fortiss

Parking Team

Sensor Data Fusion

July 4, 19

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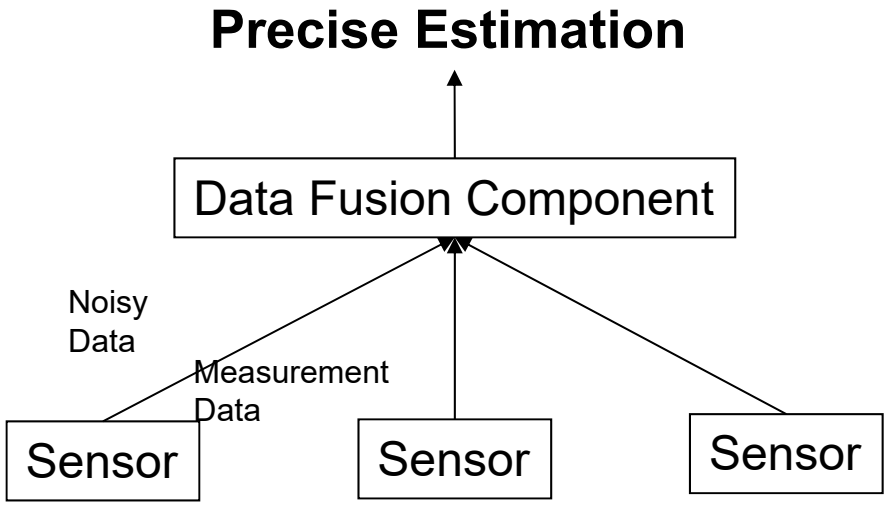
- Data Fusion Architecture
- Sensor Fusion Functions
- Relation to our Project

Introduction to Sensor Data Fusion

Definitions:

Sensor fusion is combining of sensory data or data derived from sensor sources such that the resulting information has less uncertainty.



Introduction to Sensor Data Fusion

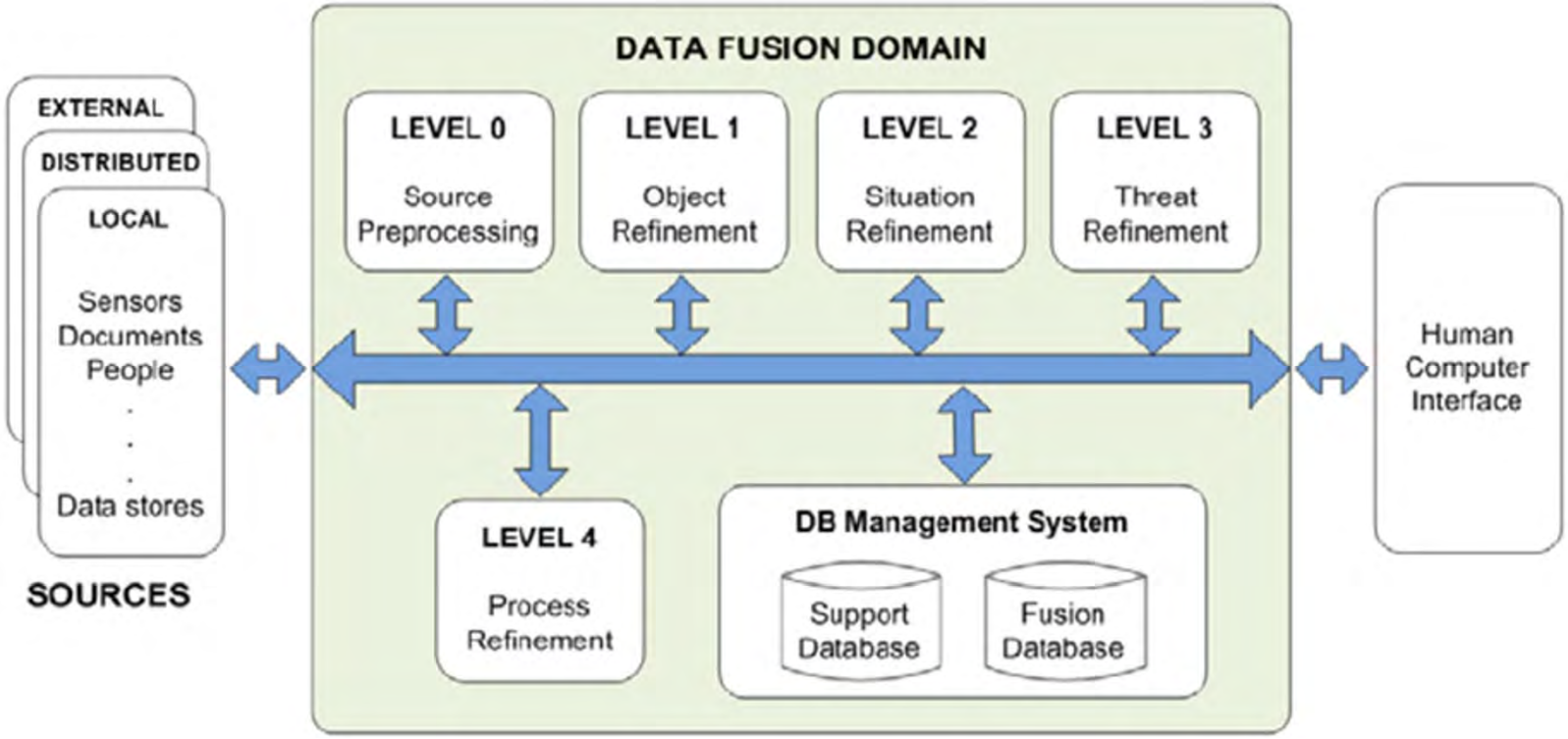
Advantages:

- Improves accuracy
- Improves precision
- Improves availability
- Reduces uncertainty
- Supports effective decision making

Challenges:

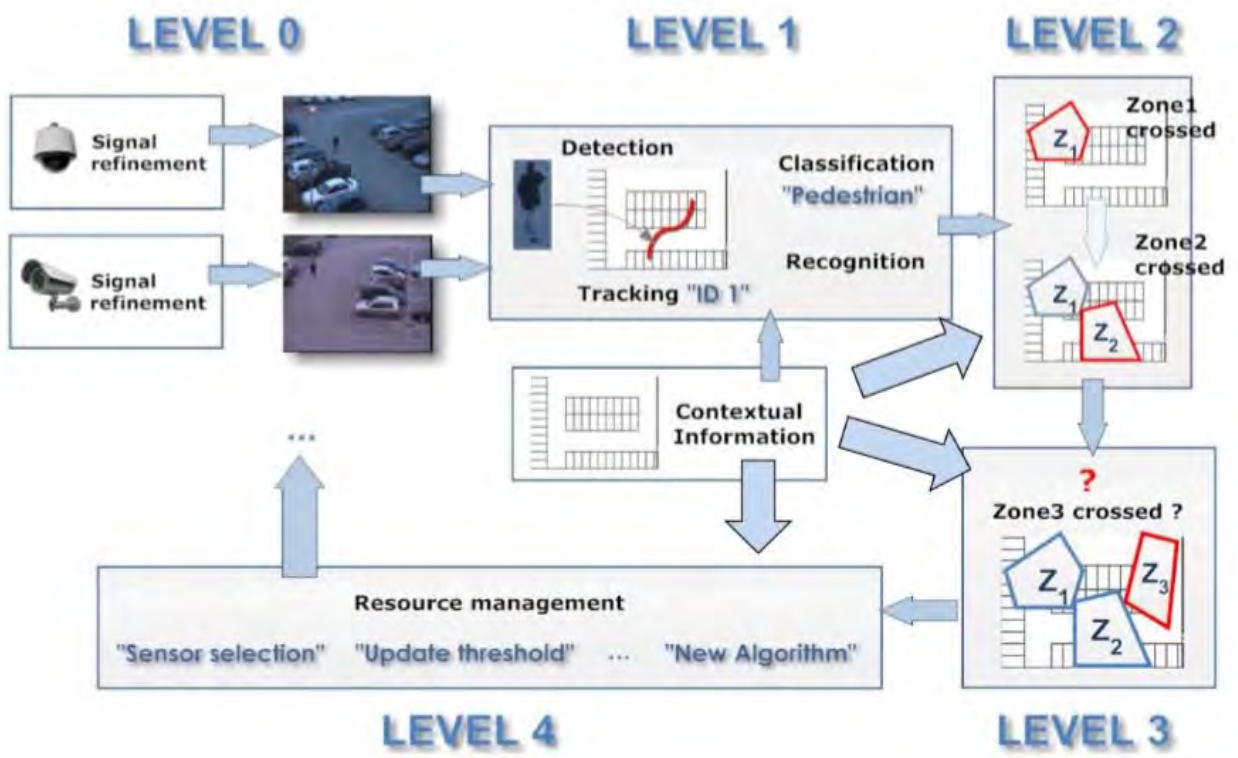
- There is no guarantee for the raw data quality
- The fused answer may be worse than the sensor
- There are no magic algorithms
- There will never be enough training data
- It is difficult to quantify the value of data fusion

