Definition of Driving Risk by Mixture of Experts

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Objetives and Ideas

1. We present a methodology to define several types of driving risks as the solution of a mixture of experts problem.
2. We have recorded a video from a truck simulator.
3. Two experts were asked to evaluate the driving risk using a Visual Analog Scale (VAS).
4. We present four different definitions of driving risk.
5. A method to calculate these risks by the maximization of a similarity measure between experts evaluations is proposed.

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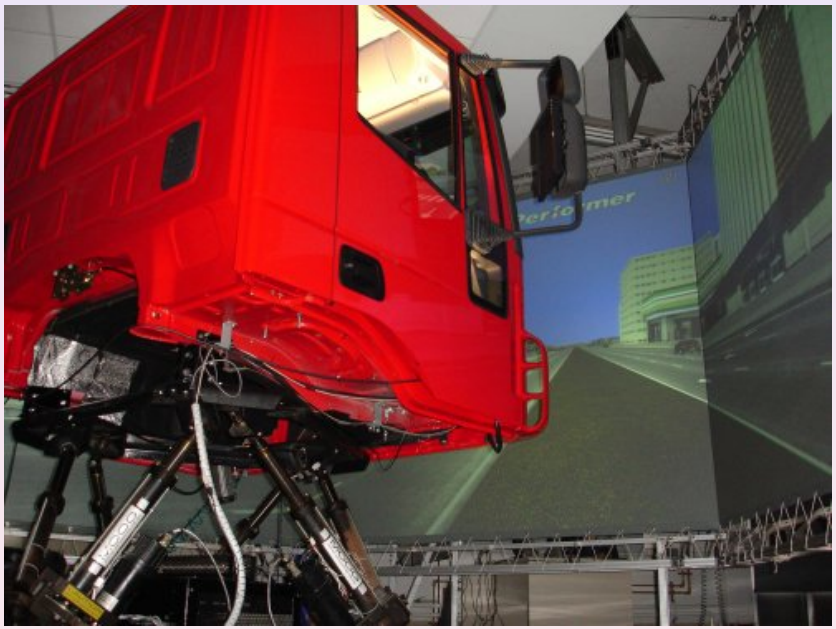
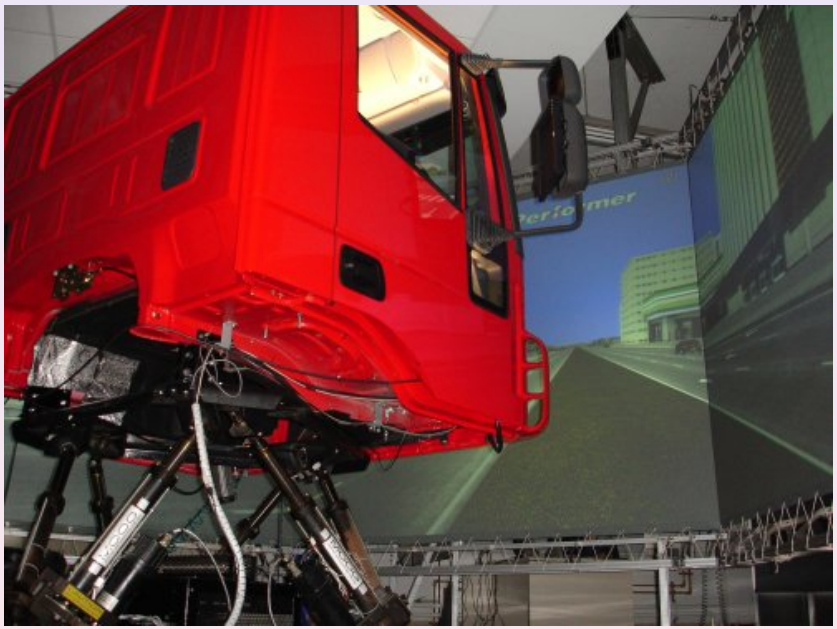
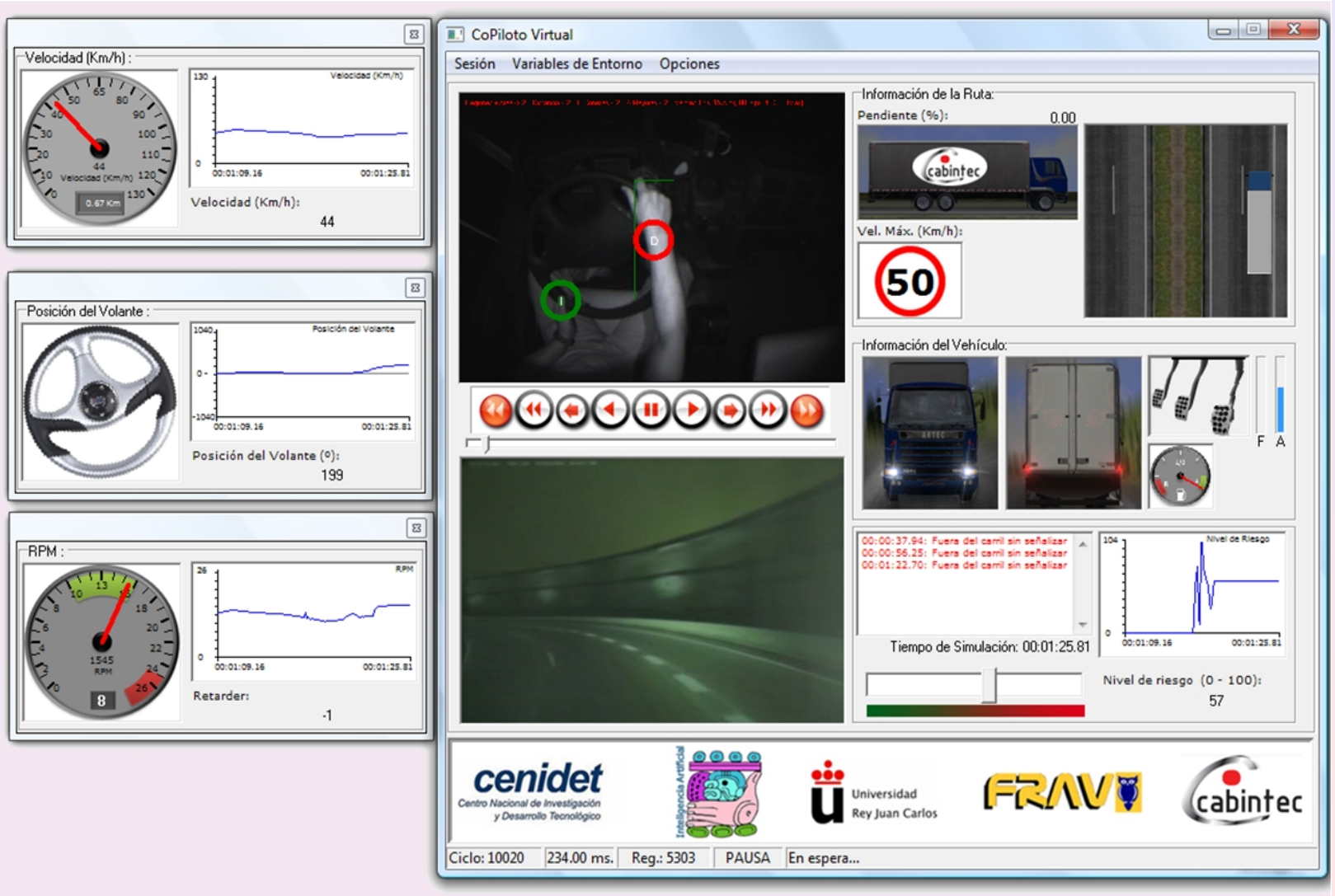
CABINTEC ("Intelligent cabin truck for road transport") is an ongoing project funded by the Spanish Ministry of Science and Innovation involving 16 partners (universities, research centres and private companies). This project is focused in risk reduction for traffic safety. The three main aspects of traffic safety are considered: road, vehicle and driver.

