CENTER FOR
MACHINE PERCEPTION

CZECH TECHNICAL
UNIVERSITY

ACTIVITY REPORT

Center for Machine Perception ACTIVITY REPORT 1997

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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 Department of Education of the Czech Republic through a five year grant (No. VS96049). The CMP is a part of the Department of Control Engineering, Faculty of Electrical Engineering, Czech Technical University (CTU).

Current main CMP research interests lie in the following areas: reconstruction of 3D models from range images (Pajdla, Hlaváč) or unorganised 3D points (Šára), design of a color-coded range finder (Smutný), represention of 3D scenes by a collection of 2D images (Werner, Pajdla, Hlaváč), quantum and fuzzy logic (Navara, Pták), Markov random field models for vision (Haindl), 3D shape reconstruction from intensity images (Šára), object recognition (Matas). The CMP also performs research and development for the industry (Texas Instruments, Rockwell Int.).

Summary of main **scientific results**:

computer vision We have dealt with theoretical questions concerning *image based scene representation*. One of our theoretical results is the argument that the boundary between image based and model based approaches to visualization is not sharp and we propose to distinguish *three different groups of approaches to visualization*: image interpolation, image extrapolation, and 3-D model reconstruction [87].

A *surface model and a reconstruction algorithm* have been proposed that are based on semi-local fuzzy geometric primitives and a relation that links them to larger-scale structures [72].

The design of an optimal *optical sensor for mobile robot* navigation has been studied and an *omnidirectional* visual sensor proposed. Its design, image formation function and related epipolar geometry is presented in [77, 78].

Interesting results have been obtained in the study of *topologies for image processing* [34, 33].

A six degree of freedom CRS A 465 robot has been acquired for *active vision experiments*.

mathematical modeling of uncertainty New results were obtained in fuzzy and quantum logics including the generalization of characterization of spaces of measures on quantum and fuzzy logics [55, 53, 57, 8, 43, 42, 3, 5, 64], an extension of characterization of T-tribes from Frank t-norms to strict t-norms [2]. An interesting link between Boolean, quantum and fuzzy logic in the study of dependence in these structures [54, 61, 56, 59] has been found. Combinatorial techniques in the study of finite logics were improved in [49, 50, 51]. Applications of fuzzy logic in computer vision are investigated [58].

More details about ongoing research at the CMP and recent **publications** can be found at

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

for **demos** of our research results, 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 eleven members of academic and research staff (two part-time), ten PhD students, a group administrator and a system manager. In 1997, two new researchers, Radim Šára and Jiří (George) Matas, joined CMP from GRASP at the University of Pennsylvania, USA, and CVSSP at the University of Surrey, UK, respectively.

Academic and Research Staff

Dr. Ing. Václav Hlaváč	head, senior lecturer
Prof. Pavel Pták, DrSc	professor (part time)
Dr. Ing. Michal Haindl	lecturer (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
Ing. Tomáš Werner	research fellow
Ms. Eva Matysková	group administrator
Ing. Dan Večerka	system administrator

Doctoral students

	supervisor	proposed thesis title
Tomáš Svoboda	V. Hlaváč	Panoramic vision.
Vít Zýka	R. Šára	Shading consistency analysis for local shape modeling.
Pavel Krsek	V. Hlaváč	Differential surface characteristics and their use in creating 3D model from range images.
Martin Urban	V. Hlaváč	Image interpolation based on the trilinear relation among views.
Jan Vydržel	V. Hlaváč	Improving correspondence algorithms.
Jaroslav Fojtík	V. Hlaváč	Lossless image compression.
Ondřej Drbohlav	V. Hlaváč	Physically valid image based 3D rendering.
part time students		
Svatopluk Kraus	V. Hlaváč	Image analysis tools for precise optical measurement (gaging).
Pavel Mrázek	M. Navara	Modeling uncertainty in image processing.
Jan Müller	V. Hlaváč	Analysis of structural lines in documents.

2.1 CMP Scientific Advisory Board

The role of the 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	Technical University Vienna, Austria
Prof. Jan Uhlíř	Dean of the Faculty of Electrical Engineering CTU Praha, Czech Rep.
Prof. Shimon Ullman	Weizmann Institute, Israel
Prof. Luc Van Gool	Catholic University Leuven, Belgium
Prof. Vladimír Mařík	Head of the Dept. of Control Engineering, CTU, Czech Rep.

3 Research

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

We have continued research on visualization of real scenes using image based representation. One of the relevant issues we focused on was correspondence acquisition. We have suggested a new approach based on analysis of an image sequence rather than just two distant images as e.g. in stereo. A *robust correspondence algorithm* for tracking edges in a dense sequence has been developed [88, 89].

