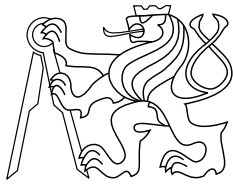




CENTER FOR
MACHINE PERCEPTION



CZECH TECHNICAL
UNIVERSITY

ACTIVITY REPORT

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1 Executive summary

The Center for Machine Perception (abbreviated CMP) is a research unit active in the fields of computer vision, pattern recognition, and mathematical modeling of uncertainty. The CMP, established in 1996, is a part at the Department of Cybernetics of the Czech Technical University (CTU), Prague. CMP is funded partially by the CTU and through a number of national, European and industrial grants.

Main CMP research interests lie currently in the following areas:

	<i>contact person</i>	<i>more info</i>
◆ reconstruction of scenes from multiple images	T. Pajdla	Sec. 3.1
◆ omnidirectional vision, non-classical cameras	T. Pajdla	Sec. 3.2–3.3
◆ physics-based vision	O. Drbohlav	Sec. 3.4
◆ stereo matching	R. Šára	Sec. 3.5
◆ object recognition and image retrieval	J. Matas	Sec. 3.7–3.8
◆ pattern recognition, genomic informatics	V. Hlaváč	Sec. 3.9, 3.12
◆ nonlinear diffusion filtering	P. Mrázek	Sec. 3.10
◆ quantum and fuzzy logic, digital topology	M. Navara	Sec. 3.11

Achievements in 2001:

- ◆ CMP participates in Fifth Framework EU Projects: OMNIVIEWS No. IST-1999-29017 (T. Pajdla), ActIPret IST-2001-32184 (V. Hlaváč).
- ◆ CMP has become part of MIRACLE (Machine Intelligence Research and Application Centre for Learning Excellence), funded by an EU grant No.: ICA1-CT-2000-70002 under the "Centres of Excellence" programme.
- ◆ A contract on face verification technology signed with Samsung Electronics Co., Ltd. (J. Matas).
- ◆ M. Navara received the DrSc degree (Doctor of Science).
- ◆ P. Mrázek defended his PhD thesis on "Nonlinear Diffusion for Image Filtering and Monotonicity Enhancement".
- ◆ CMP PhD graduates accepted the following positions: T. Svoboda (ETH Zurich, Switzerland), T. Werner (University of Oxford, U.K.), M. Urban (Vision Wizards Ltd., Guildford, U.K.).

Scientific output, summary of main results obtained in 2001:

Computer vision. A theory of non-central cameras and multiple non-central images has been created [69, 75]. Projective reconstruction by factorization for perspective images with occlusions has been developed [47]. New constraints between multiple images of points and lines were found by considering orientation of camera rays [90, 92]. It was shown that photometric stereo with uncalibrated light directions gives metric reconstruction of normals when separability of reflectance is employed [22].

Mathematical modeling of uncertainty. Investigation of measures on quantum and fuzzy logics continued and results were published in top international journals [19]. A substantial progress was made in the study of fuzzy arithmetic [67] and satisfiability and compactness properties of fuzzy logics [63].

Consultancy and research and development for the industry (e.g. Samsung, Korea, Airforce Research Institute, Czech Republic) has been performed by the CMP. Our expertise is channelled to the industry via Neovision, a spin-off company specialising in machine vision. For successful applications, see <http://www.neovision.cz>.

For more information about the CMP and on-line **publications**, see <http://cmp.felk.cvut.cz>
Demos of our research are available at <http://cmp.felk.cvut.cz/demos/>

2 The CMP Research Group

The CMP group comprises fifteen members of academic and research staff (two part-time), eleven full-time PhD students, a group administrator and a system manager. Since September 2000, T. Svoboda has been on a 3-year leave with Prof. L. Van Gool's group at ETH Zurich. In 2001, K. Hanton and J. Paleček became members of the staff to work on two EU funded research projects.

