Fast classification of Static and Dynamic Environment for Bayesian Occupancy Filter

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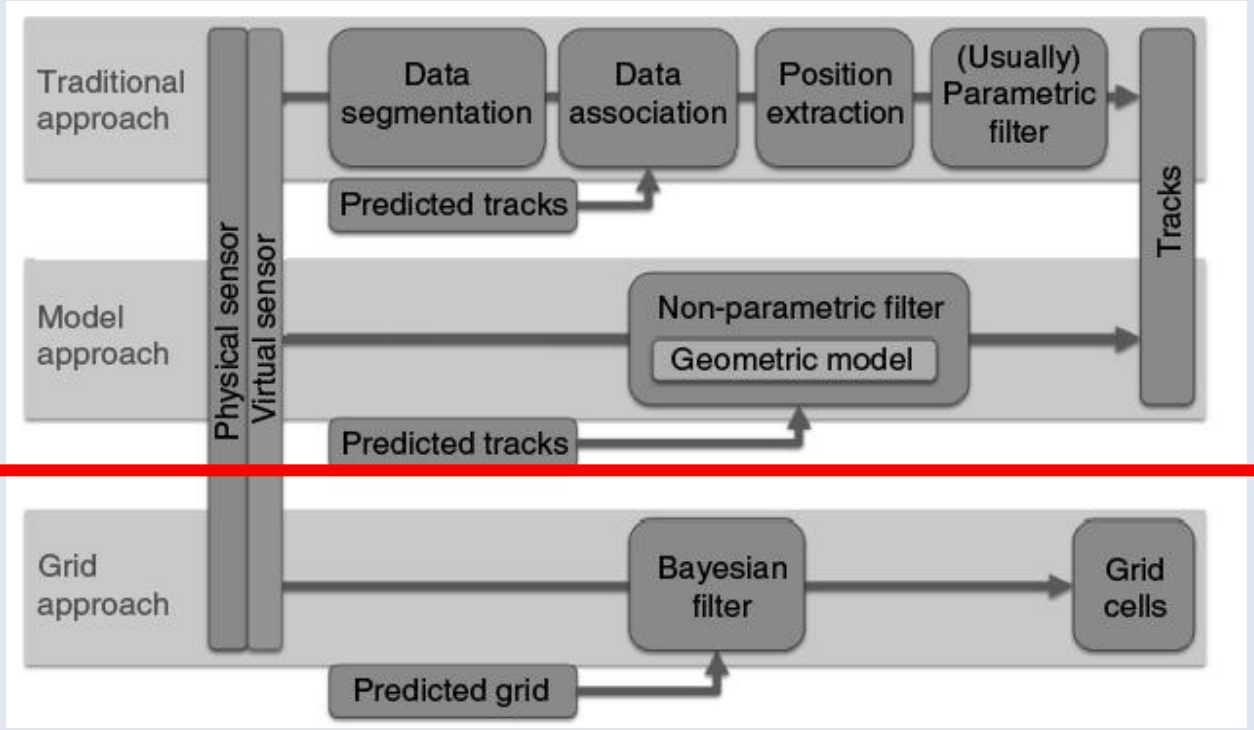
Outlines

- Environment monitoring in the Bayesian Occupancy Filter (BOF) framework
- Fast Motion Detection
- First results
- Conclusion

Grid based DATMO

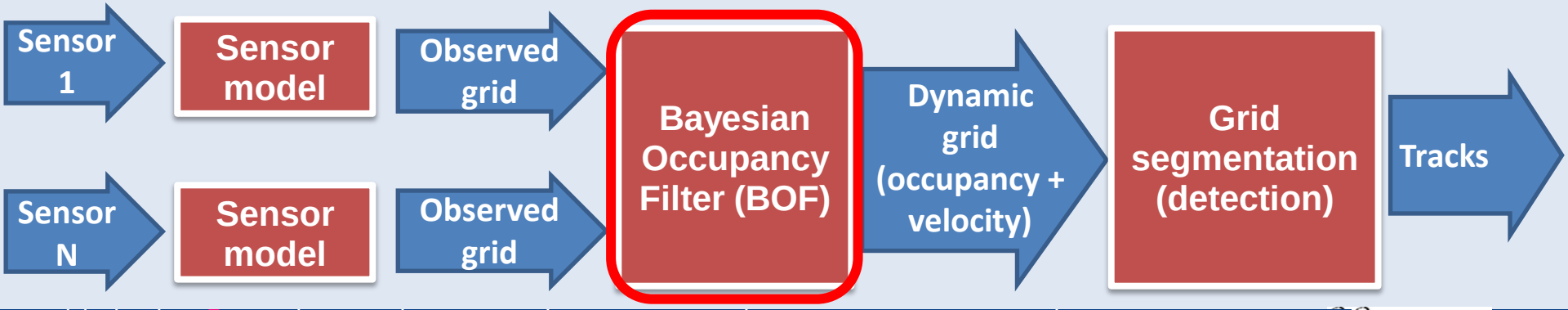
- For mobile robots: Detection and Tracking of Moving Objects (DATMO) is essential for navigation
- For intelligent vehicles : DATMO is essential for risk estimation/ADAS
- Three main approaches for DATMO [*Petrovskaya11*]:



Grid based DATMO

- Grid-based DATMO:
  - Occupancy grid framework [Elfes 89]
  - Each cell as a probability of being occupied
  - No ”objects”

➔ No data association



Bayesian Occupancy Filter (BOF)

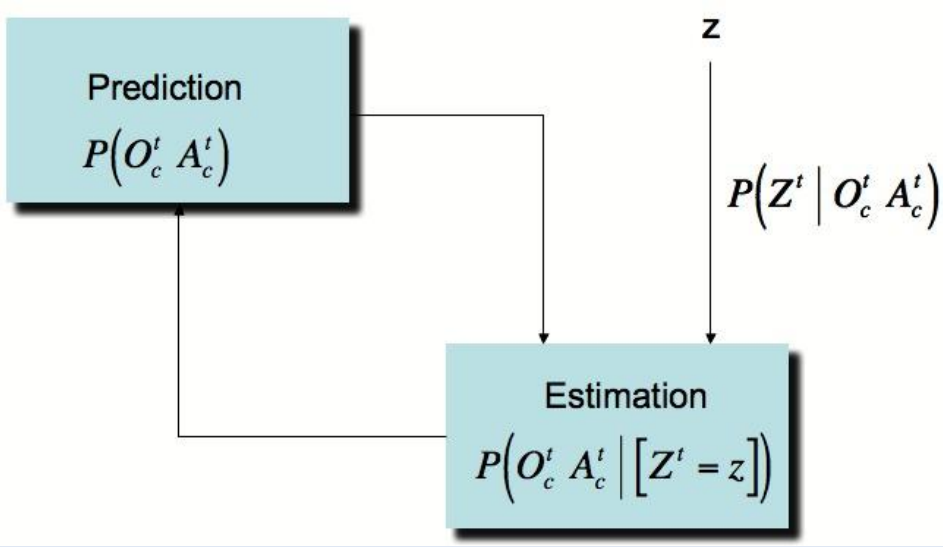
Coué IJRR 2005

- Grid-based approach for Bayesian Filtering
  - **Prediction/estimation** loop
  - Each cell has an estimated **occupancy** and a probability distribution over possible **velocities**

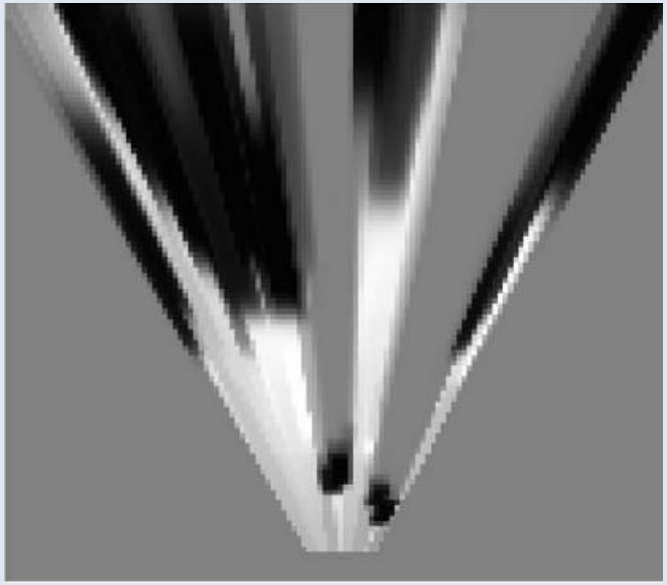
➔ **Allows to estimate velocities from grid measurements**

