

interactIve



Accident avoidance by active intervention for Intelligent Vehicles

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**Frontal/Side-Rear Object Perception and all around
track ID maintenance**

**Nikos Floudas, Angelos Amditis, ICCS
interactIve final event**

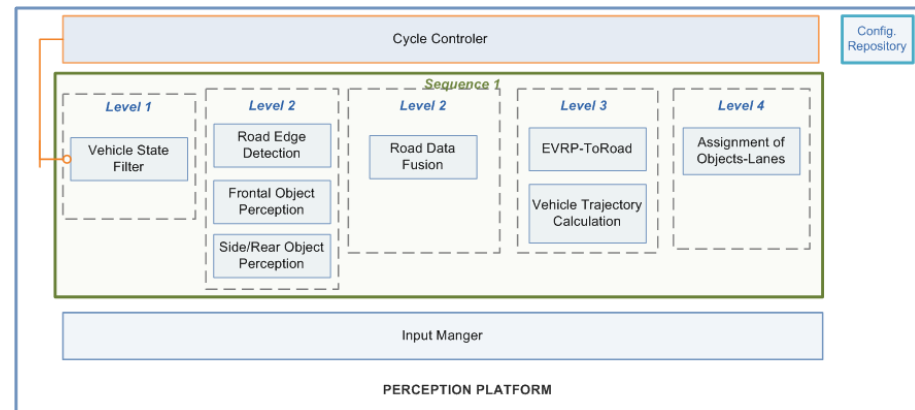
20th-21st November 2013

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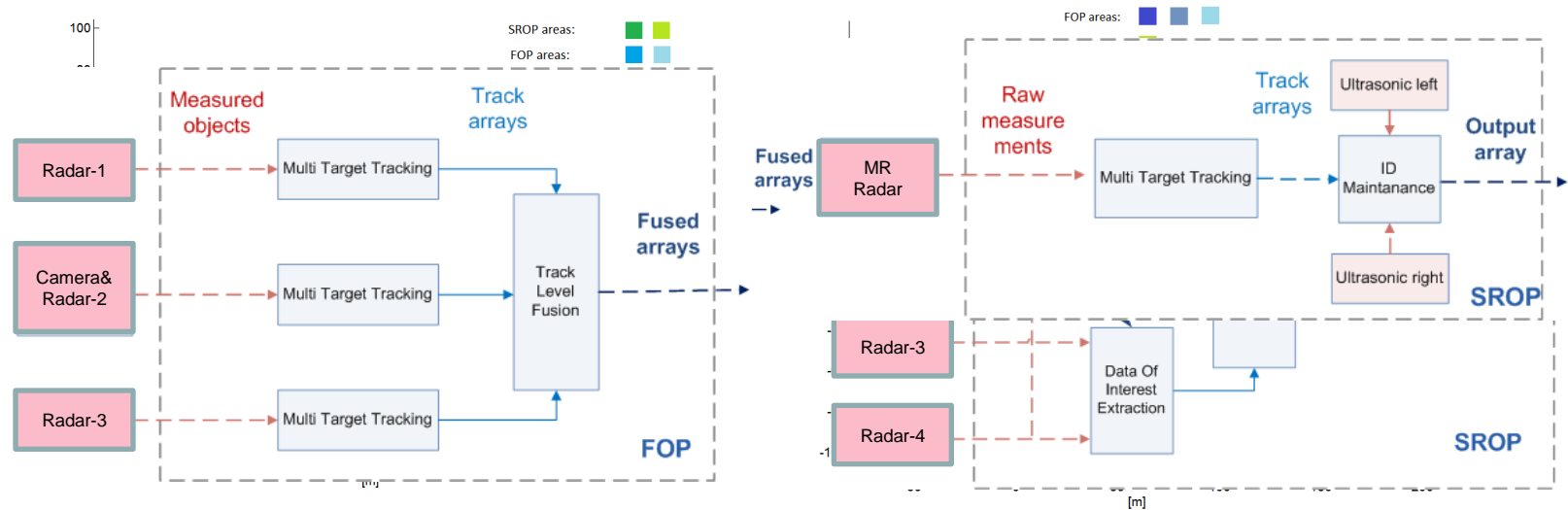
Introduction

