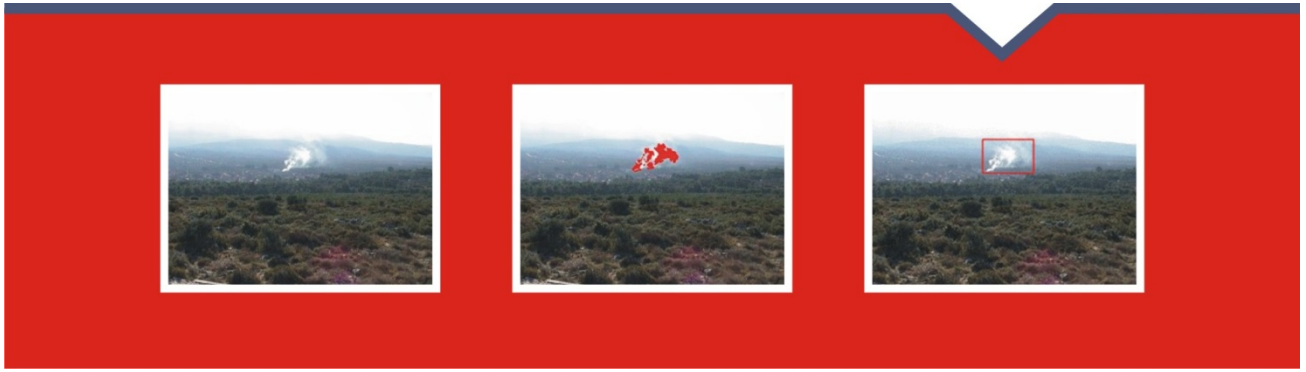
UNIVERSITY OF SPLIT
UNIVERSITAS STUDIORUM SPALATENSIS
FACULTY OF ELECTRICAL ENGINEERING, MECHANICAL ENGINEERING AND NAVAL ARCHITECTURE

Reasarch activities at FESB related to computer vision and image understanding

Prof.dr.sc.Darko Stipaničev
Department for Modelling and Intelligent Systems & Centre for Wildfire Research
Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture
UNIVERSITY OF SPLIT, Split, Croatia



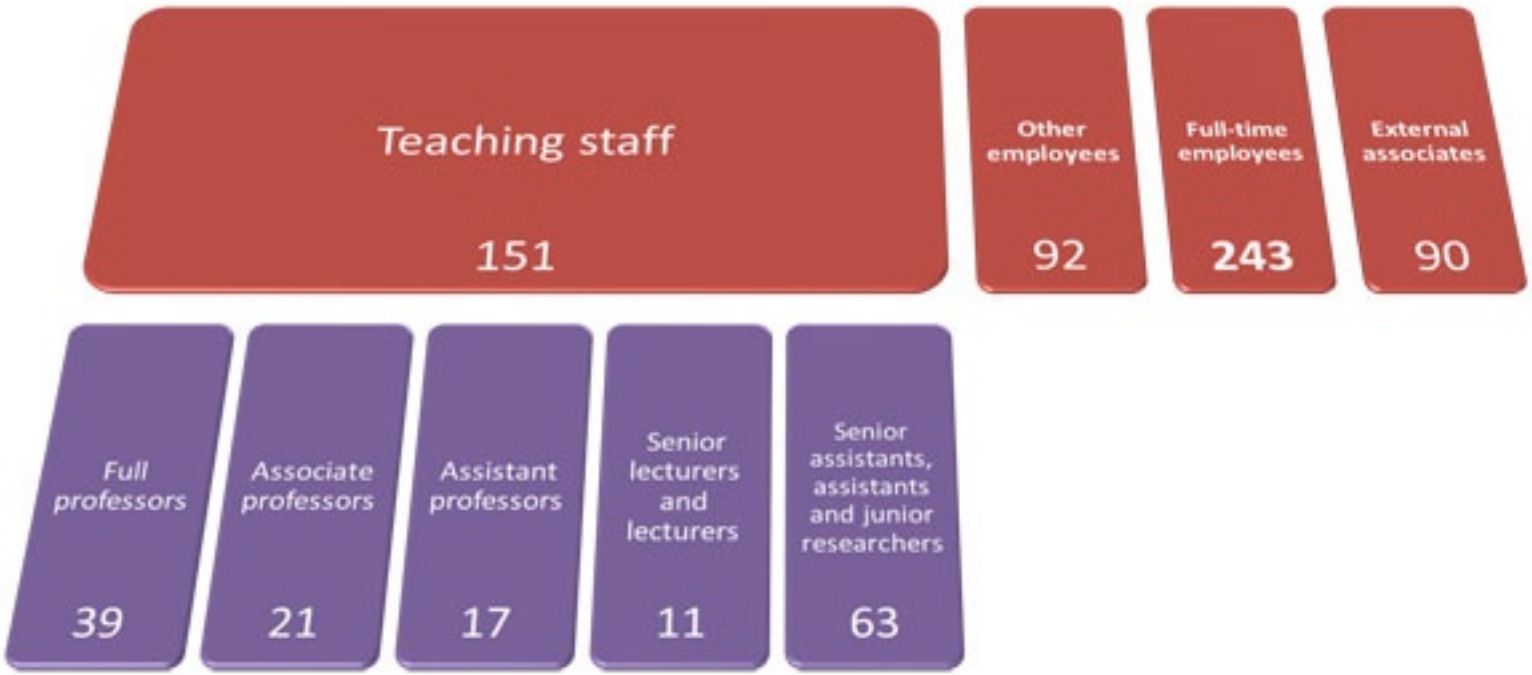
FESB, Split

FESB is a polytechnical faculty whose fundamental activities are higher education teaching and research in the fields of **Technical Science** and scientifuc areas

- **Electrical Engineering,**
- **Mechanical Engineering,**
- **Naval Architecture,**
- **Computing,**
- **Basic Technical Sciences,**
- **Natural Sciences - Mathematics** and **Physics.**

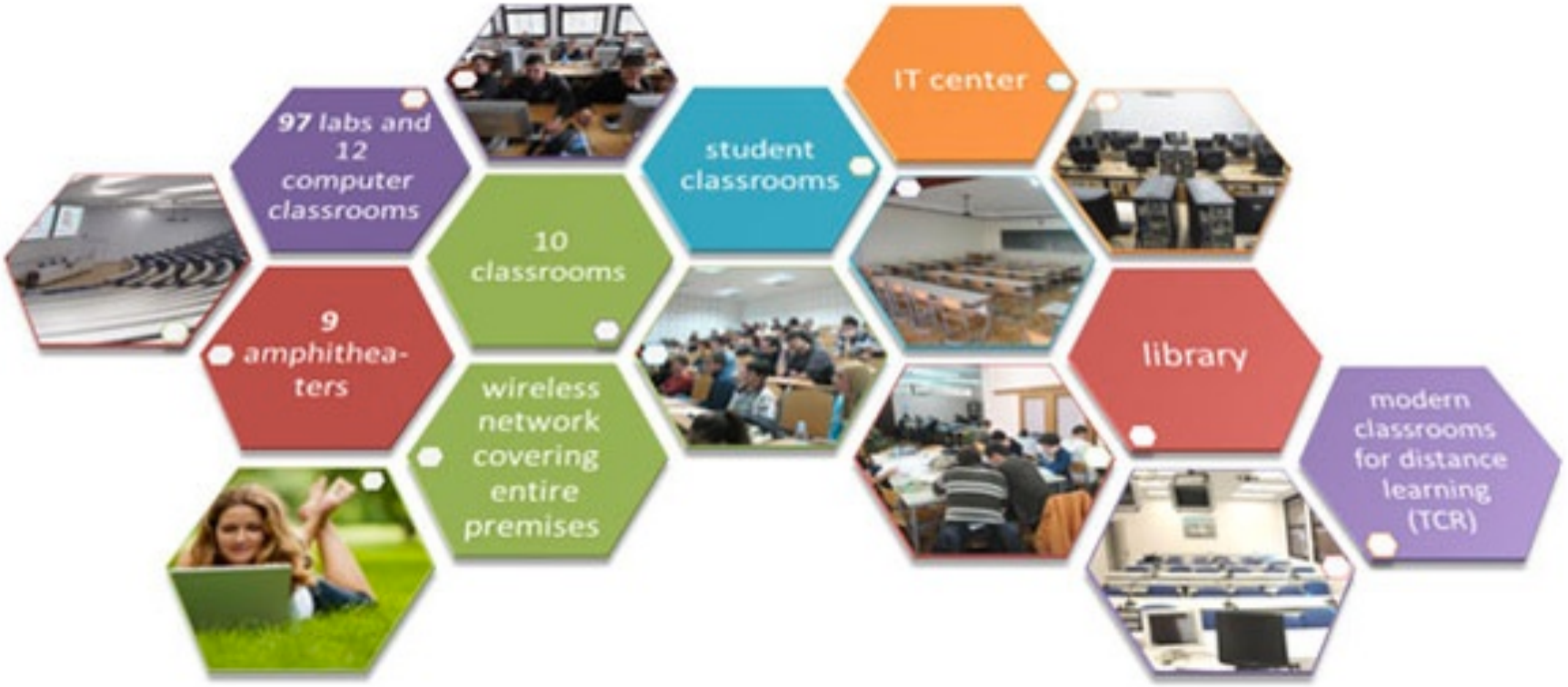
FESB, Split

2700 students
243 full–time employees + 90 external associates



FESB, Split

FESB, Split


97 labs and 12 computer classrooms
student classrooms
IT center
10 classrooms
9 amphithea-ters
wireless network covering entire premises
library
modern classrooms for distance learning (TCR)

Computer Vision at FESB

The Faculty has an internal division of organizational units for teaching and scientific research, administrative and technical work, but for our today's topic related to research connected with Computer Vision two departments are important:

- Department for Modelling and Intelligent Systems
- Department for Automatic Control and Systems

Their current research interests are more or less conected with this field but let us first go a little bit in the past and explain when and how this kind of research has started.

Semial Computer Vision Research at FESB

Twenty-three years ago, in 1990, a research concerning **vision based robot control** (visual servoing), particularly **visual based eye-hand coordination** and development of **simple compound eye like artificial vision** sensor called **fuzzy eye** has been started.

Fuzzy Eye (1991 – 1998)

The man made copy of a **lens eye** is a **video camera**. The camera lens correspond to the eye lens and CCD sensor to the eye retina. We have proposed a men-made copy of the **compound (insect) eye** and called it a **fuzzy eye** because

- The image captured by this eye was a rather fuzzy, and
- The fuzzy set theory could be easily applied for analysing and transforming its image for futher processing and control applications.

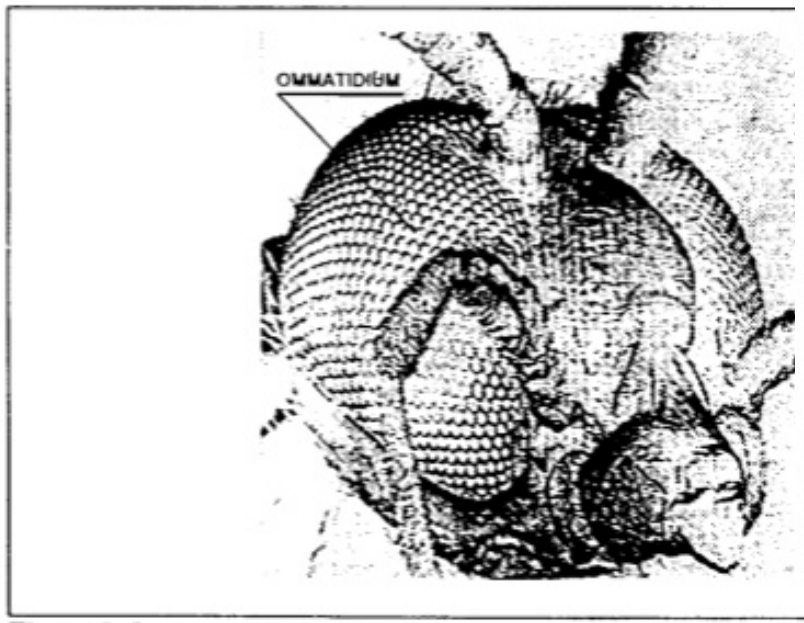


Figure 2. Insect compound eye

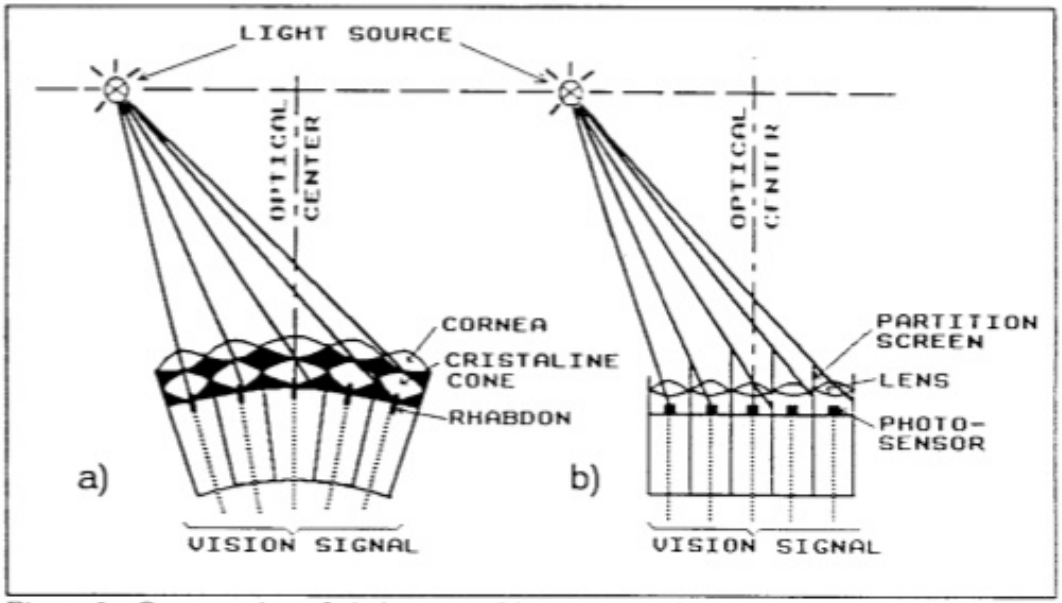
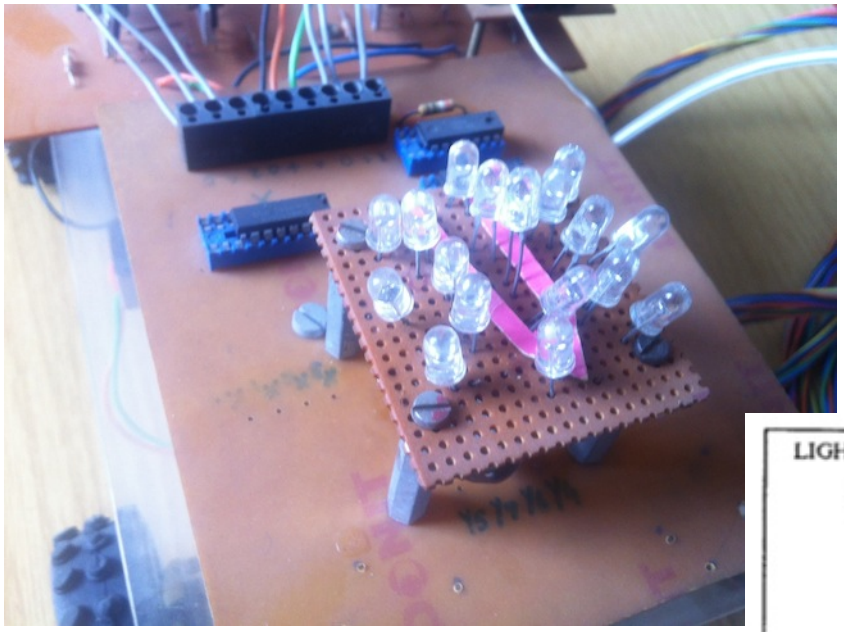


Figure 3. Cross section of a) the apposition compound eye and b) the fuzzy eye

From: D.Stipaničev, Fuzzy vision and fuzzy control, **Proc.of 13th IMACS World Congress on Computation and Applied Mathematics**, Dublin, Ireland,July 1991, pp.1210-1211

