On-Line Object Behaviour Analysis for Surveillance Systems

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Surveillance system

- net of sensors (cameras, microphones)
- public and private places monitoring
- actually low level of signal processing in practice
- no possibility for later querying the surveillance data
- many human-resources "exploring" the data

Specificity

- surveillance video system for underground scenarios
- data characteristics
  - high noise, low resolution
  - bad but stable lighting conditions
- algorithm demands
  - work in real-time
  - robustness

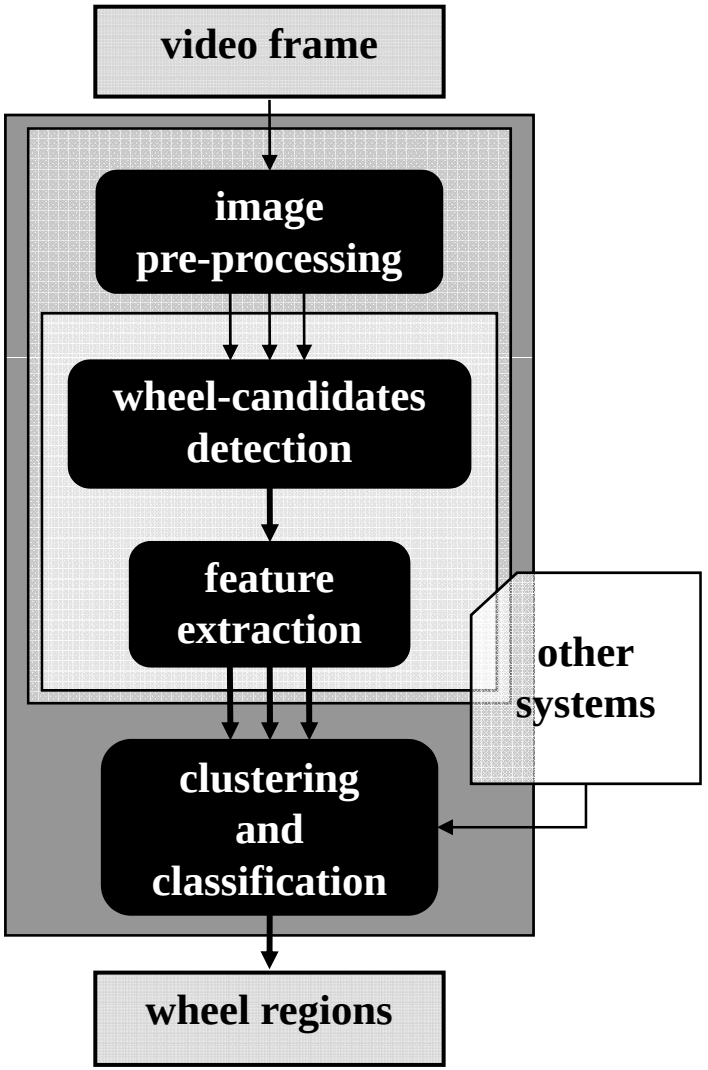
Event types

- statistical approaches for ***simple event*** detection
  - ad-hoc *bicycle detector*
  - *dog detector* based on AdaBoost classifier
  - *trajectory classification* of general moving objects based on HMM
- spatio-temporal rules for ***compound event*** detectors
  - *dangerous occurrence of the person on the platform edge*

Bicycle Detection

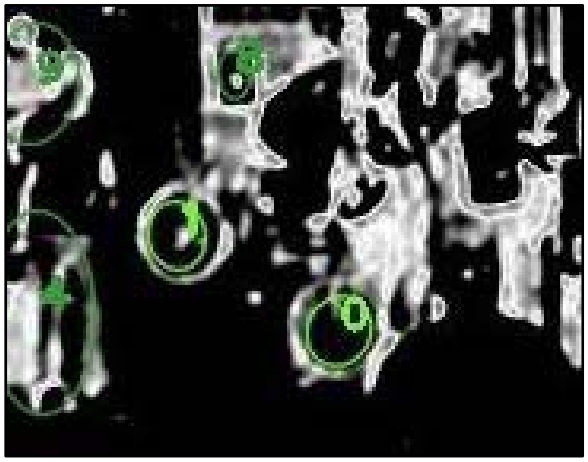
Bicycle Detection

- image pre-processing
  - several probability levels based on wheel colour model
- wheel candidates on each level
- classification & validation
- candidate's clustering over levels



