First Croatian Computer Vision Workshop

September 20-21, 2012, Zagreb, Croatia

Abstract Book

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First Croatian Computer Vision Workshop

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September 20-21, 2012, Zagreb, Croatia

organized by:
Center of Excellence for Computer Vision,
University of Zagreb

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Dear Colleagues,

On behalf of the Organizing Committee it is my pleasure to welcome you to Zagreb for the First Croatian Computer Vision Workshop. The objective of the workshop is to bring together professionals from academia and industry in the area of computer vision theory and applications in Croatia in order to foster research and encourage academia-industry collaboration in this dynamic field. The Workshop program includes invited lectures by twelve distinguished international researchers presenting state-of-the-art in computer vision research. Furthermore, the program includes invited lectures by researchers from three major Croatian universities in Split, Rijeka, and Osijek, and from Ruđer Bošković Institute in Zagreb. The members of the Center of Excellence for Computer Vision at the University of Zagreb will present overviews of their research activities. An important feature of the program are poster presentations that will be on display during the whole duration of the workshop. Company representatives will also participate and provide perspective on needs and activities of the industry.

The Workshop is organized by the Center of Excellence for Computer Vision, which is located at the Faculty of Electrical Engineering and Computing (FEEC), University of Zagreb. The Center joins eight research laboratories at FEEC and research laboratories from six units of the University of Zagreb: Faculty of Forestry, Faculty of Geodesy, Faculty of Graphic Arts, Faculty of Kinesiology, Faculty of Mechanical Engineering and Naval Architecture, and Faculty of Transport and Traffic Sciences. I would like to use this opportunity to express our gratitude to the University of Zagreb Development Fund for providing financial support for establishment of the Center and for organization of the Workshop.

I wish you all a pleasant and successful participation in the First Croatian Computer Vision Workshop.

With my best wishes,

Sven Lončarić
General Chair

Thursday, September 20, 2012

15:00… …15:40	**Invited lecture: Sampling, Sparsity, and Inverse Problems** Martin Vetterli, Ecole Polytechnique Fédérale de Lausanne, Switzerland	page 2
15:40… …16:00	**Coffee break, Poster session**	
16:00… …16:30	**Invited lecture: The Coverage Model -- Towards high precision image analysis** Nataša Sladoje, University of Novi Sad, Serbia	page 3
16:30… …17:00	**Invited lecture: Coverage Segmentation by Energy minimization -- A practical example of sub-pixel image processing** Joakim Lindblad, University of Novi Sad, Serbia and Uppsala University, Sweden	page 3
17:00… …17:30	**Invited lecture: One-shot absolute pattern for dense reconstruction using Structured Light** Sergio Fernandez, University of Glasgow, UK	page 4

Friday, September 21, 2012

9:00… …9:30	**Invited lecture: FESB Research Activities related to digital image processing and analysis** Darko Stipaničev, University of Split, Croatia	page 4
9:30… …10:00	**Invited lecture: Fast processing of data in imaging metods based on relaxation processes** Željko Jeričević, University of Rijeka, Croatia	page 5
10:00… …10:30	**Invited lecture: Sparse component analysis: sparse coding, inpainting, denoising, segmentation and feature extraction** Ivica Kopriva, Institute Rudjer Boskovic, Zagreb, Croatia	page 5
10:30… …11:00	**Coffee break, Poster session**	
11:00… …11:30	**Invited lecture: Vision-based and optical measurement at EMT, TU Graz** Axel Pinz, TU Graz, Austria	page 6
11:30… …12:00	**Invited lecture: Geometric Modeling and Characterization of the Circle of Willis** Hrvoje Bogunović, Pompeu Fabra University, Barcelona, Spain	page 6

12:00… …12:30	**Center for Computer Vision activities: Lossless Image Compression Based on Contextual Adaptation of Predictor Blends** Josip Knezović, University of Zagreb	page 11
12:30… …13:30	**Lunch, Poster session**	
13:30… …14:00	**Center for Computer Vision activities: Computer vision for stereo imaging and visual quality inspection** Tomislav Pribanić, Tomislav Petković, University of Zagreb,	Page 11
14:00… …14:30	**Invited lecture: Overhead camera feedback control of multiple terrestrial vehicles in a suburban environment** Max Blanco, CNRS, Institut Pascal, Aubiere, France	page 7
14:30… …15:00	**Invited lecture: Computer vision research at Faculty of Electrical Engineering Osijek** Ivan Aleksi, Robert Cupec, Damir Filko, Irena Galić, Željko Hocenski, Tomislav Keser, Tomislav Matić, Emmanuel Karlo Nyarko, University of Osijek, Croatia	page 7
15:00… …15:30	**Coffee break, Poster session**	
15:30… …16:00	**Invited lecture: Real-Time Facial Landmark Localization using Advanced Correlation Filters** Vitomir Štruc, University of Ljubljana, Slovenia	page 8
16:00… …16:30	**Center for Computer Vision activities: The advanced multisensor system for the airborne reconnaissance and surveillance in emergency situations and the environment protection** Dubravko Gajski, Renata Pernar, University of Zagreb	page 12
16:30… …16:40	**Closing session**	

Poster Session September 20-21, 2012

Ten Years of Computer Vision Research in Machine Vision Lab at the UL FE

Stanislav Kovačič, University of Ljubljana, Slovenia

During the last ten years the computer vision activities in the Machine vision laboratory at the Faculty of Electrical Engineering University of Ljubljana have been largely influenced by the advancement and accessibility of video and computer technologies, national funding programs and international opportunities, research trends, and sporadic user needs. In other words, our interests gradually drifted from analyzing a single image to video analysis, from using one camera to engaging many cameras, from centralized vision to embedded distributed vision. In this talk we give a brief overview of our research and development in (a) visual tracking and motion analysis with the emphasis on sport environments, (b) multi-camera person detection and localization, (c) embedded vision sensors, and (d) selected applications.

Skeletonization in 3D via thinning and its applications

Kalman Palagyi, University of Szeged, Hungary

Skeletons are frequently used region-based shape features which summarize the general form of objects. Skeleton-like shape descriptors in 3D (i.e., centerlines, medial surfaces, and topological kernels) play important role in various applications in image processing, pattern recognition, and visualization. I shall overview the major skeletonization techniques (i.e, distance-based, Voronoi-based, and thinning as an iterative object reduction). Then various sequential and parallel thinning algorithms will be presented. Finally some medical applications will be briefly outlined.

