

A DISTRIBUTED VISION SYSTEM FOR BOAT TRAFFIC MONITORING IN THE VENICE GRAND CANAL

*L. locchi, D. Bloisi, R. Leone, R. Pigliacampo
L. Novelli, L. Tombolini*

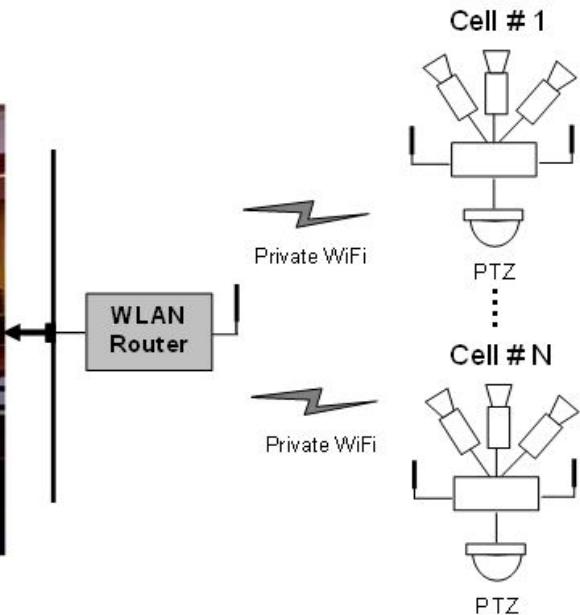
CITTA' DI
VENEZIA



ARGOS Project Overview

Automatic Remote Grand Canal Observation System

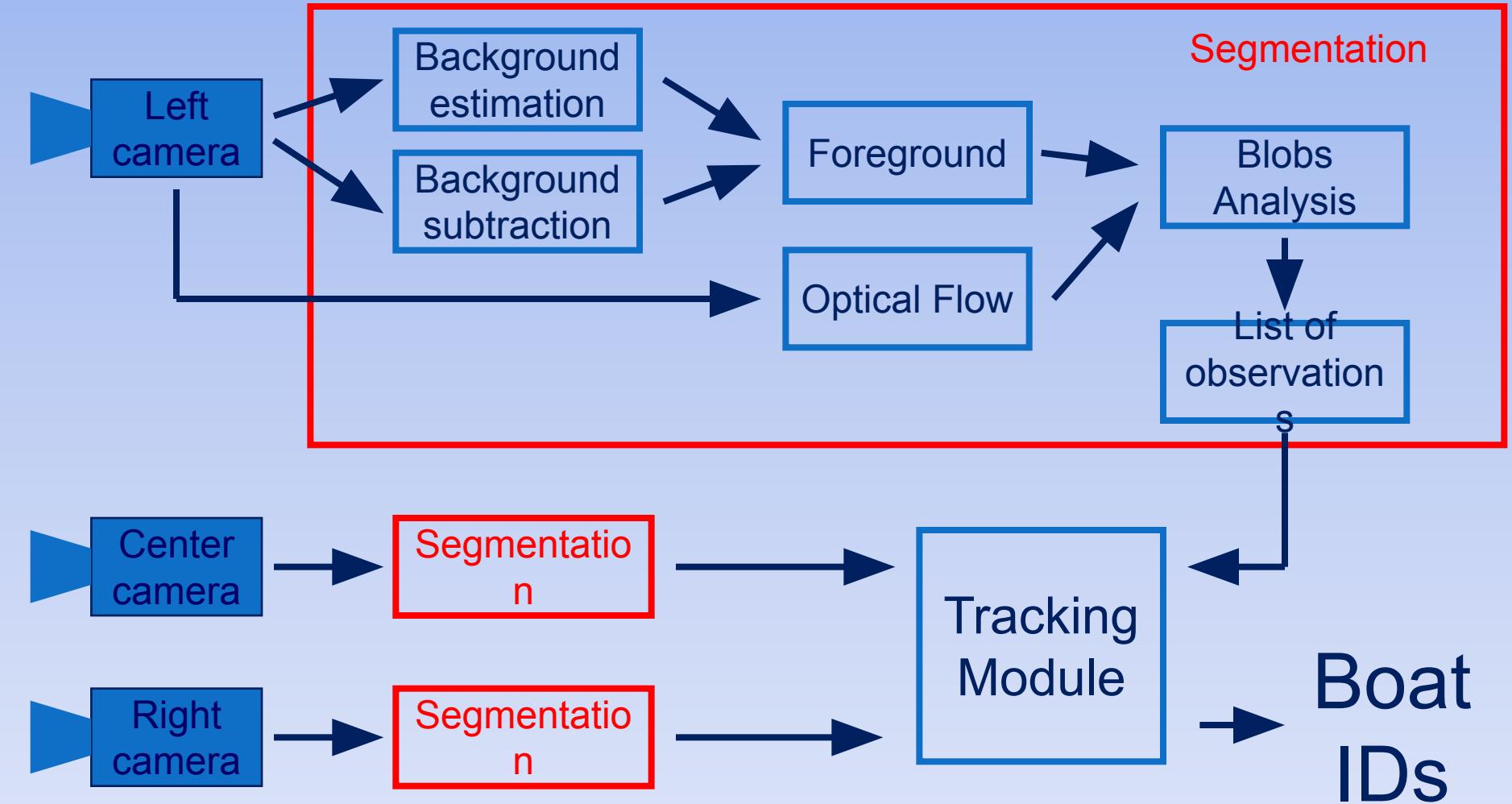
The ARGOS system is going to control a waterway of about 6 km length, 80 to 150 meters width, through 13 observation posts (Survey Cells).



