Report for the Evalution of the Institute

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INSTITUTE OF COMPUTER SCIENCE

ACADEMY OF SCIENCES OF THE CZECH REPUBLIC

Report for the evaluation of the institute

Editor: Július Štuller

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Institute of Computer Science of the Academy of Sciences of the Czech Republic

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Report for the evaluation of the institute

Prague, June 21, 1996

Revised version

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0 General information

0.1 Institute Conception

0.1.1 Short history

The Institute was founded in 1975 as a service unit of the Czechoslovak Academy of Sciences under the name General Computing Centre. In November 1980 it turned into a scientific institute within the first department of the Academy (sciences on non-living nature) and was named the Centre of Computing Techniques. This new institute was both a unit of scientific research and still a regular computing centre of the Academy. Since the 1st of January 1993 the Institute has been a fully-fledged institute of scientific research bearing the name the Institute of Computer Science. By this the stepwise transformation from a computing centre to an institute of scientific research has been completed.

0.1.2 Research subjects and plans

Main directions of research On one hand, they have been determined by the historical development; on the other hand, they have been continuously re-evaluated. The main research directions correspond to scientific departments of the Institute; we list them, each with a summarized characteristics.

- *Theoretical computer science.* Construction and complexity analysis of effective sequential, parallel and distributed computational models, algorithms and data structures, including computational analysis of neural networks; simulation of computing models and a means for object-oriented distributed systems.
- *Computational mathematics:* Development of new original optimization methods, methods of numerical linear algebra and methods for problems described by partial differential equations. Principal attention is focussed on iterative methods for large scale structured problems.
- *Knowledge based systems:* Theoretical foundations and computational problems of knowledge and data processing in the presence of vagueness and uncertainty; logics of approximate reasoning.
- *Neural networks.* Mathematical foundations of neural networks with fixed or variable structure and the investigation of new types of neural networks motivated either biologically or by particular applications as signal processing, adaptive and neuro-fuzzy control.
- *Non-linear modelling.* Theory and application of non-linear time series and data analysis.
- *Medical informatics* (joint unit with the Faculty of Mathematics and Physics of the Charles University): establishment and running of the European center of medical

informatics, statistics and epidemiology (EuroMISE) for the education of experts from the countries of central and Eastern Europe, with its own research activity in cardiology, oncology, genetics and epidemiology.

Present state and trends The above mentioned research directions are not fixed once for ever; the Institute (i.e. the Director and the Scientific Council) repeatedly confronts them with major research trends in Computer Science (as formulated e.g. in the classification of Computing Reviews). The quality of our orientation is guaranteed first by the activity of key researchers, who are top ranked well-informed creative senior scientists that are able to influence their colleagues. Updating the conception is the task of heads of departments and of the Institute Scientific Council.

However, it is reasonable to attempt to re-evaluate the system of main research directions from the point of view of a unifying program or topic. In the past this happened around 1986 by the orientation towards neural networks. Presently an attempt is being made to see the whole of the Institute's scientific activity from the point of view of *intelligent computing* understood as an approach which is tolerant to suboptimality, impreciseness and errors and emphasizing parallelism, distributedness and robustness. The term "intelligent computing" is modern and may appear fashionable; but this should not prevent a serious and thorough attempt to equip it with an exact approach (see the outline of the future research conception in section 11).

0.1.3 Activities and ways to reach the aims

The main aim of the Institute, having absolute priority, is scientific research in computer science satisfying the most demanding criteria on an international level. Besides the question of whether we produce good science of sufficiently high quality, it is necessary to deal with the question of how to maintain and improve the position and the results of the Institute. This concerns financial matters (success in grant proposals, collaboration on applications), human relations, technical tools for the research, international cooperations and relations, cooperation inside the Czech republic, pedagogical activities on a pregradual and postgradual level.

Funding Similarly as other institutes of the Academy, available finances are not sufficient and we have to take care of additional sources. Besides money obtained directly from the Academy (institutional budget) the main source must be grants. Therefore, the success in getting grants is highly evaluated. The next source is cooperation with commercial subjects; some of them have been in process for years, but it is necessary to be prepared for a situation demanding more of them. Presently the management of the Institute and its Scientific Council are working on general rules for a possibly broader cooperation with commercial subjects, still insisting on the absolute priority of scientific research for the Institute as a whole as well as for each of its scientists.

Internal structure and management Internally the Institute is divided into three sections:

1. scientific
2. informational support
3. technical and economical service.

In the scientific section the structure of departments is complemented by the structure of running grants; both structures coexist successfully.

There are regular weekly meetings of the scientific management with the heads of scientific departments; once a month there is a whole-institute briefing with a general discussion.

The Scientific Council meets once a month on average; its presidium meets the director as the occasion demands.
The following matters are stressed:

- education of young scientists
- international cooperation
- pedagogical activity and cooperation with universities
- sufficient supply of technical means and of the literature

Managerial measures are mostly based on a consensus of the leadership, scientific council and heads of departments.

0.1.4 Conclusion

Similarly to the conception of the Academy, the conception of the Institute will be a matter of a permanent adjustment along the lines of the development of the Computer Science.

