BASIC INFORMATION

about Department of Adaptive Systems

Institute of Information Theory and Automation

The Academy of Sciences of the Czech Republic

Head: Miroslav Kárný

Mailing address:	P.O. Box 18, 182 08 Praha 8 Czech Republic Dept. of Adaptive Systems
Visiting address:	Pod vodárenskou věží 4 Praha 8 - Libeň
Tel.:	+42(2)815 2274
Fax:	+42(2)847452
Tlx:	122018 atom c
E-mail:	adapt@cspgas11.bitnet

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Contents

1 Introduction **2**
1.1 Academy of Sciences 2
1.1.1 What is the Academy 2
1.1.2 Budget 2
1.1.3 Relation to Universities 2
1.1.4 Working Teams 3
1.2 Institute of Information Theory and Automation 3
1.2.1 Research Departments Generally . . . 3
1.2.2 Contact Tree 4
1.2.3 Position of the Institute 6

2 Department of Adaptive Systems **6**
2.1 Personnel 6
2.1.1 Research Staff 6
2.1.2 Other Staff and Support 11
2.2 Department Characteristics 11
2.3 Department Strategy 12
2.3.1 Research 12
2.3.2 Applications 13
2.4 Reached Results 13
2.4.1 Theory and Algorithms 13
2.4.2 Applications 15
2.5 International Cooperation 17

2.5.1 Contacts 18
2.5.2 Cooperation 18
2.5.3 Joint Work 19
2.5.4 Important Results 20
2.6 Current Profile of the Department 20
2.6.1 Solved Research Problems 21
2.7 Contacts to Czech Enterprises 25

3 Conclusions **26**

1 Introduction

This material gives the key information about background achievements and aims of the Department. It could serve as a starting point for discussions about possible cooperations both in fundamental and applied research.

For a deeper understanding, it is fruitful to learn about still valid organization of science in the Czech Republic, about the role of the Academy of Sciences as well as about the tradition and position of the Institute of Information Theory and Automation.

1.1 Academy of Sciences

1.1.1 What is the Academy

In contrast to the majority of “western” countries, the Academy has its own research institutions (about 60) of various size (from 20 to 600 employees) covering wide range of science (natural, technical as well as social sciences).

1.1.2 Budget

Up to now the budget has been mostly covered by government; however, this support is being strongly decreased to the level which enforces a search for supplementary sources which are rare in the Czech Republic at present.

Experimentally, the Academy distributed about 20% of the state support through an internal grant system in 1991.

1.1.3 Relation to Universities

Fundamental research is the claimed aim of the Academy. Thus, as the institution, it is not involved in undergraduate teaching. Of course, its researchers are often partly employed by Universities for this purpose. The education of Ph.D. students is, however, one of the regular activities of the Academy.

At present, there is tendency to make interrelation of the Academy and Universities tighter.

1.1.4 Working Teams

Stable staff, tradition and continuity in the research which lead to harmonized working teams are the major advantage of the organization described above. It has given an opportunity to deal with projects of unusual complexity and with long horizon. The danger of overstabilized and sterile atmosphere is naturally connected with this key advantage.

1.2 Institute of Information Theory and Automation

The Institute covers selected topics which fall under its name. The current profile can be judged from the latest Activity report available which is attached. The following paragraphs give additional information.

1.2.1 Research Departments Generally

Staff of the eight current research Departments varies between 8 to 24 persons. The Departments have substantial and increasing amount of autonomy. They are supported by common management and by a reasonable (in Czech context) computing power. At present PC-AT, PC-386, Apollo, Pericolor system, Ethernet network with 4 workstations HP 720 connected to the international net Internet and central computer IBM 4361 cover the need. For publishing the institutional journal Kybernetika, a desktop publishing system works, too.

1.2.2 Contact Tree

Director:
Ing.Vladimír Kučera, DrSc.
Member of the Academy of Sciences
of the Czech Republic

Research Vice-Director:
RNDr. Milan Mareš, DrSc.

