University of Ljubljana

Faculty of Electrical Engineering
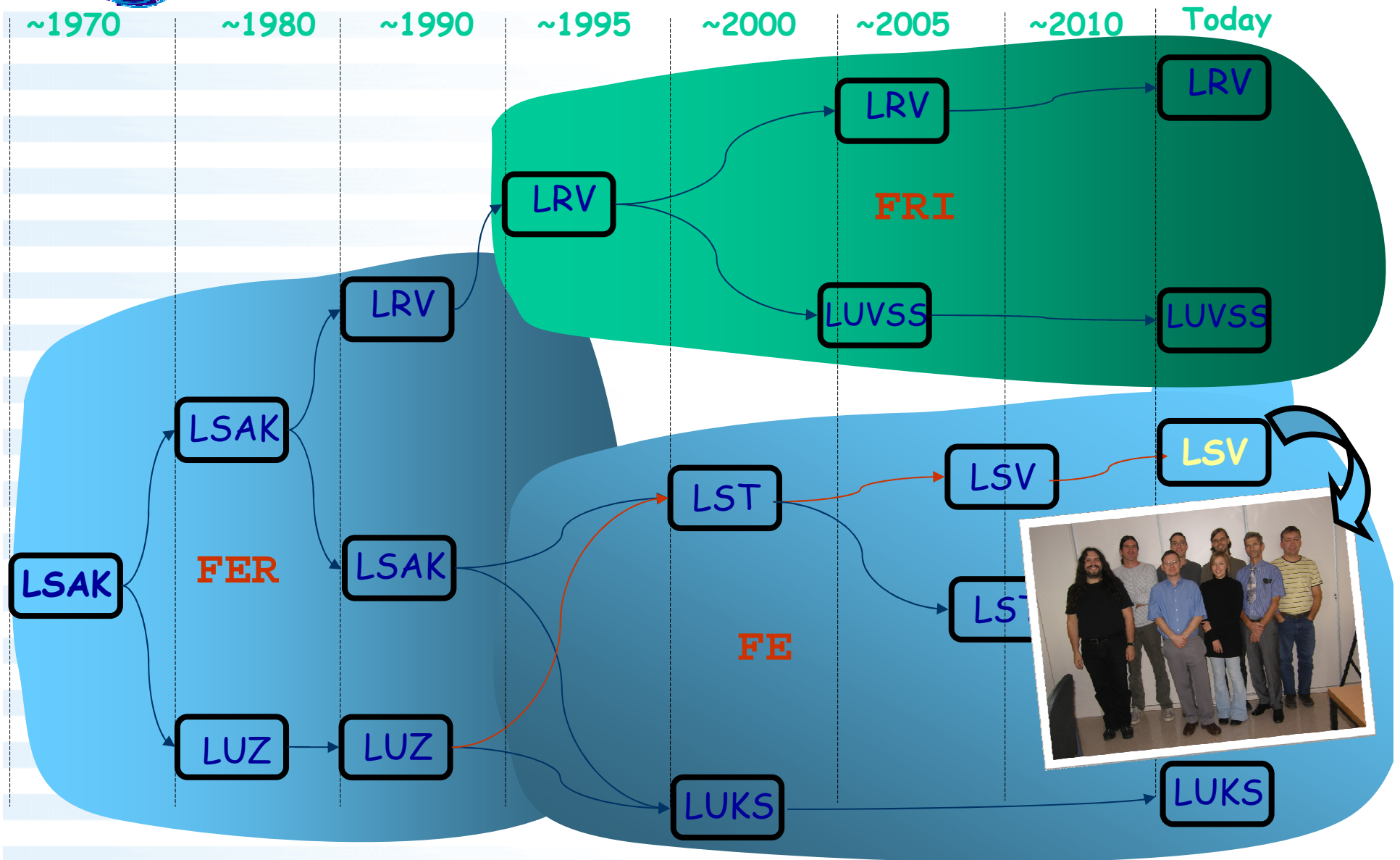
Ten Years of CV in MVL at UL FE

Stanislav Kovačič

1st CCVW 2012, Zagreb, 20. September 2012
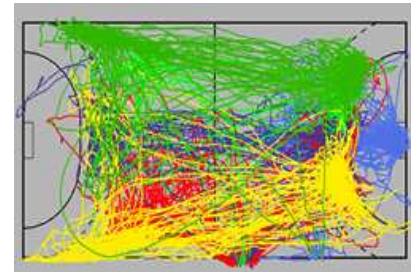
Who we are
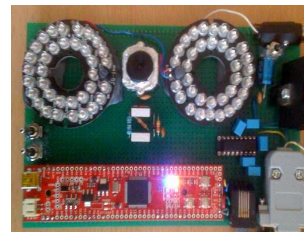

~1970　~1980　~1990　~1995　~2000　~2005　~2010　Today

FRI

LRV → LRV

LRV → LUVSS → LUVSS

FER

LSAK

LSAK → LRV

LSAK → LSAK

LUZ → LUZ

FE

LST → LSV → LSV

LST → LST

LUKS → LUKS

What we do

Industrial vision – applications
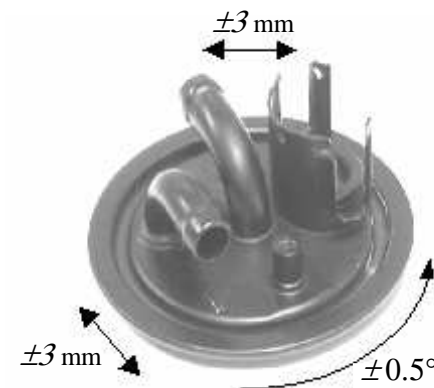
Visual tracking and motion analysis - in sports