- The CABINTEC project will be tested in a truck simulator.
- All the visual field of the driver is covered by a detailed 3D scene simulation.
- The scene and the actuators are coordinated by a computer.
- The scene involves real traffic and interactions with other vehicles.



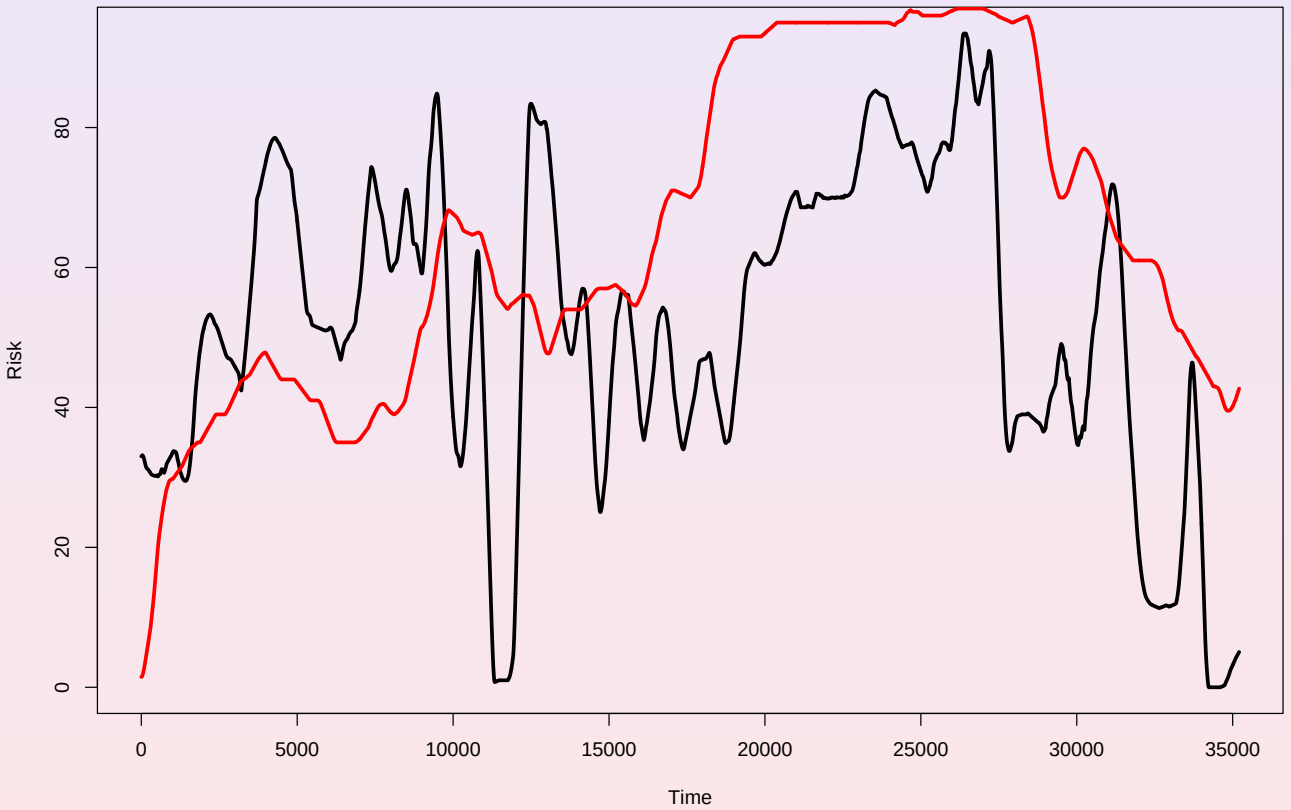


- Several videos were recorded from the truck simulator.
- A professional driver was employed.
- Information on several variables were collected at the simulator.
- A graphical interface was used in order to get the risk evaluation from the experts.


Velocidad (Km/h) :
Velocidad (Km/h):
44
Posición del Volante :
Posición del Volante (º):
199
RPM :
Retarder:
-1
CoPiloto Virtual
Sesión
Variables de Entorno
Opciones
Información de la Ruta:
Pendiente (%):
0.00
Vel. Máx. (Km/h):
50
Información del Vehículo:
Tiempo de Simulación: 00:01:25.81
Nivel de riesgo (0 - 100):
57
cenidet
Centro Nacional de Investigación y Desarrollo Tecnológico
Universidad Rey Juan Carlos
FRAV
cabintec
Ciclo: 10020
234.00 ms.
Reg.: 5303
PAUSA
En espera...


RACE
RACE

Driving Risk



Driving Risk

Let $C_i = \sum_t^T R_i(t)$ be the total number of points under risk. We proposed to calculate the threshold as the solution to:

$$\begin{aligned} \max_{\varepsilon_1, \varepsilon_2} \quad & s_{(1,2)} \\ s.t. \quad & C_i < \tau \quad , \; i = 1, 2 \end{aligned} \tag{1}$$

where $s_{(1,2)}$ is a similarity measure between the risks given by expert 1 and 2, and τ is an upper bound to control the number of points under risk.

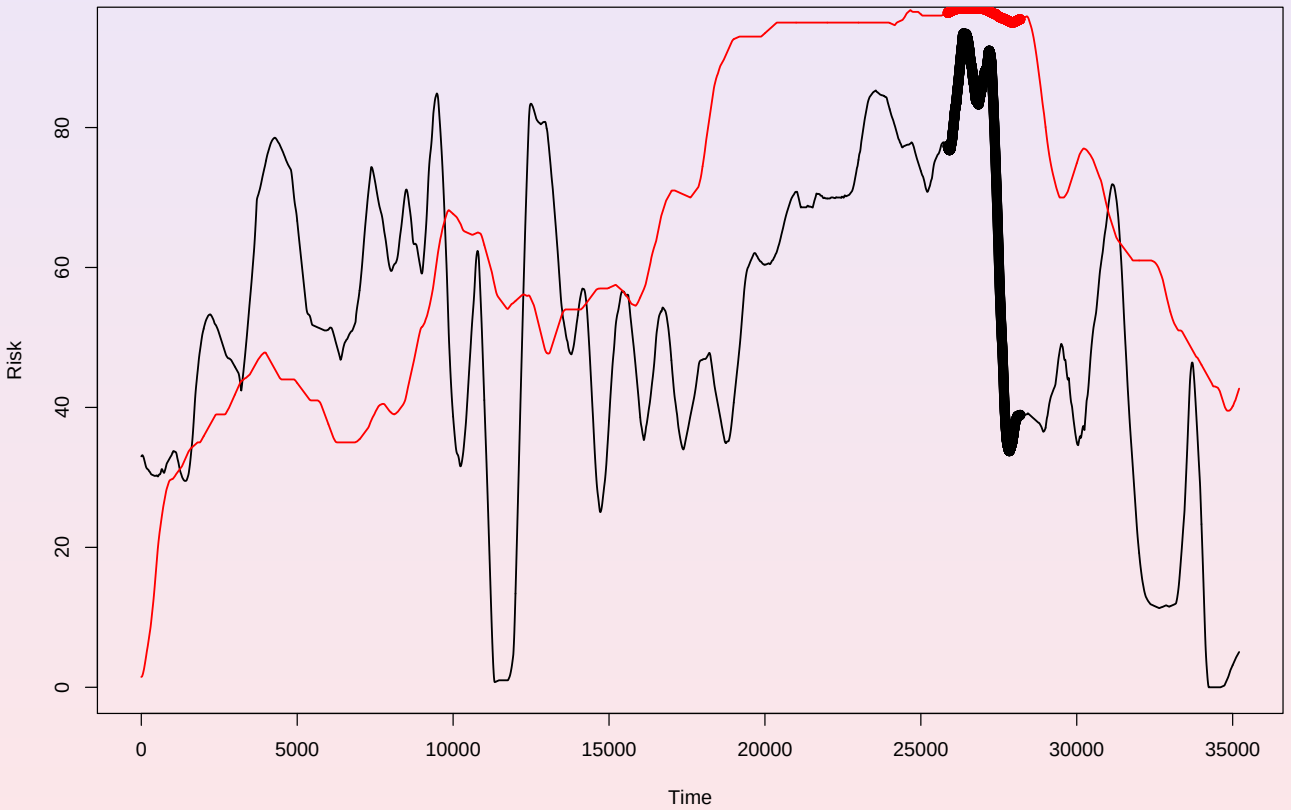
High Level Risk

The High Level Risk is defined as true if the risk level provided by the experts is higher than a threshold.

