VISTA

Computer vision innovations for safe traffic

CVC
COMPUTER VISION CENTER

Investing in future!

Ministry of Science, Education and Sports

STRUKTURNI I INVESTICIJSKI FONDOVI

COMPETITIVE CROATIA

SCIENCE & INNOVATION Investment Fund

This action is co-financed by the European Union from the European Regional Development Fund

Contact:
Prof. dr. sc. Sven Lončarić
Tel: +385-1-6129-891
E-mail: sven.loncaric@fer.hr
WWW: http://vista.fer.hr

Address:
University of Zagreb
Faculty of Electrical Engineering and Computing
Unska 3, 10000 Zagreb
Croatia

Zagreb, 2014.

VISTA – Computer Vision Innovations for Safe Traffic

VISTA is a project focused towards the application of advanced computer vision techniques in the traffic and automotive industry sector. The project coordinator is the University of Zagreb, Faculty of Electrical Engineering and Computing, in partnership with the Faculty of Transport and Traffic Sciences.

This Action is co-financed by the European Union from the European Regional Development Fund.

Project objectives

The main project objectives are:

- strengthening of technology transfer from partner HEIs to SMEs in the automotive sector;
- strengthening the commercialization capacities of partner HEIs;
- transfer of existing computer vision applications from HEIs to SMEs;
- developing new traffic- and transportation-related computer vision applications with commercial potential in collaboration with SMEs in the automotive industry sector.

The objectives will be achieved through two specific activities:

- R&D activities towards commercialization of specific innovative computer vision applications;
- networking of HEIs and SMEs in Croatian automotive industry sector to improve the SME access to high-tech knowledge, stimulate the commercialization of existing innovations developed at HEIs and foster the conception of future joint R&D projects.

Project team

Project leader

Prof. Sven Lončarić

Administrative project manager

Marijana Jurić Fraculj

Senior researchers

Prof. Mato Baotić
Prof. Hrvoje Gold
Prof. Edouard Ivanjko
Prof. Niko Jelušić
Prof. Zoran Kalafatić
Prof. Ivan Petrović
Prof. Slobodan Ribarić
Prof. Marko Subašić
Prof. Siniša Šegvić

Junior researchers

Nikola Banić
Josip Ćesić
Ivan Filković
Iva Harbaš
Darko Jurić
Kristian Kovačić
Ivan Krešo
Markan Lopar

Research and Development activities

The first specific objective of the action is conducting R&D activities towards commercialization of specific innovative computer vision applications. Implementation of R&D activities requires purchase of research equipment and employment of R&D engineers, which will represent enhancement of the R&D capacity. R&D results on seven computer vision applications will enhance amount of intellectual property that will be available for commercialization.

Four specific levels of R&D activities are planned:

- industrial research and development in collaboration with SMEs;
- proof of concept development;
- prototype development;
- prototypes testing in collaboration with commercializing partners.

Four research groups from both partner faculties will collaborate in research activities to develop seven innovative automotive computer vision system for driver assistance:

- surround view parking assistance;
- detection of road side vegetation;
- automatic headlight detection;
- lane departure and collision warning;
- traffic sign detection and recognition;
- lane detection and recognition;
- driver fatigue monitoring.

Networking activities

An important component of the VISTA project is establishing partnerships with companies in the automotive industry sector. Through collaboration with companies it is expected to find and define new challenging knowledge-based applications and innovative products with high added value.

In achieving that goal the following activities are planned:

- informing companies in the automotive sector on research and development capacities of the partner HEIs through workshops that will be periodically held;
- establishing direct contacts with interested companies through visits and meetings, in order to identify the needs of individual companies and the opportunities for joint development of future innovative products;
- establishing a project website that will ensure visibility of the project and serve as a communication channel between partners;
- appearance at exhibitions and fairs related to the automotive sector will increase national and international visibility of project results, and its participants;
- informing the public about the evolving capacities of faculties and companies, as well as examples of successful cooperation with companies should contribute to improving the investment climate in Croatia.

Target groups

The target groups of the project are:

- SMEs from automotive industry sector;
- partner faculties.

Through implementation of planned activities, including the development of commercially interesting technologies and prototypes, the partner faculties will indirectly strengthen their technology transfer and commercialization capacity. The project will directly contribute to the competitiveness of Croatian knowledge-based SMEs. By strengthening of the local industry, the project will also contribute to sustainable regional development.