Human action recognition: The challenges and recent progress

Ivan Laptev, INRIA, France

Automatic recognition of human actions is a quickly growing research area urged by demands from emerging industries in video indexing, automatic video surveillance, human-computer interaction and other fields. Most applications require action recognition to operate reliably in diverse and realistic video settings. While significant progress towards this goal has been achieved during the last decade, the problem remains highly challenging. This talk will give an overview of the state of the art in action recognition. I will first discuss the problem definition and will argue that action recognition must be addressed within a joint framework together with object recognition and scene understanding. I will then focus on the recent successful methods enabling action recognition in realistic video settings. In

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particular, I will discuss the new statistical and structural models of actions and the learning issues associated with the training of such models from real data. I will conclude by discussing open questions and promising future research directions.

Perceived Quality of a Medical Image: Evaluation and Improvement

Gianni Ramponi, University of Trieste, Italy

A doctor examining a medical image for diagnostic purposes, e.g. in the context of a screening procedure, should be enabled to gather in the shortest possible time the maximum amount of information, about both the general structure and the details of the image. For this purpose, methods are being devised to evaluate and improve the visual quality of the displayed image. Such methods should take into account some general properties of the human visual system (photoreceptor response, optical glare, etc.), and if possible also the specific characteristics of the observer. It should also be noticed that the environment in which an image is observed in a real clinical setting is often far from its theoretical specifications (e.g., strength and position of other light sources); a modern display should be able to sense the actual ambient conditions and suitably tune its output. Recent results and work in progress in this field at the Image Processing Laboratory of the University of Trieste will be presented.

Sampling, Sparsity, and Inverse Problems

Martin Vetterli, Ecole Polytechnique Fédérale de Lausanne, Switzerland

Sampling is a central topic in signal processing, communications, and in all fields where the world is analog and computation is digital. The question is simple: When does a countable set of measurements allow a perfect and stable representation of a class of signals? This allows the reconstruction of the analog world, or interpolation. A related problem is when these measurements allow to solve inverse problems accurately, like source localization. Classic results concern bandlimited functions and shift-invariant subspaces, and use linear approximation. Recently, non-linear methods have appeared, based on parametric methods and/or convex relaxation, which allow a broader class of sampling results. We review sampling of finite rate of innovation (FRI) signals, which are non-bandlimited continuous-time signals with a finite parametric representation. This leads to sharp results on sampling and reconstruction of such sparse continuous-time signals. We then explore performance bounds on retrieving sparse continuous-time signals buried in noise. While this is a classic estimation problem, we show sharper lower bounds for simple cases, indicating (i) there is a phase transition and (ii) current algorithms are close to the bounds. This leads to notions of resolution or

resolvability. We then turn our attention to sampling problems where physics plays a central role. After all, many sensed signals are the solution of some PDE. In these cases, continuous-time or continuous-space modeling can be advantageous, be it to reduce the number of sensors and/or the sampling rate. First, we consider the wave equation, and review the fact that wave fields are essentially bandlimited in space-time domain. This can be used for critical sampling of acquisition or rendering of wave fields. We also show an acoustic source localization problem, where wideband frequency probing and finite element modeling show interesting localization power. Then, in a diffusion equation scenario, source localization using a sensor network can be addressed with a parametric approach, indicating trade-offs between spatial and temporal sampling densities. This can be used in air pollution monitoring and temperature sensing. In all these problems, the computational tools like FRI or CS come in handy when the modeling and the conditioning is adequate. Last but not least, the proof of the pudding is in experiments and/or real data sets.

The Coverage Model -- Towards high precision image analysis

Nataša Sladoje, University of Novi Sad, Serbia

Digital image analysis is the extraction of quantitative and qualitative information from digital images. However, when the aim is to acquire information about imaged objects, the digital image provides at most a sampled and quantized representation. In combination with image noise and other artefacts, even seemingly simple measures provide hard challenges. The coverage model provides a framework for representing continuous objects present in digital images as spatial fuzzy subsets. We present the basic definitions and properties of this model and show how it can be used to improve information extraction from digital images and to reduce problems originating from limited spatial resolution. We present methods for estimating several geometric features of a shape from coverage representations and derive the corresponding maximal estimation errors as functions of sampling density and number of quantization levels. Compared to a classic binary approach the coverage model provides greatly increased precision.

Coverage Segmentation by Energy minimization -- A practical example of sub-pixel image processing

Joakim Lindblad, University of Novi Sad, Serbia and Uppsala University, Sweden

We present one method for coverage segmentation, where the coverage percentage of each image element by each of the image components is estimated. The method enhances a model for linear unmixing of image intensities by incorporating criteria for regulating spatial smoothness and for imposing a theoretically plausible result.

The segmentation task is formulated as an optimization problem and is solved by the Spectral Projected Gradient method. Excellent performance of the method in noisy conditions is demonstrated, with a particular emphasis on its combination with feature estimation methods utilizing the coverage information to provide high precision results. The generality of the model, combined with the flexible energy minimization approach, facilitates further extensions; we demonstrate the option of super-resolution segmentation as well as processing of blurred signals.

One-shot absolute pattern for dense reconstruction using Structured Light

Sergio Fernandez, University of Glasgow, UK

Shape reconstruction using coded structured light (SL) is considered one of the most reliable techniques to recover object surfaces. Having a calibrated projector-camera pair, a light pattern is projected onto the scene and imaged by the camera. Correspondences between projected and recovered patterns are found and used to extract 3D surface information. Among SL techniques, the combination of dense acquisition and real time constitutes an active field of research. To achieve density and real-time, many of the works present in the literature are based on the projection of a single one-shot fringe pattern, where depth is extracted analysing phase deviation of the imaged pattern. However, the algorithms employed to unwrap the phase are computationally slow and can fail in the presence of depth discontinuities and occlusions. In this work, a proposal for a new one-shot dense pattern is presented. The technique combines DeBruijn coding and fringe pattern projection using adaptive Windowed Fourier Transform (WFT) to obtain an absolute and computationally fast 3D reconstruction. The experimental results show that the proposed method obtains accuracy levels comparable to DeBruijn algorithm.

