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)

Main perception functions & Applications

- **Two interdependent key functions: *SLAM + DATMO***
  - Mapping of the surrounding environment & Localizing in this environment
    ➔ *Simultaneous Localization and Mapping – SLAM*
  - Detection & Tracking surrounding Mobile Objects ➔ *DATMO*
  - Under computation constraints
    - ✓ *… through noisy sensor data*
    - ✓ *… at discrete time steps*
    - ✓ *… in real time*

- **For which task ?**
  - For navigation ➔ *Where am I & where can I go?*
  - For interaction ➔ *Who/where are the others scene participants & potential obstacles?*
  - For anticipation ➔ *Where are the other scene participants going to move?*
  - For collision risk estimation ➔ *Might I be soon in trouble?*

Environment modeling

- **Trade-offs between four main criteria**
  - Precision of the representation
  - Precision of the uncertainty modeling
  - Computation & Storage requirements
  - Capacity to represent the knowledge

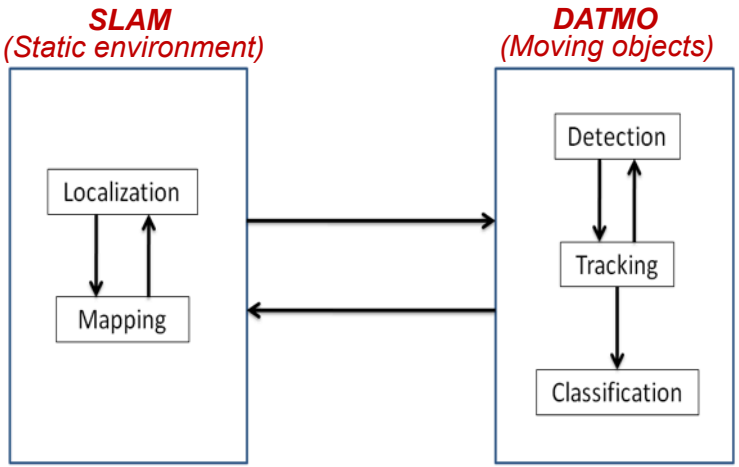
➔ *The trade-off is different for a car on a road, for a urban street with pedestrians, or for cycles*

- **Representation of the environment**
  - High level : Object based (with possible semantics)
  - Low level : Grid based
  - Medium level: Gaussians, stixels, octree…

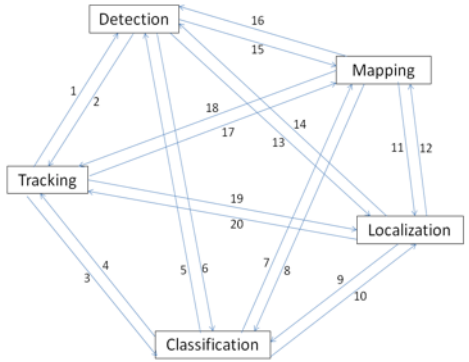
SLAM + DATMO: Interdependent perception functions

- **Objectives**
  - ✓ ***Construct a Map & Localize*** *the vehicle in the Map (SLAM)*
  - ✓ ***Detect & Track*** *moving objects on the navigable space (DATMO)*

