

Comparison of Different Tracking Approaches on Pre-Fused Data for Automotive Perception System

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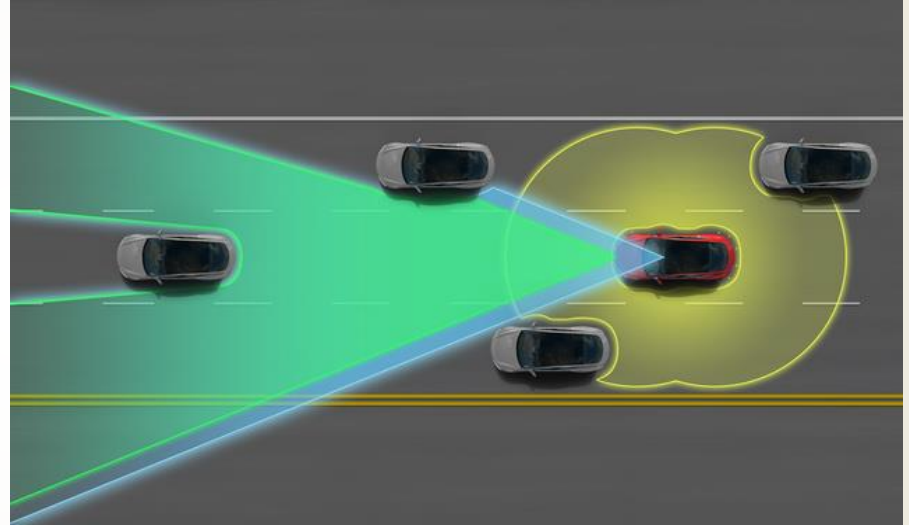
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Motivation of the Topic

Autonomous Vehicles

- Increase traffic safety 
- Optimizing the organization of transport 
- Economical benefits \$



Environment Perception

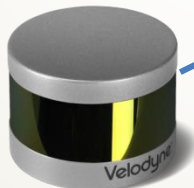
„The environment perception would be the easiest task of autonomous vehicles, if the weather and visibility conditions were perfect and just one peer object surrounded the ego vehicle” – a sensor data fusion engineer

