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

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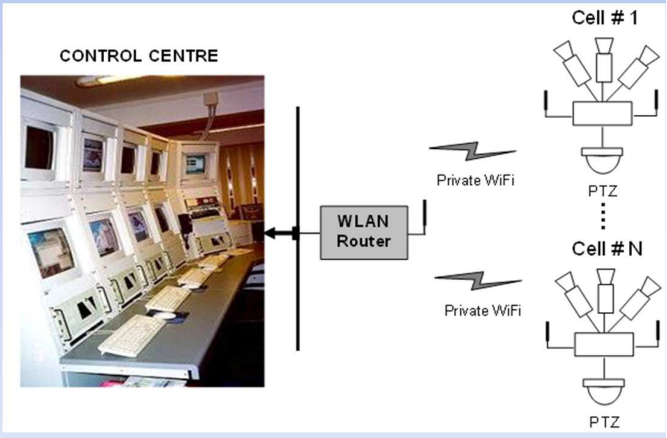
ecotema

ARGOS Project Overview

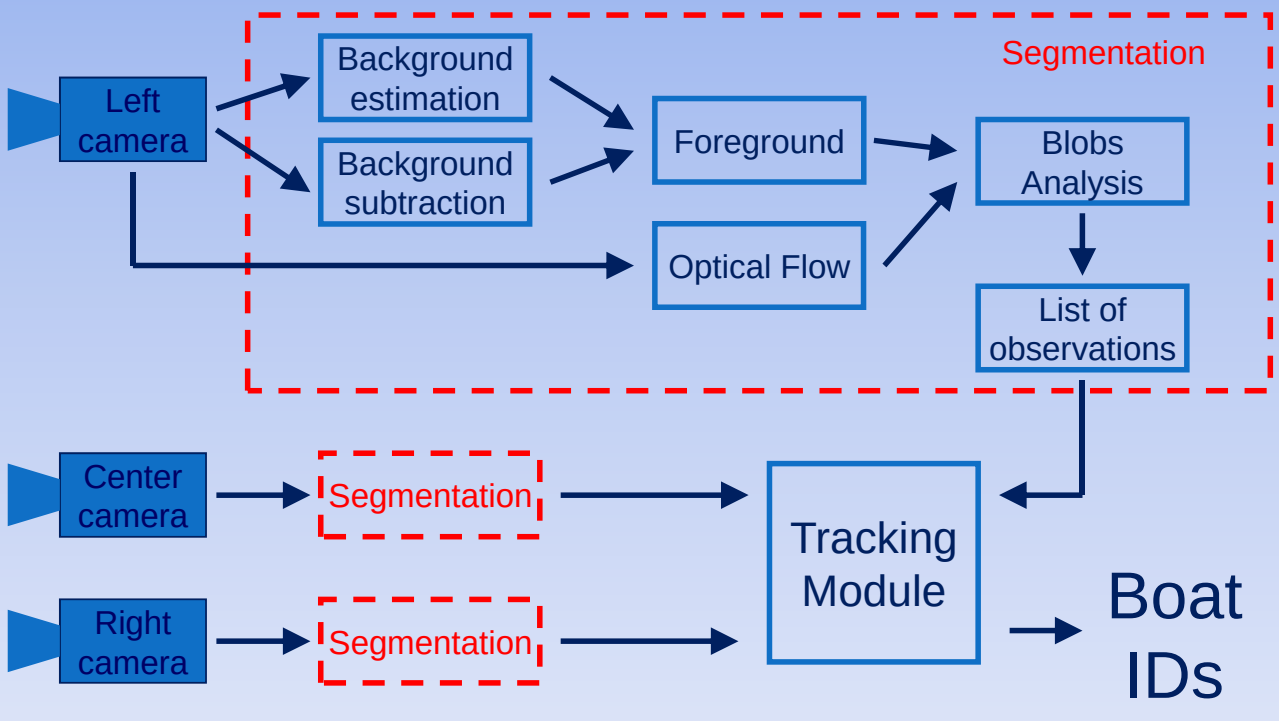
Automatic Remote Grand Canal Observation System