0.2 Indicators of Institute's scientific level

Below we summarize basic information on some indicators of the global scientific level of the Institute. For details we refer to tables at the end of this report as well as to the Supplement containing detailed bibliographical information. Detailed information on the active teams is the main content of this report (**Sections 1-10**).

0.2.1 Publications

Here we only present a table with summarized numerical information; the Supplement contains a detailed bibliography of publications (classified as books, papers in journals, papers in proceedings etc.) as well as a bibliography of citations. Note that the report on each working team contains a similar table with the information on the publications and citations of the team as well as full references for most important publications; here we also inform on the impact factors of relevant journals (even if we are rather skeptical to the informational value of this number for various fields of computer science).

Number of publications

		1991	1992	1993	1994	1995	1996	in print	total
1.	papers in **journals :**								
	— *international*	27	40	36	41	43	3	31	**223**
	— others	40	19	23	10	17	2	3	**114**
2.	**proceedings** of conferences								
	— *international* (full texts):	15	26	37	63	50	-	17	**209**
	— others (full texts) :	10	20	6	8	4	-	2	**50**
	— international (abstracts) :	2	6	10	20	17	-	4	**59**
	— others (abstracts) :	-	14	-	5	-	-	-	**19**
	— *invited papers* :	1	3	5	7	12		3	**31**
3.	**monographs** or their parts :	5	5	5	5	6	1	2	**30**
4.	**textbooks :**	1	3	1	2	1	-	-	**8**
5.	**dissertations :**	1	5	4	1	-	-	-	**11**
6.	**reports :**	34	22	30	47	56	-	3	**192**
7.	CITATIONS :	74	59	99	132	147	12	-	**523**

0.2.2 Editorial activity

The Institute is the scientific sponsor of the international journal Neural Networks World, published by IDG Czechoslovakia. The chief editor is from the Institute and so are some other members of the editorial board.

0.2.3 Grants

For detailed information on grants (6 international grants, 3 ministerial grants, 20 grants of the Grant Agency of the Czech Republic and 17 grants of the Grant Agency of the Academy of Sciences) see subsection **12.1**.

0.2.4 Pedagogical activity and cooperation with universities

The Institute is active in the education of both undergraduate and postgraduate students, and cooperates with several Czech universities. The Institute takes part in organizing postgraduate studies, and its specialists hold lectures at these faculties :

1. Faculty of Mathematics and Physics (FMP), Charles University (CU), Prague
2. Faculty of Electrical Engineering (FEE), Czech Technical University (CTU), Prague
3. Faculty of Nuclear Sciences and Physical Engineering (FNSPE), CTU, Prague
4. Masaryk's Institute of Higher Education (MIHE), CTU, Prague
5. Philosophical Faculty (PF), CU, Prague
6. Faculty of Transportation (FT), CTU, Prague
7. University of Pardubice
8. West Bohemia University (WBU) of Plzeň

The lectures are being held on :

1. mathematical logic
2. uncertainty processing
3. probabilistic algorithms
4. mathematical methods of data processing
5. database systems
6. numerical linear algebra
7. theory of matrices
8. sparse matrix computations
9. optimization and non-linear approximation
10. advanced numerical methods
11. parallel computer architectures and their programming
12. theory of neural networks
13. methodology of programming
14. algorithm design
15. complexity theory

(See subsubsections **12.5.1** and **12.5.2** for the complete list of semestral lectures.)
Postgraduate students are provided with the opportunity to use the computer facilities of the Institute. The list of current post-graduate students (25 persons) is in the subsubsection **12.4.3**.

The Institute houses the Joint European Project under the TEMPUS Scheme EuroMISE - European Education in Medical Informatics, Statistics, and Epidemiology which is active through the cooperation of 12 European research institutes and universities. The main goal of the project is to establish the European Centre of interdisciplinary research and higher education in the field of EuroMISE, in close cooperation with the Faculty of Mathematics and Physics of the Charles University in Prague.

Furthermore, the Institute has been approved as the Examination Institute in the Czech-Dutch project AMBI/CR which provides the extramural education on information technologies, computer science and engineering for about 20 courses. The examination standards and the high vocational level will be guaranteed by the Institute.

Some scientists from the Institute are members of the Field Councils of Doctoral Study at the Faculty of Mathematics and Physics, Charles University, and at the Faculty of Nuclear Sciences and Physical Engineering of the Czech Technical University.
Some additional numerical information can be found bellow in subsection **0.3 - Visibility**.

0.2.5 Applications and cooperation with commercial subjects

Besides scientific results some teams also produce special software systems, e.g. for medicine (CRACTES – diagnostics in oncology, see subsubsection **9.1.6**), numerical mathematics (UFO, see [4] in section **2**), and data analysis (GUHA, see [7] in section **5**). This development is a part of grant projects.
From other applications we mention prediction methods for Czech energetic network (see subsubsection **9.1.5**).
Further possibilities of commercial utilization are being investigated.

0.2.6 Popularization

Several people contribute articles concerning some activities of the Institute to popularizing computer journals like Computer Echo.
The Institute presented itself at the exhibitions INVEX '95 and Essentia '95.
There were also a few relations on the radio, e.g. on expert systems or on mathematics and music.

