



Fourth Croatian Computer Vision Workshop

September 22, 2015, Zagreb, Croatia

ABSTRACT BOOK



University of Zagreb
Center of Excellence
for Computer Vision

CCVW 2015

4th Croatian Computer Vision Workshop

Zagreb, Croatia, September 22, 2015

Organizing Institution

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University of Zagreb, Croatia

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Preface

On behalf of the Organizing Committee it is my pleasure to invite you to Zagreb for the 4th 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 order to foster research and encourage academia-industry collaboration in this dynamic field. The Workshop program includes oral and poster presentations of original peer reviewed research from Croatia and elsewhere. Furthermore, the program includes invited lectures by distinguished international researchers presenting state-of-the-art in computer vision research. Workshop sponsors will provide perspective on needs and activities of the industry. Finally, one session shall be devoted to short presentations of activities at Croatian research laboratories.

The Workshop is organized by the Center of Excellence for Computer Vision, which is located at the Faculty of Electrical Engineering and Computing (FER), University of Zagreb. The Center joins eight research laboratories at FER and research laboratories from six constituent 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.

Zagreb is a beautiful European city with many cultural and historical attractions, which I am sure all participants will enjoy. I look forward to meet you all in Zagreb for the 4th Croatian Computer Vision Workshop.

September 2015

Sven Lončarić, General Chair

Acknowledgements

The 2015 4th Croatian Computer Vision Workshop (CCVW) is the result of the committed efforts of many volunteers.

All included papers are results of dedicated research. Without such contribution and commitment this Workshop would not have been possible.

Program Committee members and reviewers have diligently reviewed submitted papers and provided extensive reviews which will be an invaluable help in future work of collaborating authors. Managing the electronic submissions of the papers, the preparation of the abstract booklet and of the online proceedings also required substantial effort and dedication that must be acknowledged. The Local Organizing Committee members did an excellent job to guarantee a successful outcome of the Workshop.

We are grateful to the Technical Co-Sponsors, who helped us in granting the high scientific quality of the presentations, and to the Donators that financially supported this Workshop.

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09:30 – 09:45	Multiple-Dataset Traffic Sign Classification with OneCNN <i>Fran Jurišić, Ivan Filković, Zoran Kalafatić</i>
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11:20 – 11:40	Computer Vision in Styria DataScience <i>Marko Velić</i>
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12:15 – 13:30	Oral Session 2: Hough Transform, Color, and Microscopy
12:15 – 12:30	An Extension to Hough Transform Based on Gradient Orientation <i>Tomislav Petković, Sven Lončarić</i>
12:30 – 12:45	Laser Spot Tracking Based on Modified Circular Hough Transform and Motion Pattern Analysis <i>Damir Krstinić, Ana Kuzmanić Skelin, Ivan Milatić</i>
12:45 – 13:00	Analysis of Color Impact of Wildfire Smoke on Image Background <i>Maja Braović, Darko Stipaničev, Ljiljana Šerić</i>
13:00 – 13:15	Color Based Region Classification in Mediterranean Landscape Images <i>Maja Braović, Darko Stipaničev, Damir Krstinić</i>
13:15 – 13:30	Offset-Sparsity Decomposition for Enhancement of Microscopic Images of Stained Specimens in Histopathology <i>Ivica Kopriva, Marijana Popović Hadžija, Mirko Hadžija, Gorana Aralica</i>

Tuesday, 22nd September, 2015

13:30 – 14:30 Lunch Break and Poster Session

Poster Session

Luka Kedmenec, Ante Poljičak, Lidija Mandić. Discrete cosine transform-based Watermarking Method for Social Media.

Mirjana Bonković, Ana Kuzmanić Skelin, Zoran Vulević. A Semi-automatic Procedure for Texturing of Large Laser Scanning Point Clouds.

Igor Cvišić, Ivan Petrović. Stereo Odometry Based on Careful Feature Selection and Tracking.

Josip Krapac, Siniša Šegvić. Fast Approximate GMM Soft-Assign for Fine-Grained Image Classification with Large Fisher Vectors.

Valentina Zadrija, Josip Krapac, Siniša Šegvić, Jakob Verbeek. Patch-level Spatial Layout for Classification and Weakly Supervised Localization.