Final beneficiaries

Results of the project could eventually have a positive impact on the groups related to traffic and transportation. Therefore, end-users include:

- society at large;
- traffic participants;
- automotive industry sector in Croatia;
- traffic law enforcement agencies;
- road infrastructure management companies.

The project addresses specific needs of the traffic and transport sector which has a remarkable significance in the modern society. Action outputs, once successfully brought to market, have a potential to increase safety, efficiency and environmental qualities of intelligent transport systems, which are an important factor of the local sustainability.

Center of Excellence for Computer Vision (CVC)

Director: Sven Lončarić
www: http://www.fer.unizg.hr/crv

The Center of Excellence for Computer Vision at the University of Zagreb, Croatia had a significant role in initiating the VISTA project. The Center was established with the financial support of the University of Zagreb Development Fund and brings together researchers from seven faculties of the University of Zagreb.

The Center is located at the Faculty of Electrical Engineering and Computing (FEEC), University of Zagreb. It joins eight research laboratories at FEEC and research laboratories from six other constitutional units of the University of Zagreb: the Faculty of Forestry, the Faculty of Geodesy, the Faculty of Graphic Arts, the Faculty of Kinesiology, the Faculty of Mechanical Engineering and Naval Architecture, and the Faculty of Transport and Traffic Sciences. The research team of the Center consists of more than twenty professors and more than fifty doctoral students, representing a significant research and development resource at the University of Zagreb.

With its expertise in advanced computer technology, the Center members conduct research and applied engineering projects in a wide range of computer vision technologies including:

- image processing;
- pattern recognition;
- model-based computer vision;
- biomedical imaging and image analysis;
- robot vision;
- remote sensing;
- intelligent systems for computer vision;
- stereo imaging;
- real-time implementations of image processing and computer vision systems;
- applications of image analysis in biometrics, forestry, agriculture, transport and traffic, industry automation, visual product inspection, automotive industry, advanced driver-assistance systems, graphics industry, multimedia, visualization, and other areas.

The main goals of the Center of Excellence for Computer Vision are: i) to advance the state-of-the-art in theory and applications of computer vision, and ii) to encourage science-industry collaboration and transfer of technology from academia to industry to foster development of innovative knowledge-based products.

Four research groups from the Faculty of Electrical Engineering and Computing and the Faculty of Transport and Traffic Sciences participate in the VISTA project team.

Image Processing Group (IPG)

Director: Sven Lončarić
Members: Damir Seršić, Tomislav Pribanić, Marko Subašić, Tomislav Petković, Vedrana Baličević, Pavle Prentašić, Iva Harbaš, Darko Jurić, Nikola Banić
www: http://www.fer.unizg.hr/ipg

The Image Processing Group conducts research in theory and applications of image processing, pattern recognition and computer vision methods in various areas including biometric security, biomedical imaging, visual inspection, and automotive applications. The main research problems include image feature extraction, image segmentation, image registration, and motion analysis. In the area of biomedical image processing and analysis, we have investigated methods for retinal image analysis, real-time intravascular catheter tracking from X-ray image sequences and 3-D reconstruction of catheter tip, atlas-based image analysis of cardiac ultrasound Doppler images, nuclear medicine image analysis, and CT and MR brain image analysis. For automotive multi-camera systems we developed real-time methods for non-linear and perspective correction of fisheye lenses and image stitching. In biometric security applications we developed methods for personal ID image analysis for quality control of passport photographs. We developed a system for tiled multi-projector visualizations on flat or cylindrical surfaces for large panoramic visualizations and simulation of virtual environments. IPG has available various research equipment including industrial GigEVision and Firewire digital video cameras and network IP cameras for multi-view scene analysis such as multi-view face recognition for security applications, intelligent surveillance applications, and complex object tracking problems. A high-performance computing cluster is used for research of complex information processing algorithms. IPG also has equipment for realization of virtual reality and augmented reality systems including active and passive 3-D stereo visualization of virtual environments using LCD shutter glasses, and a position tracking device. Computer-controlled multi-source lighting equipment is available for 3-D object analysis. The group has organized a series of international scientific symposia and a couple of international summer schools on image processing. The group initiated formation of the Center of Excellence for Computer Vision at the University of Zagreb, Croatia.