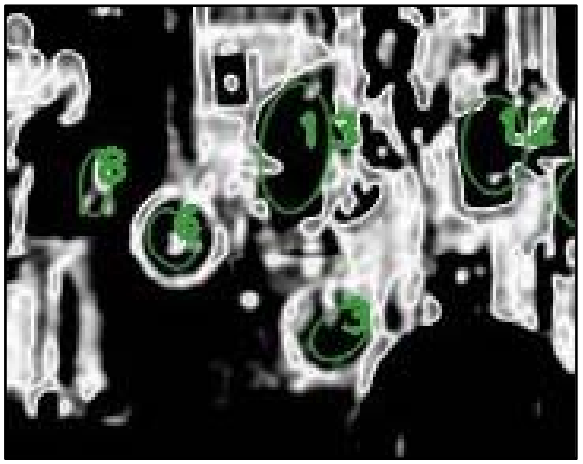
Candidates Classification

- feature extraction
  - geometrical constraints
  - multi-scale template matching
  - ellipse profiling



Level 0

Level 1



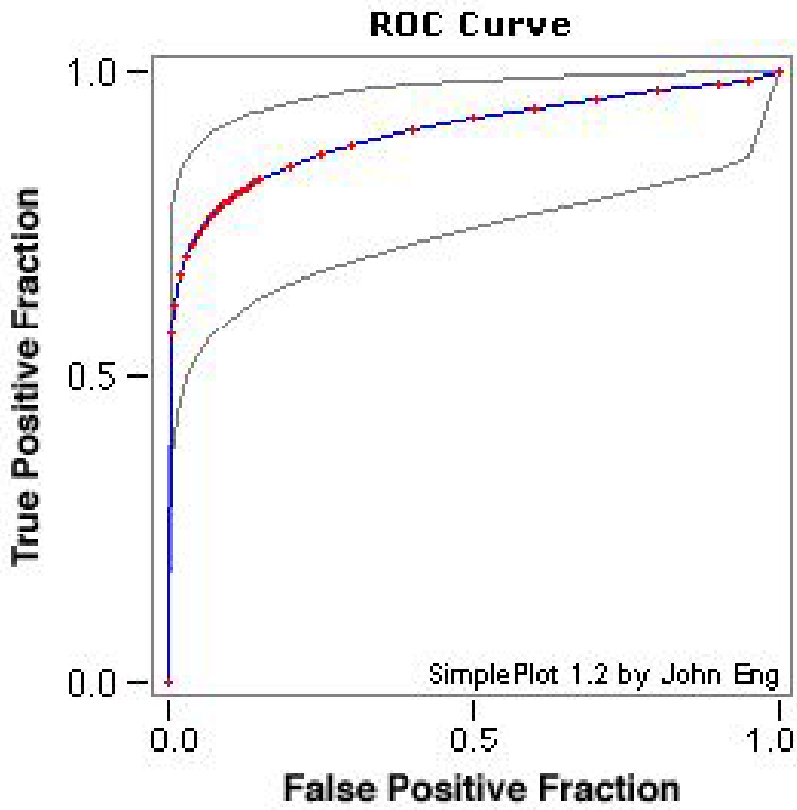
Level 2

Evaluation

- images from video of Roma underground
- resolution 720x576 using format 24bits/pixel
- RGB colour model

- evaluation dataset
  - 60 still images containing bicycles
  - manually annotated

- about 120 positive samples (wheels)



Examples


FIT
caretaker
Detected bicycle candidates


BIKE DETECTION ON

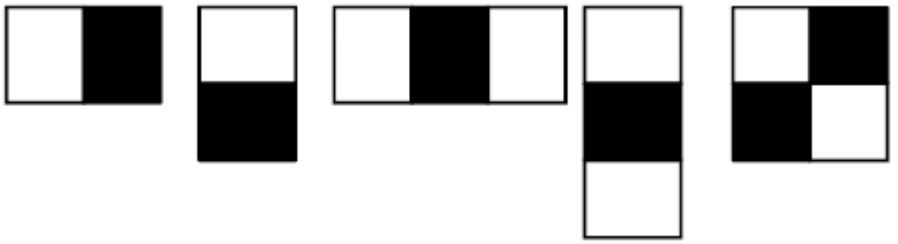
Dog Detection

AdaBoost – Adaptive Boosting

- linear combination of *weak classifiers*
  - error < 0.5

$$\mathrm{H}(\mathbf{x}) = sign[\alpha_1 \mathrm{h}_1(\mathbf{x}) + \alpha_2 \mathrm{h}_2(\mathbf{x}) + \alpha_3 \mathrm{h}_3(\mathbf{x}) \ldots \alpha_T \mathrm{h}_\mathrm{T}(\mathbf{x})]$$