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

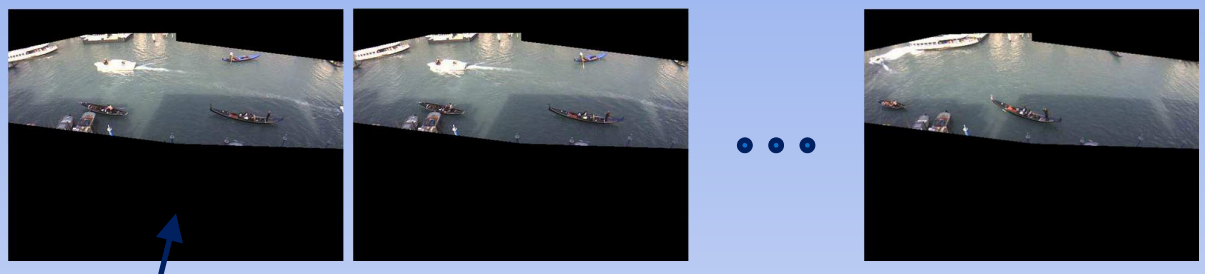


Background Estimation

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)

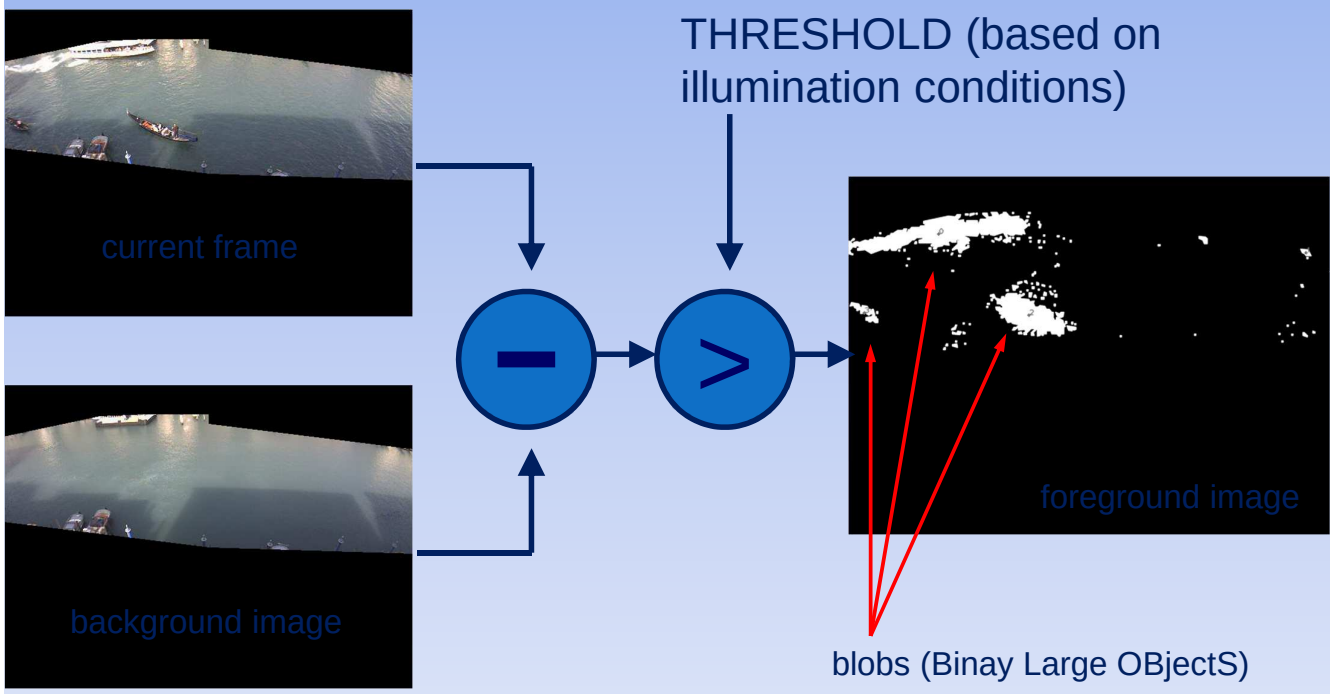


Set S of 20 images from a camera

Mask for cuttting 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 classiefied into one of the four principal directions NE, NW, SE, SW.