We have dealt with theoretical questions concerning image based scene representation. One of our theoretical results is the argument that the boundary between image based and model based approaches to visualization is not sharp. We propose to distinguish *three different groups of approaches to visualization*: image interpolation, image extrapolation, and 3-D model reconstruction [87]. Further, we have realized that image based methods are very similar to rendering a projective model and suggested new efficient algorithms performing this task [89, 87]. In this algorithm, calibration is needed only for positioning the virtual camera but *not for visibility solution*. A side result of this effort is a documented prototype of an image-based visualization device [89].

Estimation of camera poses and structure from several uncalibrated cameras with equal intrinsic parameters is central to the positioning of the virtual camera (and hence for visualization from uncalibrated cameras). We have further dealt with this difficult task and achieved some theoretical results [82, 83] potentially allowing simplification of previously proposed algorithms.

Many 3-D computer vision tasks, including the one above, assume pinhole cameras. We developed a method for removing the most significant part of non-linear camera distortion (radial lens distortion) *without knowledge of scene structure* [63].

3.2 Reconstruction and representation of shape

We have continued development of range finders based on structured light. Laser Plane Range Finder and Binary Coded Range Finder have been routinely used since their completion last year. The Color Coded Range Finder is still under development. We have improved calibration of the camera–projector rig and improved color decoding [86, 85, 84].

We have made an advance in integration of methods for surface triangulation, registration, fusion, and segmentation into a software package. This allows construction of complete geometrical models from partial scans with user assistance (to avoid the hard problem of surface matching) [62].

Extraction of geometrical primitives from surfaces, e.g. parabolic lines, has been studied. The primitives are stable enough to provide good features for automatic surface matching [38, 36, 37, 35].

A surface model and a reconstruction algorithm have been proposed that are based on semi-local fuzzy geometric primitives and a relation that links them to larger-scale structures [72].

Two novel *range image segmentation algorithms* were tested on structured light and laser range finder data. The first method is based on robust object face edge detection, while the second one completes edge information with a fast region growing process currently restricted to planar face scene objects. These results were published in [18, 17, 19, 20].

3.3 Images and other sensor data for autonomous vehicle navigation

The design of an optimal optical sensor for mobile robot navigation has been studied. Egomotion estimation from images taken by a perspective camera becomes ill-conditioned for certain scene arrangements. The relationship between uncertainty in camera calibration parameters and the uncertainty of the motion estimation has been addressed in [81, 79]. The design of the omnidirectional visual sensor, its image formation function and related epipolar geometry is presented in [77, 78].

3.4 Markov random fields for pattern recognition

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 complex multidimensional data space reconstruction problems and in a natural colour texture synthesis application.

We have proposed a novel method based on spectrally factorized and decomposed non-causal Gaussian Markov random fields. Results published in [13, 12, 14] include spectral and frequency decomposition, contextual support set estimation, model parameter estimation, and inverse transformation, respectively.

In the area of causal random field modeling we were studying fast robust modeling algorithms. An original multidimensional scratch reconstruction algorithm was developed and demonstrated on astronomical data reconstruction [16].

We acknowledge the partial research support from the European Union grant INCO Copernicus no. 960174 Autonomous Acquisition of Virtual Reality Models from Real World Scenes (VIRTUOUS) and the MŠMT grant No. OK 276 (1997).

3.5 Mathematical studies of descriptions of uncertainty

Different types of logics (classical, quantum, fuzzy) describe different types of uncertainty. We proved that they lead also to different types of dependence specific for each logic [54, 61, 56]. In these questions, Frank t-norms (fuzzy conjunctions) appeared to play a prominent role [59]. On the other hand, their role in tribes of fuzzy sets (generalizations of Boolean σ-algebras) is not special; description of tribes with respect to Frank t-norms was successfully generalized to other strict t-norms in [2, 59]. The study of T-measures (as a generalization of measures on Boolean σ-algebras) lead to the conclusion that continuous T-measures exist (only) on tribes with respect to so-called nearly Frank t-norms (a class of t-norms more general than Frank t-norms but not covering all strict t-norms [53]). On the other hand, the study of another generalization of classical probability measures — P-measures introduced by Piasecki — lead to the conclusion that they allow to describe only systems which have a Boolean analogue [57]. We also contributed to the questions of characterizations of diagonals of t-norms, i.e., the functions $\delta(x) = T(x, x)$, where T is a t-norm. We found necessary and sufficient conditions for a function to be the diagonal of a continuous t-norm and we found the description of all continuous t-norms with a given diagonal [44, 45]. We proved that a fuzzy propositional logic with infinite operations based on Frank t-norms (as described by Butnariu, Klement and Zafrani) can be improved. We do not need to assume its closedness with respect to an implication, because the implication can be expressed using a strict Frank t-norm with infinitely many arguments [22]. We contributed also to constructions of noncontinuous t-norms. New techniques described in [9, 8] form also a base for the future study of finitely-valued t-norms. We studied also applications of fuzzy logic in image processing and computer vision [58].