Data Fusion Architecture

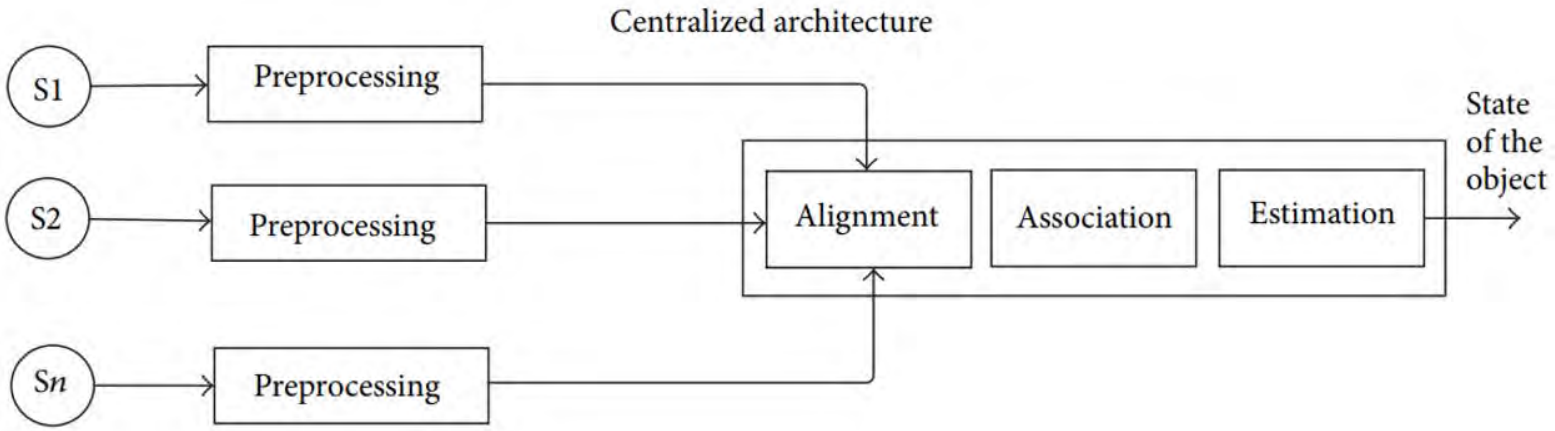


Data Fusion Architecture

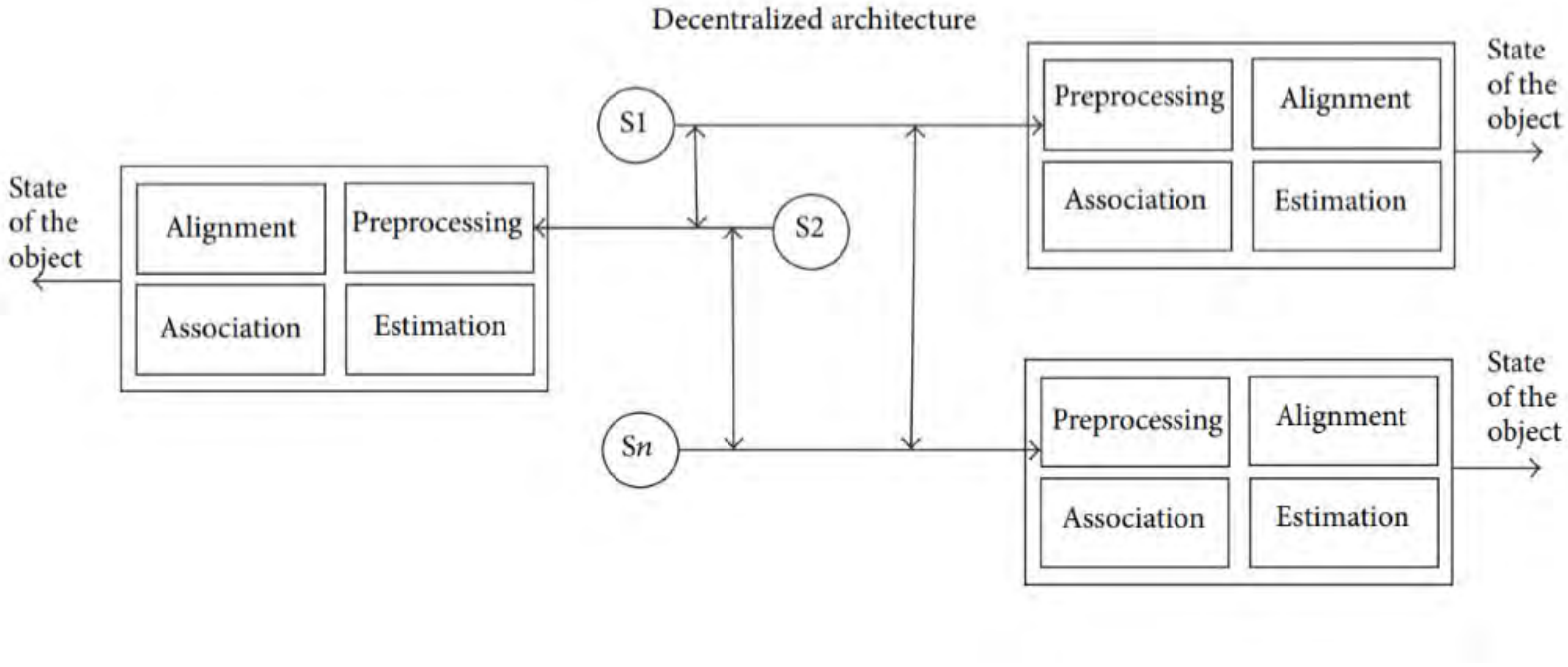
- Level 0—Sub-Object Data Association and Estimation
- Level 1—Object Refinement
- Level 2—Situation Refinement
- Level 3—Significance Estimation
- Level 4—Process Refinement