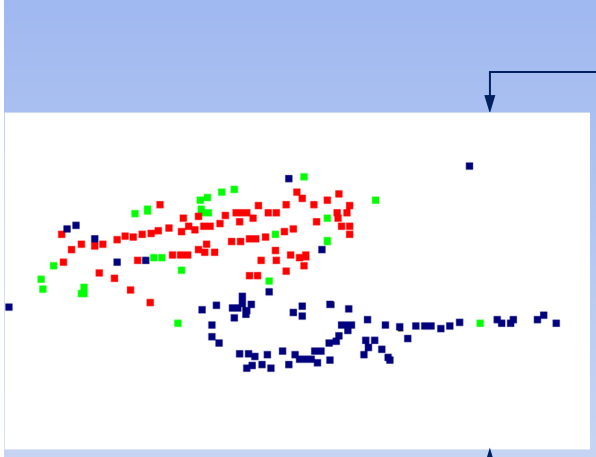
Segmentation

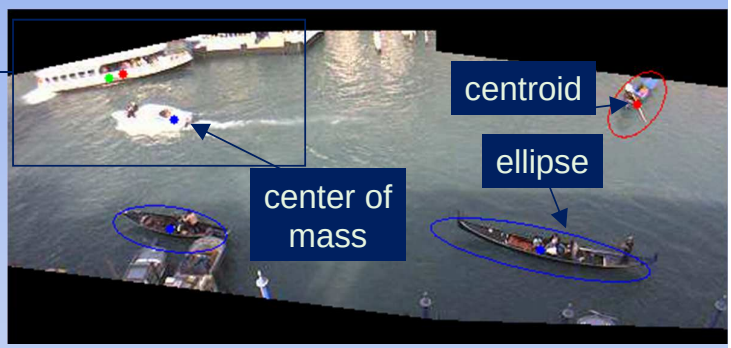
Exploiting the foreground image and the optical flow image, for every blob we obtain

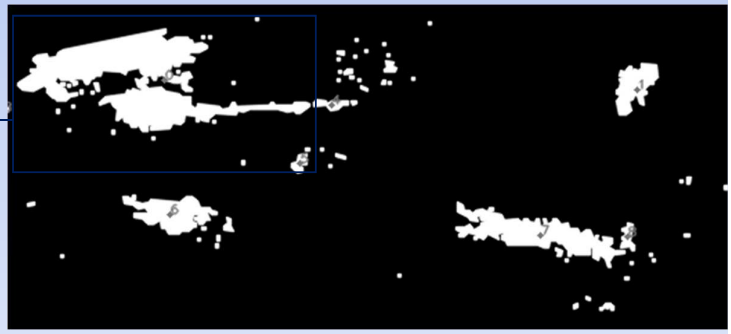
- its centroid (that is *(x, y)* position into the current frame)
- its direction (and consequentely the probability of under segmentation if the blob is classified into more than one of the principal directions)
- its ellipse approximation (and consequentely its dimensions in meters through homography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