Sensor Data Fusion

- Precise distance
- Precise velocity

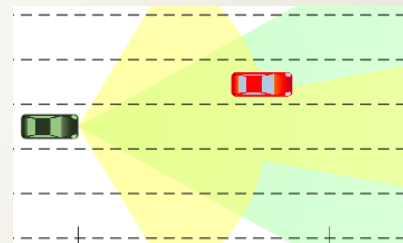
- Classification
- Lateral position

- Robust 3D
- Precise distance

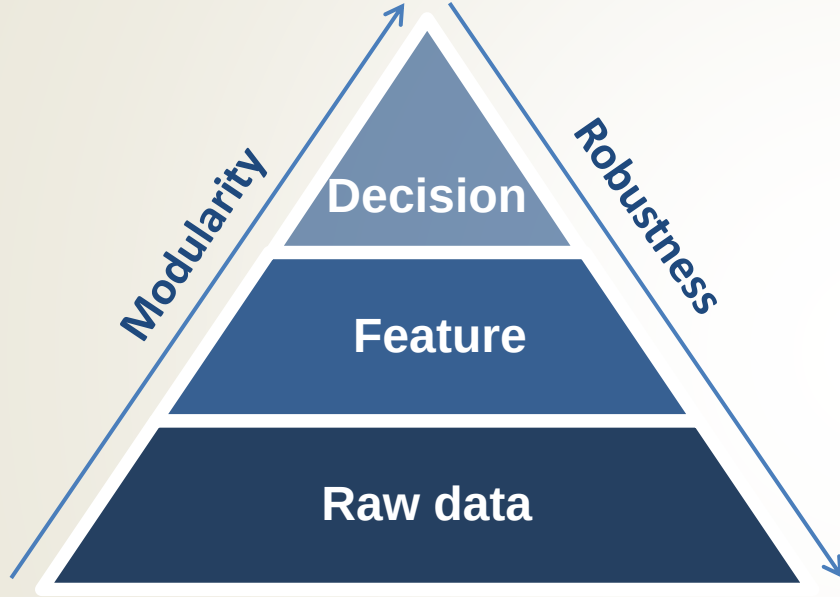


Fusion

**General
Environment
Model**



Problem Description

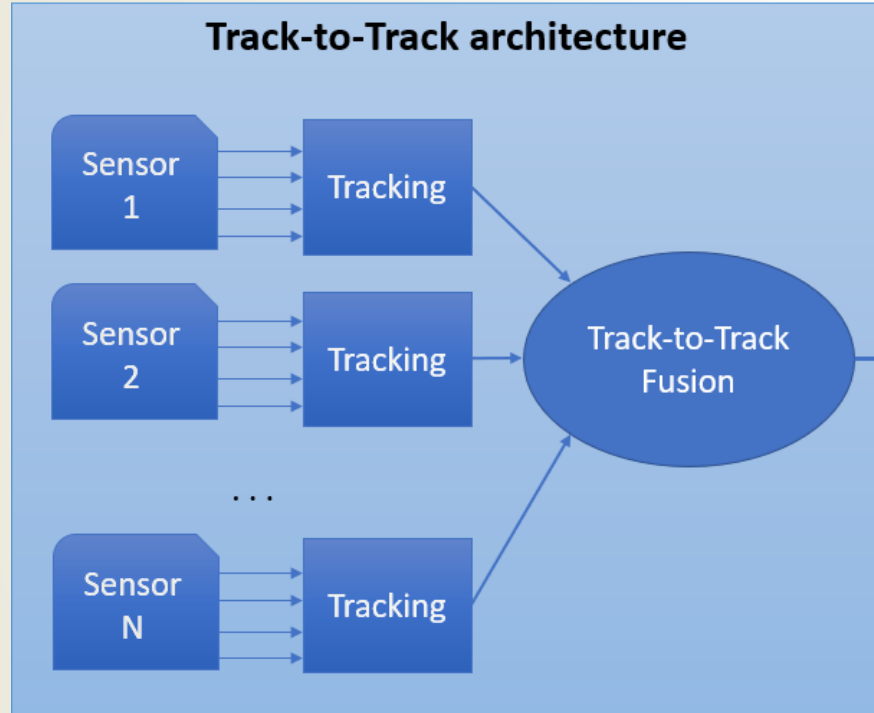


- Development of Sensor Technology
- Varied sensor clusters
- Modular vs. Robust Sensor Fusion