- **Interdependent Perceptual Tasks**



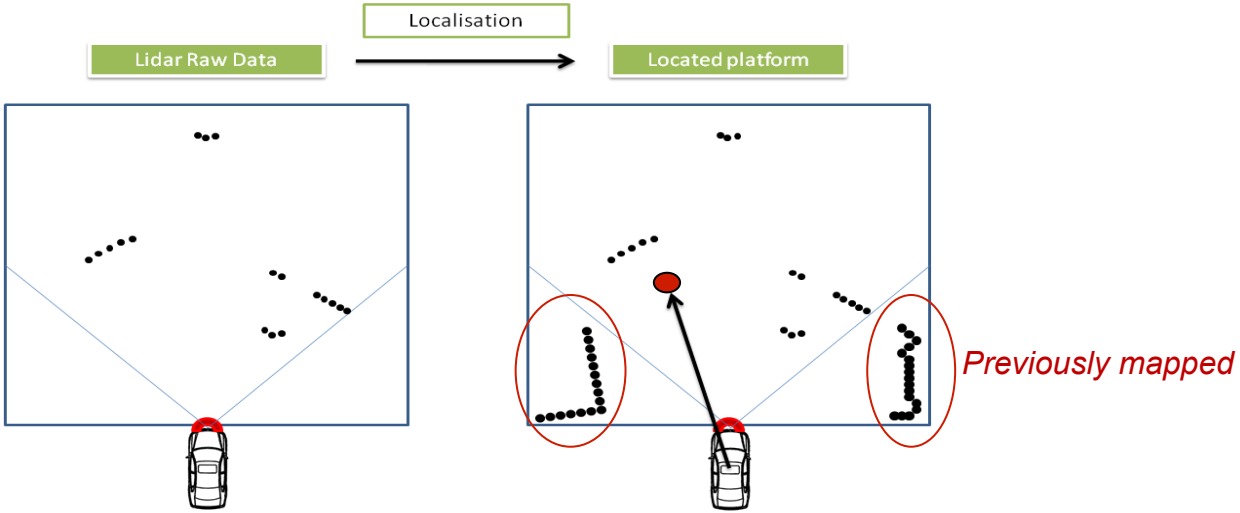
Schematic view of SLAM & DATMO algorithms



Interdependency of 5 perceptual tasks
[Gâté 2009]

SLAM + DATMO: Interdependent perception functions

- **Perceptual Task 1: *Localization (using lidar)***



Localization ➔ Current scan + Previously mapped features

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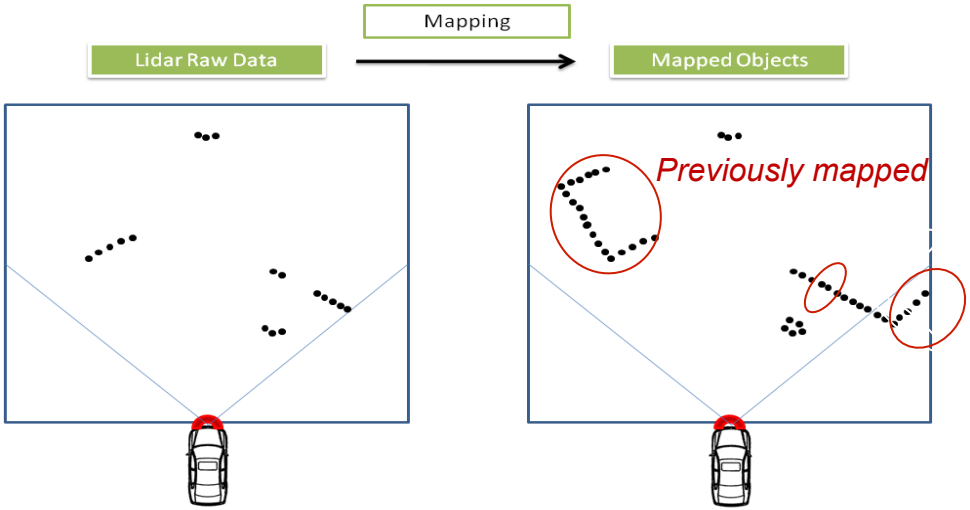
SLAM + DATMO: Interdependent perception functions

- **Perceptual Task 2:** ***Mapping (using lidar)***



Mapping update ➔ Previous map + Fusion with new scan data
(in red color on the right picture)

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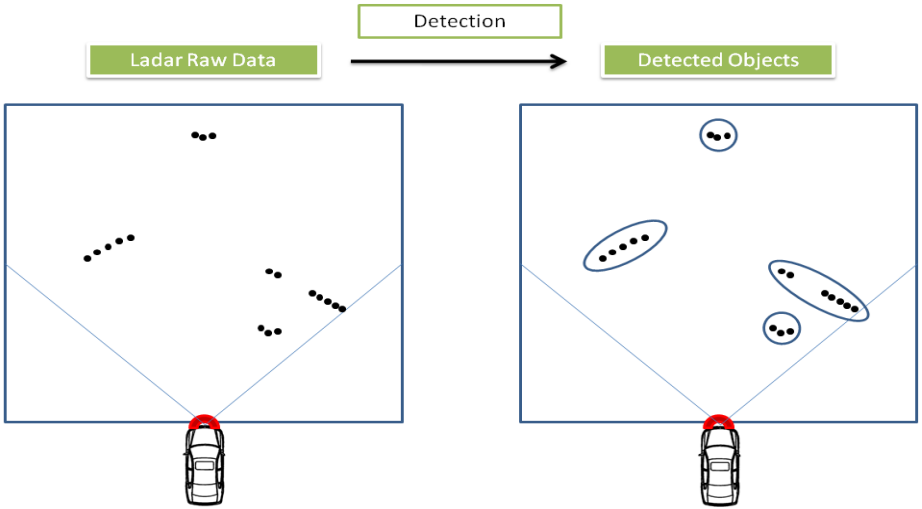
SLAM + DATMO: Interdependent perception functions