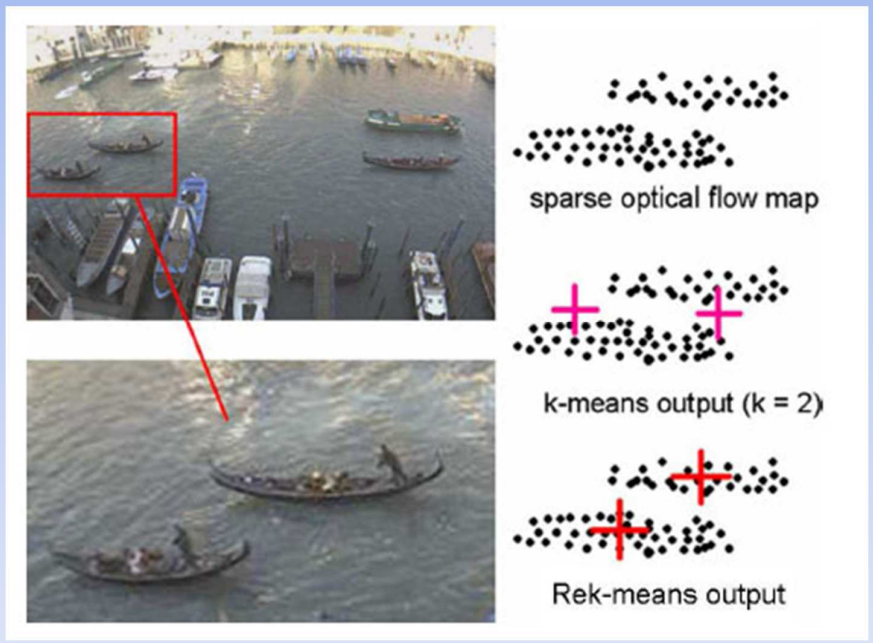




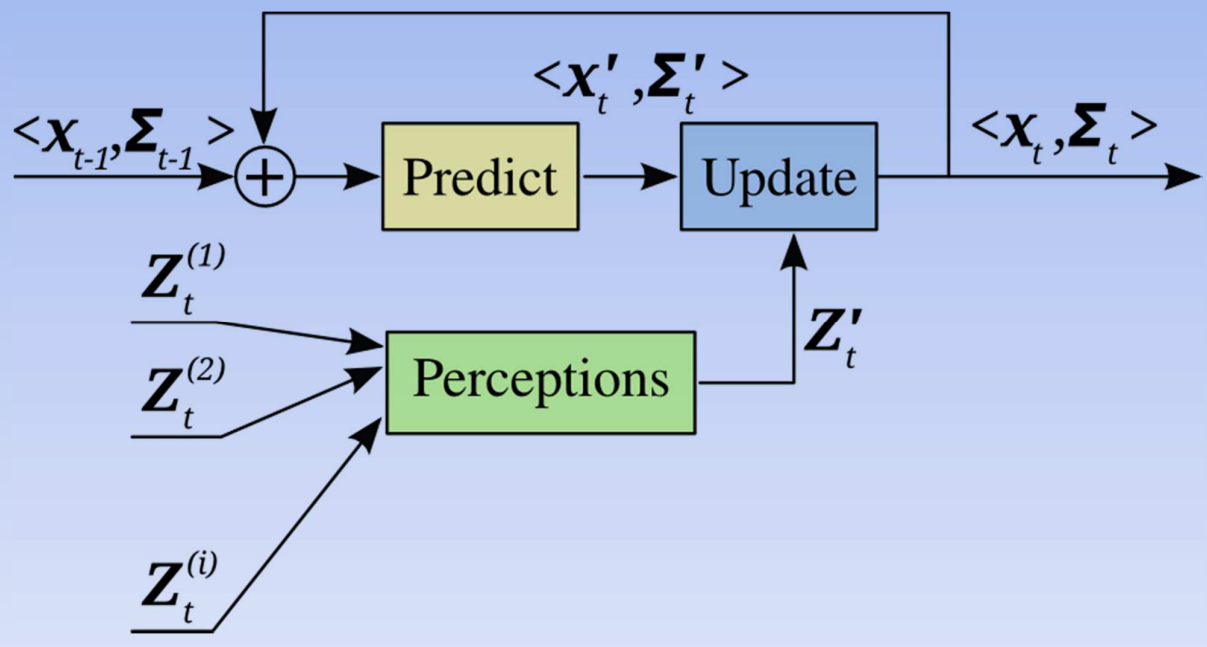
blue → NW direction
red → NE direction
green → SE direction

Segmentation (3)