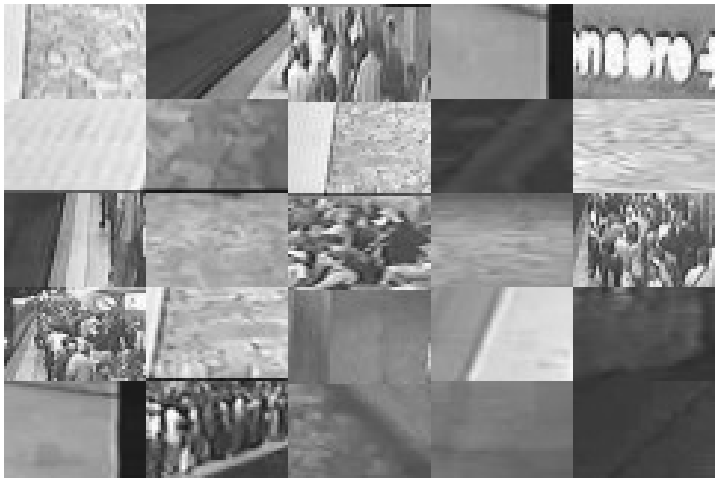
- iterative training – selection of weak classifiers
  - *Haar wavelets*



- *cascade* of classifiers – early results
- based on *integral image*

Training and Evaluation

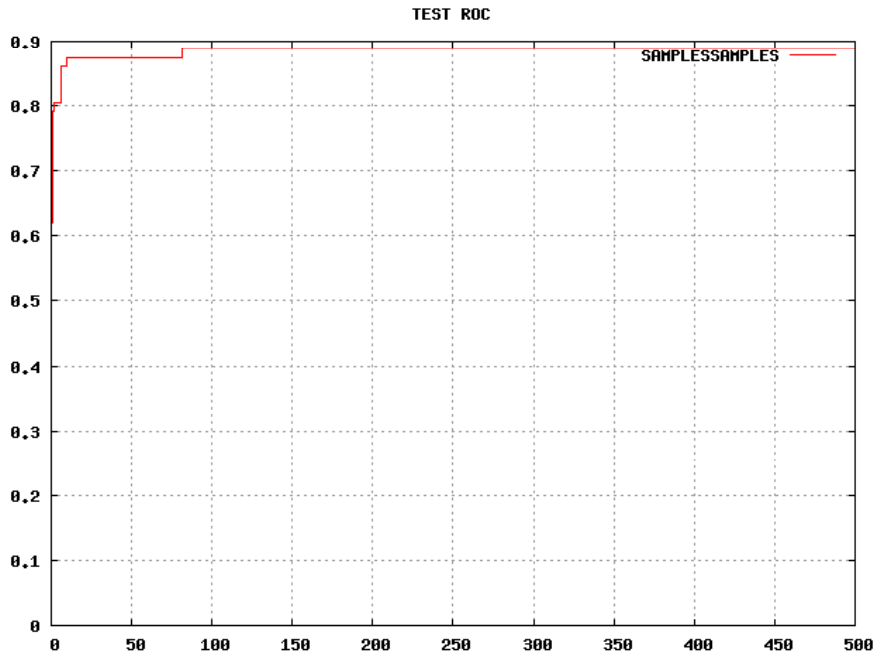
- not ideal data for underground detection
  - mostly taken from outdoor scenes
- positive samples
  - several hundreds of dog images
- negative samples (background)
  - random sub-windows from underground videos (practically unlimited amount)

