

Bayesian Perception & Decision for Intelligent Mobility

E-Motion & Chroma teams

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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)

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Challenge

Safe & Socially Compliant Robot Navigation in Open & Dynamic Human Environments Focus on Perception & Decision <u>under Uncertainty</u>





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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



Key Technology 2: Bayesian Decision => Understand the situation + Avoiding Pending & Future Collisions



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)

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Risky situations (Grid level, Conservative prediction) ⇒ Detect "Risky Situations" a few seconds ahead (0.5 – 3 s) ⇒ Risky situations are localized in Space & Time

=> Almost no false alarm (car, pedestrians ...)





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)

Main features

- Real-time & Embedded & Sensor Fusion
- Static & Dynamic parts characterization
- Mapping & Localization & Detection
- * Probabilistic Risk for Decision-making



Road infrastructure monitoring (Sensors & V2X)



* Mobility assistance (Individual or Public areas)













Thank you for your attention Christian. laugier@inria.fr

