CENTER FOR
MACHINE PERCEPTION

CZECH TECHNICAL
UNIVERSITY

ACTIVITY REPORT

Center for Machine Perception ACTIVITY REPORT 1999

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№ CTU–CMP–2000–12

June 1, 2000
version 1.1

Available at
ftp://cmp.felk.cvut.cz/pub/cmp/articles/activity_report99.ps.gz

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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 was established in August 1996 under the “Support of Research at Czech Universities” initiative of the Ministry of Education of the Czech Republic through a five year grant (No. VS96049). The CMP is a part of the Department of Cybernetics, Czech Technical University (CTU) Prague, Czech Republic.

Current main CMP research interests lie in the following areas: reconstruction of 3D models from range images (Pajdla) or unorganised 3D points (Šára), stereo matching (Šára), physics-based vision (Šára, Drbohlav), representation of 3D scenes by a collection of 2D images (Werner, Pajdla, Hlaváč), reconstruction of scene from multiple images (Pajdla, Werner, Urban, Hlaváč), panoramic vision (Pajdla, Svoboda, Hlaváč), image compression (Hlaváč), quantum and fuzzy logic (Navara, Pták), object recognition (Matas, Haindl, Hlaváč).

Summary of main **scientific results** obtained in 1999 :

Computer vision A generalization of the Hartley’s trifocal tensor estimation method was proposed allowing to obtain a projective reconstruction of a scene from many uncalibrated images [73]. A new approach to *stereo correspondence problem* based on stable matching was proposed [62]. A new concept of *polarimetric stereo* applicable for a wide class of reflectance models was proposed and tested [7]. The *Invariant Pixel Set Signature* approach, a new appearance-based object recognition method was proposed [35]. In [12], the *Progressive Probabilistic Hough Transform* (PPHT) was introduced.

Mathematical modeling of uncertainty Characterizations of spaces of measures on quantum and fuzzy logics were generalized and published in high quality journals (Journal for Mathematical Analysis and Applications, International Journal of Theoretical Physics). A detailed comparison of semantical strength of various fuzzy logics was given in [29, 28]. A progress was made in the analysis of mathematical foundations of fuzzy controllers [41, 42].

<u>Achievments in 1999</u>

- V. Hlaváč co-authored a **monograph** “Ten lectures on statistical and structural pattern recognition theory”, CTU Press, 1999 [63].
- Image Processing, Analysis, and Machine Vision, a monograph by Sonka, Hlaváč and Boyle was **awarded** the Rector’s prize for ’The best CTU book’. Currently, it is the image processing textbook with the second largest number of copies sold (after Gonzales, Woods).
- A new Socrates EU student exchange agreement was signed with Aristotle University of Thessaloniki, Greece.
- The number of **PhD theses submitted** – four – was larger than the number of PhD students enrolled in a year.
- A first long term visit (1 year) of an EU researcher started (Anna de Simonne from the University of Naples, Italy).

Consultancy and industrial applications. The CMP performed **consultancy** and **research and development** for the industry (e.g. Boeing, St. Louis, USA, Instutite of Criminology, Czech Republic). CMP 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`

For **demos** of our research, visit `http://cmp.felk.cvut.cz/cmp/cmp_demos.html`

2 The CMP Research Group

The CMP group is more than twenty members strong, comprising thirteen members of academic and research staff (two part-time), ten PhD students, a group administrator and a system manager. In 1999, two former PhD. students, T. Svoboda and M. Urban became members of research staff after submitting their PhD. theses. J. Fojtík became a research fellow at Honeywell Research Laboratory in Prague and S. Kraus became a sofware developper at Miracle Ltd. Prague, a company designing and producing microwawe data-communication links. Both J. Fojtík and S. Kraus submitted a PhD thesis.