Management Vice-Director:
Ing. Miloš Thoma

Mailing address:
POB 18, 182 08 Praha 8, Czech Republic

Visiting address:
Pod vodárenskou věží 4, Praha 8 - Libeň

Tel.:
+42(2)847173, 42(2)815 2422

Fax:
+42(2)847452

Telex:
122018 atom c

E-mail:
utia@cspgas11.bitnet

RESEARCH DEPARTMENTS

Decision-Making Theory Tel:+42(2)815 2806
Head: Dr. Radim Jiroušek, CSc. Tel: + 42(2)815 2046
Key Words: Artifical Intelligence, Discrete and Syntactical Methods, Optimization and Differential Equations.

Computer Aided Decision-Making and Control (Tel:+42(2)815 2505)
Head: Ing. Jiří Záworka, DrSc. Tel: +42(2)815 2277
Key Words: Pattern Recognition, Discrete Event Systems, Large Scale Systems.

Control Theory (Tel:+42(2)815 2325
Head: Dr. Jiří Fiedler, CSc. Tel:+42(2)815 2222
Key Words: Linear Systems, Nonlinear Systems, Feedback and Feedforward Control.

Adaptive Systems (Tel:+42(2)815 2061
Head: Ing. Miroslav Kárný, DrSc. Tel:+42(2)815 2274
Key Words: System Identification, Adaptive Control, Adaptive Signal Processing.

Stochastic Informatics (Tel:+42(2)815 2466
Head: Ing. Igor Vajda, DrSc. Tel: +42(2)815 2572
Key Words: Random Processes and Fields, Mathematical Statistics, Information Theory.

Analysis and Modelling of Stochastic Systems (Tel:42(2)815 2045)
Head: Ing. Miloslav Vošvrda, CSc. Tel:+42(2)815 2400
Key Words: Spectral Analysis, Statistical Data Processing, Stochastic Modelling.

Image Processing Tel:+42(2)815 2045
Head: Ing. Stanislav Saic, CSc. Tel:+42(2)815 2551

Key Words: Digital Methods, Optical Methods, Restoration and Classification of Multisource Images.

1.2.3 Position of the Institute

Currently as well as in long terms, the Institute is counted to the top 10% within the Academy — due to the success in the internal grant system ranking of published books and papers, good co-operation with research institutions within Czech Republic as well as around the world, positions of its members within International organizations like IFAC, IFIP etc.

Within Czech industry, the Institute has also high reputation gained through the successful co-operation on technical projects, extensive consultations as well as tradition of seminars which are regularly organized by the Institute for practicioners.

2 Department of Adaptive Systems

2.1 Personnel

2.1.1 Research Staff

Ing. Miroslav Kárný, DrSc., head of the Department
∗ 1948, Ing. (M.Sc.) 1973 Faculty of Engineering Sciences and Nuclear Engineering, Czech Technical University Prague, field theoretical cybernetics; degree CSc. (Ph.D.) 1977 from Czechoslovak Academy of Sciences, topic: reproducing probability density functions and Bayesian order determination; degree DrSc. 1990 from the Academy, topic: identification for adaptive control; with the Institute since 1973.

He is oriented both to theory and applications of adaptive systems and he is (co)-author of about 70 papers.

Problems related to prior design of adaptive controllers and their easy and repetitive use are in the center of his current research activities.

At the application side, he has been involved in variety of particular cases like adaptive control of a cold-rolling mill, a rotary kiln and paper machines; Bayesian estimation of integral dosimetric quantities using a multicomponent dosimetric system; Bayesian solution of calibration problems in analytic chemistry; application of factor analysis to dynamic radionuclid studies (image processing in medicine).

Ing. Rudolf Kulhavý, CSc., senior researcher
∗ 1957, Ing. 1981 from Faculty of Electrical Engineering, Czech Technical University Prague, field automatic control systems; degree CSc. 1985 from the Czechoslovak Academy of Sciences, topic: probabilistic identification of time-variable systems; with the Institute since 1981.

He is mostly oriented to theory but with a strong feeling for the needs of practice and software implementations. He is author of about 30 papers with original results having strong impact on the field. In 1990, he won the Young Author Prize at the IFAC World Congress in Tallinn. During 1992 – 1993 he worked one year as SERC Visiting Fellow at the Control Systems Centre, UMIST, Manchester, UK.