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



Tracking module



Tracking module

Single-hypothesis Tracking

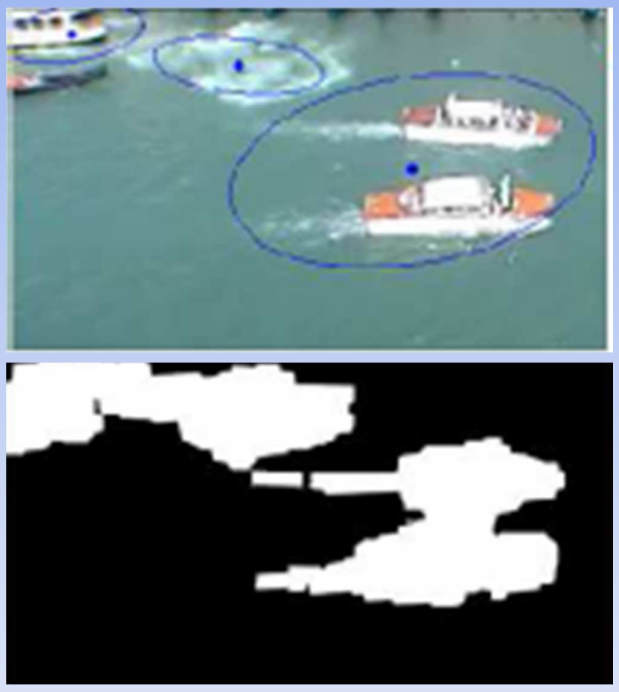
We use a set of Kalman Filters (one for each tracked boat).

Data Association: Nearest Neighbor rule
Track formation: unassociated observations
Track deletion: high covariance in the filter

Multi-hypothesis Tracking

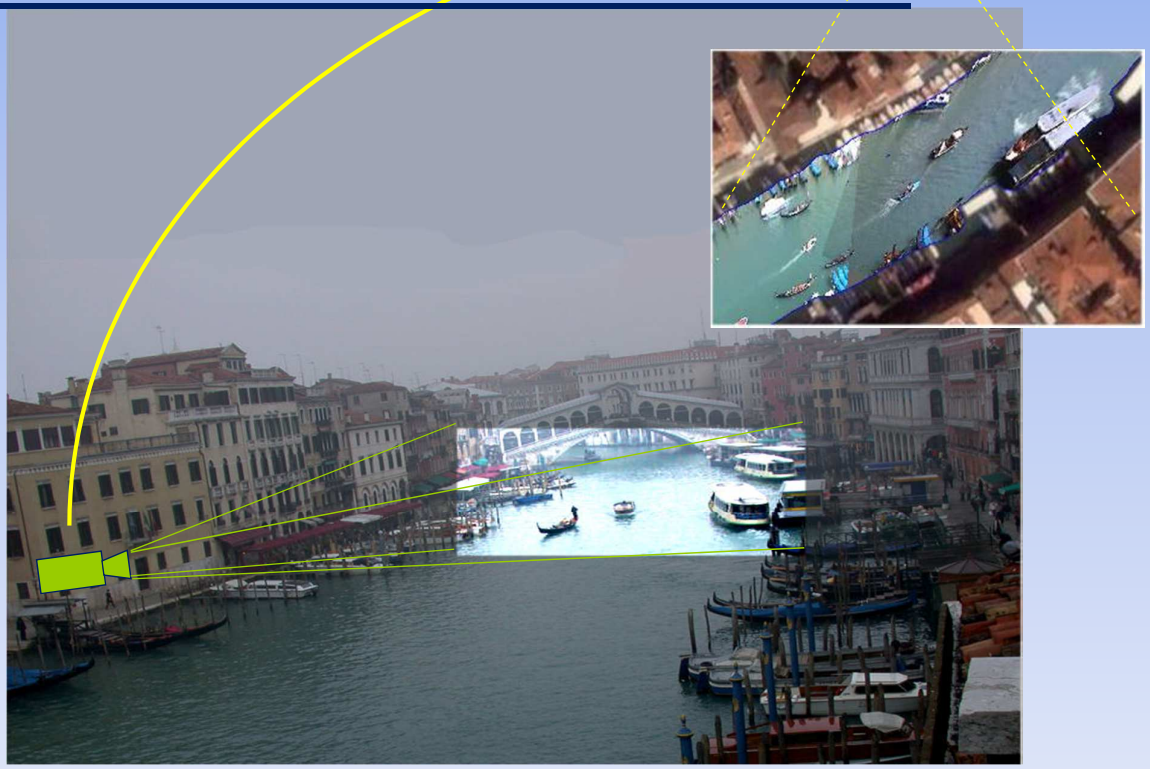
Track splitting: in ambiguous cases (data association has multiple solutions)
Track merging: high correlation between tracks