Academic and Research Staff

Prof. Václav Hlaváč	head, professor		
Prof. Pavel Pták, DrSc.	professor (part time)		
Dr. Mirko Navara, DrSc.	senior lecturer		
Ondřej Drbohlav	lecturer	Jan Paleček	research fellow
Karel Hanton	research fellow	Vladimír Smutný	lecturer
Pavel Krsek	research fellow	Dr. Radim Šára	research fellow
Dr. Jiří (George) Matas	research fellow	Dr. Tomáš Svoboda	lecturer (on leave)
Dr. Pavel Mrázek	research fellow	Dr. Martin Urban	research fellow (part time)
Tomáš Pajdla	lecturer	Vít Zýka	research fellow
Eva Matysková	group administrator		
Daniel Večerka	system administrator		

Doctoral students

	<i>supervisor</i>	<i>proposed thesis title</i>
Hynek Bakstein	V. Hlaváč	3D reconstruction
Petr Bílek	J. Matas	Illumination-invariance in object recognition
Ondřej Chum	J. Matas	The correspondence problem
Jan Dupač	V. Hlaváč	Gene expression analysis using pattern recognition techniques (on leave in Hitachi Japan since Oct. 2001)
Vojtěch Franc	V. Hlaváč	Learning in statistical pattern recognition
Rostislav Horčík	M. Navara	Mathematical properties of fuzzy logics
Jana Kostková	R. Šára	Stereoscopic matching
Daniel Martinec	M. Navara	3D reconstruction
Martin Matoušek	V. Hlaváč	Correspondence in dense sequences
Branislav Mičušík	V. Hlaváč	Omnidirectional cameras
Štěpán Obdržálek	J. Matas	Object recognition
<i>part time students</i>		
Jan Buriánek	J. Matas	Appearance-based recognition
Ondřej Drbohlav	R. Šára	Physics-based surface features for computer vision
Pavel Krsek	V. Hlaváč	Differential surface characteristics
Jan Vydržel	V. Hlaváč	Improving correspondence algorithms
Vít Zýka	R. Šára	Shading consistency analysis for local shape modeling

2.1 CMP Scientific Advisory Board

The role of the CMP Scientific Advisory Board is to comment on CMP scientific goals and research results and to advise on future directions of research. The scientific advisory board consists of:

Prof. Ruzena Bajcsy	University of California, Berkeley, USA
Prof. Josef Kittler	University of Surrey, U.K.
Prof. Walter Kropatsch	Vienna University of Technology, Austria
Prof. Jan Uhlíř	Faculty of Electrical Engineering CTU Praha, Czech Republic
Prof. Shimon Ullman	Weizmann Institute, Israel
Prof. Luc Van Gool	Catholic University Leuven, Belgium
Prof. Vladimír Mařík	Head of the Dept. of Cybernetics, CTU, Czech Republic

CMP group (in alphabetical order)



Hynek Bakstein



Petr Bílek



Ondřej Chum



Ondřej Drbohlav



Jan Dupač



Vojtěch Franc



Karel Hanton



Václav Hlaváč



Rostislav Horčík



Jana Kostková



Pavel Krsek



Daniel Martinec



Jiří (G.) Matas



Martin Matoušek



Eva Matysková



Branislav Mičušík



Pavel Mrázek



Mirko Navara



Štěpán Obdržálek



Tomáš Pajdla



Jan Paleček



Pavel Pták



Vladimír Smutný



Tomáš Svoboda



Radim Šára



Martin Urban



Daniel Večerka



Vít Zýka

3 Research

3.1 Reconstruction of 3D scenes from multiple images

A generalization of projective reconstruction by factorization for perspective images with occlusions has been proposed [46, 47].

A closed form solution in the form of an algebraic equation of degree eight for the geometrical error between noisy points related by a planar homography has been derived [14, 15, 16] and the geometrical error has been compared to a commonly used linear approximation.

An unifying approach to wide-baseline stereo correspondence problem based on the randomized version of the hypothesis–verification paradigm has been proposed [52, 49].

The theoretical analysis of the correspondence in dense sequences of images was proposed in [53] and tested the idea in real-world setup.

Related links:



3D reconstruction demos

<http://cmp.felk.cvut.cz/demos/Reconstruction.html>

- ◆ Recx Matlab toolbox: <http://cmp.felk.cvut.cz/cmp/recx>

3.2 Omni-directional vision

The analysis of epipolar geometry of catadioptric panoramic cameras has been finished and published in a monograph of panoramic vision [79]. The transformation of corresponding image windows between catadioptric panoramic images has been studied and a correct correlation-based correspondence search between panoramic catadioptric images has been proposed [89]. A point triangulation based on panoramic images has been studied [21].

