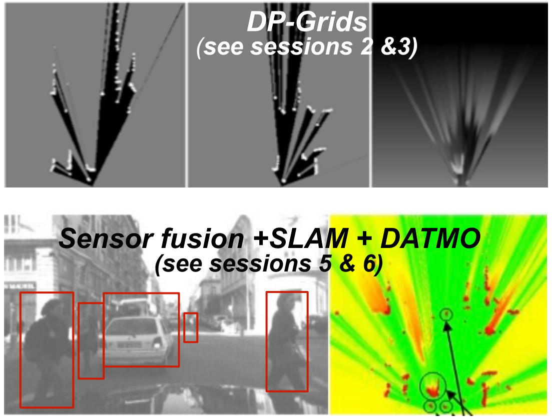
W4. Perception & Situation Awareness & Decision making

- Robot Perception for Dynamic environments: Outline & DP-Grids concept
- Dynamic Probabilistic Grids – Bayesian Occupancy Filter concept
- Dynamic Probabilistic Grids – Implementation approaches
- Object level Perception functions (SLAM + DATMO)
- Detection and Tracking of Mobile Objects – Problem & Approaches
- Detection and Tracking of Mobile Objects – Model & Grid based approaches
- **Embedded Bayesian Perception & Short-term collision risk (DP-Grid level)**
- Situation Awareness – Problem statement & Motion / Prediction Models
- Situation Awareness – Collision Risk Assessment & Decision (Object level)

Embedded Bayesian Perception – *Main features*

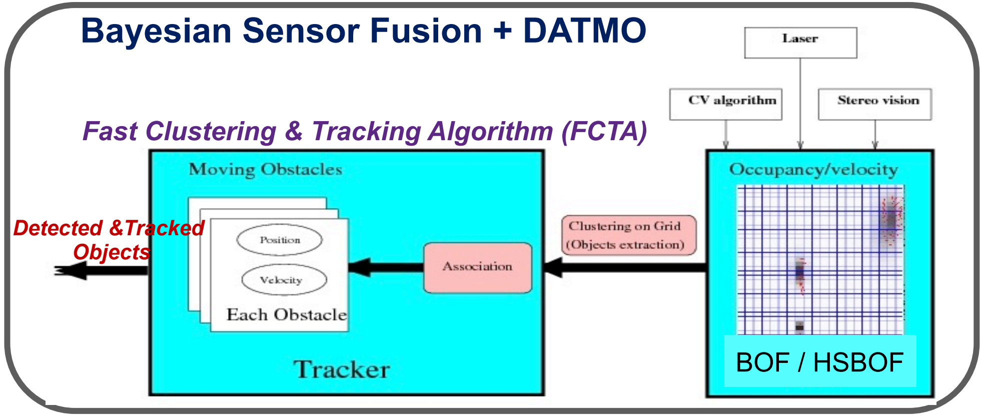
Perception process
(reminder session 1)



- **Main difficulties**
  - *Noisy data, Incompleteness, Dynamicity, Discrete measurements + Real time!*
- **Approach: Bayesian Perception**
  - *Reasoning about **Uncertainty** & **Time window** (Past events & Near future)*
  - *Improving robustness using **Bayesian Sensor Fusion** (Multiple sensors + Sensors & Dynamic models + Bayesian Inference)*
  - ***Scene Interpretation** using Semantic & Contextual information*

Embedded Bayesian Perception on a real vehicle

DP-Grid based Architecture



Architecture combining:

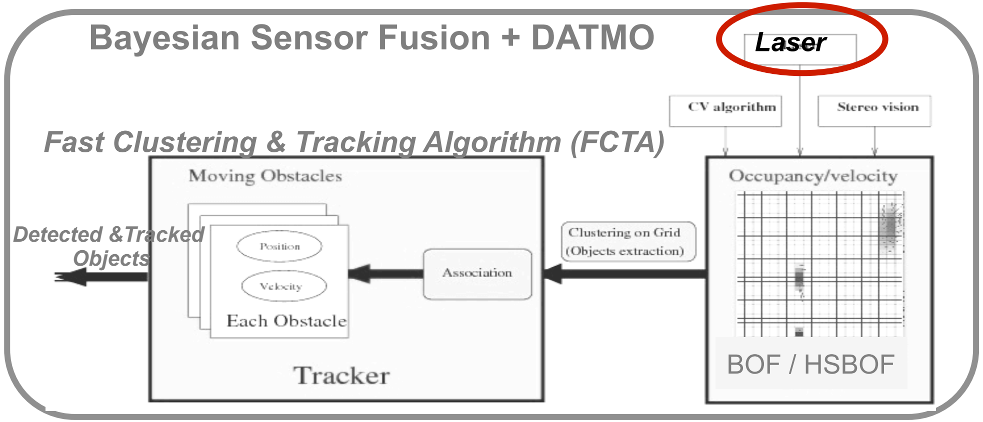
- DP-Grid construction
- Grid-based SLAM & DATMO

- **Construct & Update on-line** (real-time) a DP-Grid model of the Dynamic Environment ➔ *Sensor Fusion & BOF / HSBOF*
- **Extract Object level data** using FCTA & Specialized perception functions *(e.g. lane tracking & localization)*

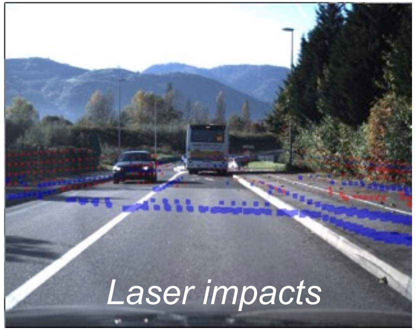
[Mekhnacha 09] [Laugier et al ITSM 11]

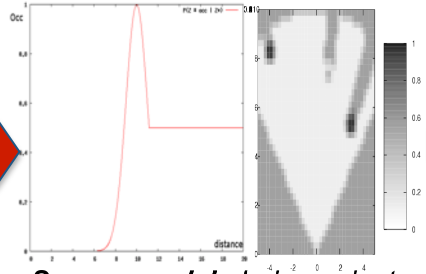
Embedded Bayesian Perception on a real vehicle

DP-Grid based Architecture



Laser perception





Sensor model *: Independent beam model*

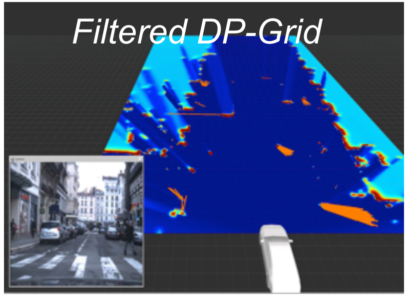
Laser Data Fusion (BOF / HSBOF)