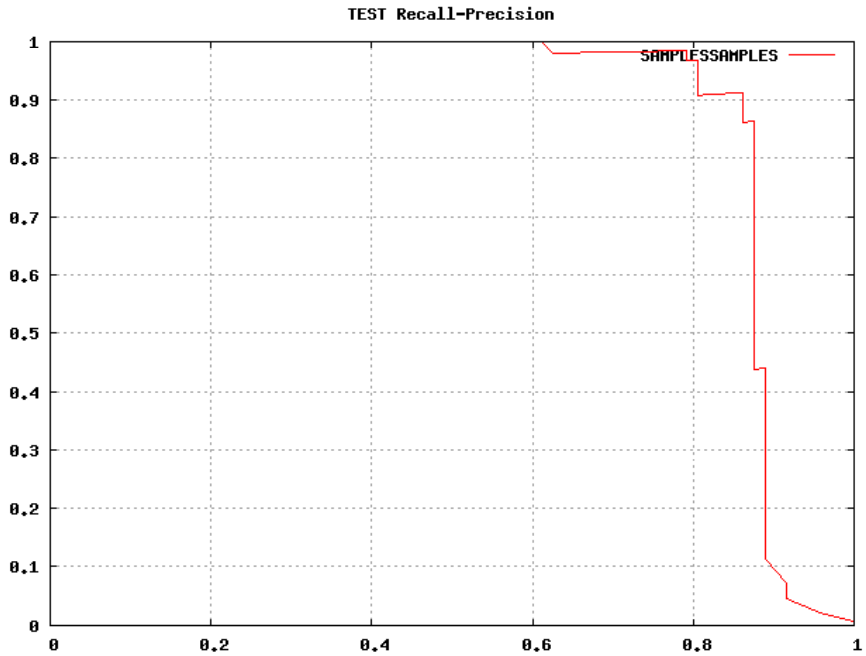


	Training	Validation	Testing
dog	236	190	162
background	21292	21291	10646

Results

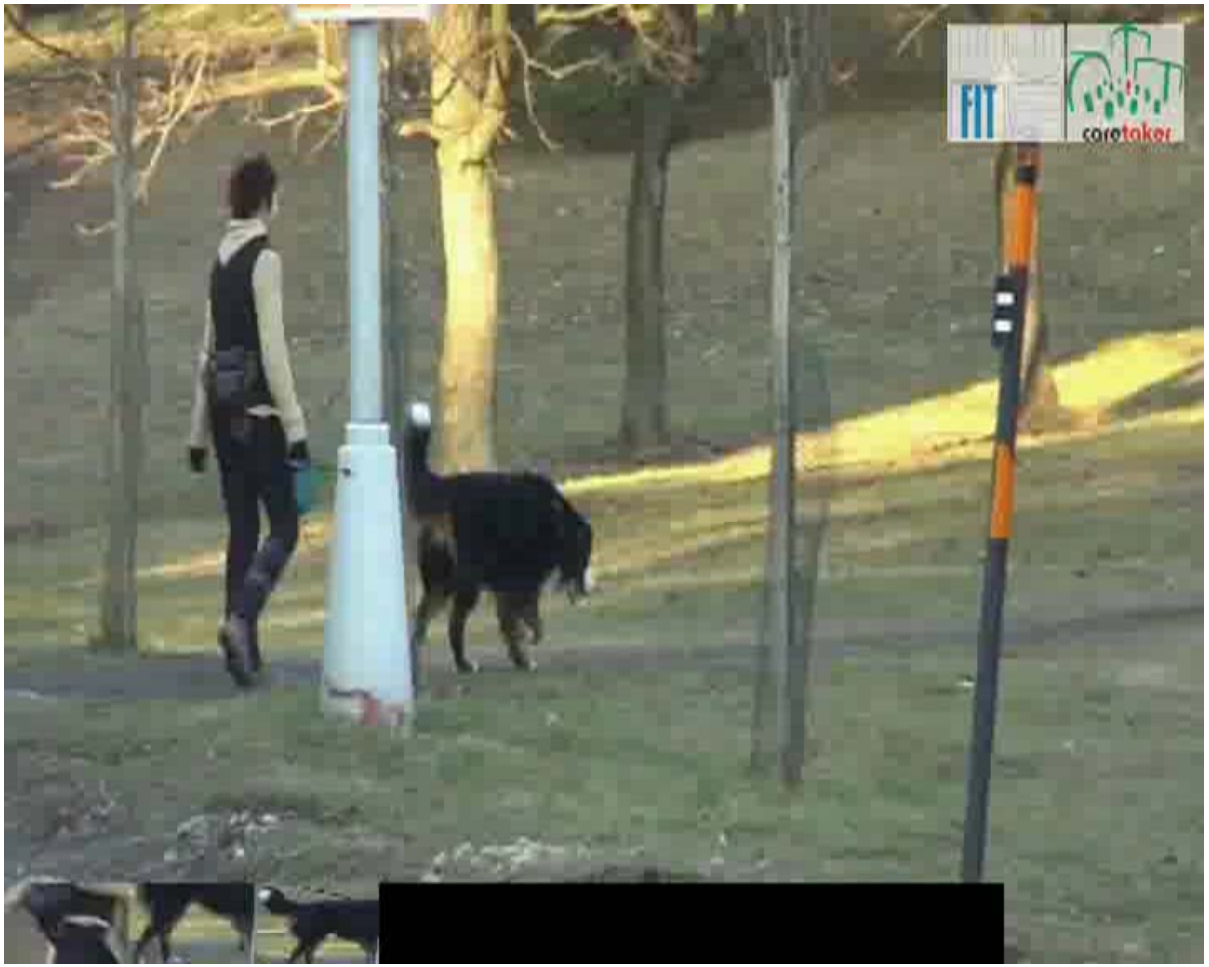
- classifiers trained on data that differ from detection application
- classifier trained for dark and light dogs together





ROC and PRC of dog detection classifier (alpha=0.05 – 5% False Negative Rate)