We studied the orientation of rays of cameras. It has been shown that orientation of rays has to be considered when dealing with omnidirectional images [91, 90] and that new constraints between images can be constructed [92].

We started the analysis of omnidirectional cameras for mosaicing [5] and derived the relationship between coordinates of the reconstructed and real points [2, 3]. A model of wide-angle lens suitable for mosaicing and its calibration has been proposed [4].

We worked out a method for computing mirror shapes to obtain catadioptric cameras with desired course of resolution across the view-field [34, 32, 77, 77, 54] and build various mirrors for a uniform resolution cameras with standard and log-polar arrangements of pixels. A uniform resolution panoramic camera has been demonstrated in a surveillance application [33].

Localization for a mobile robot from panoramic images has been studied. An Image based compass has been proposed in [78] and the use of special spatial fiducials has been studied in [73, 70].

3.3 Non-central cameras

We were the first to propose a new paradigm in Computer Vision, namely to study non-central cameras [69, 74], which are the cameras that do not have a single projection center, and to build a theory of multiple non-central images. We have provided a generalization of epipolar geometries for non-central cameras and characterized those cameras that possess it [69, 68, 72, 71]. We described an extreme case of non-central cameras that possess a generalized epipolar geometry and sees all points in space exactly once [75, 76].

3.4 Physics-based vision

The study of reflectance mechanisms was continued and it was shown that the inherent symmetries of reflectance models which are separable with respect to the viewing and illumination directions enable

to design two geometrical constraints on normals. The two constraints represent projections of normals onto planes perpendicular to the viewing and illumination directions, respectively. Experiments were conducted on dielectric objects, where the reflectance was modeled as Lambertian, while the two new constraints were constructed from polarization measurement. The constraints were then used to remove the inherent ambiguity of uncalibrated Lambertian photometric stereo [22, 23].

3.5 Stereoscopic Matching

We generalized our preliminary results on stable matching [81] to Sigma-Delta Stable Matching [80]. Existence and uniqueness theorem was proven and an algorithm has been suggested and proven. A version of the general $\sigma\delta$ -stable matching called Confidently Stable Matching proved on real and artificial scenes that stable matchings show very low mismatch rate. Confidently stable matching uses confidence intervals instead of single-valued correlations. Stability ensures ambiguous matches are rejected.

3.6 Sonographic Image Analysis

We studied the problem of constructing optimal texture features for segmented sonographic image recognition problem. We have shown that it is possible to construct n th-order feature vector that has the following property: no other feature vector of the same or lower dimension can achieve better recognition success rate [82].

We achieved 8.1% leave-one-out error using fourth-order features on the set of 37 subjects. The results were later confirmed on the set of 100 subjects achieving 12.3% LOO error with the optimal features constructed from the set of 37 subjects (unpublished).

3.7 Wide-baseline Stereo

In [52], the concept of distinguished region was introduced and formally defined. Two new types of distinguished regions, the Separated Elementary Cycles of the Edge Graph (SECs) and the Maximally Stable Extremal Regions were proposed. In experiments on indoor and outdoor image pairs good estimates of epipolar geometry were obtained on challenging wide-baseline problems. Locally fully affine distortions and significant occlusion were present in the tests.

3.8 Face Recognition

Face verification algorithms based on a fast implementation of Support Vector Machines were tested on dataset provided by Samsung, Korea [50, 43, 31].

J. Matas participated in the development (at the University of Surrey) of a face identity verification using the ECOC (Error Correcting Output Codes) technique [41, 42, 40]. State of the art results were obtained on XM2VTS, a large, publicly available database.

A framework for robust human face localization with minimal amount of constraints on scene conditions (illumination, head pose etc.) and facial expressions has been suggested. The appearance of the face is modeled locally in terms of discriminative regions and their spatial relationship. Most of the free parameters are learned from training examples and as little as possible information from a human expert is needed. [12, 10]

3.9 Pattern Recognition

The collaborative effort with Prof. M. I. Schlesinger from the Ukrainian Academy of Sciences in Kiev resulted in a monograph [84]. An English edition manuscript was submitted to the Kluwer Academic Publishers, The Netherlands, at the end of 2001 and should appear in 2002.