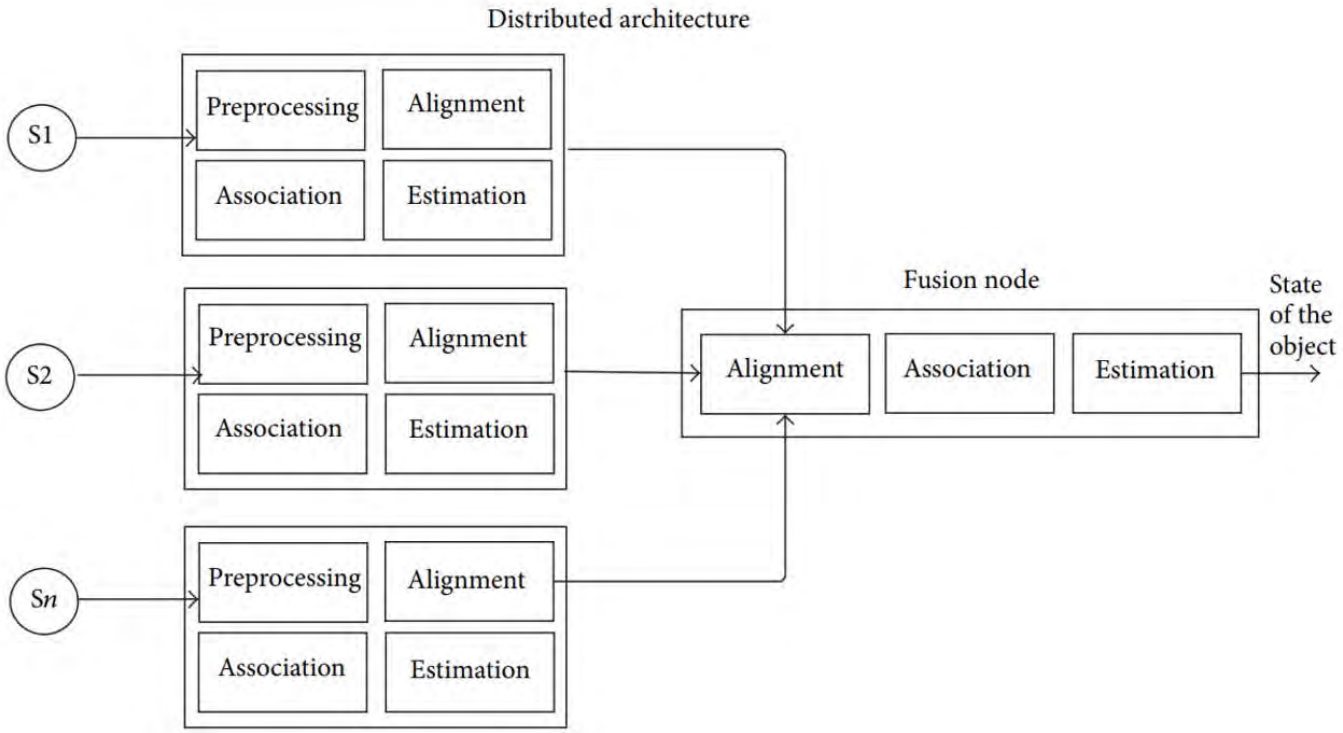
Data Fusion Architecture



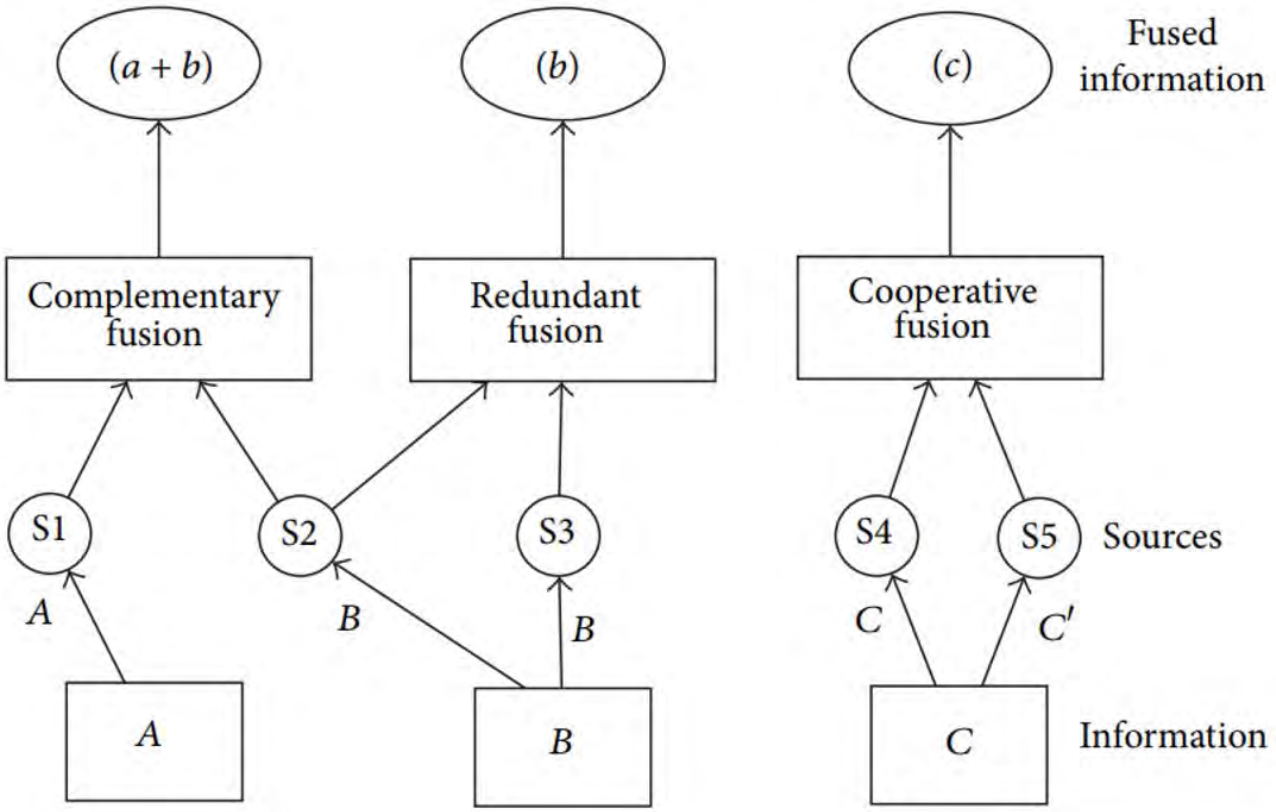
Data Fusion Architecture



Data Fusion Architecture



Data Fusion Architecture



Sensor Fusion Functions

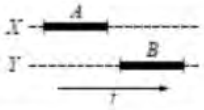
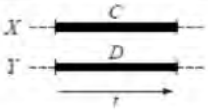
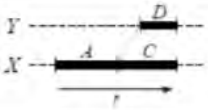
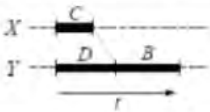
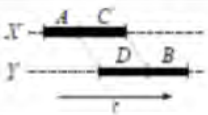
• By splitting Sensor Data Fusion into these subtasks, they can be studied individually

• Data Fusion functions include:

Data Alignment, Data Association, State estimation

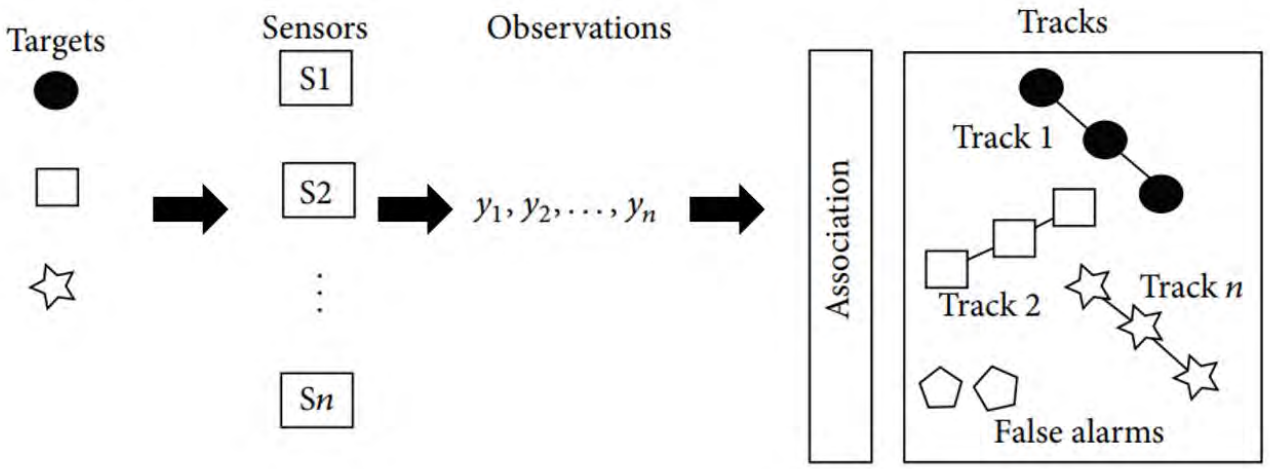
Sensor Fusion Functions

- Data Alignment
- Detect temporal differences
- Adjust the collected data
- Synchronize using shared time.
- Synchronize via communication protocol.

Logical mappings		Scenario example
precedes:	$A \rightarrow B$	
simultaneous:	$C \mid\mid\mid D$	
ends:	$A \rightarrow (C \mid\mid\mid D)$	
starts:	$(C \mid\mid\mid D) \rightarrow B$	
overlaps:	$A \rightarrow (C \mid\mid\mid D) \rightarrow B$	