Progress has been made in the study of probability measures (states) on quantum logics. (The term "quantum logic" comes from a motivation in quantum mechanics, but the same logic appears also in artificial intelligence and other areas.) In particular, orthoalgebras appeared to be very interesting structures [60, 50, 51]. It is shown in [43] that many natural classes of orthomodular lattices which came into existence through the state-space properties of quantum logics are quasivarieties. The proof is based on topological reasoning. It is shown in [42] that many quasivarieties of orthomodular lattices, in particular those related to states, allow for a characterization in terms of implicative equations. Other new properties of state spaces of quantum logics are described in [3]. Progress was made in the study of relations between state spaces and other attributes of quantum logics in [55]. The cooperation with J. Harding brought new results in this direction which are now prepared for publication. A classical example of a quantum logic is the lattice of closed subspaces of a Hilbert space. The problem of possible generalizations of this example lead to numerous deep mathematical results, e.g. the Amemiya-Araki Theorem. Its improvement and further consequences are presented in [66, 67]. Radical simplification of some calculations and proofs in quantum logics was enabled in [49]. Combinatorial techniques were improved by finding a basically new description of probability measures in [50, 51]. One successful application of this technique brought a negative solution to the problem of existence of the Jordan decomposition of countably additive measures in [4, 5]. New results concerning observables (i.e. random variables on quantum logics) were presented in [65]. Another description of some quantum logics based on group-valued measures, was given and further analogies to Boolean algebras were clarified in [64]. Difficult calculations over finite structures require sometimes computer proofs and a machinery of computer algebra systems. Maple V 4 was found useful for this purpose. Some experience with it was collected in [52].

3.6 Other research results

Research of digital topologies concerns the question of when, for a given neighbourhood adjacency, the path-connectedness given by the neighbourhood adjacency coincides with topological connectedness. The question is first clarified for all homogeneous and symmetric neighboorhood adjacencies in Z^2, then the same question is studied for Z^3 and a characterization is found for homogeneous and symmetric adjacencies, too, and, moreover, some nonhomogeneous adjacencies are found to be topological [34, 33].

Doctoral student Jaroslav Fojtík proposed a new lossless image compression method based on an unusual nonlinear predictor. The compression rates are better than those achieved by reference methods [26], [23].

Doctoral student Svatopluk Kraus studies the precision of the chain: backlight illuminant, measured object, microscopic lens and camera for submicron precise gaging [76].

Doctoral student Jan Müller attempts to analyze automatically structured lines in graphical documents [48].

4 Projects

RECCAD, Copernicus CP941068

Duration: March 95 - March 98

Investigators: Václav Hlaváč , Tomáš Pajdla, Vladimír Smutný, Pavel Krsek.

Funding: European Union, 400K Kč (US$ 11K)

Objectives: The project aims at creating automatically a CAD model from several range images taken from different viewpoints. The CMP contribution focuses on range image acquisition, range image registration from different views based on point clouds, and differential surface characteristics. Structured light range finders developed at the CMP are used (laser stripe, one-shot binary-coded, color-coded). Industrial applications are planned in the following areas: 1. measurement of patient's body for planning cancer irradiation treatment and 2. rapid prototyping for car manufacturer Škoda Mladá Boleslav.

Partners: University of Wales, College of Cardiff, Dept. of Computer Science, Cardiff, U.K., Dr. Ralph Martin; Institute for Computer Science and Automation, Hungarian Academy of Sciences, geometric modeling group, Dr. Tamas Varady; University of Ljublana, Department of Computer Science, Ljubljana, Slovenia, Prof. Franc Solina.

Reconstruction of 3D shape from intensity images

Duration: March 1995 - December 1997

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

Funding: Grant Agency of the Czech Republic No. 102/95/1378 , 290K Kč (US$ 8K)

Objectives: To investigate methods for reconstructing 3D shape from intensity images. The focus is on photometric methods (like shape from shading and photometric stereo), on correct geometry and radiometry modeling, and on methods for fusing information from multiple viewpoints and different algorithms.

Partners: Information Theory and Automation, Czech Academy of Sciences Prague, (Dr. Jan Flusser).