We contributed to Schlesinger's algorithm separating Mixtures of Gaussians [27]. We extended the efficient Schlesinger–Kozinec algorithm finding maximal margin linear classifier to the non-linear and non-separable case [30].

The Statistical Pattern Recognition toolbox is continuously updated [28]. The Markovian chains toolbox in Matlab was extended [25].

Related links:

- ◆ Statistical Pattern Recognition toolbox:
<http://cmp.felk.cvut.cz/~xfrancv/stprtool/>
- ◆ Hidden Markov Models toolbox:
http://cmp.felk.cvut.cz/~xdupac/DHMM_toolbox/

3.10 Nonlinear diffusion filters

Pavel Mrázek summarized his research of nonlinear diffusion for data restoration in the PhD thesis [56], defended in December 2001. The main contributions consist of a generalization of nonlinear diffusion for piecewise linear or piecewise monotone data [58], study of discrete numerical methods for anisotropic nonlinear diffusion [59], and a new method to estimate a good stopping time (i.e. a good regularization parameter) for nonlinear diffusion [57].

Related links:



Nonlinear diffusion demos

<http://cmp.felk.cvut.cz/demos/ImageProcessing.html>

3.11 Mathematical studies of descriptions of uncertainty

The investigation of uncertainty continued in the directions of basic and applied research.

The study of convex properties of measures on quantum logics, in particular their decompositions generalizing classical notions, has brought substantial progress in [19].

We succeeded in generalization of the classical Cantor–Bernstein theorem to structures appearing in quantum logics [20] and fuzzy logics [17].

Generalization of satisfiability of a set of formulas from classical to fuzzy logic is studied in [39]. This lead to analogues of compactness theorems in fuzzy logics [63].

Practical applications of fuzzy arithmetic appeared to brought difficulties in the implementation of so called constrained fuzzy arithmetic (introduced by G. Klir). We classified these problems and suggested methods for their efficient solution in a relatively general context [67].

A new type of fuzzy controller was suggested and tested [66].

3.12 Other research results

A cooperation with the Hitachi Central Research Institute Tokyo, Biosystems Department continues. Doctoral student J. Dupač has been there as a visiting researcher since October 2001 (for one year in total).

A photogrammetric method for measuring breathing movements was proposed and preliminary tested as a preparation for a three-year project in cooperation with the Postgraduate Medical School and Faculty of Physical Education and Sports, both in Prague [83].

Sonographic image alignment was proposed and tested for myocardial contrast echocardiography [26] as a proof of concept.

In [35], gradient direction constraint was studied within in the *Progressive Probabilistic Hough Transform* (PPHT) framework.

4 Projects

ActIPret

Interpreting and Understanding Activities of Expert Operators for Teaching and Education



Duration: November 2001 – October 2004

Investigators: Václav Hlaváč, Jiří (George) Matas, Jan Paleček

Funding: European Union IST-2001-32184, 257K EUR for the whole 3-year project

Objectives: The objective of ActIPret (Activity InterPretation) is to develop a vision methodology and system that interprets, understands and records the activities of persons handling tools. The focus is on the active observation and interpretation of the activities, on parsing the sequences into constituent behaviour elements, and on the extractivity of the essential activities and their functional dependence.

Partners:

- ◆ Institute of Flexible Automation, Vienna University of Technology, Vienna, Austria.
- ◆ University of Sussex, School of Cognitive and Computing Sciences, Brighton, UK.
- ◆ FORTH–Foundation for Research and Technology, Heraklion, Greece.
- ◆ PROFACTOR Produktionsforschungs GmbH, Steyr, Austria.

Czech-Chinese project

Computer Vision Based 3D Scene Reconstruction and Visualisation

Duration: January 2001–December 2004

Investigators: Václav Hlaváč, Jiří (George) Matas, Tomáš Pajdla, Vladimír Smutný, Radim Šára

Funding: Czech Ministry for Education, 250K Kč (US\$ 7K) (in 2001)

Objectives: The aim is to conduct joint research in 3D vision and establish academic links between both institutions and countries.

Partner: Chinese Academy of Sciences, Institute for Automation, National Laboratory for Pattern Recognition, Beijing, China.