Examples



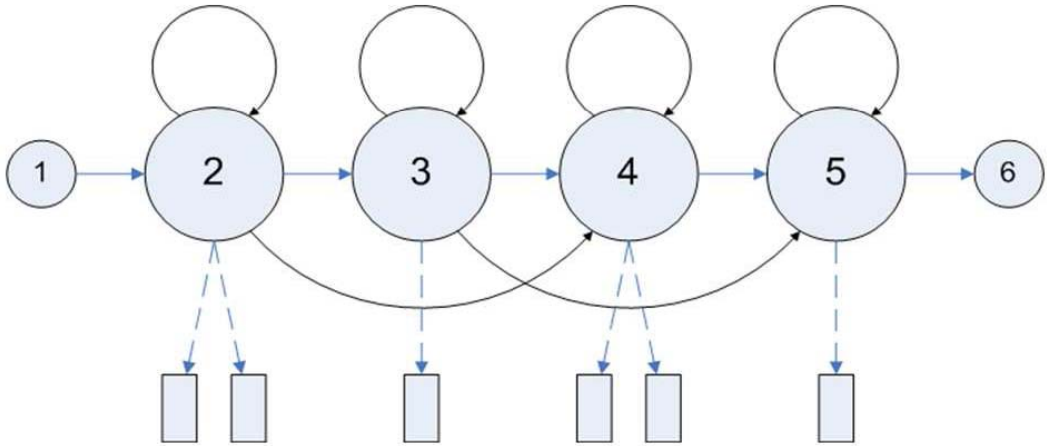
Abnormal Behaviour Detection

Trajectory

- spatial information about object in time
- object detection
  - simple activity detection based on foreground detection

- quadruple
  - position *x*, *y*
  - velocities *dx*, *dy*

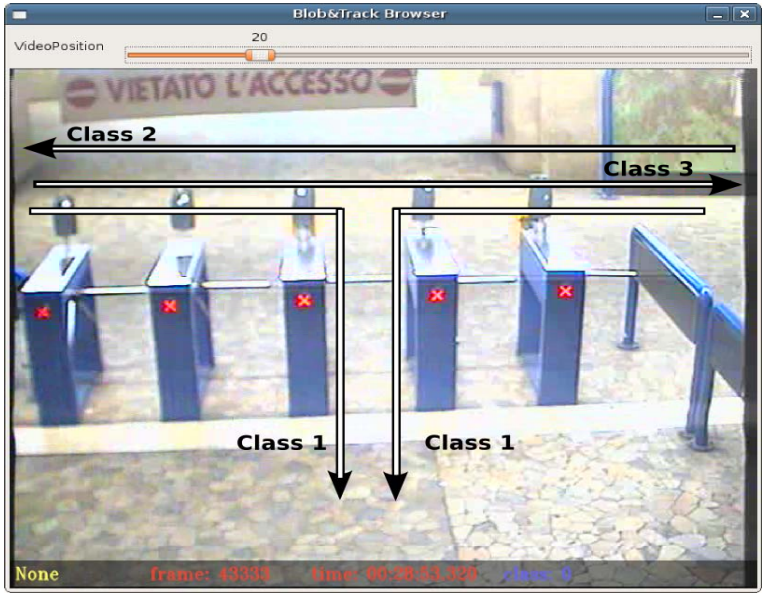
Hidden Markov Models



- hidden states
- transition probabilities between states
- train the model by changing transition weights
- model evaluation – find *best way* through the model
- usage – walk classification, gesture recognition, etc.