0.2.7 Computer equipment

Nearly all rooms in the Institute are interconnected by the LAN running NOVELL system and several file and print servers. This local network (with several sections) is connected to the Institute's UNIX network with two SONYs, one SUN and four Silicon Graphics (Crimson and Indigo 2 with two Indy) workstations. The computing capacity of Indigo satisfies most of the Institute's research worker requirements.
The UNIX part of the local Institute's network is connected to the INTERNET.

Presently an agreement between the Institute and the private company I.C.C.C. is in the process of ratification. According to this agreement I.C.C.C. will establish the educational centre for the parallel computer architectures equipped with the Hewlett-Packard - Convex SPP 1200 XA system with 16 nodes in the Institute building. The Academy of Sciences will obtain 50% of the capacity available for the projects approved by a special Academic Board which can be viewed as a considerable contribution by the Institute to enlarge the computing facilities at the Academy of Sciences.

0.3 Visibility

A summarization table follows:

	1991	1992	1993	1994	1995
Employees (equivalent number)	121	105	83	87	88
Lectures at universities - teaching hours	260	416	676	741	1371
Pedagogical activities - number of universities	3	6	6	5	8
PhD students	19	13	13	17	25
Finished PhD students	2	2	6	0	1
Diploma works - guidance	?	?	10	9	15
Students working in ICS AS CR	6	7	5	3	3
Invited lectures	?	?	12	28	23
Invited lectures of foreign specialists	?	?	19	22	20
Membership on Editor Boards	13	17	15	13	18
Posts in international societies	3	4	4	5	5

Let us add some details.

There were at least six important awards obtained by individuals from the Institute:

1. the Hans Schneider Prize awarded by International Linear Algebra Society (ILAS) to M. Fiedler in 1993
2. the SIAM Activity Group on Linear Algebra (SIAG/LA) Prize awarded to Z. Strakoš in 1994 for the Most outstanding paper in applicable linear algebra published in the years 1991–93 for the finite precision analysis of Lanczos and CG algorithms.
3. P. Růžička and D. Hrycej were awarded the prize for the most outstanding contribution at the conference "Neuro Nimes '93".
4. 1.–3. award (from 45 presentations) at 2nd International HSBCR Congress, Kos, Greece, October 25–28, 1995 (L. Pecen, K. Eben).
5. V. Kůrková was awarded prize for the best east-european contribution at ECAI '92 conference in Vienna.
6. second award in poster section (from 49 presentations) at 12th International Conference on Human Tumor Markers in New York, June 11–14, 1995 (L. Pecen, K. Eben, M. Sláma)

For the list of conferences in which the Institute was, is or will be the main organizer or one of the organizers (13 conferences in the past and 5 conferences in the near future) see subsection **12.2**.
For references on the 31 invited conference talks (with full paper in the proceedings) see the Supplement.
Long-term stays abroad of Institute employees : Strakoš, Holeňa, Eben, Harmanec, Neruda.
The following is a list of international scientific journals which have members of the Institute on their editorial boards:

- Czechoslovak Mathematical Journal (Fiedler - Chief Editor, Hájek, Pták)
- Mathematica Slovaca (Fiedler)
- Archive for Mathematical Logic (Hájek)
- Studia Logica (Hájek)
- Fundamenta Informaticae (Hájek)
- Kybernetika (Kramosil)
- Computers and Artificial Intelligence (Hájek)
- Applications of Mathematics (Lukšan)
- Numerische Mathematik (Fiedler)
- Linear Algebra and its Applications (Fiedler, Pták)
- SIAM Journal of Matrix Analysis and Applications (Strakoš)
- Neural Network World (Novák - Chief Editor, Hamata, Jiřina, Kufudaki)
- Neural Networks (Novák)
- Neural Processing Letters (Kůrková)
- International Journal on Circuit Theory and Applications (Novák)
- International Journal of Forecasting (Pelikán)

Some functions in international and national scientific societies:

- Hájek is the first vice-president of the International Union for History and Philosophy of Science - Division Logic, Methodology and Philosophy of Science
- Hájek was recently (1992-1994) a member of the Council of the Association for Symbolic Logic
- Kramosil is the president of the Czech Society for Cybernetics and Informatics
- Czechoslovak National Committee for Mathematics (Fiedler - chairman)
- National Committee of IEEE (Novák)
- National Committee of IFIP (Jiřina)

0.4 Structure of the rest of this report

The main body of the remaining part of the report contains detailed information on the activities of ten scientific teams. In four cases (**Sections 1, 5, 9** and **10**) the team consists of all members of the department. Two departments decided to report on themselves as on three teams each (Department of Computational mathematics - **Sections 2 - 4** and Department of Neural networks - **Sections 6 - 8**).
Section 11 outlines the conception of future research and **Section 12** contains various enclosures.
Complete bibliographical references are contained in an extra volume of Supplements.