- Multi-sensor data fusion quite mature research area
- Current active safety systems:
 - A significant amount of sensors used
 - Increased cost (luxurious vehicles)
 - Independent functions (different sensor set for each function)
- Proposed approach:
 - Same algorithms for different vehicles
 - Sensor set for different functions
 - Decreased cost
- Applicable to all type of sensors:
 - Short range radars
 - Long range radars
 - Cameras

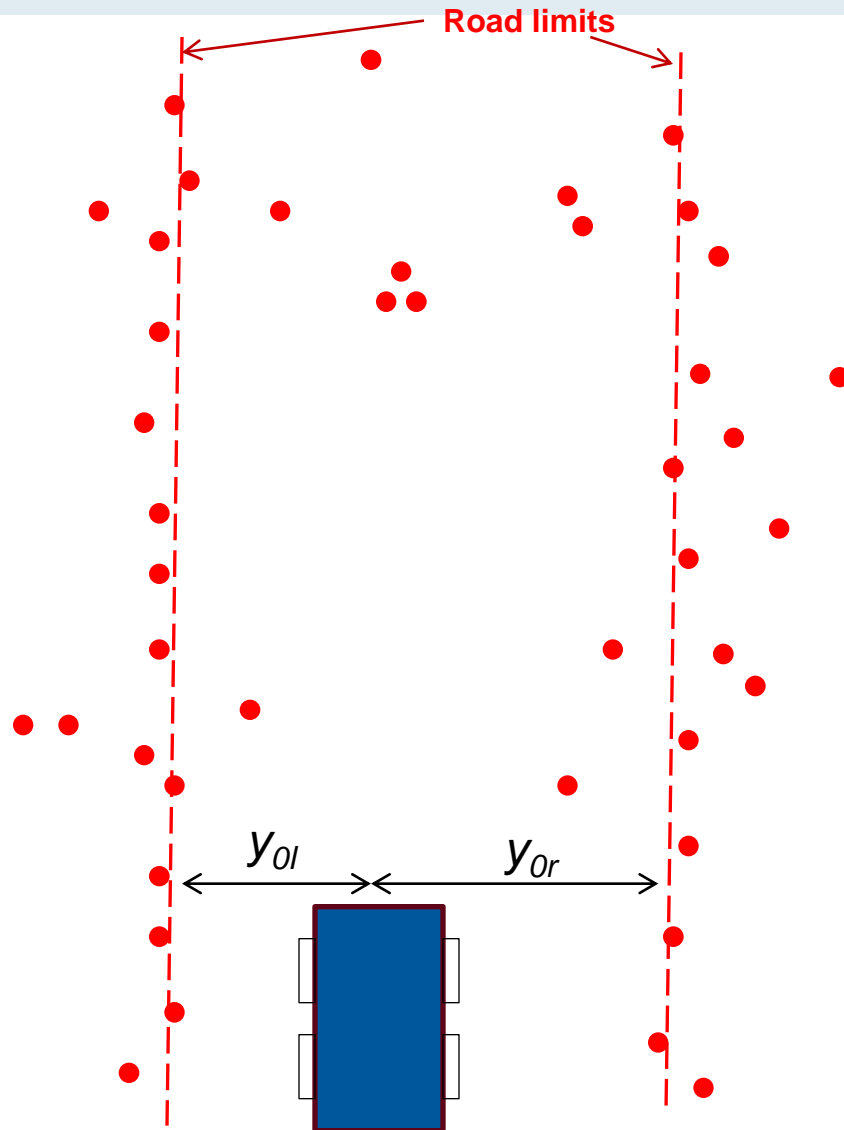


Innovation & Challenges / Module Architecture

- Multiple sensors covering all around areas
- Modular architecture to track/fuse the measurements from multiple sources and sets of sensors
- Interoperable common processing blocks for various architecture: data clustering, data association, multi-target-tracking.