FESB Research Activities related to digital image processing and analysis

Darko Stipaničev, University of Split, Croatia

Research related to digital image processing and analysis has a long history at Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture (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 has been started. Since that time, research concerning digital image processing and analysis and its application in various advanced and intelligent systems was and is the main research topic in two FESB departments – Department for Modelling and Intelligent Systems and Department of Automatic Control and Systems. A short

review of our past and present research related to digital image processing and analysis will be given with particular emphasize on our recent research. Visual based natural risk observers will be described and explained, particularly because they are not only our main scientific research topic, but also a successful commercial product widely used in Croatian National and Nature Parks and Regions. Recent and future research activities, particularly related to their vision parts will be presented and discussed.

Fast processing of data in imaging metods based on relaxation processes

Željko Jeričević, University of Rijeka, Croatia

Imaging methods of fluorescence and nuclear magnetic resonance (MRI) are based on characterization of relaxation processes from excited state. Typical signal coming from such processes is sum of exponential functions. This type of signal is also characteristic for decay of mixture of radio-nuclides, parallel chemical reactions, pharmacological modeling, etc. Inverse problem of finding the components with close decay constants in multi-exponential signal is inherently ill-posed because of non-orthogonality of exponential functions. The result is very sensitive to noise and chosen optimization methodology. The general solution for the problem of separating exponentials based on linear approximation through repeated numerical integration has been developed. The algorithm does not require any intervention from user. Algorithm is based on the least squares method with the possibility of using non-negative constrains. Using linear approximation avoids problem with supplying a good initial guess, nonproductive iterations, and local minima. Algorithm also includes implementation of global method by Knutson. The advantages of algorithm are especially impressive in imaging methods like MRI and FLIM

Sparse component analysis: sparse coding, inpainting, denoising, segmentation and feature extraction

Ivica Kopriva, Institute Rudjer Boskovic, Zagreb, Croatia

Algorithms of sparse component analysis (SCA) aim to solve linear instantaneous underdetermined blind source separation (uBSS) problem, whereas solution is enabled by presumed sparseness of latent variables (a.k.a. sources). It will be pointed out how solutions of seemingly different inverse problems are reduced to sparsity regularized linear uBSS problem that is solved by probabilistic and deterministic algorithms of, respectively, independent component analysis (ICA) and SCA. In particular, probabilistic ICA approach to sparse coding (dictionary learning) will be presented. Learned dictionary in combination with $\ell\ 0< p \leq 1$ -norm minimization will be used in image inpainting and denoising of high density

salt and pepper noise. Clustering and ℓ $0< p \leq 1$ -norm minimization, yielding deterministic SCA algorithms, will be demonstrated in unsupervised decomposition (segmentation) of multichannel (multispectral image).

Vision-based and optical measurement at EMT, TU Graz

Axel Pinz, TU Graz, Austria

There has been a long tradition of two schools in Computer Vision research, one advocating 3D reconstruction, the other one 2D or 3D recognition to understand and represent what is going on where (the Marr paradigm for the interpretation of single 2D images) and when (its more recent extension to image sequence analysis) in a scene. In my research, I have been advocating the need for a confluence of these two schools, and indeed, in recent years we see a progress towards merging of vision-based reconstruction, recognition, and visualization. This process has led to a number of highly interdisciplinary research projects that require vision-based and optical measurement as an enabling technique. The group at EMT, TU Graz, hosts a unique combination of labs and experienced staff to address issues of optics, reconstruction and recognition, ranging from the high-precision nano- and micrometer scale to the qualitative interpretation of dynamic scenes.

Geometric Modeling and Characterization of the Circle of Willis

Hrvoje Bogunović, Pompeu Fabra University, Barcelona, Spain

Cerebrovascular diseases can result in stroke, which is among the leading causes of morbidity and mortality in the developed countries. This motivated a search for the configurations of vasculature that provoke high hemodynamic stress on the vessel wall, which is assumed to be associated with the development of vascular diseases. In this talk we describe the methods that starting from angiographic image enable the geometric analysis of the major cerebral vasculature, in particular the part known as the Circle of Willis (CoW). Special emphasis was put on making methods automated to produce results that are objective (operator-independent) and repeatable to minimize variability propagation to later analysis. We start with a vascular segmentation method which is robust to segmenting images coming from different imaging modalities and clinical centers and we provide exhaustive segmentation validation. Once the vasculature is successfully segmented, we present a methodology to extensively characterize the geometry of the internal carotid artery (ICA). This includes the development of a method to automatically identify the ICA from the segmented vascular tree. Finally, this automatic identification is generalized to a collection of vessels including their connectivity and topological relationships to obtain a method for anatomical labeling of the vascular segments forming the entire CoW.

Overhead camera feedback control of multiple terrestrial vehicles in a suburban environment

Max Blanco, CNRS, Institut Pascal, Aubiere, France

An autonomous helicopter has been projected to be the locus of supervisory control for a multi-agent terrestrial vehicle system for purposes such as the Fukushima clean-up. The supervision here has been branded 'Omniscient Observer' and is based on a 'perch and stare' computer Graphics Visual Feedback Regulation (GROOFV). This talk will break down some of the more important algorithms employed in the present GROOFV system, and document the suburban field test environment at the Institut Pascal in Clermont-Ferrand, as well as the apparatus needed to implement the prototype GROOFV system. Future work plans will be discussed to miniaturise the GROOFV system into a European smart camera that is to be transported at Fukushima by a Korean 125kcc helicopter in order to regulate the actions of surface decontamination or rescue intervention robots.

Computer vision research at Faculty of Electrical Engineering Osijek

Ivan Aleksi, Robert Cupec, Damir Filko, Irena Galić, Željko Hocenski, Tomislav Keser, Tomislav Matić, Emmanuel Karlo Nyarko, University of Osijek, Croatia

In this talk, an overview of the research in the field of computer vision conducted at the Faculty of Electrical Engineering, J. J. Strossmayer University of Osijek is given. The presentation briefly presents the research of 3 teams. 1.) The team of Prof. Željko Hocenski develops machine vision systems for quality control, inspection and classification in ceramic tile production. This includes visual inspection of ceramic tile integrity in chromatic tile abnormality, edge and corner defects, cracks and scratches, dot shaped and blob defects, glazing defects and printed texture anomaly. The developed system consists of one or more digital cameras and several computer algorithms for image processing, failure detection and product classification. Another research conducted by the same team is in the field of automated submarine ship inspection based on 3D sonar system. The system uses graphic processors in order to achieve real-time 3D reconstruction of underwater objects. 2.) The team of Prof. Robert Cupec develops a mobile robot navigation system based on the data provided by a Microsoft Kinect 3D camera. The robot localization is achieved by registration of sets of 3D planar surface patches. The surfaces are extracted from the 3D point cloud obtained by the 3D camera and matched to the model surfaces. As a byproduct of this research two algorithms for image segmentation are developed. 3.) Doc. dr. sc. Irena Galić develops a framework for image compression called EEDC that relies on an adaptive sparsification of the image data using triangulation from B-tree triangular

coding (BTTC) and makes use of the interpolation qualities of edge-enhancing diffusion (EED). BTTC is adaptive triangulation method for removing less significant pixels from the image. The remaining points serve as scattered interpolation data for diffusion process. EEDC on high compression ratios can come close to or even be better than present compression standard # JPEG2000.