Nenad Markuš, Miroslav Frlijak, Igor S. Pandžić, Jürgen Ahlberg, Robert Forchheimer. High Performance Face Tracking.

Tomislav Petković, Tomislav Pribanić, Matea Đonlić. The Self-Equalizing De Bruijn Sequence for 3D Profilometry.

Ante Seletković, Renata Pernar, Jelena Kolić, Mario Ančić. Assessment of Forest Damage Caused by Natural Disasters (Ice Storm) using Remote Sensing.

Vladan Papić, Mirjana Bonković, Marjan Sikora, Tea Marasović, Denis Štajduhar. Prototype of Image Processing Based System for Search and Rescue.

Tomislav Hrkać, Karla Brkić, Zoran Kalafatić, Ivan Filković, Darjan Marčetić, Slobodan Ribarić. De-identification Methods for Soft and Non-biometric Identifiers.

Tomislav Pribanić et al. CSF project 3DHumanTorso.

Siniša Šegvić et al. CSF project MULTICLUD.

14:30 – 16:10 Presentations of Projects and Laboratories 1

14:30 – 14:50 A Semi-Automatic Procedure for Texturing of Large Laser Scanning Point Clouds
Mirjana Bonković, Ana Kuzmanić Skelin, Zoran Vulević

14:50 – 15:10 3D Computer Vision in Robotics, Medicine and Agriculture
Robert Cupec, Damir Filko, Ivan Vidović, Emmanuel Karlo Nyarko

15:10 – 15:30 Research Activities of Visual Computing Group @ETFOS
Irena Galić, Časlav Livada, Hrvoje Leventić, Krešimir Romić

15:30 – 15:50 Stereo Odometry Based on Careful Feature Selection and Tracking
Igor Cvišić, Ivan Petrović

15:50 – 16:10 Neonatal Brain MRI Analysis
Jelena Božek Mouthuy

16:10 – 16:25 Coffee Break

16:25 – 17:45 Presentations of Projects and Laboratories 2

16:25 – 16:45 Medical Applicability of a Low-Cost Industrial Robot Arm Guided with an Optical Tracking System
Filip Šuligoj, Bojan Jerbić, Marko Švaco, Bojan Šekoranja, Dominik Mihalinec, Josip Vidaković

16:45 – 17:05 A Low-Cost Automated System to Measure the Three-Dimensional Shape of Trunk Surface
Tomislav Pribanić, Tomislav Petković, Matea Đonlić

17:05 – 17:25 Project Multiclod: Multiclass Object Detection
Siniša Šegvić, Josip Krapac, Ivan Krešo, Valentina Zadrija, Ivan Sikirić

17:25 – 17:45 Presentation of IPA project "VISTA: Computer vision innovations for safe traffic"
Sven Lončarić

17:45 – 18:00 Closing

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Invited Speakers

Commercializing Computer Vision. Why and how?

J. Ahlberg

Doing research in computer vision is fun and stimulating; it is a fast moving topic, there is a plethora of scientific challenges, and the last decade it has also proven to be very useful. Moreover, when various sensors (cameras etc.) become increasingly inexpensive and ubiquitous, the hardware investments needed for practical usefulness become less of an obstacle. This makes the step from academic research to commercial products or services small, and as a result there are now numerous spin-off computer vision companies at universities and science parks.

Abstracts

Oral Session 1: Transportation and 3D

Measurement of Road Traffic Parameters based on Multi-Vehicle Tracking

K. Kovačić, E. Ivanjko, N. Jelušić

Development of computing power and cheap video cameras enabled today's traffic management systems to include more cameras and computer vision applications for transportation system monitoring and control. Combined with image processing algorithms cameras are used as sensors to measure road traffic parameters like flow volume, origin-destination matrices, classify vehicles, etc. In this paper we propose a system for measurement of road traffic parameters (basic motion model parameters and macro-scopic traffic parameters). The system is based on Local Binary Pattern (LBP) image features classification with a cascade of Gentle Adaboost (GAB) classifiers to determine vehicle existence and its location in an image. Additionally, vehicle tracking and counting in a road traffic video is performed by using Extended Kalman Filter (EKF) and virtual markers. The newly proposed system is compared with a system based on background subtraction. Comparison is performed by the means of execution time and accuracy.