$$R_i(t) = \begin{cases} 1, & \text{if } y_i(t) > \varepsilon_i \ , \\ 0, & \text{otherwise}. \end{cases} \tag{2}$$

We choose the level thresholds such that the similarity between the different experts evaluations will be maximum.

High Level Risk



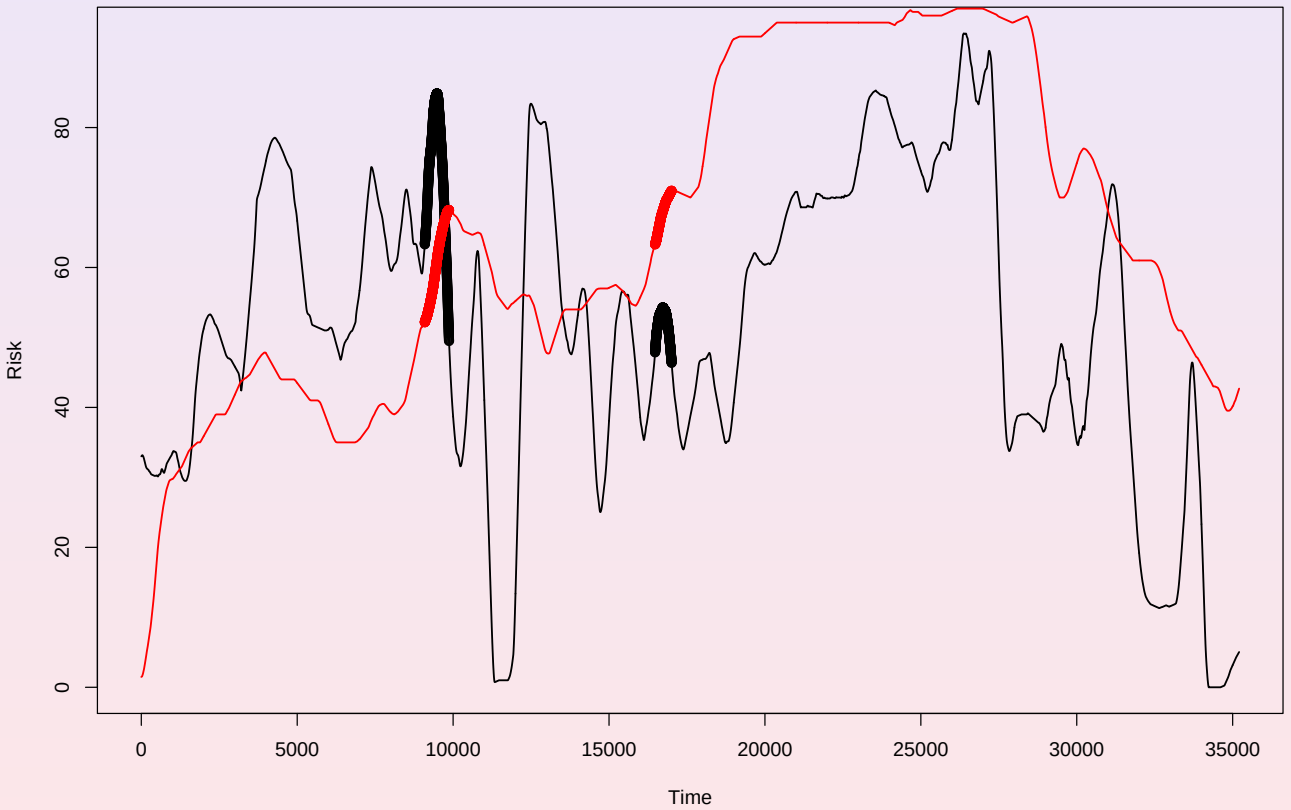
Incremental Level Risk

The Incremental Level Risk is defined as true if the risk level provided by the expert is such that the first derivative is higher than a threshold.

$$R_i(t) = \begin{cases} 1, & \text{if } \Delta y_i(t) > \varepsilon_i \ , \\ 0, & \text{otherwise}. \end{cases} \tag{3}$$