Department of Theoretical Informatics

Head: **Ing. Václav Šebesta, DrSc.**

1 Department of Theoretical Informatics

Participants:

Mgr. Jiří Šíma, CSc. (since 1991)
RNDr. Jiří Wiedermann, DrSc. (since 1993)
RNDr. Petr Savický, CSc. (since 1995)
Ing. Václav Šebesta, DrSc. (since 1995)
RNDr. Stanislav Žák, CSc. (since 1994)
Doc. Ing. František Plášil, CSc. (part time — 50% since 1994)
Ing. Jan Kleindienst, PhD student (since 1995)
Ing. Michal Fadljevič, PhD student (since 1995,
currently at military civil service)
RNDr. Daniela Kostková (since 1995)

1.1 Main research projects

The department was founded in the beginning of 1994, first with J. Wiedermann, and later on, from 1995, with V. Šebesta as its head. Internally the department consists of two research groups, the complexity theory group and software engineering group.
The main research focus of the complexity theory group has been oriented towards studies in abstract machine models of both sequential and parallel computing, the design and analysis of efficient algorithms and data structures, and the theory of neurocomputing.
The research within the software engineering group has been focused towards the theory and methodology of programming in parallel and the distributed environment and the architecture of the respective real computing systems.
The current research projects are entirely determined by the on-going grants in which individual department members participate (cf. the list of grants in the sequel).

National grants

1. Grant Agency of Academy of Sciences of the Czech Republic — Grant No. 23003 : Model Search Techniques (1991–1993) (leader: V. Šebesta).

2. Grant Agency of the Czech Republic — Grant No. 201/95/0976 : project "HYPERCOMPLEX" — Complexity Issues in High Performance Computing, since 1995 (leader: J. Wiedermann)

Foreign grants

1. International pilot research project of EU "ALTEC" — Algorithm for Future Technologies, Cooperative Action IC 1000 (1992–1995) (leader: J. Wiedermann).

2. COPERNICUS CP 940247 : TOCOOS Project (Tools for the Composition for Open Object-oriented Distributed Systems) together with IONA Technologies Ireland, MARI, Great Britain, Cyfronet, Poland;
   more particularly on the implementation of selected CORBA services (1995–96)

1.2 Relation to the previous research and goals for the future

In spite of the fact that the department is relatively new, it mostly consists of researchers with good previous experience in the related topics. Therefore the current research presents a natural continuation of the preceeding research of individual key researchers. The research is oriented towards the main topics of the grants mentioned above. The unifying long term joint idea for both the current and future research is the study, exploitation and systematic introduction of new computational paradigms into (experimental) applications. Depending on the particular field these paradigms take various forms — parallelism, distributivness, connectionism, object—orientation, etc.

1.3 The most important results of the last five years

1. The result [1] is a contribution to the study of pseudorandom generators. The formulas described in the paper provide a generator of pseudorandom bits, which belongs to the class of bounded depth circuits in the basis $\{\wedge, \oplus\}$. This is probably the smallest complexity class, where a reasonable pseudorandom generator may be found. In order to obtain 2^n bits, such that each d of them is independent with an error ε, it is sufficient to use $O(n(\log d)^2 \log(1/\varepsilon))$ truly random bits. This result improves a previous construction of Razborov, where $O(nd \log d \log(1/\varepsilon))$ are needed. Savický and Žák proved an exponential lower bound on branching program, which may read at most $k(n)$ out of n of its input variables more than once. The lower bound is proved under the assumption that $k(n) < n^{1-\varepsilon}$ for any positive ε. This is an improvement of the previous result, where the exponential lower bound was proved provided $k(n) < n^{1/2-\varepsilon}$.

2. In [3], a theoretical basis for a neural expert system has been developed. This system is able to create its knowledge base automatically from example inferences using a generalized back–propagation learning algorithm and to cope with incomplete information, as well as to provide inference explanations. These ideas were implemented in the user–friendly software product EXPSYS, which is a general tool for a neural expert system design. This program has been successfully used to solve several problems in medicine, energetics, etc.

3. In [2], the NP-completeness of the neural learning problems for deep networks and especially for the popular continuous back–propagation networks, has been proven. This answers one of the important open questions in the area of neural learning complexity. The computational power and the descriptional complexity of the general

neuromata (finite discrete neural networks) and their various subclasses have been fully characterized.

4. In [4], an interesting relationship between nondeterministic Turing machine computations and the convergence of Hopfield neural networks was shown. It was proved that finding the proper initial configuration of a general Hopfield network from which the convergence into a global minimum will follow is a NP-complete problem.
   In [6] a so called *Parallel Turing Machine* has been described which represents the class of so–called *weak parallel machines*. The first known complexity–theoretic characterization of the respective class (that includes e.g. systolic meshes, cellular automat, etc.) with the help of period bounded computation was given. This model has been included in the monograph *Handbook of Computer Science* by J. van Leeuwen (Editor), Elsevier, 1990 and 1992.

5. The work [8] has been included in the prestigious recent monograph *Computer Science Today*, which has appeared as a special anniversary Vol. 1000 in the LNCS Series in Springer Verlag. Its full version has appeared as an invited talk in [9].

6. The research within the software engineering group is oriented towards designing and developing distributed system components. The group that started with Objix microkernel [10] is currently working on the TOCOOS Copernicus project (Jan 1995 – Dec 1996) which is based on the OMG CORBA architecture. The project successfully passed the EU evaluation, and one of its main results will be the set of building blocks and guidelines for building the portable layer of CORBA Object Services.

7. In [11], the concurrent method for the search of dependencies in experimental data is shown. The transputer motherboard for PC is the special hardware component used, and the program nucleus in parallel programming language OCCAM has been developed for the parallelization of the GUHA method, described by Hájek and Havránek.