Academic and Research Staff

Prof. Václav Hlaváč	head, professor
Prof. Pavel Pták, DrSc.	professor (part time)
Dr. Ing. Michal Haindl	research fellow (part time)
Dr. Ing. Mirko Navara	senior lecturer
Dr. Ing. Jiří (George) Matas	research fellow
Ing. Tomáš Pajdla	lecturer
Ing. Vladimír Smutný	lecturer
Dr. Ing. Radim Šára	research fellow
Dr. Ing. Tomáš Werner	research fellow
Ing. Tomáš Svoboda	lecturer
Ing. Martin Urban	research fellow
Ms. Eva Matysková	group administrator
Ing. Daniel Večerka	system administrator

Doctoral students

	supervisor	proposed thesis title
Ondřej Drbohlav	R. Šára	Physics-based surface features for computer vision.
Pavel Mrázek	M. Navara	Modeling uncertainty in image processing.
Jan Buriánek	J. Matas	Appearance-based recognition.
Jan Dostál	R. Šára	Stereo algorithm testing.
Petr Bílek	J. Matas	Illumination-invariance in object recognition.
Hynek Bakstein	V. Hlaváč	3D reconstruction.
part time students		
Jan Vydržel	V. Hlaváč	Improving correspondence algorithms.
Vít Zýka	R. Šára	Shading consistency analysis for local shape modeling.
Pavel Krsek	V. Hlaváč	Differential surface characteristics.

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 Pennsylvania, 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

3 Research

3.1 Representation of 3D scenes by collection of 2D images

Project GAČR 102/97/0855 "3D Scene Representation by 2D Images" (principal investigator V. Hlaváč) has finished and was successfully defended. As a result of the project, we understand that the difference between an image and reconstruction based approach to the scene representation lies in the existence of occlusion. Whenever an occlusion is present a form of reconstruction is called for.

A projective or Euclidean reconstruction of 3D scenes from collection of 2D uncalibrated images has recently been a focal point of our activity. We have continued in the projective reconstruction direction that opened by the T. Werner's PhD dissertation (submitted in 1998, defended in 1999). We found a method allowing projective reconstruction (Eucledean if additional constraints as perpendicularity of some object holds) from collection of more than three uncalibrated views [74, 73].

The practical outcome of the research is the software tool *REC3D* built on top of Matlab [75]. It integrates all particular tools for solving correspondence problem, allowing semiautomatic acquisition of correspondence and various levels (projective, oriented projective, Euclidean) of reconstructions from multiple uncalibrated images, using the latest available knowledge. The system allows fast 3-D visualization of projective reconstruction too.

We studied the question of camera calibration from a broader perspective than it is common in a pin hole model. A question how to calibrate from a bundle of rays is studied in [58].

3.2 Reconstruction of 3D scene from images

We have focused on the problem of a projective reconstruction of 3D scenes from collection of many uncalibrated images. We have proposed and elaborated a new method for obtaining a projective reconstruction from many uncalibrated images in so called "cake configuration" [74, 73] what means that the views share a common reference view. The method is a natural generalization of the Hartley's trifocal tensor estimation method for an arbitrary number of views.

Methods for camera self-calibration were studied. A new relation between the Kruppa equations and the projection matrices was derived [74]. A possibility to calibrate camera from sets of parallel lines in an industrial environment was explored [58].

A number of techniques for acquiring the correspondences, computing projective, quasi affine and similarity reconstruction, and visualization of reconstructions were implemented in the form of the Matlab toolbox *REC3D* [75].

3.3 Reconstruction of 3D shape from range data

The project GAČR 102/97/0480 "Construction of Complete 3-D Models from Range Images" (principal investigator T. Pajdla) has finished and was successfully defended. This final year, we have concentrated on a measurement planning [11] and further experiments with curvature signatures [31] for surface matching.

3.4 Omni-directional vision

A rotation invariant representation of panoramic images as well as an image based compass useful for a mobile robot localization [54, 55] has been worked out. The representation has been tested in experiments in an indoor environment with promising results [2, 25].