Sensor Fusion Functions

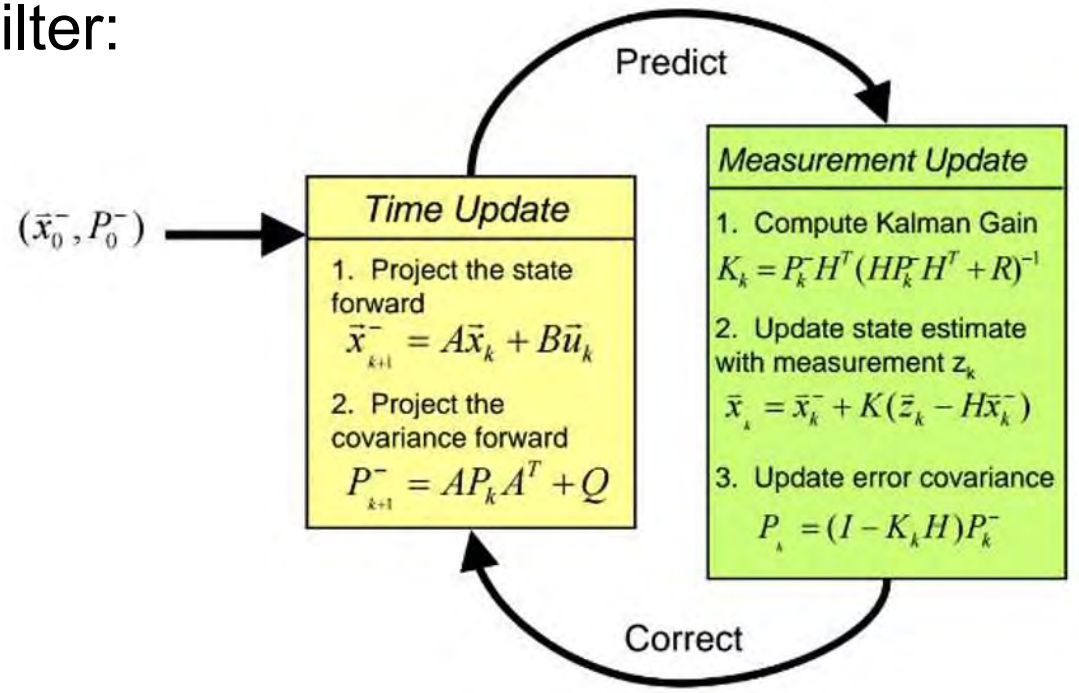
- Data Association
- Clustering: Nearest Neighbors and K-Means, Probabilistic Data Association



Sensor Fusion Functions

- State Estimation Methods

Kalman Filter:



Sensor Fusion Functions

- State Estimation Methods

A standard Kalman Filter can only handle linear models

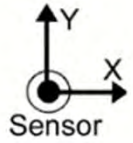
• Non-linear process and sensor models：

Extended Kalman Filter (EKF) Unscented Kalman Filter (UKF)

• Extended Kalman Filter uses the Jacobian matrix to linearize non-linear functions

• Unscented Kalman Filter takes representative points from a Gaussian distribution