CWT-Based Detection of Roadside Vegetation Aided by Motion Estimation

I. Harbaš, M. Subašić

In this paper we present a method for roadside vegetation detection intended for traffic safety and road infrastructure maintenance. While many published methods are using Near Infrared images which are suitable for vegetation detection, our method uses features from the visible spectrum allowing the use of a common color camera. The presented method uses a set of carefully selected color and texture features. Texture features are based on two-dimensional Continuous Wavelet Transform with oriented wavelets. Because texture can vary as the distance from the camera varies, we limit detection to the regions closer to the camera. We use optical flow as an approximate estimator of distance. The classification is done using nonlinear SVM. For training and testing purposes we

recorded our own video database which contains roadside vegetation in various conditions. We present promising experimental results as well as a comparison with several alternative approaches.

Multiple-Dataset Traffic Sign Classification with OneCNN

F. Jurišić, I. Filković, Z. Kalafatić

We take a look at current state of traffic sign classification discussing what makes it a specific problem of visual object classification. With impressive state-of-the-art results it is easy to forget that the domain extends beyond annotated datasets and overlook the problems that must be faced before we can start training classifiers. We discuss such problems, give an overview of previous work done, go over two publicly available datasets and present a new one. Following that, classification experiments are conducted using a single CNN model, deeper than used previously and trained with dropout. We apply it over multiple datasets from Germany, Belgium and Croatia, their intersections and union, outperforming humans and other single CNN architectures for traffic sign classification.

Towards Reversible De-Identification in Video Sequences Using 3D Avatars and Steganography

M. Blažević, K. Brkić, T. Hrkać

We propose a de-identification pipeline that protects the privacy of humans in video sequences by replacing them with rendered 3D human models, hence concealing their identity while retaining the naturalness of the scene. The original images of humans are steganographically encoded in the carrier image, i.e. the image containing the original scene and the rendered 3D human models. We qualitatively explore the feasibility of our approach, utilizing the Kinect sensor and its libraries to detect and localize human joints. A 3D avatar is rendered into the scene using the obtained joint positions, and the original human image is steganographically encoded in the new scene. Our qualitative evaluation shows reasonably good results that merit further exploration.

The Self-Equalizing De Bruijn Sequence for 3D Profilometry

T. Petković, T. Pribanić, M. Donlić

Using color in 3D profilometry usually requires a tedious color calibration to mitigate the undesired effects of ambient lighting, object albedo, non-equal channel gains, and channel cross-talk. We propose a novel De Bruijn sequence for multi-channel structured light that removes the need for color calibration of a camera-projector pair. The proposed sequence has the following desirable properties: (1) it enables the extraction of ambient lighting, (2) it enables the cancellation of object albedo, and (3) it enables the equalization of channel gains.

Industry Session

Computer Vision in Styria DataScience

M. Velić

Styria DataScience is a newly formed team focused on applying state-of-the-art methods to commercially applicable computer vision and text analysis tasks. Typical use cases include image classification, object detection and tracking, scene recognition and description, augmented reality etc. Our aim is to form a team of top experts in the fields of computer vision, machine learning, deep neural networks and computer science in general. Local talent, vast amounts of high-quality data and access to high-end hardware are prerequisites for this kind of research and all of them are met within our business. Styria's databases include image and text resources from top sites in multiple countries (Austria, Croatia, Slovenia...). After achieving state-of-the-art results, there is still a task of making successful products and services for market so this is also one challenge for us. All of this implies a once-in-a-lifetime opportunity to work and research in a dynamic, globally oriented development team. Visit our lecture and learn more!

Project Wonderland – Outdoor Augmented Reality

S. Grahovac

The main goal of Project Wonderland is to implement a working prototype of a wearable augmented reality system in outdoor environment, showing that with today's technological advancements such a system is viable (proof of concept prototype), and with tomorrow's refined technology can become commercial in next 2-3 years. Project's final product will be an integrated system which will consist of a VR helmet upgraded with precise positioning sensors. Integrating

the sensor information from various sources such as GPS, stereo camera rig and inertial measurement unit is crucial for precisely determining the user's position. We will present a range of methods that are currently being researched as well as further steps to successfully accomplish project goals.