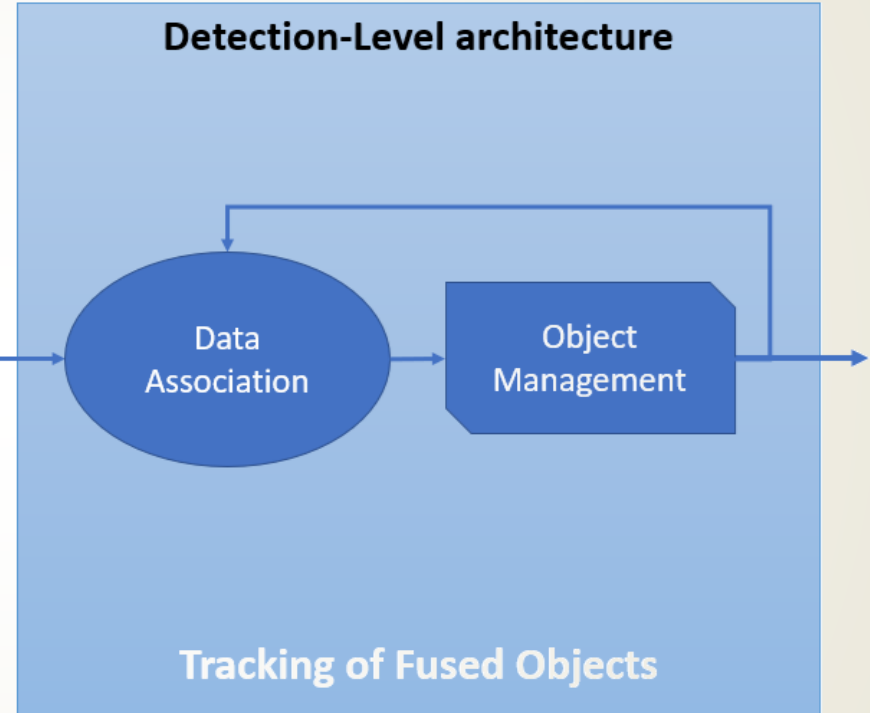


- Master – Slave Sensor Fusion
- Master can cause failures
- Serious accidents

Feature Level Sensor Fusion

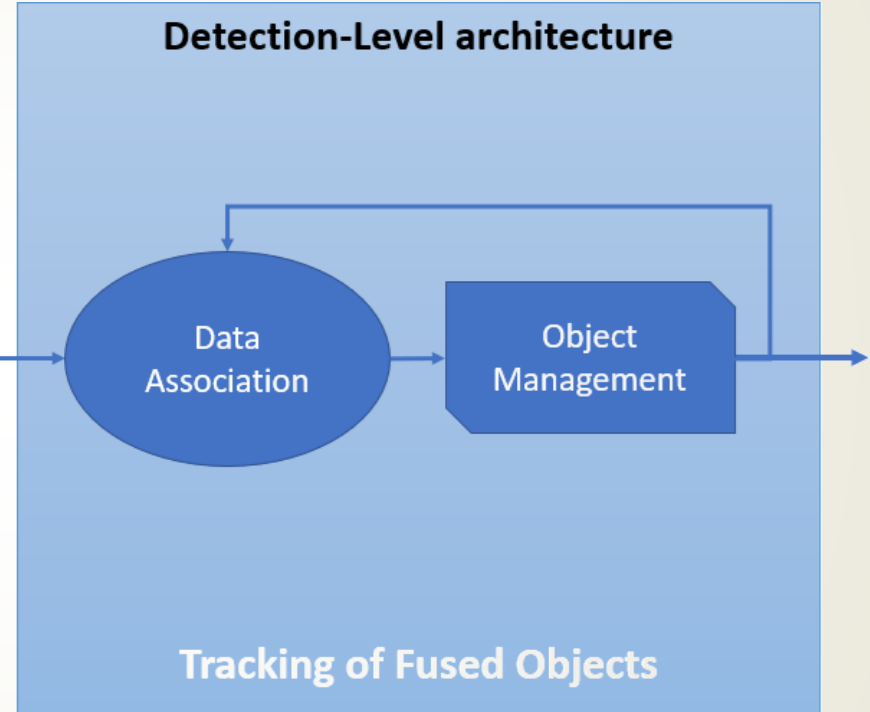
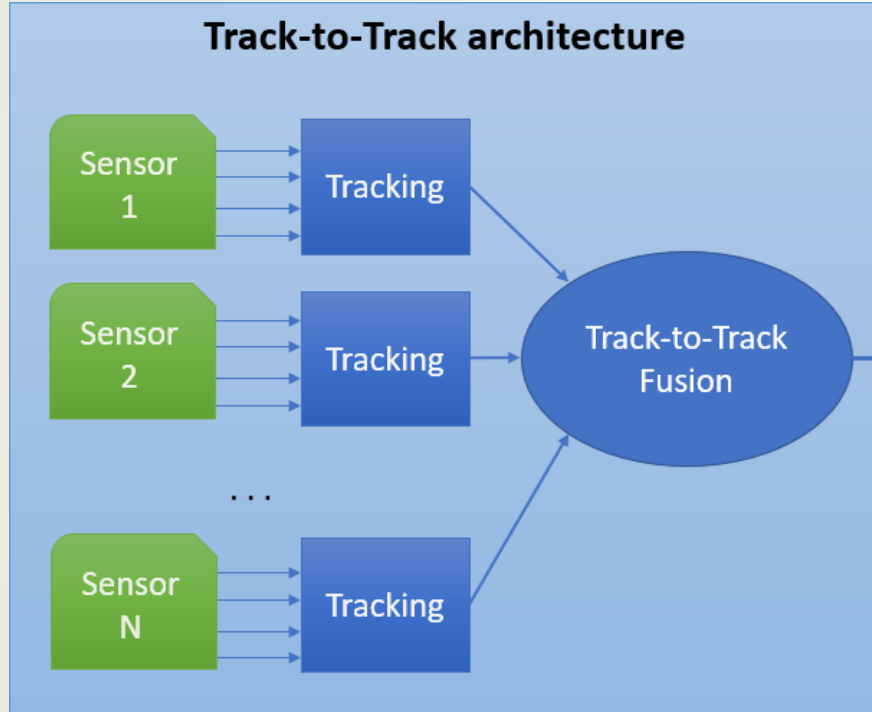