• **Prediction:** propagates occupancy and velocity to neighboring cells, using dynamic models

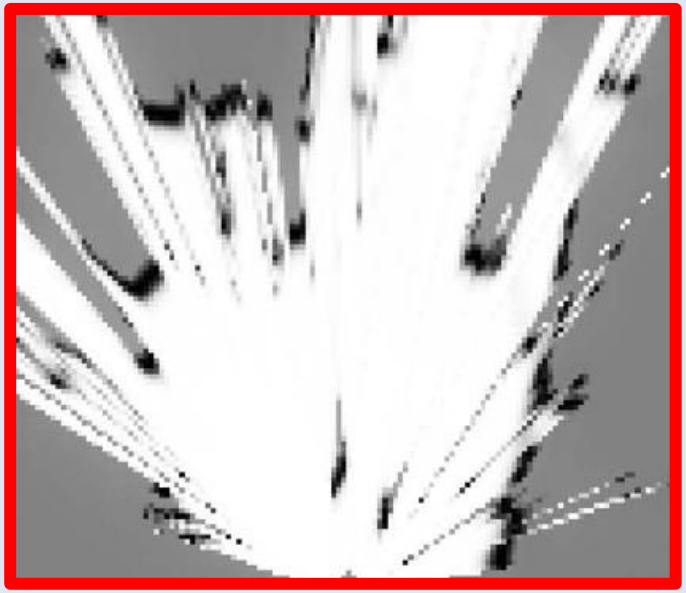
• **Estimation:** corrects predicted grids using observation grids computed using sensor model



BOF : input grids



Using stereo-vision
Perrollaz, T-ITS 2012



Using multi-layers laser scanners
Adarve, ICRA 2012

Moving objects vs Static environnement

- Separating dynamic (moving) objects from static ones (map)
  - Simplify the tracking (less hypotheses)
  - Allow to reason on behaviors for further risk estimation
  - Toward semantic description of the scene

- Classic approaches :
  - background substraction, mostly in vision [Jain 1979, Li 2000, Taleghani 2009]
  - SLAM-based approaches for occupancy grids [Wang 2007,Burlet 2007, Vu 2009]
    - SLAM + DATMO
    - SLAMMOT

    ➔ the complete SLAM needs be solved !

Fast classification of the environment

- Fast classification of static/dynamic environment
  - Separate static from dynamic environment within the BOF framework
  - Not solving the complete SLAM problem
  - Fast and computationally efficient

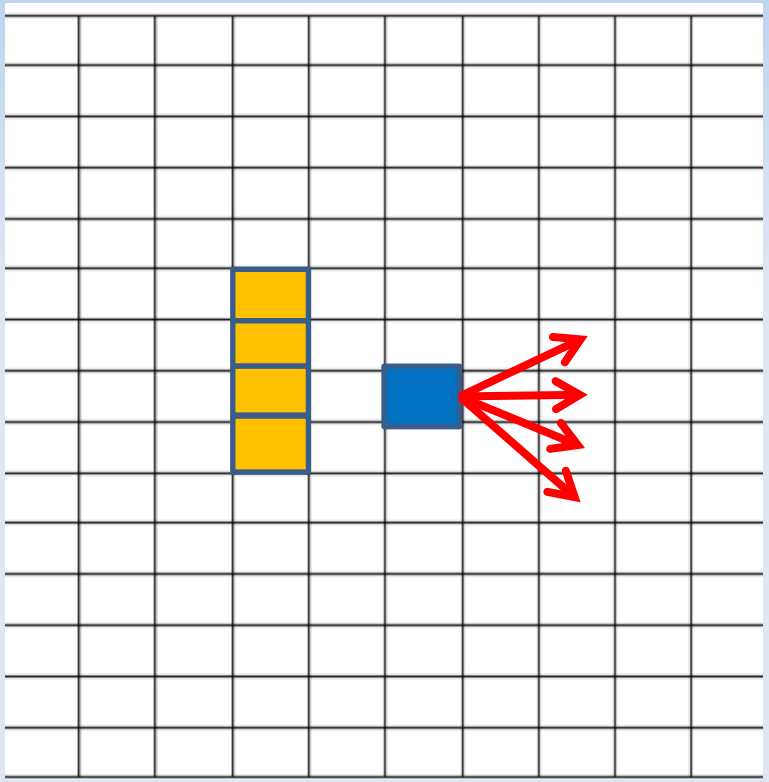
➔ First idea : filtering the grid using the cells' velocities estimated by the BOF