Fuzzy Eye



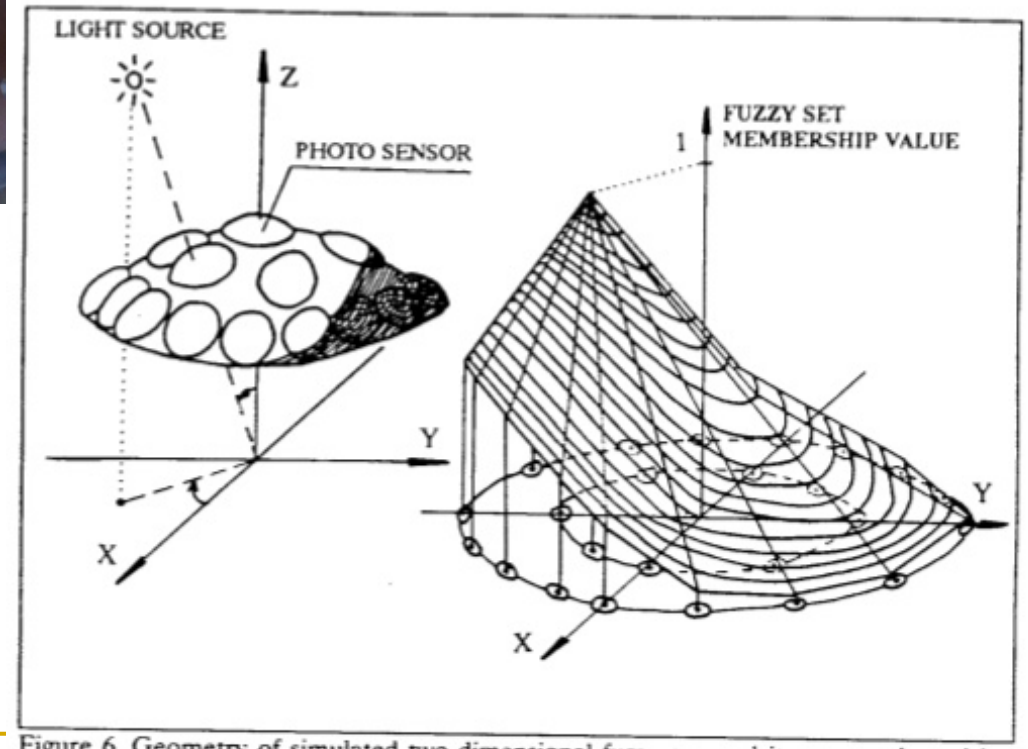


Figure 6. Geometry of simulated two dimensional fuzzy eye and its appropriate vision signal

Application of Fuzzy Eye

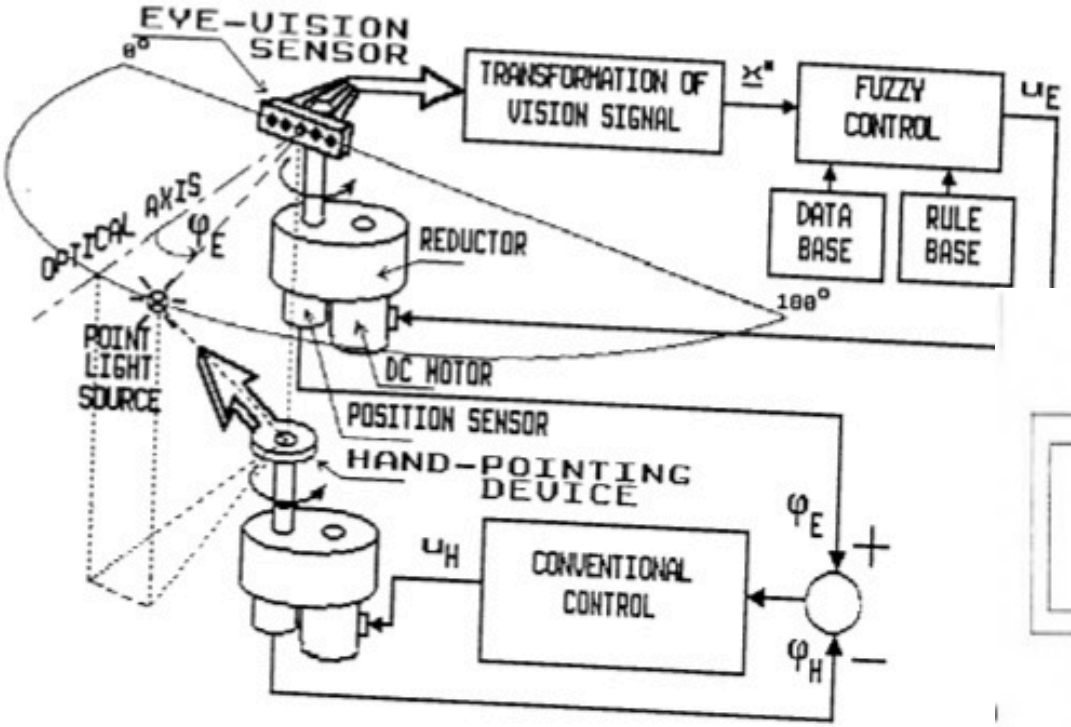


Fig. 3. Fuzzy position control based on principles of eye - hand coordination

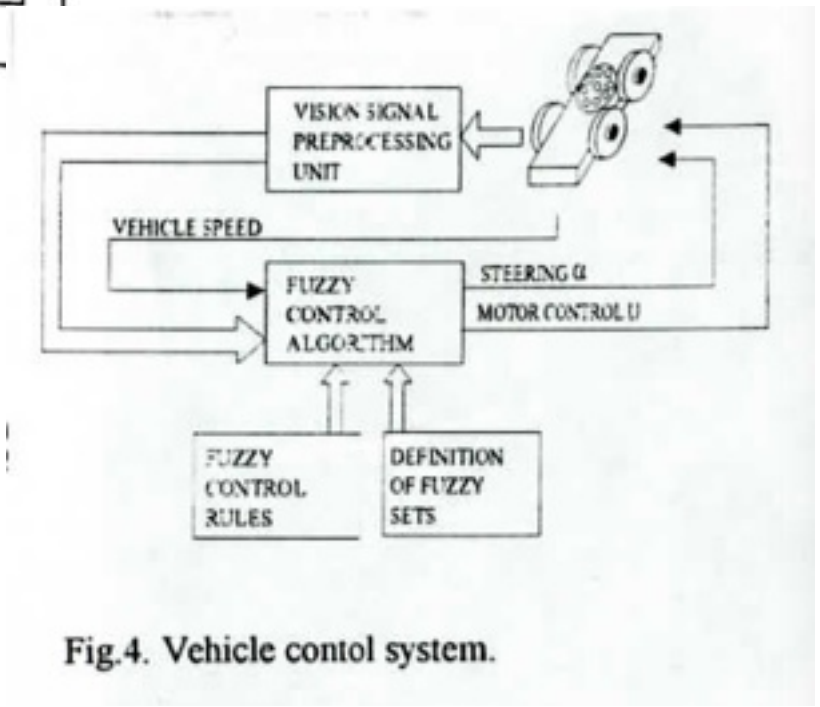


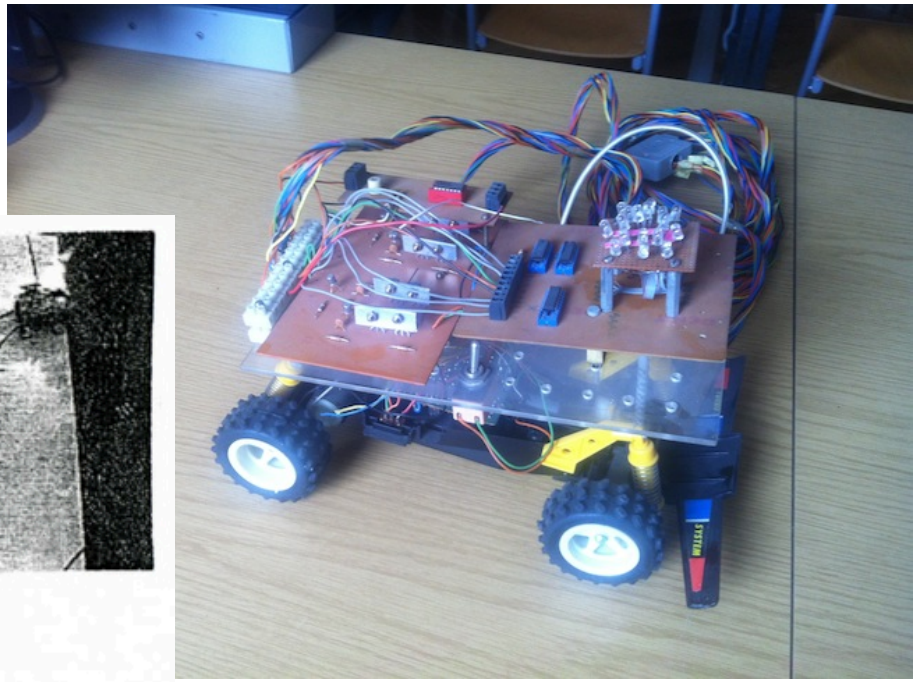
Fig.4. Vehicle contol system.

From: D.Stipaničev, M.Cecić, Eye-hand coordination based on fuzzy vision transducer, **Proc. of FUZZ'IEEE 92,** San Diego, USA, March 1992, pp.29-**35**

D.Stipaničev, Fuzzy vision transducer and its application in control, **Proc. of IFAC Symp. on Intelligent Components and Instruments for Control Application,** Malaga, May 1992.

D. Stipaničev, Vision based fuzzy servo control, **Proc. of EUFIT'93-First European Congress on Fuzzy and Intelligent Technologies**, Aachen, Sept. 1993, pp. 1618-1624 Malaga

Fuzzy Eye Based Vehicle Control System



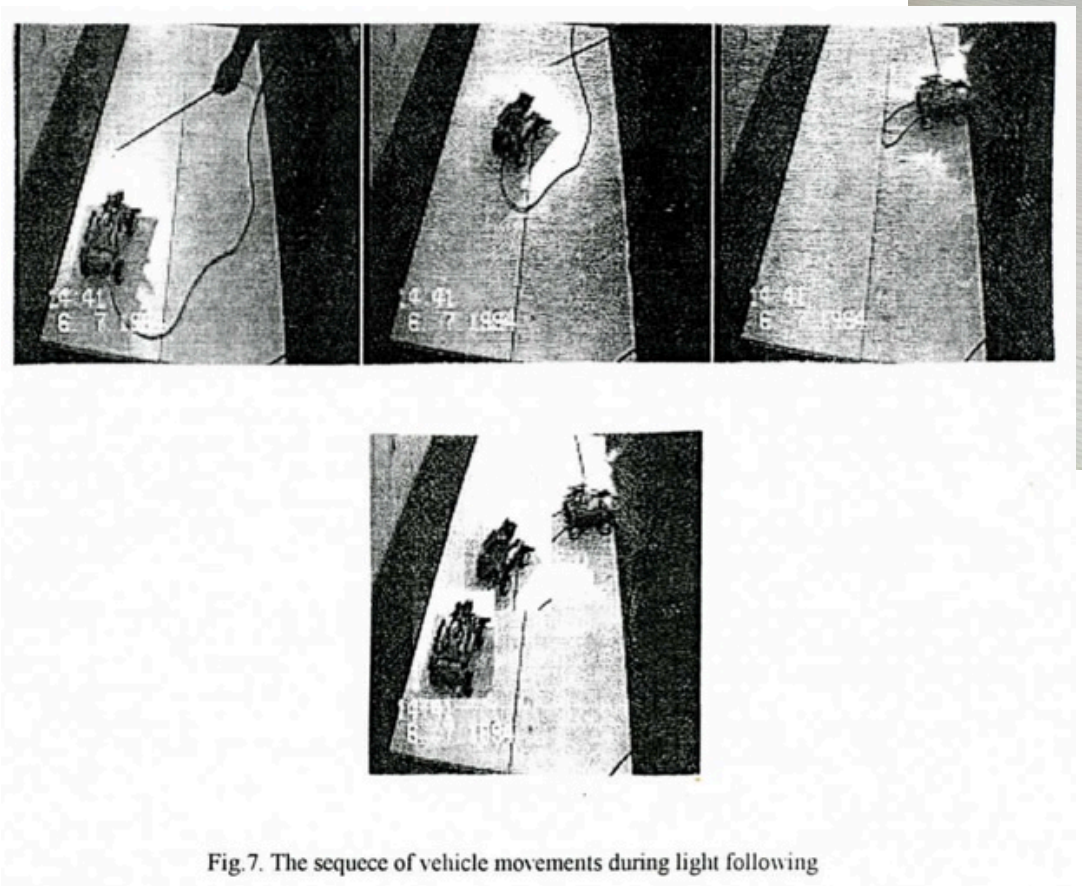


Fig.7. The sequece of vehicle movements during light following

From: D. Stipaničev, M. Bonković, Light Following Vehicle Control System, **Proc.of 3 rol IFAC Symp. on Intelligent Autonomus Vehicle**, Madrid, Spain, March 25-27 1998, pp. 199-204

Visual Servoing (1998 – today)

Non-calibrated vision based robot arm control system. The sytem consists of three cameras, two of them responsable for rough target approach and the third one (eye in hand) for final target approach)

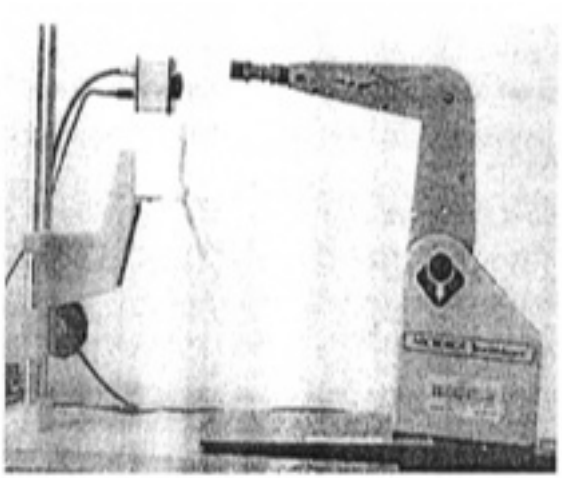
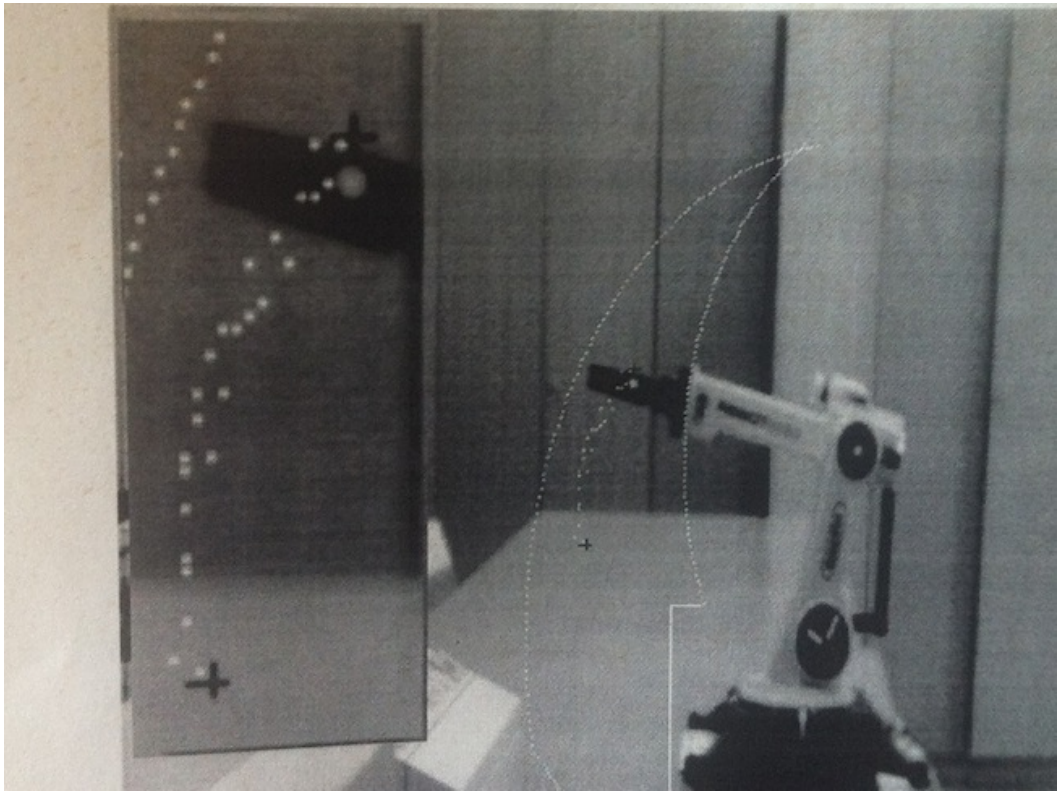


Fig. 8. Photo of the experimental system



From: M.Bonković, D.Stipaničev, M.Štula, Control of Robot Arm Approach by Fuzzy Pattern Comparison Technique, u knjizi B.Reusch (ed), **"Computational Inteligence - Theory and Applications"**, Springer - Berlin (Lecture Notes in Computer Science No.1625), 1999, pp.246-252

M.Bonković, D.Stipaničev, M.Štula, 2D Motion Analysis by Fuzzy Pattern Comparator, u knjizi F.Solina, A.Leonardis (ed), **"Computer Analysis of Images and Patterns"**, Springer - Berlin (Lecture Notes in Computer Science No.1689), 1999, pp. 472-479

Mirjana Bonković, Inteligentno vođenje robota u prostoru vizualnom povratnom vezom, disertacija obranjena 2000.