We will detect positive sharp changes on the VAS expert evaluation of the risk

Incremental Level Risk



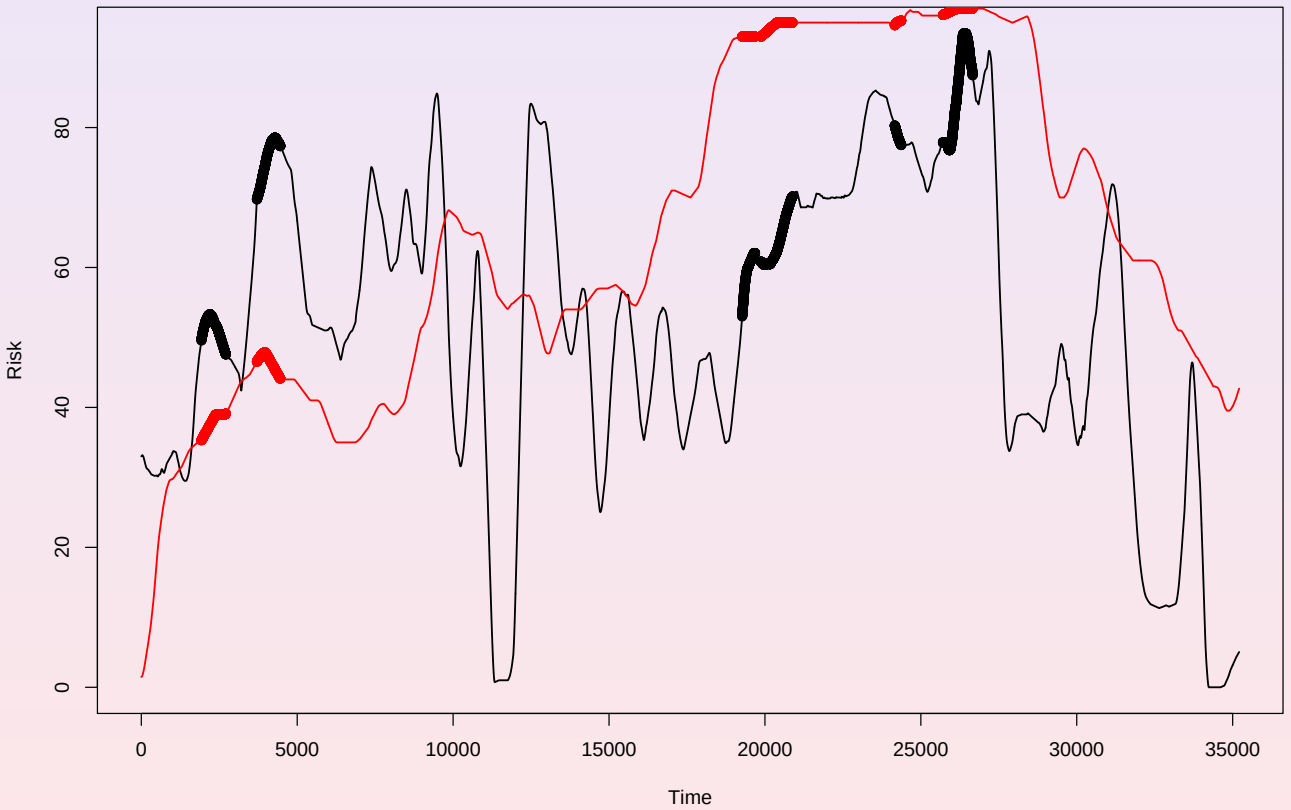
Run Risk

The Run Risk is defined as true if the risk level provided by the expert is such that the first derivative is positive for a period of time higher than a threshold.

$$R_i(t) = \begin{cases} 1, & \text{if } \Delta y_i(j) > 0 \text{ for } j = t, t-1, \ldots, t-\varepsilon_i\,, \\ 0, & \text{otherwise}\,. \end{cases} \tag{4}$$

Using this definition we will detect periods of time associated to a **positive increment in the evaluation of the risk made by the experts**.