Mathematical Formalism of Quantum Theories

Duration: January 1996 - December 1998;

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

Funding: Grant Agency of the Czech Republic, 254K Kč (US$ 7K)

Partners: Project is held by the Dept. of Mathematics, Faculty of Elec. Eng, CTU with participation of investigators from CMP.

Objectives: The project deals with operator algebras and ordered structures with orthocomplementation, investigation of mathematical structures of quantum logic: operator algebras (von Neumann algebras, Hilbert lattices), orthomodular lattices and posets, orthoalgebras, effect algebras (difference posets), together with measure-theoretical aspects.

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, 150K Kč (US$ 4K)

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

Objectives: The principal aim of the project is 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 intend to generalize these results and investigate their consequences for the theory of games and fuzzy propositional and predicate calculi. Besides enriching the mathematical theory, a long-term task is to establish a group of experts providing advisory service for people from application areas.

COMORI - Construction of Complete 3D Models from Range Images

Duration: March 1997 - March 2000

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

Funding: Czech Grant Agency, Grant No. 102/97/480 673K Kč (US$ 19K) (in 1997)

Objectives: The goal of the project is to develop and improve existing methods for matching and registration of surfaces and for fusion of partial surface measurements into a consistent geometrical model. Measurement planning for complete surface model acquisition will be investigated as well. Theoretical results will be demonstrated on an experimental prototype of the system for model construction of an industrial object.

Representation of 3-D Scene by 2-D Images

Duration: January 1997 - January 2000

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

Funding: Czech Grant Agency, Grant No. 102/97/855 1466K Kč (US$ 43K) (in 1997)

Objectives: The project addresses the problem of rendering a real 3-D Scene from an arbitrary viewpoint. The scene is represented by a sparse set of 2-D views. Arbitrary views are obtained by interpolation of coordinates and intensity. Geometrically consistent correspondence algorithms will be investigated. Scene structure will be expressed as a projective reconstruction based on trillinear relations among view. The approach will be tested on images from uncalibrated videosequences for virtual reality.

Intelligent Technologies in Signal Processing and Quality Control

Duration: May 1997 - April 1998;

Investigators: Mirko Navara, Pavel Mrázek, Pavel Pták, Jan Vydržel, Vít Zýka.

Funding: Aktion Österreich – Tschechien 16p12(Intelligent Technologies in Signal Processing and Quality Control), 100K Kč (US$ 2K)

Partners: Johannes Kepler Universität Linz, Austria.

Objectives: The project deals with theoretical studies and practical applications of intelligent technologies based on nonstandard logics (multivalued, fuzzy or quantum logics). The main application areas are automatic control, expert systems and signal processing, including computer vision. Several basic mathematical questions should be solved in order to get criteria for the existence and stability of solutions for concrete problems.

Many-valued logics for computer science applications

Duration: January 1996 - December 1998;

Investigators: Mirko Navara, Pavel Pták

Funding: COST Action 15, 20000 Kč (US$ 588)

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.

State spaces of quantum logics

Duration: January 1997 - December 1997;

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

Funding: CTU, 71K Kč (US$ 2K)

Partners: Project is held by the Dept. of Mathematics, Faculty of Elec. Eng, CTU with participation of investigators from CMP.

Objectives: Investigation of state spaces of nonstandard logics, their descriptions and characterizations, analogies and differences from classical logics.

5 Consultancy, Applied R & D, Industrial Applications

Texas Instruments - Digital Camera Control SW

Duration: July 1996 - running

Funding: 680K Kč (US$ 20K) (in 1997)

Description: Development of control software for a TI digital CCD camera interfaced via the Fire-on-Wire bus (IEEE 1394 standard). In 1997, Microsoft video capture driver for the camera has been developed.

EUREKA project 1518 VIMP - Orthoscope

Duration: July 1996 - 1998

Funding: Dept. of Health, Dept. of Education, Czech Rep., 500K Kč (US$ 14K) (in 1997)

Description: 'Orthoscope' – a device for acquisition and processing of undistorted images of the teeth arch has been developed. It is expected to improve the process of documenting and evaluating progress of treatment in dentistry (orthodoncy, prosthetics) and dermatology.

Five pieces of the Orthoscope device have been built. A pilot study will be carried out in 1998.

Rockwell Automation

Duration: long term

Funding: 250K Kč (US$ 7K) (in 1997)

Description: CTU researchers are regularly consulted by the Rockwell Automation Research Center in Prague.