Visual Servoing (1999 – 2001)

In that time we did a lot of experiments with a device called fuzzy pattern comparator, specially for final camera approach.

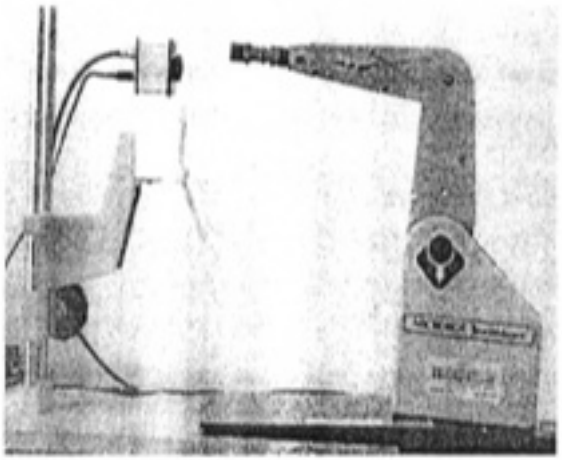


Fig. 8. Photo of the experimental system

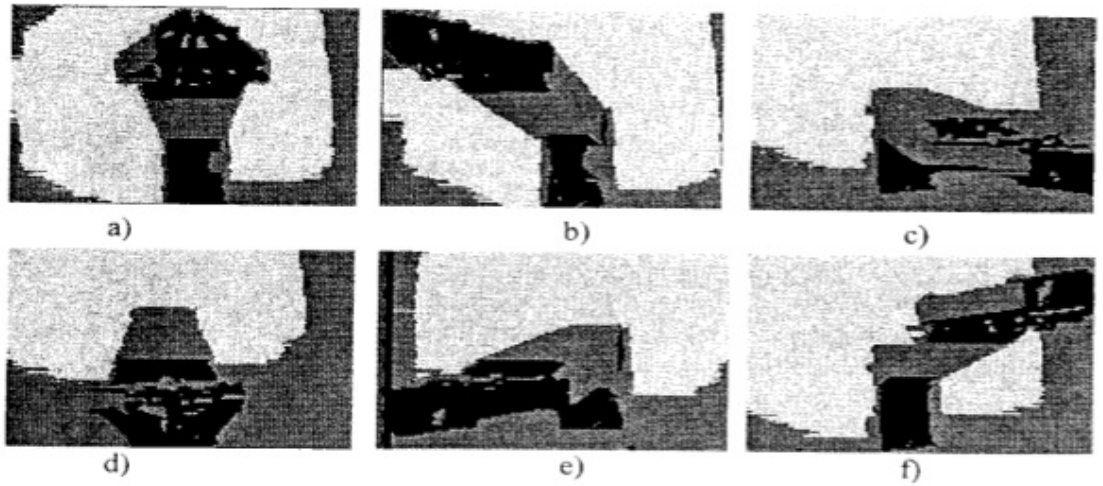


Fig. 2. Images of the predefined displacements: a) up, b) left-up, c) right-down, d) down, e) left-down and e) right-up

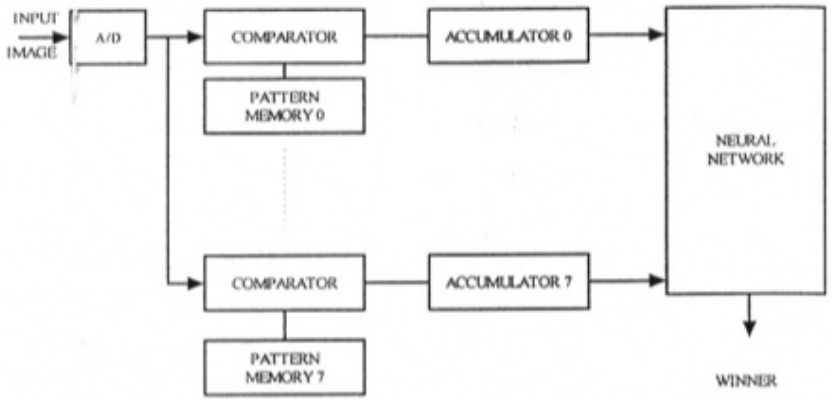


Fig. 3. The Fuzzy Pattern Comparator

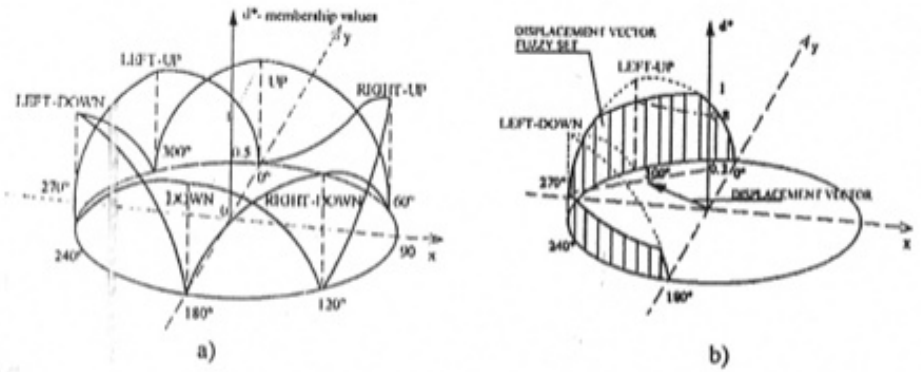


Fig. 6. a) Fuzzy sets of direction defined on a circle
b) Example of the displacement vector fuzzy set

Semial Computer Vision Research at FESB

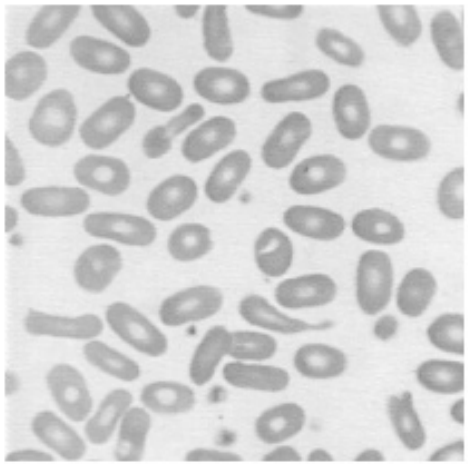
Parallely with these, more theoreticaly and laboratory oriented “toy problems”, in 1994 we have started to work on more practicaly and commertialy oriented applications concerning cpmputer vision, and one of our first products was:

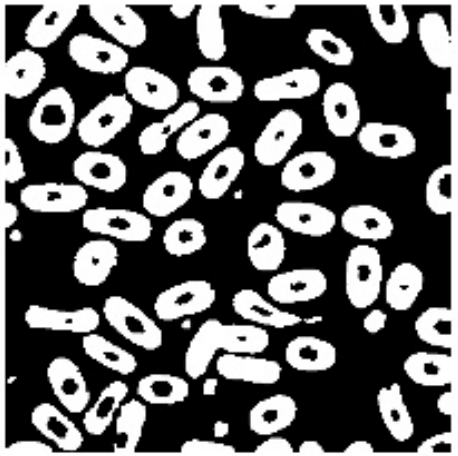
CHRONOLAB Color Vision - Software for Digital Image Processing and Analysis, CHRONOLAB, Zug, Switzerland, 1995.

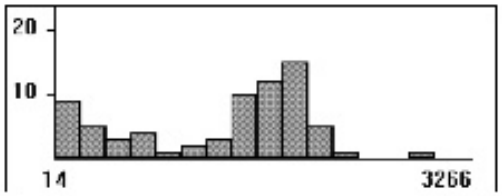
developed primarily for medical video microscopy.

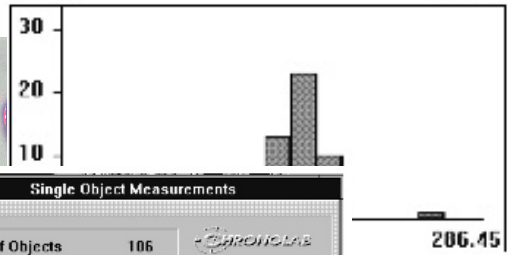
Chronolab Color Vision (1995)

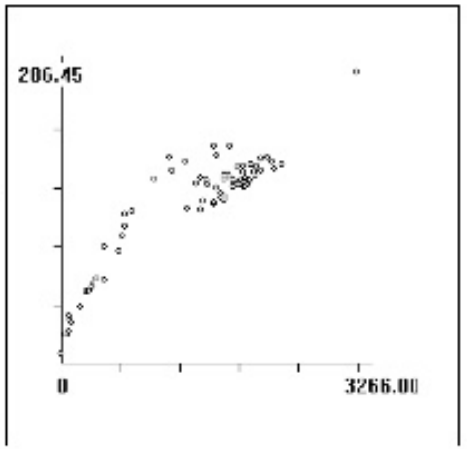
CRONOLAB Color Vision was a Windows program (based on CORECO Frame Grabbers) with few hundreds various digital image processing and analysis procedures, particulary adapted for video microscopy applications.

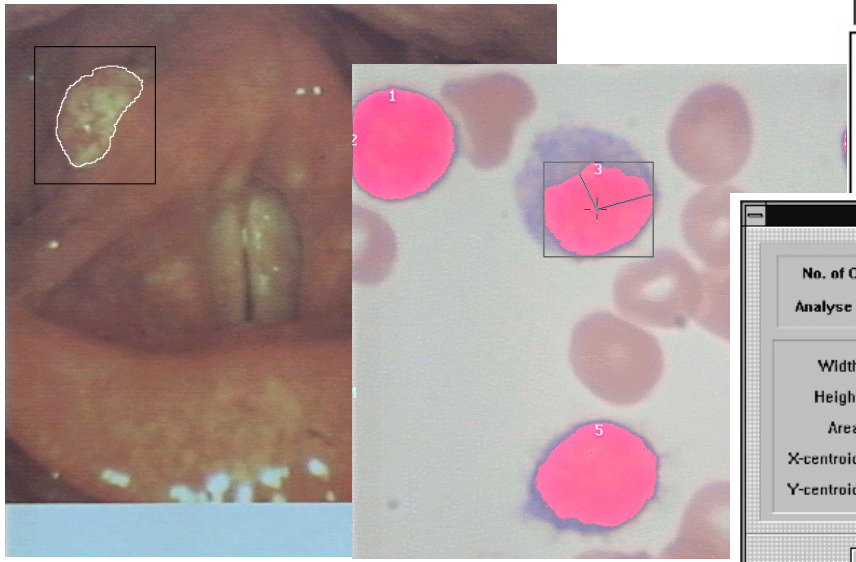


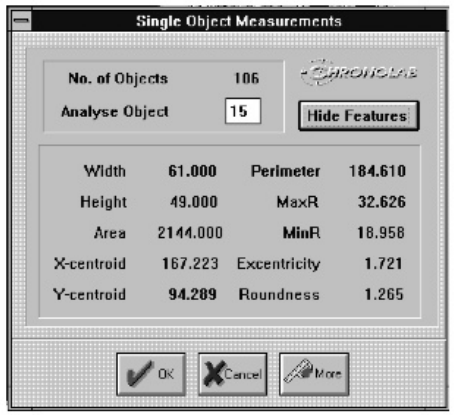


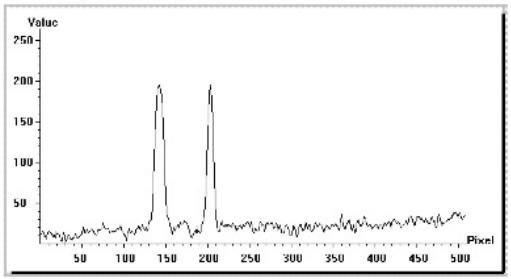












Recent Computer Vision Research at FESB

That was selection of our past activities, but let us now concentrate on our more recent research (last 10 years).

Our recent research concerning computer vision could be divided in following groups:

Recent Computer Vision Research at FESB

- Artificial perception – image understanding of natural scenes and natural risk phenomena detection primarily wildfires
- Augmented reality based video surveillance
- Image based visual servoing
- Image super-resolution
- Image processing for surveillance – artificial and natural objects detection and classification
- Text extraction and OCR
- Vision based sport analysis

Artificial perception

- Perception is the process of acquiring, interpreting, selecting, and organizing sensory information
- The goal of the perception is to identify the occurrence of an event or scenario using only available particles of information and some a priori knowledge.
- Human observer is very reliable in identifying the scenario using his or her senses and heuristic knowledge.

Artificial perception

- Artificial visual perception is based on colour analysis, texture analysis, object shape analysis, context analysis and local and global image features.
- Our focus is primarily on **image understanding of natural scenes and natural risk phenomena detection**, primarily **wildfires**
- We are working in this area since 2003, both on scientific level, but also on practical level and of final result is

iForestFire

Intelligent Forest Fire monitoring system

What is iForestFire ?

iForestFire is integrated and intelligent video IP based system for early detection of forest fires in incipient stage using advanced image processing and image analyses methods.

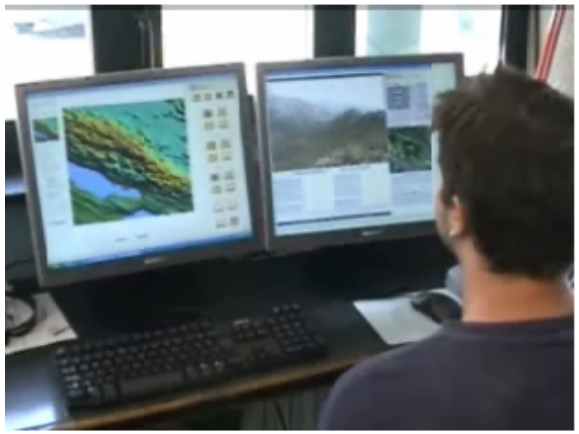
iForestFire - MONITORING FIELD UNIT

Monitoring field unit includes:

- video IP based camera controlled by pan, tilt and zoom
- mini meteorological station
- intelligent monitoring and control unit
- communication unit (mostly wireless in non-licensed or licensed range)

Experimental system on Marjan Hill (Split), worked during 2005. i 2006.

iForestFire - CENTRAL UNIT



All analysis, calculation, archiving, simulations and presentation are running on central processing unit which:

- collects and presents image data from multiple cameras (max. 6 per server)

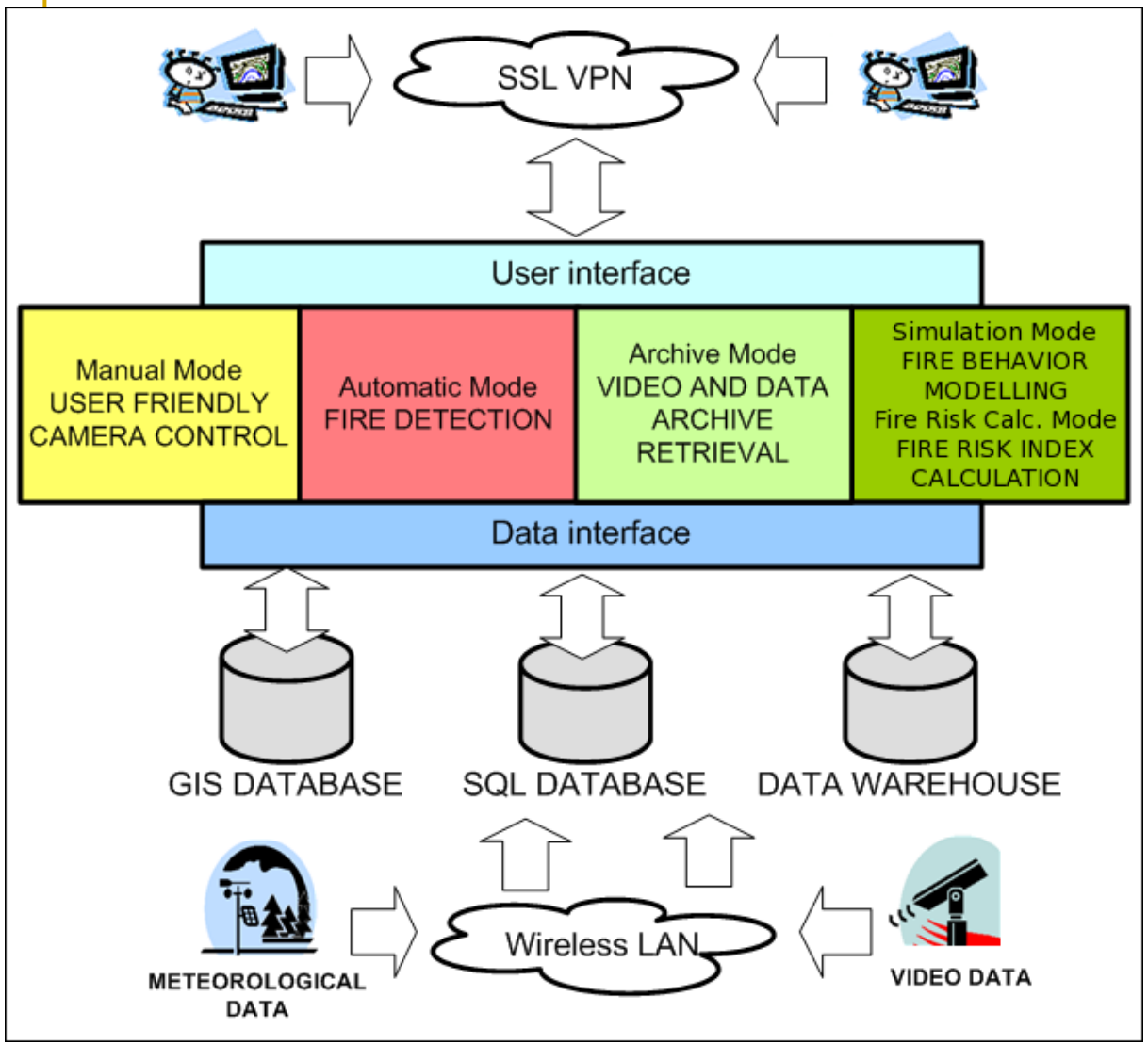
- collects and presents data from multiple mini meteorological stations

- archives all the data for later analysis

- micro-location wildfire risk calculation

- simulation of fire behavior and spread

iForestFire



iForestFire was conceived as a Cloud Computing or Web information system (WIS) which means that user can connect to the system from any place that is connected to Internet using standard web browser.