Run Risk


Risk
0
20
40
60
80
0
5000
10000
15000
20000
25000
30000
35000
Time

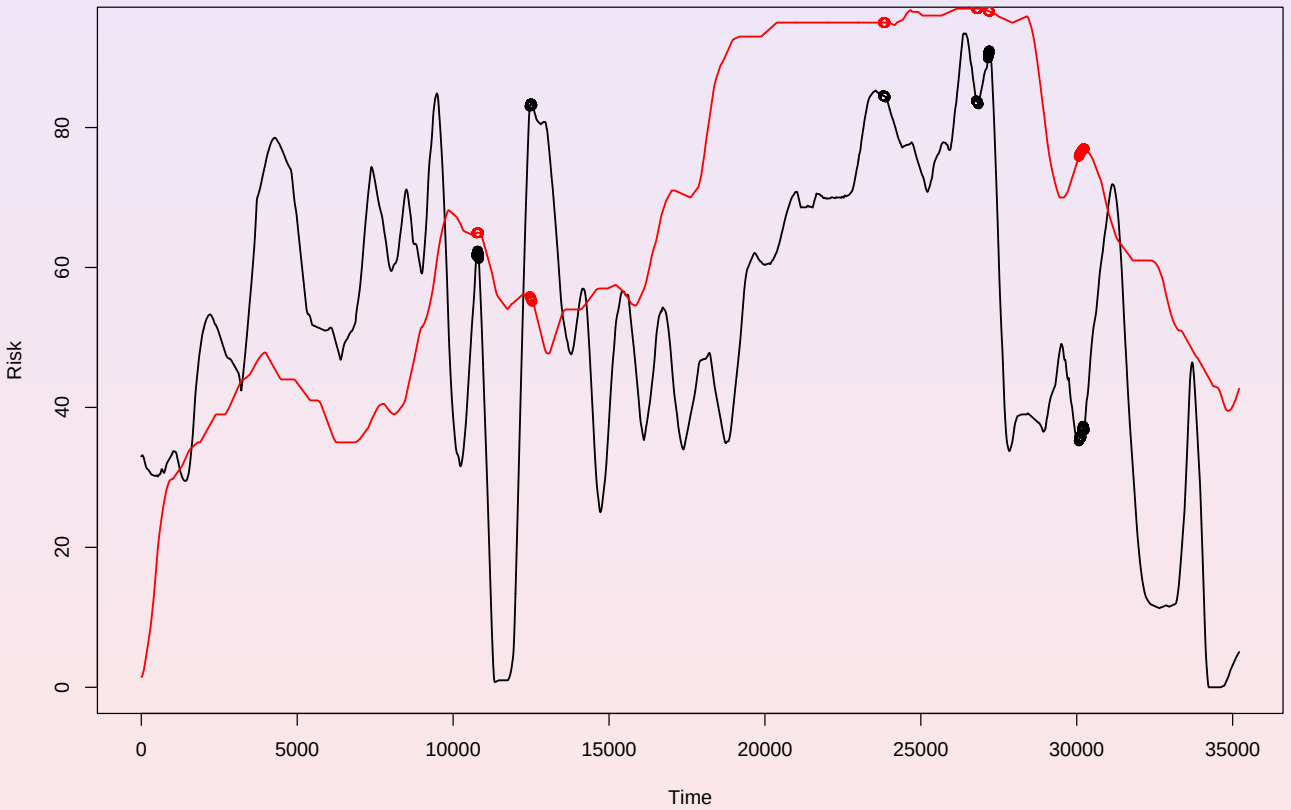
Peak Risk

The Peak Risk is defined as true if the risk level provided by the expert achieves a local maximum. In this particular case, the threshold is defined as the number of cycles before and after the cycle corresponding to the local maximum.

$$R_i(t-\varepsilon_i) = \ldots = R_i(t-1) = R_i(t) = R_i(t+1) = \ldots = R_i(t+\varepsilon_i) = \begin{cases} 1, & \text{if } \Delta y_i(t) = 0\,, \\ 0, & \text{otherwise}\,. \end{cases} \tag{5}$$

We will detect periods of the time with local high level risk.

Peak Risk


Risk
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20000
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30000
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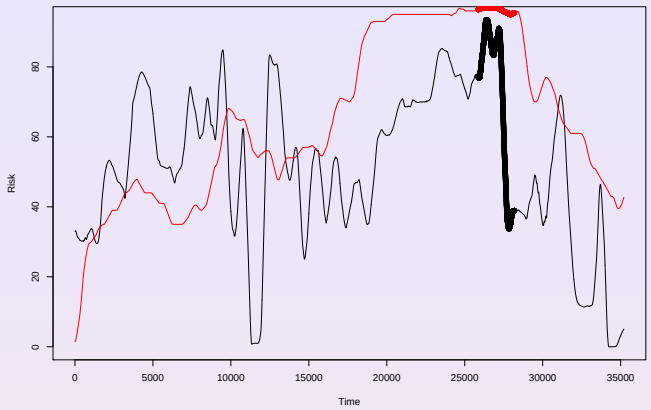
Time

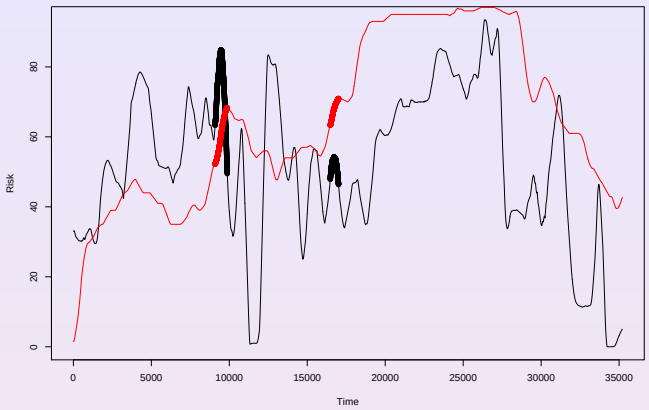
Results

Thresholds, percentage of points at risk given by the experts and the mixture of experts, and Jaccard similarity between experts.

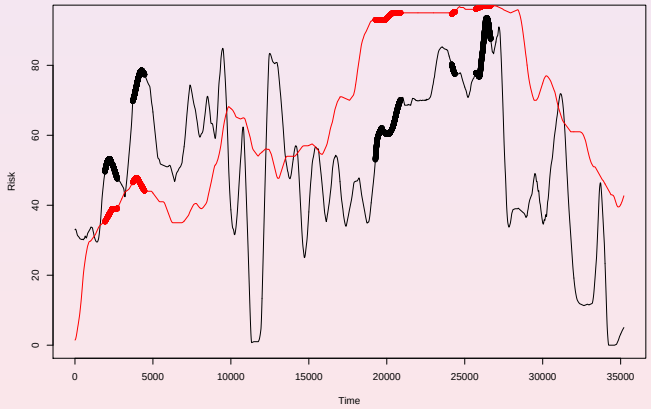
	Expert 1		Expert 2			Mixture
Type	**Risk**	**Threshold**	**Risk**	**Threshold**	**Similarity**	**Risk**
High Level Risk	11.5 %	86	13.2 %	95	0.344	6.3 %
Incr. Level Risk	18.4 %	0.6	13.5 %	0.2	0.130	3.9 %
Run Risk	6.0 %	900	16.1 %	1800	0.076	1.6 %
Peak Risk	8.9 %	37	15.3 %	220	0.062	1.4 %
Total Risk	-	-	-	-	-	12.6 %