- High-Level Sensor Data Fusion
- Modular architecture with unified interface

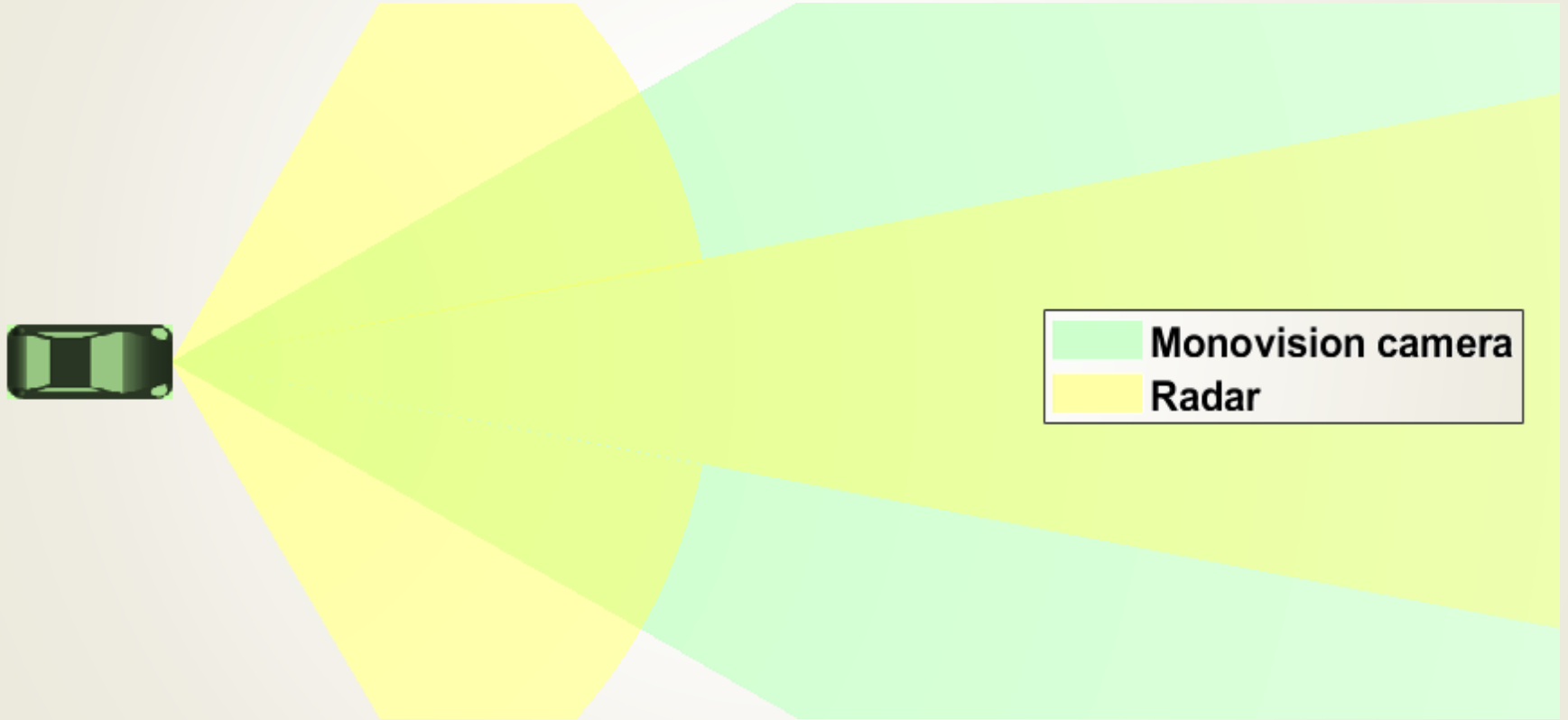