Advanced automatic wildfire surveillance and monitoring network

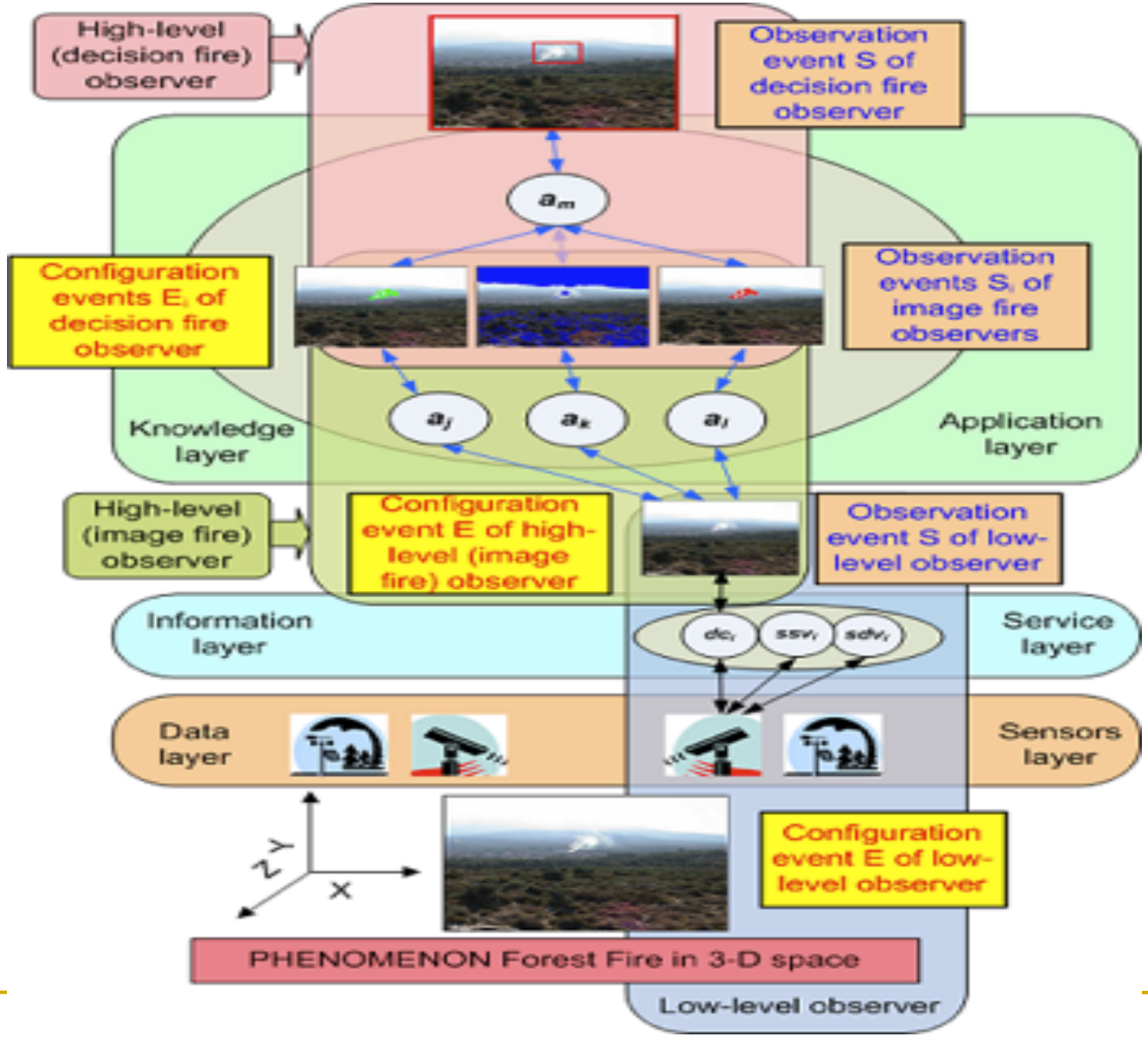
As it belongs to the last generation of wildfire video monitoring systems it has few innovative and advanced features.

The most important features are:

iForestFire advanced features

1. Theoretical background of iForestFire is wildfire observer network theory based on the three-layer sensor network architecture, formal theory of perception and notation of observer.

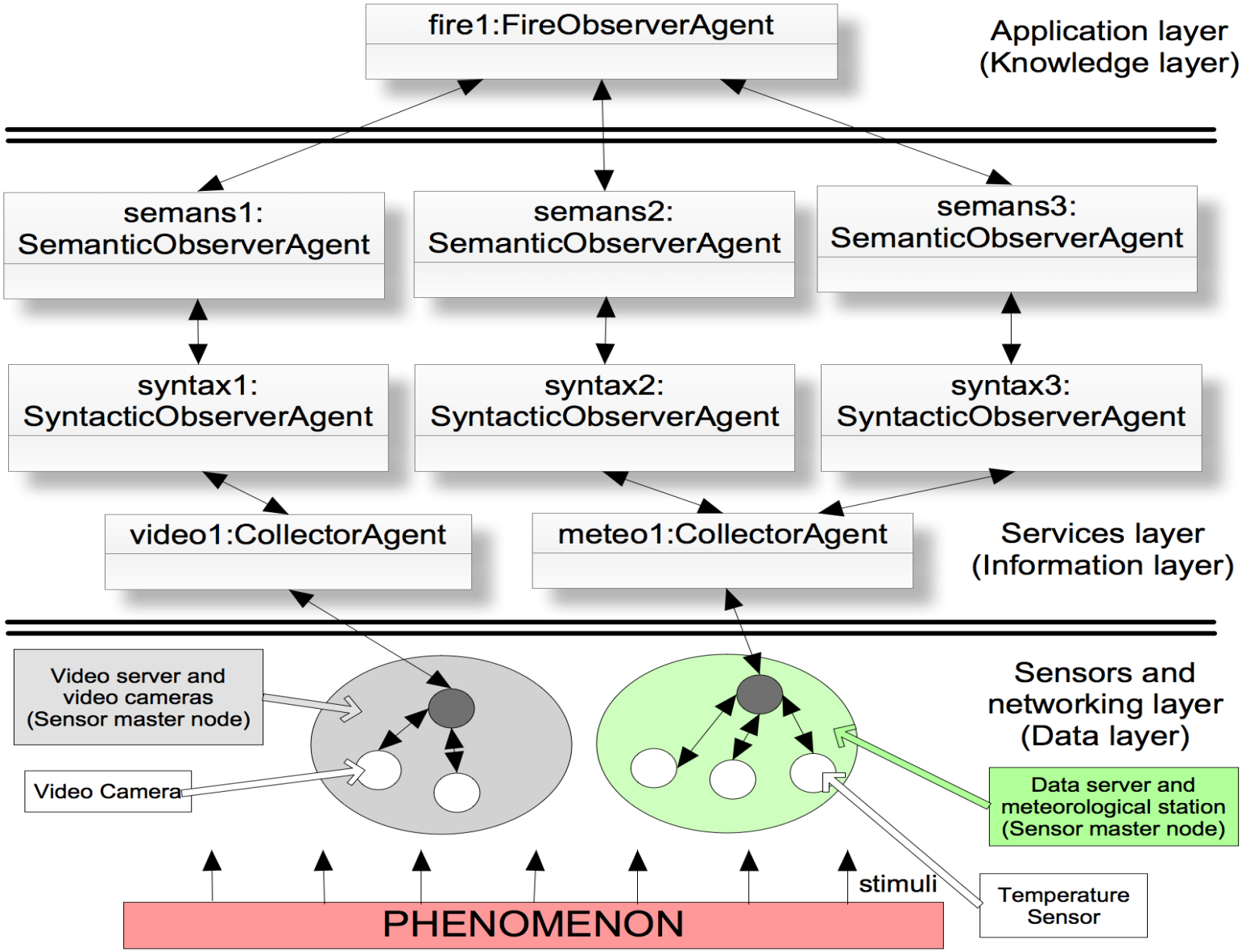
iForestFire – OBSERVER NETWOK STUCTURE



iForestFire advanced features

2. Its software architecture is based on multi-agent technology. Several hundred software agents and intelligent software agents are responsible for almost everything from image acquisition to false alarms reduction.

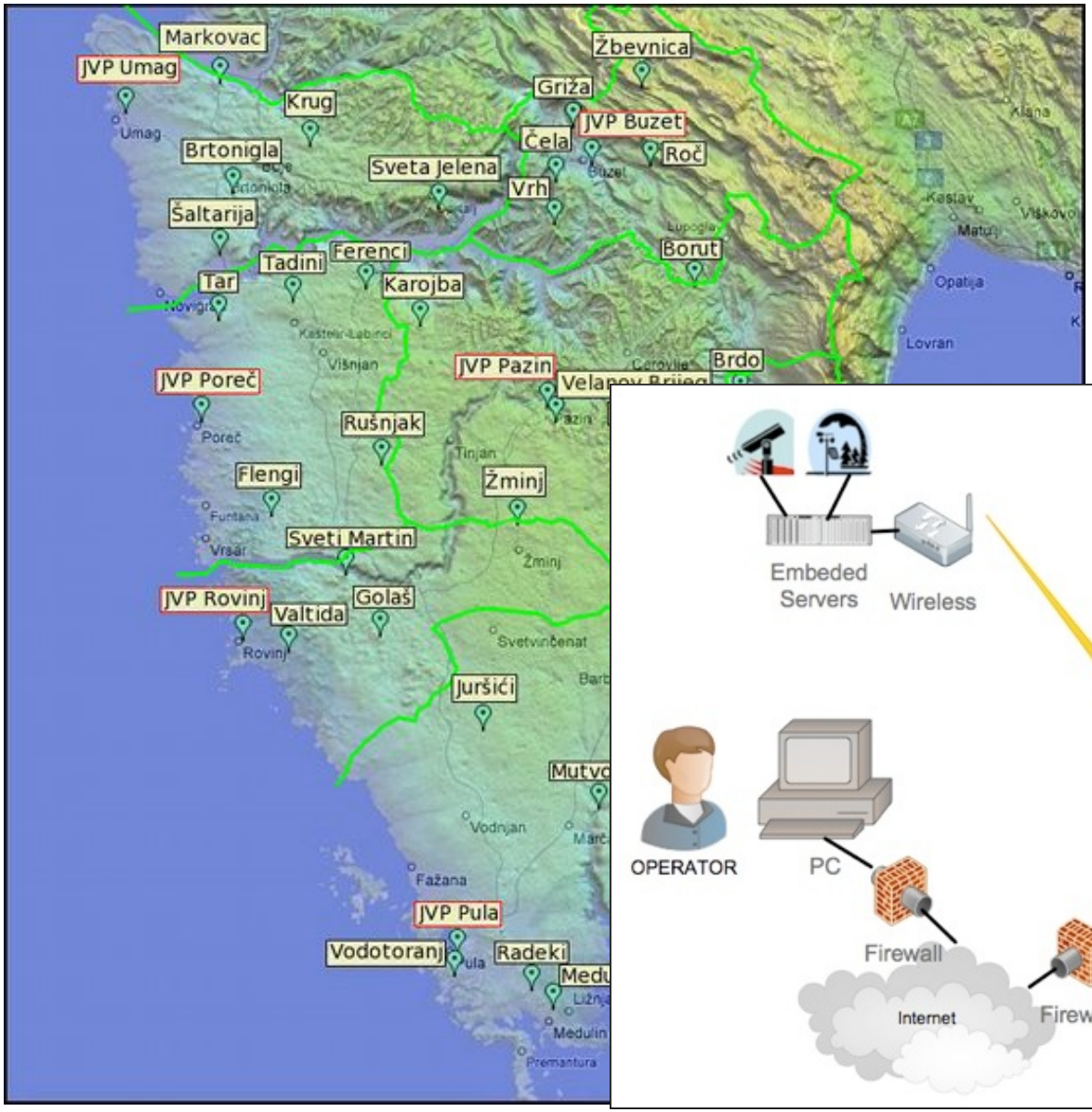
iForestFire – MULTI-AGENT ARCHITECTURE



iForestFire advanced features

3. It is an example of Cloud Computing because it is entirely distributed and Web based. The only user interface is standard Web browser and users could be located in any place having broadband Internet connection.

iForestFire – CLOUD COMPUTING – WEB BASED SYSTEM



Istra iForestFire Net

29 monitoring stations

29 cameras

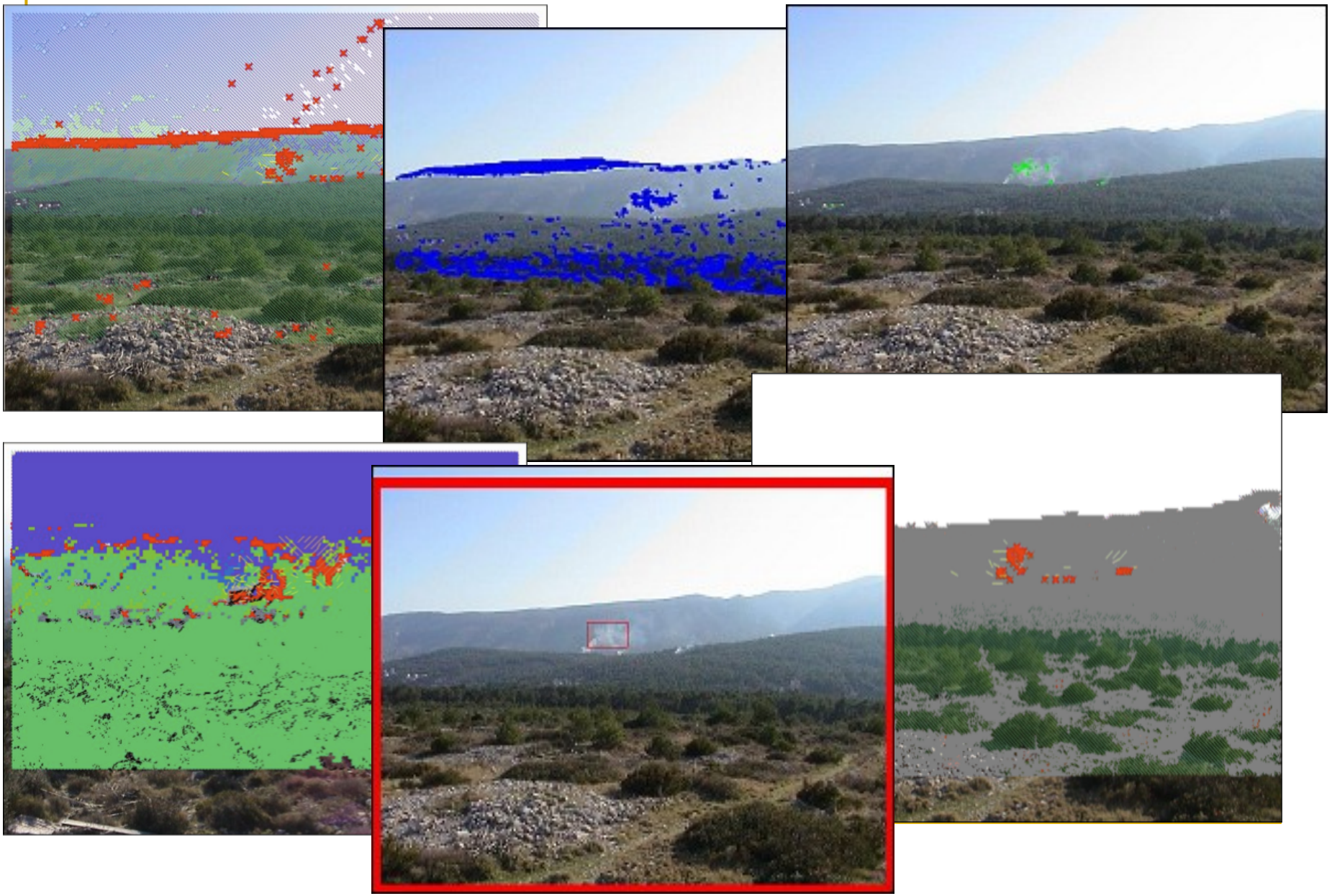
17 meteorological st.

