Background characterization of one-dimensional images from a Smart-Camera Network

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Outline

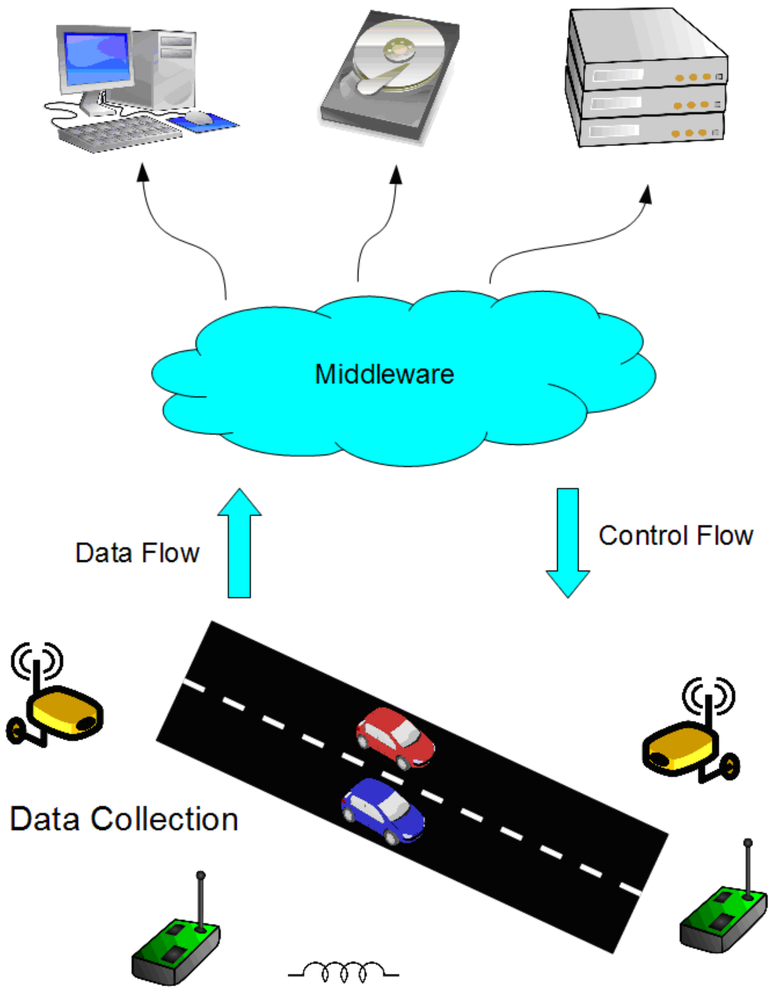
- The Smart Camera Networks in the ITS context
- Line-Sensors in WSN: constraints and processing capabilities
- Single metric stochastic background model
- The ghost avoidance algorithm
- Performance evaluation

The Smart Camera Networks in the ITS context

The IPERMOB Project

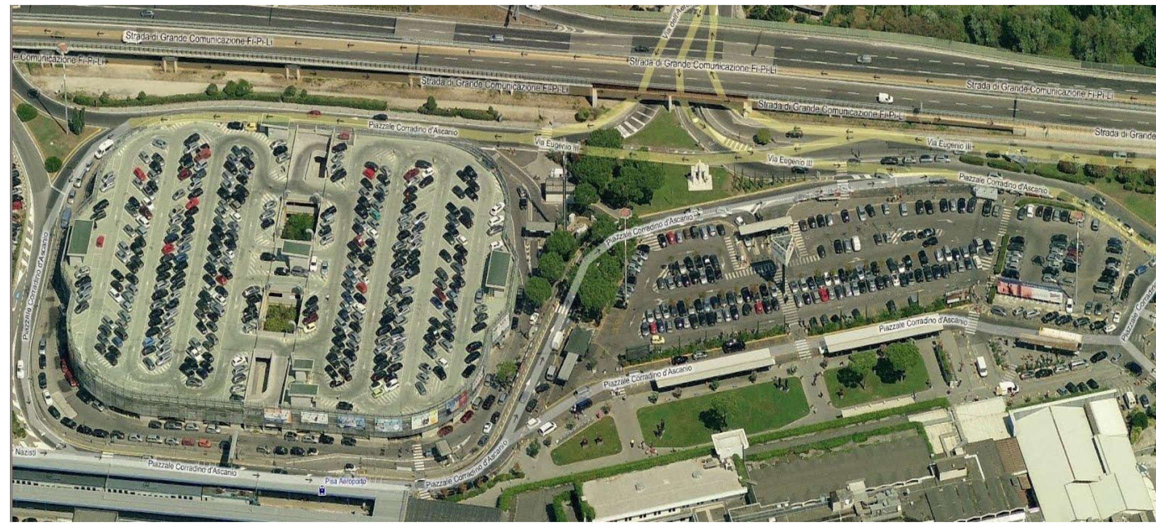
- Pervasive and heterogeneous infrastructure to monitor and control urban mobility
- 3-tier architecture
- Our Smart Camera Network (ScanTraffic) is the data collection layer
- Link:

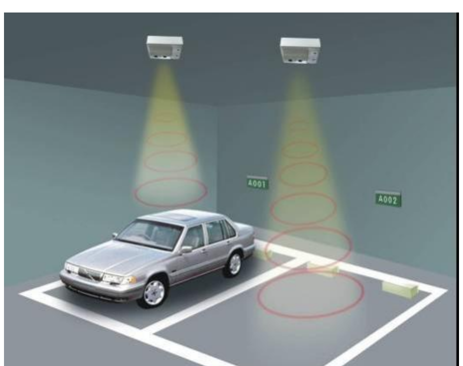
http://www.ipermob.org

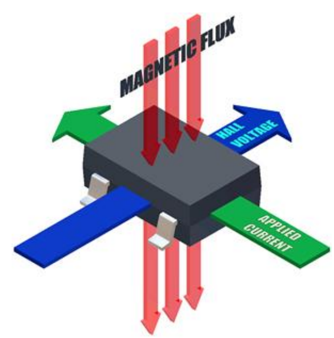


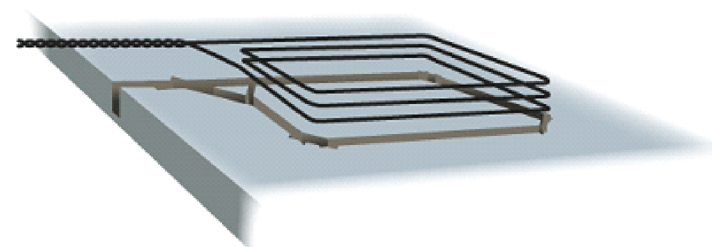
ScanTraffic

- Real deployment at the landside of Pisa Airport
- 21 smart cameras monitoring
  - 83 parking spaces
  - 8 traffic lanes
- Smart cameras as an effective replacement of traditional sensors