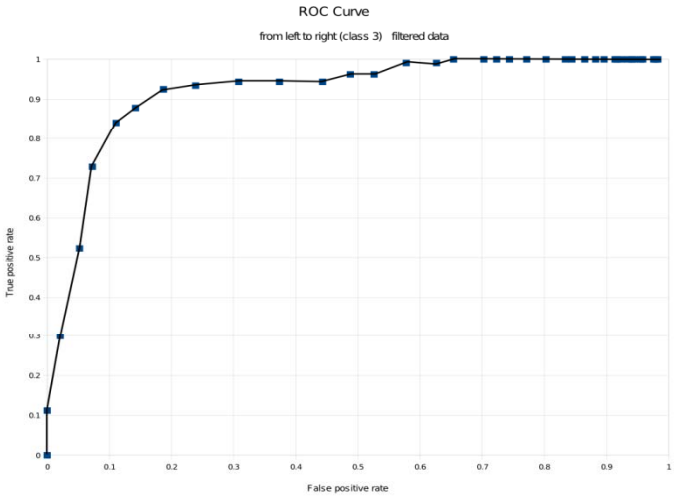
Trajectory Classification

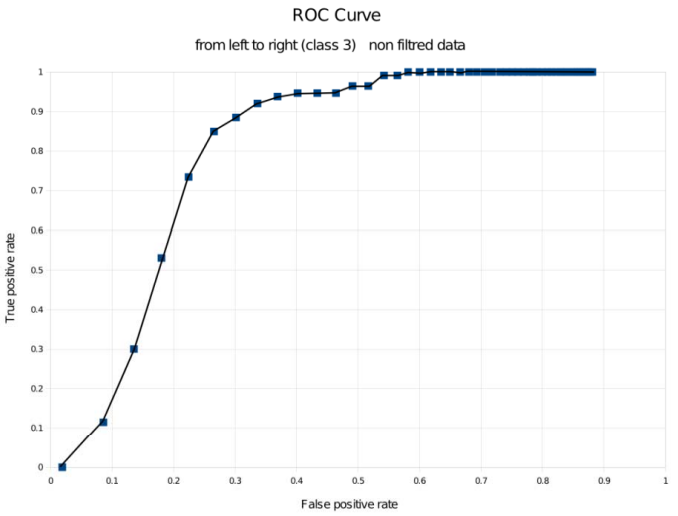
- each scene needs particular configuration
- definition of all normal trajectories in scene
- data annotation
- model estimation
  - each trajectory class is modelled by HMM
- unusual trajectory
  - none of known class



Trajectory classification

- classifier behaviour described by ROC
  - example of class 3
- results on filtered data
  - containing only well defined trajectories
  - classifier accuracy 92%
- results on non-filtered data
  - containing also merged trajectories and ambiguous trajectories
  - classifier accuracy 37%