1.4 Number of publications

1.	international journals :	11
2.	proceedings of conferences	
	— international (full texts) :	23
	— others (full texts) :	1
	— international (abstracts) :	5
	— others (abstracts) :	3
3.	monographs or their parts :	3
4.	dissertation :	1
5.	reports :	21

The most important publications of the last five years

[1] Savický P.: Improved boolean formulas for Ramsey graphs. — Random Structures and Algorithms 6 (1995), 4, 407–415 (impact factor 0.439)

[2] Šíma J.: Loading deep networks is hard. — Neural Computation 6 (1994), 842–850

[3] Šíma J.: Neural expert systems. — Neural Networks 8 (1995), 261–271 (i.f. 1.895)

[4] Wiedermann J.: On the Computational Efficiency of Symmetric Neural Networks. — In: Theoretical Computer Science, Vol. 80, 1991, 337–345 (i.f. 1.895)

[5] Wiedermann J.: Efficient Simulations of Nondeterministic Computations and their Speed–up by the Ring of Cooperating Machines (Invited Paper). — In: International Workshop on Fundamentals of Artificial Intelligence Research, Proceedings of FAIR '91, LNCS 535, Springer Verlag, Berlin, 1991, 59–70

[6] Wiedermann J.: Weak Parallel Machines: A New Class of Physically Feasible Parallel Machine Models (Invited Paper). — In: Proceedings Mathematical Foundations of Computer Science 1992, LNCS 629, Springer Verlag, Berlin, 1992, 95–111

[7] Wiedermann J.: Fast Sequential and Parallel Simulations of Nondeterministic Computations. — In: Computers and Artificial Intelligence 13 (1994), 6, 521–536

[8] Wiedermann J.: Quo Vadetis, Parallel Machine Models? (Invited Paper) — In: Computer Science Today — Recent Trends and Developments, LNCS 1000, Springer Verlag, Berlin, 1995, 101–114

[9] Wiedermann, J.: Parallel Machine Models: How They Are and Where Are They Going. (Invited Paper) — In: Proceedings SOFSEM '95: Theory and Practice of Informatics, LNCS 1012, Springer Verlag, Berlin, 1995, 1–30

[10] Plášil F., Grof M.: Using both Virtual 8086 and Protected Modes to Implement OBJIX Microkernel on I80386. — Journal of Microprocessor Application 17 (1994), 381–396

[11] Šebesta V.: Utilization of Transputers for the Statistical Model Search. (Invited paper) — In: Proceedings of the International Workshop "Progress in Transputer Computing Technology", ITIA AS CR, May 1993, 25–32

Number of citations: 13

1.5 International cooperation

A sizeable international cooperation, which has been established with the help of the past and current international grants, exists.

- Currently there are efforts in establishing a new cooperation within the field of neurocomputing with the Department of Computer Science, University of Helsinki, Finland (Professor Pekka Orponnen), and Technion, Israel (Professor Hava Siegelmann). The first exploratory visits professors, mentioned previously, in the ICS have taken place in 1995.

- The part of the department international visibility is based on organizational activities of some of its members.

  - In 1995, the complexity group organized the annual 20-th international conference MFCS'95 — Mathematical Foundation of Computer Science (see the proceedings: Wiedermann, J. — Hájek, P. (Eds.): Mathematical Foundation of Computer Science 1995, August/September 1995, Prague, Czech Republic, LNSC Vol. 969, Springer Verlag, Berlin, 1995), with roughly 150 participants from 15 countries, from all over the world.

  - Since 1974, J. Wiedermann has been involved in the organization of a long term series of SOFSEM winter schools which have served as Czechoslovak foremost seminars, in theory and practice of informatics. Since 1995, SOFSEM proceedings are published in the series Lecture Notes in Computer Science, Springer Verlag, Berlin (see Bartošek, M. — Staudek, J. — Wiedermann, J. (Eds.): SOFSEM '95 — Theory and Practice of Informatics, 22nd Seminar on Current Trends in Theory and Practice of Informatics, Milovy, Czech Republic, November/December 1995, LNSC Vol. 1012, Springer Verlag, Berlin, 1995).
    Since 1995, J. Wiedermann is the Chair of the SOFSEM Endowment Board.

  - The Institute of Computer Science has been appointed by the Ministry of Economy to be the permanent Examination Institute for the project AMBI ČR.
    This project is engaged in the transfer of a complex set of about 20 educational courses in informatics and information systems from the Netherlands to the Czech Republic. These courses have a modular structure and each of them contains about 200–300 study hours.
    According to the Licence agreement conditions, the teaching and education in AMBI must be completely separate from the knowledge examination and certificate administration. From this point of view ICS is fully responsible for the examination part of the project, i.e. for the translation and localization of all automatized and classical examination tests, and by the means of the Examination Board, for the professional level of education materials also. Our counterpart on the Dutch side is the EXIN foundation in Utrecht. The chairman of the Examination Board and the EXIN ČR coordinator is V. Šebesta.