- **Perceptual Task 3:** ***Detection (using lidar)***



Detection ➔ Clustering scan data for reconstructing objects

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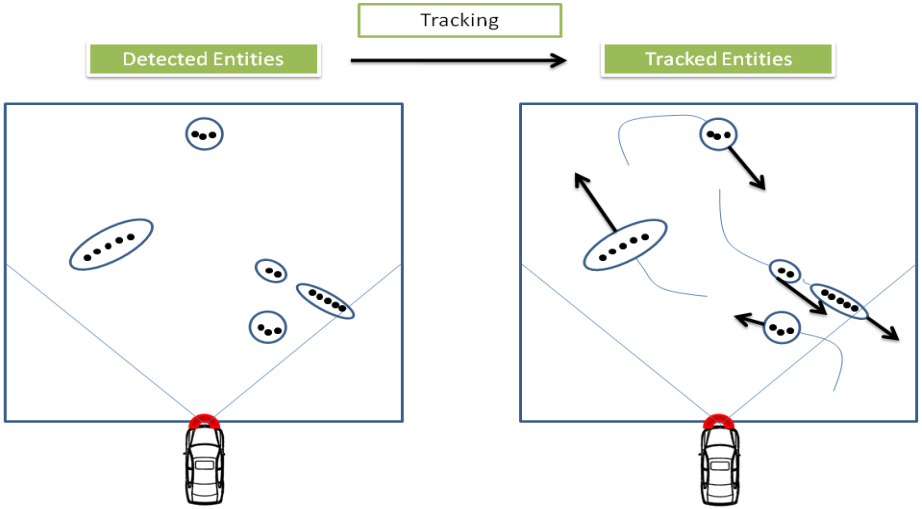
SLAM + DATMO: Interdependent perception functions

- **Perceptual Task 4: *Tracking (using lidar)***



Tracking ➔ Track over time & Characterize objects motions
(using previous detections)

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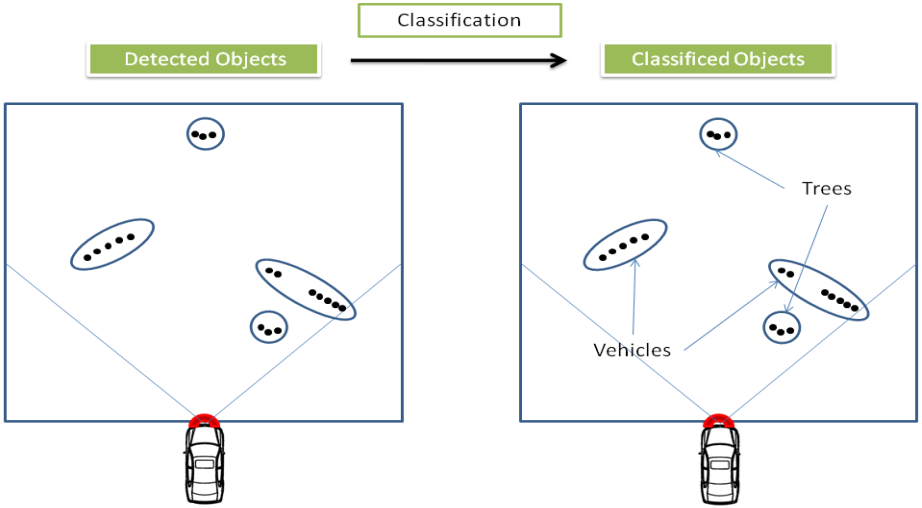
SLAM + DATMO: Interdependent perception functions

