Final Seminar

DRIVER SUPPORT WARNING
(« Black spots » warning, Rollover)

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ROLLOVER RISK APPLICATION
Objectives

• Develop on-board concepts design of systems to increase safety.

• To prevent in real time the rollover risk (Alarm to the driver)

→ Recommended speed calculation
Use Cases

• Truck driver provides information during tour: (the driver is informed about driving relevant status and status changes given by the database..)
• Reliable safety warnings in vehicle
• Give recommended speed to avoid any accident during journey
• ...

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Since we do not have sensors, the following states have been off-line estimated:

- Estimation of impact forces,
- Estimation of the Center of gravity height,
- Recommended speed calculation,
- Lateral acceleration $\Rightarrow \text{Acc}=\frac{V^2}{R}$. 
Rollover risk prediction

The rollover risk is detected when one of the wheels of the same axle leaves the ground

\[ LTR = \frac{|F_{zL} - F_{zR}|}{F_{zL} + F_{zR}} = \frac{2m_2}{m \cdot T} \left( h_0 + h \cos \phi \right) \frac{a_y}{g} + h \sin \phi < R_{\text{lim}} = 1 \]

- \( m \): total masse,
- \( m_2 \): sprung masse
- \( T \): distance between Wheels of the axle
- \( a_y \): lateral acceleration,
- \( \phi \): roll angle
- \( h_0 \): roll axis height
- \( H = (h_0 + h \cdot \cos \phi) \): center of gravity height
Selected Truck Model

Tractor/Semi-trailer model

**Inputs:** Road profile, skid resistance, radius of curvature, Longitudinal and transverse slope.

\[
M(q)q + C(q, q)q + G(q) = F_g \in \mathbb{R}^{12}
\]

\[
q = [x, y, z, \phi, \psi, \gamma, q_1, q_2, q_3, q_4, q_5, q_6]^T
\]

**\(F_g\):** Forces vector (internal and applied)
- Tyres forces
- Suspensions forces
Tractor/Semi-trailer model description

Engine Torque
- Couple Moteur
- $M_3(\omega,1) \cdot \text{couple}\$
- Vitesse corrigé
- $[t,V_c]$

Vehicle speed
- $v_{\text{corr}}$

Infrastructure Data Base
- Braquage2
- Pente
- Unl
- Devers
- Infrastructure

Dynamic States (Positions, Speeds, accelerations)
- Etats Dynamiques
- app

Modélisation PL/Infrastructure
- MODELE PL
- INTERACTION PNEUMATIQUE/CHAUSSEE
<table>
<thead>
<tr>
<th>INPUTS</th>
<th>OUTPUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road data :</td>
<td>Vehicle positioning (X, Y and Z)</td>
</tr>
<tr>
<td>Radius of curvature, Longitudinal</td>
<td>Longitudinal, lateral and vertical</td>
</tr>
<tr>
<td>and transverse slop, Skid resistance, road profile, GPS</td>
<td></td>
</tr>
<tr>
<td>Steering angle</td>
<td>Roll, pitch and yaw angle</td>
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<tr>
<td>Engine Torque</td>
<td>Suspension deflections</td>
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<td></td>
<td>Vertical displacements of the wheels</td>
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<td></td>
<td>Impact forces (Fx, Fy and Fz)</td>
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<tr>
<td></td>
<td>Vehicle speeds</td>
</tr>
<tr>
<td></td>
<td>(Vx, Vy and Vz)</td>
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<tr>
<td></td>
<td>Vehicle accelerations</td>
</tr>
<tr>
<td></td>
<td>(Ax, Ay and Az)</td>
</tr>
</tbody>
</table>
Rollover Risk Predictive System

- Speed reducing
- Route changing

Map data base GPS

- Speed limits
  - Acceleration limits
  - Rollover risk

Rollover predictive system
Acceleration limit

\[ ay \leq \frac{gmT}{2m_2H} - \frac{gh \sin(\phi)}{H} \]

\[ ay = \frac{V^2}{R} \]

\[ V \leq \sqrt{R \frac{gmT}{2m_2H} - R \frac{gh \sin(\phi)}{H}} \]

Recommended speed

\[ V_{\text{max}} = \sqrt{R \frac{gmT}{2m_2H} - R \frac{gh \sin(\phi)}{H}} \]

\( R \): Radius of curvature
Rollover warning integration

Collected data (from CAN bus):

• BreakPedalPos - % of fully pressed
• CurrentGear - gear nr (maximum 12)
• SteeringWheelAngle – radians ➔ Used
• VehicleSpeed - km/h ➔ Used
• YawRate - rad/s ➔ Used
• FuelRate - instant l/h
• GPS_Latitude - decimal degrees N
• GPS_Longitude - decimal degrees E
• GPS_Speed - m/s ➔ Used
• GPS_Altitude - m (uncalibrated)
• GPS_Time - seconds since 1970
• CummulatedFuelRate - fuel used since the logging started observe! Unit in dl
Rollover warning integration

Off line study along the route

Recommended speed (Rsp)

Asp > Rsp

Actual measured speed (Asp)

No Action

NO

YES

Rollover risk

ALARM

Speed reducing
Experimental results
Experimental results
Experimental results
Experimental results
Experimental results
Experimental results
Experimental results

Route 3

Speed (km/h)

Time (s)

measured
recommended

Rollover risk zone
Experimental results
Conclusion

• The dynamic states of the vehicle are estimated, the recommended speed is calculated and the alarm is sent to the driver.

• Some false alarms are occurs. This is due to the fact that:
  1- the calculation is done off-line and not in real time
     ➔ The vehicle dynamics can be changed during the trip.
  2- The road data base is incomplete (SFC value)
  3- The vehicle parameters are not known

• Adding some sensors (measures) are necessary to have robust speed calculation and reducing false alarms.