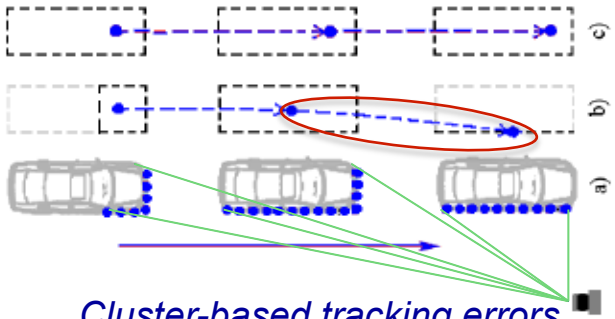
W4. Perception & Situation Awareness & Decision making

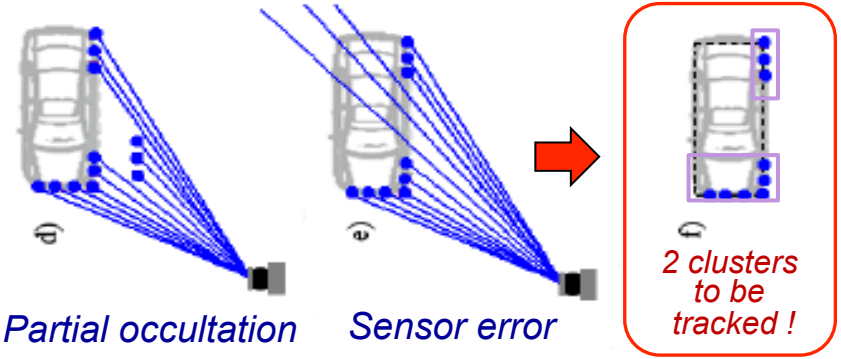
- Robot Perception for Dynamic environments: Outline & DP-Grids concept
- Dynamic Probabilistic Grids – Bayesian Occupancy Filter concept
- Dynamic Probabilistic Grids – Implementation approaches
- Object level Perception functions (SLAM + DATMO)
- Detection and Tracking of Mobile Objects – Problem & 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)

Tracking problems with
Traditional "Point clouds" approach

- Objects are represented by **clusters of points** *(laser impacts)*
  - **Tracking clusters** *(i.e. geometric means)* may lead to a degradation of tracking results
  - **Object splitting** *(occlusions, glass-surfaces …)* makes the tracking harder



Cluster-based tracking errors
(because the geometric mean of the cluster changes)