Projects:

- Retinal Image Analysis of Diabetic Retinophaty, BICRO, 2012
- Software for Vegetation Detection and Recognition, BICRO, 2011
- Intelligent methods for image processing and analysis, Ministry of Science, Education and Sports, 2007-2013
- panoVRama: System for tiled visualization using multiple projectors, Ministry of Science, Education and Sports, 2009-2010
- Virtual Physiological Human NoE, EU FP7 Network of Excellence, 2009-
- Analysis of photographs for personal ID documents, Siemens PSE, Austria, 2005-2008
- Real-time tracking of objects in biomedical X-ray image sequences, Philips Medical Systems, Netherlands, 2005-2010
- Methods for real-time geometric correction, perspective correction and video stitching using multiple cameras, Xylon, Croatia, 2008-2010
- Medical imaging and image processing, CEEPUS, 1998-2010
- Intelligent multidimensional image processing and analysis, Ministry of Science, Education and Sports, 2005-2007

- Physiological Modeling of MR Image Formation, COST B21, 2003-2008

Laboratory for Pattern Recognition and Biometric Security Systems (RUBIOSS)

Director: Slobodan Ribarić
Members: Zoran Kalafatić, Siniša Šegvić, Tomislav Hrkać, Branko Samaržija, Marijo Maračić, Darijan Marčetić, Markan Lopar, Ivan Krešo, Ivan Filković
www: http://rubioss.zemris.fer.hr/

The Laboratory is a part of the Department of Electronics, Microelectronics, Computer and Intelligent Systems at the Faculty of Electrical Engineering and Computing, University of Zagreb, Croatia. The research areas covered by the Laboratory include pattern recognition, biometry, computer vision and intelligent multiagent systems. The research results have been applied for solving various practical problems such as: palm and face detection and recognition for biometric identification; object detection and tracking; traffic sign detection and recognition; assessing the state of traffic infrastructure; driver mental state monitoring; 3D structure and motion estimation. Recent research includes biometric deidentification of persons in multimedia content.

Projects:

- De-identification Methods for Soft and Non-Biometric Identifiers, Croatian science foundation, 2014-2017
- De-identification for Privacy Protection in Surveillance Systems, Croatian science foundation, 2014-2018
- Multi-class object detection for smart vehicles and safer roads, Croatian science foundation, 2014-2017
- De-identification for privacy protection in multimedia content, ICT COST Action IC1206
- Theory, Modeling and Application of Autonomy-oriented Computing Structures, Ministry of science, education and sports, 2007–2011
- Biometrics for Identity Documents and Smart Cards, COST action 2101
- Advanced techniques for traffic infrastructure detection, University of Zagreb Development Fund, 2012
- Mapping and assessing the state of traffic infrastructure, Croatian science foundation, partly funded by IPV Zagreb (SME), 2008-2011
- Model based traffic sign detection, Croatia-Austria bilateral project, 2010-2011
- Biometrics for Secure Authentication (BioSecure), FP6 project, 2004-2006
- Biometrics-Based Recognition of People over the Internet, COST action 275
- Fuzzy Knowledge Representation and Reasoning for Multi-agent Systems, bilateral project, 2006
- Multiagent systems for dynamic scene interpretation, Ministry of science, education and sports, 2002-2006
- System for object state diagnostics based on multispectral image analysis, Ministry of science, education and sports, Technology project, 2004–2005

Autonomous Mobile Robotics (AMOR)

Director: Ivan Petrović
Members: Marija Đakulović, Andrej Kitanov, Ivan Marković, Igor Cvišić, Ivan Maurović, Domagoj Herceg
Web: http://act.rasip.fer.hr/groups_amor.php

Autonomous Mobile Robotics (AMOR) group is a part of the Department of Control and Computer Engineering, Faculty of Electrical Engineering and Computing, University of Zagreb. It is intensively researching autonomous navigation of mobile robots in unknown dynamic environments, mobile manipulation, cooperative robot-robot and human-robot systems and robot embodiments in the iSpace. Various methods from control theory and estimation, sensor fusion as well as the artificial intelligence have been successfully applied. AMOR group currently consists of 3 Postdoc and 5 PhD students directed by prof. Ivan Petrović. AMOR group has available a lot of equipment, including mobile platforms, lightweight manipulators and many advanced sensors for environment perception. The group is active in several national and international research projects.