7 operational centers

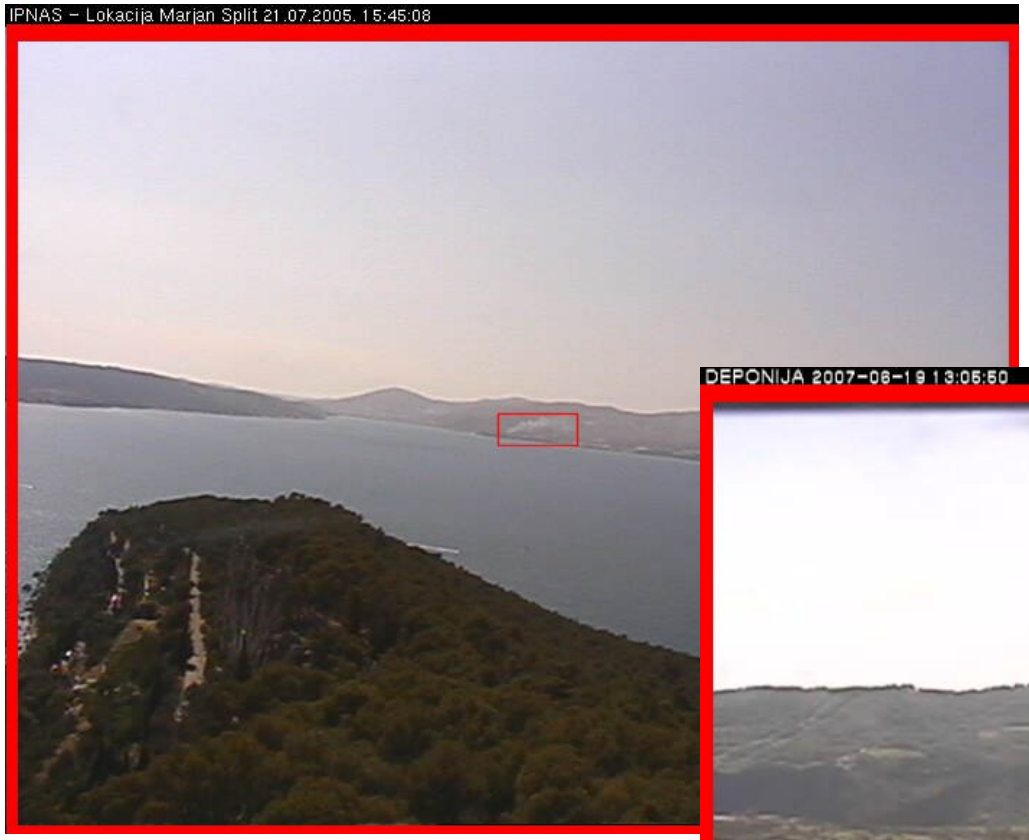
iForestFire advanced features

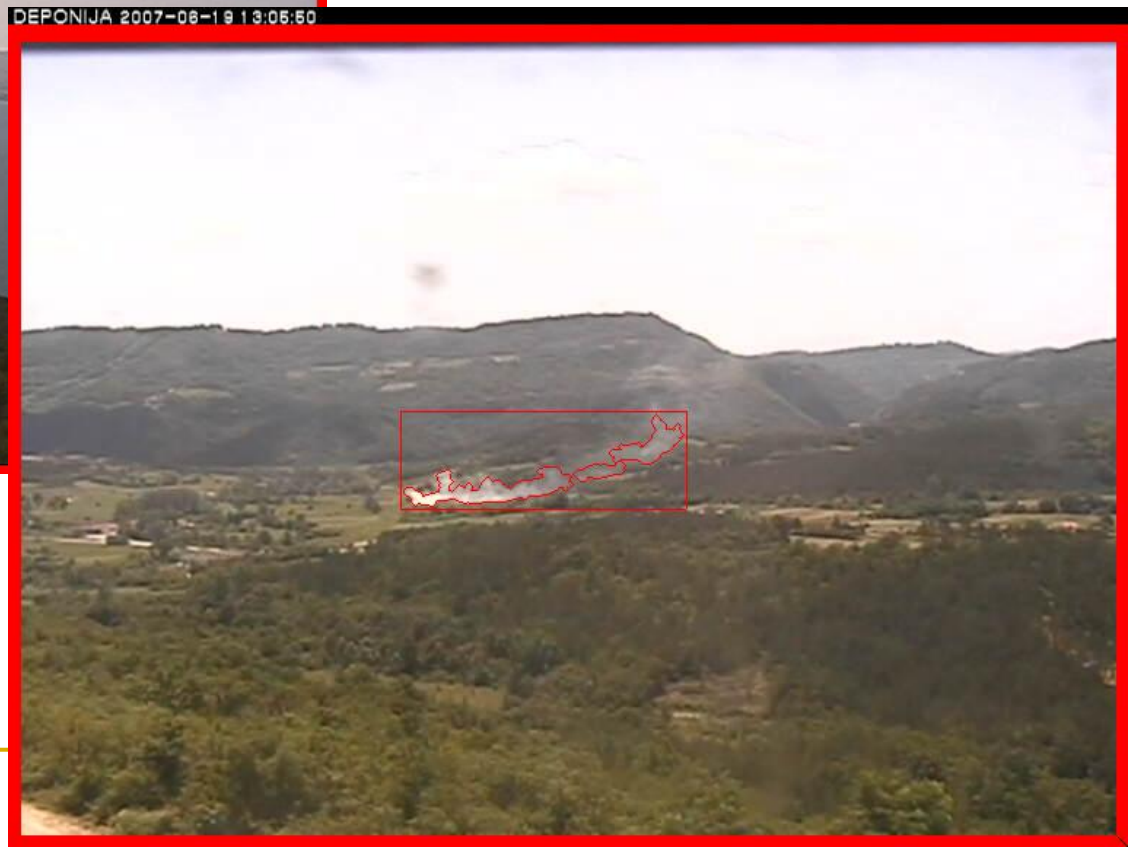
4. Advanced image analysis algorithms working in parallel (parallel programming) are responsible for smoke and fire recognition on analysed images.

iForestFire – ADVANCED IMAGE ANALYSIS ALGORITHMS



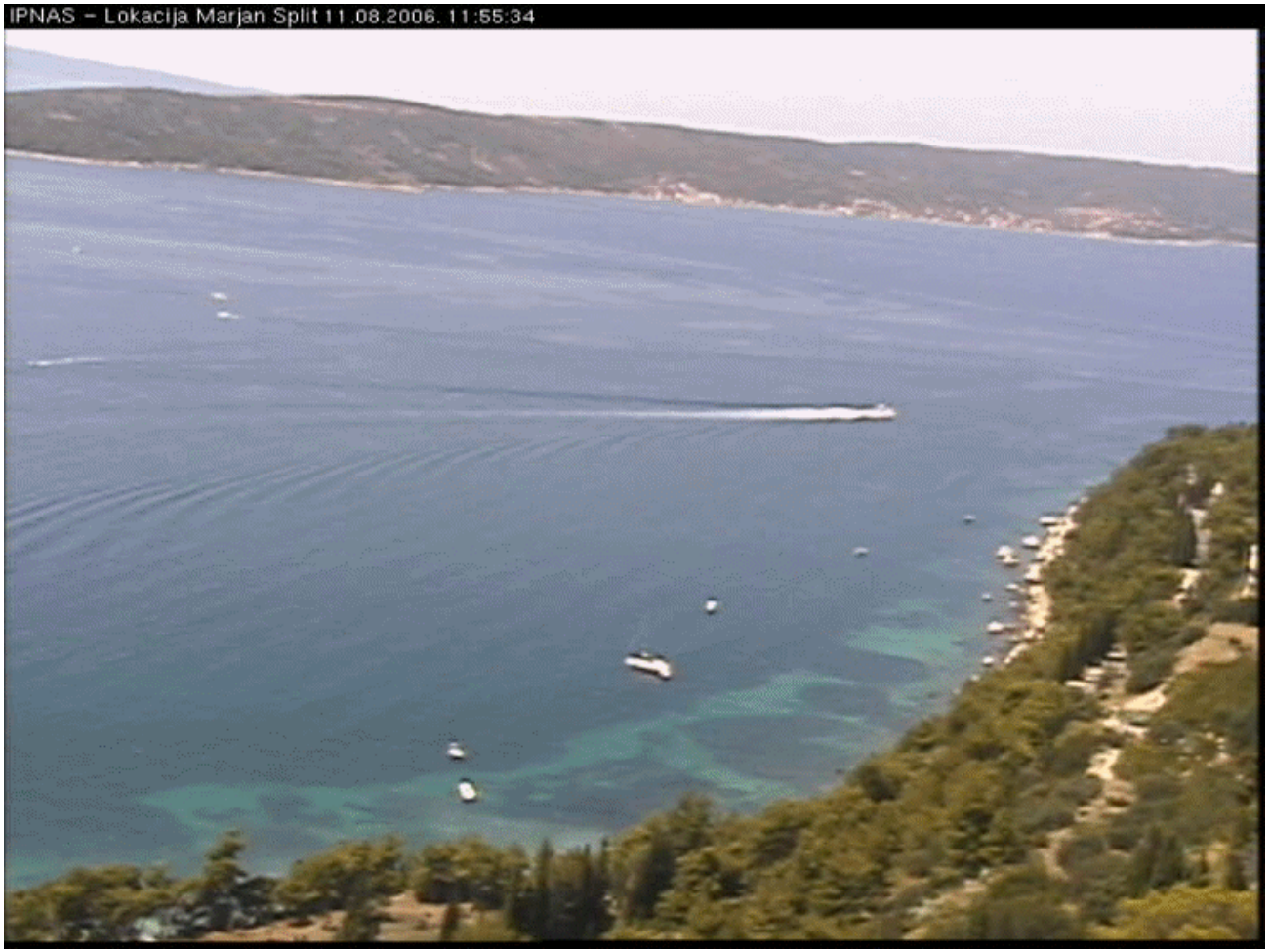
Automatic detection of forest fires



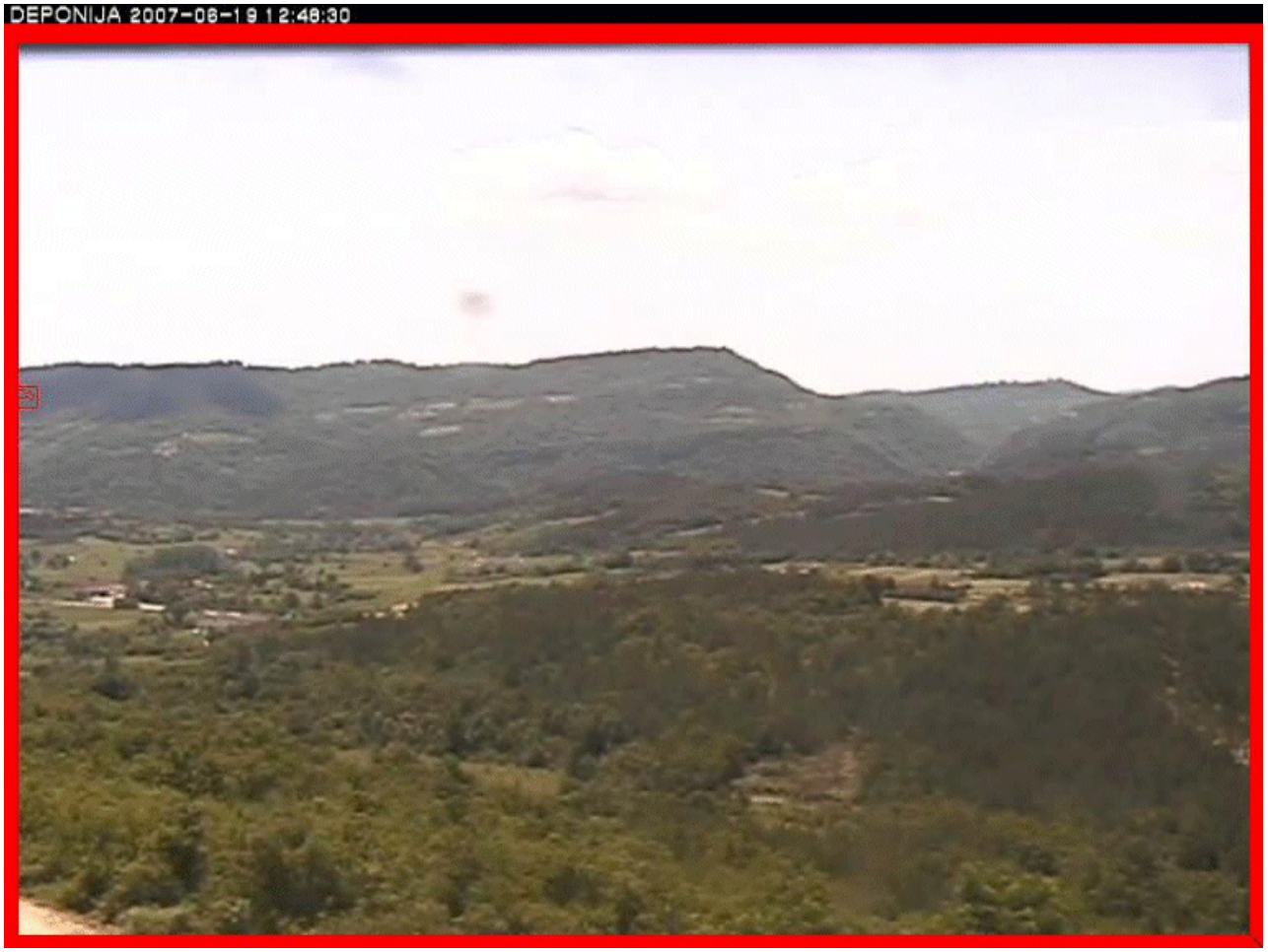


DETECTION - testing at Vrboska, Island of Hvar 2004.