- Since 1994, the Institute has been active in approaching the prestigious European Research Consortium in Informatics and Mathematic (ERCIM) which is an international consortium of the leading computer science institutes in Europe.
  Currently, a so-called Czech Research Consortium in Informatics and Mathematics (CRCIM) is being established. It consists of the Faculty of Mathematics and Physics, Charles University, Prague; the Faculty of Informatics, Brno; the Institute of Theory of Information and Automation, AS CR, and of the Institute of Computer Science, AS CR, which has J. Wiedermann as the CRCIM director. CRCIM will become a member of ERCIM in the near future.

1.6 Related Activities and Remarks

- All senior scientists act as PhD advisors and most of junior researchers act as the university student project leaders.
  Following lectures :

  - "Models of Sequential and Parallel Computers"
  - "Parallel Architectures and their Programming"
  - "Theoretical Foundations of Neural Networks"
  - "Operating Systems"
  - "Distributed and Object Oriented Operating Systems"

  are given by the department members at the

  - Faculty of Mathematics and Physics
  - Faculty of Electrical Engineering
  - Faculty of Nuclear Sciences and Physical Engineering
  - Faculty of Transport
  - Masaryk's Institute of Advanced Studies:

- F. Plášil, V. Šebesta and J. Wiedermann are members of several examination boards for both the undergraduate and postgraduate students at the above mentioned faculties and also members of boards of referees in national and academic grant agencies.

- J. Wiedermann is the member of the Council of the Academy of Sciences.

- Since 1995, a working seminar called HORA INFORMATICÆ has existed in the department which is also open for students and other participants.

- The internal organization of the department is informal. It is assumed that the software engineering group will gradually increase and eventually will act as a separate department. In the field of neural computing there are tight cooperating relations with the Department of Neural Networks and the Department of Nonlinear Modelling.

Department of Computational Mathematics

Head: **Ing. Ladislav Lukšan, DrSc.**

Research teams:

1. Numerical Optimization
2. Applied Linear Algebra
3. Mathematical Modelling

2 Numerical Optimization

Participants:

Ing. Ladislav Lukšan, DrSc.
Ing. Jan Vlček, CSc.
Ing. Martin Šiška (till 1991)
Doc. RNDr. Jiří Rohn, DrSc. (part time — 33% since 1994).
Doc. RNDr. Jan Zítko, CSc. (part time — 33% since 1995).

2.1 Main research projects

Research in optimization methods and the development of a software system for universal functional optimization.

National grants

1. Grant Agency of the Academy of Sciences of the Czech Republic — Grant No. 23012: Research of optimization methods and the development of an interactive system for universal functional optimization, Jan. 1991 – Dec. 1993

2. Grant Agency of the Czech Republic — Grant No. 101/93/0838: Framework-based workbench for concurrent engineering of mechatronics products,
   Oct. 1993 – Dec. 1996

3. Grant Agency of the Czech Republic — Grant No. 201/93/0429: Research of optimization methods and the development of an interactive system for universal functional optimization, Oct. 1993 – Dec. 1996

4. Grant Agency of the Czech Republic — Grant No. 201/96/0918: Development of methods for solving large-scale problems of nonlinear analysis,
   Jan. 1996 – Dec. 1998

2.2 Relation to the previous research and goals for the future

The Group of Numerical Optimization, lead by L. Lukšan, originated in 1974. Its most important activity concerned numerical methods in nonlinear analysis with their application in science and technology, including the development of a software package for optimization and nonlinear approximation SPONA. This package has been awarded the Czechoslovak Academy of Sciences Prize in 1982. The present research is a continuation of our previous activity in the field of numerical optimization. The interactive system UFO mentioned below is a new modern version of the previous system SPONA. We suppose a continuation of our research also in the future. Numerical methods for large-scale nonlinear analysis and numerical methods for a nonsmooth analysis will especially be studied and the interactive

system UFO will be enlarged. Independently, J. Rohn is interested in the area of linear problems with interval matrices, where the complexity of numerical algorithms is especially studied. For the future, a preparation of a special monograph is being planned.

2.3 The most important results of the last five years

1. Effective scaling of variable metric methods for unconstrained optimization: This technique, which is described in [1], significantly improved the convergence of variable metric methods.

2. Efficient globally and superlinearly convergent methods for solving large sparse systems of nonlinear equations based on the smoothed CGS method with incomplete LU preconditioning: These iterative methods, presented in [2], significantly outperform commonly used direct elimination methods based on sparse LU factorization.

3. Efficient methods for large-scale nonlinear least squares problems based on trust-region realizations of the Gauss-Newton method together with Newton corrections and variable metric updates: These methods are proposed in [3].

4. Efficient bundle-Newton method for nonsmooth unconstrained optimization together with proof of its global and superlinear convergence: This quite new approach, based on second-order information, leads to numerical methods whose convergence is much faster than the convergence of the classical proximal bundle method. The paper describing bundle-Newton methods was submitted to SIAM Journal on Optimization.

5. Interactive system for universal functional optimization UFO: This system contains more than 1400 Fortran modules for solving various optimization problems, including large-scale and nonsmooth ones. The last version of the UFO system is described in detail in [4].

6. New theoretical results on linear problems with interval matrices together with a complexity analysis of developed numerical algorithms: The most important results are contained in [5] and [6].