BOF: Velocities

- Cell antecedents: knowing antecedent of a cell tells its velocity

  ➔ Relative velocities

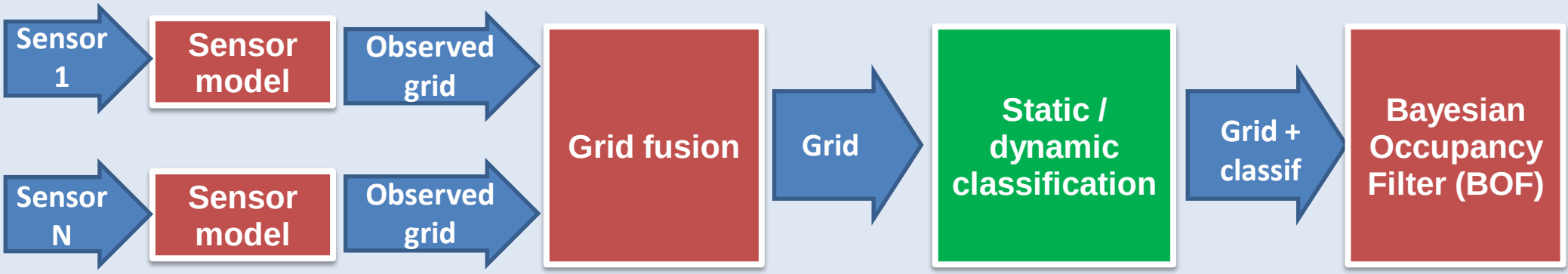
- Problem:
  - No information about the robot's motion
  - Too many tracking hypotheses
  - Static objects are also tracked
  - Convergence is slow in large regions