Sensor Fusion Functions



RMSE
X: 0.1067
Y: 0.165928
VX: 0.276554
VY: 0.634738

Lidar Measurement
Radar Measurement
Record Data
Run

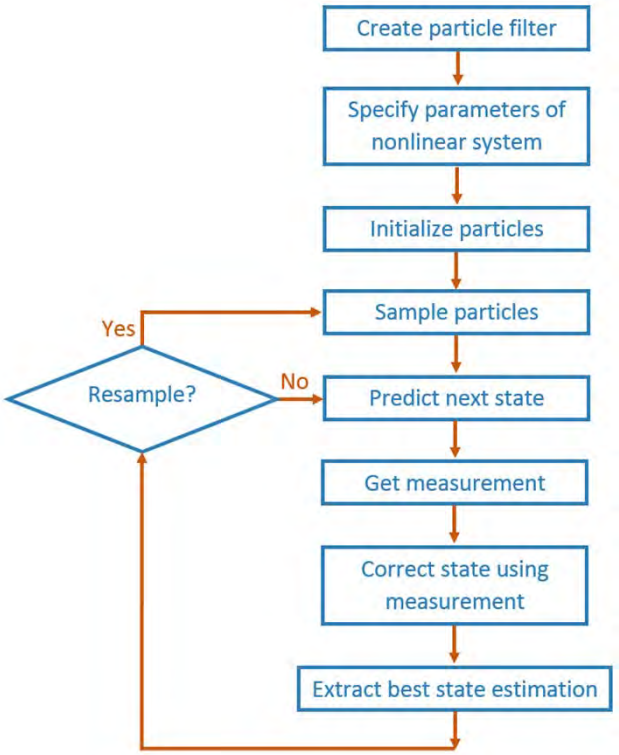
Sensor Fusion Functions

- State Estimation Methods

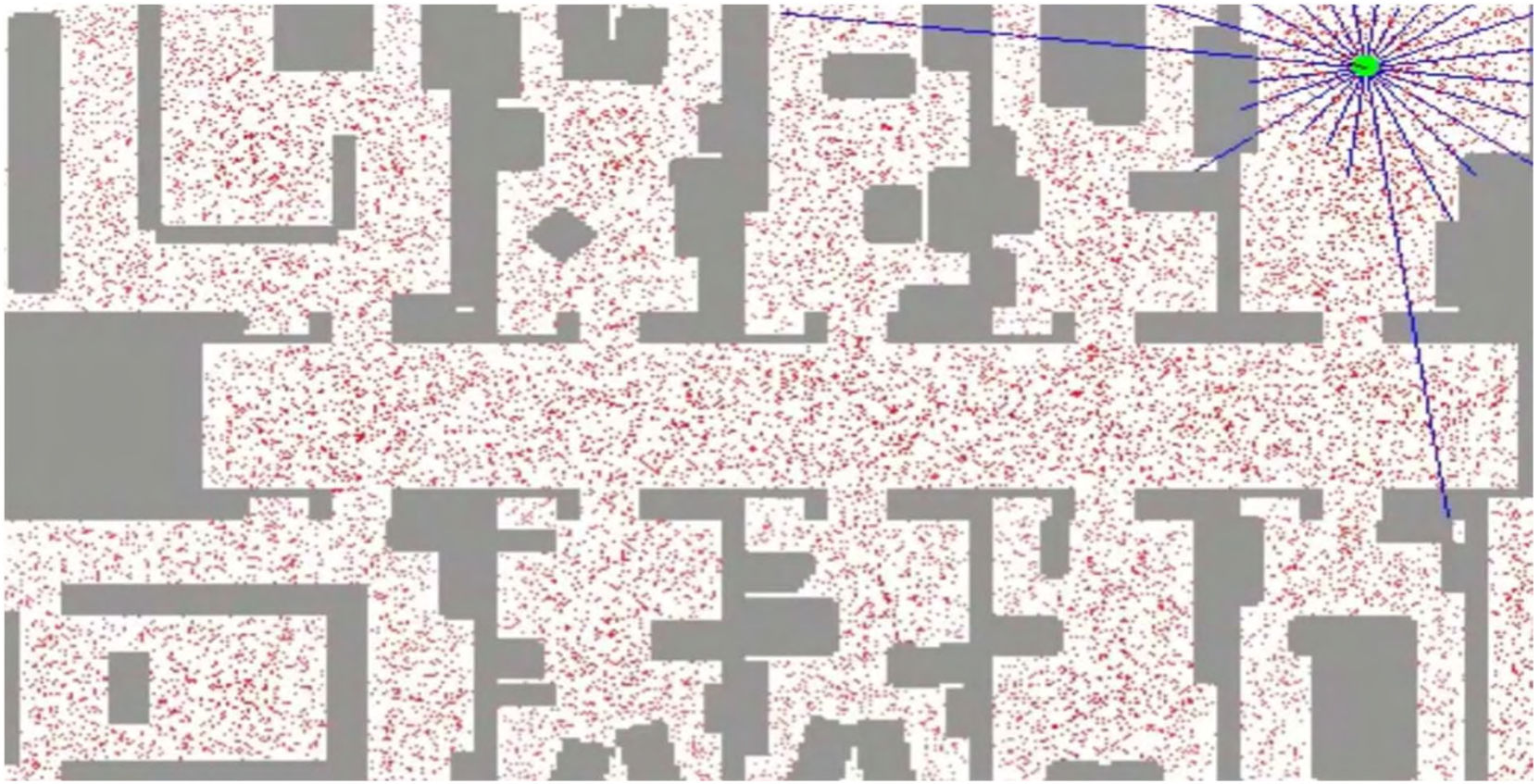
Particle Filter:

Particle filters is a set of Monte Carlo algorithms used to solve filtering problems