Algorithmic Concept

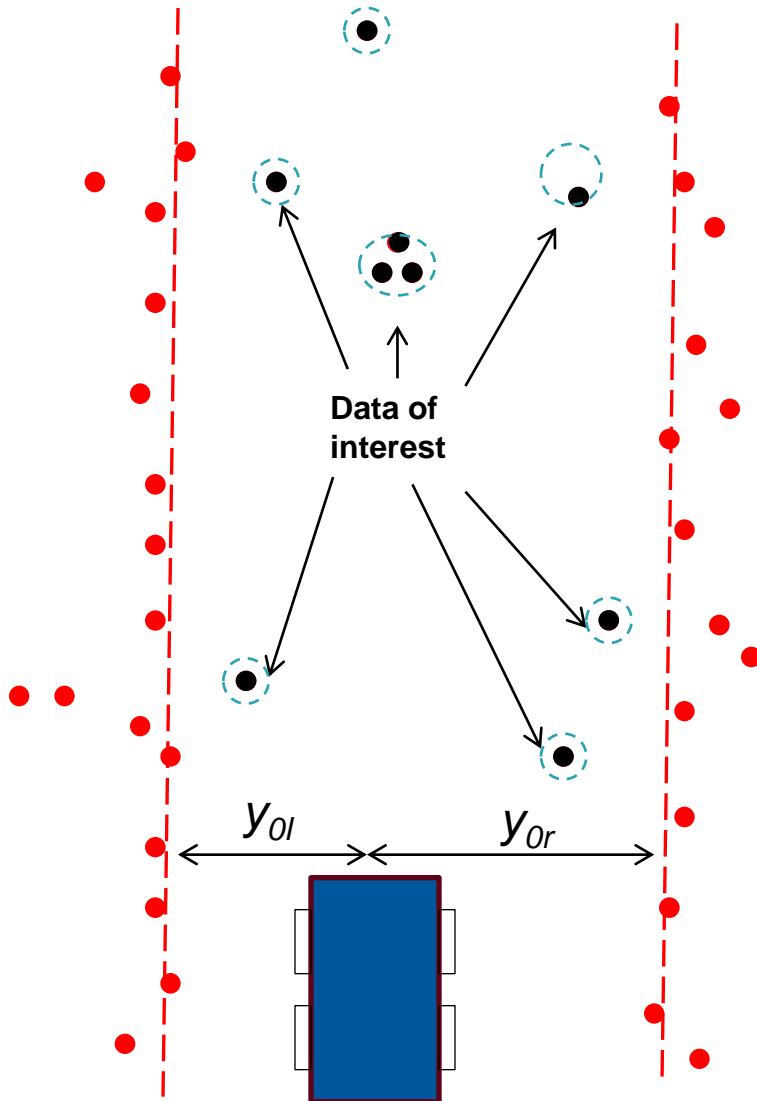


Road Limits Estimation

Curvature: c_0 $\mathbf{x}_{RB} = (c_0, c_1, y_{0l}, y_{0r})^T$

Curv. Rate: $c_1 \mathbf{y}_{RB} = (y_{1l}, \dots, y_{Nll}, y_{1r}, \dots, y_{Nrr})^T$

Algorithmic Concept



Road Limits Estimation

$$\text{Curvature: } c_0 \quad \mathbf{x}_{RB} = (c_0, c_1, y_{0l}, y_{0r})^T$$

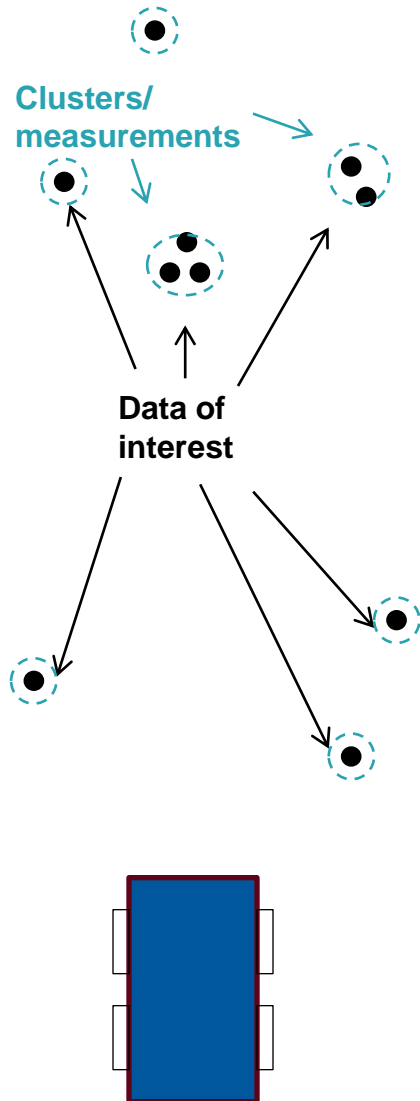
$$\text{Curv. Rate: } c_1 \mathbf{y}_{RB} = (y_{1l}, \dots, y_{Nll}, y_{1r}, \dots, y_{Nrr})^T$$