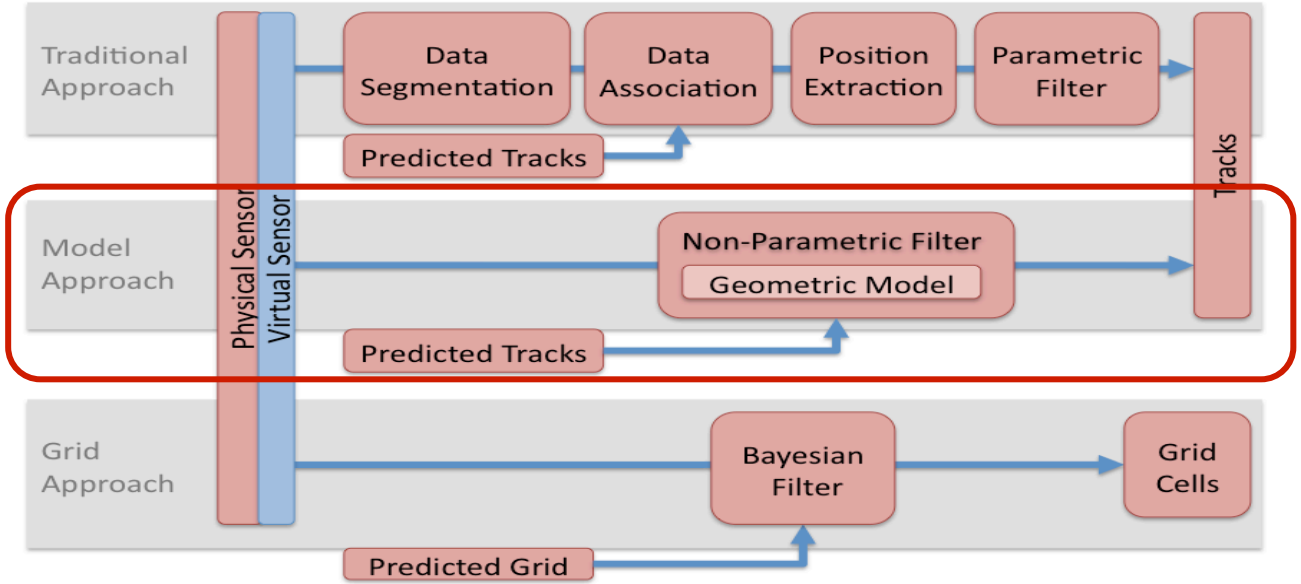


Partial occultation *Sensor error*

➔ *Using **"geometric models"** in the filtering step can help to overcome these tracking problems*

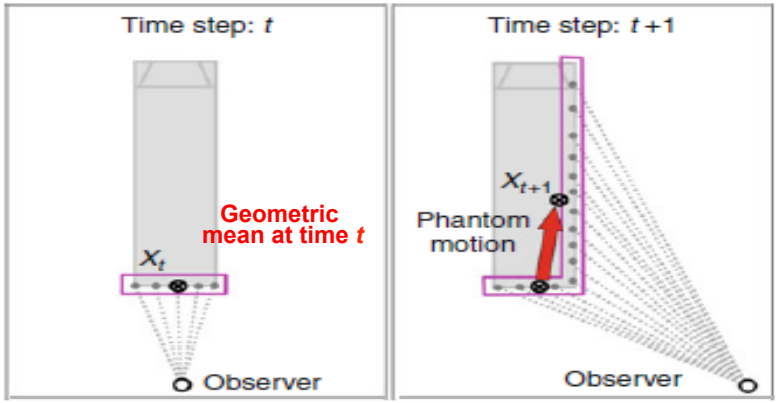
DATMO: The Model Approach

Objective: *To overcome the above-mentioned problems of classical point-cloud tracking*

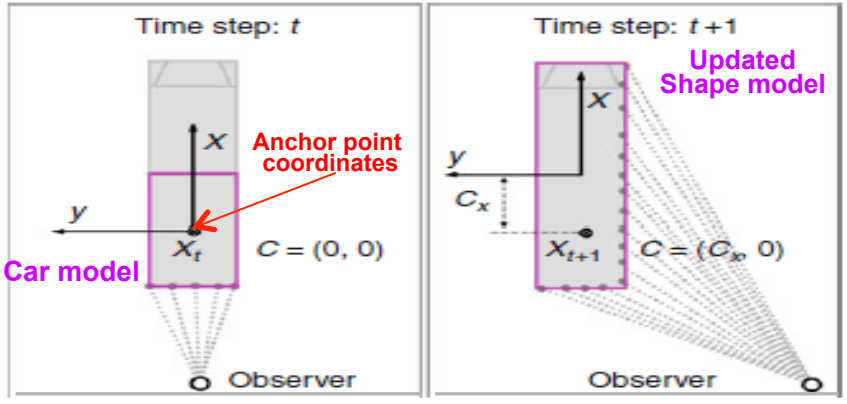


[Handbook of IV 2012 (chap. 54)]

Model based Tracking – *Outline*



Cluster model may lead to "Phantom motion" *(geometric mean changes)*



Geometric models => *shape sizes may be updated without changing the reference frame*

- **The model** *(shape)* of the object is **inferred during tracking**

  => Several classes depending on the shape / characteristic of the tracked object (e.g. rectangles, circles, ovals …). Shapes sizes may also be parameterized.