Embedded vision, multi-camera solutions, networked cameras, fusion

MV applications 1

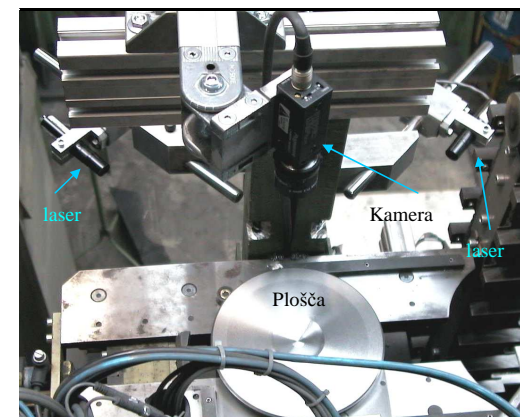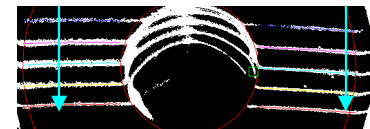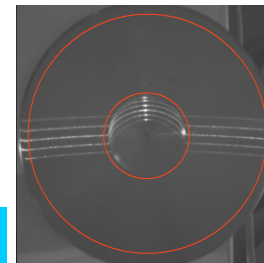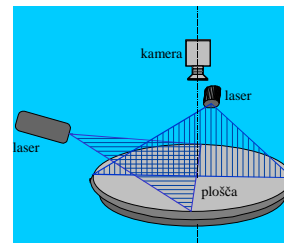Positioning and verification of oil filters ≈ 0,5°

UL FE with Eta Cerkno

MV applications 2

Dimensional measurements of cooking plates, +- 0.15mm

Plate concavity, 0:0.5deg, +- 0.05 deg

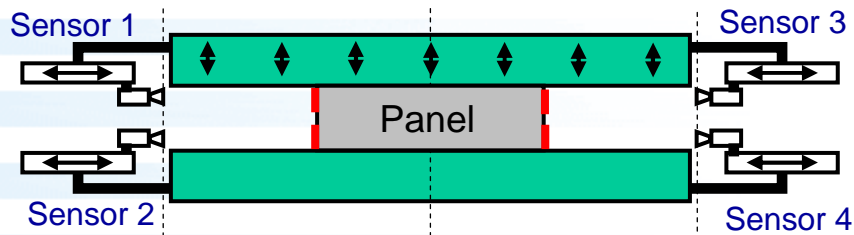Detection of surface defects, ~ 0.3 mm

UL FE with/for Eta Cerkno

MV applications 3

Measurements of sandwich panels and profiles
Eureka E! 3450, Q-SPAI 2004-2007
Trimo, iS Mainz, UL FRI, UL FE

Sensor 1
Sensor 3
Panel
Sensor 2
Sensor 4

EUREKA
Doing business through technology

Raising the productivity and competitiveness of Europ
technology. Boosting national economies on the inter
strengthening the basis for sustainable prosperity and

ABOUT EUREKA   NEWS & MEDIA   ACTIVITIES

Projects   » Success Stories

EUREKA SUCCESS STORY > E! 3450 QSPAI

'SMART' QUALITY CONTROL SYSTEM
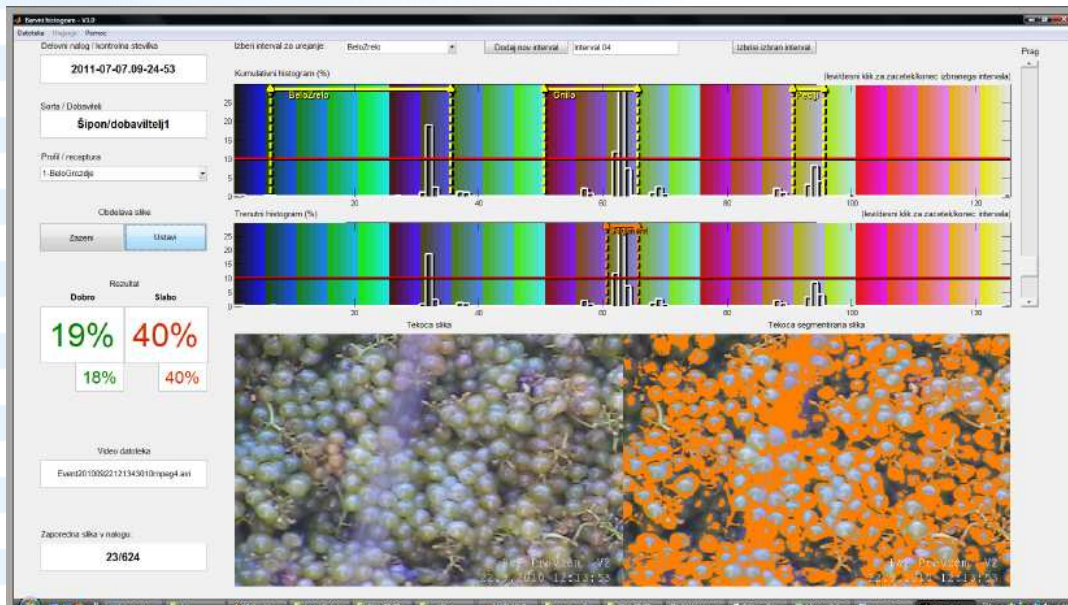CUTS RISK OF HUMAN ERROR ON
ASSEMBLY LINES

A EUREKA-backed project has demonstrated that assembly
line errors can be avoided by enabling the equipment to
learn from previous actions.
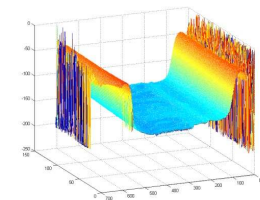
MV application 4