Survey Cells



SC Software Architecture



Background Estimation

Problems:

- gradual illumination changes and sudden ones (clouds)
- motion changes (camera oscillations)
- high frequency noise (waves in our case)
- changes in the background geometry (parked boats).

Approach:

- computation of color distribution of a set of frames
- highest component form the background

Background Estimation (2)



• • •



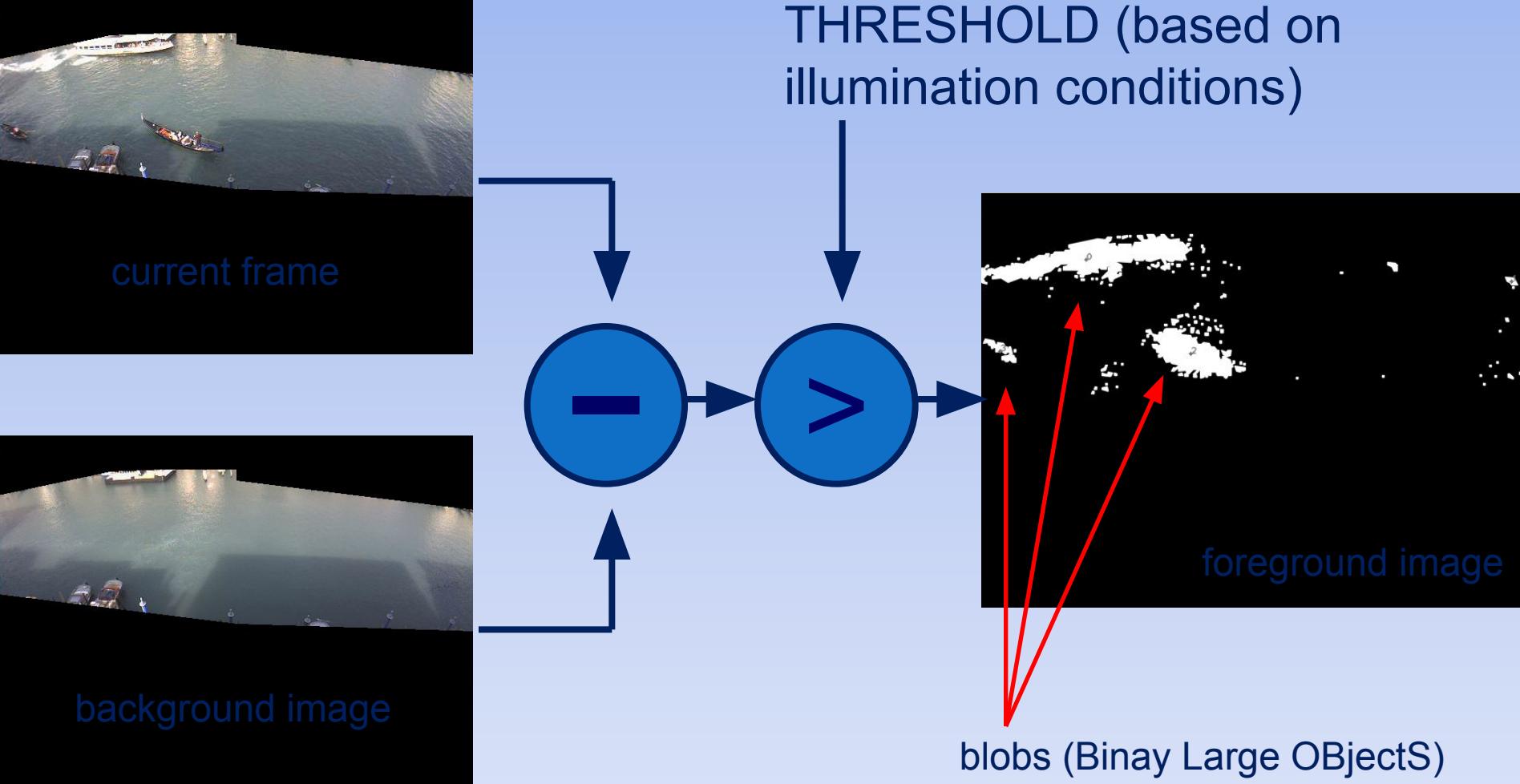
Set S of 20 images from a camera

Mask for cutting off
buildings from
computation



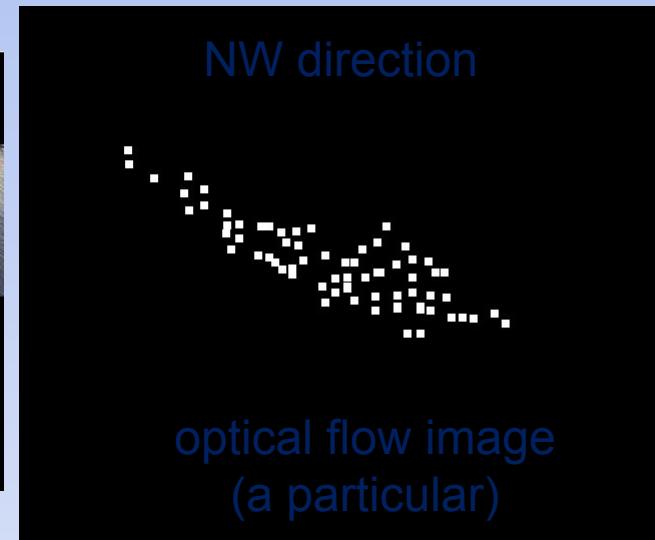