- Estimation takes into account a **window of time** *(filtering)*

- Improves both **tracking / detection / classification**

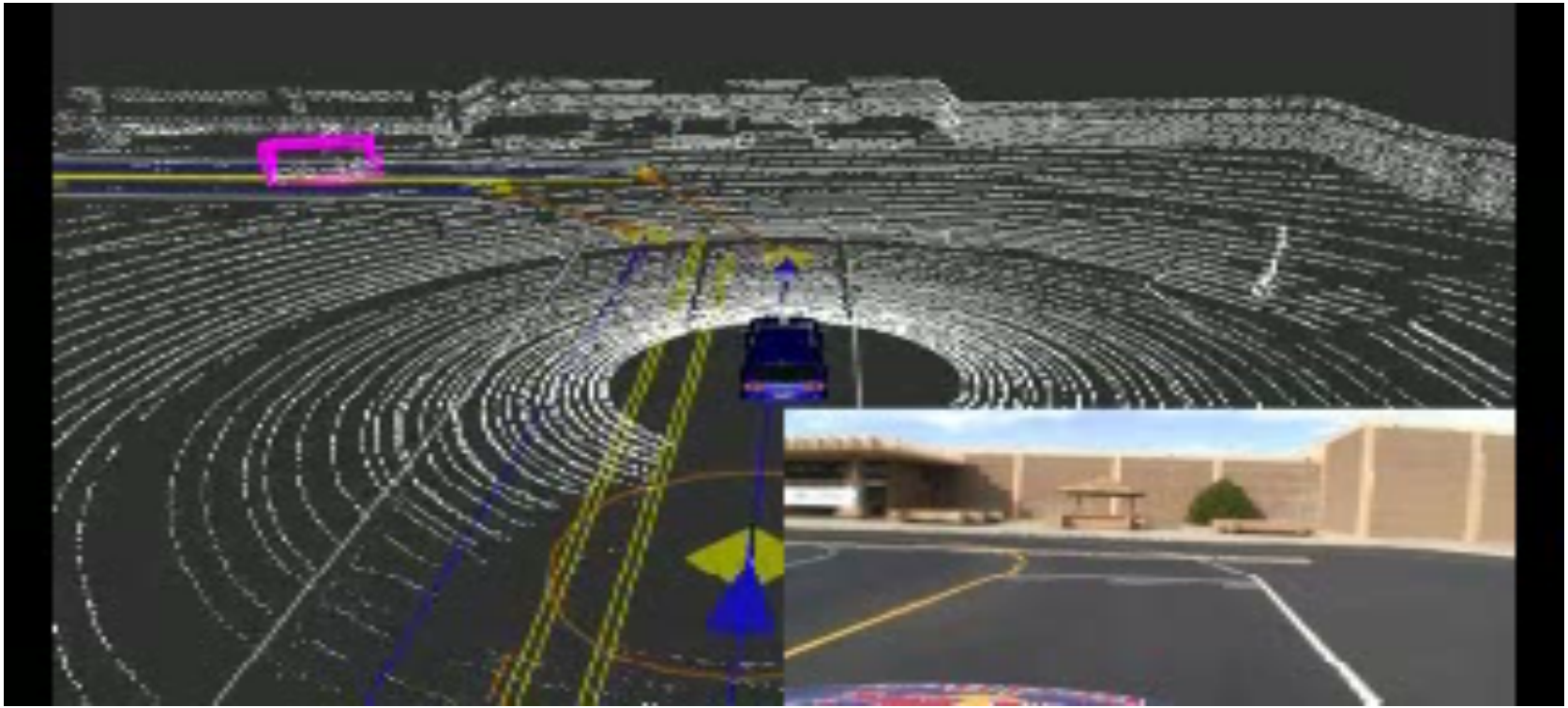
  => Avoid Phantom motion & Objects splitting + More accurate

[Petrovskaya 08] [Vu 09] [Handbook of IV 2012 (chap. 54)]

Model based Tracking – *Example using 3D laser*

Darpa Urban Challenge 2007, Stanford team

Courtesy Petrovskaya & Thrun



[Petrovskaya & Thrun 08]