Quality control in agriculture ~ 2011
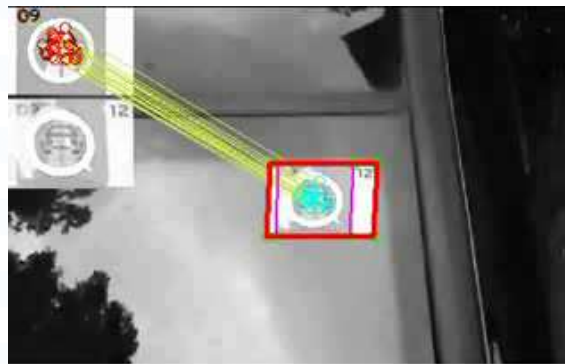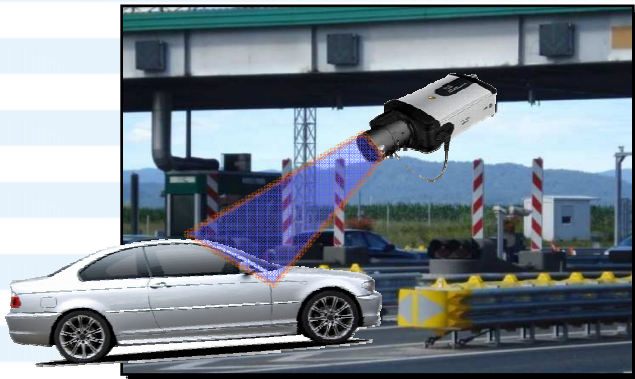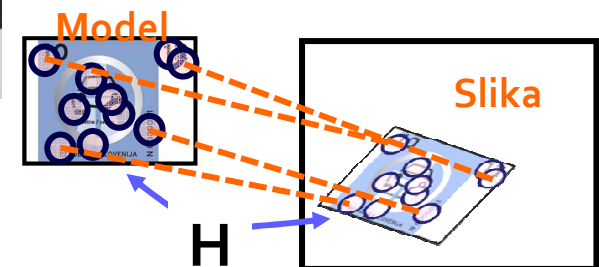**PACE, TGA and P&F, UL FE**

MV application 5

Highway licence sticker control
UL FE, Iskra sistemi and partners

Matej Kristan (2009),
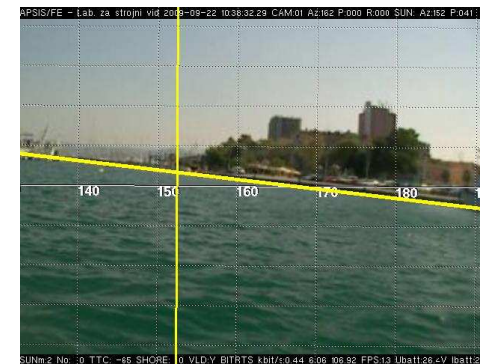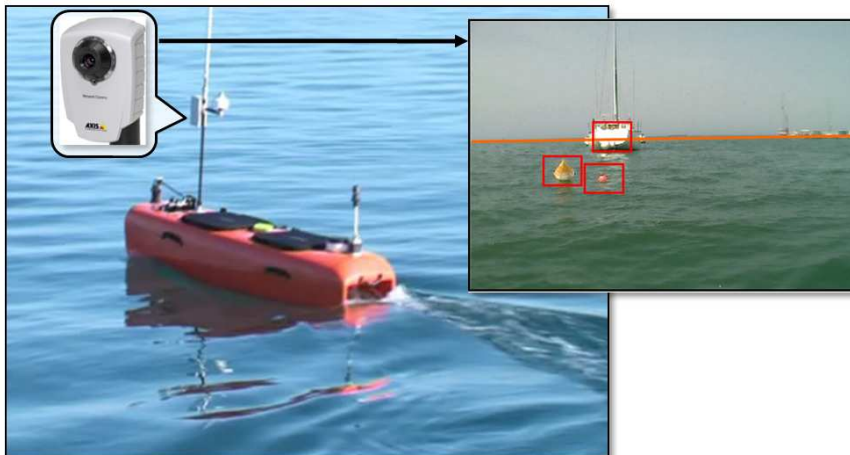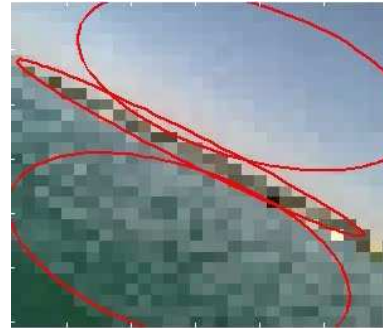Machine Vision Group, University of Ljubljana