Geometry and Appearance of a 3-D Scene Based on a Large Set of 2-D Images



Duration: January 2000 - December 2002

Investigators: Václav Hlaváč, Tomáš Pajdla, Radim Šára, Martin Urban, Tomáš Werner.

Funding: Czech Grant Agency, Grant No. 102/00/1679, 482K Kč (US\$ 13K) (in 2001)

Objectives: The project studies reconstruction of 3-D scenes from several views. The interest is in:

- ◆ minimizing errors in the reconstruction by providing more than three views,
- ◆ studying the correspondence problem in dense sequence of images,
- ◆ unifying various reconstruction methods in the developed toolbox RECX (publicly available).

Physics Based Computer Vision



Duration: January 2001 - December 2003

Investigators: Radim Šára, Ondřej Drbohlav, Vladimír Smutný

Funding: Grant Agency of the Czech Republic, Grant No. 102/01/1371, 629K Kč (US\$ 17K) (in 2001)

Objectives: The goals of the project are: (1) shape reconstruction based on reflectance symmetries for a broad class of surfaces, (2) intrinsic surface texture (spectral albedo map) reconstruction, (3) reflected light component separation, and (4) the application of these methods in accurate geometric stereo.

OMNIVIEWS

Omni-directional Visual System



Duration: September 2000 - September 2001

Investigators: Tomáš Pajdla, Hadas Roth, Stefan Gächter, Branislav Mičušík

Funding: European Union IST-1999-29017, 35K EUR

Objectives: The goal of the project is to integrate optical, optoelectronic, hardware, and software technology to realize a smart visual sensor, and to demonstrate its utility in key application areas. In particular our intention is to design and realize a low-cost, miniaturized digital camera acquiring panoramic (360 deg) images and performing a useful low-level processing on the incoming stream of images in real-time. Target applications include surveillance, quality control and mobile robot and vehicle navigation.

Partners:

- ◆ LIRA-Lab, DIST - University of Genoa, Italy
- ◆ CMP, Czech Technical University in Prague, Czech Republic
- ◆ IST/ISR, Instituto Superior Técnico, Lisboa, Portugal

Photogrammetry Method for Measurement and Analysis of Lower Jaw Motion in Temporo-Mandibular Joint



Duration: June 2000 – December 2002

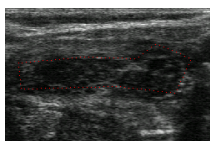
Investigators: Vladimír Smutný, Radim Šára

Funding: Ministry of Health of the Czech Republic, NN6333-3/2000, 305K Kč (US\$ 8K) (in 2001)

Objectives: The project aims to build a system for measuring the shape of a jaw joint.

Partner: Institute of Dental Research, Prague

Texture Analysis of Sonographic Images for Endocrinopathies and Metabolic Diseases



Duration: January 1999 - December 2001;

Investigators: Petr Sucharda (Charles University), Daniel Smutek (Charles University), Radim Šára, Martin Švec (student).

Funding: Ministry of Health of the Czech Republic, NB 5472-3, funding through Charles University

Partner: 1st School of Medicine, Charles University Prague

Objectives: The goal of the project is to aid the diagnosis of diffusion processes in thyroid gland parenchyma, which is currently done (a) subjectively from a sonogram and/or (b) quantitatively by a laboratory immunological, hormonal, and metabolic sample analysis. In the project, we aim (1) to help diagnose the various parenchyma conditions based solely on the sonogram texture analysis and (2) to attempt a correlation analysis between standard laboratory measurements and the quantitative properties of the visual texture of the sonograms.

Presentation of Department of Cybernetics at the Brno International Engineering Fair



Duration: January 2000 – December 2002

Investigators: Vladimír Smutný

Funding: Czech Ministry of Education, LP0042 125K Kč (US\$ 3K) in 2001

Partners: Certicon a.s., Neovision s.r.o.

Objectives: The aim of the project is to present our department at Brno International Engineering Fair. The CMP was already present on the fair from 1997. We obtained the financial support for three years.

5 Consultancy, Applied R & D, Industrial Applications

Samsung, Korea

Duration: 2001

Investigators: Jiří (George) Matas, Vojtěch Franc

Funding: 1800K Kč (US\$ 50K)

Objectives: Face verification technology (in cooperation with the University of Surrey, UK).

