations may be considered as incidents where a rider is engaged to an unusual - far from the mean - riding behavior and, thus, may be candidate riding situations with high accident risk.

Results

Scatter plot of the actual versus the predicted Mahalanobis distance di



The mean standard deviation of the Mahalanobis distance d_i for each varied input



Results

- Braking is most influential factor
- Wheel speed is the less critical parameter
- Throttle seems to be more influential than steering
- Riding parameters' influence to the deviation from the mean riding behavior is closely related to the manner a rider reacts to specific stimuli

Conclusions

- A simple and flexible methodology to detect incidents from massive datasets
  - The method is validated in various trips
    - all outliers detected can be considered as incidents
    - Traffic related parameters were not influential to the detection of incidents

- Identify custom-made riding profiles
  - influence of each input parameter to the manner the rider reacts to external or internal stimuli

Conclusions

- Incidents may vary with regards to the accident risk they encompass.

- Results on the riding style may not claim transferability to either different riders, or different types of trips

- Further research
- uncovering the determinants of each riding behavior with respect to the manner a rider conduct a maneuver in the beginning or during a critical riding situation.