- Lower-Level architecture
- Cardinality (number of objects) Problem

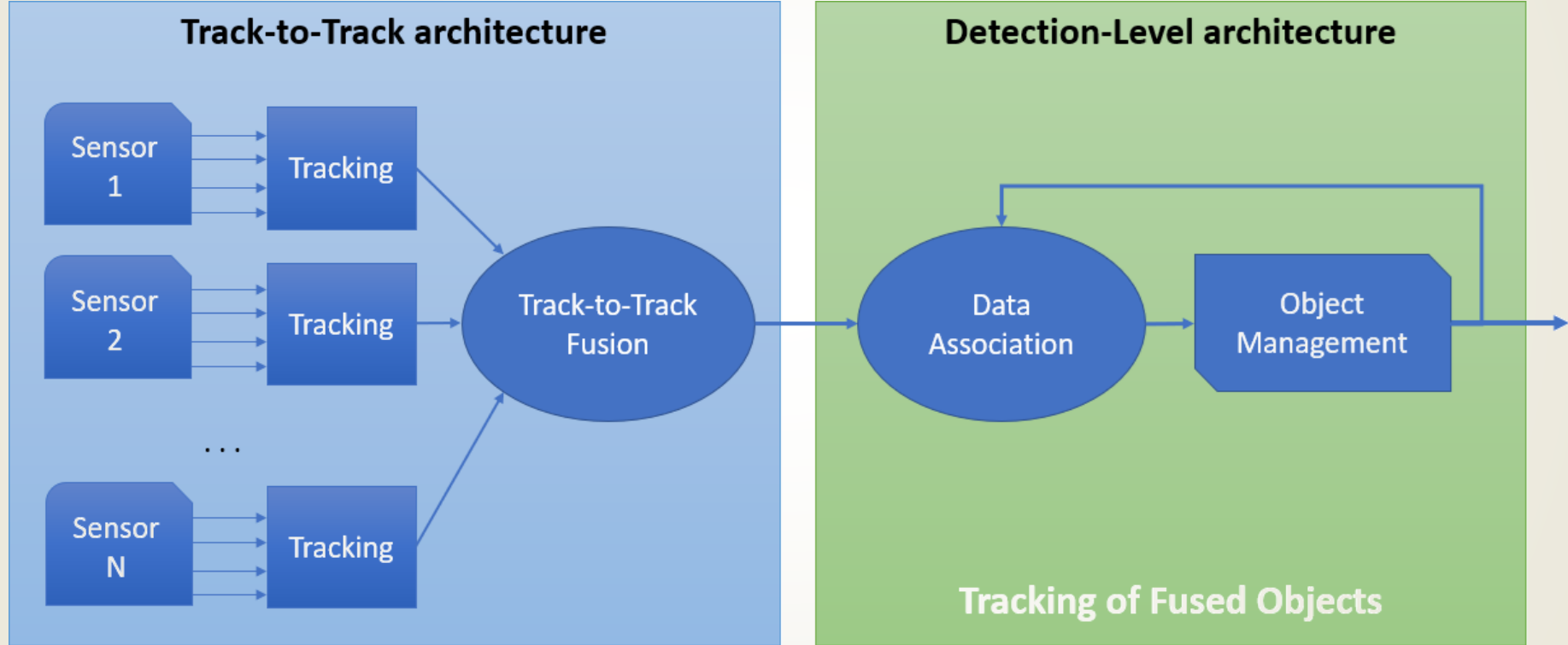
Sensors ((•))



Sensors ((•))