Oral Session 2: Hough Transform, Color, and Microscopy

An Extension to Hough Transform Based on Gradient Orientation

T. Petković, S. Lončarić

The Hough transform is one of the most common methods for line detection. In this paper we propose a novel extension of the regular Hough transform. The proposed extension combines the extension of the accumulator space and the local gradient orientation resulting in clutter reduction and yielding more prominent peaks, thus enabling better line identification. We demonstrate benefits in applications such as visual quality inspection and rectangle detection.

Laser Spot Tracking Based on Modified Circular Hough Transform and Motion Pattern Analysis

D. Krstinić, A. Kuzmanić Skelin, I. Milatić

Laser pointers are one of the most widely used interactive and pointing devices in different human-computer interaction systems. Existing approaches to vision-based laser spot tracking are designed for controlled indoor environments with the main assumption that the laser spot is very bright, if not the brightest, spot in images. In this work, we are interested in developing a method for an outdoor, open-space environment, which could be implemented on embedded devices with limited computational resources. Under these circumstances, none of the assumptions of existing methods for laser spot tracking can be applied, yet a novel and fast method with robust performance is required. Throughout the paper, we will propose and evaluate an efficient method based on modified circular Hough transform and Lucas-Kanade motion analysis. Encouraging results on a representative dataset demonstrate the potential of our method in an uncontrolled outdoor environment, while achieving maximal accuracy indoors. Our dataset and ground truth data are made publicly available for further development.

Analysis of Color Impact of Wildfire Smoke on Image Background

M. Braović, D. Stipaničev, L. Šerić

Detection of smoke in images of natural environment is not an easy task. Due to its semi-transparency, smoke is not easily distinguished from other objects (in the image of natural environment) by only looking at its visual features. Although color of the smoke is greyish, color of image region containing smoke can not be easily extracted based on region color and the search for regions whose color is grayish on average. In this paper we presented an analysis of relative change that appearance of smoke brings to the region that is affected by smoke. This analysis resulted in new insights about the relative change in average value of certain channels of various color spaces that can be presented as set of rules for validation of smoke region. These rules can easily be implemented for validation if certain phenomenon in sequence of images contains smoke or other non hazardous phenomenon.

Color Based Region Classification in Mediterranean Landscape Images

M. Braović, D. Stipaničev, D. Krstinić

Color is one of the most useful features when it comes to segmentation and classification of regions on images. As there are various color spaces, the question is which one is the most suitable for these tasks. Of course the answer depends of the region we want to classify and the image types. It is not the same if we have indoor or outdoor images. The main focus of this presentation is color-based segmentation and classification of regions in single images of Mediterranean landscape captured mostly by wildfire video based surveillance and monitoring systems. Therefore classes have been specially chosen in order to improve algorithms for wildfire smoke detection. The main goal of this presentation is to discover which color spaces, out of the nine different ones that we tested, are most suitable for the color-based classification of 11 different classes that can usually be found in natural Mediterranean landscape images. Additionally, we will also present a FESB MLID (FESB is a Croatian acronym for the Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture and MLID means Mediterranean Landscape Image Dataset) that we have collected during our research and make public for all researchers.

Offset-Sparsity Decomposition for Enhancement of Microscopic Images of Stained Specimens in Histopathology

I. Kopriva, M. Popović Hadžija, M. Hadžija, G. Aralica

We propose an offset-sparsity decomposition method for the enhancement of a color microscopic image of a stained specimen. The method decomposes vectorized spectral images into offset terms and sparse terms. A sparse term represents an enhanced image, and an offset term represents a “shadow.” The related optimization problem is solved by computational improvement of the accelerated proximal gradient method used initially to solve the related rank-sparsity decomposition problem. Removal of an image-adapted color offset yields an enhanced image with improved colorimetric differences among the histological structures. This is verified by a no-reference colorfulness measure estimated from 35 specimens of the human liver, 1 specimen of the mouse liver stained with hematoxylin and eosin, 6 specimens of the mouse liver stained with Sudan III, and 3 specimens of the human liver stained with the anti-CD34 monoclonal antibody. The colorimetric difference improves on average by 43.86% with a 99% confidence interval (CI) of [35.35%, 51.62%]. Furthermore, according to the mean opinion score, estimated on the basis of the evaluations of five pathologists, images enhanced by the proposed method exhibit an average quality improvement of 16.60% with a 99% CI of [10.46%, 22.73%].