Air Force Research Institute Prague, Czech Republic

Duration: 2001

Investigators: Jiří (George) Matas, Radim Šára, Vít Zýka, Pavel Mrázek, Vladimír Smutný

Funding: 150K Kč (US\$ 4K)

Objectives: Image processing and computer vision methods suitable for autonomous plane reconnaissance were analysed.

RAKO, Czech Republic

Duration: 2001

Investigators: Vladimír Smutný, Radim Šára, Vít Zýka, Pavel Krsek

Funding: 63K Kč (US\$ 2K)

Objectives: The method based on the photometric stereo was developed for 3D reconstruction of relief on the floor tile models.

Neovision, Czech Republic

Duration: long term

Funding: 34K Kč (US\$ 1K) in 2001

Investigators: Tomáš Pajdla, Vladimír Smutný, Daniel Večerka

Description: Neovision s.r.o. (www.neovision.cz) is a small machine vision company closely associated with CMP. Neovision s.r.o. uses CMP facilities for special measurements and consults CMP members.

Institute of Criminalistics, Prague, Czech Republic

Duration: 1999-2001

Funding: 15K Kč (US\$ 0K) (in 2001)

Investigators: Vladimír Smutný, Pavel Krsek

Description: CMP scans human skulls of recovered bodies for research in identification of missing people.

6 Facilities and Equipment

The CMP has good facilities for controlled image acquisition and precise radiometric and colorimetric measurements. These include

- ◆ a four meter optical bench
- ◆ two optical tables
- ◆ a wide range of cameras:

<i>make/type</i>	<i>number</i>	<i>properties</i>
EPIX / Silicon Video 2112C	1	1300 × 1000, 0-30-1000fps, 3 × 10 bit, color, digital
VDSVosskühler / Cool-1300	2	1300 × 1000, 12.5fps, 12 bit, cooled, digital
Pulnix / TM 1000	1	1000 × 1000, 15fps, 8 bit, digital
Pulnix / TM 9701	6	760 × 480, 30fps, 8 bit, digital; custom built synchronization hardware allows synchronous acquisition
Santa Barbara Instr. / SB-7	1	640 × 480, 0.1fps, 16 bit, cooled, digital
Hitachi / HV-C20	1	768 × 576, 25fps, 3 × 8 bit, color analog
Canon / PowerShot G2	1	2270 × 1704, 3 × 8 bit, color
Nikon / Coolpix 950	1	1600 × 1200, 3 × 8 bit, color; fish eye lens 0°–360° by 0°–91°

- ◆ an industrial microscope to measure objects with size in the range of 2–50 mm
- ◆ two panoramic cameras utilizing convex mirrors which provide view angles about 360° × 110°
- ◆ digital camcorder Canon XM-1 allows capturing video sequences outdoor and indoor; video editing card Matrox RT-2000

Three rangefinders are in routine use: a laser plane rangefinder (resolution 0.2 mm), one-shot binary coded rangefinder (resolution 64 × 80 points, video frame rate acquisition) and a laser plane range finder carried by a six degree of freedom manipulator. Four-camera synchronised stereo vision system with stereo matching and surface reconstruction software is installed in the laboratory. Panoramic camera and a video radio link were added to an autonomous vehicle that was built by the group.

CMP computing facilities comprise 30 computers connected to the university-wide network (ATM). Besides two Silicon Graphic workstations (Indigo² and Indy) all the computers are high-end PCs running either Linux or MS Windows 9x/NT. Four new powerful portable computers were bought in 2001.

The CMP equipment includes a postertime colour printer HP DesignJet 755CM, the HP ScanJet 6100C scanner and a film scanner Nikon LS-30. For more detailed information on CMP equipment, visit <http://cmp.felk.cvut.cz/cmp/hardware> .

