Bayesian Perception & Decision for Intelligent Mobility

E-Motion & Chroma teams
Team objectives & local collaborations

- R&D work performed in the e-Motion & Chroma Inria teams
  - The objective is to develop technologies for “Cooperative & Human-Aware Robots in Dynamic Environments”

- Work related to “Smart Cities & Mobility Innovations”:
  - Focusing on “Perception & Decision for Intelligent Mobility in Human environments”

- Collaborations: Toyota, Renault, Stanford & Berkeley (context Inria@SV)
  - Several stays (Stéphanie Lefevre, former PhD student) in Stanford & Berkeley (about 3 years)
  - Several Publications & Awards & Patents (Toyota, Renault, Inria-Berkeley)
Challenge

Safe & Socially Compliant Robot Navigation in Open & Dynamic Human Environments

Focus on Perception & Decision under Uncertainty

Mobile Robots among peoples

ADAS & Autonomous Vehicles
Key Technology 1: Bayesian Perception

- **Main difficulties**
  
  Noisy data, Incompleteness, Dynamicity, Discrete measurements + **Real time**!

- **Approach: Bayesian Perception**
  
  - Reasoning about **Uncertainty** & **Time window** *(Past & Future events)*
  - Improving robustness using **Bayesian Sensors Fusion**
  - Interpreting the dynamic scene using **Semantic & Contextual** information
Main difficulties
Uncertainty, Partial Knowledge, World changes, Human in the loop + Real time

Approach: Prediction + Risk Assessment + Bayesian Decision
- Reasoning about Uncertainty & Contextual Knowledge (History & Prediction)
- Estimating the collision risk (at $t+\delta$)
- Decision-making by taking into account the Predicted behavior of the observed mobile entities (cars, cycles, pedestrians …) & the Social / Traffic rules
A new framework using “Probabilistic Grids”

- Patented by Inria & Probayes, Commercialized by Probayes
- Used by: Toyota, Denso, Probayes, IRT Nanoelec / CEA

- Processing Dynamic Environments using DP-Grids (Occupation & Velocity Probabilities)
- Bayesian Inference + Probabilistic Sensor & Dynamic Models (Robust to sensing errors & occultation)
- Highly parallel processing (Hardware implementation: GPU, Many-core architecture, SoC)
Risky situations (Grid level, Conservative prediction)

⇒ Detect “Risky Situations” a few seconds ahead (0.5 – 3 s)
⇒ Risky situations are localized in Space & Time

Urban street experiments
⇒ Almost no false alarm (car, pedestrians …)

Crash scenario on test tracks
⇒ Almost all collisions predicted before the crash (0.5 – 2 s before)
Collision risk (Object level, Behavior-based) => Increased time horizon & complexity

- Trajectory prediction & Collision Risk => Patent Inria - Toyota - Probayes 2010

- Intention & Expectation => Patents Inria - Renault 2012 & Inria - Berkeley 2013
Main Features & Application domains

Possible applications

- Driving Assistance & Autonomous Driving

- Industrial mobile robots (AGV)

- Road infrastructure monitoring (Sensors & V2X)

- Mobility assistance (Individual or Public areas)

Main features

- Real-time & Embedded & Sensor Fusion
- Static & Dynamic parts characterization
- Mapping & Localization & Detection
- Probabilistic Risk for Decision-making
Thank you for your attention

Christian. laugier@inria.fr