His current research interests include identification of non-stationary, non-linear, or non-Gaussian systems, self-tuning control, and computer-aided design of control systems.

Ing. Jiří Kadlec, CSc, senior researcher
∗ 1958, Ing. 1982 from Faculty of Electrical Engineering,

Czech Technical University, field technical cybernetics and automation; CSc. 1987 from the Czechoslovak Academy of Sciences, topic: fast, normalized algorithms for identification of adaptive systems; with the Institute since 1982.

He is oriented to combination of hardware, software and theoretical tools needed for speech processing applied to PC terminals for the blind. The developed algorithms suit to control problems as well. He is (co-)author of about 20 papers and of 2 patents. He dealt with some specialized hardware like digital signal processor of TMS32 family and transputers. From November 1991 he got Fellowship in Department of Electrical and Electronic Engineering, Queens University of Belfast, Belfast, UK.

Currently, he concentrates on derivation and implementation of parallel and extremely fast fixed-point system-identification algorithms with special tracking abilities. Part of this work he performed while he was with the Ruhr University Bochum, FRG, supported by the Alexander von Humboldt Foundation and at the University of Athens, Greece, supported through European Fellowship.

Ing. I. Nagy, CSc., senior researcher
∗ 1956, Ing. 1980 from the Czech Technical University, Faculty of Electrical Engineering, field control theory; the degree CSc. 1983 from the Czechoslovak Academy of Sciences, topic: hybrid adaptive control of stochastic systems; with the Institute since 1980.

His interests are both of theoretical and of applied nature. He is (co-)author of about 20 papers. He was one of those who were opening the area of hybrid adaptive controllers. In the application area, he kept the main load when designing adaptive control of cross-profile of paper sheets.

His current research includes non-linear estimation, spline approximations of convolution models, hybrid control, and connection between continuous-time and discrete-time descriptions of systems.

Ing. P. Nedoma, CSc., senior researcher
* *1943, Ing. 1966 from the Czech Technical University, Faculty of Nuclear and Technical Physics, field digital simulation; CSc. in Computer Science from the Czechoslovak Academy of Sciences, topic: simulation of Markov chains; with the Institute since 1966.*

He is mostly oriented to creation of sophisticated software enviroments which support special requirements arising in research area. He is the author or co-author of about 40 (mostly conference) papers and research as well as industrial reports, and several special programs and program systems.

His current research interests are in computer-aided design of control systems and parallel processing.

Ing. Alena Halousková, CSc., senior researcher
* *1934, Ing. 1957 from Faculty of Electrical Engineering, Czech Technical University, field communications and control; CSc. 1965 from the Czechoslovak Academy of Sciences, topic: multivariate digital control; with the Institute since 1960.*

She deals with various aspects of adaptive control both at theoretical and application side. She is (co-)author of about 30 papers related to various theoretical aspects. She was involved in applications related to paper mills and cementary kilns.

Preliminary design of adaptive controller and applications of adaptive control in industrial systems are her current major research interests.

Ing. Josef Böhm, CSc., senior researcher
∗ 1942, Ing. 1964 from the faculty of Electrical Engineering, Czech Technical University, Prague, field control engineering; the CSc. degree in 1970 from Czechoslovak Academy of Sciences, topic: identification of nonlinear systems; with the Institute since 1965.

His major skill lies in algorithmization of control design. His engineering sense is invaluable throughout applications. He dealt with rotary kiln problem and control of drum boilers. He is (co)-author of about 30 papers.

Reliable, efficient and robust numerical solution of LQ optimization for on-line applications under mismodelling is his major research interest at present.

Ing. Jaroslav Maršík, CSc., senior researcher
∗ 1929, Ing. 1952 from the faculty of Electrical Engineering, Czech Technical University, Prague, field control engineering; the CSc. degree in 1957 from Czechoslovak Academy of Sciences, topic: automatic control of concentration of gas mixtures; with the Institute since 1957.

He deals with a separate line of so-called signal-based adaptive controllers which need his engineering sense and experience. His simple controllers are quite popular within our country.

