Fast classification of Static and Dynamic Environment for Bayesian Occupancy Filter

Qadeer Baig, Mathias Perrollaz, Jander Botelho Do Nascimento, Christian Laugier

e-Motion team,
Inria Rhône-Alpes (Grenoble), France
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]:

![Diagram of Grid based DATMO approaches]
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)

- 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 environment

- 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 + 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 prior 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 hypothesis of static environment.

- 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:

- FreeCounter\textsubscript{t}[i] = 1, if OG\textsubscript{t}[i] < 0.5
- OccupiedCounter\textsubscript{t}[i] = 1, if OG\textsubscript{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\textsubscript{t}[i] += FreeCounter\textsubscript{t-1}[j]
  - OccupiedCounter\textsubscript{t}[i] += OccupiedCounter\textsubscript{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:

\[
\text{MotionGrid}_t[i] = \begin{cases} 
1, & \text{if } OG_t[i] > 0.5 \text{ and } FreeCount_t[i] > 2 \times OccupiedCount_t[i] \\
0, & \text{otherwise}
\end{cases}
\]

- 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 environment
  - Use only dynamic environment 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?