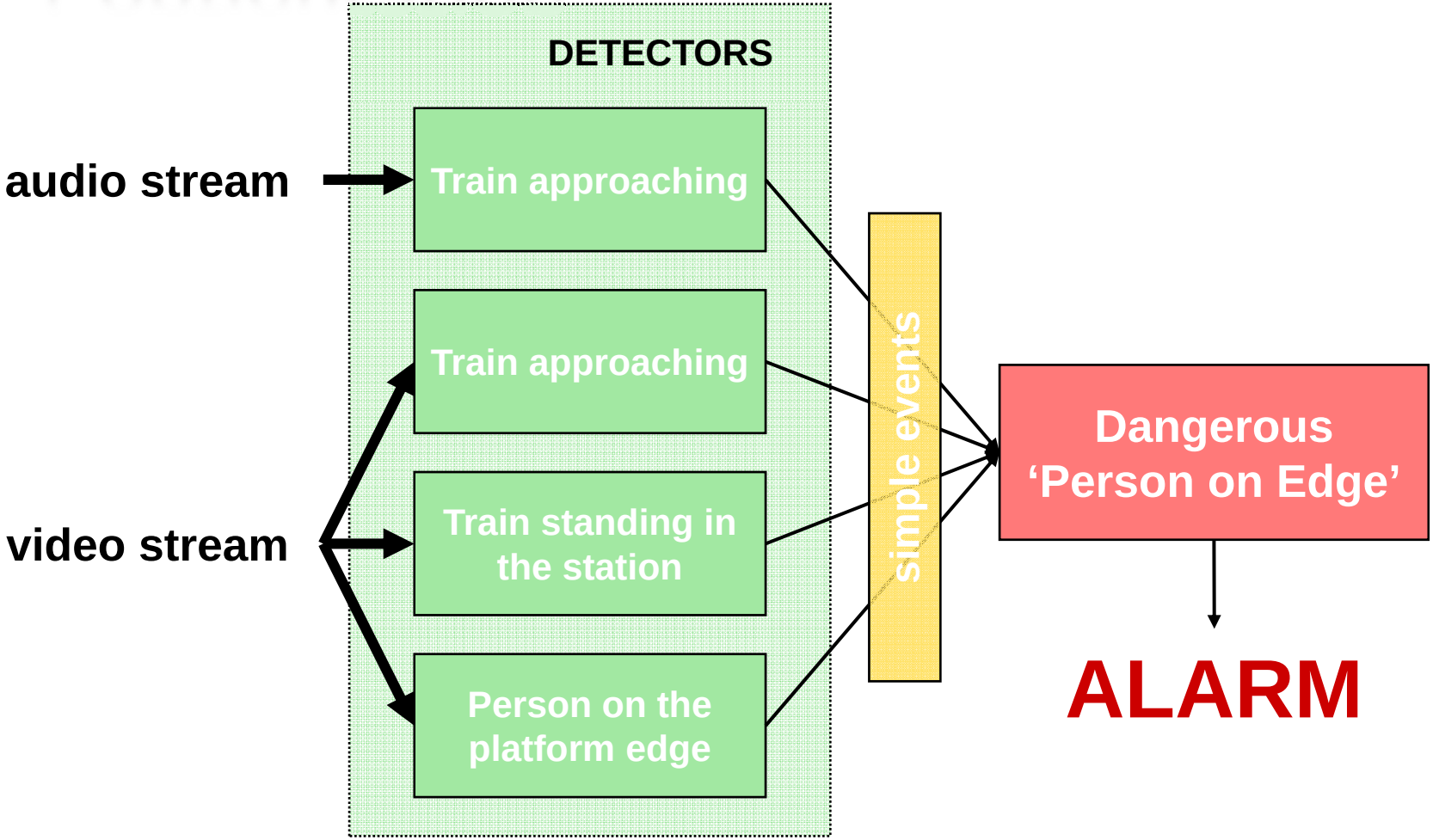
Example

On-line Compound Event

- detection of complex audio/video events
- temporal and spatial relations

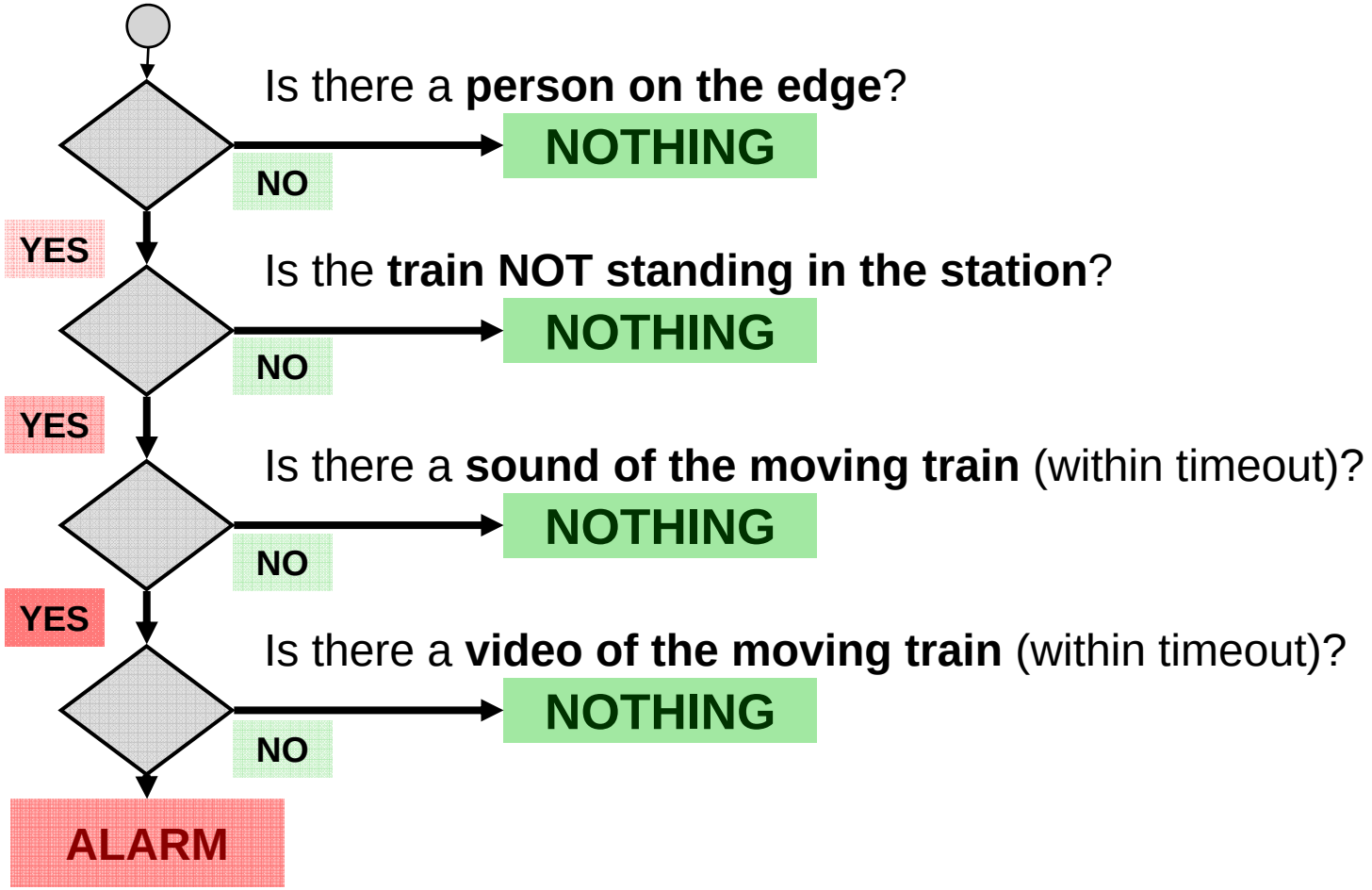
"dangerous occurrence of a person on an edge of a platform"

