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# Increasing Driving Safety : Perception & Assessment of Collision Risks with other Road Users

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► **To cite this version:**

Christian Laugier. Increasing Driving Safety : Perception & Assessment of Collision Risks with other Road Users. Workshop "Safety of Autonomous Vehicles", Final scientific event of the French Tornado project, Nov 2020, Paris & on-line event, France. hal-03147801

**HAL Id: hal-03147801**

**<https://inria.hal.science/hal-03147801v1>**

Submitted on 20 Feb 2021

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# Increasing Driving Safety

## *Perception & Assessment of Collision Risks with other Road Users*

**Dr. Christian LAUGIER**

*Research Director at Inria ([christian.laugier@inria.fr](mailto:christian.laugier@inria.fr))*

Invited Talk

*Workshop “Safety of Autonomous Vehicles”*

*Final Scientific event of the French Tornado R&D project*

*Paris, On-line event, November 5<sup>th</sup> 2020*

# Increase Driving Safety

## Perception & Assessment of Collision Risks with other Road Users

*C. Laugier, Research Director at Inria*

*Workshop « Safety of Autonomous Vehicles », Tornado project, Nov 5<sup>th</sup> 2020*

- **Technological breakthrough & Numerous AV experimentations in real traffic conditions**



- **Millions of miles driven last decade... but SAFETY is still not fully guaranteed !**

*=> Several benign or fatal accidents involving AVs (Perception failure & Takeover difficult)*



**=> Perception & Decision-making technologies have still to be improved for mixt traffic !!!**





**Situation Awareness & Decision-making**

=> *Safe intentional navigation (using semantics)*



**Dealing with unexpected events**

=> *Avoiding upcoming collisions with "something"*

## Main difficulties

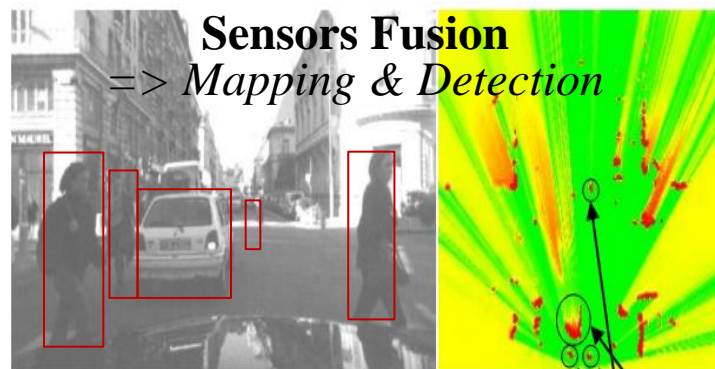
- Dynamic & Open Environments, Incompleteness & Uncertainty, Sensors limitations, Real-time + Validation
- Mixed traffic (Human in the loop) => ***Human Aware Decision-making process***

*Taking into account Interactions + Behaviors + Social & Traffic rules*

# 1<sup>st</sup> Paradigm: Embedded Bayesian Perception



**Embedded Multi-Sensors Perception**  
 => *Continuous monitoring of the dynamic environment*



**Dynamic scene interpretation**  
 => *Using Context & Semantics*



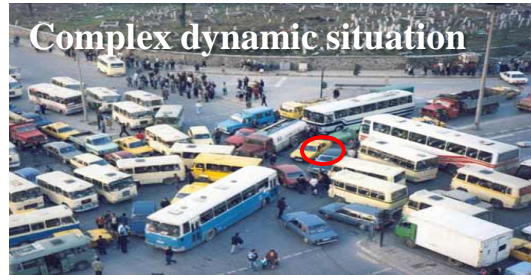
**Characterization of the local Safe Navigable Space & Collision Risk**

- ✓ *Exploiting the Dynamic information for a better understanding of the scene !!!!*
- ✓ *Reasoning about Uncertainty & Time window => Past & Future predicted events*
- ✓ *Bayesian Sensors Fusion + Scene interpretation using Contextual & Semantic information*