7 Teaching

In 2001, CMP members taught the following courses:

<i>Course name</i>	<i>level^a</i>	<i>language</i>	<i>lecturer</i>
Mathematical logic	MSc/1	CZ	P. Pták
Introduction to algebra	MSc/1	ENG	P. Pták
Mathematics 4 [complex functions, probability, first order differential equations]	MSc/2	ENG	P. Pták
Robotics	MSc/4	CZ	V. Smutný
Computer vision for informatics	MSc/4	CZ	T. Pajdla
Signal and image processing	MSc/4	ENG, CZ	V. Hlaváč
Pattern recognition	MSc/4	CZ	J. Matas
Mathematics 6F [statistics and fuzzy logic]	MSc/4	CZ	M. Navara
General systems theory	MSc/5	CZ	R. Šára
Computer vision and virtual reality	MSc/5	CZ	V. Hlaváč
Intelligent robotics	MSc/6	CZ	T. Pajdla
Introduction to computer vision and pattern recognition [for students of the Faculty of Mathematics and Physics, Charles University in Prague]	MSc/1-5	CZ	V. Hlaváč
Numerical methods	MSc/1-5	CZ	M. Navara
Mathematics for cybernetics	PhD	CZ	P. Pták
Introduction to computer vision	PhD	CZ	V. Hlaváč
Pattern recognition	PhD	CZ	V. Hlaváč
3D computer vision	PhD	CZ	R. Šára

^aIndicates whether the course is intended for PhD or MSc students. For MSc courses, the marker is followed by the recommended year.

Currently, the CMP offers students the opportunity to study abroad for periods ranging from 3 weeks to 10 months. The receiving institutions are image processing laboratories in Finland, the United Kingdom, Austria, Slovenia and the Netherlands. A full list, with details on funding, is available at

<http://cmp.felk.cvut.cz/cmp/opport.html>

CMP members participated in the following teaching-related project:

Fuzzy Control and Fuzzy Logic

Basic facts: Coordinator Radko Mesiar (Slovak Technical University in Bratislava, Slovakia), contact person at CTU Mirko Navara, CEEPUS network, No. SK-042; funds in 2001 72K Kč (US\$ 2K); started September 1995, ends August 2002.

Project topic: Coordination of education in fuzzy control and fuzzy logic, mobility of teachers, undergraduate and postgraduate students.

Miscellaneous: Participating institutions: Slovak Technical University (coordinator); Technical University of Budapest, Hungary; Linz University, Austria; Ostrava University in Ostrava, Czech Republic. Technical University Cracow, Poland.

8 Visits to CMP

(ordered by the length of the visit)

name	institution	duration
Marshall David A.	University of Wales College of Cardiff, UK	7 weeks
Khachaturov Georgii	Universidad Autónoma Metropolitana - Azcapotzalco, Mexico	7 weeks
Chetverikov Dmitri	Computer and Automation Institute, Hungary	6 weeks
Špaček Libor	University of Essex, UK	6 weeks
Zuzana Krivá	Slovak Technical University, Bratislava, Slovakia	4 weeks
Hagedoorn Michiel	Max-Planck-Institut für Informatik, Germany	7 days
Glantz Roland	TU Wien, Austria	5 days
Pollefeys Marc	Katholieke Universiteit Leuven, Belgium	5 days
Reulke Ralf	Deutsches Zentrum für Luft- und Raumfahrt, Berlin, Germany	5 days
Kittler Josef	University of Surrey, UK	5 days
Eklundh Jan-Olof	Royal Institute of Technology, Sweden	5 days
Granlund Gösta H.	Linköping University, Sweden	5 days
Zisserman Andrew	University of Oxford, UK	5 days
Bruckstein Alfred	Technicon, Israel	5 days
Schmitt Francis	Ecole Nationale Supérieure des Télécommunications, France	5 days
Krawiec Krzysztof	Poznań University of Technology, Poland	5 days
Fischer Robert	University of Edinburgh, UK	5 days
Mundici Daniele	University of Milan, Italy	5 days
Kämpke Thomas	FAW Ulm, Germany	4 days
Umemura Shin-ichiro	Hitachi Central Research Laboratory, Japan	4 days
Buxton Hilary	University of Sussex, Brighton, UK	4 days
Leonardis Aleš	University of Ljubljana, Slovenia	4 days
Jones Gerald	WRc plc, Wiltshire, UK	3 days
Bischof Horst	TU Wien, Austria	3 days
Jahn Herbert	Deutsches Zentrum Luft- und Raumfahrt, Berlin	3 days
Kenmochi Yukiko	Japan Advanced Institute of Science and Technology, Japan	3 days
Vincze Marcus	TU Wien, Austria	3 days
Orphanoudakis Stelios	Institute of Computer Science, Heraklion, Greece	3 days
Trahanias Panos	Institute of Computer Science, Heraklion, Greece	3 days
Zillich Michael	TU Wien, Austria	3 days
Kakadiaris Ioannis A.	University of Houston, USA	2 days
Christof Eberst	Profaktor, Steyer, Austria	2 days