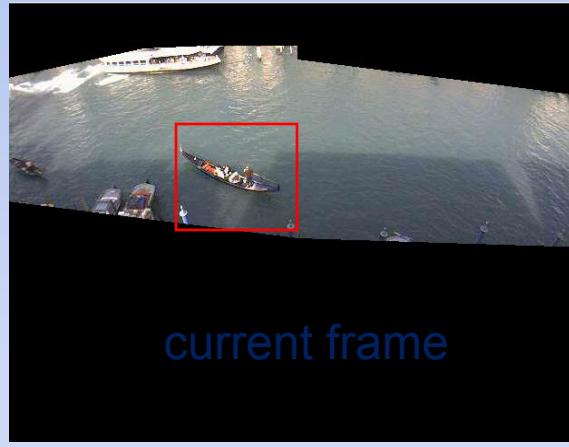
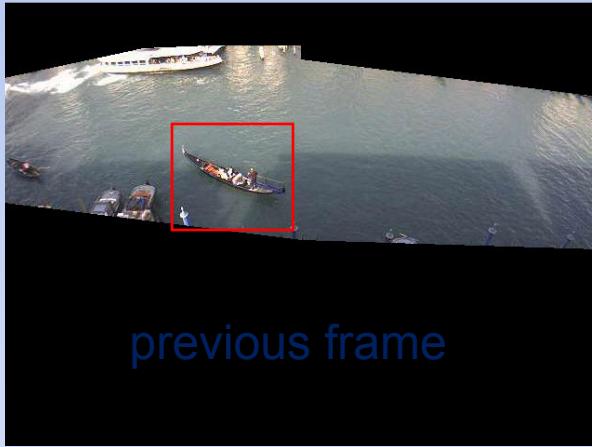
Background Image
computed from S
(the image display
only the higher
gaussian values)

Background Subtraction



Optical Flow Computation

We use a sparse iterative version of Lucas-Kanade optical flow in pyramids ([Bouget00]). It calculates coordinates of the feature points on the current video frame given their coordinates on the previous frame. The function finds the coordinates with sub-pixel accuracy. Every feature point is classified into one of the four principal directions NE, NW, SE, SW.