⇒ 8 layers, 2 lasers

+

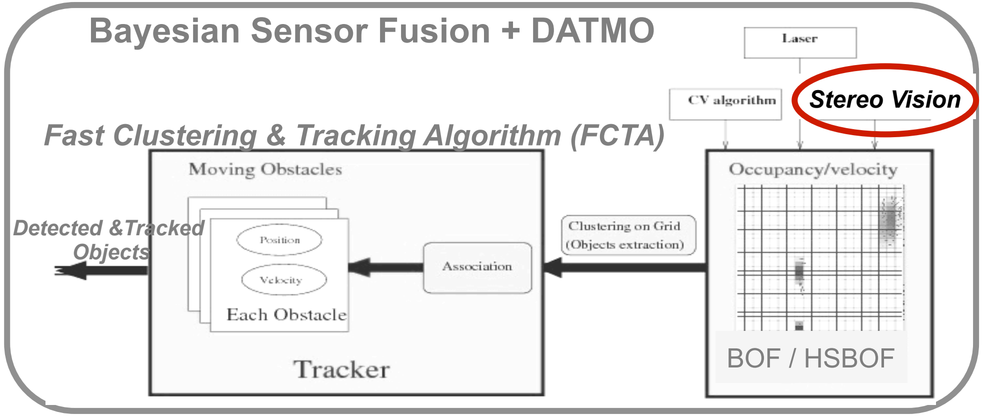
Motion detection

⇒ Odometry & IMU

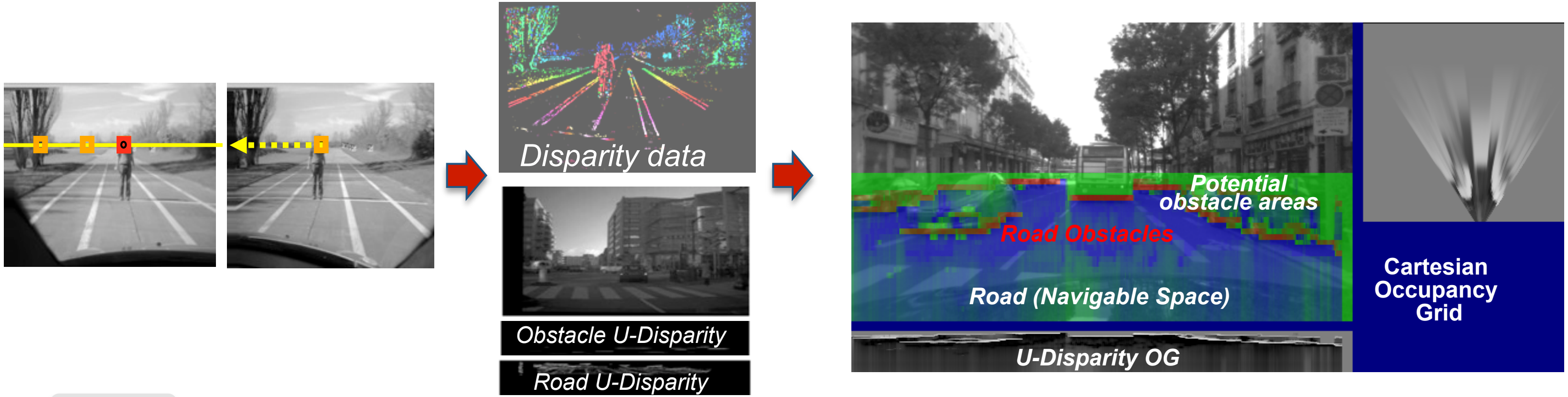


Embedded Bayesian Perception on a real vehicle

DP-Grid based Architecture



Stereo Vision



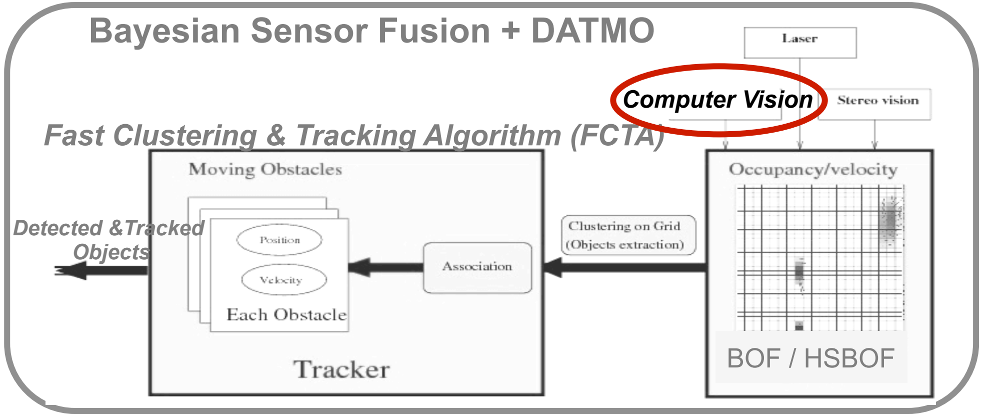
Embedded Bayesian Perception on a real vehicle

Stereo-vision perception (experimental results)

- Scene view provided by vehicle front camera
- Superimposition of Road Free space (blue) & Obstacles (red)
- Display Cartesian Occupancy Grid & U-Disparity