➔ Solution: Finding static parts before using the BOF

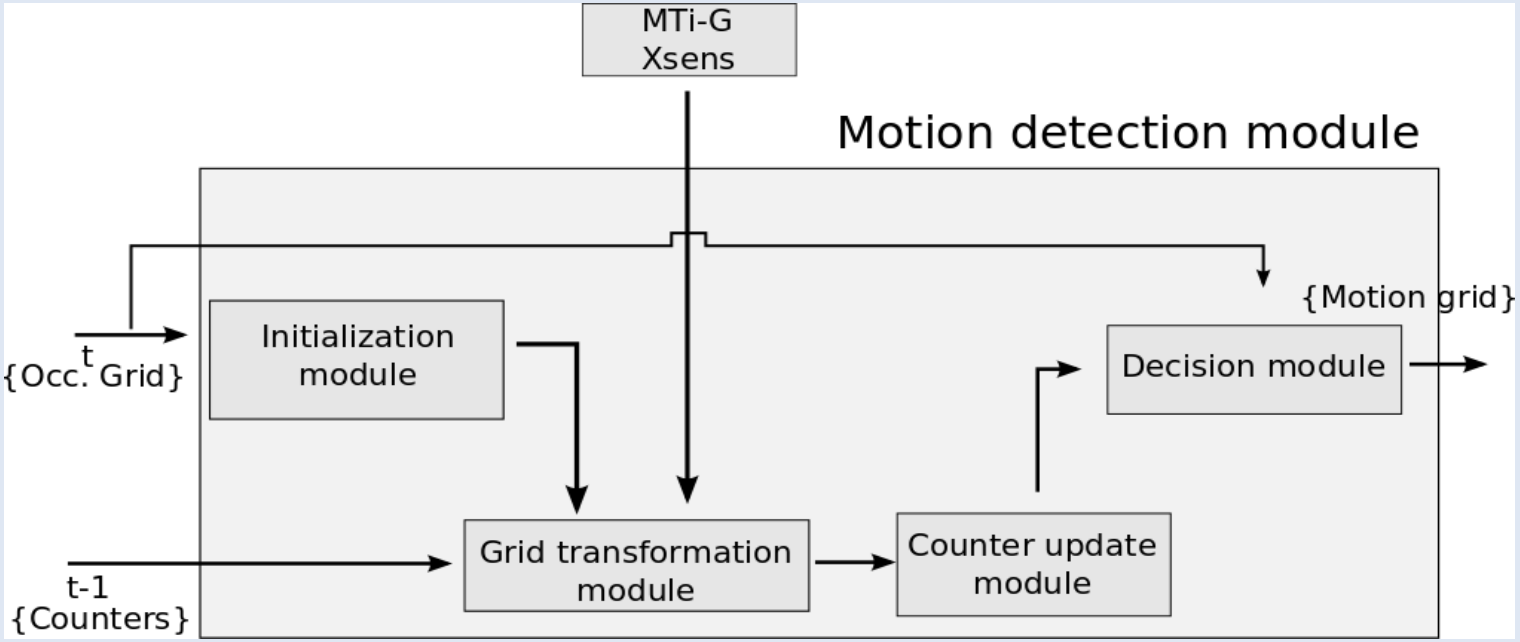
BOF: Velocities

- Solution: Finding static parts before using the BOF
- Advantages:
  - Reduces the number of hypotheses for BOF filtering
  - Can provide pior information about velocities to the BOF



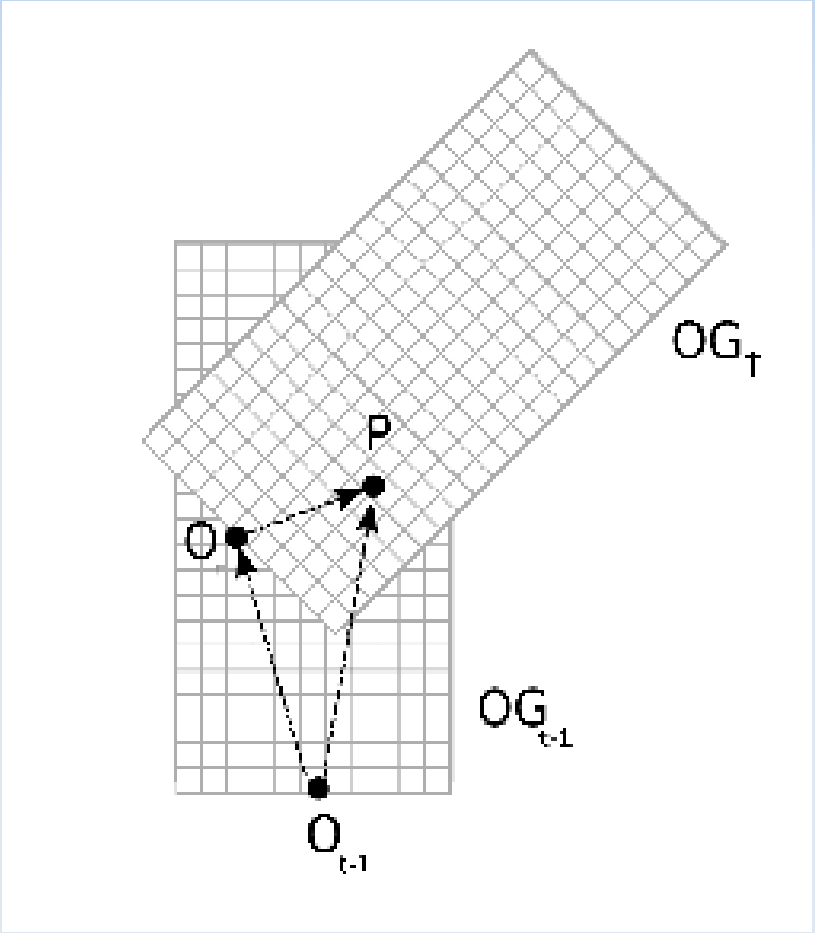
Fast Motion Detection

- Main idea: How many times a cell is observed as free and how many times occupied, in a global coordinate system
  - Use free/occupied counters for each cell
  - Map cells from t-1 to t, using robot's motion
  - Update counters at each timestep
  - Framework:



Grid Transformation

- The objective is to map a cell *j* in grid OG_{t-1} to cell *i* in grid O_t, with the hypothesys of static environnement
- Method :
  - Using motion data from IMU
    - Velocity
    - Angular velocity
  - and circular motion model find pose of O_t w.r.t O_{t-1}
  - Using a global coordinate system to avoid border effects



Initialization and update

- Initialization:
  - $FreeCounter_t[i] = 1$, if $OG_t[i] < 0.5$
  - $OccupiedCounter_t[i] = 1$, if $OG_t[i] > 0.5$