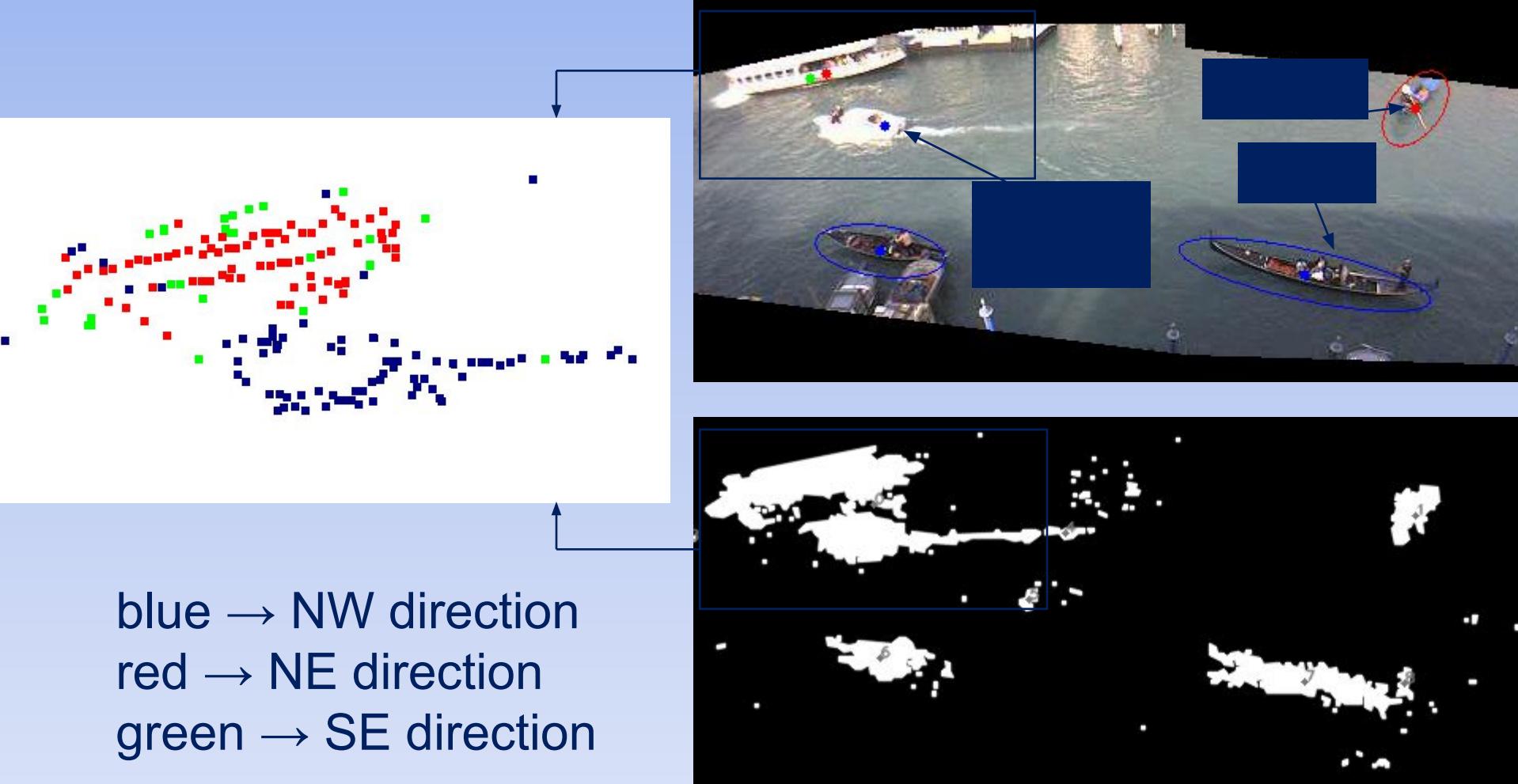
Segmentation

Exploiting the foreground image and the optical flow image, for every blob we obtain

- its centroid (that is (x, y) position into the current frame)
- its direction (and consequently the probability of under segmentation if the blob is classified into more than one of the principal directions)
- its ellipse approximation (and consequently its dimensions in meters through homography matrices)