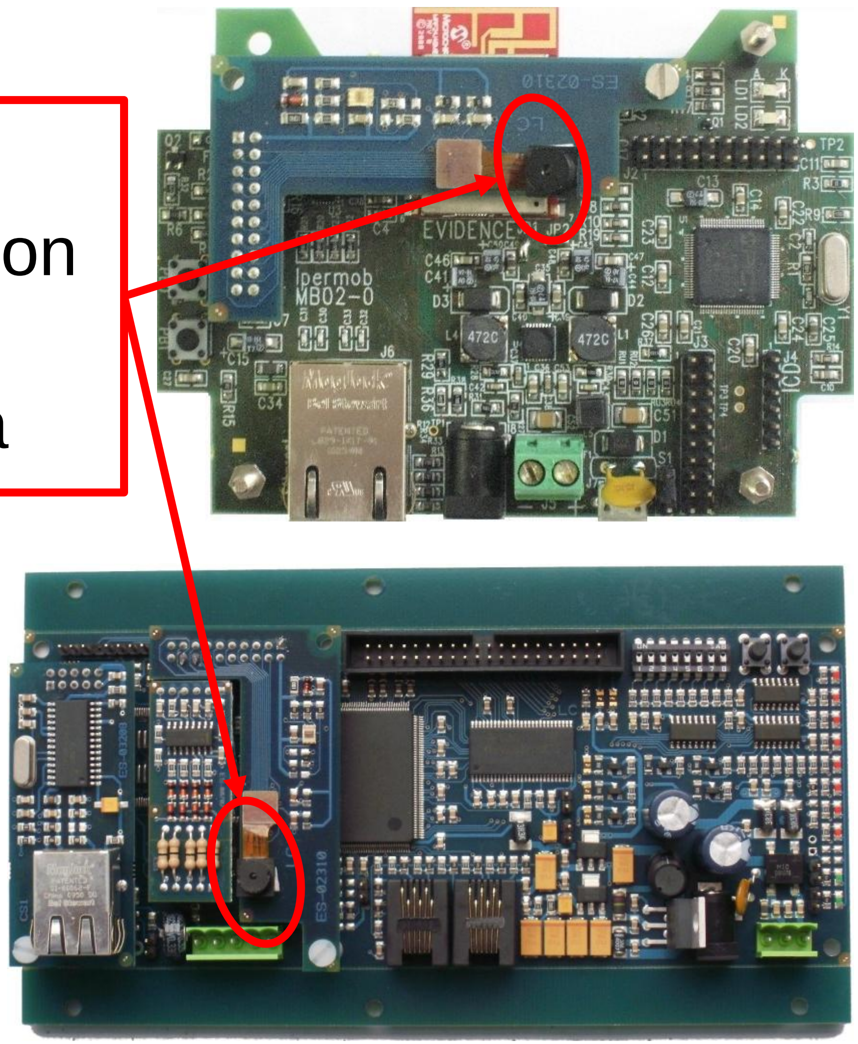






Hardware Platforms

Low resolution CMOS camera



Pic32-based board

- 80 MHz internal bus
- 128 kB of RAM
- 512 kB of Flash

FPGA-based board

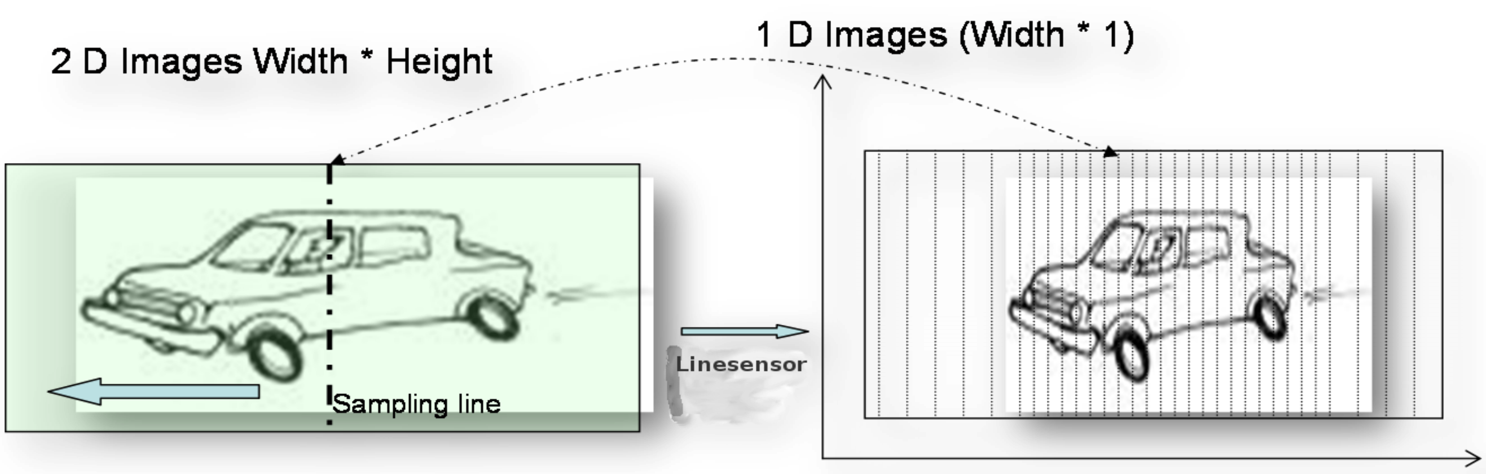
- Soft-core@40 MHz
- 32 MB of RAM
- 2 MB of Flash

