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

Christian Laugier

Increasing Driving Safety

Perception & Assessment of Collision Risks with other Road Users

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Invited Talk

Workshop "Safety of Autonomous Vehicles"

Final Scientific event of the French Tornado R&D project

Paris, On-line event, November 5th 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 5th 2020

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

Tesla Autopilot L2 (ADAS)

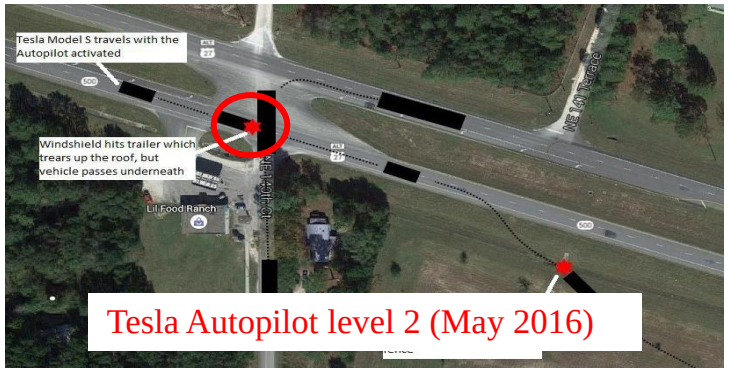
- *32 millions km covered since 2009*
- *1st US self-driving taxi service L3 (Phoenix, since Dec 2018)*

Robot taxi

Autonomous Shuttle service

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

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

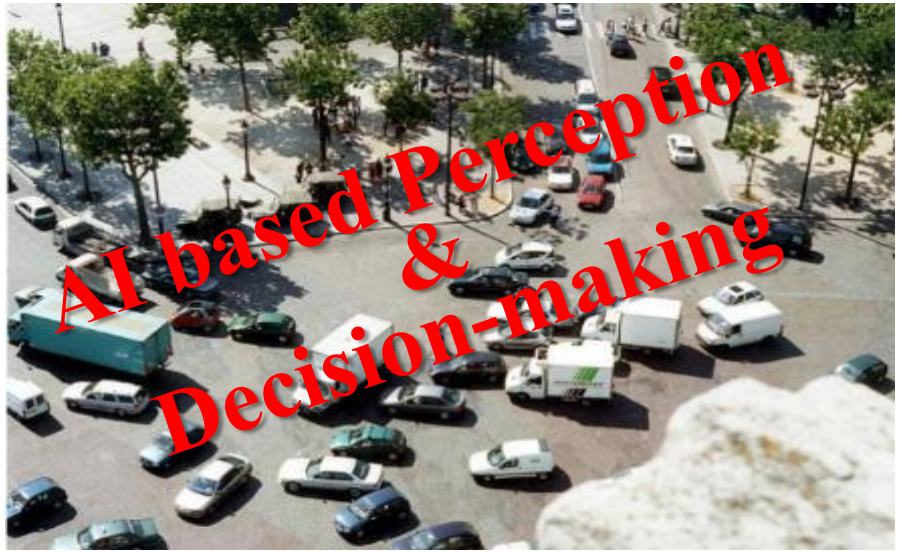


Tesla Autopilot level 2 (May 2016)


Self-driving Uber L3 (March 2018)

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

Perception & Situation Awareness Challenges



Situation Awareness & Decision-making

=> Safe intentional navigation (using semantics)

Dealing with unexpected events

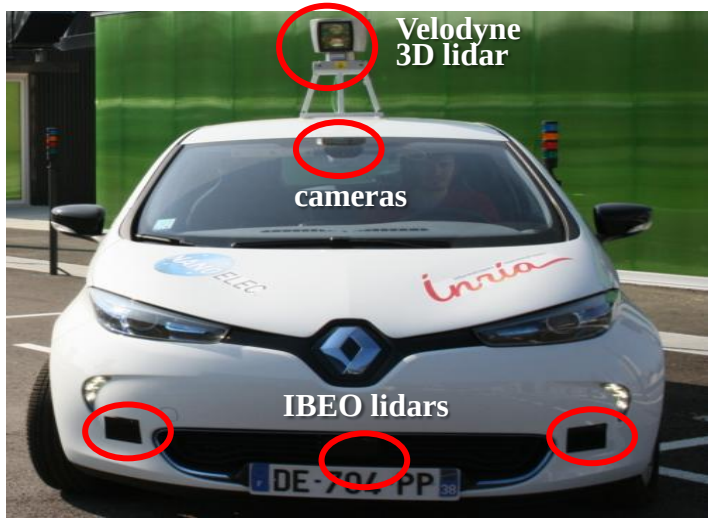
=> Avoiding upcoming collisions with "something"