Poster Session

Discrete Cosine Transform-Based Watermarking Method for Social Media

L. Kedmenec, A. Poljičak, L. Mandić

Aim of the research was to develop a watermarking method that is robust to different attacks such as social network attacks, JPEG compression, blur, sharpen, scale, and noise but still that it doesn't degrade the image quality. Acceleration of the code was the second task in order to save time and to prepare it for possible device implementation. The method has significant capacity and shows good robustness against different attacks.

Fast Approximate GMM Soft-Assign for Fine-Grained Image Classification with Large Fisher Vectors

J. Krapac, S. Šegvić

We address two drawbacks of image classification with large Fisher vectors. The first drawback is the computational cost of assigning a large number of patch descriptors to a large number of GMM components. We propose to alleviate that by a generally applicable approximate soft-assignment procedure based on a balanced GMM tree. This approximation significantly reduces the computational complexity while only marginally affecting the fine-grained classification performance. The second drawback is a very high dimensionality of the image representation, which makes the classifier learning and inference computationally complex and prone to overtraining. We propose to alleviate that by regularizing the classification model with group Lasso. The resulting block-sparse models achieve better fine-grained classification performance in addition to memory savings and faster prediction. We demonstrate and evaluate our contributions on a standard fine-grained categorization benchmark.

Patch-level Spatial Layout for Classification and Weakly Supervised Localization

V. Zadrija, J. Krapac, S. Šegvić, J. Verbeek

We propose a discriminative patch-level model which combines appearance and spatial layout cues. We start from a block-sparse model of patch appearance based on the normalized Fisher vector representation. The appearance model is responsible for i) selecting a discriminative subset of visual words, and ii) identifying distinctive patches assigned to the selected subset. These patches are further filtered by a sparse spatial model operating on a novel representation of pairwise patch layout. We have evaluated the proposed pipeline in image classification and weakly supervised localization experiments on a public traffic sign dataset. The results show significant advantage of the combined model over state of the art appearance models.

High Performance Face Tracking

N. Markuš, M. Frljak, I. S. Pandžić, J. Ahlberg, R. Forchheimer

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 extended abstract briefly describes our implementation of a high-performance

multi-platform face and facial feature 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.

Assessment of Forest Damage Caused by Natural Disasters (Ice Storm) using Remote Sensing

A. Seletković, R. Pernar, J. Kolić, M. Ančić

In February 2014 on the area of Gorski Kotar there have been considerable damage to forest ecosystems due to freezing rain. Main problem is physical access to affected area. In case of limited or completely restricted access to forest, remote sensing has advantage over terrestrial methods. Remote sensing methods allow fast and reliable assessment of affected area and precise information on range and intensity of damage caused to forest. Research in this paper involves visual and digital interpretation of WorldView 2, a high spatial resolution satellite image, with a goal of estimating damages on individual trees and forest stands. Results will be compared and the possibility of forest damages assessment according to two interpretation methods (visual and digital) will be determined. In combination with existing data (database, digital orthophoto, maps of spatial distribution of damage) we will get a high-quality data for determination and inventory of damages (mapping) that are required for silviculture, ordination, protection and exploitation of forests. Remote sensing methods are hence superior choice for assessment of damage distribution, intensity and monitoring of success of sanitation. In the above natural disasters, it is necessary to define an area as soon as possible and the intensity of damage, as well as the characteristics of the habitat. The benefits of remote sensing in this research are size of inventoried surface, inaccessibility of the area and time spent.

Prototype of Image Processing Based System for Search and Rescue

V. Papić, M. Bonković, M. Sikora, T. Marasović, D. Štajduhar

Search and rescue (SAR) missions generally include scavenging of large areas of non-urban or at a very least sub-urban terrain, such as forests, mountains, deserts, sea, etc. Any solution that can speed up the search and/or increase the chances of finding a lost person(s), should be thoroughly investigated, because eventual benefits are almost priceless. Proposed solution uses image processing

for automatic detection of humans and artificial artefacts in natural surroundings. Input data is gathered using GPS-navigated drones capable of recording high-resolution images. In the next phase, images are processed on the ground-based computer. Obtained results are comparable to those of a human trackers.