Popular methods for Model-based approaches

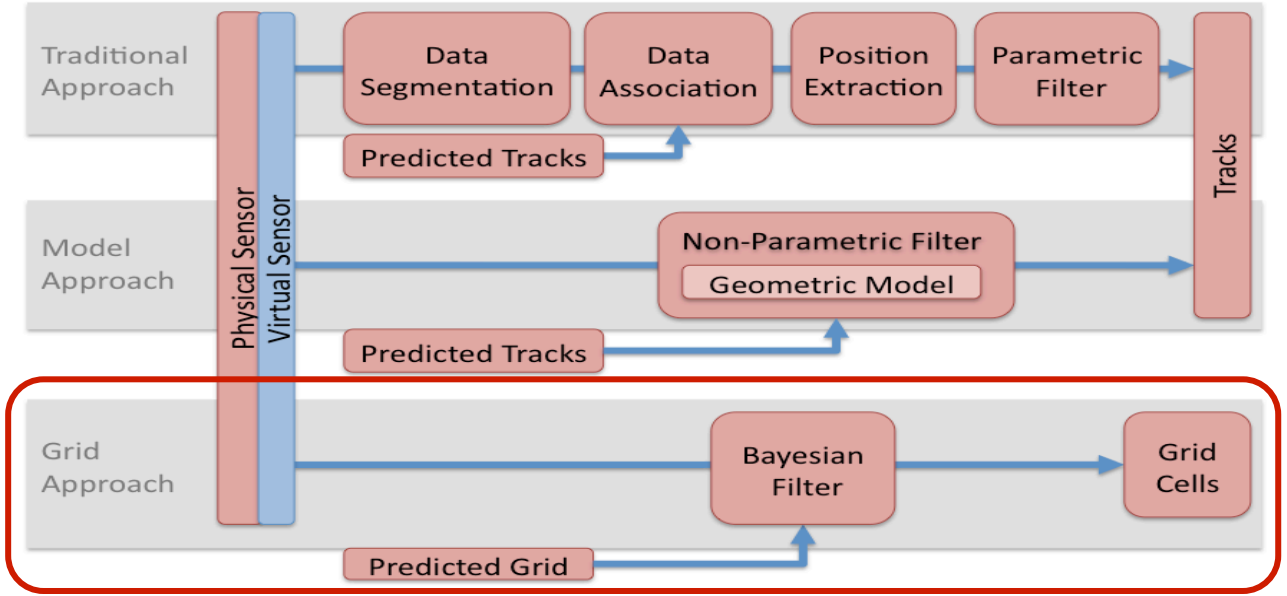
Main features & References

- **Vision** ➔ *More info for detection & classification, Less accurate distance for tracking*
  - MCMC + KF ➔ *Vehicles* *[Song & Nevatia 2005]* & *People* *[Zhao & Nevatia 2008]*
  - MHT + EKF (stereo vision) ➔ *People* *[Ess et al 2008]*

- **Laser** ➔ *Less informative, Accurate distance , More robust to environment conditions*
  - GNN + PF (Flexible models) ➔ *Vehicles* *[Petrovskaya & Thrun 08]*
  - GNN + EKF (Fixed models) ➔ *Vehicles* *[Urmson et al. 08]*
  - MCMC (N-Scan) + IMM (Fixed models) ➔ *Vehicles & Pedestrians* *[Vu 09]*

DATMO: The Grid Approach *(brief introduction)*

Objective: *To overcome data association problems & to be more robust to sensors errors*

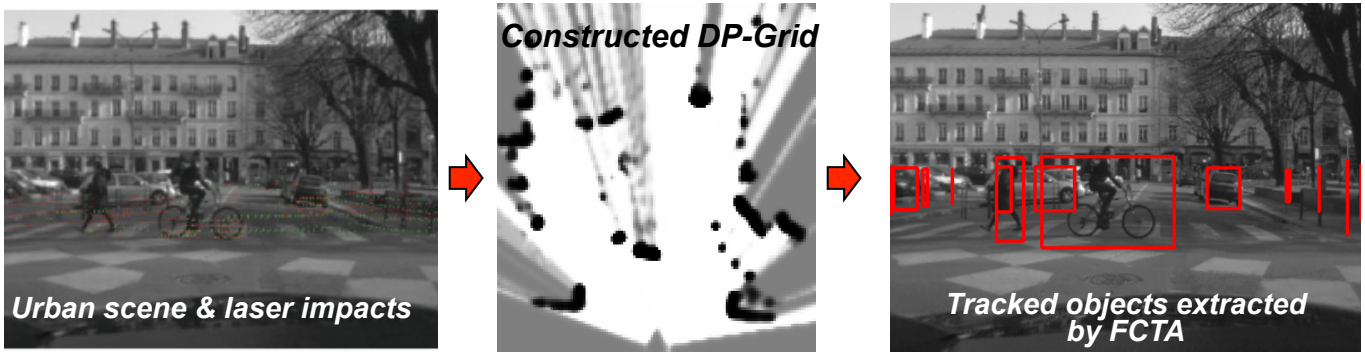


[Handbook of IV 2012 (chap. 54)]