Multi hypothesis tracking



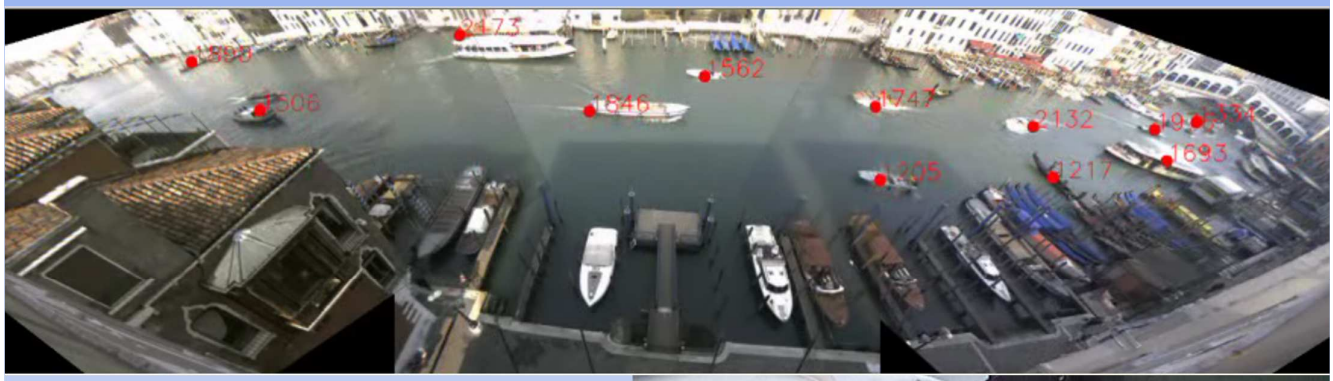
3 tracks (240, 247, 285)
only 1 actual observation (285)

Rectification



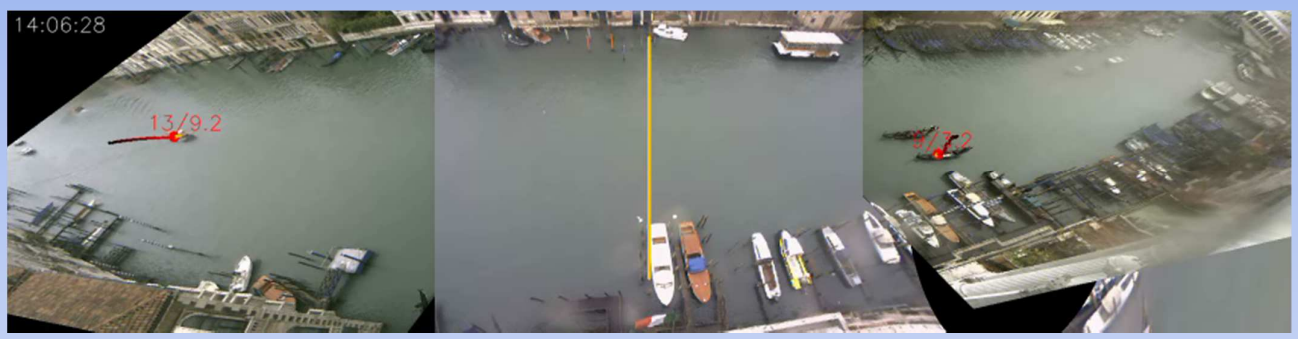
Unified Views

Panoramic view



PTZ Camera

Example



ARGOS (DualCore 2.4 GHz)
3 video streams 640x480 -> 6.5 fps

HYDRA (QuadCore 2.4 GHz)
4 video streams 640x480 -> 6 fps

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

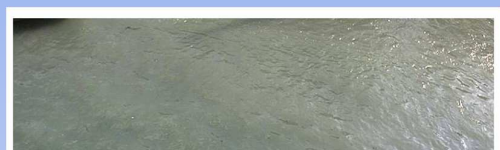
COUNTING EVALUATION (percentage error)

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**

Boat Classification

Snapshots are automatically taken when tracked boats pass below the survey cell.