Neovision

Duration: long term

Funding: 60000 Kč (US$ 1764) (in 1997)

Description: Neovision is small machine vision company closely associated with CMP. Neovision uses CMP facilities for special measurements and consults CMP members.

6 Facilities and Equipment

The CMP 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. An industrial microscope allows us to measure objects with size in the range of 2–50 mm. Several computers are equipment with mid-range cameras and frame grabbers.

We have built three rangefinders: a laser plane rangefinder, one-shot binary coded rangefinder and colour illumination based one-shot rangefinder (under construction). An autonomous vehicle that was built in the lab is used in navigation experiments.

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 (Pentium, Pentium Pro) running either Linux or MS Windows.

For more detailed information on CMP equipment, visit

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

7 Teaching

In 1997, CMP members taught the following courses (**course name,** *lecturer*, laboratory supervisor):

Introduction to computer vision for graduate students *V. Hlaváč*, Pajdla and V. Smutný.

3D computer vision for graduate students *V. Hlaváč*, T. Pajdla.

Robotic systems *V. Chalupa*, V. Smutný.

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

Computer Vision for Informatics *T. Pajdla, V. Smutný.*

Pattern Recognition *M. Haindl*

Fuzzy sets for master students *M. Navara.*

Calculus (English course) *P. Pták.*

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

CMP members participated in two teaching-related projects:

CAS and Their Application in Education at CTU

Basic facts: Responsible person Aleš Němeček (Dept. of Mathematics.), institution Faculty of Electrical Engineering, Dept. of Mathematics; financed by CTU Development Fund, grant No. 32-97007, funds 364K Kč (US$ 10K); start January 1997, finish December 1997; investigators from CMP participating in the team: Mirko Navara.

Project topic: Development of a coordinated approach to the application of computer algebra systems and their inclusion into teaching of mathematics, physics and other courses at technical universities.

Miscellaneous: Project is conducted at the Department of Mathematics, with a participation of investigators from CMP. Cooperating institutions: Faculty of Nuclear Engineering, Faculty of Machine Engineering and Faculty of Civil Engineering of CTU.

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; financed by CEEPUS; funds in 1997 25000 Kč (US$ 735); start September 1995, finish August 1998.

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

Hans Weber	Univ. of Udine, Italy, February 97, 2 weeks.
Anna De Simone	Univ. Federico II, Napoli, Italy, March 97, 1 week.
Paolo de Lucia	Univ. Federico II, Napoli, Italy, May 97, 10 days.
Zdena Riečanová	Slovak Technical University, Bratislava, Slovakia, June 97, 1 week.
Dan Butnariu	Univ. of Haifa, Israel, June 97, 2 weeks.
Gianpiero Cattaneo	Univ of Milano, Italy, June 97, 1 week.
Karl Svozil	Vienna Univ. of Technology, Austria, November 97, 2 days.
Vladimír Olejček	Slovak Technical University, Bratislava, Slovakia, December 97, 2 days.
Bernhard Moser	Johannes Kepler Universität, Linz, Austria, December 97, 1 week.
Peter Klement	Johannes Kepler Universität, Linz, Austria, December 97, 1 week.

9 Selected CMP Seminars

Axel Pinz	TU Graz, Austria *Computer Vision at the Techincal University of Graz*
Vito di Gesu	University of Palermo, Italy *Symmetry Operators in Computer Vision*
Joseph Kushi	Data Translation Inc., USA *Data Acquisition Products*
Gianpiero Cattaneo	Univerisity of Milano, Italy *A unified framework for the algebra of unsharp quantum mechanics*
Ivan Bruha	McMaster University, Hamilton, Canada *Unknown attribute value processing in rule-inducing algorithms: survey and trends*
Luqi	Naval Postgraduate School, Monterey, CA, USA *Formal Models and Prototyping*
Michal Schlesinger	Academy of Sciences of the Ukraine, Kijev *Minimax decision strategies with incomlete statistical knowledge*
Karl Svozil	TU Vienna, Austria *Quantum complementarity modelled by finite automata*
Peter Klement	Johannes Kepler Universität, Linz, Austria *Quality control with fuzzy logic - some case studies*
Bernhard Moser	Johannes Kepler Universität, Linz, Austria *Introduction to equality relations and their relevance for fuzzy control*
Bernhard Moser	Johannes Kepler Universität, Linz, Austria *Sugeno controllers with a bounded number of rules are nowhere dense*
Zdena Riečanová	Slovak Technical University, Bratislava, Slovakia *Strongly compactly atomistic orthomodular lattices*
Andrea Stupňanová	Slovak Technical University, Bratislava, Slovakia *Operations with fuzzy numbers*

Selected 1997 publications of CMP members.

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