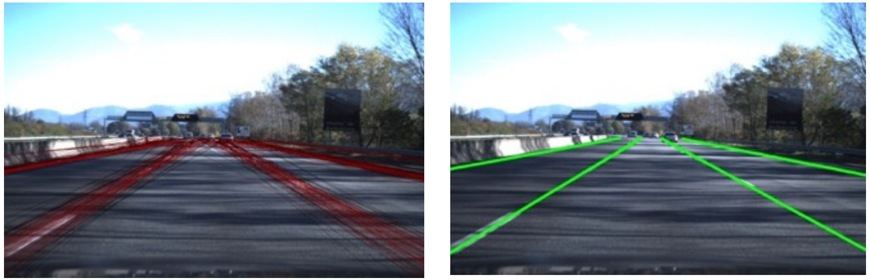
Embedded Bayesian Perception on a real vehicle

DP-Grid based Architecture

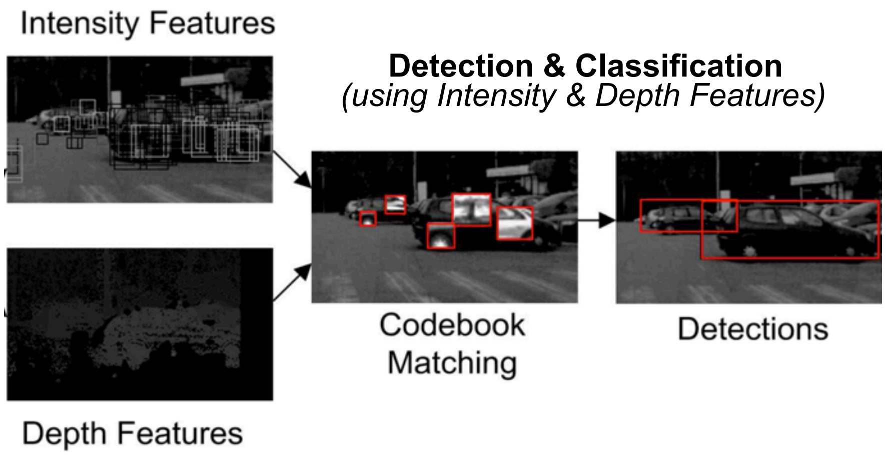


Computer Vision

Specialized perception functions



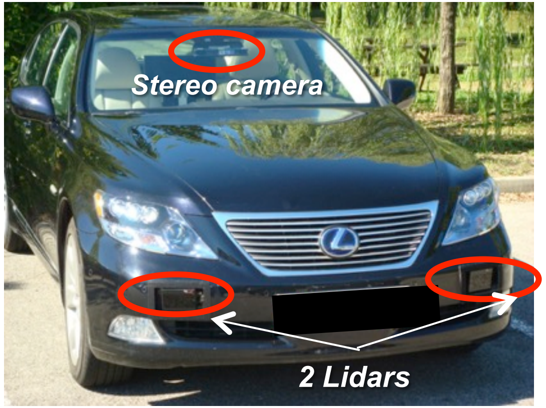
Multi-Lane tracker & Localization
(vision + Open Street Map)

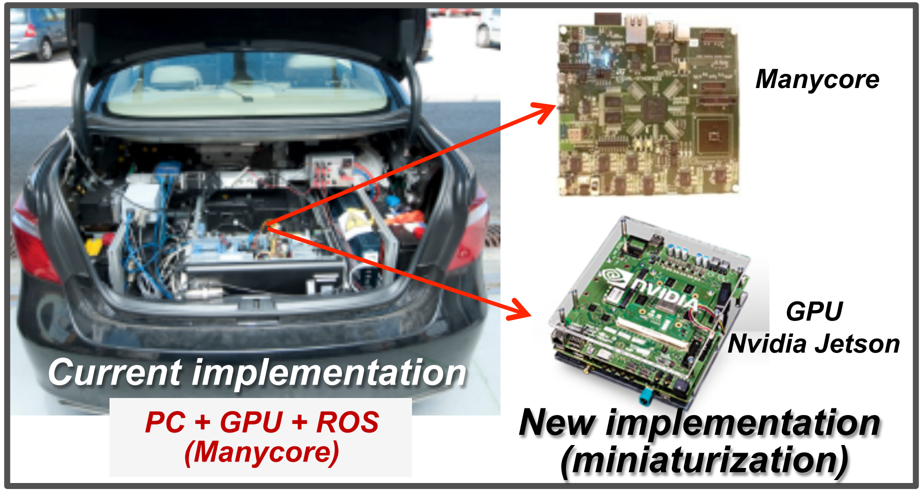


Detection & Classification
(using Intensity & Depth Features)