T. Pajdla, T. Svoboda and V. Hlaváč previously worked out a construction of panoramic cameras using convex mirrors, the epipolar geometry of central panoramic cameras, and they also experimented with estimating the ego-motion from panoramic images [72]. These results form a substantial part of the PhD. thesis submitted by T. Svoboda [71]. The work will also be presented as a chapter in a monograph about panoramic vision [57] which is in preparation.

3.5 Physics-based vision

A novel approach to extraction of surface shape information from radiometric measurements – called *polarimetric stereo* – was proposed [7]. Polarimetric measurement are exploited in order to obtain surface orientation. At least one controlled polarized illuminant and a camera with polarization analyser are required. The approach is albedo-independent and does not rely on the exact knowledge of the surface reflectance model. It assumes a whole class of reflectance models sharing the same polarized light reflection mechanism. If compared to standard approaches, the method is more robust to interreflections. The capability of the method of separating between body and interface reflection components is the subject for ongoing research that is a part of PhD thesis work of Ondřej Drbohlav.

3.6 3D model reconstruction from passive vision

A new method for stereo matching and fusion was developed for wide-baseline stereo [62]. The matching is robust with respect to insufficient texture, texture repetitiveness, large-depth occlusions, and performs well in thin objects appearing against a distant background.

The problem of local surface model verification in a collection of images that is independent on surface texture statistical distribution was studied as a part of PhD thesis work of V. Zýka [77]. The activity is a part of the fish-scale surface model reconstruction project [61].

Quadrinocular stereo system with synchronized image capture became available for routine use, including camera calibration, stereo matching, and surface reconstruction software implemented in Matlab. Equipped with random texture projector, the system is used to capture precise models of objects of unknown geometry of the size of human head.

3.7 Sonographic image analysis

Texture modeling was used for sonographic image analysis for diagnosing and monitoring chronic thyroid gland diseases. The project initially focuses on distinguishing between normal tissue and chronic lymphocytic thyroiditis (Hashimoto's Thyroiditis)[70].

3.8 Object Recognition

A new appearance-based object recognition method has been proposed [35]. The "invariant pixel set signature" method (IPSS) is based on computation of invariants computed on pixels sets inside convex hulls of n-tuples of interest points.

3.9 Pattern Recognition

A series of lectures given at the CMP in Spring 1996 by Prof. M.I. Schlesinger from the Ukraininan Academy of Sciences in Kiev renewed our interest in the theory of pattern recognition. The collaborative effort resulted in a monograph [63]. An English edition is being prepared and is expected to be published by Kluwer Academic Publishers, The Netherlands.

The theory of random field models is one of the basic tools for modeling spatial, temporal and spectral relations in complex pattern recognition and image processing tasks. Different Markov random field models, simultaneous autoregressive models, and problems with their parameter estimation, synthesis and optimal contextual support set detection were our primary research interest. Research results were applied in texture segmentation [14], texture mapping [15], shape and testure data fusion [17], image restoration [13], and in a natural colour texture synthesis [16] application.

We have proposed a novel recursive Gaussian Markov random field pseudolikelihood parameter estimator [14] which was applied in a colour texture segmentation algorithm [14], [18]. This segmentation algorithm is an order of magnitude faster than the best previously published algorithms of similar type. Two original image restoration algorithms using a combination of causal and non-causal weak Markov models were introduced in [13]. Test results of a new causal weak Markov colour texture model are in [16].

3.10 Detection of Geometric Primitives

In [12] the *Progressive Probabilistic Hough Transform*(PPHT) was introduced. Unlike the Probabilistic HT of Kiryati, where Standard HT is performed on a pre-selected fraction of input points, PPHT minimises the amount of computation needed to detect lines by *exploiting the difference in the fraction of votes needed to reliably detect lines with different numbers of supporting points*. The fraction of points used for voting need not be specified ad hoc or using a priori knowledge, as in the probabilistic HT; it is a function of the inherent complexity of data.