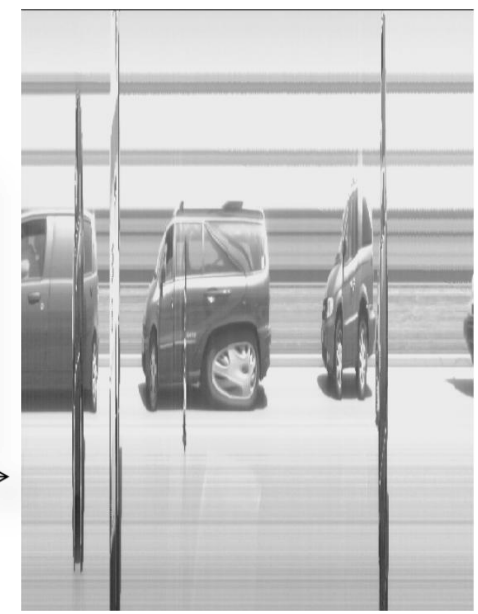
in collaboration with:

Line-Sensors in WSN: constraints and processing capabilities

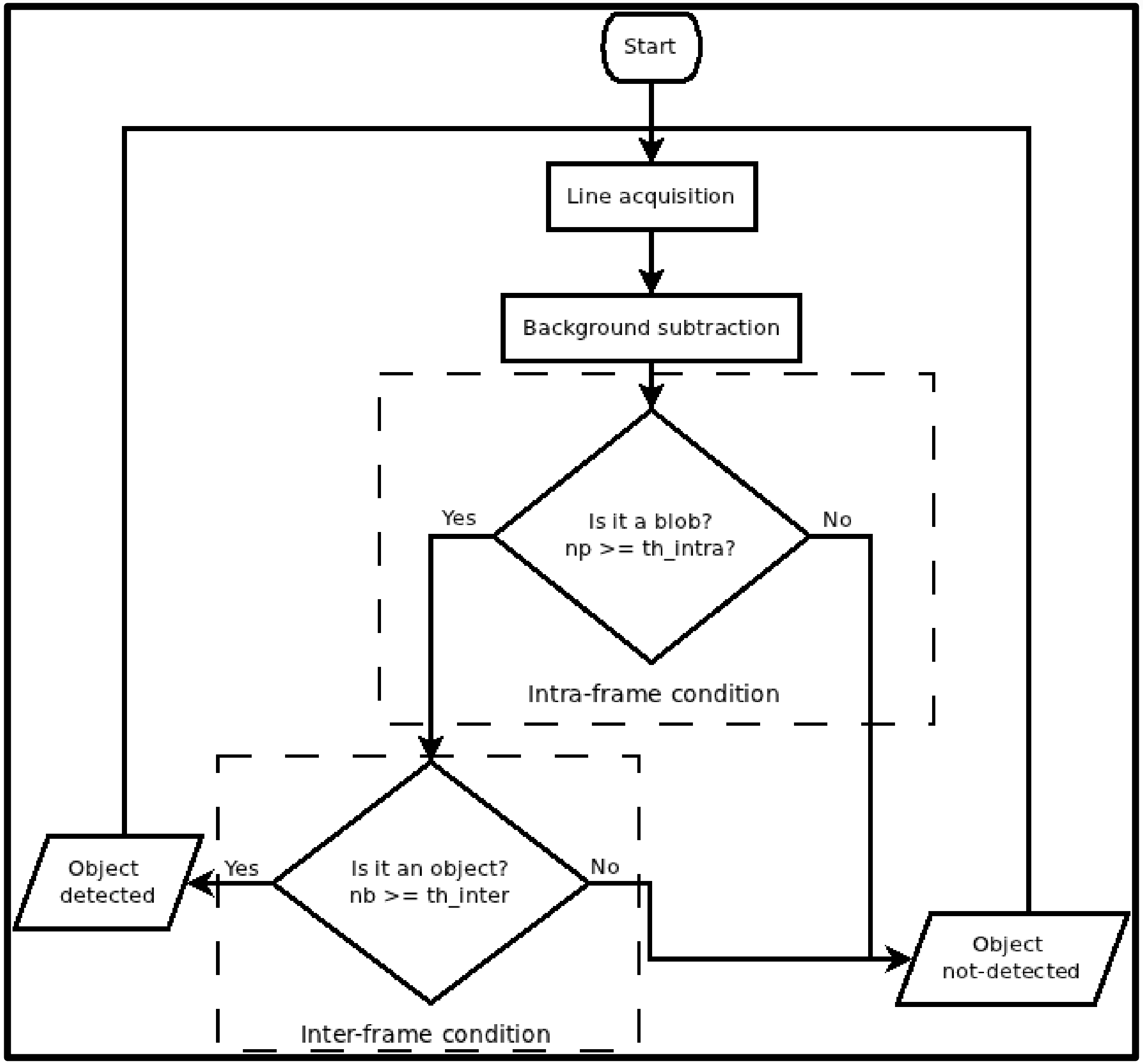
What is Line-Sensor?