Data of Interest Extraction

A measurement point $P_0\{x_0, y_0\}$ is a point of interest if:

$$\frac{x_0^2}{2} \cdot c_0 + \frac{x_0^3}{6} \cdot c_1 + y_{0R} < y_0 < \frac{x_0^2}{2} \cdot c_0 + \frac{x_0^3}{6} \cdot c_1 + y_{0L}$$

Algorithmic Concept



Road Limits Estimation

$$\text{Curvature: } c_0 \quad \mathbf{x}_{RB} = (c_0, c_1, y_{0l}, y_{0r})^T$$

$$\text{Curv. Rate: } c_1 \mathbf{y}_{RB} = (y_{1l}, \dots, y_{Nll}, y_{1r}, \dots, y_{Nrr})^T$$

Data of Interest Extraction

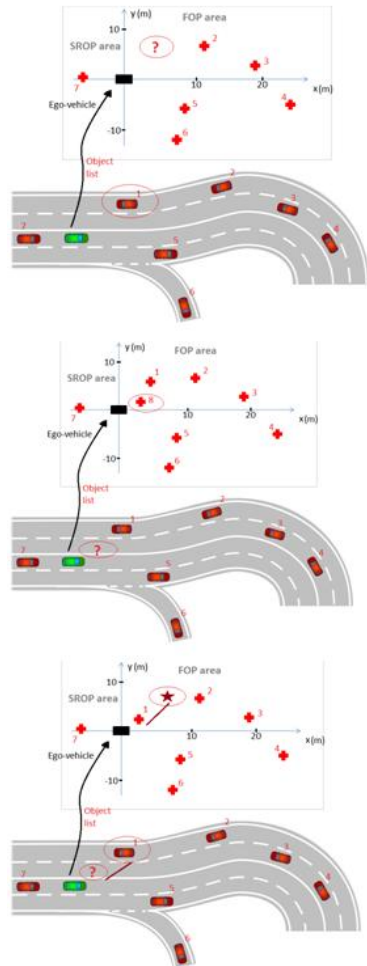
A measurement point $P_0\{x_0, y_0\}$ is a point of interest if:

$$\frac{x_0^2}{2} \cdot c_0 + \frac{x_0^3}{6} \cdot c_1 + y_{0R} < y_0 < \frac{x_0^2}{2} \cdot c_0 + \frac{x_0^3}{6} \cdot c_1 + y_{0L}$$

Data Clustering & Tracking

- CV motion model
- GNN data association solved with “auction algorithm”
- Rule based track management
- Kalman filtering

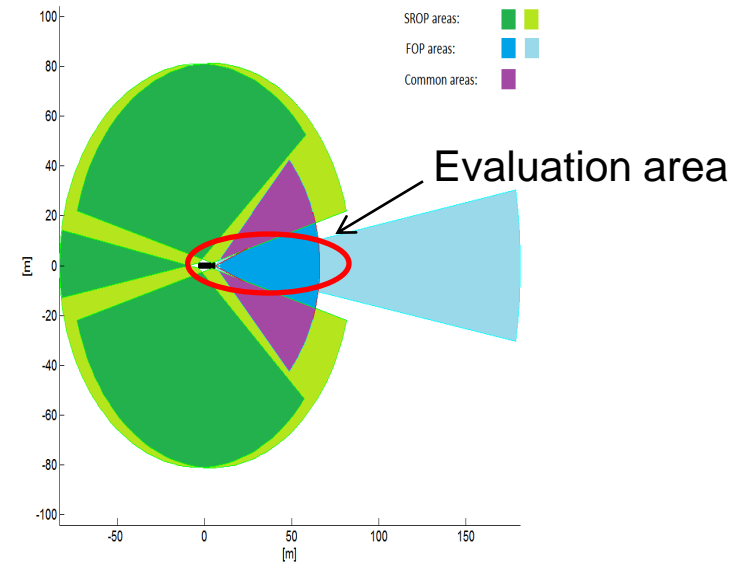
Evaluation Criteria



Track miss

False track

Erroneous detection



Performance Results

Scenarios

(S1) road with **no divider** and **oncoming traffic**, (337s), (5281 vehicles).