Configuration

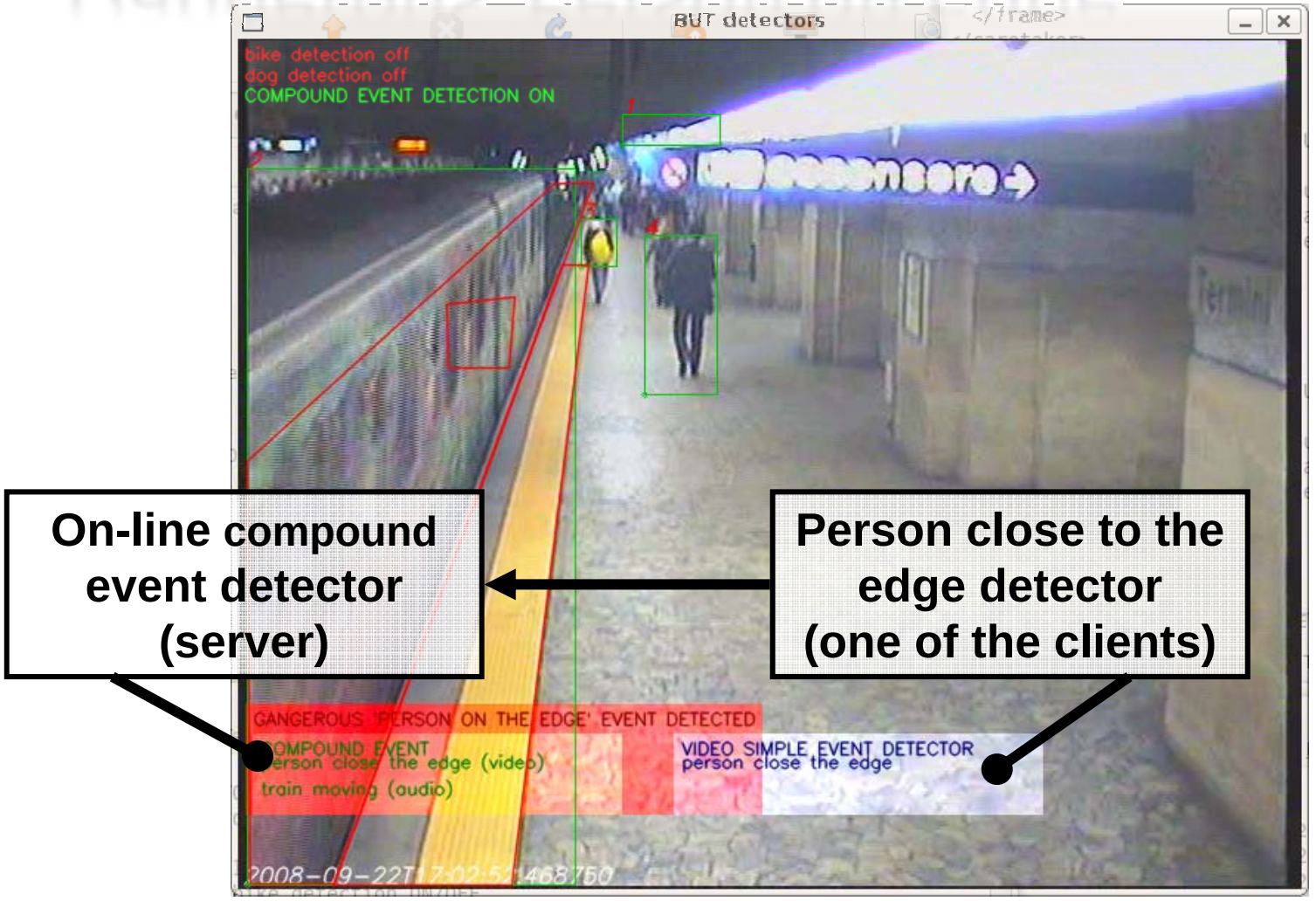


Rules

- Rule based compound audio/video event evaluation



Dangerous 'Person on Edge'



Conclusion

- methods are implemented in the running surveillance system (CARETAKER project)
  - underground stations in Roma and Torino
- methods was proven to be usable in such scenarios
- results are also used to off-line events processing (data mining, statistics, etc.)

Thank you for your attention.