# 2<sup>nd</sup> Paradigm: Collision Risk Assessment

=> Avoiding Pending & Future Collisions

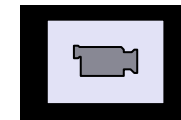


Several PhD theses

- ✓ Predict environment changes on a given “time horizon  $t+\delta$ ” => Using **History & Motion models**
- ✓ Estimate the Probabilistic Risk of Collision at  $t+\delta$  ( $\delta$  = a few seconds ahead)
- ✓ Make Driving Decisions by taking into account the **Predicted behavior** of all surrounding traffic participants (cars, cycles, pedestrians...) & **Social / Traffic rules** (traffic participants interactions)

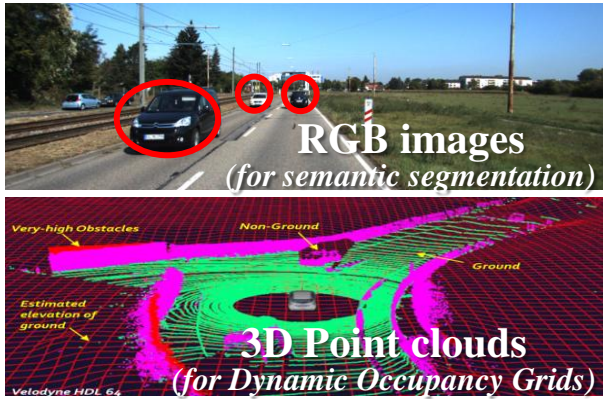
<p><b>Real world</b></p> <p>Moving Dummy</p> <p>Observed moving Car</p> <p>Camera view (in ego vehicle) 1s before the crash</p>	<p><b>Static</b></p>	<p><b>Dynamic</b></p> <p>No risk (White car) =&gt; safe motion direction</p> <p>High risk (Pedestrian)</p>	<p><b>Risk / Alarm</b></p> <ul style="list-style-type: none"> <li>• Risk Location</li> <li>• Collision Probability</li> <li>• TTC</li> </ul>
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- Video: Collision Risk Assessment**
- Yellow => time to collision: 3s
  - Orange => time to collision: 2s
  - Red => time to collision: 1s



# 3<sup>rd</sup> Paradigm: Models improvements using Machine Learning

□ Perception level: *Construct “Semantic Grids” using Bayesian Perception & DL*



□ Prediction & Decision-making level: *Learn driving skills for Autonomous Driving*



- 1<sup>st</sup> Step: Modeling Driver Behaviors using IRL
- 2<sup>nd</sup> Step:
  - Predict behaviors of surrounding vehicles (using Perception & learned Behavior models)
  - Make “safe & consistent” Driving Decisions for Ego Vehicle

□ Open questions: *Training step (Available Datasets limited), Real-time processing (difficult), Classification Errors (often not explainable), Domain adaptation (e.g. changing weather conditions)*

# Concluding remarks & Discussion

- Increasing impact of AI + Real-time data processing capacity + Increased sensor performance + New Models & Embedded algorithms + Multiplication of tests in real conditions
  - => *The unmanned car is gradually becoming a technological reality*
- Safety is not yet fully guaranteed !
  - *Current Perception & Scene Understanding algorithms are not robust enough for complex & highly dynamic environments*
  - *Need to take better account of Interactions with other road users (using also AI approaches)*
  - *Need to develop Validation & Certification Tools and Methodologies => Realistic simulators, Real-world testing protocols, Formal methods (e.g. Enable-S3 EU project & future French project Prissma)*
- User confidence & Acceptance by the human society will be decisive to allow a real deployment (e.g. “cohabitation” with other users such as pedestrians, bicycles, scooters ...)
  - *Autonomous vehicles a priori safer than cars driven by humans (inattention).... but 0 tolerance in the event of a fatal accident involving an autonomous vehicle !*
  - *Ethics & Responsibility issues must also be taking into account before any deployment*