Projects:

- ACROSS – Centre of Research Excellence for Advanced Cooperative Systems, European FP7 project, 2011-2014
- ThermalMapper – Thermal 3D Modeling of Indoor Environments for Saving Energy, SEE-ERA.NET Plus, Joint European Research Project, 2010–2012
- Thermal Perception, Mapping and Exploration of Environments for Energy Efficiency, Ministry of science, education and sports and DAAD, 2012–2014
- Intelligent robot systems and autonomous vehicles. Ministry of science, education and sports, 2007–2011
- Navigation of mobile robots in unknown dynamic environments, Ministry of science, education and sports, 2007–2011

Faculty of Transport and Traffic Sciences Computer Vision Group (FTTS-CVG)

Director: Hrvoje Gold
Members: Edouard Ivanjko, Niko Jelušić, Marko Ševrović, Kristian Kovačić

The Faculty of Transport and Traffic Sciences Computer Vision Group conducts research regarding theory and application of image processing for problem solving in the area of road traffic and transport. Members of the group are from different technical areas (computer science, control theory, robotics, traffic science) ensuring high interdisciplinary benefits for problem solving. The main research problems include image feature extraction, image segmentation, object recognition, object tracking, and video geo-referencing. Research results obtained individually and in collaboration with other similar research groups include origin-destination matrices extraction from road intersection video footage, measurement of traffic parameters using one camera for multiple lanes, video geo-referencing for road evaluation, mobile robot vision based localization for automatized odometry calibration applications, traffic sign detection including geo-referencing, algorithms for hyperspectral imaging and airborne multisensory remote sensing system development. FTTS-CVG group is equipped with a vehicle (Mercedes-Benz Viano) for road inspection consisted of four 1080p HD cameras (three front cameras for traffic sign and road-side infrastructure evaluation, and one rear view camera for road surface inspection), DGPS sensor and Dynamic Retroreflectiometer for road horizontal signalization assessment. Vehicle on-board equipment enables recording in H.264 FullHD video at 30 fps, progressive scan for further off-line examination. The system is equipped with Inspection System software. Group has access to airborne multisensory remote sensing system that consists of imaging (RGB, near-infrared, thermal, hyperspectral) and GPS/IMU sensors. Additionally, the group is equipped with several cameras for road traffic surveillance and measurement of traffic parameters (flow, vehicle classification, vehicle trajectory estimation).

Projects:

- Computer vision innovations for safe traffic VISTA, IPA IIIc, 2013–
- iRAP - EuroRAP – Road safety assessment programme, National program for road safety of Republic Croatia, 2009–
- Mapping and Assessing the State of Traffic Infrastructure, Croatian science foundation, and Institute of transport and communications, Zagreb, Croatia, Graz University of Technology, 2008–2011
- Control of mobile robots and vehicles in unknown and dynamic environments, Croatian Ministry of Science and Technology, 2007–2012
- OptaGIS – GIS based transport infrastructure management system, Institute of transport and communications, Zagreb, Croatia, and Faculty of Transport and Traffic Sciences, Zagreb, Croatia 2005–
- System for the multisensory airborne reconnaissance and surveillance in the crisis and the protection of environment, Croatian Ministry of Science and Technology, 2007–2008

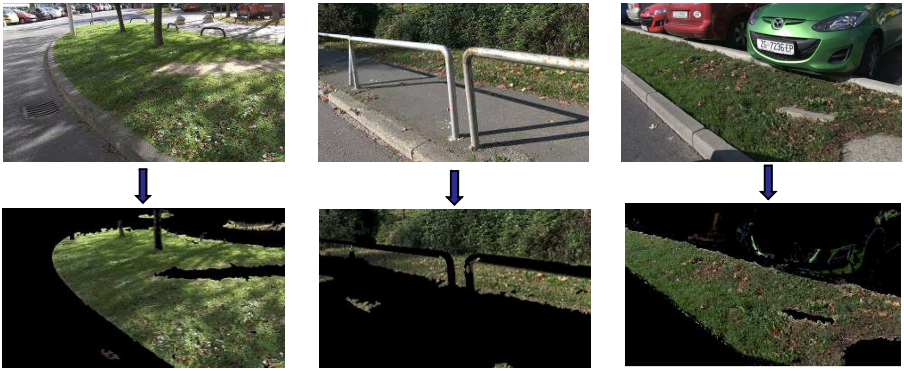
Automatic image color correction

The aim of this research is to remove the influence of illumination on image colors. The algorithm has to estimate the illumination and then perform chromatic adaptation to remove the illumation influence. The brightness of every pixel is adjusted according to its local neighborhood. The operations are performed using various subsampling techniques without loss of quality. Potential applications include: image enhancement for making the images more appealing; digital camera color constancy by performing a fast and accurate illumination estimation; and tone mapping for dynamic range compression.