Ing. Petr Klán, senior researcher
∗ 1957, Ing. 1981 from the faculty of Electrical Engineering Czech Technical University, Prague, field control theory; external student of Faculty of Mathematics and Physics of the Charles University, Prague, field theoretical cybernetics; with the Institute since 1981.

He is interested in the study of the possibilities of digital expert advisors. The purpose is to obtain data-based rules for determining the mechanism of control advising.

2.1.2 Other Staff and Support

Within the Department research is now supported by one programmer (Ing. Lenka Kulhavá) by three Ph.D. students (Ing. Jan Schier, Ing. František Hrnčíř, Ing. Lenka Zörnigová) and by one secretary (Jaroslava Hradcová).

Computing services are centrally organized.

Friendly atmosphere within the Institute guarantees that specialists from other Departments are willing to co-operate in their field of interest (at present, for instance, two mathematicians are co-operating with us).

2.2 Department Characteristics

As it is seen from personal biographies, the group is well balanced covering the art of adaptive systems from theoretical, algorithmic and software aspects up to real-life applications. We have fully exploited possibilities offered by the organization of science discussed above. The group has been dealing with adaptive (control) systems and related problems more than 20 year. Through these years it has created a unified theoretically and algorithmically well grounded approach to solving problems met in the area. The approach which can be labelled as Bayes-based theory of control under uncertainty is now perceived as Prague school of adaptive controllers.

The distinguished features of the group are:

- a unified theory forms the barycentre of its activities;

- the control problem is solved as the *technical* one in its maximal possible completeness;

- the constructive approach dominates the work (the best possible solution is searched for: improvements are rarely started from the analytical side);

- a unique stage of know-how has been reached throughout the years of co-operation;

- excellent long-term interpersonal relations.

2.3 Department Strategy

2.3.1 Research

Essentially two planning horizons are covered; none of them can be suppressed completely:

- *"short term"* activities with horizon about three years which aim at completion of the former research results into technically acceptable product (typically, the project of prior tuning of LQG adaptive controller);

- *"long term"* activities with almost unbounded horizon which aim at opening new ways of solving control problems (typically, research oriented to general solution of non-linear on-line estimation).

Of course, there is no sharp boundary between those lines. The attempt to master parallel computation is a typical new line of research which covers inherently both horizons.

2.3.2 Applications

Applications the Department is dealing with are a source of vital *feedback* in order to answer real, not just "academical" questions.

A desirable increase of our *budget* is another aspect of applications which has become important in the present Czech economical situation.

2.4 Reached Results

The results of the group are results of more than 200 man-year research effort. Clearly, just "highlights" can be referred only.

2.4.1 Theory and Algorithms

The papers describing one of the earliest selftuners [106] and optimal control design which does not rely on knowledge of the stability of inverse system [107] are cited as the seminal ones.

A unified Bayesian theory of identification with some original contributions, described in prestigious international IFAC monograph [112], became classic in the field. The strength of the theory is well seen on successful applications in variety of problems even outside adaptive system context (forecasting of market penetration by new technologies [111], analysis of dosimetric systems [12, 13, 47, 48], calibration in automatic chemistry [11, 46], factor analysis in medical image processing [121, 122, 123] etc.).

Theory and algorithms for estimation of model structures [34, 43] (of influence of various factors on predicted/controlled variables) [118] is another excellent result of the Bayesian theory with immediate practical impact especially in its fast versions [17, 18].

The estimation of both the model structure and parameters can be positively influenced by initialization of the algorithms. The Bayesian framework is open to including user's prior knowledge for this purpose. A theoretical approach has been developed, enabling the user to translate many items of his prior knowledge (possibly uncertain and contradictory) into favourable initial conditions of the estimation algorithms [135].

Safe and theoretically well-grounded solution of parameter tracking problem [71, 72, 73] which makes the system truly adaptive has been widely recognized as a new breakthrough in the area. Again, the theory had immediate practical impact on estimation practice. The impact has been strengthened by original fast, parallel and fixed point implementations e.g. [19, 23, 24, 25].

Feedback of special applications to the theory development is nicely illustrated by results reached through the design of adaptive control of paper cross-profile [44, 10, 98] which led to new promising complement of hybrid adaptive controllers [96, 97, 15].