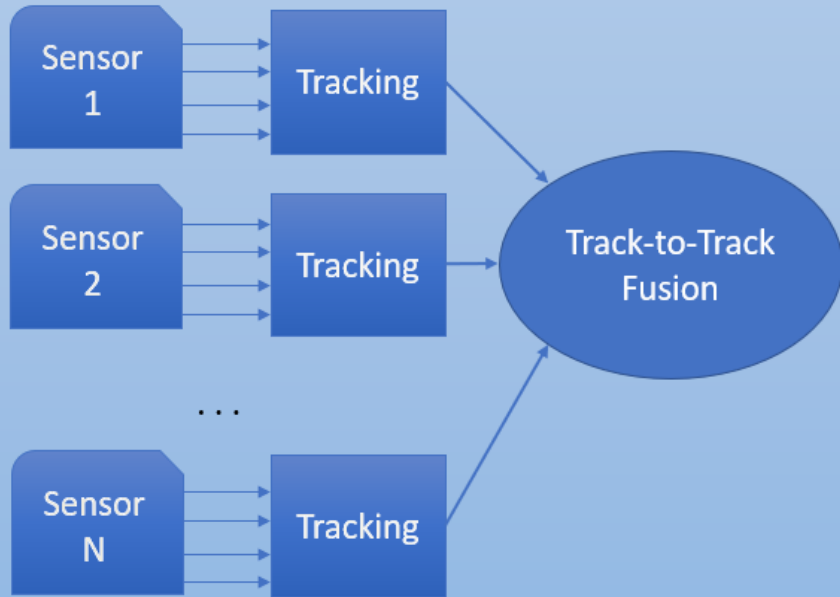
Tracking of Fused Objects



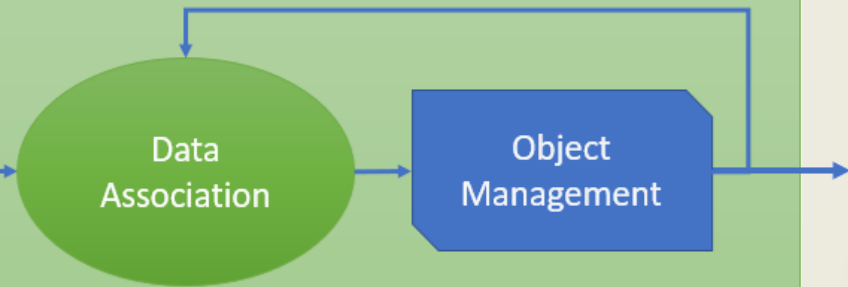
Data Association



Track-to-Track architecture



Detection-Level architecture

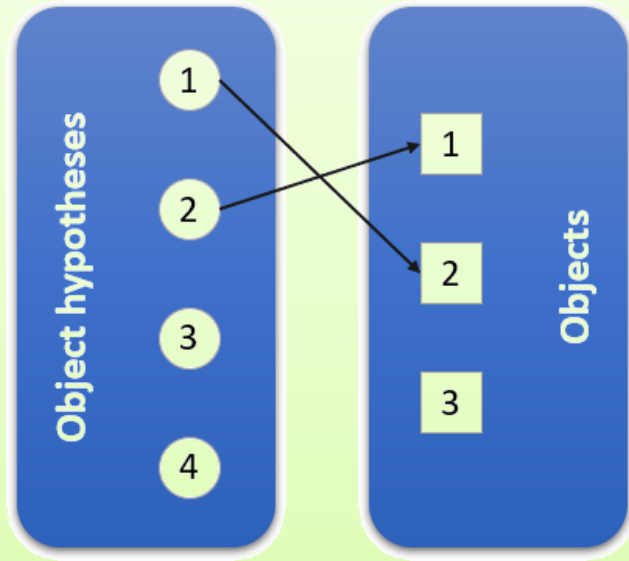


Tracking of Fused Objects

Data Association



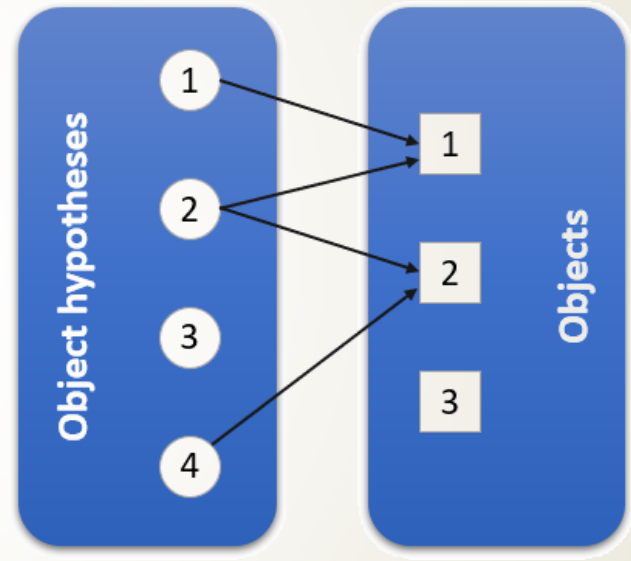
Binary Data Association



$$a_{ij} \in A, a_{ij} = 1, \text{ if } (o_i \leftrightarrow o_j)$$

$$a_{ij} \in A, a_{ij} = 0, \text{ otherwise}$$

Probabilistic Data Association

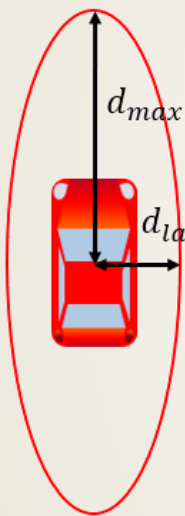


$$a_{ij} \in A, a_{ij} = p(o_i \leftrightarrow o_j)$$

Data Association



Point-to-Point Association



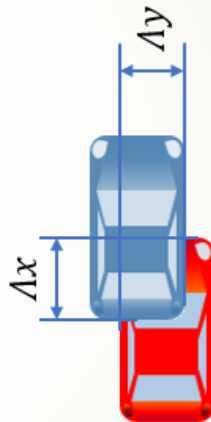
$$d_{max}(d(x_i)) = c_2 d(x_i)^2 + c_1 d(x_i) + c_0$$