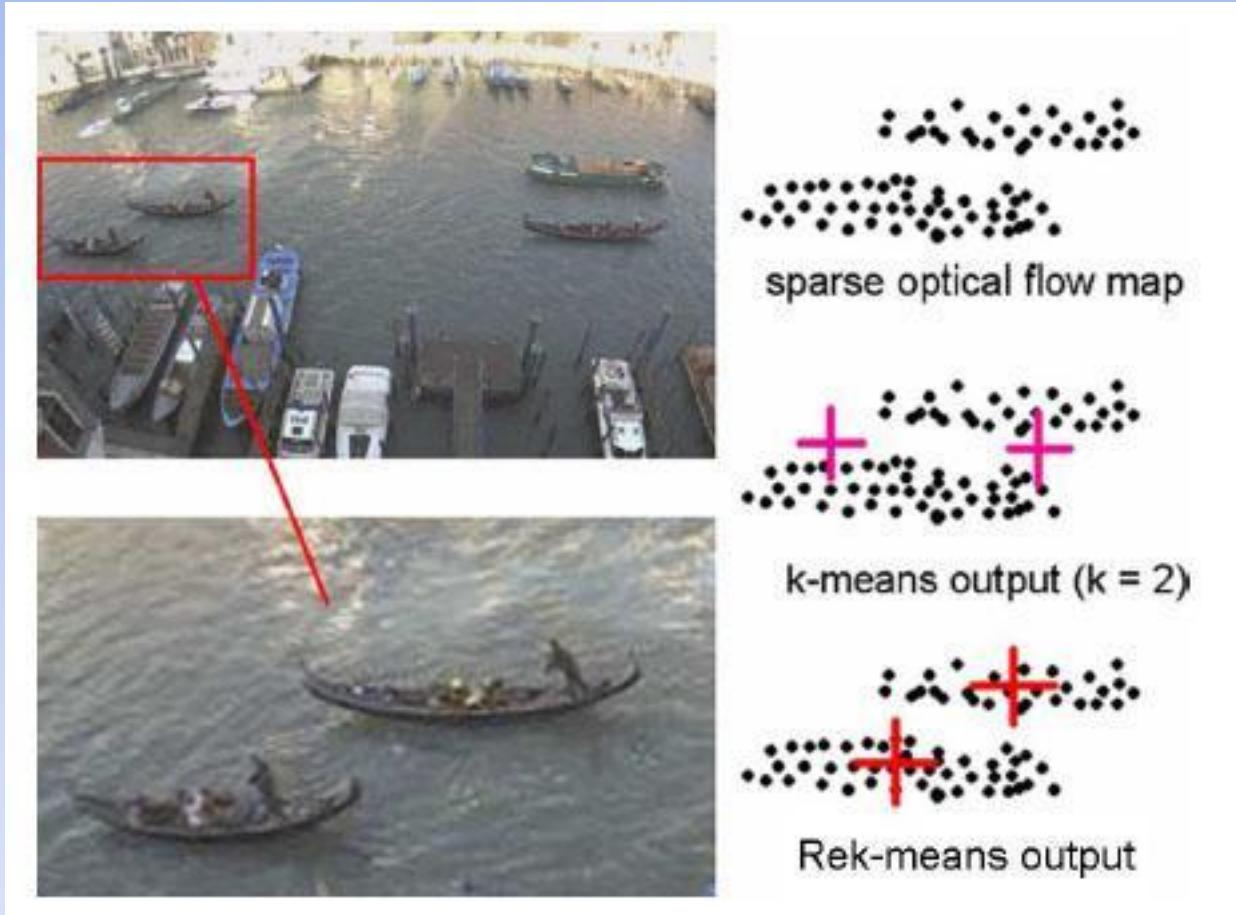
- ✓ Blob filtering: If a blob is too small according to the minimal dimension a boat must be in order to navigate the Gran Canal)
- ✓ Under segmentation: If a blob has two or more directions we compute the center of mass and the variance for every of the four predetermined principal direction.

Segmentation (2)