- It is a visual sensor able to count moving vehicles, capitalising their temporal redundancy.
  - The amount of data to be processed is reduced up to a line.
- Algorithm based on *background subtraction*: a *background model* has to be defined!!





Linesensor algorithm flow chart



Line-Sensor constraints

- To detect moving vehicles, to satisfy the inter-frame condition, the frame-rate (R) is constrained by this formula

$$R = \frac{th_{inter} \, v_{MAX}}{l}$$

  - i.e. th_{inter} = 5, v_{MAX} = 250km/h, l = 4m => R = 87 fps
  - The proposed algorithm has to be very fast
- The Line-Sensor algorithm is able to process one road-lane only .
  - In a line is present at maximum *only one object.*

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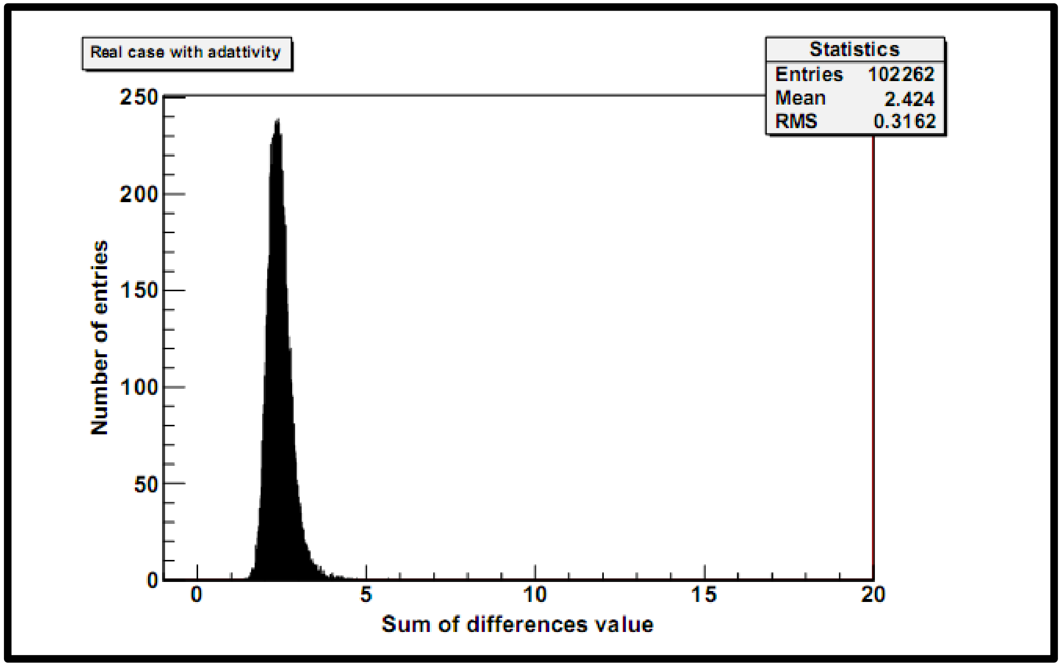
Single metric stochastic background model

The selected metric

$$d_i = \sum_{j=1}^{N} \left| I_{i,j} - B_j \right|$$

- In absence of light changes and of events:
  - **Ideal case**: $d_i = 0$
  - **Real case**: $d_i \neq 0$ (Gaussian)