- **Perceptual Task 5:** ***Classification (using lidar)***



Classification ➔ Identify detected objects using known models

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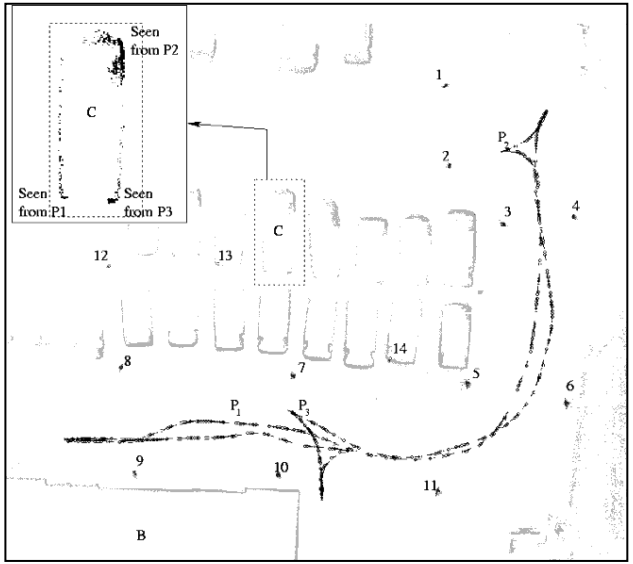
SLAM + DATMO – *Illustration*



Example of SLAM output [Pradalier 04]

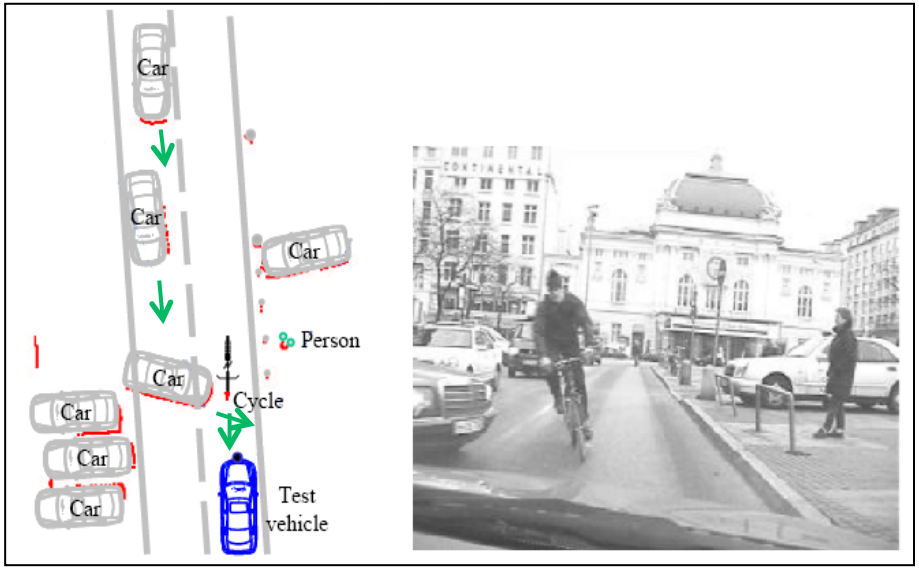
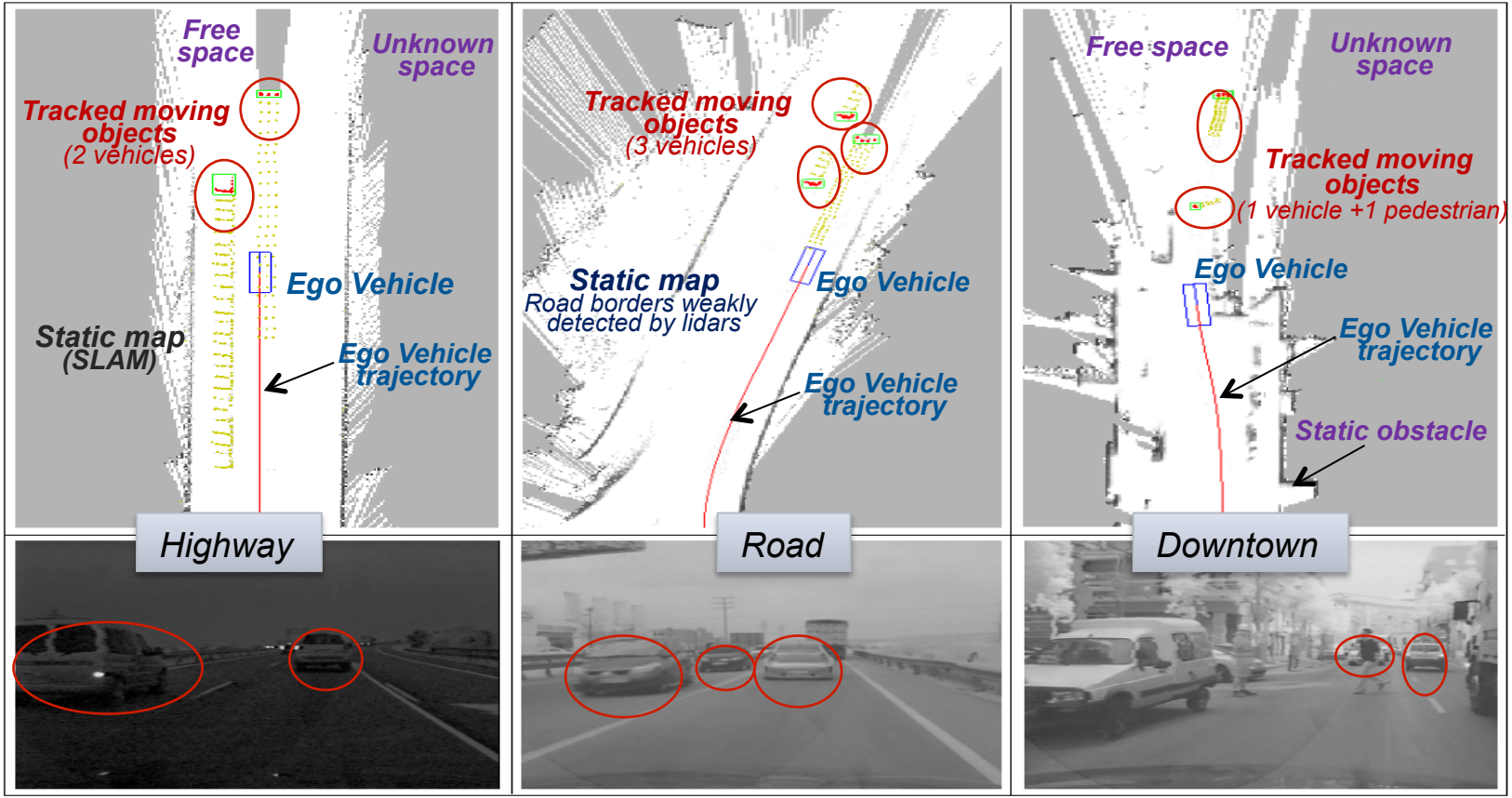