Model

Slika
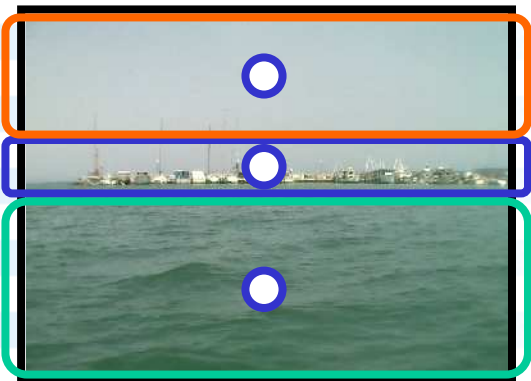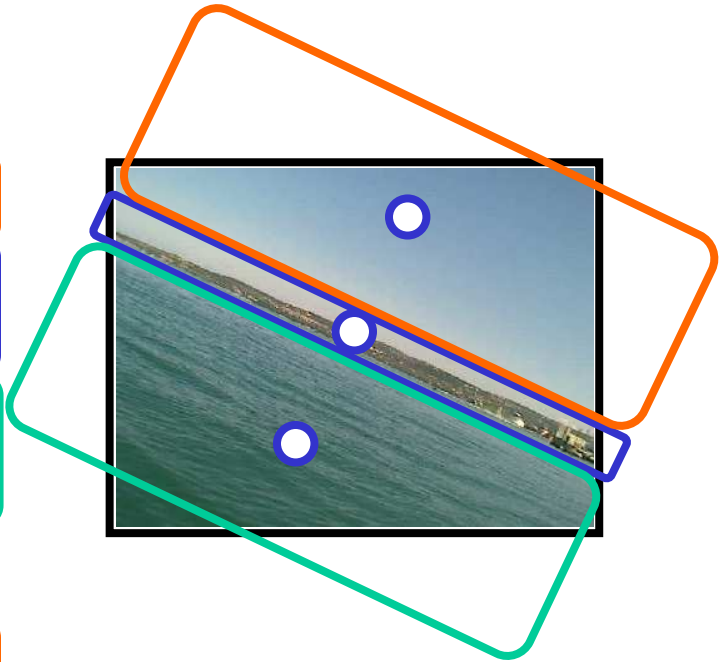
H

TP-MIR APSIS

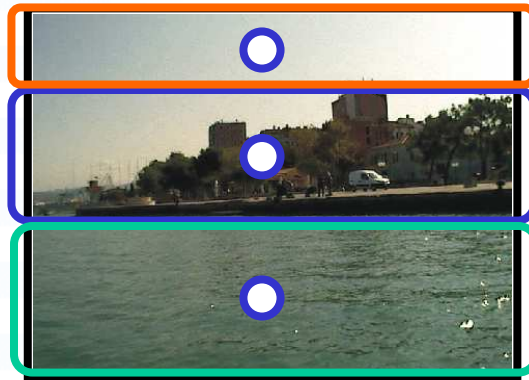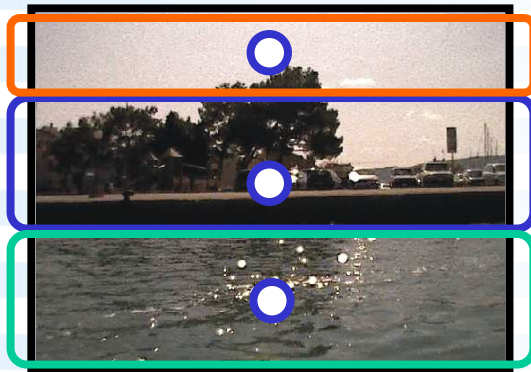Autonomous vessel, prototype

Environmental monitoring, data acquisition ~ 2007 - 2008
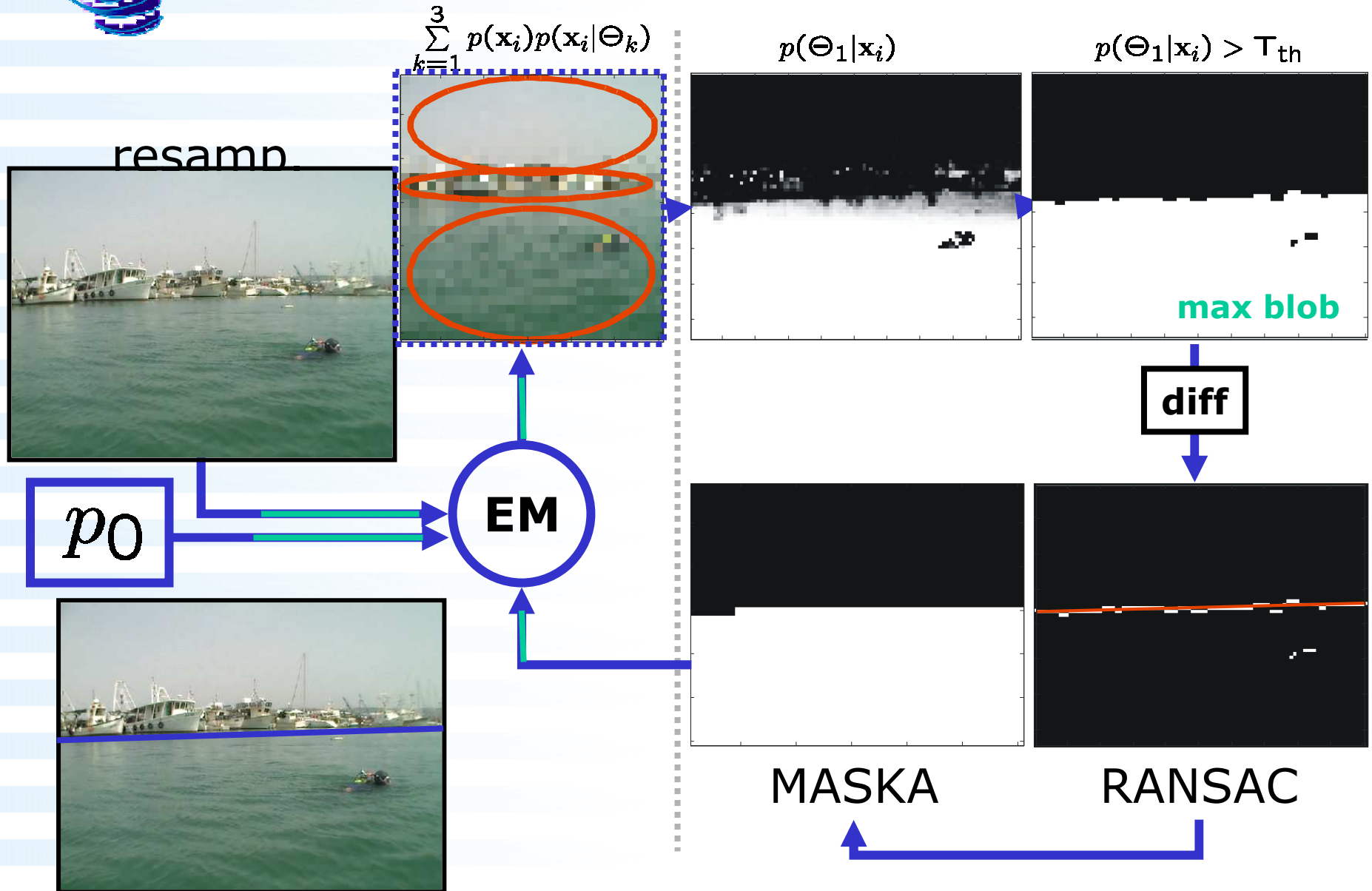
Harpha Sea, Ames, IFB, Acorn, Xenya, PINT, UL FE