(S2) **highway** with divider and **low traffic**, (166s), (3486 vehicles).

(S3) **highway** with divider and **heavy traffic**, (295s), (12390 vehicles)

Results*

Scenarios	Failed Objects			Correct Objects (%)
	Miss (%)	False (%)	Error (%)	
S1	5.8	1.4	1.6	92.6
S2	2.6	1.5	0.3	97.1
S3	3.1	1.2	1.1	95.8

* **NOTE:** *False Targets because of sensor fault velocity measurements were not included.*

Performance example

The screenshot displays the ADTF Development Environment interface. At the top left, the 'ADTF Control' window shows a playback status: '00:01:05.758 Playback' with a progress bar and control buttons. Below it, the 'PH Output - Numerical D...' window displays a table of processing module values.

Processing Module	Value
Vsf	
Red	
Rdf	
Fop	
TiStamp	1665.81
InpAvInfo	1
NrObj	2
Objects	
[1]	
ObjId	39
ObjFusInf	1
ObjMntnFlg	0
ObjXpos	52.1791
ObjYpos	-0.386681
ObjXV	0.444482
ObjYV	0.127128
ObjYawRate	0
ObjXA	-0.145221
ObjYA	0.0641782
ObjConf	50
ObjLifeCnt	73
DetConf	255

The central 'View Display' window shows a 3D visualization of a sensor field. It features a central vehicle (red rectangle) with two overlapping sensor cones: a green one on the left and a purple one on the right. The field is populated with red triangles representing detected objects. Two specific objects are labeled 'Id: 39' and 'Id: 46'. The background is a yellow-to-green gradient. The 'interactIve' logo is visible at the bottom of the visualization area.

At the bottom left, a block diagram shows the 'Fentia_Object_Perception' module with various input and output ports.

Research Targets

Initial Objectives

1. Data clustering techniques for homogeneous sensors
2. Maintenance of Global Track ID

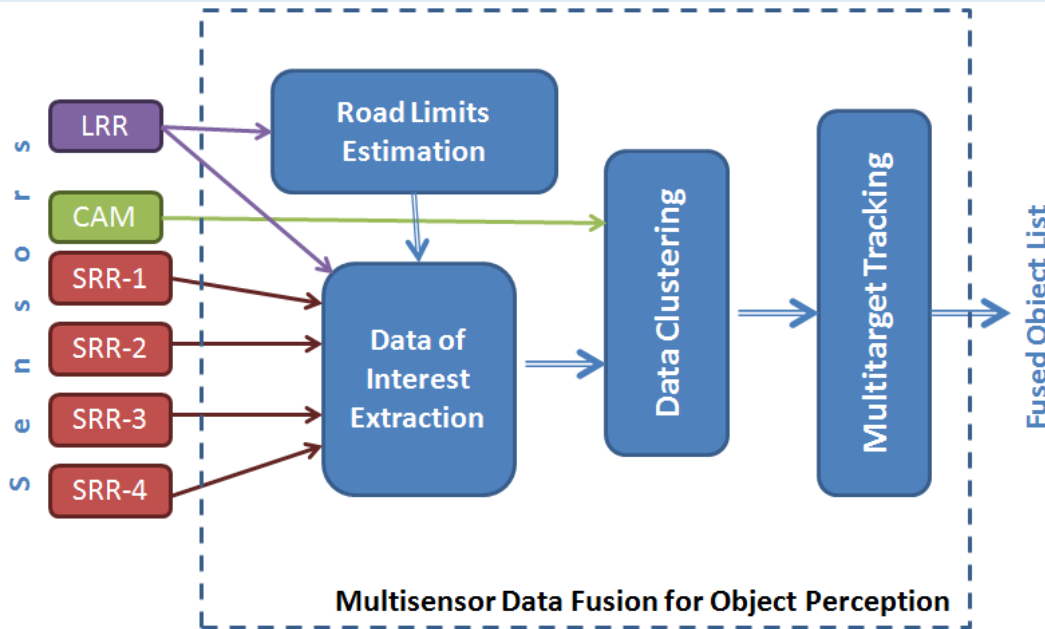
Delivered Modules

- Objective (1) covered → data of interest extraction & data clustering => treating set of homogeneous sensor data as a single sensor.
- Objective (2) partially covered → common ID for FOP and SROP sensor sets separately.