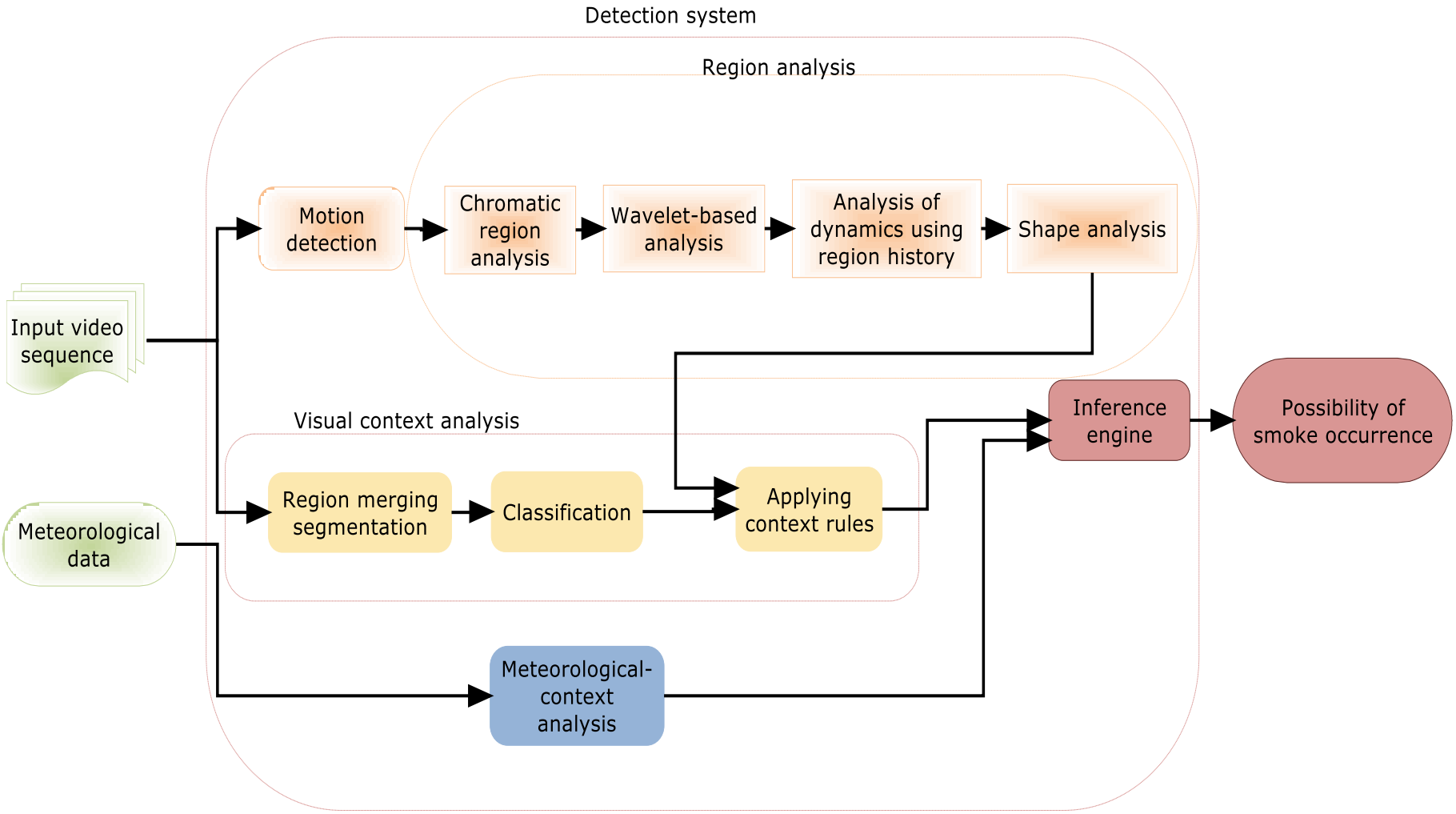
DETECTION - experimental system Marjan Hill, Split 2005. i 2006.



DETECTION - operational system at Buzet, Istra 2007.



Visual spatial-context based wildfire smoke detection

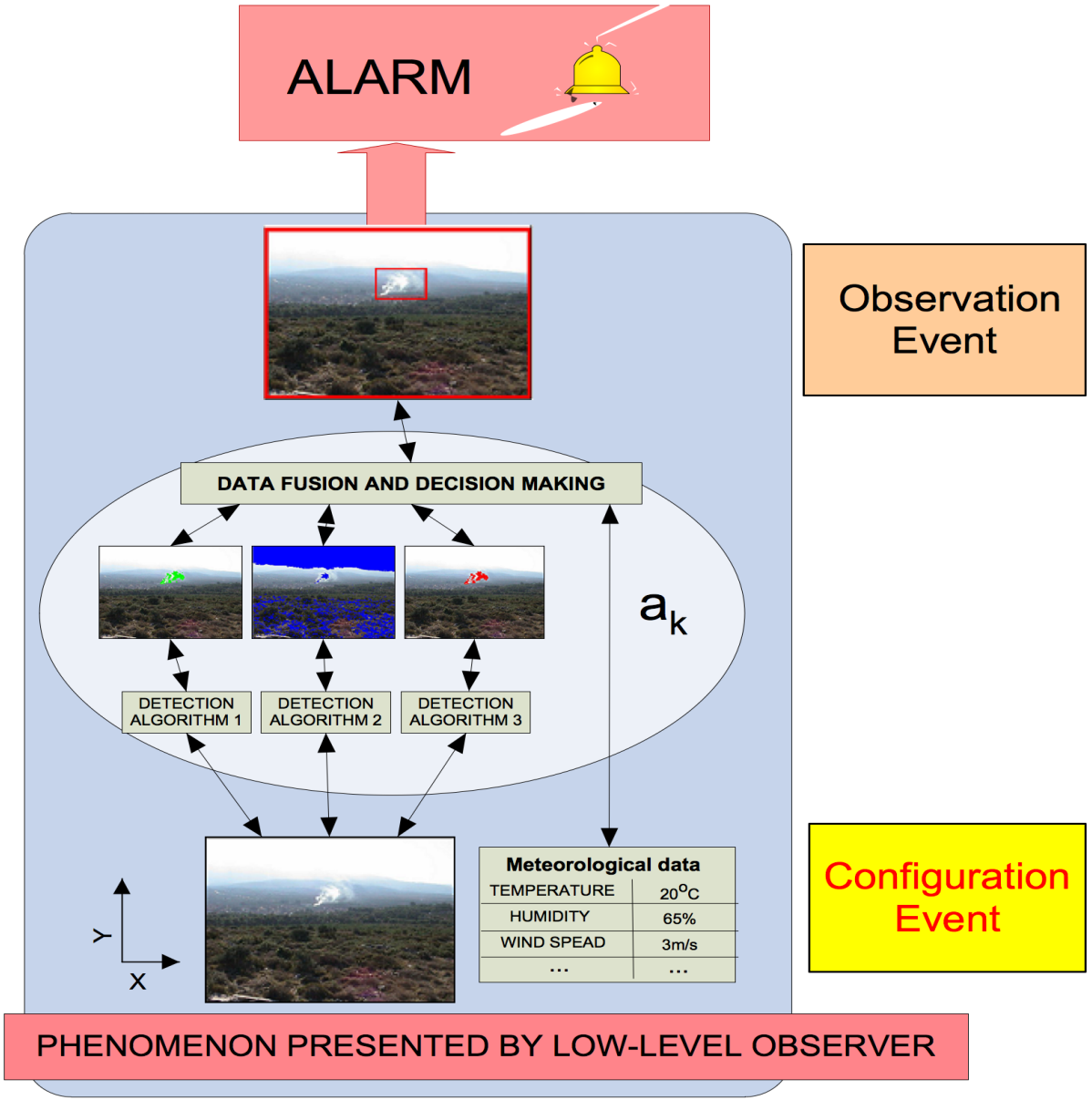


Researchers: Toni Jakovčević, Darko Stipaničev, Damir Krstinić.
Maja Braović

iForestFire advanced features

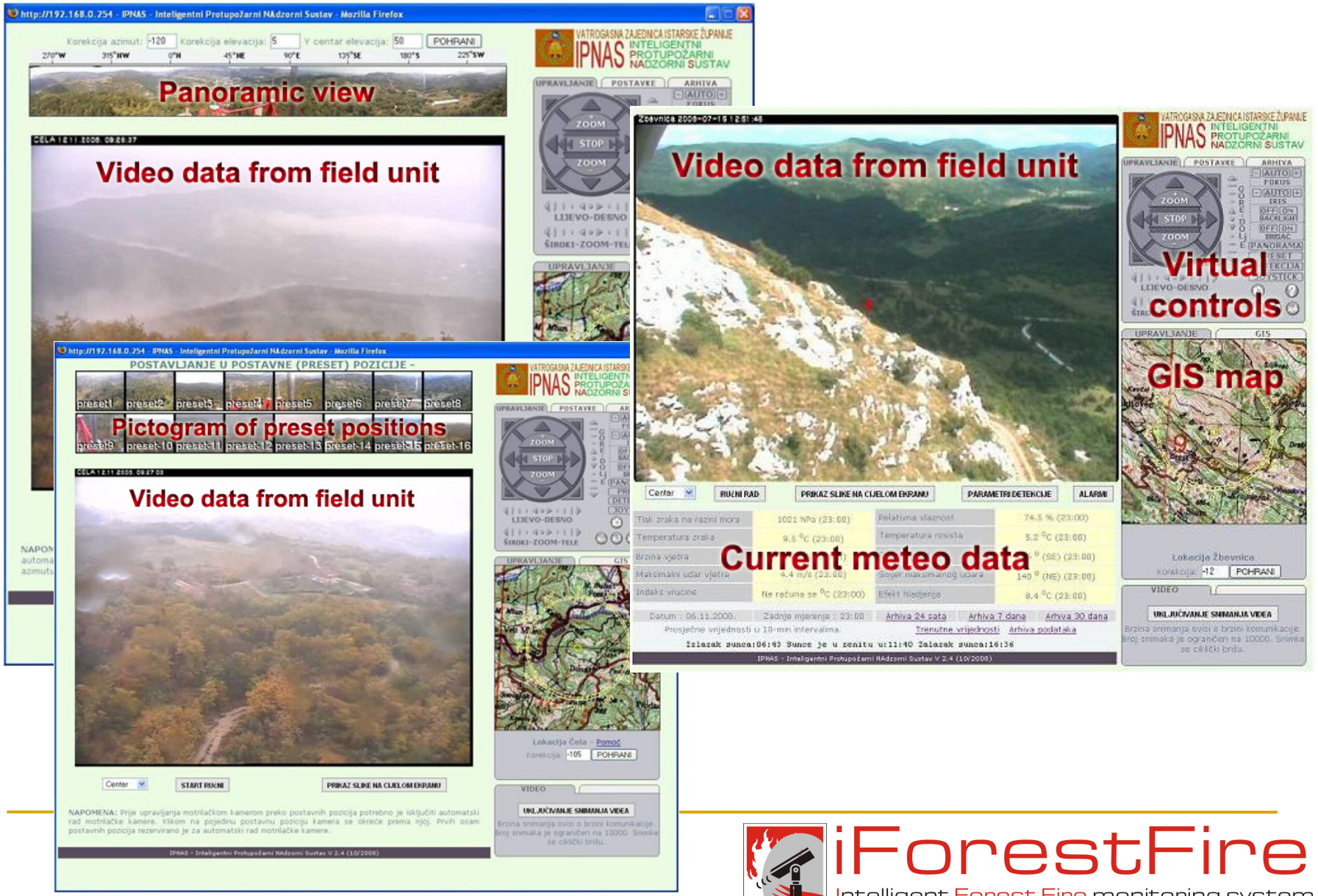
5. Intelligent technologies and data fusion of image analyses results, meteorological data and simulation results are used for fire detection and false alarm reduction.

iForestFire – INTELLIGENT TECHNOLOGIES & DATA FUSION



6. Advanced user-friendly, geo-referenced and collaborative manual camera control is used for virtual video presence.

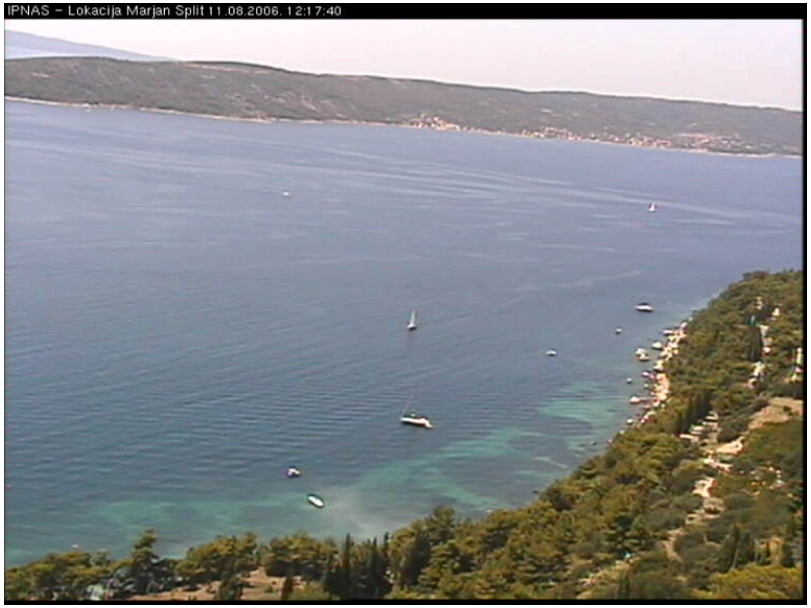
iForestFire - ADVANCED MANUAL CAMERA CONTROL



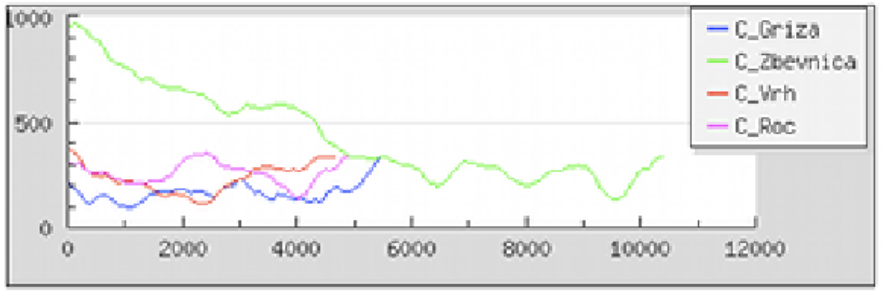
iForestFire
Intelligent Forest Fire monitoring system

iForestFire - MANUAL MODE – virtal video presence

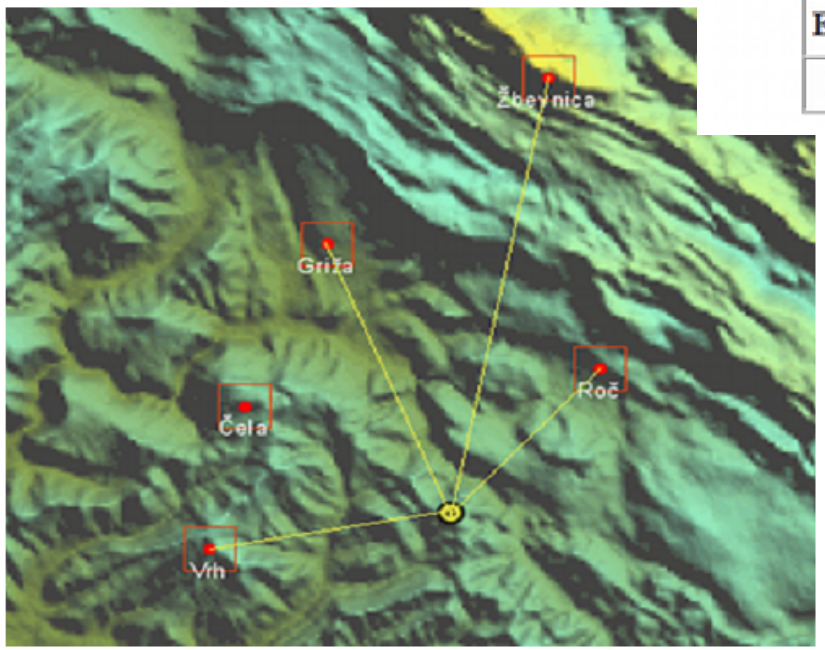
iForestFire - MANUAL MODE – virtal video presence

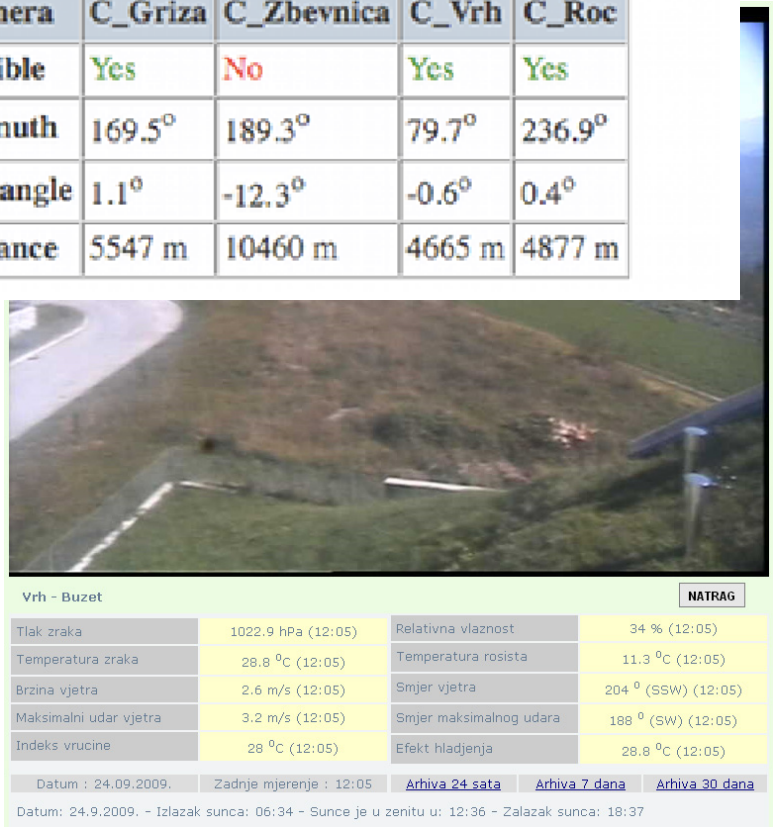


iForestFire – MULTIPLE CAMERA CONTROL (GIS integration)