Real-Time Facial Landmark Localization using Advanced Correlation Filters

Vitomir Štruc, University of Ljubljana, Slovenia

The alignment of the facial region with a predefined canonical form is one of the most crucial steps in a face recognition system. Most of the existing alignment techniques rely on the position of the eyes and, hence, require an efficient and reliable eye localization procedure. In the lecture we introduce a novel technique for this purpose, which exploits a new class of correlation filters called Prinicpal directions of Synthetic Exact Filters (PSEFs). The proposed filters exhibit desirable properties, such as relatively short training times, computational simplicity, high localization rates and real time capabilities. We present the theory of PSEF filter construction, elaborate on their characteristics and finally develop an efficient procedure for facial landmark localization using several PSEF filters. The effectiveness of the developed technique is demonstrated on the task of eye localization using more than 40000 facial images pooled from the FERET and LWF databases. The results of our experiments suggest that the PSEF filters produce significantly better localization results than, for example, the Haar-cascade object detector, while ensuring a more than 10-fold improvement in the processing time.

Computer vision for robotics

Bojan Jerbić, Zdenko Kovačić, Ivan Petrović, University of Zagreb

Recent scientific achievements in cognitive science and robotics enable shaping of different, nondeterministic approaches to automation of production systems. It is expected from such approaches to provide adaptability and high level of intelligence and autonomy enabling the machines to work in unstructured environment, learn and improve and cooperate with other agents including humans. Computer vision is essential element of such systems assumed to sense and understand the environment in an active way. Recently, there have been many attempts to use Microsoft Kinect motion capture sensor for remote and autonomous robot control. A short review of ongoing Kinect-based robot control research in three robotics laboratories at the Univerrsity of Zagreb encompasses human gesture-based control of an industrial robot, velocity-based remote control of industrial, mobile and humanoid robot, and simultaneous localization of mobile robot and mapping (SLAM) by fusion of data acquired from a set of audio-visual sensors.

Computer vision for traffic and transportation

Hrvoje Gold, Zoran Kalafatić, Sven Lončarić, Siniša Šegvić, Marko Subašić, University of Zagreb

Traffic and transportation applications offer many challenges asking for computer vision solutions. We will briefly present some of the activities in the field of transport planning, infrastructure management, road safety assessment and environmental protection. The first of these activities is related to the measurement of traffic flow parameters at road intersections. Number of vehicles and traffic flow distribution extracted from video footage provides input for the origin-destination matrices used in demand/supply modeling. Measurement of traffic-related parameters with computer vision techniques is also one of the goals in our new FP7 project entitled “Intelligent Cooperative Sensing for improved traffic Efficiency”. Another project is dealing with exploitation and maintenance of roadside infrastructure inventory and road safety assessments. Special vehicle equipped with HD cameras, GPS and retroreflectometer is used for that purpose. One of the problems was the detection and recognition of traffic signs, where we combined standard cascaded detectors with bootstrap filtering and differential tracking to improve detection precision and localization accuracy, which in turn resulted with high recognition rates. We also reached some results in lane detection and recognition as well as in stereo structure and motion estimation. A closely related project considered detection and recognition of vegetation alongside railroad tracks as a support for railroad maintenance. Finally, we will show some results in developing a surround view parking assistance system utilizing four video cameras mounted on the vehicle.

Computer vision for biomedicine

Mislav Grgić, Sven Lončarić, Vladimir Medved, University of Zagreb

Research group related to medical imaging at the Video Communications Laboratory of the University of Zagreb, Faculty of Electrical Engineering and Computing works on the research project "Intelligent Image Features Extraction in Knowledge Discovery Systems". As a part of the project mammographic images are analyzed and computer-aided detection of breast cancer is performed. The research has been focused on the mammogram segmentation using adaptive contrast enhancement and detection of microcalcifications as well as on bilateral mammogram registration and temporal analysis of lesions in digital mammograms. Image Processing Group at the Faculty of Electrical Engineering and Computing has conducted several projects in the area of medical imaging and medical image analysis. The projects include segmentation of intracerebral brain hemorrhage from CT images, a technique for segmentation of abdominal aortic aneurysm from CT images, a virtual bronchoscopy method, a procedure for segmentation and registration of aortic blood velocity profiles obtained by ultrasound Doppler imaging, methods for analysis of functional X-ray angiography images, and real-time tracking of guidewire for intravascular procedures using C-arm X-ray imaging. The field of kinesiological biomechanics is concerned with studying various kinds of human movements, and movement patterns, using biomechanical methodology. This implies measurement of kinematics of movement in a semi-automatic manner, i.e. by motion capture. Following projects have been realized: „Creating center of excellence for locomotion study“, „Automated motion capture and expert evaluation in the study of locomotion“ (Croatian), and “Computer aided neuro-muscular biomechanical analysis and diagnostics of complex movements” (bilateral Croatia-Austria).

An overview of the research activity of the Pattern Recognition & Biometric Research Group at the Faculty of EE and Computing

Slobodan Ribarić, University of Zagreb

An overview of activities of the Pattern Recognition & Biometric Research Group at the Department of Electronics, Microelectronics, Computer and Intelligent Systems, Faculty of EE and Computing is given. Examples of palmprint-based recognition systems, hand-aliveness detection system, biometric systems based on fusion of hand features, and biometric system based on fusion of palmprint and face features are described. A new COST project proposal “De-identification for privacy protection in multimedia content” is described in short.