- Updating counters from previous time step :
  - Mapping of cells of grid at time t-1 to grid at t
  - Update counters:
    - $FreeCounter_t[i]$ += $FreeCounter_{t-1}[j]$
    - $OccupiedCounter_t[i]$ += $OccupiedCounter_{t-1}[j]$

Motion grid

- Motion
  - MotionGrid[i] = F(OG_t[i], $FreeCounter_t$[i], $OccupiedCounter_t$[i])
  - F can be a decision function, like:

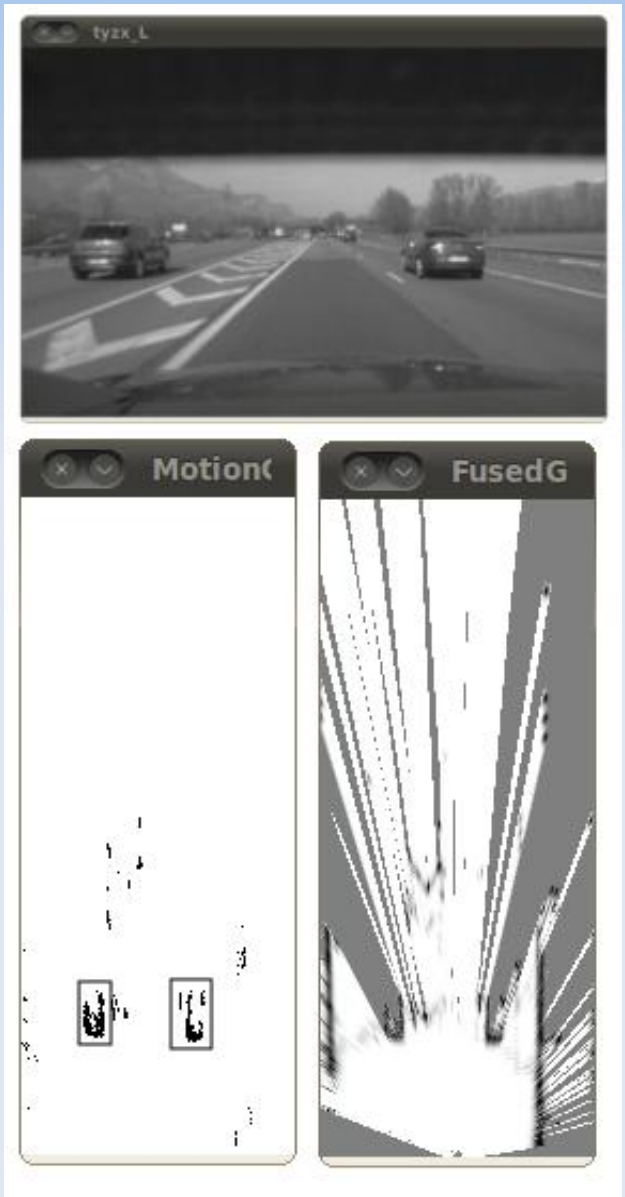
$$MotionGrid_t[i] = \begin{cases} 1, & OG_t[i] > 0.5 \text{ and} \\ & FreeCount_t[i] > 2 * OccupiedCount_t[i] \\ 0, & \text{otherwise} \end{cases}$$