Camera	C_Griza	C_Zbevnica	C_Vrh	C_Roc
Visible	Yes	No	Yes	Yes
Azimuth	169.5°	189.3°	79.7°	236.9°
Elev. angle	1.1°	-12.3°	-0.6°	0.4°
Distance	5547 m	10460 m	4665 m	4877 m



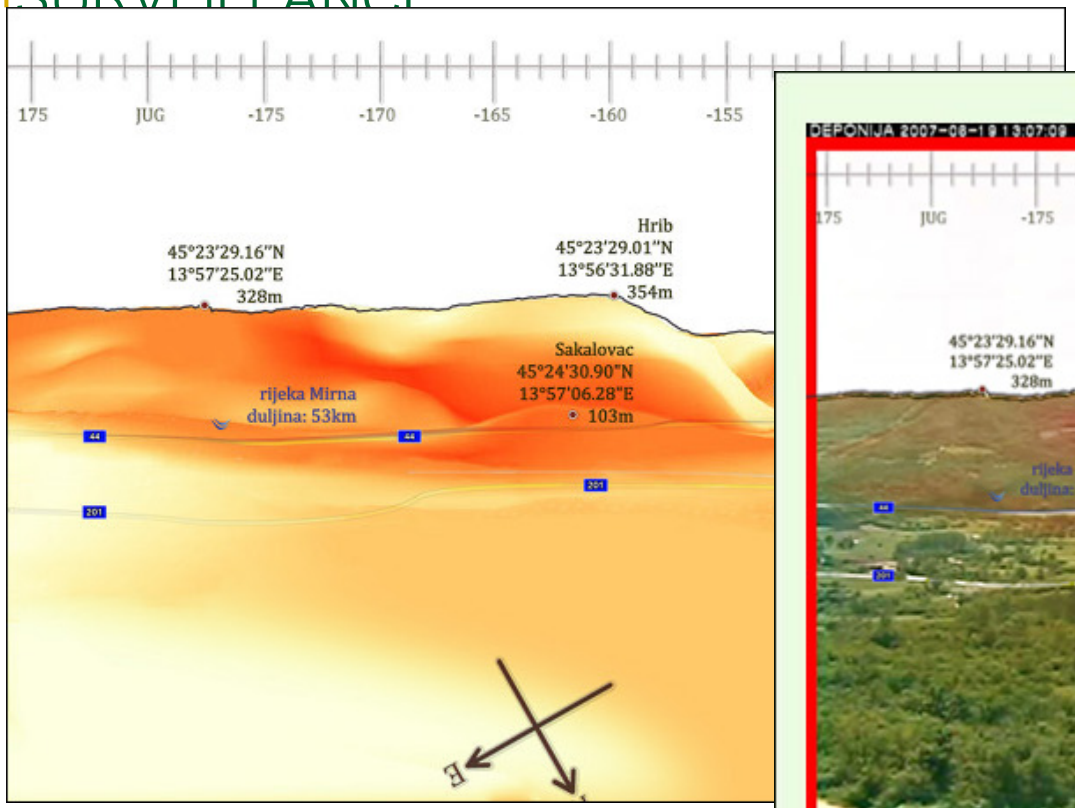


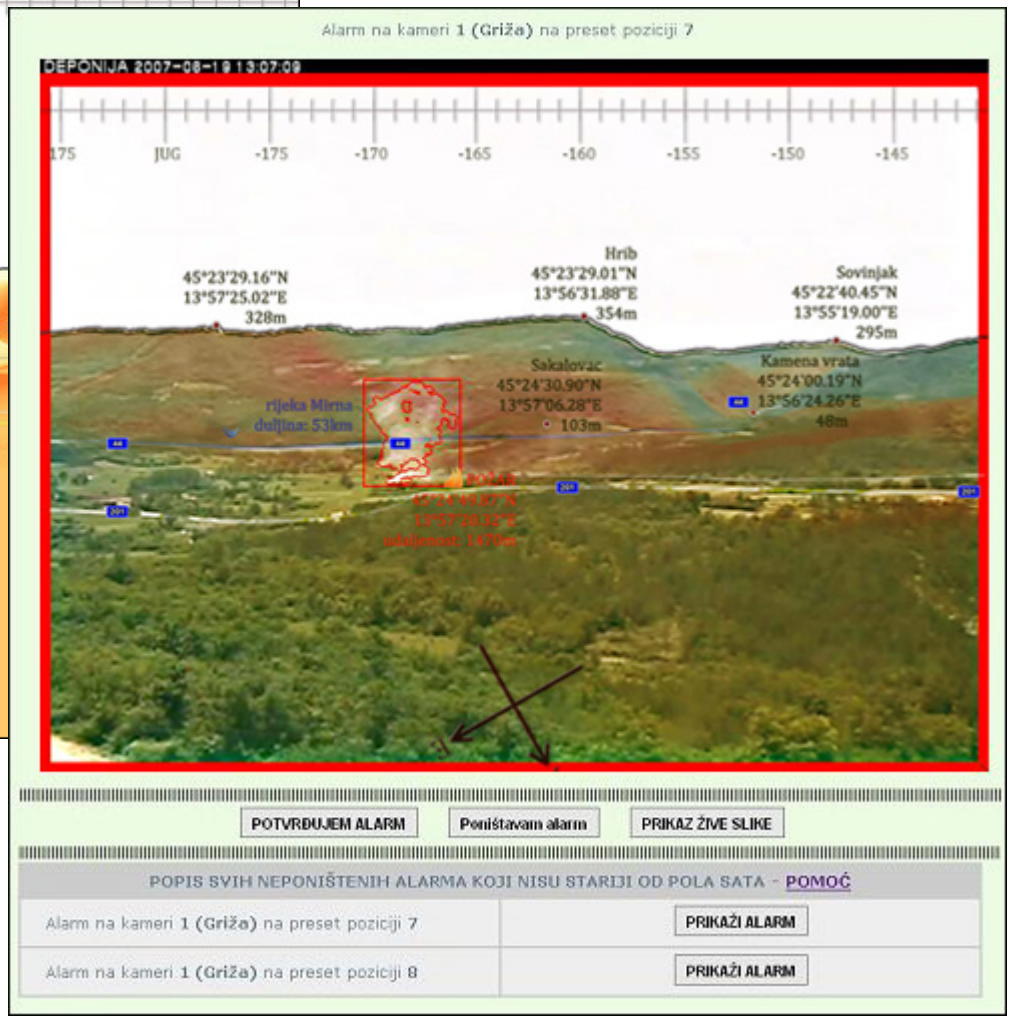
iForestFire
Intelligent Forest Fire monitoring system

iForestFire advanced features

7. Augmented Reality features - real time video content is enhanced by additional information from GIS, data bases and simulations

iForestFire – AUGMENTED REALITY BASED VIDEO SURVEILLANCE





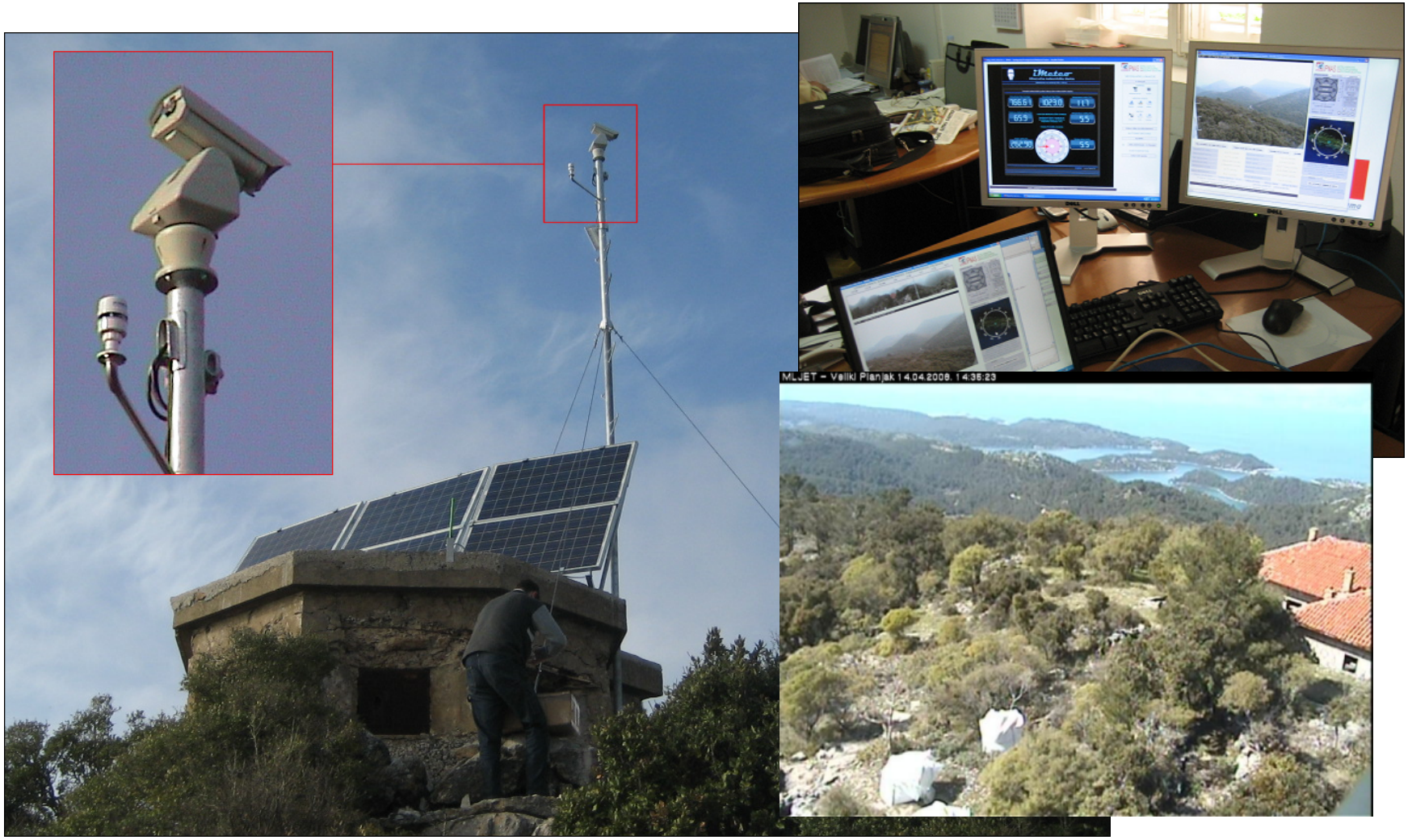
iForestFire
Intelligent Forest Fire monitoring system

iForestFire as a research platform

iForestFire **was and is** a system used both for:

- Scientific research incuding projects,masters and PhD thesis research and paper publishing , but also
- A completely functioning, **commertial system** widely implemented in various Croatian national and Nature parks and Adriatic regions, but also exported to Portugal, Spain, Greece ...

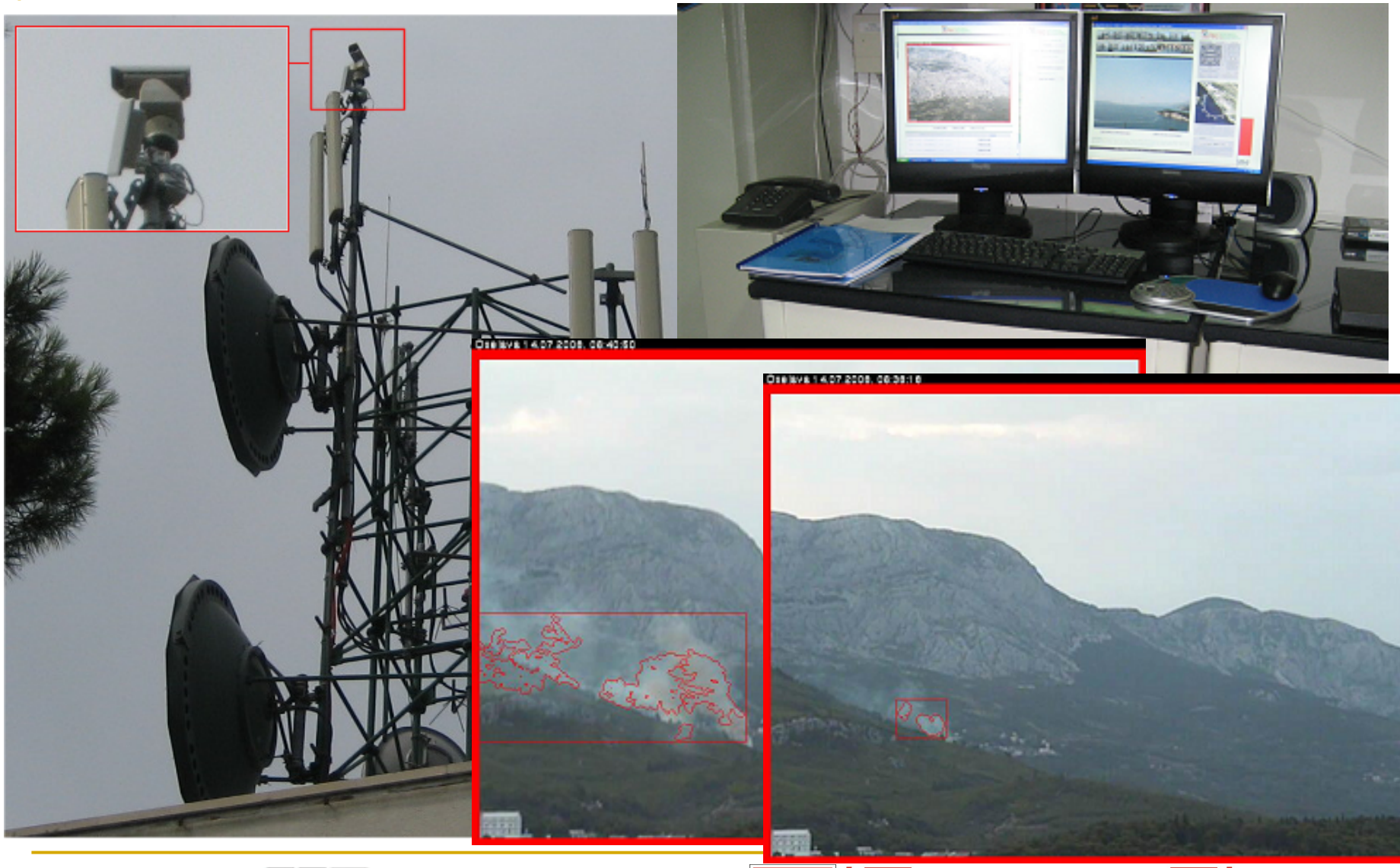
National Park of MLJET - 2008



Lama IT solutions

iForestFire
Intelligent Forest Fire monitoring system

Nature Park of BIOKOVO (Osejava) - 2008



Lama IT solutions

iForestFire
Intelligent Forest Fire monitoring system

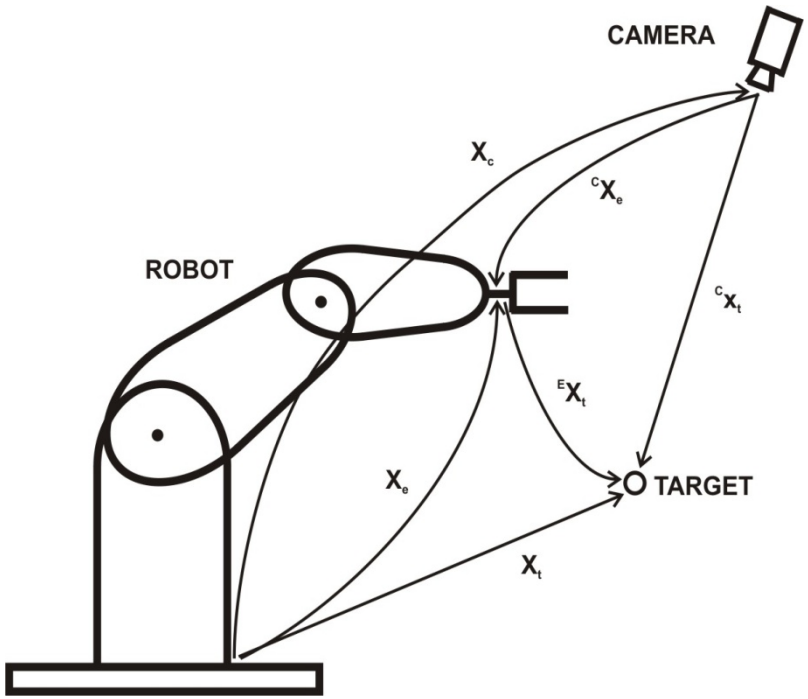
iForestFire as a research platform

In this moment a team consisting of 8 researchers are working on this project:

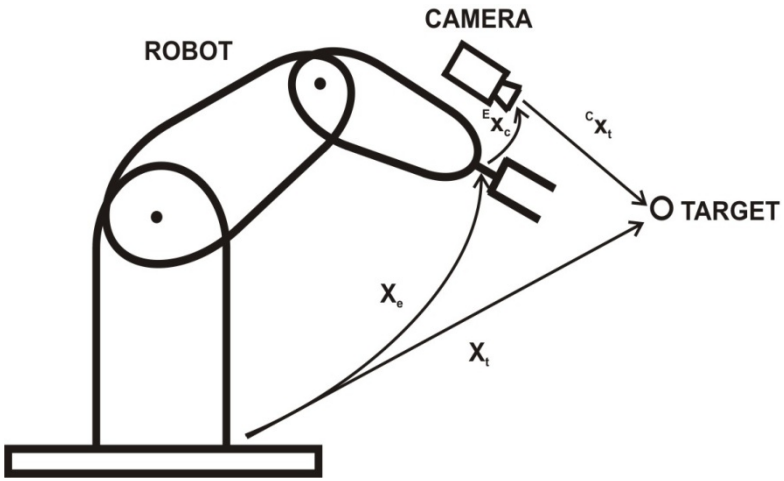
Prof.dr.sc.Darko Stipanicev
Prof.dr.sc.Maja Štula
Doc.dr.sc.damir Krstinić
Doc.dr.sc.Ljiljana Šerić
Dr.sc.Toni Jakovčević
Marin Bugarić, PhD student
Josip Maras, PhD student
Maja Braović, PhD student

Other research topics concerning computer vision and image understanding at FESB

Image based visual servoing



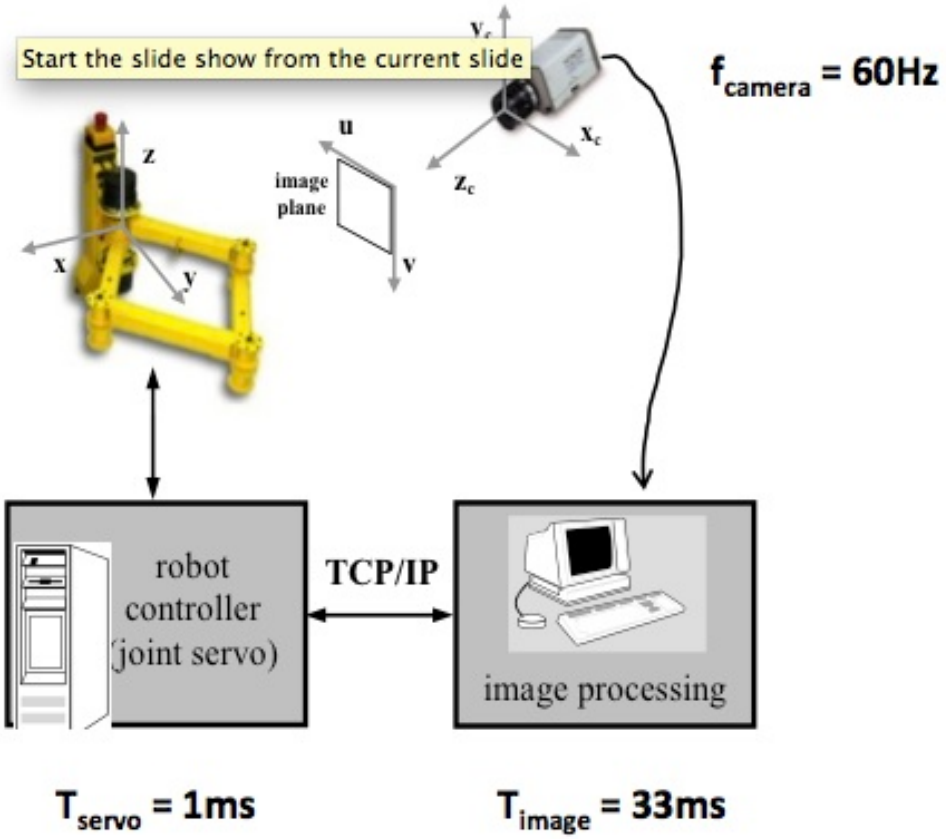
Fixed camera configuration

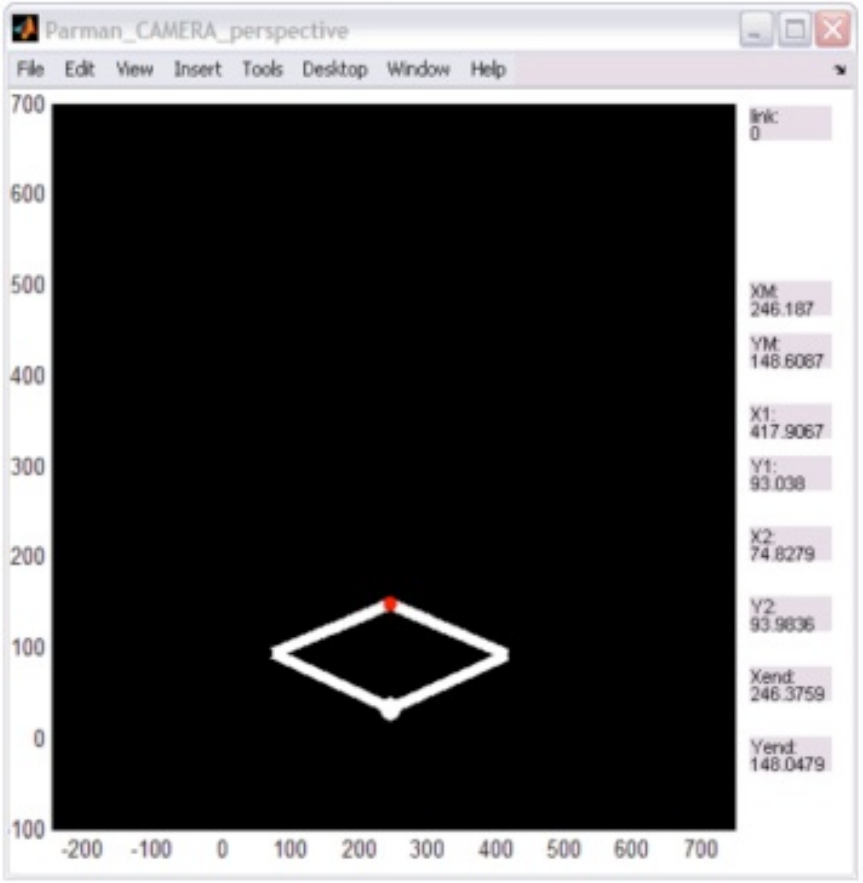


Eye-in-hand configuration

From: Bonković M., Hace A.,Jezernik K., Population based visual servoing, *IEEE/ASME Transaction on Mechatronics*. Vol. **13** (2008)

Image based visual servoing





The main researcher in this field is **Prof.dr.sc.Mirjana Bonković** in cooperation with University of Maribor.

Image super-resolution

Super-resolution and **de-mosaicing** in one process **(SRD).**

The main researchers in this field are **Prof.Mirjana Bonković and Barbara Barišić, PhD student** in cooperation with University of Oxford.

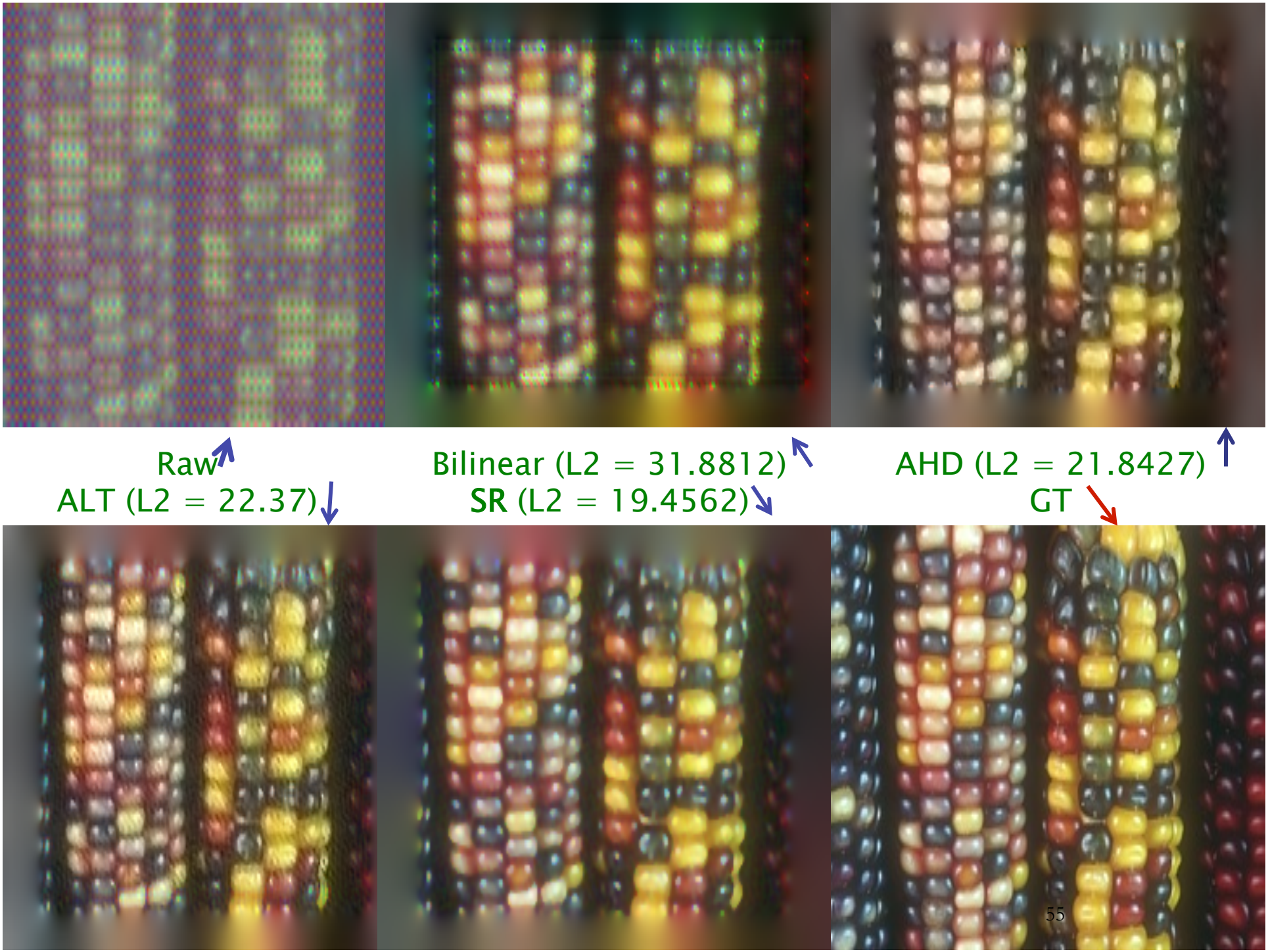
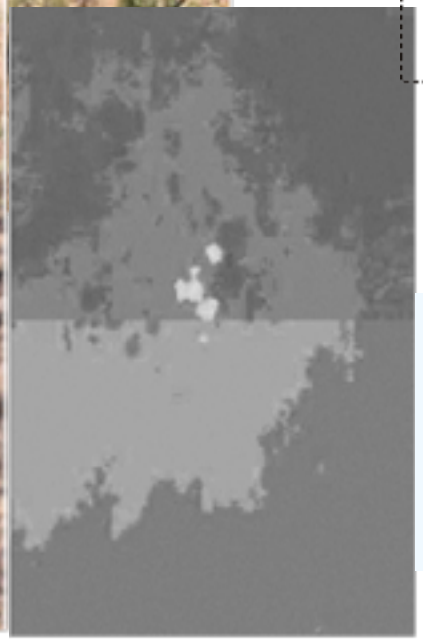
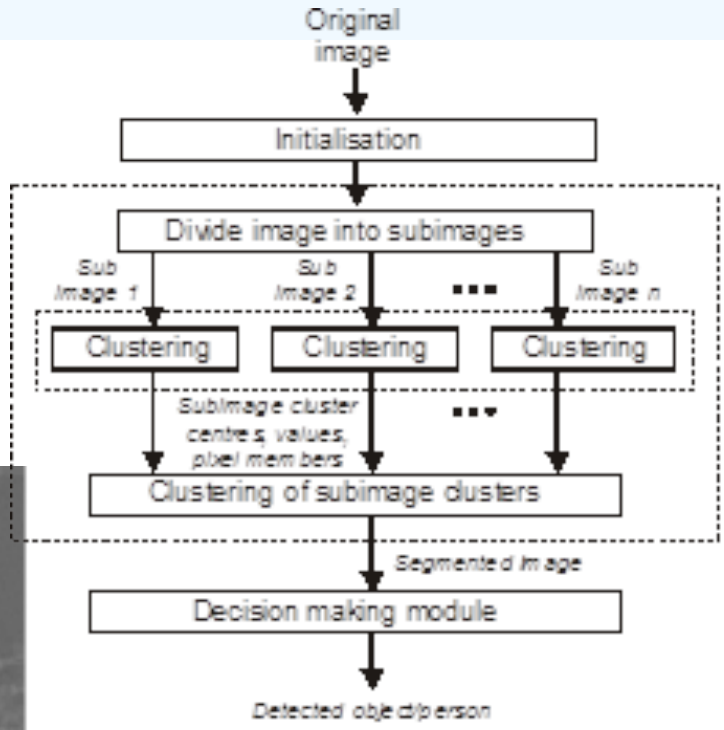

Raw
Bilinear (L2 = 31.8812)
AHD (L2 = 21.8427)
ALT (L2 = 22.37)
SR (L2 = 19.4562)
GT

Image processing for surveillance:

- artificial and natural objects detection and classification
- Fast analysis of areal images (human surveillance)
- Parallel processing on GPU



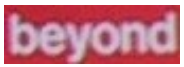


Researchers:

- Prof.dr.sc. Vladan Papić
- Prof.dr.sc. Hrvoje Dujmić
- Hrvoje Turić, PhD student

Text extraction and OCR

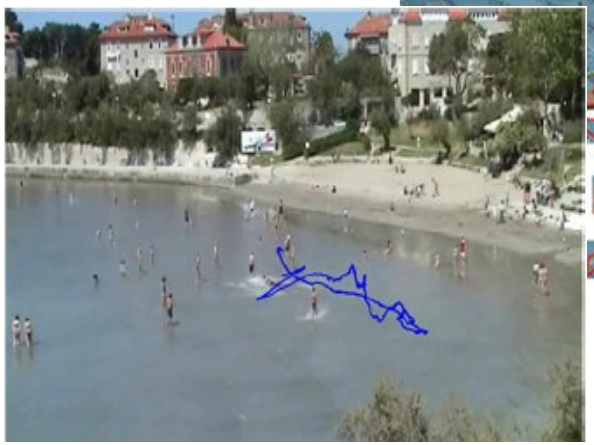
- Text extraction and image segmentation
- Virtual video magnifier



Researchers:
Prof.dr.sc. Hrvoje Dujmić
Dr.sc. Matko Šarić

Vision based sport analysis

- Feature detection
- Tracking algorithms



Researchers:
Prof.dr.sc. Vladan Papić
Vladimir Pleština, PhD student

Detection of natural phenomena on stereo images

- Smoke distance is a very important factor in the detection process
- Using stereo vision to enhance detection accuracy
- Building a stereo rig with variable baseline length and based on open source software

Future work: Stereo wildfire detection

Possible **enhancements**:

- Improved motion detection (regulating sensitivity)
- More accurate dynamics analysis
- More accurate location information for appropriate intervention
- Better texture and energy analysis

Possible **problems**:

- Depth resolution dependent on baseline length
- Distortion
- Repetitive patterns

Researchers:
- Dr.sc. Toni Jakovčević
- Prof.dr.sc. Darko Stipaničev
- Marin Bugarić, PhD student