Embedded Bayesian Perception platform
Vehicle Architecture

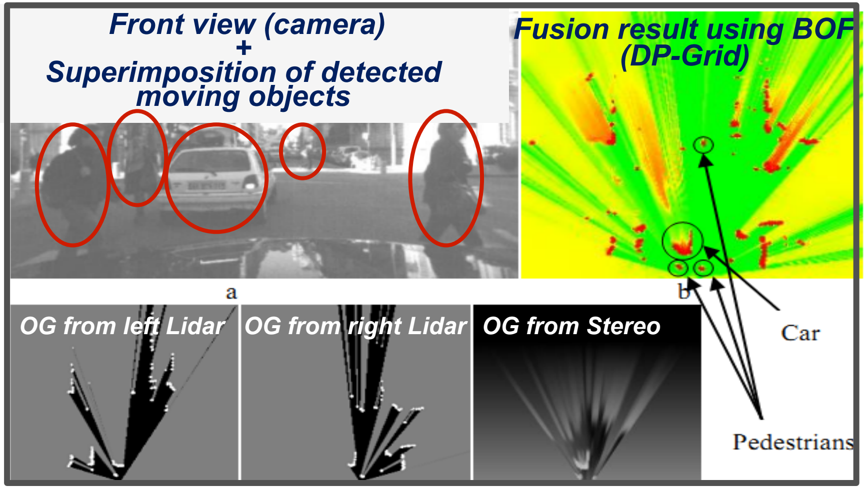
Lidars + Stereo + Inertial sensor + GPS





Embedded Bayesian Perception platform
System outputs

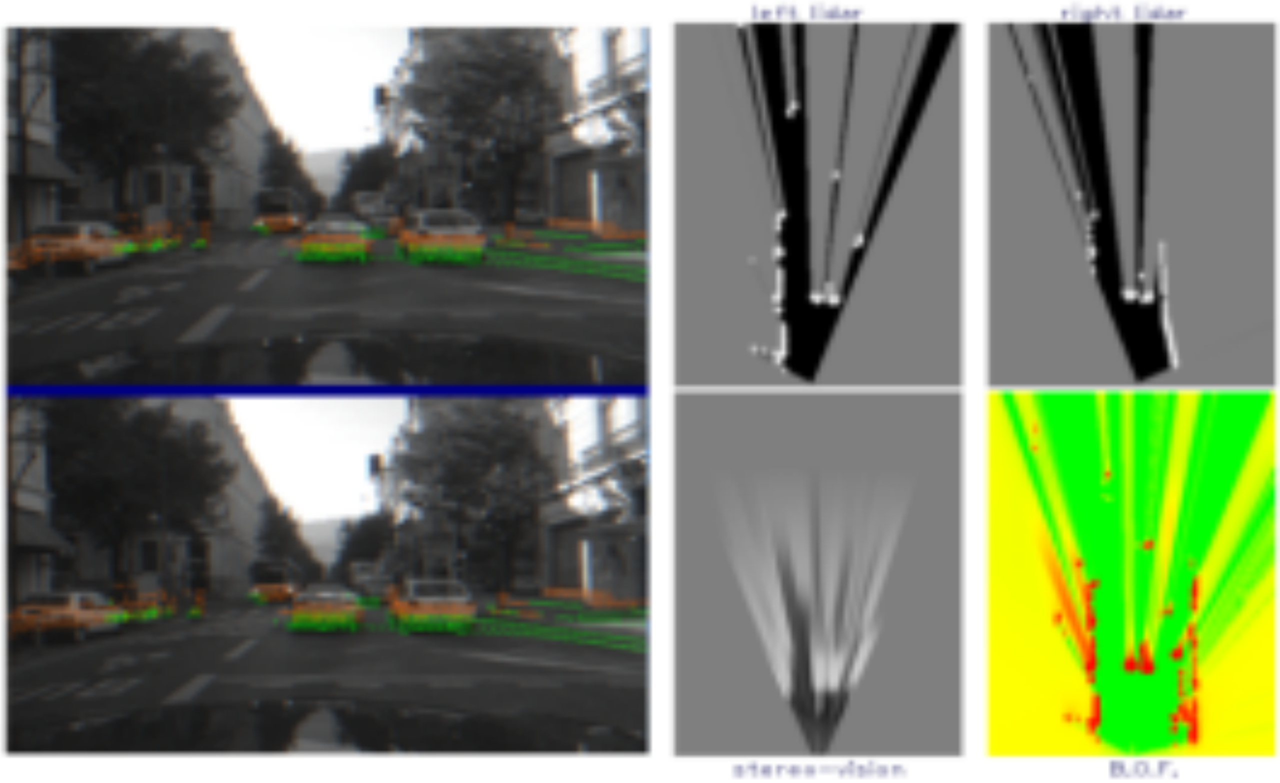
Localization & Recorded Trajectory
Open Street Map + GPS + IMU + Odometry