TP MIR APSIS
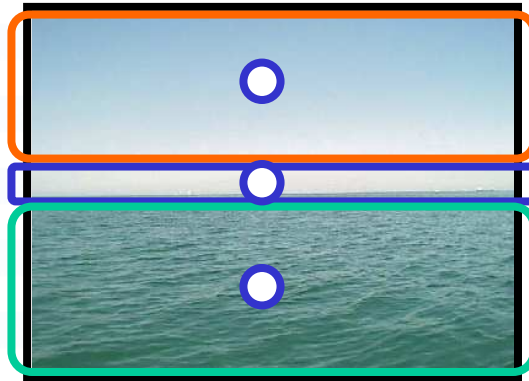
Vertically structured image segments.
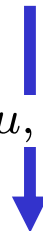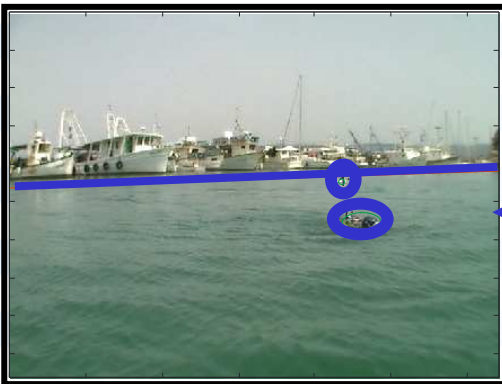*The lower part defines the sea border.*

"Horizon" detection

$\sum\limits_{k=1}^{3} p(\mathbf{x}_i) p(\mathbf{x}_i | \Theta_k)$

$p(\Theta_1 | \mathbf{x}_i)$

$p(\Theta_1 | \mathbf{x}_i) > \mathsf{T}_{th}$

resamp.

p_0

EM

max blob

diff

MASKA

RANSAC

Obstacle detection

$$\mathbf{x}_i = [h_i, s_i, v_i]^T$$
$$p(\mathbf{x}_i) = \mathcal{N}(\mathbf{x}_i | \mu, \Lambda)$$

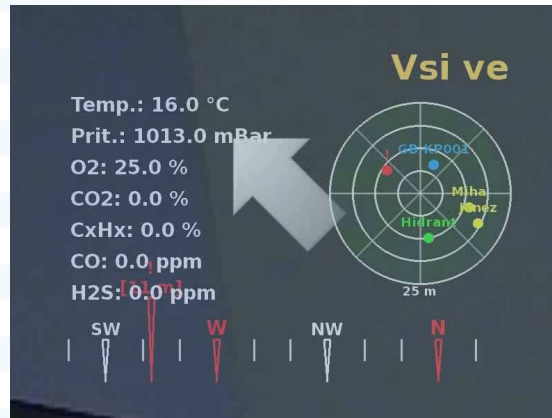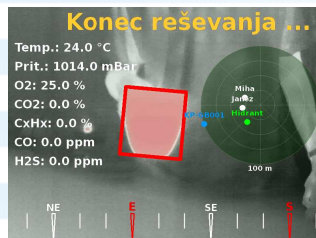$$\mathcal{N}(\mathbf{x}_i | \mu, \Lambda) > T_{th}$$
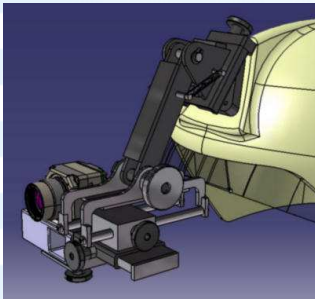
blob det.