- To handle non linear processes
- To handle non Gaussian Noise

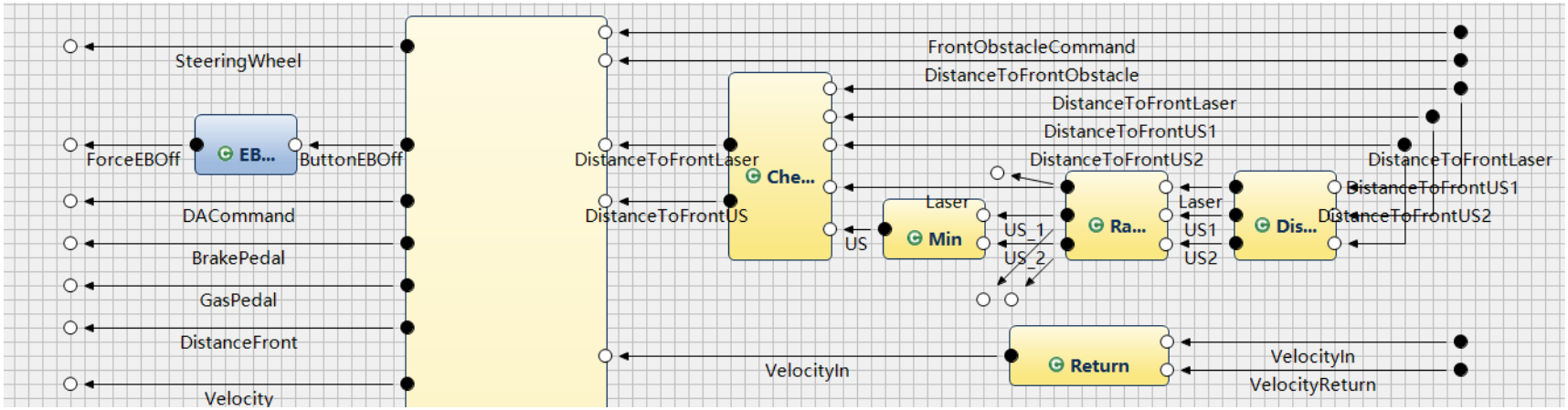


Sensor Fusion Functions



Relation to our Project

- AF3 – Sensor Data Fusion

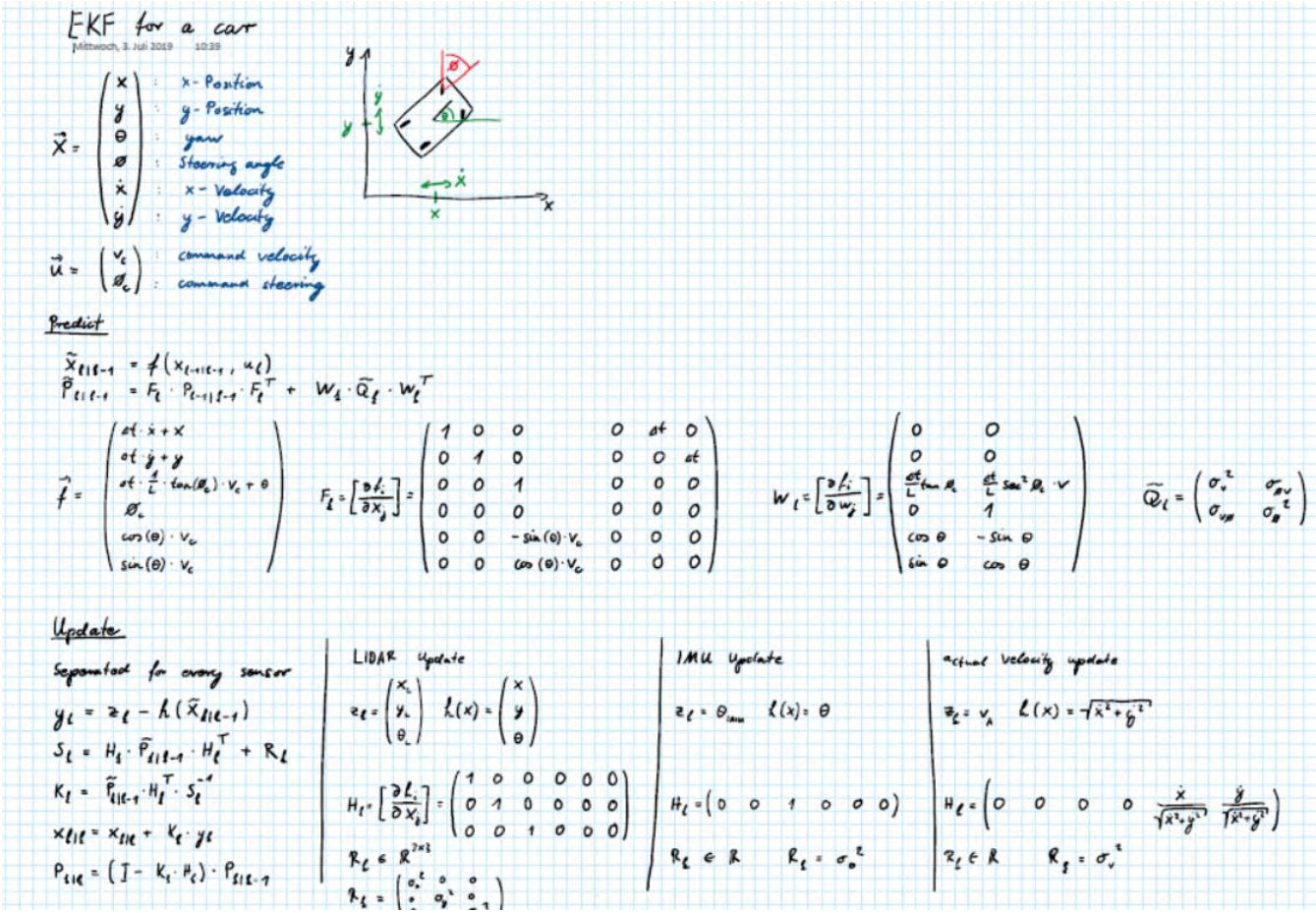


Relation to our Project

- AF3 – Sensor Data Fusion

```
if (FrontObstacleCommand != NoVal && FrontObstacleCommand) {
    DistanceFront = DistanceToFrontObstacle;
}
else {
    if (DistanceToFrontLaser == NoVal && DistanceToFrontUS == NoVal) {
        DistanceFront = NoVal;
    }
    else {
        if (DistanceToFrontUS != NoVal && (DistanceToFrontLaser == NoVal || DistanceToFrontUS <= DistanceToFrontLaser)) {
            DistanceFront = DistanceToFrontUS;
        }
        else {
            DistanceFront = DistanceToFrontLaser;
        }
    }
}
```

Relation to our Project



Resources

- Gereon Hinz, lecture Autonomous Fahren
- Darius Burschka. lecture Robot Motion Planning
- https://en.wikipedia.org/wiki/Extended_Kalman_filter
- https://www.youtube.com/watch?v=XswKMtQBTCo
- https://en.wikipedia.org/wiki/Expectation–maximization_algorithm
- https://en.wikipedia.org/wiki/Monte_Carlo_method