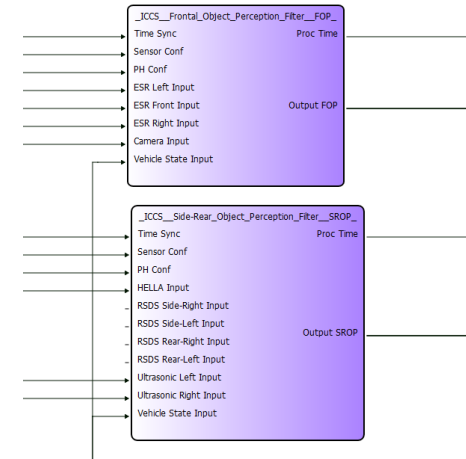
Research Module (Extra)

- Current architecture does not allow a Global Track ID → Creation of a new offline research platform that hosts a global tracking module OP (=FOP+SROP) and produces a single object list.

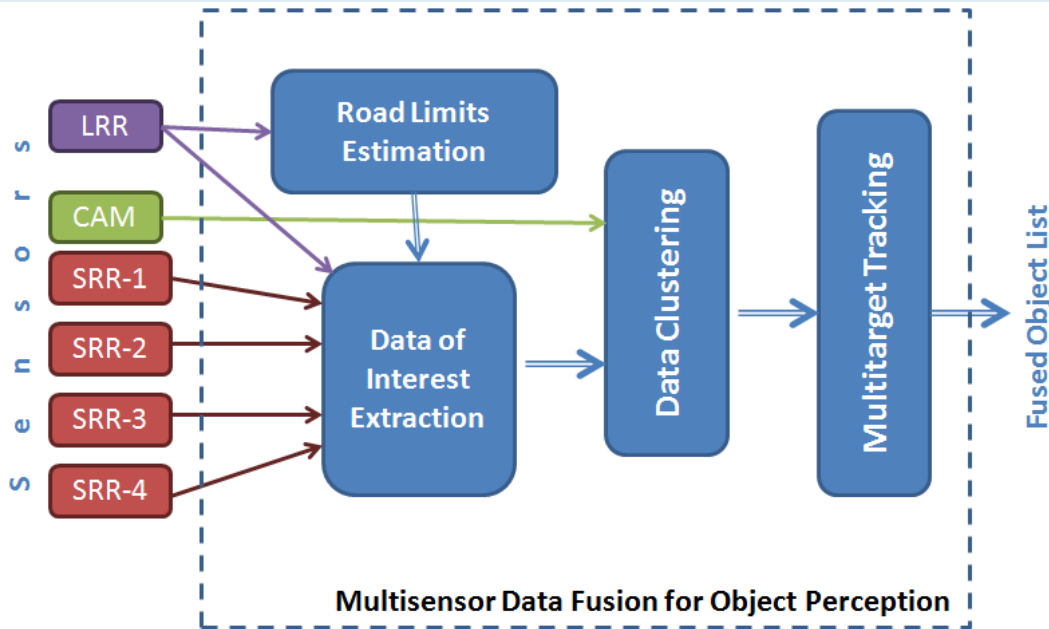
Research module



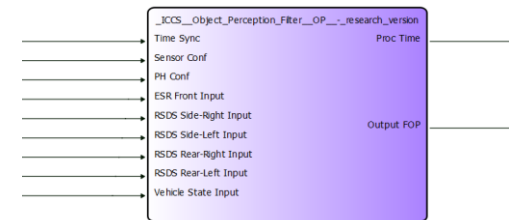
Version in interactive demonstrators



Research module



Research module (All-around tracking OP)