De-identification Methods for Soft and Non-biometric Identifiers

T. Hrkać, K. Brkić, Z. Kalafatić, I. Filković, D. Marčetić, S. Ribarić

Advances in audio and video recording devices, web technology and signal processing have highly facilitated the efficacy of audio and video acquisition. This capability is now widely exploited in a variety of scenarios to obtain audio-video recordings of people, raising serious privacy concerns. The protection of sensitive private data is required by EU's Data Protection Directive (95/46/EC). De-identification in multimedia content can be defined as the process of concealing identities of individuals captured in a given set of data (images, video, audio, text), for the purpose of protecting their privacy. Soft biometric and non-biometric characteristics such as tattoos, birthmarks scars or dressing style also carry potentially identity-revealing information and have to be dealt with in the process of de-identification. This is an interdisciplinary challenge, involving such scientific areas as image processing, video tracking and biometrics. This project proposal aims to development of novel and robust methods for de-identification of soft and non-biometric identifiers in videos and images.

Presentations of Projects and Laboratories 1

A Semi-Automatic Procedure for Texturing of Large Laser Scanning Point Clouds

M. Bonković, K. Skelin, Z. Vulević

In this paper we present a method for the development of precise photorealistic 3D models of cultural heritage sites using terrestrial laser scanners and latest achievements in 3D photogrammetry, modeling and virtualization with an aim to build the innovative visual content with commercial and scientific purpose. The problem of combining geometric and textural information provided by 3D laser scanner and high quality images, as two independent information sources, is analyzed and the visualization procedure elements are elaborated. The resulting photorealistic 3D models of cultural heritage site are presented as an interactive 3D content on the Web, thus demonstrating the feasibility of the proposed method to enable both, scientific and popular utilization of detailed and complex cultural heritage data.

3D Computer Vision in Robotics, Medicine and Agriculture

R. Cupec, D. Filko, I. Vidović, E. K. Nyarko

Robotics and 3D Vision Group at Faculty of Electrical Engineering Osijek is engaged in research in the fields of robotics, computer vision and artificial intelligence. Currently, the focus of the group is on three applications: localization of mobile robot in indoor environments using RGB-D camera, 3D reconstruction and segmentation of wounds using RGB-D camera, and detection of crop rows in camera images for automatic guidance of agricultural machines. The group is also preparing to start with a new project “Advanced 3D Perception for Mobile Robot Manipulators” funded by the Croatian science foundation. This presentation provides an overview of the developed solutions and an introduction to the research in the forthcoming project.

Research Activities of Visual Computing Group @ETFOS

I. Galić, Č. Livada, H. Leventić, K. Romić

Visual Computing Group at Faculty of Electrical Engineering, University of Osijek is involved in various research activities. One part of research field encompasses image analysis and processing by means of lossy image compression, objective and subjective image quality assessment with leading compression algorithms – JPEG and JPEG2000. Current results show significant improvement in quality compared to state of the art compression algorithms. In the area of medical image analysis most of the work is based towards the subjective quality enhancement of the medical images in collaboration with experienced medical personnel. Research also focuses on segmentation and visualization of organs from non-invasive medical diagnostic images, where the models generated in the process of visualization and segmentation have two goals: to help the medical personnel in the diagnosis of cardiovascular diseases and to serve as a tool for the assessment of subjective quality enhancement of medical images. Another research area is image and video processing in assisting the blind and visually impaired. Methods for detection of various obstacles such as staircases are being developed and tested on multiple platforms. This research area has its main goal to help the blind and visually impaired in navigation and orientation in unfamiliar areas.

Stereo Odometry Based on Careful Feature Selection and Tracking

I. Cvišić, I. Petrović

We present a novel algorithm for fast and robust stereo visual odometry based on feature selection and tracking (SOFT). The reduction of drift is based on careful selection of a subset of stable features and their tracking through the frames. Rotation and translation between two consecutive poses are estimated separately. The five point method is used for rotation estimation, whereas the three point method is used for estimating translation. Experimental results show that the proposed algorithm has an average pose error of 1.03% with processing speed above 10 Hz. According to publicly available KITTI leaderboard, SOFT outperforms all other validated methods. We also present a modified IMU-aided version of the algorithm, fast and suitable for embedded systems. This algorithm employs an IMU for outlier rejection and Kalman filter for rotation refinement. Experiments show that the IMU based system runs at 20 Hz on an ODROID U3 ARM-based embedded computer without any hardware acceleration. Integration of all components is described and experimental results are presented.