3.11 Approximation methods for image processing

P. Mrázek studied interpolation and approximation methods for application to data processing, with a focus on the desired monotonicity of the data. The previous research results have been summarized in [44] and extended to a monotonicity-enhancing nonlinear diffusion filter [45].

3.12 Mathematical studies of descriptions of uncertainty

The investigation of uncertainty continued in the directions of basic and applied research. One of the main results is a comparison of fuzzy logics according to their semantical strength — several interesting relations were proved and presented in [29, 28].

One of the main new results is the characterization of measures on tribes of fuzzy sets [46]. It reopened basic questions of properties of fuzzy logical operations, in particular fuzzy conjunctions (t-norms) [39]. The study of their relation to applications in fuzzy controllers brought quite promissing results: we succeeded to motivate some procedures that were — up to now — used without sufficient theoretical background. At the same time, we generalized them substantially [41, 42]. These results are close to future applications.

We almost finished basic studies which possess a new view on quantum logics together with a very general tool for modelling of state spaces using hypergraphs [49, 51, 36].

3.13 Other research results

Lossless compression of image data was studied. A compression technique based on a non-linear predictor that processes an image bit-plane by bit-plane was proposed [24]. The second result relates to pseudo-colour (palette) images. A method seeking a semi-optimal reordering of the palette for lossless compression was proposed in a PhD. thesis submitted by J. Fojtík [9].

The submitted PhD. thesis of S. Kraus [30] dealt with precise sub-pixel precision gauging of objects observed under back-light illimunation.

We have studied the problem of curve extraction and segmentation into a set of predefined models and the application of these techniques in precise optical measurement. It was experimented with an occluding boundary extraction using color background [60]. The complexity of curve segmentation as a function of some curve parameters was derived [56]. Principles of precise measurement in back-light illumination based on occluding contour interpretation were uncovered and published [66].

During his research fellowship at the University of Surrey, U.K., P. Mrázek worked on the estimation of the position of body joints using non-invasive computer vision techniques [69, 68].

4 Projects

Representation of 3-D Scene by 2-D Images

Duration: January 1997 - December 1999

Investigators: Václav Hlaváč , Tomáš Pajdla, Vladimír Smutný, Radim Šára, Tomáš Werner.

Funding: Czech Grant Agency, Grant No. 102/97/855, 306K Kč (US$ 9K) (in 1999)

Objectives: The problem of rendering a real 3-D scene from an arbitrary viewpoint using a collection of images was addressed in this project. It was made clear that the border between an images-based and object-based approach to the scene representation lies in the existence of occlusion. The project project has finished and was successfully defended.

COMORI - Construction of Complete 3D Models from Range Images

Duration: January 1997 - December 1999

Investigators: Tomáš Pajdla , Václav Hlaváč, Vladimír Smutný, Radim Šára.

Funding: Grant Agency of the Czech Republic, Grant No. 102/97/480 333K Kč (US$ 10K) (in 1999)

Objectives: Within the project, we have developed and improved existing methods for matching and registration of surfaces and for fusion of partial surface measurements into a consistent geometrical model. The results were exploited in an industrial application ProfEx for measurement of profiles of rolled products that was developed, realized, and delivered in cooperation with Neovision s.r.o. The project finished and its results were successfully defended at the end of this year.

Mathematical Models of Uncertainty

Duration: January 1997 - December 1999;

Investigators: Mirko Navara, Josef Hekrdla (Dept. of Mathematics), Pavel Pták, Josef Tkadlec (Dept. of Mathematics).

Funding: Grant Agency of the Czech Republic No. 201/97/0437, 330K Kč (US$ 10K) (in 1999)

Partners: Dept. of Mathematics, Faculty of Elec. Eng, CTU.