2.4 Number of publications

1.	international journals :	11
2.	proceedings of conferences	
	— international :	1
	— others :	3
3.	monographs or their parts :	1
4.	reports :	35

The most important publications of the last five years

[1] Lukšan L.: Variationally Derived Scaling and Variable Metric Updates from the Preconvex Part of the Broyden Family. — Journal of Optimization Theory and Applications 13 (1992), 299–307 (impact factor 0.333)

[2] Lukšan L.: Inexact Trust Region Method for Large Sparse Systems of Nonlinear Equations. — Journal of Optimization Theory and Applications 81 (1994), 569–590 (i.f. 0.333)

[3] Lukšan L.: Hybrid methods for large sparse nonlinear least squares. — To appear in Journal of Optimization Theory and Application. (i.f. 0.333)

[4] Lukšan L., Šiška M., Tůma M., Vlček J., Ramešová N.: Interactive System for Universal Functional Optimization (UFO), Version 1995. — Report No. 662, Institute of Computer Science, Academy of Sciences of the Czech Republic, Prague 1995

[5] Rohn J., Kreinovich V.: Computing exact componentwise bounds on solutions of linear systems with interval data is NP-hard. — SIAM Journal on Matrix Analysis and Applications 16 (1995), 415–420 (i.f. 0.862)

[6] Rex G., Rohn J.: A note on checking regularity of interval matrices. — Linear and Multilinear Algebra 39 (1995), 259–262

Number of citations: 39

2.5 International cooperation

1. University of Bergamo, Italy (E. Spedicato)
2. Computer Center of the Russian Academy of Sciences (V. Zhadan)
3. University of Leipzig, Germany (G. Rex).

2.6 Remarks — see 4.7

3 Applied Linear Algebra

Participants:

Ing. Zdeněk Strakoš, CSc.
Ing. Miroslav Tůma, CSc.
Ing. Miroslav Rozložník
RNDr. Jitka Drkošová
Ing. Jiří Maryška, CSc., PhD. (part time — 33% since 1995)
Ing. Martin Stýblo (part time — 33% since 1995)

3.1 Main research projects

Research on iterative and direct methods for solving large and sparse systems of linear equations and eigenvalue computation.

National grants

1. Grant Agency of the Academy of Sciences of the Czech Republic — Grant No. 23007: Convergence and Stability of the Conjugate Gradient Type Methods for Solving Linear Systems and Computing Eigenvalues, Jan. 1991 – Dec. 1993

2. Grant Agency of the Academy of Sciences of the Czech Republic — Grant No. 230401: Numerical Solution of Linear Algebraic Systems with Applications to Nonlinear Problems, Jan. 1994 – Dec. 1996

3. Grant Agency of the Czech Republic — Grant No. 201/93/0067: Mathematical Models of Underground Water Flow and of Transport of Dissolved Substances for the Purpose of Remadiation of Consequences of Uranium Mining in Northern Bohemia, Oct. 1993 – Dec. 1995

Foreign grants

1. NSF Grant INT-9218024: Iterative Methods for Nonsymmetric Linear Systems and Eigenvalue Problems (A joint project with Prof. A. Greenbaum),
   June 1993 – June 1996

3.2 Relation to the previous research and goals for the future

The Group of Applied Linear Algebra, lead by Z. Strakoš, was established in 1990. Research of this group has been based on previous activity of its individual members in the area of parallel computing and numerical linear algebra during the period 1984–1990. The present research concerns direct and iterative methods for the solution of large sparse systems of linear equations and for eigenvalue computations. In the future, we anticipate a

development of new preconditioning techniques for linear equations, an analysis of convergence of iterative methods and an investigation of influence of roundoff errors to their stability. In particular, an implementation of efficient iterative methods for large sparse linear systems as well as their practical application to the solution of problems described by partial differential equations are anticipated (see [5]).

3.3 The most important results of the last five years

1. SIAM Activity Group on Linear Algebra Prize (Z. Strakoš — A. Greenbaum): The most outstanding paper [2] in applicable linear algebra published in the years 1991–93 for the finite precision analysis of Lanczos and CG algorithms.

2. Results on the characterization of the convergence rate of the Krylov space methods: It was shown [6] that it is not possible to characterize the convergence rate of Krylov space methods only by the eigenvalue distribution in the general non-normal case.

3. Numerical stability analysis of GMRES: Rounding error and backward stability analysis of the implementation of the GMRES based on the Householder transformations (see [4]).

4. Approximate inverse preconditioning of CG-type methods: New cheap approximate inverse preconditioners were proposed which are very efficient even in the scalar computations (see [7]).