TP-MIR SOVZO

Firifighter support system, prototype ~ 2009-2010
Harpha Sea, Ames, IFB, Acorn, Xenya, Visport, UL FE, UL FGG

Sports tracking

Visual tracking in sports, individual and team sports
Begining already in 1998 (Marta Bon, Janez Perš)

InspireWorks, Inc., 2004-2005

Still our main focus of research
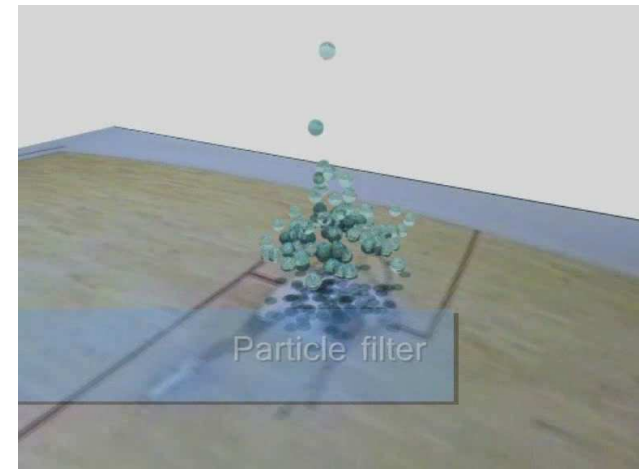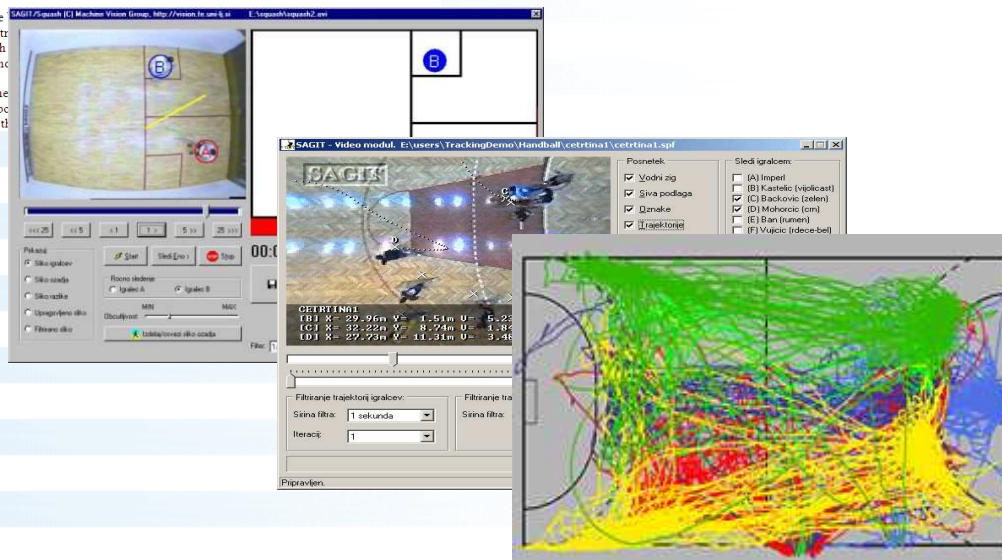
Excellent cooperation with sport experts

Sprots tracking

(on)

0- 8 km

| A | B | C | D | E | F | G |
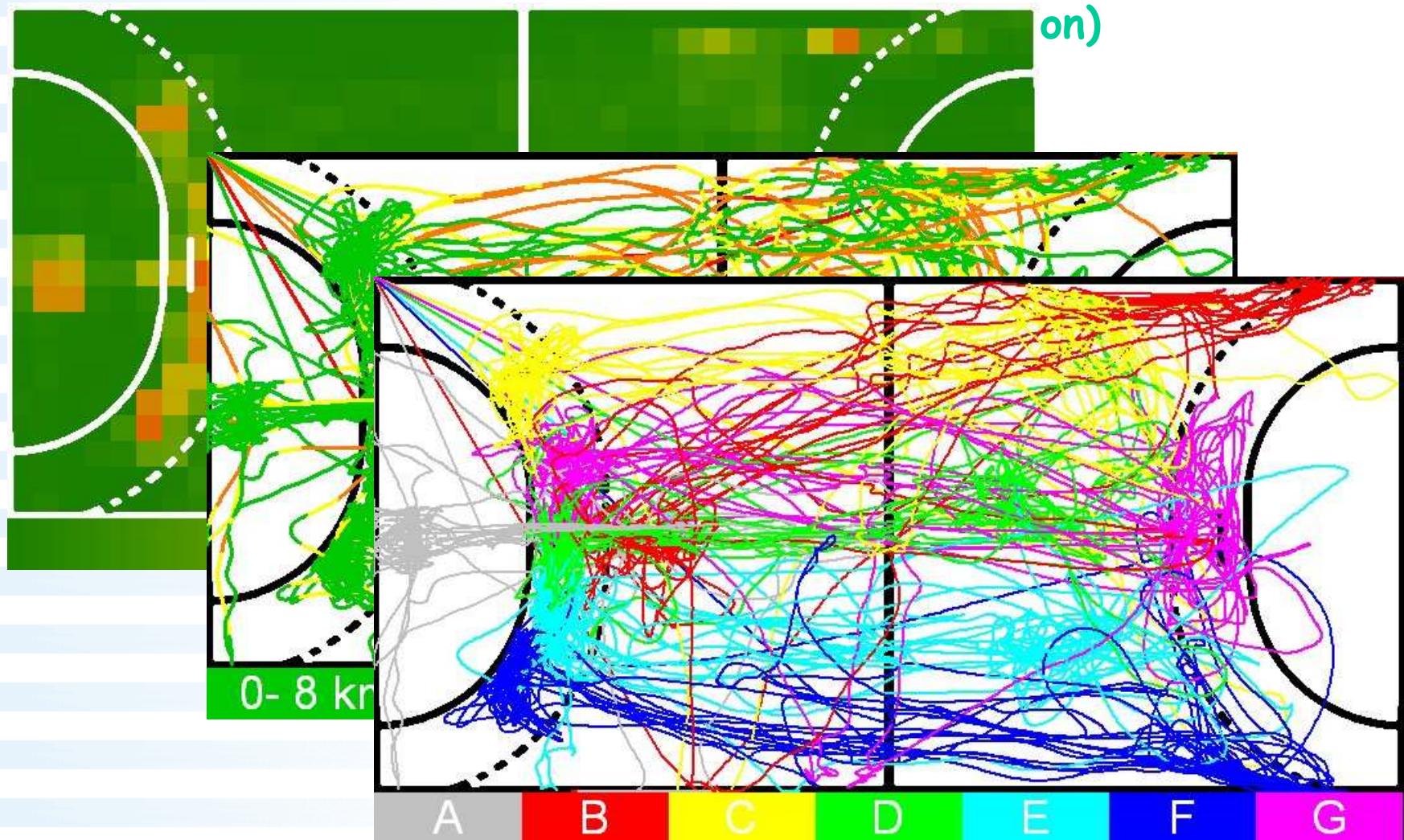
Sports tracking