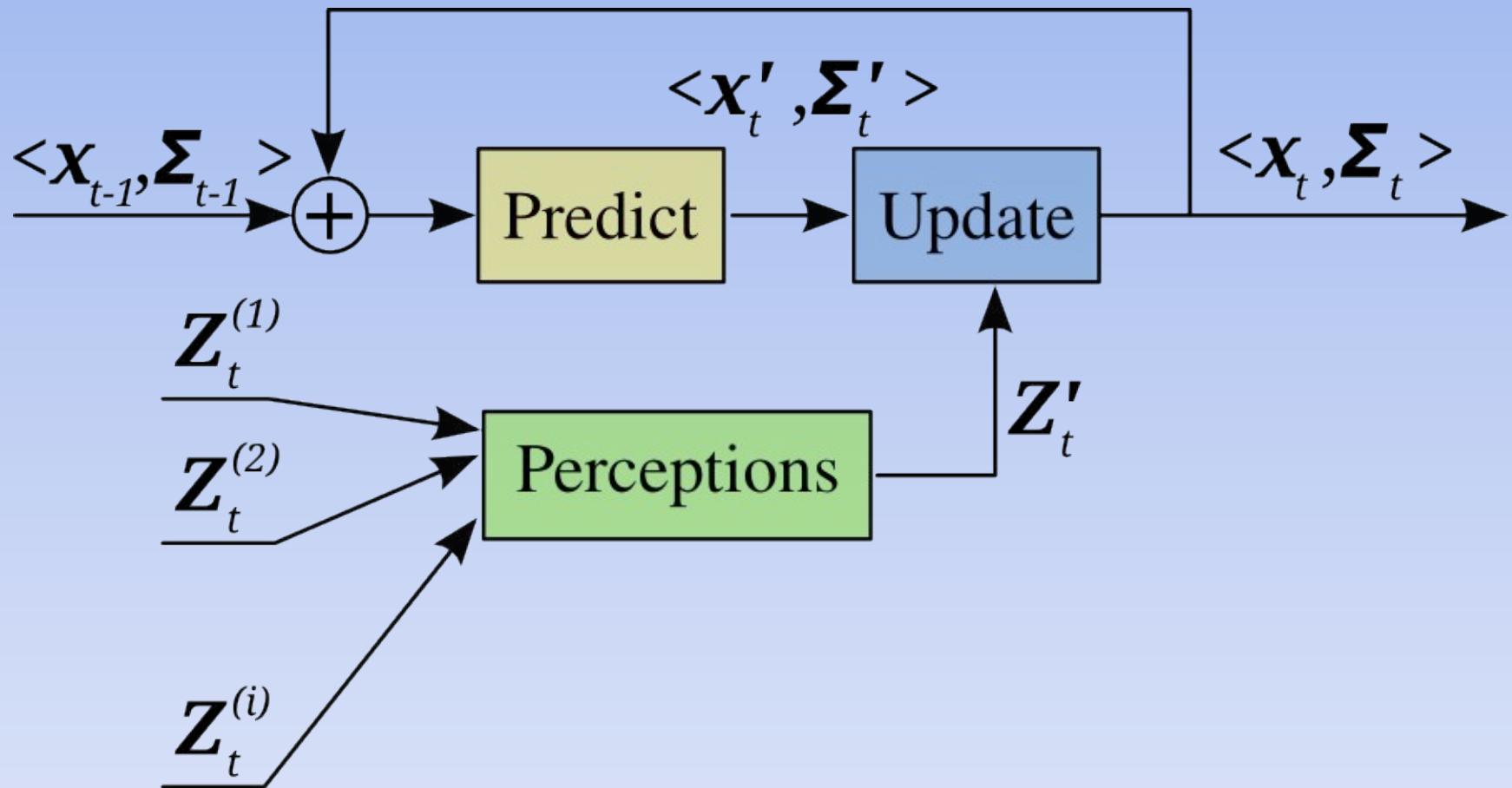


Segmentation (3)

Unsupervised clustering with Rek-means [Bloisi, Iocchi 2008]



Tracking module



Tracking module

Single-hypothesis Tracking

We use a set of Kalman Filters (one for each tracked boat).

Data Association: Nearest Neighbor rule

Track formation: unassociated observations

Track deletion: high covariance in the filter

Multi-hypothesis Tracking

Track splitting: in ambiguous cases (data association has multiple solutions)

Track merging: high correlation between tracks

Multi hypothesis tracking (2)



3 tracks (240, 247, 285)
only 1 actual observation (285)

