

Embedded Bayesian Perception by Dynamic Occupancy Grid Filtering

Lukas Rummelhard, Christian Laugier

▶ **To cite this version:**

Lukas Rummelhard, Christian Laugier. Embedded Bayesian Perception by Dynamic Occupancy Grid Filtering. GTC 2017 - GPU Technology Conference, May 2017, San Jose, California, United States. , pp.1, 2017. hal-01672134

HAL Id: hal-01672134
https://inria.hal.science/hal-01672134

Submitted on 23 Dec 2017

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Public Domain

Embedded Bayesian Perception by Dynamic Occupancy Grid Filtering

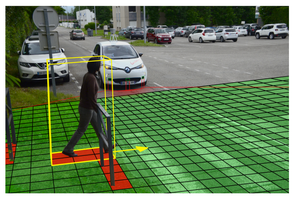
Lukas Rummelhard, Christian Laugier

Chroma Research Team, Inria

Abstract

A generic Bayesian perception framework, designed to estimate a dense representation of dynamic environments, by fusing and filtering multi-sensor data, has been developed, implemented and tested on embedded devices.

- Data from multiple sensors are properly fused in probabilistic occupancy grids
- Motion and robust occupancy are estimated by a specific Bayesian filter.
- Short-term collision risks and object parameters are assessed
- The whole system has been implemented and tested on Nvidia embedded devices, and produces real-time results

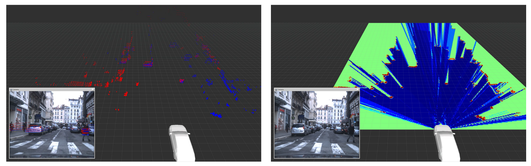


Context and Objective

- Development of low cost sensors and miniaturized computing units enables advanced perception technologies to be embedded on realistic products.
- Most solutions based on a single-sensor approach are limited by its specific constraints, while multi-sensor fusion remains complicated.
- Object-based methods restrict the surrounding representation, and have difficulty in managing highly dynamic environments.
- Objective : propose a generic perception framework, especially suited to sensor data fusion and filtering at a sub-object level, offering performances adapted to the constraints of embedded systems.

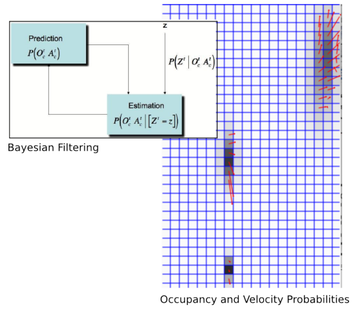
Multi-Sensor Fusion in Occupancy Grids

- The environment is represented through probabilistic occupancy grids, a dense and generic representation especially adapted to parallel computing and clear management of uncertainty
- Each sensor data is converted to occupancy estimation using specific sensor model
- Sensor occupancy estimates are combined by Bayesian fusion in every cell.



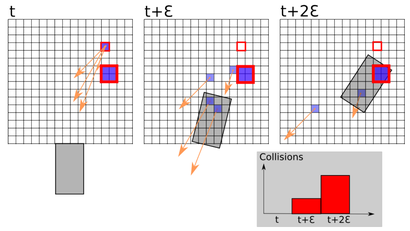
Temporal Filtering and Velocity Estimation

- Spatial occupancy is filtered and motion field inferred by a Bayesian filtering at the cell level (CMCDOT)
- The method combines different forms of models to optimize computations (occupancy grids for static components, particles for dynamic parts)
- Areas with contradictory data and without data are processed differently, improving both estimation precision and computation efficiency

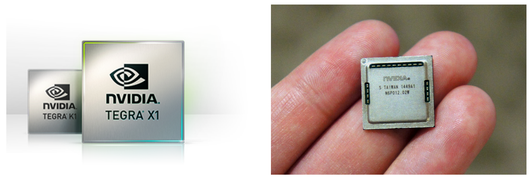


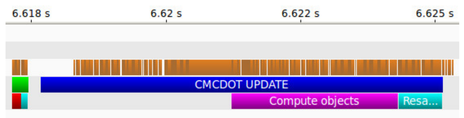
Risk Estimation and Object Detection

- The occupancy and the vehicle are projected over time using the estimated dynamics, potential collisions are referenced and accumulated.
- Risk grids are thus generated, where collision risks are localized in space and time
- Dynamic parts of the scene are segmented into objects using particle propagation markers.



Cuda Implementation



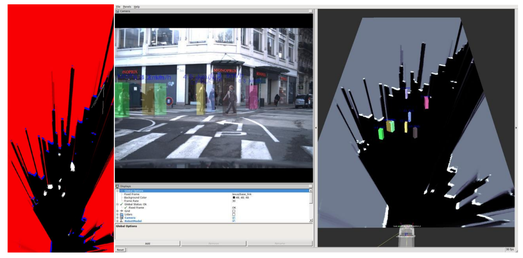


- Highly parallelizable framework, over cells and particles.
- Real-time implementation, optimized using Nvidia profiling utils
- Configuration with 8 Lidar layers (2x4), 1400x600 grids and 65536 velocity samples
- Jetson K1: Grid Fusion 17ms, CMCDOT 70ms
- Jetson X1: Grid Fusion 0.7ms, CMCDOT 17ms



Experimentations and Results

- Tests are conducted on real-time embedded perception systems, integrated on vehicles or dedicated perception units.



References

- A.Negre et al, "Hybrid Sampling Bayesian Occupancy Filter", IV 2014.
- L.Rummelhard et al, "Probabilistic Grid-based Collision Risk Prediction for Driving Application", ISER 2014.
- L.Rummelhard et al, "Conditional Monte Carlo Dense Occupancy Tracker", ITSC 2015.
- www.youtube.com/watch?v=TDaK3Yku8OA
- www.youtube.com/watch?v=DhKItJIhOho
- www.youtube.com/watch?v=uwIrk1TLFiM

Contact Information

- christian.laugier@inria.fr
- lukas.rummelhard@inria.fr