The effect of white balance and brightness adjustment.

Detection of road side vegetation

It is necessary for autonomous vehicles to understand the environment in which the vehicle is located. This includes the detection of a variety of typical objects (e.g. traffic signs) using a video camera. There is very little research done in detection of other objects located along the road. The purpose of detecting roadside vegetation is increasing traffic safety. The intention is to achieve a successful detection using a single color camera mounted on a vehicle. Potential applications include advanced driver assistance for preventing traffic accidents; avoidance of vegetation-based obstacles; guidance of service vehicles in maintenance tasks (mowing the grass, etc.); and off-road navigation as additional information in navigation systems of autonomous vehicles.



Examples of vegetation detection results.

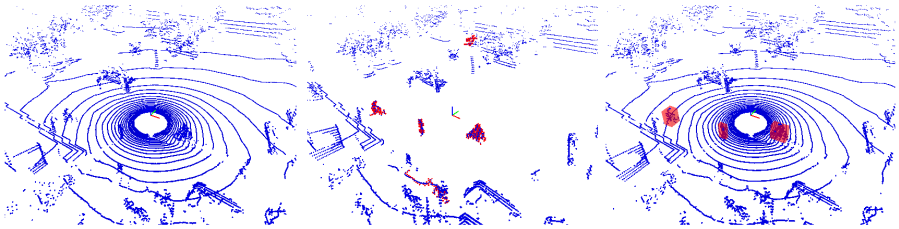
Automatic headlight detection

The objective of this research is developing robust algorithms for automatic vehicle headlight detection and tracking. To that end various image processing methods are used for improving the input image and extracting image features. Machine learning is used to learn approprate detectors able to discriminate light blobs representing vehicle lights from other nuisance lights such as street lights. Potential applications include: automatic vehicle headlight control or dimming; and forward collision warning.

On-road night-time vehicle headlight detection and tracking.

Lane departure and collision warning

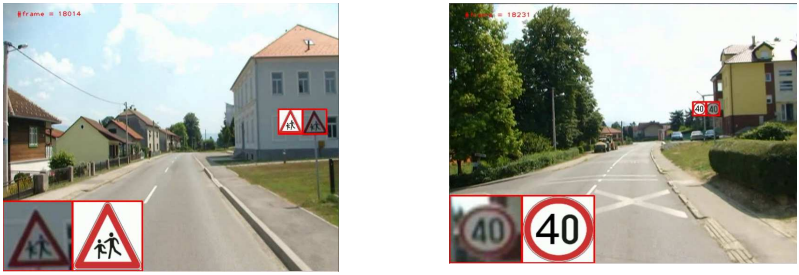
The aim of this research is to develop robust algorithms for detecting moving objects based on laser range sensor scans or omnidirectional camera acquisition. The moving objects in the surrounding of a vehicle have to be extracted and tracked in order to predict their future states. The results can be used in Advanced Driver Assistance Systems to inform the driver about potential collision points and generate a warning if necessary. The information can be used to initiate autonomous breaking in high risk situation or even for autonomous driving.



Moving objects detection.