The publications [35, 53, 51, 52, 135, 55] reflect current "short-horizon" research which tries to provide practically aplicable adaptive controllers [36, 3, 4, 5, 6] with tools for off-line computer design which could be mastered by process engineers.

The "long term research" oriented to estimation of non-linear/non-Gaussian systems which are often more suitable for modelling reality has its roots in [37, 38] which gave practically interesting robust estimation [42]. However, the alternative line based on a proper formulation of recursive approximation [79, 81] proved to be superior and brought interesting connections with differential geometry [80, 82]; the research effort has been concentrated to this line now.

2.4.2 Applications

The Department has been involved in many applied projects. We shall list the most successful of them.

- Industrial experiment with multivariate adaptive control (pressure and temperature) of a drum boiler performed in 1976 lasted several months and was evaluated as quite successful. The stage of permanent installation was not reached because of management problems. The experiment, however, gives a high chance for successful control of such processes.

- Adaptive control in paper industry has been running more than decade [90]. Quantities like the average moisture or basis weight of the produced paper have been controlled with significant economical impact (energy saving, higher quality). Adaptive control of cross-profile was prepared (not implemented because of major economical changes) [98].

- Adaptive control of metal thickness in a cold rolling system [8] has now been succesfully running for several years and new installations are under preparation. Quality of the produced strip increased to achieve the measurement precision (about 1μm).

- Installation of adaptive control of a temperature within a rotary kiln used in alluminium industry (similar to cementary kiln) is now finished. It is based on a successful full-scale experiment which manages to resolve problems being attacked unsuccessfully for couple of years.

- Applications out of control area were mentioned above. The routine applications of resulting sophisticated data handling continue in neutron dosimetry and nuclear medicine image processing.

- Finishing of the basic development of the experimental software monitor X*lab* [105] under an internal grant of the Institute. It has been designed as an ideal environment for research and education in CAD of Control Systems (CADCS).

- The automatic advisor PIDEQER for tuning PID controllers has been completed [66, 67, 68, 69]. It is based on an evaluation of properly selected dynamic properties of the inspected control loop. Its extraordinary feature is its ability to tune the controller just by observing normal operation conditions without additional test signals.

- The toolset PARASOL (PARallel SOLver) reported in [103, 102, 101, 104] has been designed and tested. It connects CADCS shell interpreters [95] (MATLAB – Mathworks, X*lab* – ÚTIA) with a single process library running on a transputer (INMOS Ansi C toolset was used for coding). PARASOL can
  • run the library on PC or on a transputer without changing its code;
  • be used with no knowledge of transputer programming;
  • be exploited for fast real-time control.

- The multivariate LQG adaptive controllers developed in the Department are quite powerful in solving complex control problems. To support their wider use in practice, the package DESIGNER for their computer aided design has been prepared [52, 55, 58, 59] covering model structure and parameter estimation, control optimization under input constraints and preliminary estimate of future control performance.

It is usual to refer about successes only. Our experience with unsuccessful attempts led us to observation that

- the majority of failures is due to management/hardware problems which we are not able to influence;

- an insufficient computer support of the preliminary design stage is responsible for the remaining minority: the project supporting the design stage arose from this experience (decrease of management problems can be expected too as by-product of a more systematic methodology).

2.5 International Cooperation

The range of contacts is quite wide but the depth is strongly varying.

Mutual exchange of information and random contacts are the weakest (still extremely useful) form of co-operation which we label *contacts*. Real *cooperation* means more regular mutual visits with courses. The *joint work* means joint publications/projects or organization of joint events (workshops).

2.5.1 Contacts

Belgium

Catholic University, Louvain-la-Neuve, Prof. R. Gorez, adaptive control

Lithuania

Inst. of Technical Cybernetics, Dr. V. Simonyte, identification and software for research

Sweden

Lund, Lund Institute of Technology, Prof. K.J. Åström, adaptive control

Uppsala, Uppsala University, Prof. T. Soderström, identification, signal processing

Stockholm, Royal Institute of Technology, Prof. J. Valis, identification, computer implementation

U.K.