An Embedded Bayesian Perception platform

Experimental results *(Bayesian sensor fusion, 25 Hz)*

left & right laser raw data



left & right laser OG

Resulting DP-Grid
(occupancy + velocity)

Stereo vision OG

Estimating short-term collision risk
DP-Grid level *(using HSBOF)*

- **Objective**
  - **Collision risk** estimation at time t *(horizon t+δ)*
  - Localization of risks in ***Space & Time***
  - Still before object analysis *(DP-Grid level)*

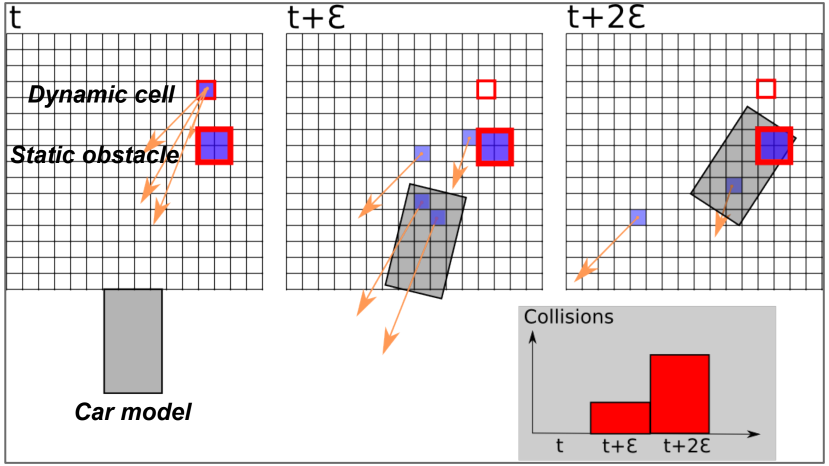
δ= 0.5 s => Precrash
δ= 1 s => Collision mitigation
δ = 1.5 s => Warning / Braking