Neonatal Brain MRI Analysis

J. Božek Mouthuy

The talk will present medical image analysis part of research activities at the Video Communications Laboratory. As a continuation of a postdoctoral research we collaborate with FMRIB Centre at the University of Oxford, King's College London and Imperial College London, UK on the Developing Human Connectome Project. The goal of the project is to create a dynamic map of human brain connectivity in the foetal and neonatal brain. Modelling of the foetal and neonatal connectome development is performed using structural, functional and diffusion MRI and advanced methods for MR image analysis. This talk will focus on the structural aspects of neonatal MR image analysis, including surface modelling of the cortex, creating surface template using multimodal surface matching (MSM) based on sulcal depth maps and registration of subjects to the template.

Presentations of Projects and Laboratories 2

Medical Applicability of a Low-Cost Industrial Robot Arm Guided with an Optical Tracking System

F. Šuligoj, B. Jerbić, M. Švaco, B. Šekoranja, D. Mihalinec, J. Vidaković

Robot systems used in surgical procedures can autonomously position tools at points correlated with preoperative imaging techniques such as magnetic resonance (MR) and computed tomography (CT). The aim of this paper is to measure and assess medical applicability of a low-cost, lightweight industrial robot arm (Universal robot UR5) guided with the medically certified optical tracking system (Polaris Vicra) to positions registered from a CT scan. Technical setup, measurement equipment, device communication and robot control based on OTS feedback are described. Robot intrinsic accuracy, CT scan accuracy and two methods of robot tool positioning with aid of the optical tracking system (OTS) are measured. Measurements show RMS error of the robot (0.669 mm) is decreased 55.4% when guided with OTS using a single marker probe (0.29 mm) and 40.5% when using OTS with relative referencing (0.39 mm). RMS error of the CT scan readings is 0.46 mm.

A Low-Cost Automated System to Measure the Three-Dimensional Shape of Trunk Surface

T. Pribanić, T. Petković, M. Đonlić

The aim of this project is to develop a low-cost automated system for measuring the 3D shape of the human torso. It will enable numerous physicians to acquire a model of the patients trunk surface (TS). TS symmetry is one of the key elements in diagnostic and evaluation of various treatments in patients with trunk deformities. Common radiographic evaluation methods are known to expose patients to a radiation with harmful side effects. Thus, there has been a constant motivation among researchers to develop an optimal methodology for accurate 3D reconstruction of the trunk and to investigate development of a 3D reconstruction system which will capture both back and front of the patient, i.e. the entire trunk surface, including dynamic and static conditions. In turn it would enable a more thorough analysis of the patient's deformity pattern. In this presentation we give an overview of developed methods and recent experimental results for the 3D object reconstruction. A second major goal during this project is to derive certain clinical parameters using generated three dimensional trunk model in order to quantify trunk deformities. In designing 3D system we underline that we plan to research the implementation of both passive and active stereovision

strategies. Researching the implementation of combined best features from passive and active stereo for one concrete of 3D system aimed at TS reconstruction (scoliosis), would be a great contribution for potential other 3D applications.

Project Multiclod: Multiclass Object Detection

S. Šegvić, J. Krapac, I. Krešo, V. Zadrija, I. Sikirić

The research project MULTICLOD addresses localization of objects in stereoscopic video of various traffic environments. We study local and global image representations based on cues extracted by combining classification and reconstruction methods. Our goal is to devise novel weakly supervised and multi-class localization models capable of contributing to various applications in the fields of smart vehicles and intelligent transportation systems.

We study calibrated stereoscopy as an affordable and powerful perceptual modality which shows a clear mass production potential in traffic and transportation applications. We address the fundamental problem of detecting and localizing objects of multiple classes at the same time. We approach this problem by combining cues arising from object appearance and structure.

Presentation of IPA project “VISTA: Computer vision innovations for safe traffic”

S. Lončarić

An overview of the project VISTA – Computer vision innovations for safe traffic will be presented. The two-year project was funded from the IPA program and had a goal of strengthening research capacity of two partner institutions in the area of computer vision. The main research topics were computer vision systems for advanced driver assistance systems.

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