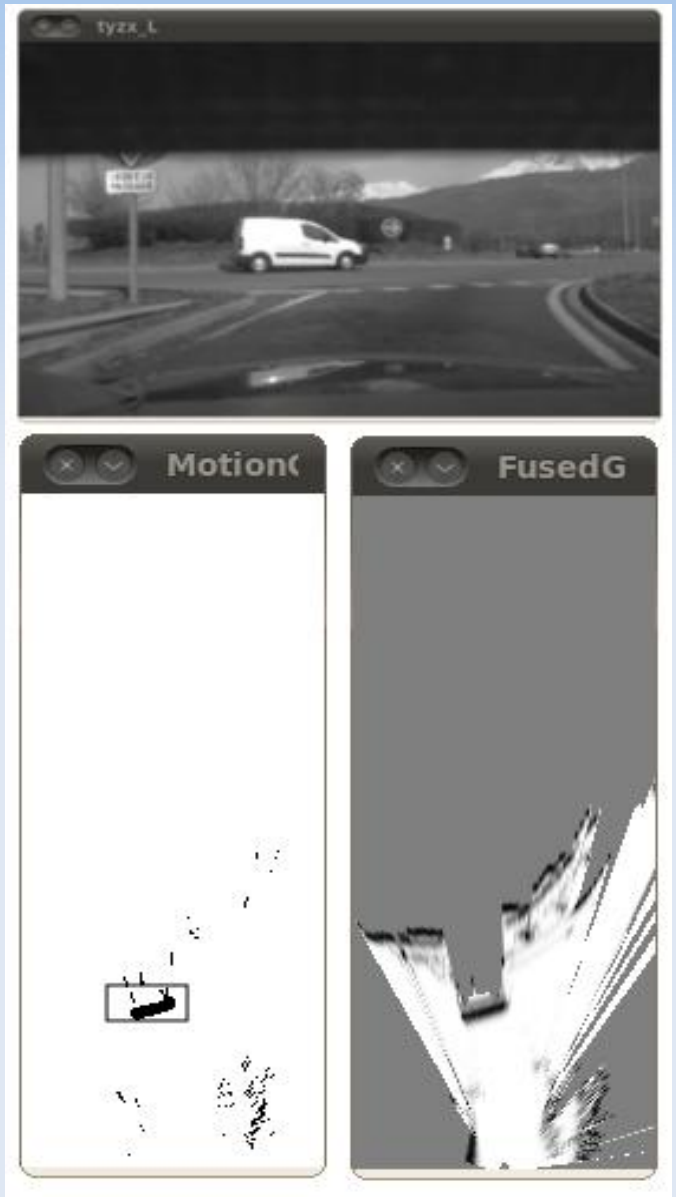
  - Or F can be a probabilistic function, for further decision

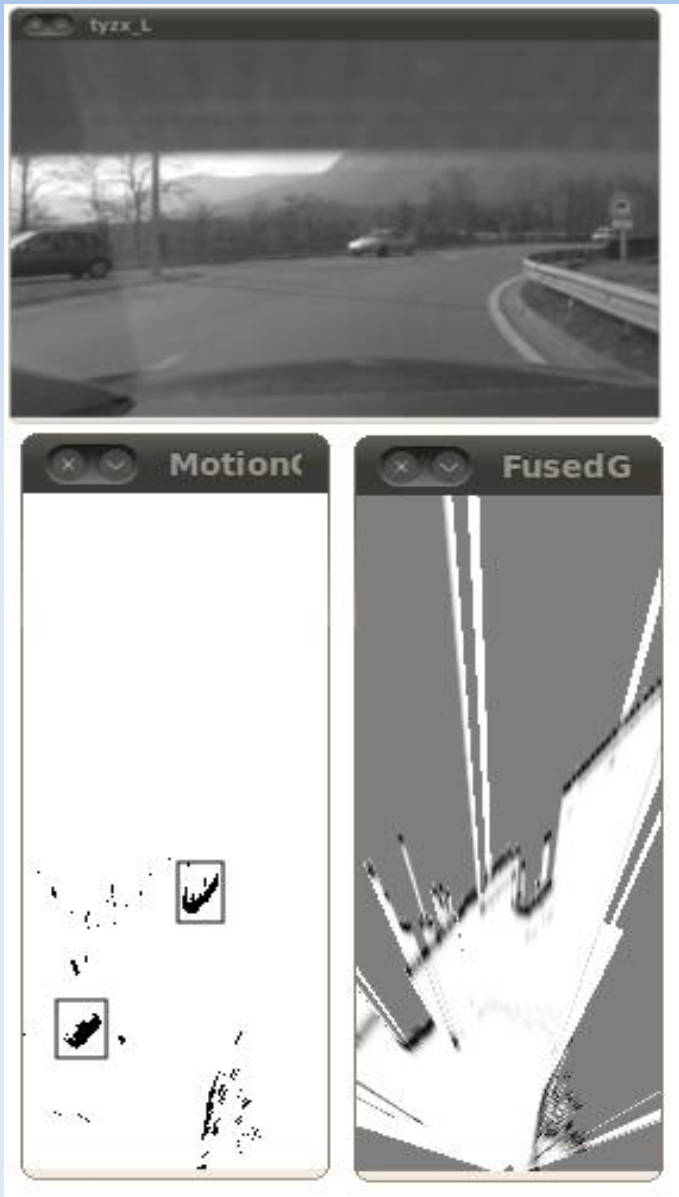
First results

- 2 IBEO Lux laser scanners (4 layers each)
- 1 TYXZ stereo camera (baseline 22cm)
- Xsens MTI-G inertial sensor