Reference d_i distribution

The *"referee"* algorithm (1/3)

- Comparing the current d_i distribution with the refence one:
  - At a substantial variation of the mean-value, it correspond a variation of luminosity on the background:
    - **Background event**
    - The current image is elected as background
  - At a substantial variation of both the mean-value and the variance, it correspond a change of the image geometry:
    - **Blob event**
    - The Line-Sensor algorithm is applied

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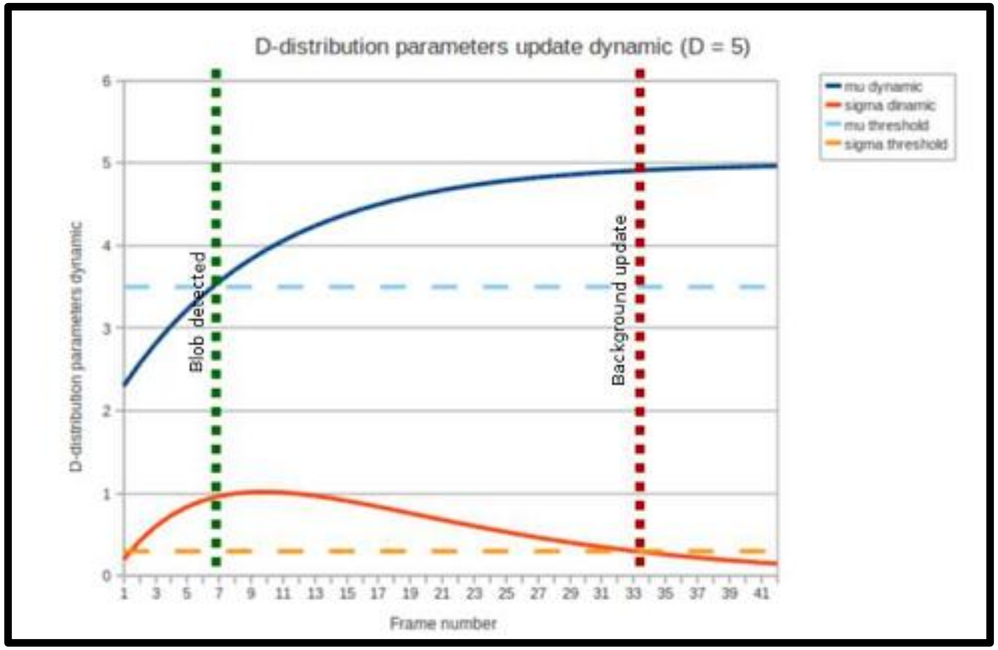
The "*referee*" algorithm (2/3)

The gaussian parameters updating rules:

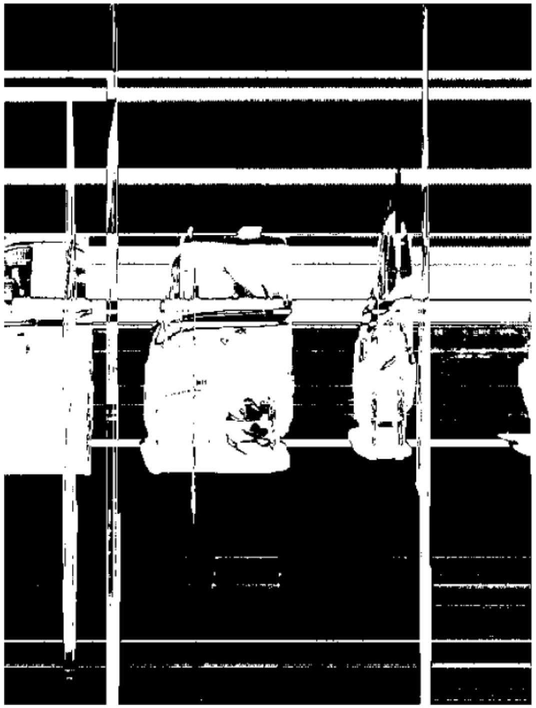
$$\begin{cases} \mu_i = (1-\delta)\cdot\mu_{i-1} + \delta\cdot d_i \\ \sigma_i = (1-\delta)\cdot\sigma_{i-1} + \delta\cdot(d_i - \mu_i) \end{cases}$$