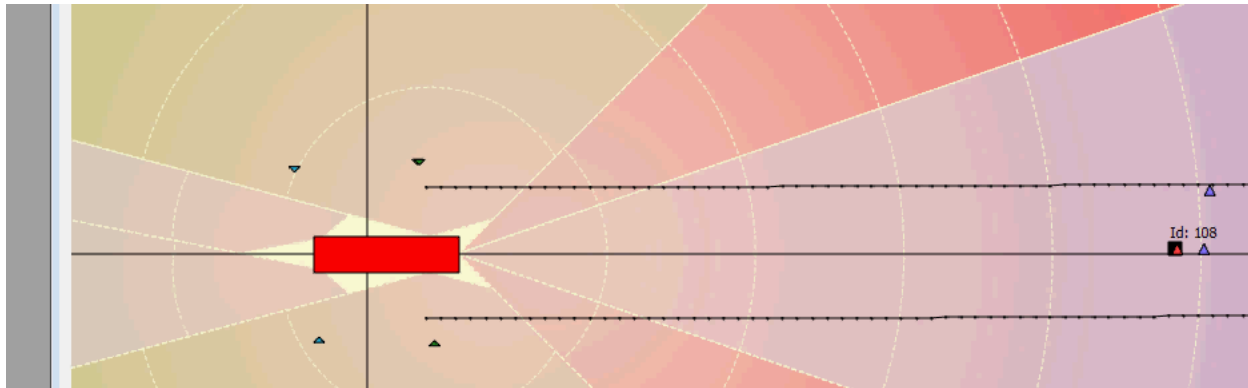
Track ID Evaluation (OP)

Less tracks by	42%
More stable tracks by	29%
More tracks (>100) by	41%

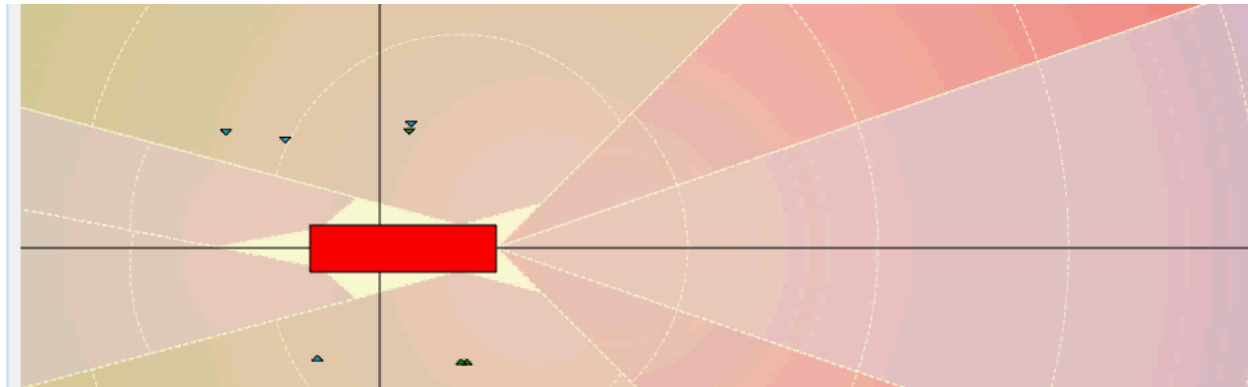
In the expense of bigger time delay and algorithm complexity.

ID Maintenance (example)

FOP & SROP ID's:



Research module OP ID's:



Conclusions & Future Work

Achievements

1. FOP & SROP online modules run in VTEC and FFA demonstrators
2. Intense offline testing and evaluation using recorded data sets from SP4/5
3. OP offline common module was tested

Lessons learned

1. All around ID maintenance could be achieved by one common sensor set.
2. In a multi-sensor set high level fusion can be proved very time consuming, homogeneous sensors could be better low level fused.
3. Proposed fusion architecture in multi-sensor all around sensor deployments
 - Homogeneous sensor inputs (short and long range radars) are low level fused
 - Heterogeneous sensor inputs (radar/fused and camera) are high level fused

Future Work

1. Elaborate Global Track ID research module in terms of real-time tracking and performance of object perception.
2. Evaluate Hybrid Fusion Architecture on other sensor topologies

Acknowledgements

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Thank you.

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