Objectives: The principal aim of the project was the improvement of mathematical foundations of fuzzy logic. Recently some types of tribes (fuzzy generalizations of Boolean σ-algebras) and measures on them were characterized in our co-operation with foreign experts. We generalized these results and investigated their consequences for the theory of games and fuzzy propositional and predicate calculi. Besides enriching the mathematical theory, a long-term task was to establish a group of experts providing advisory service for people from application areas.

Texture Analysis of Sonographic Images for Endocrinopathies and Metabolic Diseases

Duration: January 1999 - December 2001;

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

Funding: Ministry of Health of the Czech Republic, NB 5472-3 250K Kč (US$ 7K)

Partners: 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.

Many-valued logics for computer science applications

Duration: January 1996 - November 1999;

Investigators: Mirko Navara, Pavel Pták

Funding: COST Action 15, 60K Kč (US$ 2K) (in 1999)

Partners: The project is a part of a large net of cooperators from EU, Cyprus, Czech Republic, Poland, Slovakia and Turkey. The Czech part of the project is coordinated by the Institute of Computer Science, Academy of Science of the Czech Republic, Prague.

Objectives: Theoretical studies of multivalued logics, their mathematical and computational properties, and problems of application of nonstandard logics in computer science.

Physics-based method for determination of surface properties from reflected light

Duration: January 1999 - December 1999

Investigators: Onřej Drbohlav, Radim Šára

Funding: Grant CTU 3099068, 37K Kč (US$ 1K)

Objectives: The project aimed to identify the light reflection mechanisms that enables construction of methods for determining properties of an object surface (local geometry, texture, roughness). A method for a robust estimation of local geometry from analysis of the polarization state of light reflected on a surface represents the main result, indicating the possibility to approach fundamental problems in computer vision (e.g. separation of reflection components) in a novel way.

Theory and Applications of Fuzzy Control

Duration: February 1999 - December 1999;

Investigators: Mirko Navara, Pavel Mrázek, Pavel Pták, Zdeněk Žabokrtský (student).

Funding: Aktion Österreich – Tschechien 23p16 (Theory and Applications of Fuzzy Control), 90K Kč (US$ 3K)

Partners: Johannes Kepler Universität Linz, Austria.

Objectives: The project deals with mathematical principles of fuzzy control and approximation. The main application areas are automatic control, expert systems and signal processing, including computer vision.

OCAMS - Optimal Model Selection for 3D Data Segmentation

Duration: January 1999 - December 2000

Investigators: Tomáš Pajdla.

Funding: Grant of the Czech Ministry of Education, Grant No. 4/11/AIP CR (1999-2000) 55K Kč (US$ 2K) (in 1999)

Objectives: The goal of the project is to upgrade the approach to 3D data segmentation developed at the CMP for simple objects (quadrics) in two respects. Firstly, we study criterial functions optimal for different tasks and compare them to the current approach. Secondly, we plan to upgrade the surface models from quadrics to more flexible ones like NURBS.

Processing of Uncertainty in Computer Vision

Duration: January 1999 - December 1999

Investigators: Pavel Mrázek

Funding: Grant CTU 309907103, 49K Kč (US$ 1K)

Objectives: The project deals with noise reduction in images and other types of data (e.g. range data for 3D reconstruction) which are assumed to be piecewise continuous, and piecewise monotone. The main result consists in the developments of a new type of a nonlinear diffusion filter capable of enhancing the desired piecewise monotonicity of the data.

5 Consultancy, Applied R & D, Industrial Applications

Boeing, grant no. FCS-CR-01-99 part A

Duration: March 1999 - December 1999

Investigators: Václav Hlaváč , Jiří (George) Matas, Jan Buriánek.

Funding: Boeing Corp., 850K Kč (US$ 25K)

Objectives: The project focussed on appearance-based recognition of complex objects.

Virtual Reality, Hewlett Packard ISE-86L8-13

Duration: September 1998 - September 1999

Investigators: Michal Haindl.