Lossless Image Compression Based on Contextual Adaptation of Predictor Blends

Josip Knezović, University of Zagreb

Lossless compression of visual data is required in applications such as medical imaging, image archival, remote and satellite imaging etc. We present a new adaptive predictive image coding method based on the blending of multiple static predictors on a dynamically classified causal context of neighboring pixels. The idea of predictor blends is further expanded through the determination of blending context that changes its shape on a pixel--by--pixel basis using simple classification technique, thus allowing the modeling more complex image structures such as nontrivially oriented edges, the periodicity and coarseness of textures. Typical natural images are characterized as being composed of image regions with different local properties. The predictor estimates those properties around the currently unknown pixel and adjusts itself so that the presence of detected properties affect the way the final prediction is made. Predictive part is followed by a heuristic contextual model and statistical encoder.

Computer vision for stereo imaging and visual quality inspection

Tomislav Pribanić, Tomislav Petković, University of Zagreb

3D stereo imaging systems are particularly convenient to perform 3D reconstruction. A special case is when a dense reconstruction is required and a structured light principle is a powerful way to come with 3D dense acquisition. It assumes an upgrade of a passive stereo camera system with an active source of light in order to illuminate the scene. 3D structured light system, using off-the-shelf components, for scanning of the footprint will presented. The system is developed during a recent Proof of concept project, funded by BICRO (The Business Innovation Center of Croatia). Activities in the field of visual quality inspection include development of highly specific inspection systems that are not commercially available. Two developed systems will be presented: first is a custom made system for visual fault detection to prevent significant damage to the assembly line, second is a inexpensive and flexible software solution consisting of simple measurement tools for visual quality inspection. Both presented systems are currently in operation at the Elektro-kontakt d.d. Zagreb manufacturing plant.

The advanced multisensor system for the airborne reconnaissance and surveillance in emergency situations and the environment protection

Dubravko Gajski, Renata Pernar, University of Zagreb

The advanced multisensor system for the airborne reconnaissance and surveillance in emergency situations and the the environment protection is an integral part of the Advanced Intelligence Decision Support System (AI DSS). The other part (subsystem) is the Decision Support System (DSS) for support and help with making decision in conditions of uncertainty, on the basis of existing and collected data. AI DSS consists of the multisensor system (multi and hyperspectral) for aerial data acquisition of the data and methodology for an application of the AI DSS for assessment of: the mine suspected area in the frame of the humanitarian mine action, the oil pollution of the sea and forest health. The purpose of multispectral and hyperspectral imaging on silver fir damage assessment and mistletoe detection was to develop an efficient and reliable method of mistletoe detection, since mistletoe is one of the important biotic factors that impact the health condition of silver fir. The most important result of the presented method entails the successful detection of mistletoe in hyperspectral images.

Comparison of different platforms for ceramic tiles visual inspection and classification algorithm

Ivan Aleksi, Tomislav Matić, Željko Hocenski, University of Osijek

Automation of the inspection and classification stage in ceramic tiles production includes the development of machine vision systems. It is performed by digital cameras and different image processing algorithms. In this work we presents the development, implementation and performance comparison of the Moving Average with Local Difference (MALD) method for ceramic tile surface defects detection. The execution times of the image processing algorithms need to be shorter due to needs for faster ceramic tile production. The execution time of the MALD algorithm has been implemented to speed up on three different platforms: CPU, GPU and FPGA. For every platform minimum of two algorithms were developed and implemented in MATLAB's MEX/C++, C++, CUDA/C++, VHDL and Assembly programming languages. Execution times are measured and compared for different algorithms and their implementations.

The application of hyperspectral images for detection of mistletoe infected silver fir on large areas

Mario Ančić, Renata Pernar, Milan Bajić, Ante Seletković, Jelena Kolić, University of Zagreb

No systematic research into mistletoe based on remote sensing methods has been conducted in Croatia so far, including mistletoe infestation of the silver fir. Silver fir is one of the most important commercial and ecological species in the Republic of Croatia. Due to its narrow ecological valence and excessive exposure to polluted air, it is seriously endangered despite the advantages of its ecological constitution. As a result, it is currently the most damaged tree species in Croatian forests. Apart from insects as primary pests, as well as fungi, it is increasingly being infested by white mistletoe. The purpose of this research was to develop an efficient and reliable method of mistletoe detection. Surveying was performed in the area of beech-fir forests, using a hyperspectral line scanner ImSpector V9. The most important result of this method entails the successful detection of mistletoe in hpyerspectral images. The results of this research do not differ significantly from the results obtained with standard ground methods. Limitations of standard ground methods further highlight the importance and efficiency of hyperspectral imagery in mistletoe detection. The results of this research allow for the study of the distribution and intensity of mistletoe infestation as one in a series of unfavourable biotic factors for the silver fir. This is the first study that deals with the application of hyperspectral images on mistletoe detection in Croatian forestry. It outlines some of the possibilities of the application both in scientific and operative fields.

Computer Vision contribution to Citizen Security

Milan Bajić, Nikola Pavković, University of Zagreb

HCR Centre for testing, development and training is active partner in the scientific research and the development aimed mainly tothe problems of the citizen security and the protection of the environment. The intensive cooperation was developed with several faculties of the University of Zagreb (Geodesy, Traffic, Forestry, Agronomy), Institute Ruđer Bošković, many international scientific partners and institutions. The selected examples reflect different aspects of the computer vision: Fusion of hyperspectral images and photography; Reflectivity spectra, classification of hyperspectral images; Example #1: dealing with ammunition depots after an explosion; The multisensor airborne acquisition system; Automated detection of a fire or the hot regions in near real time; Estimation of the parameters of the fire from color image; Visualisation of the results to fire fighters commander; Controlled fire for testing; Hot spot detection probability; Interpretation in visible (VIS) and LW thermal IR; Insolation measurements durig the acquisition; Examples from Haiti 2010 (earthquake); Change detection by shadow analysis; Criteria: Johnson, NIIRS, IQM; The changes of NIIRS values as an outcome of the changes of height, velocity, atmosphere.