Traffic sign detection and recognition

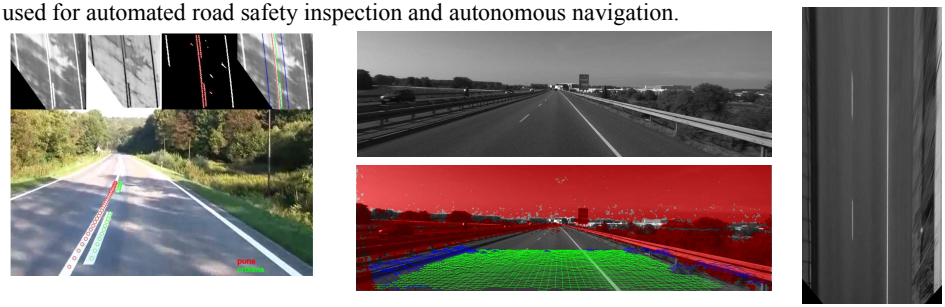
In Advanced Driver Assistance Systems (ADAS), there is a need for designing a system for the localization, tracking and classification of traffic signs in the vicinity of the vehicle. The goal is to maximize the safety of the passengers inside the vehicle and all other traffic participants. Also, a pipeline consisting of traffic sign localization, classification and tracking has application in autonomous vehicles and in mapping and assessing the state of traffic infrastructure. The aim of traffic sign localization, within frames in video sequences, is to determine regions of interest where is a potential candidate of traffic sign. Traffic sign classification methods classify discovered traffic sign candidates into specific predetermined classes or super-classes.



"Children on the road" and "speed limit" traffic sign detection and recognition example.

Lane detection and recognition

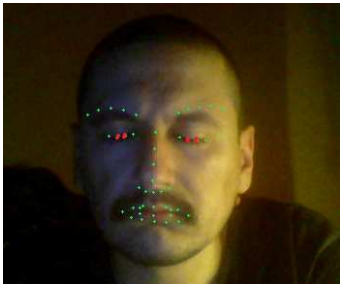
The main goal of lane detection in driver assistance systems is to assess and warn the drivers to coordinate they driving with the horizontal road signalization. Such capability could considerably diminish the rate of a specific road accident type which is known as single vehicle road departure. It should also warn a distracted driver that (s)he is about to perform a dangerous manoeuvre. There are two main types of systems relying on lane detection. The operation of lane departure warning systems is limited to alerting the driver when the vehicle is about to leave the current lane, and are therefore similar to the raised strips on road surface markings which create strong vibrations when a vehicle drives over. On the other hand, the operation of lane keeping system is more ambitious. When the driver performs no action to prevent lane departure such systems assume vehicle control in order to prevent a possible accident. Besides the driver assistance, lane detection could also be used for automated road safety inspection and autonomous navigation.



Lane detection and obstacle detection from dense stereo reconstruction examples.

Automatic driver fatigue monitoring

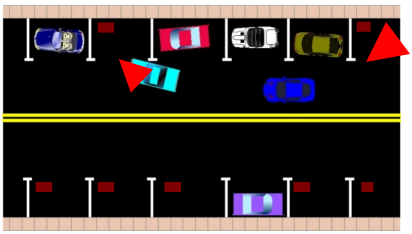
State-of-the-art technologies in computer vision and knowledge-based systems allow the non-intrusive extraction of visual bio-behavioural characteristics that typically characterize a driver's level of fatigue from his/her video images and design an intelligent warning system that is tailored to the specific biological characteristics of the individual. The aim of this task is to develop a reliable real-time system for monitoring driver fatigue and drowsiness in order to reduce the number of traffic accidents.



Facial features retrieved by supervised gradient descent method.

Methodology for testing and evaluation

In this task we aim to define experiments which will be used for achieving proof-of-concept evaluation of seven developed driver assistance systems. Experiments and testing require scenarios and criteria for quantitative measurement and comparison. Expected goals are: overview of possible computer vision techniques, algorithm for detecting vehicles and estimating their motion, method for estimation of departure and destination matrix, system architecture for road traffic management and the laboratory setup for testing developed algorithms.



Examples of execution of algorithms.

IB1 – Ministry of Science, Education and Sports
Web: www.mzos.hr
E-mail: znanost@mzos.hr

IB2 – Central Finance and Contracting Agency
Web: www.safu.hr
E-mail: info@safu.hr

More information can be found at www.strukturnifondovi.hr.

The contents of this publication are the sole responsibility of the University of Zagreb, Faculty of Electrical Engineering and Computing and do not necessary reflect the views of the European Union.

This project is conducted by the Ministry of Science, Education and Sports.

Total value of the project - 685.265,45 EUR
EU contribution - 573.841,29 EUR

University of Zagreb

Faculty of Electrical Engineering and Computing
fer.unizg.hr
Faculty of Transport and Traffic Sciences
fpz.unizg.hr

vista.fer.hr

CVC
COMPUTER VISION CENTER

Investing in future!

Ministry of Science, Education and Sports

This action is co-financed by the European Union from the European Regional Development Fund