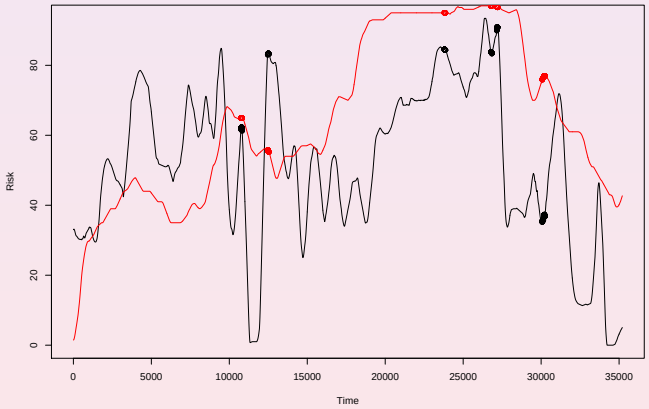
High Level Risk



Incr. Level Risk

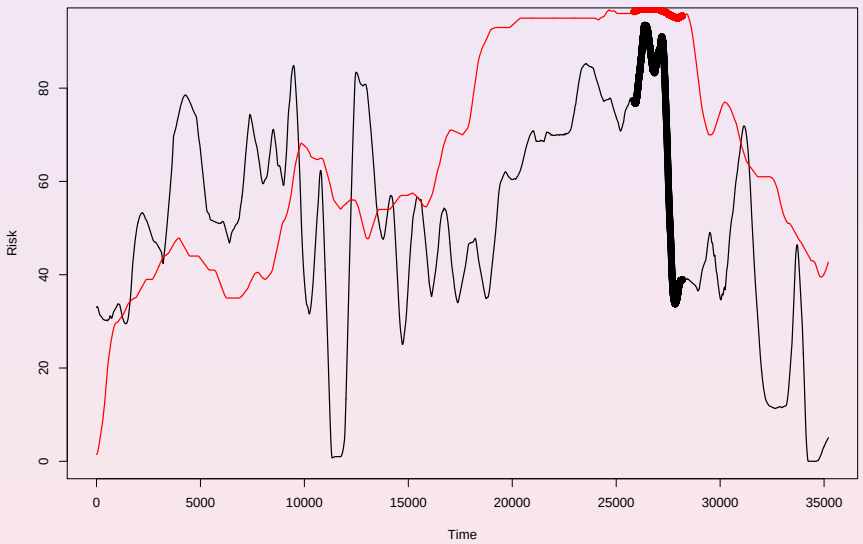


Run Risk



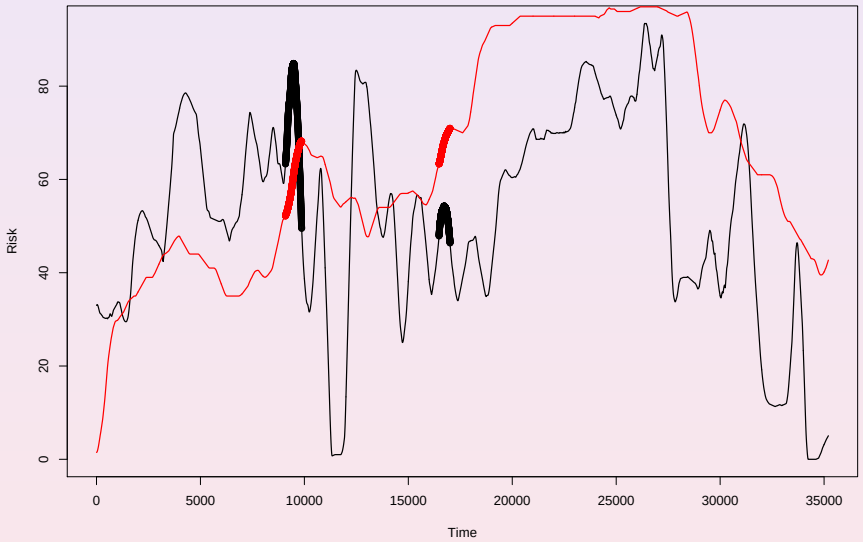
Peak Risk

High Level Risk



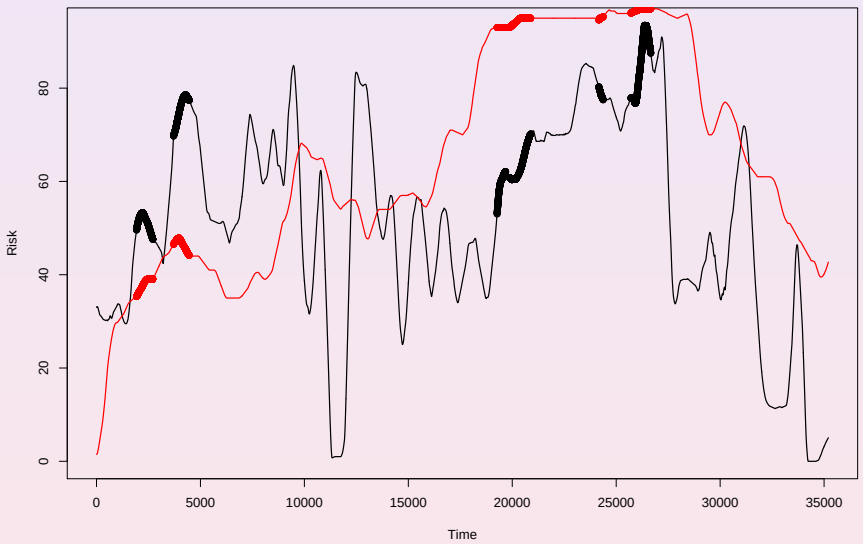
- The High Level Risk was true in an instant when the driver was using the **mobile phone** with one hand, and simultaneously using the **gearshift** with the other hand. So no hands at the driving wheel were present.