Image Analysis of Doppler Ultrasound Velocity Profiles

Vedrana Baličević, University of Zagreb

Computer-based diagnosis of cardiac diseases became an important task since the cardiovascular diseases are the leading cause of death worldwide today. Idea of this particular research is to combine the images obtained during clinical measurements (Doppler ultrasound velocity profiles of blood flow through the heart valves) with the mathematical model of blood flow through the human circulatory system, to identify the model parameters which caracterize a particular patient's condition. Mathematical model describes the mechanical behavior of the circulatory system, where each part of the system (chambers, valves, vessels etc.) has to be modeled separately, and then merged into one setup to get the complete mechanical performance. An example of such setup is CircAdapt, a set of differential equations which generate signals of blood flow and pressure in each part of the cardiovascular system. Once the simulation of this setup is done, the obtained parameters need to be altered until the results maximally correspond to the measurements. The goal is to recognize the connection between the model parameters and the diagnosis as well as the identification of the important parameters and their influence on patient's condition.

Laser scanning of small archeological artefacts

Lucija Baričević, University of Zagreb

The detailed describing of surfaces of small archeological artefacts is a very demanding task. It seemed that laser scanning techiques could be appropriate to solve it. But experiences on real artefacts dissapointed many archaelogists, because level of detail obtained by this method was not enough high. This poster presents results reached by a laser scanner dedicated for scanning small objects. Although the scanner reaches the best geometrical accuracy, the interpretability of virtual models produced that way is poor. First of all it is because of very poor radiometric information taken from the artefact. Photos have pretty good interpretability, but it is difficult to obtain geometric information about the artefact by them, as they are in a central projection. Procedures to produce a point cloud of the artefact and textures projected on it are presented. The quality of data obtained that way are discussed.

Anatomical Labeling of Vascular Trees using Maximum A Posteriori Estimation

Hrvoje Bogunović, University of Zagreb

Automated anatomical labeling of the arterial trees is of great interest as it facilitates inter-subject comparison required to discover geometric risk factors for the development of vascular pathologies. In this paper, we present a method for anatomical labeling of vascular trees by detecting the main vessel bifurcations. The method is first trained on a set of pre-labeled examples, where it learns local bifurcation features as well as global variation in the anatomy of the extracted vascular trees. Then the labeling of the target vascular tree is formulated as maximum a posteriori solution where the classifications of individual bifurcations are regularized by the prior learned knowledge of the tree they span. The method is demonstrated on the anterior circulation of the Circle of Willis and was evaluated by cross-validation on 30 subjects, which showed the vascular trees were correctly anatomically labeled in 90% of cases.

Comparison of Lesion Size Using Area and Volume in Full Field Digital Mammograms

Jelena Božek, Michiel Kallenberg, Mislav Grgić, Nico Karssemeijer, University of Zagreb, Radboud University

Size of a lesion is a feature often used in computer-aided detection systems for classification between benign and malignant lesions. However, size of a lesion presented by its area might not be as reliable as volume of a lesion. Volume is more

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independent of the view since it represents 3D information, whereas area refers only to the projection of a lesion on a 2D plane. Furthermore, volume might be better for comparing lesion size in two consecutive exams and for evaluating temporal change to distinguish benign and malignant lesions. We have used volumetric breast density estimation in digital mammograms to obtain thickness of dense tissue in regions of interest in order to compute volume of lesions. The dataset consisted of 382 mammogram pairs in CC and MLO views and 120 mammogram pairs for temporal analysis. The obtained correlation coefficients between the lesion size in the CC and MLO views were 0.70 and 0.83 for area and volume, respectively. The usage of area and volume in temporal analysis of mammograms has been evaluated using ROC analysis. The obtained values of the area under the curve were 0.73 and 0.75 for area and volume, respectively.

Histogram-Based Description of Local Space-Time Appearance

Karla Brkić, Axel Pinz, Siniša Šegvić, Zoran Kalafatić, , University of Zagreb, TU Graz

We introduce a novel local spatio-temporal descriptor intended to model the spatio-temporal behavior of a tracked object of interest in a general manner. The basic idea of the descriptor is the accumulation of histograms of an image function value through time. The histograms are calculated over a regular grid of patches inside the bounding box of the object and normalized to represent empirical probability distributions. The number of grid patches is fixed, so the descriptor is invariant to changes in spatial scale. Depending on the temporal complexity/details at hand, we introduce "first order STA descriptors" that describe the average distribution of a chosen image function over time, and "second order STA descriptors" that model the distribution of each histogram bin over time. We discuss entropy and chi-square as well-suited similarity and saliency measures for our descriptors. Our experimental validation ranges from the patch- to the object-level. Our results show that STA, this simple, yet powerful novel description of local space-time appearance is well-suited to machine learning and will be useful in video analysis, including potential applications of object detection, tracking, and background modeling.

Objective image quality measure based on steerable pyramid wavelet transform and structural similarity index

Emil Dumić, Sonja Grgić, Mislav Grgić, University of Zagreb

Image quality evaluation plays an important role in many image and video processing techniques, such as compression, interpolation and noise reduction where evaluation method is based on image quality estimation. Quality of image can be evaluated using different measures. The best way to do that is by making a

visual experiment under controlled conditions, in which human observers grade image quality. Such experiments are time consuming and costly. Much easier approach is to use some objective measure that evaluates the numerical error between the original image and distorted image. Objective quality measures can be generally divided into three categories: full-reference, reduced-reference and no-reference image quality measures. In this paper we investigate full-reference image quality measures that require knowledge of the original image which is compared with the distorted image. We present a new approach to the full-reference objective image quality evaluation based on Structural Similarity Index (SSIM) and Steerable Pyramid Wavelet Transform (SPWT). New objective image quality measure (IQM2) is compared with twelve commonly used full-reference objective measures using newly developed image quality database VCL@FER and six other image databases. Results show that proposed IQM2 measure provides best weighted average correlation with results of subjective evaluation while keeping computational time lower than other similar performing objective measures.

Inpainting of color images in learned dictionary

Marko Filipović, University of Zagreb

Sparse representation of natural images over redundant dictionary enables solution of the inpainting problem. A major challenge, in this regard, is learning of a dictionary that is well adapted to the image. Efficient methods are developed for grayscale images represented in patch space by using, for example, K-SVD or independent component analysis algorithms. Here, we address the problem of patch space-based dictionary learning for color images. To this end, an image in RGB color space is represented as a collection of vectorized 3D patch tensors. This leads to state-of-the-art results in inpainting random and some structured patterns of missing values as it is demonstrated here.