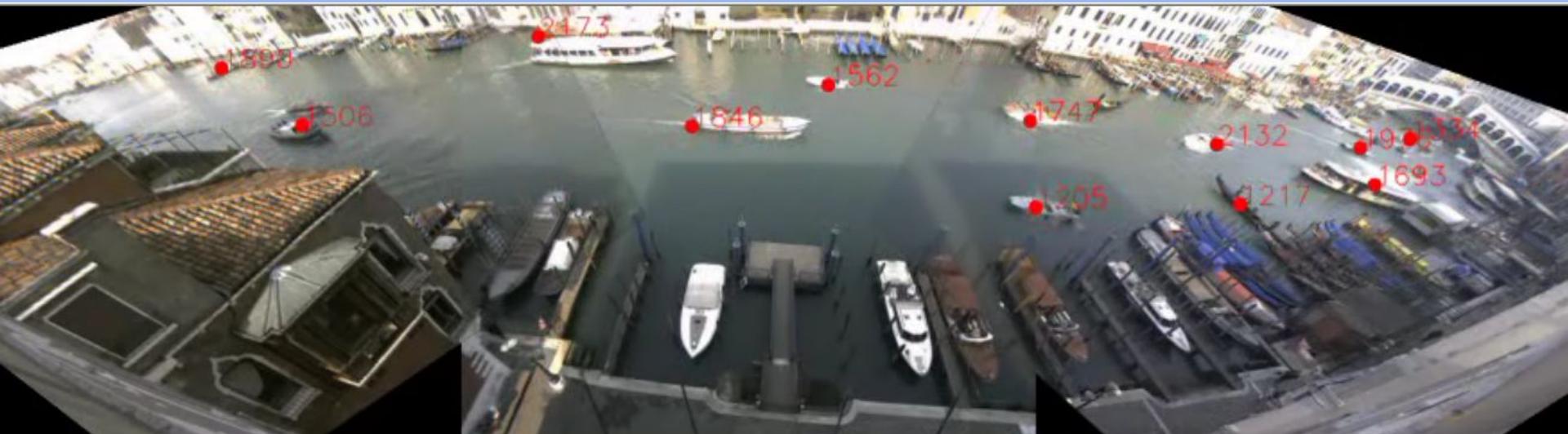
Rectification



Unified Views



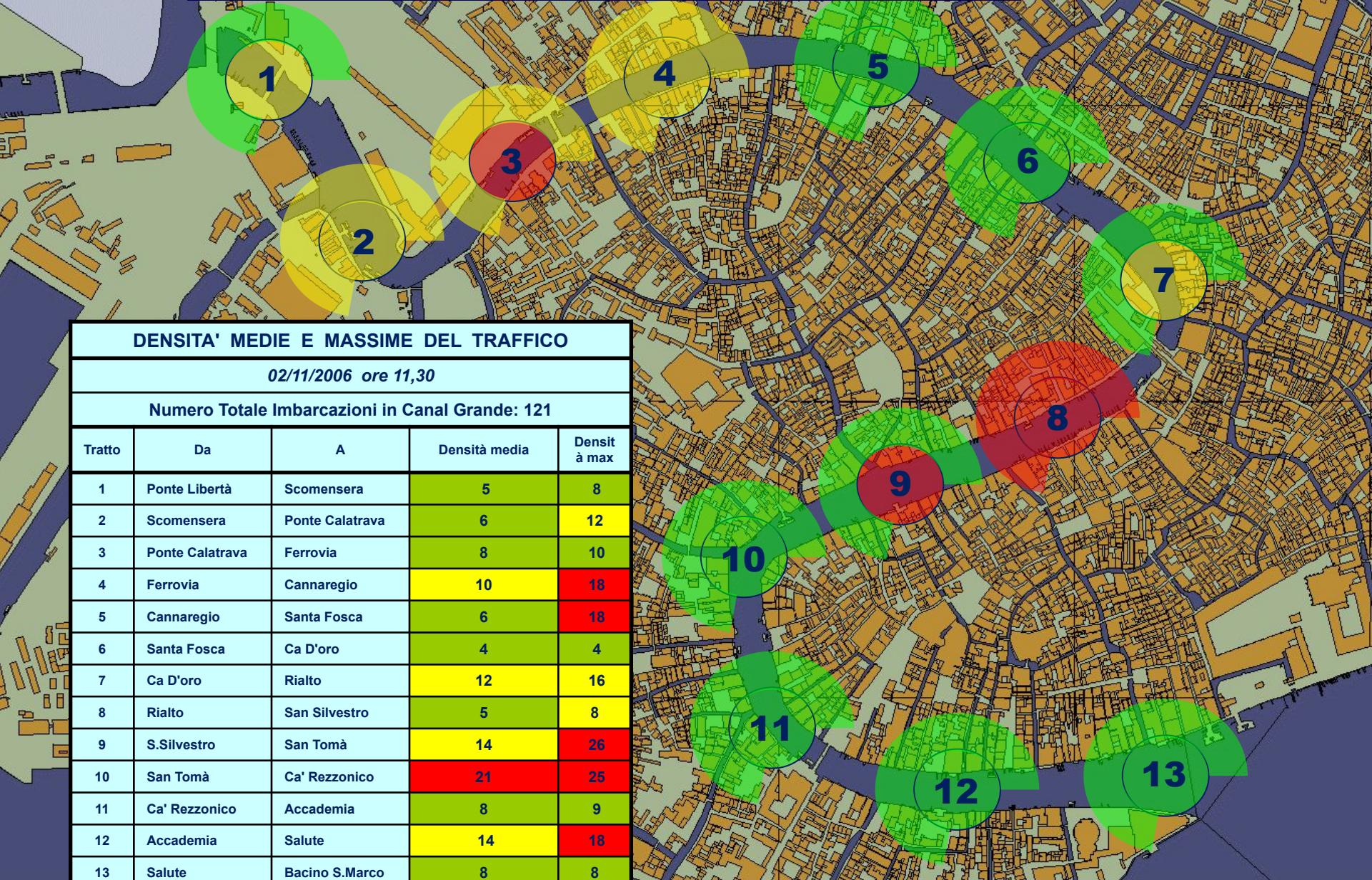
Panoramic view



PTZ Camera



DENSITA' DI TRAFFICO – TEMPO REALE



Traffic control



Multi target tracking



Count and speed estimation



Experimental Results

TRACKING EVALUATION (avg. error per minute)

	Day	Duration (min.)	Meteo	FN	FP-R	FP-W
1	07/01/2008	130	Cloud/Fog	0.062	0.215	0.531
2	08/01/2008	130	Sun/Cloud	0.038	0.192	0.431
3	15/01/2008	130	Sun/Cloud	0.031	0.154	0.323
4	31/01/2008	120	Cloud	0.075	0.158	0.400
5	01/02/2008	120	Cloud/Fog	0.000	0.150	0.392
6	04/02/2008	120	Cloud/Rain	0.000	0.200	0.342
7	05/02/2008	120	Sun/Cloud	0.000	0.225	0.392
8	06/02/2008	120	Sun/Cloud	0.017	0.200	0.333
9	07/02/2008	120	Sun	0.033	0.167	0.442
10	11/02/2008	120	Sun	0.017	0.292	0.375
11	12/02/2008	120	Sun	0.025	0.158	0.383
12	13/02/2008	120	Sun	0.033	0.267	0.367
13	14/02/2008	120	Sun	0.067	0.108	0.300
14	15/02/2008	120	Sun	0.000	0.150	0.250
Avg.	-	-	-	0.028	0.188	0.375

Experimental Results

COUNTING EVALUATION (percentage error)

Video	n boats	FN	FP	count accuracy %
20070928_1335_c09	47	0.11	0.04	93.6
20071030_1015_c07	37	0.05	0.03	97.3
20070928_1335_c10	36	0.11	0.06	94.4