Are we there yet?

No, but we can:

- Obtain motion data for some sports with almost no effort (tennis, squash)
- Obtain motion data for others within 5-10 man-days (basketball, handball)
- All this with 0.3m error in position, at 25 measurements/second.

Tracking - example

Tracking - example

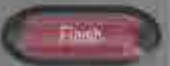Particle filter

Sensor fusion - POM + UWB

ExperimentA_1b: frame #2370 - 2010-11-26 15:44:18.810

Multi-modal fusion

- **multiple (weak) features** encoded as **feature maps**

- **fusion** via feature selection performed by a **trained classifier**

- annotated training portion of data

- the rest processed autonomously frame-by-frame; **bounded error**

feature vector for a cell

TRAINED CLASSIFIER

(specific) person
or
an empty cell?

Embedded vision

Low-cost embedded smart camera

- commoditized technologies
- low entry barrier
- tailored toward CV developers

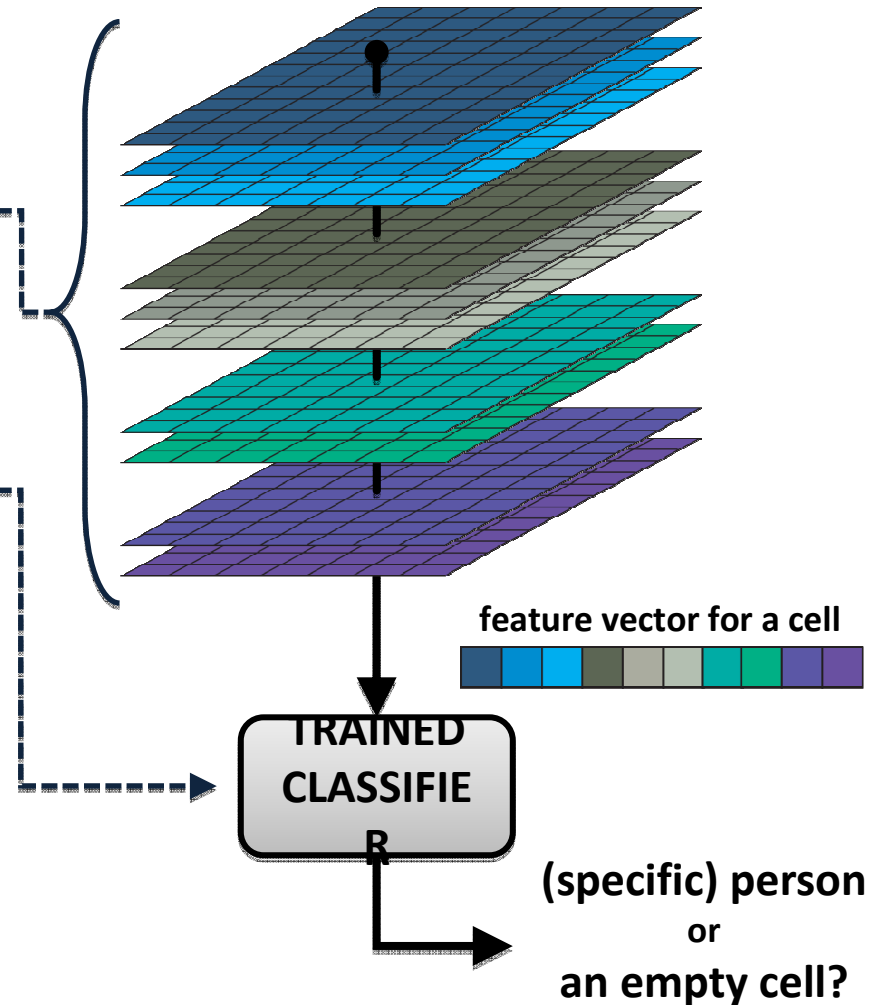| Feature	Specification	Cost [$]
MCU	Microchip PIC32MX795F512L 128 kB RAM, 512 kB FLASH MIPS32 M4K CPU, 90 DMIPS at 60 MHz	6
Lens	M12 60° (incl. with sensor) M12 180° (option)	4
Illumination	NIR LED assembly	3
	Wratten #87 NIR filter	1
Sensor	1/4" analog CCIR camera	4
Communication	RS-232 (112 kbit/s)	3
	RS-485 (2.5 Mbit/s)	3
Discrete	CCIR signal path	1
Power	voltage stabilizer + capacitors	(?) 3
Total	**w/o PCB, housing**	**28**

```
% covariance descriptor for the
% central (32x32) region of
% 50x50 pixel, 8 bit image.
function C = cov_descriptor (I)

% Copy, crop, convert
If = single(I(8:41,8:41));

% Convolution masks
f1 = [-1 0 1];
f2 = [-1 2 -1];

% Derivatives
Ix = conv2(f1, If);
Iy = conv2(f1,1,If);
Ixx = conv2(f2, If);
Iyy = conv2(f2,1,If);
```
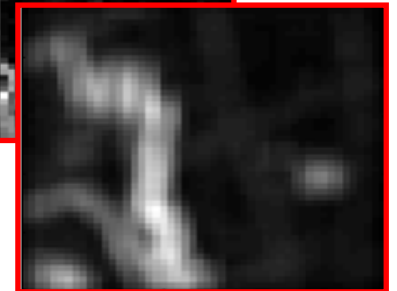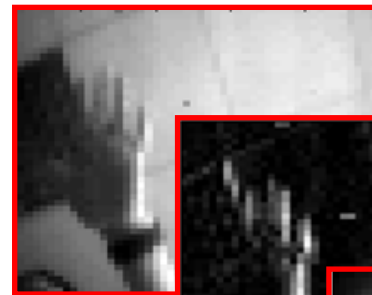
Visual-sensor networks