Noisy capture.



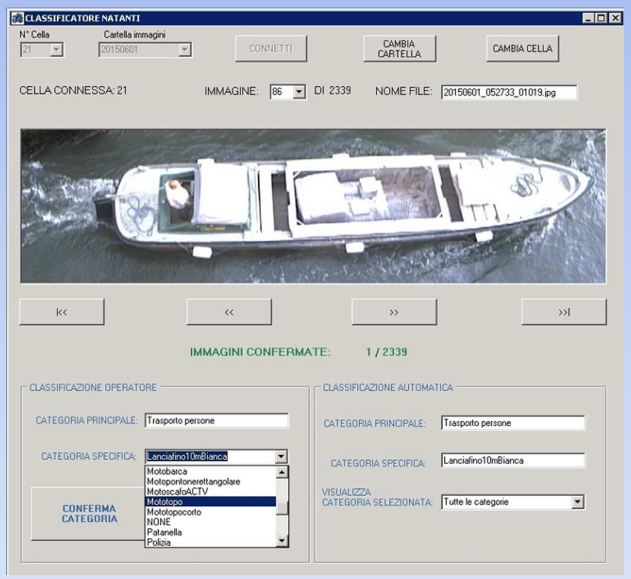
a)

b)

c)

Boat Classification

Manual labeling by Venice experts.



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Boat Classification

24 specific classes, 5 general classes

Boat Classification

Data set sc5

Training set
4,922 images

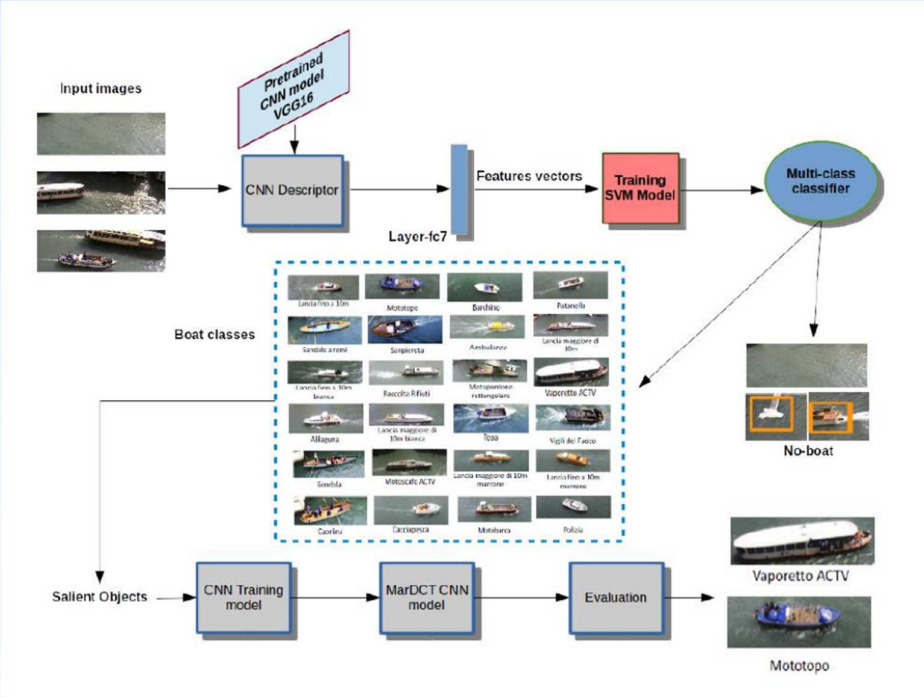
Cell	Alg.	Acc. spec.	Acc. gen.	Count spec.	Count gen.
sc5	KNN	56.79 %	66.25 %	63.45 %	77.47 %
	J48	54.56 %	66.79 %	**91.41 %**	**95.79 %**
	RF	**66.20 %**	**75.13 %**	70.40 %	81.08 %
sc9	KNN	54.66 %	67.18 %	62.91 %	77.28 %
	J48	52.23 %	65.53 %	**88.35 %**	**93.79 %**
	RF	**61.41 %**	**72.86 %**	73.69 %	86.41 %
sc12	KNN	38.87 %	56.82 %	64.62 %	77.77 %
	J48	39.97 %	57.98 %	**89.39 %**	**97.34 %**
	RF	**51.83 %**	**65.54 %**	70.37 %	78.07 %
sc33	KNN	39.93 %	59.16 %	60.69 %	77.19 %
	J48	39.65 %	58.30 %	**90.77 %**	**96.64 %**
	RF	**49.93 %**	**65.26 %**	69.73 %	86.17 %