London, Imperial College, Prof. M.H. Davis, stochastic control, nonlinear filtering

Salford, University of Salford, Prof. J. Gray, simulations, measurements

Oxford, Dept. of Engineering Science, Oxford University, Prof. D.W. Clarke, selftuning control and its implementation aspects

2.5.2 Cooperation

Denmark

Lyngby, Dept. of Chemical Engineering, University Lyngby, Prof. S.B. Jorgensen, qualitative modelling

Italy

Florence, University of Florence, Prof. E. Mosca, adaptive control and parallel processing

U.K.

Oxford, Dept. of Engineering Science, Oxford University, Dr. O.L.R. Jacobs, application of estimation methods in control

Glasgow, University of Strathclyde, Prof. M. Grimble, applications of adaptive control

Belfast, Queen's University of Belfast, Prof. G. Irwin, parallel processing

2.5.3 Joint Work

Greece

Athens, University of Athens, Prof. N. Kalouptsidis, signal processing

Hungary

Budapest, Computer and Automation Institute, Hungarian Academy of Sciences, Dr. K.M. Hangos, identification and its application in chemistry, qualitative modelling

Germany

Bochum, Ruhr University Bochum, Prof. K.H. Fasol, parallel processing in control

U.K.

Manchester, UMIST, Dr. P.E. Wellstead, Dr. M.B. Zarrop, estimation and control problems

Reading, University of Reading, Prof. K. Warwick, adaptive control, neural nets.

2.5.4 Important Results

1. Joint publications: see references.

2. Joint U.K.-Czechoslovak seminar on adaptive control [128] supported by Czechoslovak government and Department Trade and Industry, London.

3. U.K.-Czechoslovak seminar on neural nets [22], supported by the Institute of Information Theory and Automation and by IEE Society (its 1st event in East Europe).

4. Common work within a TEMPUS project (UMIST, University of Florence, Czech Technical University etc.)

5. The IFAC Workshop MICC organized in Prague, 1992.

6. Undergraduate/postgraduate courses on adaptive control (e.g. summer school Modern Control Theory – in cooperation with Czech Technical University or Laboratory Experiments in Control Engineering Courses).

7. Establishing Central European Graduate School in Systems and Control Theory (ÚTIA partners are Czech Technical University, Computer and Automation Institute of Hungarian Academy of Sciences, and University of West Bohemia).

2.6 Current Profile of the Department

At present, most effort concentrates on the solution of the research projects which gained internal research grants of the Academy: five of six submitted were successful (the sixth one is supported by the Institute). Their summaries give the most concise description of their aims.

No definite customer/sponsor is available for application projects which naturally extend the results of the research. Solutions of the corresponding theoretical problems prepare the projects but for economy (in quite broad sense) reasons we cannot start them without a prior agreement with the target user.

2.6.1 Solved Research Problems

Project title: Design of Multivariate Adaptive Controllers
Principal investigator: M. Kárný
Summary: Preparation of theoretical and algorithmic tools for computer aided support of adaptive control implementation is the global aim of the research to which the proposed project contributes. The developed theory will make possible to transform technical problem formulation (i.e. prior information, preliminary data and control objectives as well as technological restrictions) into a complete consistent specification of the so called LQG adaptive controller (Linear model recursively estimated assuming Gaussian disturbances used for optimizing Quadratic criterion).

Feasibility and usefulness of this research direction have been confirmed by results reached in a succesfully terminated research project (grant No. 27 522) which gave a couple of definite answers and opened couple of new problems. The open problems are mostly connected with the multivariate nature of the controller. Speciifically, the task to be solved are:
– continuous-time modelling of the system in a form suitable for the controller (in order to get rid off the need for a regu-

lar joint sampling and common model structure in different control loops);
– structure estimation of these continuous-time models;
– control law synthesis suitable for the control loop dependent structure and/or sampling.

Project title: Adaptive Systolic Filters with Bayesian Tracking of Optimal Structure
Principal investigator: J. Kadlec

Summary: Our objective is to develop a novel class of filters estimating uncertain or time-varying model structures in digital signal processing and control applications, implemented on a systolic array structure. This structure is realized by a field of processors, the neighbouring of them being coupled. The processed data flow through this array in a parallel manner [23]. In the algorithms, that will be described here, the array has a triangular shape.