Grid based DATMO – *Basic idea*

- **DP-Grids** are constructed as explained in session 2 & 3
- **Filtering** is performed using the BOF approach (see session 2)
- **Grid segmentation** allows to retrieve the object level representation for tracking
- **Clustering** is based on Occupancy & Velocity criteria

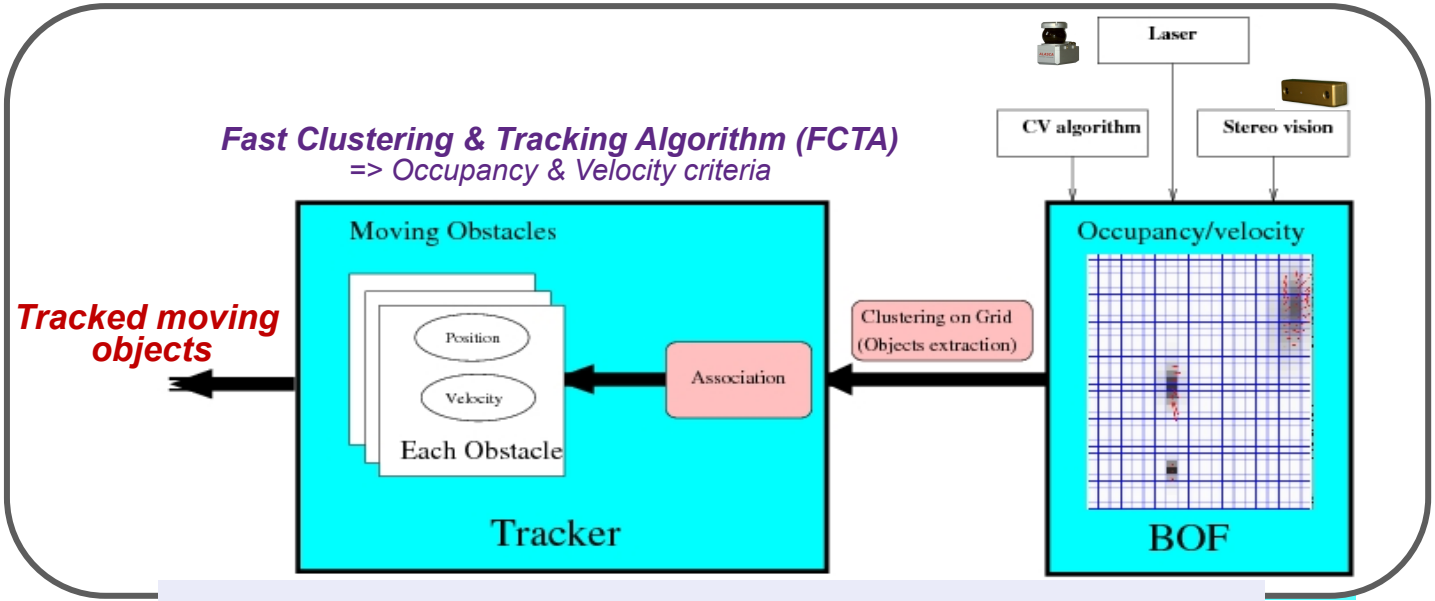
e.g. the Fast Clustering & Tracking Algorithm (FCTA)



More details in [Handbook of IV 2012 (chap. 54)]

Grid based DATMO

Bayesian sensor fusion + Grid Clustering + Tracking



- *Data association is performed as lately as possible*
- *More robust to Perception errors & Temporary occultation*

More implementation details will be given in the next session

[Mekhnacha 09] [Laugier et al ITSM 11] *[Handbook of IV 2012 (chap. 54)]*