Calibration field for geometric calibration of digital cameras

Dubravko Gajski, University of Zagreb

Digital cameras are widely used for terrestrial measurements, as well as surveying and other sciences (geology, architecture, civil engineering, archaeology), primary because of their easy accessibility and efficiency on collecting huge amount of data in a short time. Area of applications grows together with growing market of specialised software for photogrammetric measurments by high level of auomatisation, highly adopted to target application. However results of measuring have poor quality, because characteristics of digital cameras are not enough proven and documented. That is why a few years ago an initiative of the Chair of Photogrammetry and RS, and the Institute for photogrammetry Zagreb was started to plan and establish a calibration field for a geometric calibration of digital

cameras. This calibration field was planned and build in the yard of the Institute for photogrammetry Zagreb. That way conditions for investigating and prescribing standards for acquiring of terrestrial photogrammetric data by digital camera and coordination of Croatian regulations with European ones were established. This poster brings a review of the constructed calibration field and its possibilities to examine and calibrate digital photographic cameras.

Parametric geocoding of hyperspectral lines

Katarzyna Dzięgielewska Gajski, University of Zagreb

Hyperspectral line scanners for industrial applications have stressed analysis and results just in spectral domain. Space domain is very often strongly pushed back. That is why routines for spectral calibration of such sensors are very well known, even producer very often provides calibration certificate at the time of production. By transformation of industrial "off-the-shelf" hyperspectral line scanner to hyperspectral imaging system, capable of producing of hyperspectral cubes of imaged area, the positional accuracy becomes very important and calibration in the space domain is again a subject of high interest. This poster discusses the integration of hyperspectral scanner together with IMU (inertial measuring unit) and GPS (Global Positioning System). The procedures for geocoding of hyperspectral lines and producing of geocoded hyperspectral cube are presented. The given procedures are verified at test field and accuracy of geocoding is discussed.

Computer vision in Transport and Traffic

Hrvoje Gold, Sadko Mandžuka, Edouard Ivanjko, Niko Jelušić, Marko Ševrović, Mario Buntić, University of Zagreb

The Faculty of Transport and Traffic Sciences Computer Vision Group conducts research regarding theory and application of image processing for transport and traffic related problem solving. Group members are from different technical areas (traffic science, transport technology, computer science, control, robotics) ensuring high interdisciplinarity benefits for problem solving. Main research problems include origin-destination matrices extraction from intersection video footage, video geo-referencing for road evaluation, traffic sign detection including geo-referencing, automatic traffic incident detection, and hyperspectral imaging applications in protection of transport environment. Research results obtained individual and in collaboration with other research groups also include image segmentation and feature extraction, object recognition and tracking, and video geo-referencing. Research equipment includes a road evaluation vehicle (equipped with HD cameras, GPS and retroreflectometer), accessibility to multi-sensory airborne imagine system (equipped with thermal, multispectral and hyperspectral

sensors), and software package for license plate recognition. Group has also access to an test area with road, parking and airfield infrastructure enabling testing of developed applications in real world conditions. Current and future work is related to traffic parameters measurement and estimation from video-footage obtained using unmanned aerial vehicles, automated computer vision based road safety analysis, and computer vision based parking lot management evaluation in an outdoor test site.

Novel Method for Visual Wildfire Smoke Detection based on Spatial-Contex Analysis

Toni Jakovčević, Darko Stipaničev, Damir Krstinić, University of Split

Sensors for early fire detection based on visual analysis have been under constant development and improvement, especially during the last decade. However, there is still a lot of room for advancement to increase the accuracy and reliability of such sensors. On this poster a novel method for wildfire smoke detection based on spatial context analysis as well as motion detection, chromatic, texture and shape analysis is presented. The results show that the wildfire sensor based on proposed method is capable of detecting wildfire smoke accurately and reliably, and in most detection aspects it outperforms the existing methods.

Wildfire smoke-detction algorithms evaluation

Toni Jakovčević, Ljiljana Šerić, Darko Stipaničev, Damir Krstinić, University of Split

In recent years the interest for terrestrial wildfire smoke detection systems has increased, particularly those based on video systems sensitive in visible and/or infrared (IR) spectra. Although many video based smoke-detection algorithms have been developed and applied in various experimental or real life applications, the standard method for evaluating their quality has not yet been proposed and the standard databases of smoke and no-smoke images and video sequences suitable for standard algorithms testing have not been defined. This poster presents a methodology suitable for smoke-detection algorithms testing and evaluation.

Autonomous Robot Applications at Laboratory for Manufacturing and Assembly Systems Planning

Bojan Jerbic,Tomislav Stipancic, Marko Svaco, Bojan Sekoranja, Petar Curkovic, University of Zagreb

The Division for Manufacturing and Assembly System Planning focuses on various aspects of design and implementation of intelligent robotic systems and their applications. Laboratory has specific expertise in the following areas: Automation and Intelligent Robotics, Web Collaboration Systems, Intelligent Automatic Assembly Systems, Mobile robotics, Modeling and Control of Automotive Systems, Self-adaptive Systems, Multiagent systems, CAD/CAM, 2D/3D Machine Vision Systems, and Evolutionary programming. This poster presents some of ongoing projects and the results of : EvoArm© - Evolutionary based on-line planner for multiple robots with overlapping workspaces, Contextual Perception and Interpretation, Multiagent systems applied in industrial environment, and various applications of machine vision systems.

Registration and model-based analysis of transaortic valvular flow ultrasound images

Hrvoje Kalinić, Maja Čikeš, Sven Lončarić, Davor Miličić, Bart Bijnens, University of Zagreb

Detecting changes in the contractility of the heart muscle, especially in the presence of coronary artery disease, is an important medical task. To test whether there is a relationship between the morphology of the aortic outflow velocity profile and myocardial function a segmentation of the aortic outflow velocity profile is necessary as well as the morphology feature extraction. Our approach is based on atlas-based image segmentation that utilizes specially formulated geometrical transformation, image similarity measure, atlas formation and segmentation propagation. Following atlas-based image segmentation, various cardiac parameters are extracted to describe morphological properties of transaortic valvular flow.

Advanced multisensor system for airborne reconnaissance and surveillance in emergency situations and the environment

Andrija Krtalić, University of Zagreb

The system consists of two main subsystems. One is a multisensor system for collecting information about the scene from the air, and the other is a system to support decision making in conditions of uncertainty, on the basis of existing and collected data. The system was created and used in the four national and

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international projects from 2008 to the present time. Currently is using and improving in the European Commission FP7 humanitarian demining project, TIRAMISU.