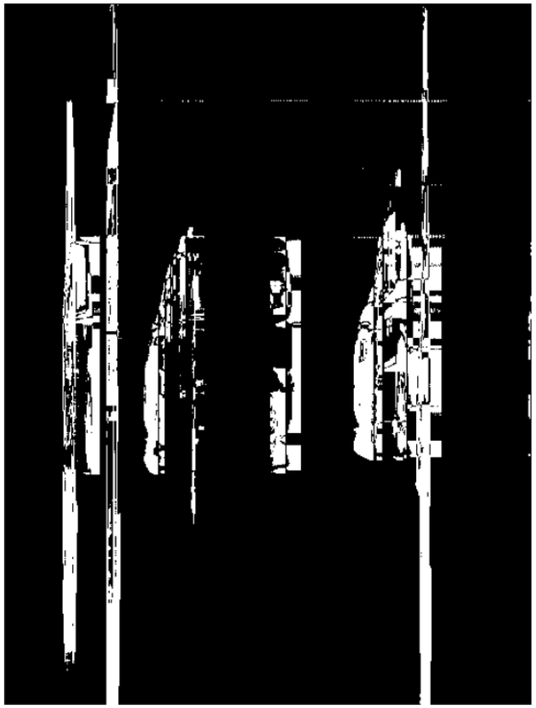
Learning rate

$$\delta \in (0,1)$$



The *"referee"* algorithm (3/3)

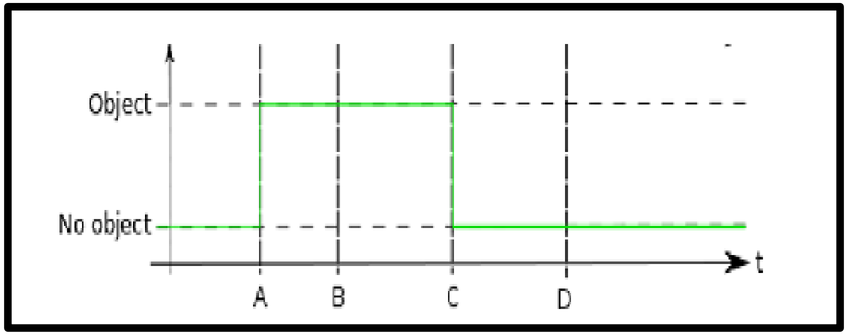




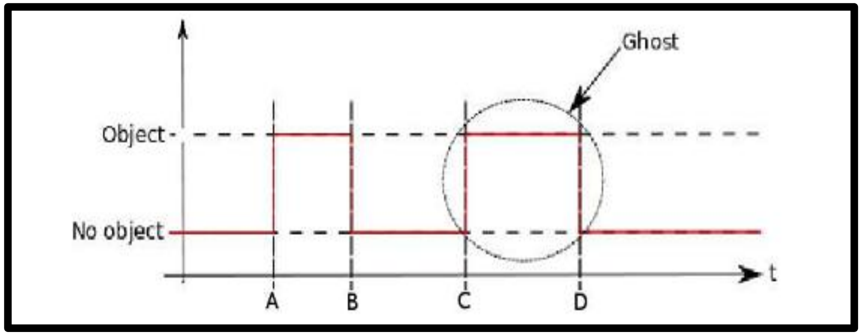
The ghost avoidance algorithm

Maximum period of event and ghost

- The period between the blob detection and its absorbtion on the background is called ***Maximum period of event***
  - It depends on the traffic conditions
  - It depends on the gray-level distribution
  - In case of high traffic a vehicle could be absorbed improperly into the background (**ghost**)



Ideal case



Real case

The ghost avoidance algorithm

- Delaying as much as possible the improper absorbtion:
  - Reducing the learning rate value during the presence of an object
  - Delaying of a fixed number of frame the background updating operation

Performance evaluation

Normal illumination conditions

Errors: 17 vehicles over 287 (5,7%)

Sudden illumination variation

Errors: 21 vehicles over 238 (8,8%)

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thank you!

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