We are building on results from a previous research project [26, 29, 30], where regularisation of systolic array filters with a known model structure has been solved by using a generalised parameter tracking concept.

The main problem to be investigated is the design of a parallel Bayesian structure estimation technique, utilizing information stored at the cell level of these generalised systolic-array filters.

Array implementations will be modelled and tested on a parallel transputer-based experimental system.

Project title: Finite–dimensional Approximation of Recursive Bayesian Parameter Estimation
Principal investigator: R. Kulhavý

Summary: General theory of parameter estimation does not take into account real constraints on computation mem-

ory and time. Complete theoretical solutions are mainly restricted to linear problems, theoretical solutions to nonlinear problems are not directly implementable in practice. The objectives of the proposed project are to suggest theory for systematic design of approximate nonlinear estimators and elaborate it for some special but practically important models. In comparison with other known approaches, the recursive form of computations will be respected since the very beginning and differential-geometric methods will be employed to solve the problem. The proposal also assumes to develop algorithms necessary for design, implementation and testing of approximate estimators. As a result, we should become able to estimate parameters of a larger class of models than so far in real time.

Project title: Theory and Facilities for Signal-based Adaptive Control
Principal investigator: J. Maršík
Summary: We have developed several types of original algorithms for identification-free adaptive control. It is possible to consider these algorithms as fundamental for a new signal-based control theory. Besides the extraordinary simplicity and high control efficiency the use of the conception in knowledge-based control systems is to be emphasized. In order to accelerate the development of the signal-based theory we have realized an original mobile station for real-time experiments and for education of specialists and students interested in adaptive control. Our main objective is to elaborate a compact theory of these algorithms and to prepare general frames for new algorithms developed for more complicated control conditions. Another goal is to complete the advanced original mobile station utilizing a CADCS package

such as MATLAB and using modern 16-bits monolithic microcomputers. The station will be used to verify a principle of these (and other) algorithms through real-time process experiments in the industrial environment.

Project title: Development of Computer Aided Design of Control Systems (CADCS)
Principal investigator: P. Nedoma
Summary: The project aspires to reach a qualitatively higher level of computer aided design of control systems (CADCS).

The grant should support:

- research of methodology and software tools for design of CADCS packages in conditions of fundamental research;
- verification of the quality of developed tools by creating two CADCS packages covering research results of the Institute in the fields of linear system theory and adaptive control.

The methodology and tools developed in the project will upgrade former software constructions and a control monitor designed in the Institute. It supports further development of new control algorithms and simplifies substantially the access of scientific/technical audience to them.

Project title: Theory and Algorithms of Adaptive Control with Enhanced Robustness
Principal investigator: J. Böhm
Summary: It is proposed to continue the research on adaptive and self-tuning control carried out since 1970. In spite of the fact that the results obtained until now have been

well accepted by the international scientific comunity in the given field and found successful practical applications in industry, further significant improvements can be expected. In this advanced stage of the research the emphasis will be laid on robustness of the resulting algorithms both with respect to modelling errors and with respect to round-off errors in real-time computation. The Bayesian methodology, which has been developed by our Prague school in the past and which appeared to be very fruitful and consistent in dealing with uncertainties, will form the basis of the theoretical part. The robustness is expected to be achieved by using new types of mathematical models, employed to describe and identify the dynamical and stochastic properties of the controlled process, and by suitable modifications of the optimality criteria in the control design procedure. Practical engineering needs and technological constraints will be reflected in the development of the control algorithms, including their fast and effective realization using microcomputer systems and special-purpose hardware.

2.7 Contacts to Czech Enterprises

The Department has extensive contacts to Universities, industrial research institutes and directly to various branches of industry (our mailing list contains about 1000 persons and/or institutions).

The situation in the industry is, however, uncertain and rapidly changing (for instance, the group we were cooperating with in paper industry does not exist any more). We are, however, keeping as many contacts as possible: we hope that the situation will become a bit clearer when basic legislative rules will be ready.

3 Conclusions

This is an incomplete and open-end story about a single research group — its activities and aims. Anybody who is interested can easily learn more about us.

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