High-performance face tracking

Nenad Markuš, Miroslav Frljak, Igor S. Pandžić, Jörgen Ahlberg, Robert Forchheimer, University of Zagreb, Linköping University

Face tracking is an extensively studied field. Nevertheless, it is still a challenge to make a robust and efficient face tracker, especially on mobile devices. This poster presents our implementation of a high-performance face tracking system. The main characteristics of our approach are that the tracker is fully automatic and works with the majority of faces without any manual initialization. It is robust, resistant to rapid changes in pose and facial expressions, does not suffer from drifting and is modestly computationally expensive. The tracker runs in real-time on mobile devices. Applications include augmented marketing and retail, games and entertainment, view-dependent rendering, safety applications, human-computer interaction, assistive technology etc. Ongoing work focuses on the possibility of using randomized forests for detection of characteristic points on the face (for example, eye or eyebrow corners). We hope that this research will result in the improvement of tracker initialization as well as increase in tracking quality and stability.

Topology Preserving 3D Thinning Algorithms Using Four and Eight Subfields

Gabor Nemeth, Peter Kardos, Kalman Palagyi, University of Szeged

Thinning is a widely applied technique for extracting skeleton-like shape features (i.e., centerline, medial surface, and topological kernel) from 3D binary images. Subfield-based parallel thinning algorithms partition the image into some subsets which are alternatively activated, and some points in the active subfield are deleted. A set of new 3D parallel subfield-based thinning algorithms are presented that use four and eight subfields.

Guidewire tracking and 3D position reconstruction using monoplane C-arm

Tomislav Petković, Sven Lončarić, Robert Homan, Tomislav Devčić, University of Zagreb

We present a real-time method for 3D reconstruction of the guidewire using monoplane x-ray. Two reconstruction methods are presented, first utilizing one projective view and second utilizing multiple projective views. Reconstruction from one view requires additional prior knowledge represented as a volume that indicates positions of blood vessels of interest thus restricting the reconstruction. It is composed of two steps: (1) finding a surface that contains the guidewire, and (2) an optimization step that utilizes additional knowledge to select one curve on the surface that is the best match under pre-specified constraints. Reconstruction from multiple views does not require additional knowledge and utilizes and exhaustive search of all ray-ray intersection for the reconstruction. Reconstruction precision is limited by the local thickness of the vessels for the first reconstruction method and is limited by image resolution for the second reconstruction method. Developed implementation achieves processing speed of 12 fps using Core\texttrademark~i7 CPU~920 at 2,67~GHz.

Discrete Fourier transform–based watermarking method with an optimal implementation radius

Ante Poljičak, Lidija Mandić, Darko Agić, University of Zagreb

In this paper, we evaluate the degradation of an image due to the implementation of a watermark in the frequency domain of the image. As a result, a watermarking method, which minimizes the impact of the watermark implementation on the overall quality of an image, is developed. The watermark is embedded in magnitudes of the Fourier transform. A peak signal-to-noise ratio is used to evaluate quality degradation. The obtained results were used to develop a watermarking strategy that chooses the optimal radius of the implementation to minimize quality degradation. The robustness of the proposed method was evaluated on the dataset of 1000 images. Detection rates and receiver operating characteristic performance showed considerable robustness against the print-scan process, print-cam process, amplitude modulated, halftoning, and attacks from the StirMark benchmark software

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Efficient approach for 3D foot reconstruction

Tomislav Pribanić, University of Zagreb

A fabrication of individual shoe insoles assumes the use of 3D foot scanners which in turn use a custom made hardware with lasers. Such scanners are commonly made for 3D foot reconstruction only and they are based on a single view. This proof of concept project verifies the idea of using 3D structured light scanner, composed from off-the-shelf components. In addition, a proposed approach should allow easier and faster scanning from multiple views, but without any additional hardware for a surface registration. Equally important, it should allow the use of the same 3D scanner for varies other applications.

Web GIS Technologies in Advanced Cloud Computing

Darko Stipaničev, Marin Bugarić, Ljiljana Šerić, Toni Jakovčević, University of Split

The last generation of video based wildfire monitoring systems have two important features, first they are integrated with Geographic Information Systems (GIS), because the complete information about wildfire is not only its existence but also its position, and second, today's wildfire monitoring "goes in cloud", which means that it belongs to cloud computing or Web Information Systems (WIS) applications. This poster presents an example of such advanced cloud computing based wildfire monitoring system, where GIS, or more precisely Web GIS system is used, not only for fire location determination, but also to improve camera's manual control and to enhance distant virtual video presence on wildfire field.

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iForestFire – Intelligent Forest Fire Monitoring System

Darko Stipaničev, Maja Štula, Damir Krstinić, Ljiljana Šerić, Toni Jakovčević, Marin Bugarić, Josip Maras, Maja Braović, University of Split

Wildfires cause significant economic damage and have quite devastating effect on environment all over the world. Early fire detection and quick and appropriate intervention are of vital importance for wildfire damage minimization. Wildfire monitoring is traditionally based on human wildfire surveillance, but modern ICT technologies today offer more advanced, video camera based wildfire-monitoring capabilities. On this poster an example of advanced automatic wildfire surveillance and monitoring system, inspired by formal theory of perception and based on observer theory, is presented. The wildfire observer called iForestFire is illustrated from its theoretical background to its features, capabilities and implementations.

Mapping and Assessing the State of Traffic Infrastructure

Siniša Šegvić, Karla Brkić, Zoran Kalafatić, Marko Ševrović, Ivan Dadić, University of Zagreb

This project was concerned with exploitation and maintenance of geoinformation inventories for storing elements of traffic infrastructure. The main motivation for developing such systems is to provide a direct and comprehensive insight into the prescribed state of the road in order to support subsequent safety inspections of a public road network in operation. We proposed to contribute to this goal by researching ways to relax the dependencies on trained human experts. In particular we wished to find out whether reliable detection and recognition of different kinds of traffic signs and surface markings could be performed automatically by computer vision techniques. Most of our work concerned the detection and recognition of triangular warning traffic signs, as the most frequent sign superclass along the Croatian local roads. Our results strongly suggest that a performance of 100% recall (all warning signs correctly detected) with near 100% precision and almost 100% correct recognition rate is feasible.