Illustration of DATMO problem [Vu 09]

Main interdependent steps for SLAM

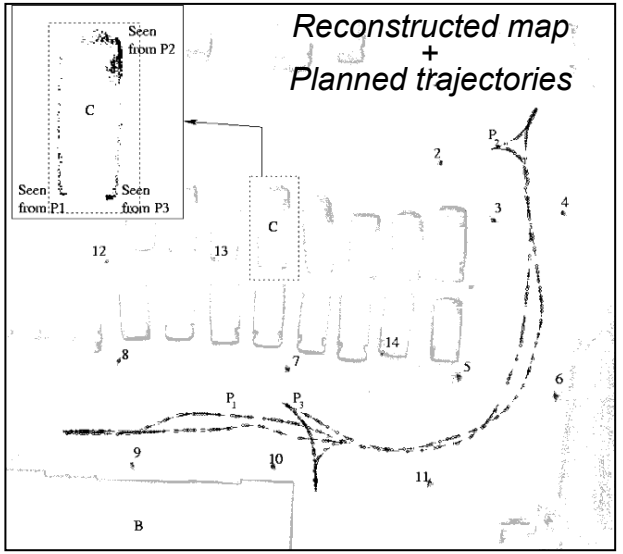
- *Registration & Loop Closure*
- *Static objects mapping*
- *Filtering out Moving Objects*

SLAM + DATMO – *Illustration*



Examples of SLAMMOT (SLAM + DATMO) results [Vu 2009]

SLAM + Motion Planning + Control – *Illustration*



[Pradalier & Hermosillo 03 -04]