Incremental Level Risk



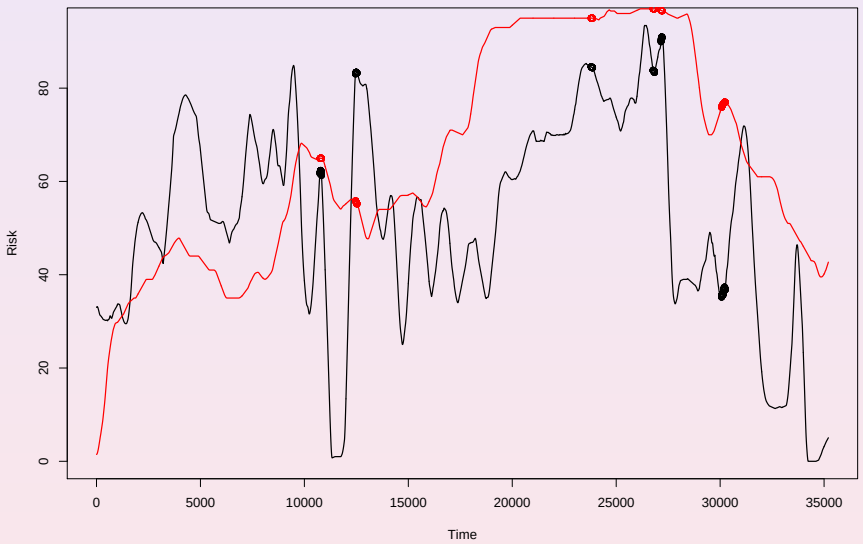
- Observing the moments classified by the Incremental Level Risk as true (at risk), it can be seen that the driver was using the **mobile phone while crosssing the traffic lines**.

Run Risk



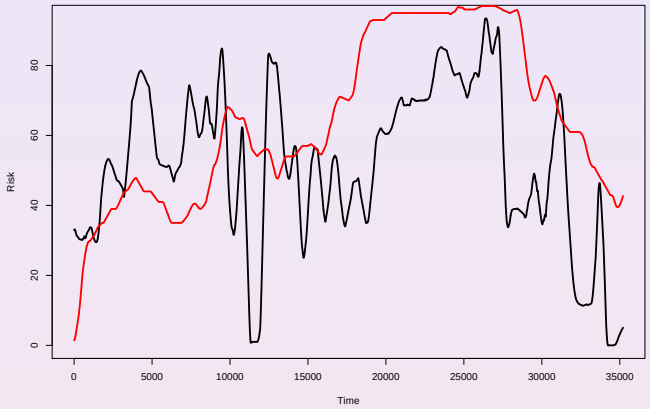
- Concerning Run Risk, two disjoint areas were selected. In the first moment, the driver was **talking with another passenger while parking**. In the second, the driver was using the **mobile phone** while turning at low speed.

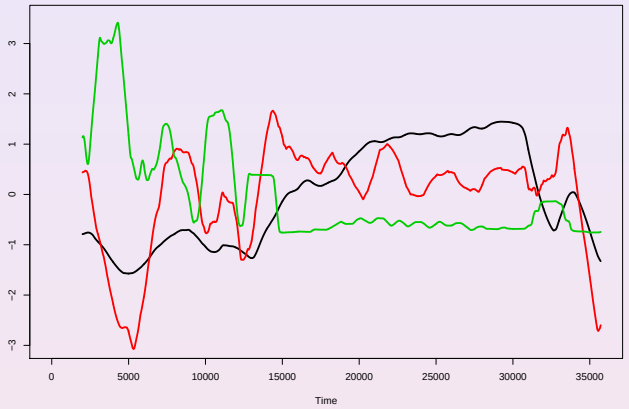
Run Risk



- In all moments classified by the Peak Risk as instants at risk, different driver behavior was observed, like the used of the mobile phone, **crossing the traffic lines**, etc...

Relation with other variables





Logistic Regression models, Odds Ratios for *speed*, *RPM* and *SWA*, and Sensitivity (Sens.) and Specificity (Sens.).

Risk	Speed	RPM	SWA	Sens.	Spec.
High Level Risk	1.303	0.977	0.987	0.842	0.841
Incr. Level Risk	0.896	1.005	0.976	0.780	0.785
Run Risk	2.313	0.937	1.055	0.927	0.927
Peak Risk	1.048	0.996	1.000	0.704	0.852
Total Risk	1.037	0.997	0.997	0.629	0.762

Conclusions

- An **innovative methodology** for the definition of **driving risk** based on the mixture of experts evaluations has been presented.
- All defined risks are useful and seems to show abnormal behaviors of the driver.
- Our results confirm that each expert manage a psychological different **concept of risk**.

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- Different **similarity measures** will be considered.

Questions?