Main difficulties

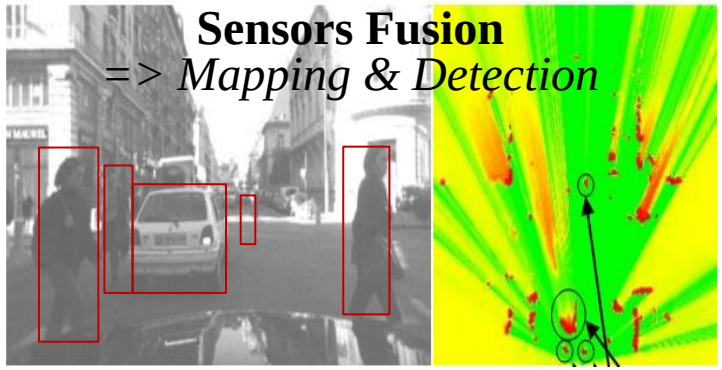
- Dynamic & Open Environments, Incompleteness & Uncertainty, Sensors limitations, Real-time + Validation
- Mixed traffic (Human in the loop) => ***Human Aware Decision-making process***

Taking into account Interactions + Behaviors + Social & Traffic rules

1st Paradigm: Embedded Bayesian Perception

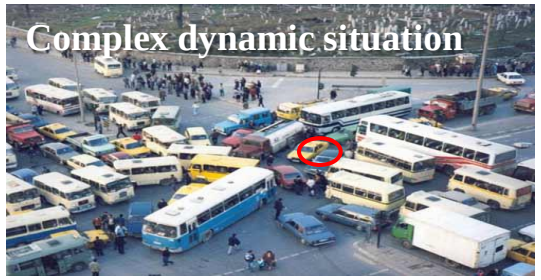


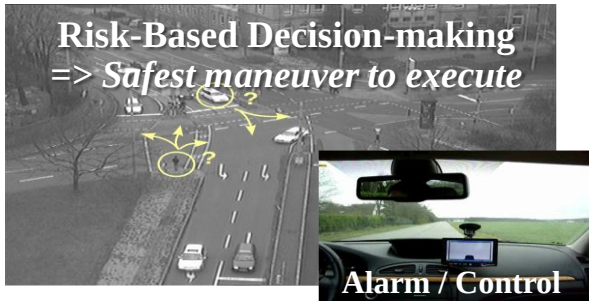
Embedded Multi-Sensors Perception
⇒ ***Continuous monitoring of the dynamic environment***



- ✓ ***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*

2nd Paradigm: Collision Risk Assessment
=> Avoiding Pending & Future Collisions



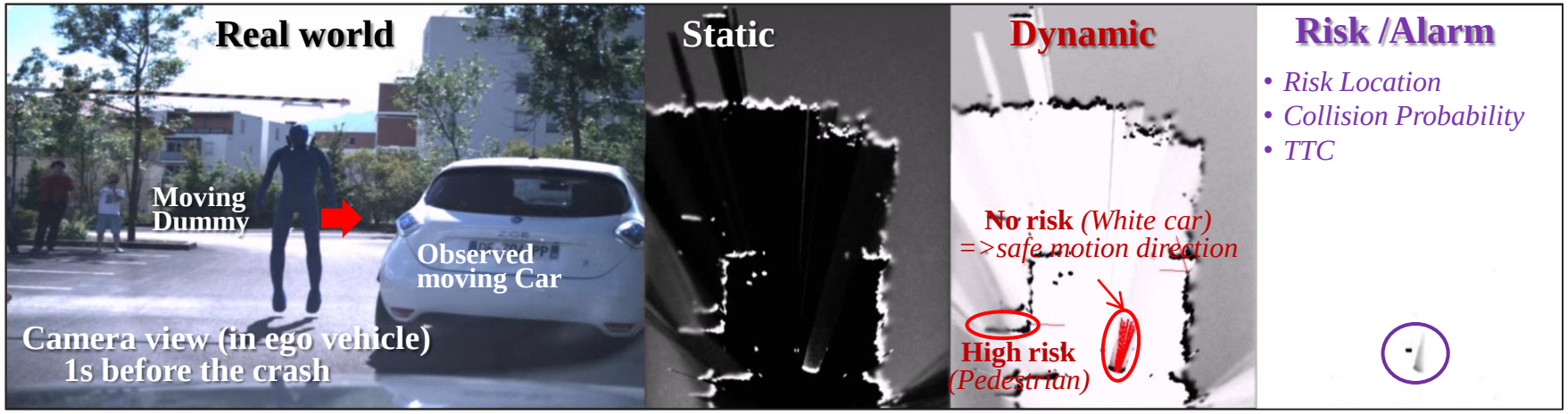


TOYOTA

RENAULT

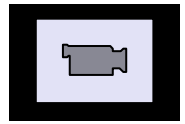
Several PhD theses

- ✓ ***Predict* environment changes** *on a given "time horizon t+δ" => Using* **History & Motion models**
- ✓ *Estimate the* ***Probabilistic Risk of Collision*** *at t+δ (δ = 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)*