Funding: Hewlett Packard, 700K Kč (US$ 21K)

Objectives: The project aimed at developing a new course in virtual reality as an extension of the computer vision and pattern recognition programs of the CMP. The course addressed the problem of building virtual reality models from real world scenes with focus on automatic methods. Many difficult outstanding problems in computer vision are related to automated model building; these include scene segmentation, data registration, 3D model building, texture analysis, synthesis and mapping, virtual data representation, ray tracing, dynamic scene viewers.

Partners: ÚTIA Institute of the Academy of Sciences,ČR

Cross-Danube cooperation in Computer Vision

Duration: January 1999 - December 1999;

Investigators: Václav Hlaváč

Funding: Czech Ministry of Education, No. 23p17, bilateral Czech-Austrian project, 199K Kč (US$ 6K)

Partners: Vienna University of Technology, Department of Pattern Recognition and Image Processing, Prof. Walter Kropatsch.

Objectives: The aim was to enhance cooperation by short visits to the partner group.

Neovision

Duration: long term

Funding: 60K Kč (US$ 2K)

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 Criminology, Prague, Czech Republic

Duration: 1999

Funding: 20K Kč (US$ 1K)

Investigators: Vladimír Smutný, Radim Šára

Description: A standard method for capturing surface maps of cylindrical lock cores was designed. The method will be used to aid visual comparison of surface marks on broken locks. The automatic procedure stadardised the acquisition of image, that will be available on a network linking criminology laboratories. Further development of the system is expected.

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, a three-chip Hitachi HV-C20 colour camera and a 16-bit Santa Barbara Instruments SB-7 cooled camera. Four Pulnix TM 9701 digital cameras allow synchroneous acquisition. Pulnix TM 1001 digital camera with 1024×1024 resolution is used for precise measurements. Several computers are equiped with mid-range cameras and frame grabbers. An industrial microscope allows us to measure objects with size in the range of 2–50 mm. Two panoramic cameras utilizing convex mirrors which provide view angles about $360° \times 110°$ were built. Digital capturing of images in the outdoor environment is now available by the digital camera Nikon Coolpix 950 with the field of view from 2×2.7 cm to infinity. The camera is also equiped with fish eye lens which enables to capture panoramic images 0°–360° by 0°–91°.

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 new 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. Panoramic camera and a video radio link were added to an autonomous vehicle that was built in the lab.

The CMP computing facilities comprise 30 computers connected to the university-wide network (ATM). Besides two Silicon Graphic workstations ($Indigo^2$ and Indy) all the computers are high-end PCs running either Linux or MS Windows 9x/NT. In 1999, the CMP computing facilities have been enhanced by 3 high-end PCs with good 3D and video editing support.

The CMP equipment includes a postersize colour printer HP DesignJet 755CM and the HP ScanJet 6100C scanner. For more detailed information on CMP equipment, visit

`http://cmp.felk.cvut.cz/cmp/hardware` .

7 Teaching

In 1999, CMP members taught the following courses (**course name,** *lecturer*, laboratory supervisor):

3D computer vision for graduate students *R. Šára*, T. Pajdla.

Robotic systems *V. Smutný*.

Introduction to computer vision and pattern recognition (for master students, Charles University, Dept. of Mathematics and Physics) *V. Hlaváč*, T. Werner.

Computer Vision for Informatics *T. Pajdla*.

Intelligent Robotics *V.Hlaváč, T. Pajdla*, T. Svoboda.

Signal and Image Processing *V. Hlaváč*, T. Svoboda.

Pattern Recognition *J. Matas, M. Haindl*, T. Svoboda.

Digital Image Processing *J. Matas*, P. Bílek.

Fuzzy logic *M. Navara.*

Numerical Analysis for master students *M. Navara*

Linear Algebra (English course) *P. Pták.*

Mathematics for undegraduate students *P. Pták.*

Mathematics for cybernetics for graduate students *P. Pták.*

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 Kindom, Austria, Slovenia, the Nehterlands and Greece. A full list, including details of funding, is available at `http://cmp.felk.cvut.cz/cmp/opport.html`
Reciprocally, CMP has received a number of MSc and PhD students from the labs listed.