$$\sigma_y = \frac{d_{lat,max}}{d_t} \sigma_x$$

$$D(i, j) = \sqrt{(z_i - \hat{z}_j)^T S_{ij}^{-1} (z_i - \hat{z}_j)}$$

- Mahalanobis – distance
- Greedy algorithm

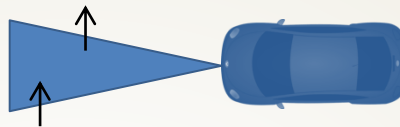
Extended 2D Association



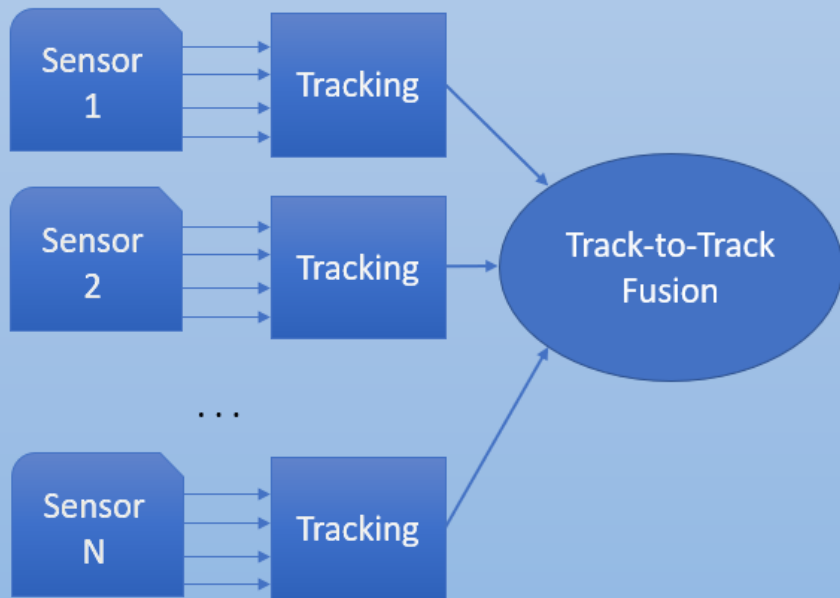
$$A_I(x_i, z_j) = \Lambda_x \Lambda_y$$

- Overlap area of objects
- Increased weights for lateral overlap

Object management



Track-to-Track architecture

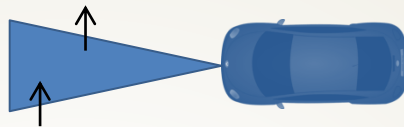


Detection-Level architecture

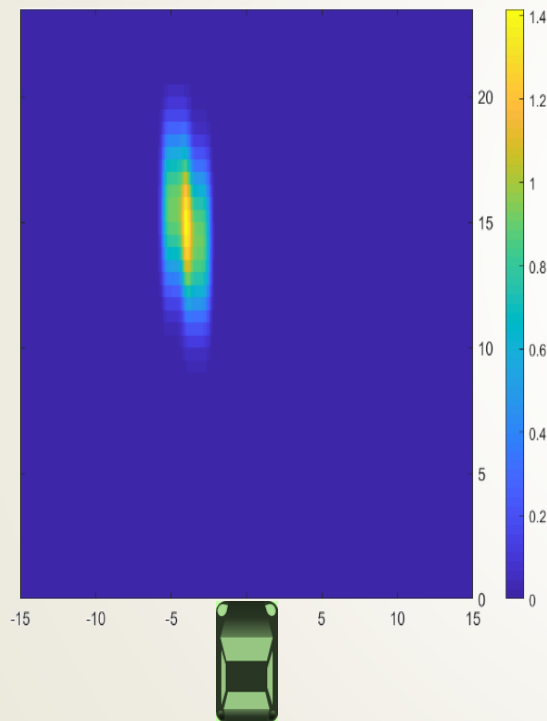


Tracking of Fused Objects

Object management

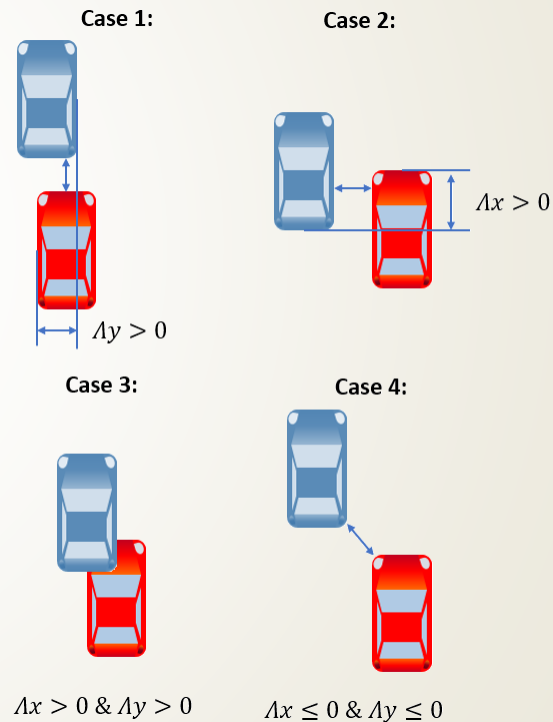


Occupancy based birth model



$$p_B(z_j | x_1, \dots, x_N) = ?$$

Distance based birth model



Results



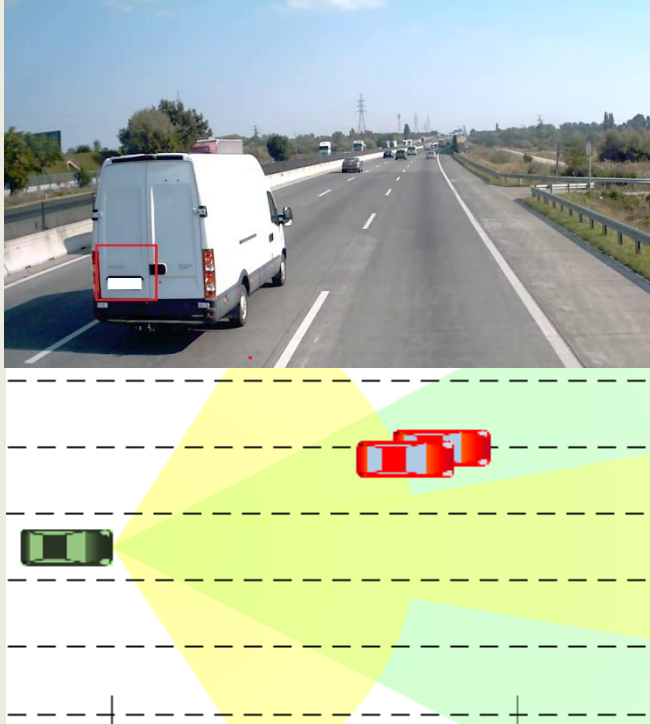
False Associations	Object management		