Update frequency : 25 Hz

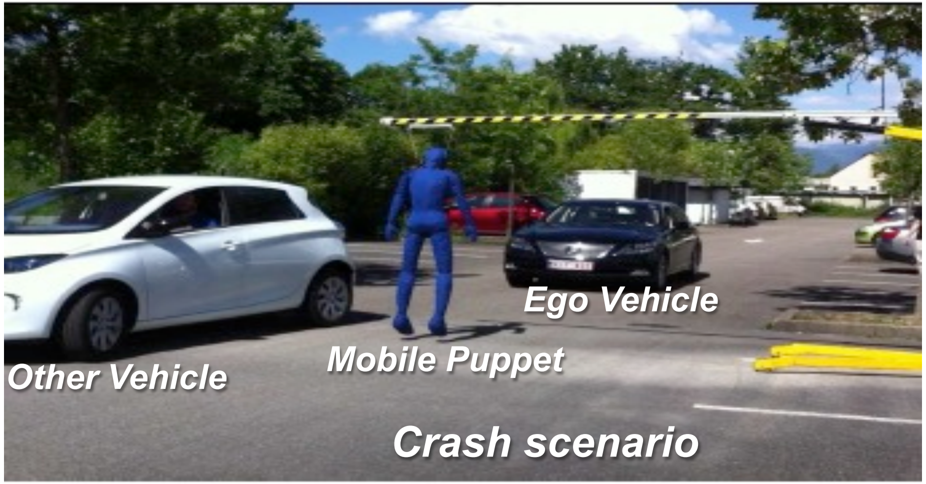
Estimating short-term collision risk
DP-Grid level *(using HSBOF)*

- **Approach**
  - **Projecting over time** the estimated scene *(Particles & Occupancy)* & Car model *(Shape & Velocity)* ➔ *Apply a **conservative motion model** (using current car motion data)*
  - Collision assessment for every next time step
  - Integration of Risk over a time range *[t t+δ]*

δ= 0.5 s => Precrash
δ= 1 s   => Collision mitigation
δ = 1.5 s => Warning / Braking



Estimating short-term collision risk
Experimental results

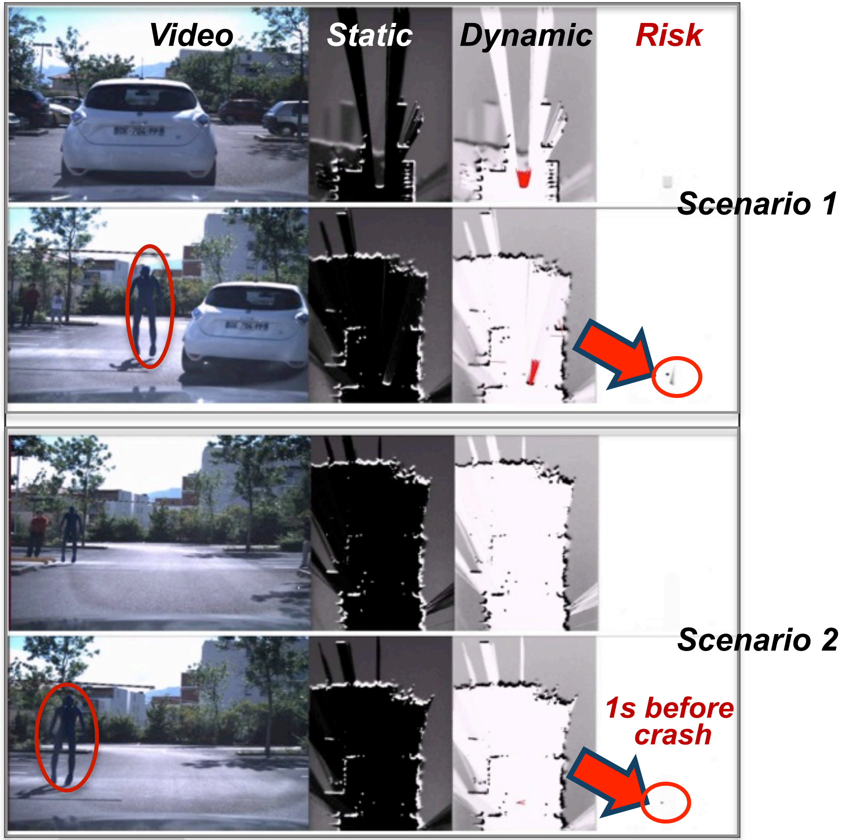


Results

- *Detection a few seconds ahead of risky situations*
  - *Urban ➔ No false alarm (cars, pedestrians…)*
  - *Crash scenarios ➔ All collisions predicted before the crash (1s or 1.5s)*

Estimating short-term collision risk

Experimental results: Crash scenario



Estimating short-term collision risk

Experimental results: Crash scenario (video)