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 1999 31K Kč (US$ 1K); started September 1995, ends August 2001.

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, Hungaria; Linz University, Austria; Ostrava University in Ostrava, Czech Republic.

8 Visits to CMP

(ordered by the length of the visit)

De Simone Anna	University Federico II, Napoli, Italy, 12 months
Jonsson Kenneth	University of Surey, Guilford, Britain, 3 months
Kropatsch Walter	TU Wien, Wien, Austria, 2 weeks
Di Nola Antonio	Univ. Salerno, Salerno, Italy 10 days
Walker Elbert, Walker Carol	New Mexico State Univ., Las Cruces, USA, 6 days
Mundici Daniele	University of Milano, Milano, Italy, 6 days
Bischof Horst	TU Wien, Wien, Austria, 5 days
Sablatnig Robert	TU Wien, Wien, Austria, 5 days
Kampel Martin	TU Wien, Wien, Austria, 5 days
Bergholm Frederik	Royal Institute of Technology, Stockholm, Scweden, 4 days
Schwartz Charles	New Mexico State Univ., Las Cruces, USA, 4 days
Scherer Stefan	TU Graz, Austria, 4 days
Heui-Keun	Choh Samsung Advanced Institute of Technology, Korea, 3 days
Zaťko Bedrich	Slovak Academy of Sciences, Bratislava, Slovakia, 3 days
Lindenbaum Michael	Technion, Haifa, Israel, 2 days
Flach Boris	TU Dresden, Germany, 2 days
Košecká Jana	Univ. of California at Berkeley, USA, 1 day

Visits of PhD students:

name	institution	duration	funding
Rogelj Peter	University of Ljubljana, Slovenia	1 month	CEEPUS
Derganc Joze	University of Ljubljana, Slovenia	1 month	CEEPUS
Rok Bernhard	University of Ljubljana, Slovenia	1 month	CEEPUS
Lahajnar Franci	University of Ljubljana, Slovenia	6 weeks	CEEPUS
Dangl Michael	TU Wien, Wien, Austria	5 days	AKTION
Jogan Matjaz	University of Ljubljana, Slovenia	10 days	(CZ-SI Cooperation Programme)
Kverh Bojan	University of Ljubljana, Slovenia	10 days	(CZ-SI Cooperation Programme)

9 Events held at CMP

The CMP started to organise regular one-day meetings on computer vision and pattern recognition. The meetings take place every three months, full programmes including abstracts are available on-line at `http://cmp.felk.cvut.cz/cmp/events/past.html` . About six talks are presented each time, making a visit to CMP worthwhile for researches outside Prague. The speakers in 1999 came from the UK, USA, Germany, Sweden, Ukraine, Slovenia, Austria and the Czech Republic.

Selected seminars held at CMP:

M. Lindenbaum	Technion, Israel	VC Dimension Analysis of Object Recognition
M. Sonka	University of Iowa, USA	In Real-time Cardiovascular Medical Image Analysis: From Dreams to (Virtual) Reality
J. Kosecka	University of South California, USA,	Multiview Geometry Revisited: A Differential Geometric Approach
H. Bischof	TU Vienna, Austria	Hierarchical eigenimages (Abstract)
S. Egerton	University of Essex, UK	Mobile robot navigation and panoramic vision
E. Turunen	Lapeenranta, Finland	Application of fuzzy similarity
H. Scharr	University of Gottingen, Germany	Steerable filters and their application to anisotropic diffusioni

Selected 1999 publications of CMP members.

[1] S. Ben-Yacoub, J. Luettin, K. Jonsson, J. Matas, and J. Kittler. Audio-visual person verification. In *Computer Vision and Pattern Recognition*, pages 580–585, Los Alamitos, California, June 1999. IEEE Computer Society.

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