Test set
1,970 images

Cell	Test	Acc. spec.	Acc. gen.	Count spec.	Count gen.
sc5	20130412	73.14 %	79.08 %	77.50 %	88.11 %
sc33	20130909	36.10 %	51.01 %	47.15 %	69.98 %

Boat Classification

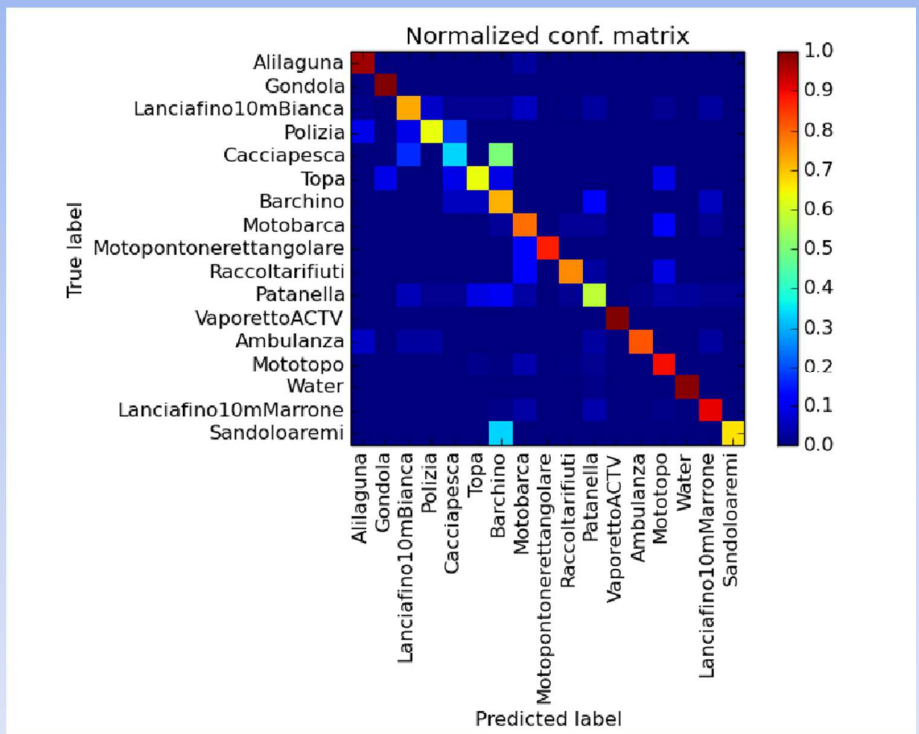
CNN



Boat Classification

Results

Confusion matrix



Homework 2

MarDCT Boat Classification dataset

Annotations are contained in the file ground_truth.txt
in the format
<image-name>;<category>

Example:

20130412_044827_56976.jpg;Vaporetto ACTV

Homework 2

Realize an image classification system

Problems:

- **Classification of 5 general classes**
- **Classification of 24 specific classes**
- **Classification of (n<24) specific classes**
- **Binary Classification (1 vs. others)**
- **Counting instances of general/specific classes**

http://www.dis.uniroma1.it/~labrococo/MAR

Homework 2

Realize an image classification system

Approaches:
- **Feature extraction + Classifier**
- **Deep features + Classifier**
- **DNN**

Output:
- **Report**
- **Code**

http://www.dis.uniroma1.it/~labrococo/MAR