Data Associations	Frame based	Occupancy based*	Distance based*
Point to-Point	49	27	5
Extended 2D	46	22	0

- Extended 2D Association does not really affect the result
- Birth models decrease the number of false associations by more than 50 %
- Distance based is more scalable, thus it provides better result than Occupancy based
- The true positive and false positive rates do not depend on these approaches

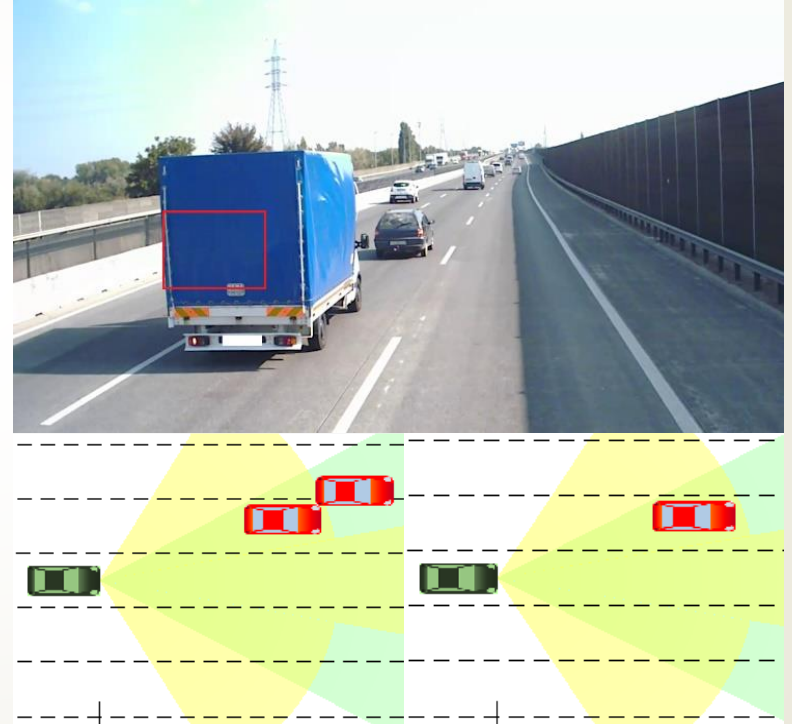
*uses a Birth model

Results

Without birth model



Occupancy based vs. Distance based



Summary



Conclusion

- Modular Sensor Data Fusion algorithm
- Continuous object detection
- Robust environment model

Future works

- JIPDA (Joint Integrated Probability Data Association)
- Neural network based object management

Thank you for your attention!