- optimal path for recognition queries in visual-sensor network

- based on hierarchically-structured features

Thanks

Dana Mitja Boštjan Rok Stane Matej Janez Marko
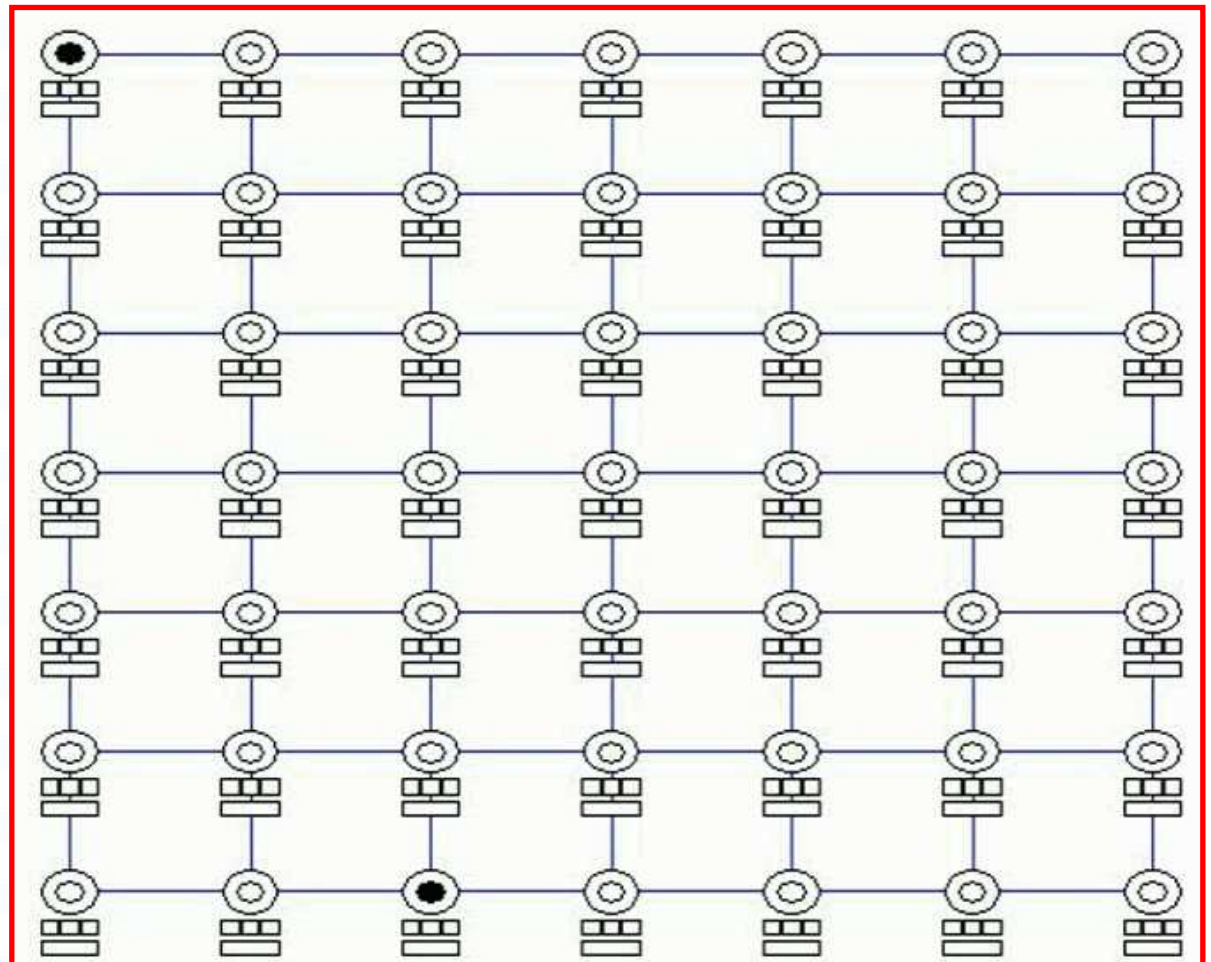
Many thanks to former MVL members

Aleš Klemenčič

Franci Lahajnar

Peter Rogelj

Matej Perše

Andreja Jarc

Aljaž Noe, Marko Knez, Klemen Polanec

ARRS, TIA, MVZT, MORS, EUREKA, InspireWorks, ...