20071031_1000_c03	35	0.17	0.03	85.7
20071030_1035_c04	35	0.06	0.06	100.0
20071030_1025_c05	33	0.03	0.00	97.0
20071214_0939_c08	31	0.10	0.00	90.3
20071030_1355_c12	29	0.03	0.03	100.0
20071210_1300_c06	17	0.12	0.00	88.2
20071213_1130_c03	17	0.00	0.06	94.1
20071030_1335_c10	14	0.07	0.07	100.0
20071210_1145_c01	9	0.11	0.00	88.9
Avg.	28.3	0.08	0.03	94.1

System Performance

ARGOS (DualCore 2.4 GHz)

3 video streams 640x480 -> 6.5 fps

HYDRA (QuadCore 2.4 GHz)

4 video streams 640x480 -> 6 fps

Boat classification

ARGOS_public dataset

20 classes

4774 training images

1686 test images

image size: 118 x 224 x 3

Noisy unbalanced dataset

ARGOS BOAT CLASSIFICATION CATEGORIES					
PEOPLE TRANSPORT					
		Lancia fino a 10m	Lancia fino a 10m bianca	Lancia fino a 10m marrone	
					
		Lancia maggiore di 10m	Lancia maggiore di 10m bianca	Lancia maggiore di 10m marrone	
GENERAL TRANSPORT					
		Alilaguna	Vaporetto ACTV	Motoscafo ACTV	
					
		Motobarca	Mototopo	Raccolta Rifiuti	
PLEASURE CRAFT					
		Motopontone rettangolare			
ROWING TRANS.					
		Barchino	Patanella	Sanpierota	
PUBLIC UTILITY					
		Cacciapesca	Topa		
ROWING TRANS.					
		Gondola	Sandalo a remi	Caorlina	
PUBLIC UTILITY					
		Polizia	Ambulanza	Vigili del Fuoco	