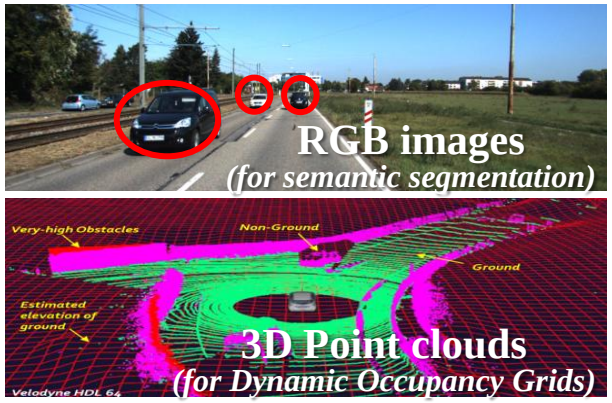
Video: Collision Risk Assessment

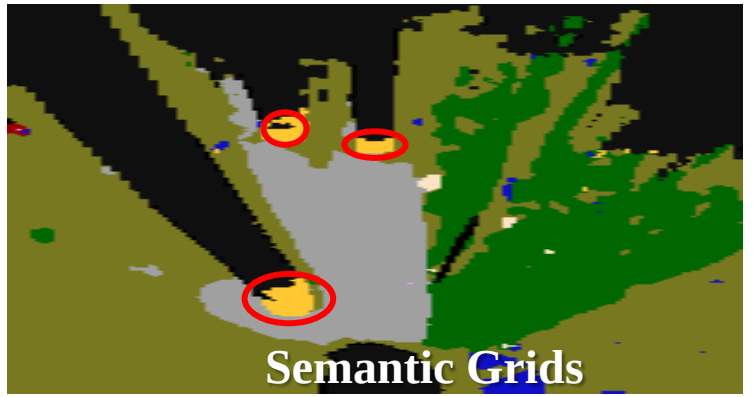
- Yellow => *time to collision: 3s*
- Orange => *time to collision: 2s*
- Red => *time to collision: 1s*



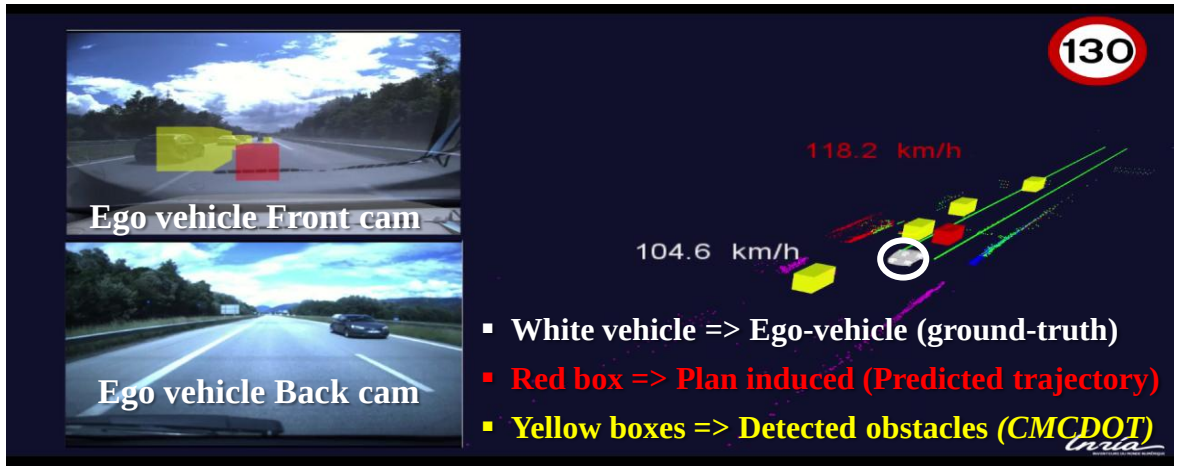
3rd Paradigm: Models improvements using Machine Learning

- **Perception level:** *Construct "Semantic Grids" using Bayesian Perception & DL*





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



- *1st Step: Modeling Driver Behaviors using IRL*
- *2nd 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*