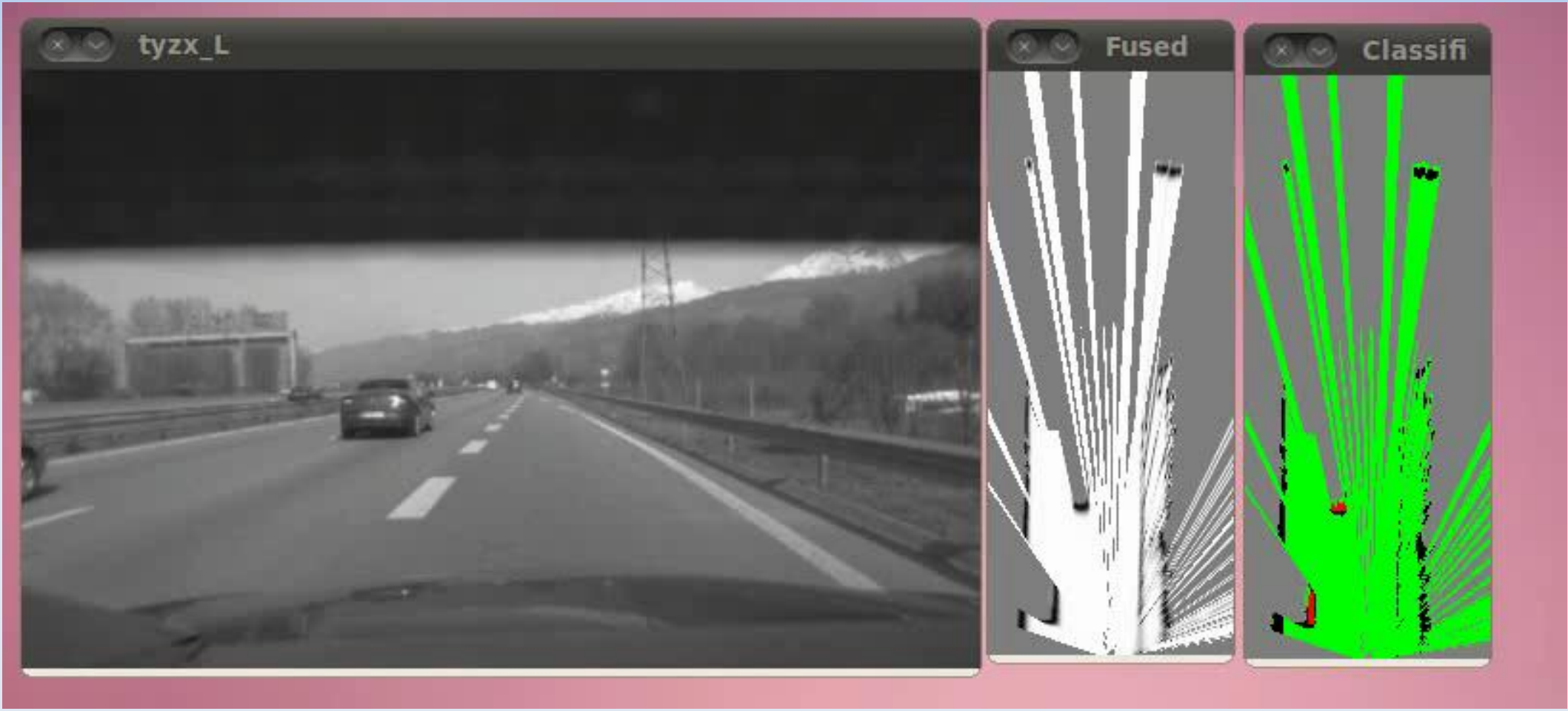
First results







Results



Next steps

- Find best way to use this in the BOF
  - Use velocities'prior information for the static environnment
  - Use only dynamic environnement in the BOF
  - Use a Bayesian combination of both approaches
  - Incorporate the classification process into the BOF
- Evaluate the influence on the clustering of the grid
- Manage uncertainty of the motion estimation

Thank You!

Questions?