Visits of students:

name	level	institution	duration
Daniel Beresford	PhD	University of Surrey, UK	6 months
Huaifeng Zhang	PhD	Chinese Acad. of Science, China	2.5 months
Stefan Gaechter	MSc	EPFL Lausanne, Switzerland	2 months
Sarah Childers	MSc	Case Western Reserve University, USA	2 months
Joanna Dudzic	MSc	Cracow University of Technology, Poland	1 month
Agnieszka Wadowska	MSc	Cracow University of Technology, Poland	1 month
Dana Smutná	PhD	Slovak Technical University, Bratislava, Slovakia	1 month
Peter Peer	PhD	University of Ljubljana, Slovenia	1 week
Janez Pers	PhD	University of Ljubljana, Slovenia	1 week

9 Events held at CMP

The CMP has been organising regular meetings on computer vision and pattern recognition. In 2001, two colloquia took place, on May 10–11 and October 25. Full programmes of these two and previous meetings including abstracts are available on-line at

<http://cmp.felk.cvut.cz/cmp/events/past.html>

The speakers in 2001 came from the UK, France, Germany, Sweden, Israel, Austria, USA, Hungary, Poland and the Czech Republic.

Selected seminars held at CMP (apart from the one- or two-day meetings):

I. Shimshoni	Technion, Haifa, Israel	Shape Reconstruction of 3D Bilaterally Symmetric Surfaces
A. Imiya	Chiba University, Japan	Discrete Curvature and Its Applications
I. Kakadiaris	University of Houston	Physics-Based Techniques for Computer Vision and Medical Data Analysis
A. Leonardis	University of Ljubljana, Slovenia	Eigenspace of Spinning Panoramic Images
R. Fisher	Edinburgh University, UK	Stabilizing Augmented Reality Overlays and Self-organization of Ubiquitous Sensors
J. Pers	University of Ljubljana, Slovenia	Tracking players in sports
P. Peer	University of Ljubljana, Slovenia	Panoramic depth imaging with a single standard camera
G. Khachaturov	Universidad Autonoma Metropolitana, Mexico	Robust Identification Based on a Processing-Oriented Object Representation
D. Chetverikov	Hungarian Acad. Sci., Budapest, Hungary	Textures I–III.
Z. Hu	Chinese Academy of Sciences	3D reconstruction, and the pose determination of objects
S. Umemura	Hitachi Central Research Laboratory, Japan	Nonlinear Acoustics in Medical Ultrasound
D. Buhagiar	University of Malta	Completeness and Ultracompleteness
L. Spacek	University of Essex, UK	Full Stereopsis and Motion from a Coaxial Vertical Pair of Omnidirectional Catadioptric Cameras
A. Kostin	Tula State University, Russia	A unified variational approach to data analysis
M. Pollefeys	Katholieke Universiteit Leuven, Belgium	3D structure and motion from images
R. Glantz	Vienna University of Technology, Austria	Visibility within the Framework of Matroids
D. Marshall	University of Wales, Cardiff, UK	Hierarchical PCA for tracking articulated human models
A. Fitch	University of Surrey, UK	Robust image matching

Publications of CMP members in 2001.

Most publications are available online at <http://cmp.felk.cvut.cz/biblio/publicat>

- [1] M. Artač and T. Pajdla. Upgrading projective reconstruction to a metric one. Research Report CTU–CMP–2001–06, Center for Machine Perception, K333 FEE, Czech Technical University, Prague, Czech Republic, February 2001.
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- [3] H. Bakstein and T. Pajdla. Non-central cameras for 3D reconstruction – thesis proposal. Research Report CTU–CMP–2001–21, Center for Machine Perception, K333 FEE Czech Technical University, Prague, Czech Republic, August 2001.
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