3.4 Number of publications

1.	journals	
	— international :	7
	— others :	2
2.	proceedings of conferences	
	— international (full texts) :	12
	— others (full texts) :	6
	— international (abstracts) :	4
	— others (abstracts) :	2
3.	reports :	33

The most important publications of the last five years

[1] Strakoš Z.: On the Real Convergence Rate of the Conjugate Gradient Method. - Linear Algebra and Its Application 154-156 (1991), 535-549 (impact factor 0.357)

[2] Greenbaum A. and Strakoš Z.: Predicting the Behavior of Finite Precision Lanczos and Conjugate Gradient Computations. - SIAM Journal on Matrix Analysis and Applications 13 (1992), 121-137 (i.f. 0.862)

[3] Golub G.H. and Strakoš Z.: Estimates in Quadratic Formulas. - Numerical Algorithms 8 (1994), 241-268

[4] Drkošová J., Greenbaum A., Rozložník M. and Strakoš Z.: Numerical Stability of GMRES Method. - BIT 3 (1995), 309-330 (i.f. 0.368)

[5] Maryška J., Rozložník M., Tůma M.: Mixed-hybrid finite element approximation of the potential fluid flow problem. - Journal of Computational and Applied Mathematics 63 (1995), 383-392 (i.f. 0.290)

[6] Greenbaum A., Pták V. and Strakoš Z.: Any Convergence Curve is Possible for GMRES. - To appear in SIAM Journal on Matrix Analysis and Applications. (i.f. 0.862)

[7] Benzi M., Meyer C.D., Tůma M.: A sparse approximate inverse preconditioner for the conjugate gradient method. - To appear in SIAM Journal on Scientific Computing (i.f. 0.880)

Number of citations: 31

3.5 International cooperation

1. Courant Institute of the Mathematical Sciences, New York University (A. Greenbaum)
2. Stanford University (G.H. Golub)
3. Linköping University (A. Björck, T. Elfving)
4. University of Bologna, CERFACS Toulouse (M. Benzi)
5. Rechenzentrum Universität Karlsruhe (R. Weiss)

3.6 Remarks — see 4.7

4 Mathematical Modelling

Participants:

Doc. Ing. Jiří Nedoma, CSc.
Mgr. Zdeněk Kestřánek
Mgr. Jan Dvořák
Prof. RNDr. Miroslav Fiedler, DrSc. (part time — 50% since 1992).
Prof. RNDr. Vlastimil Pták, DrSc. (part time — 33% since 1994).

4.1 Main research projects

Research of numerical methods in geomechanics, geodynamics and biomechanics.
Research of special matrices and their properties.

National grants

1. Grant Agency of the Czech Republic — Grant No. 308/95/0304: Mathematical models of hip joint, total prothesis of hip joint based on stress analysis.
   Jan. 1995 – Dec. 1997

2. Grant Agency of the Czech Republic — Grant No. 201/95/1484: Linear problems with inexact data. Jan. 1995 – Dec. 1997

Foreign grants

1. HIPERGEOS — Copernicus Project 94-00820: High performance computing in geosciences; safety of constructions with respect to rock deformations and movements, since 1994

2. NATO Science Programme and Cooperation Partners Linkage Grant: Numerical modelling of inverse geodynamical problems in high level radioactive waste repositories, submitted

4.2 Relation to the previous research and goals for the future

The Group of Mathematical Modelling consists of two subgroups. The first one, lead by J. Nedoma, has been interested in mathematical methods in geophysical research since 1961. This research focused mainly on the mathematical modelling of geomechanical and geodynamical processes described by partial differential equations. Presently, J. Nedoma, together with two young scientists, continues this work, and their activity is focused on new difficult physical problems such as the problem of thermo-magnetodynamics with gravity effect or the contact-two-phase Stefan problem in thermo-elasticity. The future research

will be directed towards the modelling of new complex problems arising in geodynamics and in stress analysis of hip joints, and on a numerical solution of the respective partial differential equations.

The second field of research concerns the theory of special matrices and its applications. M. Fiedler and V. Pták have worked in this field since 1954 and they have obtained extremely important and excellent results. Presently and in the future they want to focus their work on the theory of positive definite matrices and their pairs.

4.3 The most important results of the last five years

1. Proof of the existence and unicity of equations describing the magnetodynamics of incompressible thermo-Bingham's fluid under the gravity effect, as well as the nonlinear analysis of the generalized thermo-magnetodynamic problems representing the second phase transition problem: This result was presented in [1].

2. Proof of the existence and unicity of contact problems in thermoelasticity: This result was presented in [2] together with the finite element solution of corresponding partial differential equations.

3. Numerical analysis of a coupled contact-two-phase Stefan problem in thermo-elasticity representing the first phase transition problem: This theory is simultaneously applied to the stress analysis of hip joints.

4. New results in the theory of special matrices and matrix inequalities: These results concern stochastic and doubly stochastic matrices [4], Bergström and Minkowski inequalities [5], and the pair of positive definite matrices [6].

4.4 Number of publications

1.	international journals :	31
2.	proceedings of conferences	
	— international (full texts) :	8
	— others (full texts) :	4
	— international (abstracts) :	6
3.	monographs or their parts :	3
4.	dissertation :	1
5.	reports :	14

The most important publications of the last five years

[1] Nedoma J.: Equations of magnetodynamics of incompressible thermo-Bingham's fluid under the gravity effect. - Journal of Computational and Applied Mathematics 59 (1995), 109-128 (impact factor 0.290)

[2] Nedoma J., Dvořák J.: On the FEM solution of a coupled contact-two-phase Stefan problem in thermo-elasticity. Coercive case. - Journal of Computational and Applied Mathematics 63 (1995), 411-420 (i.f. 0.290)

[3] Nedoma J.: Nonlinear Analysis of the generalized thermo-magnetodynamic problem. - Journal of Computational and Applied Mathematics 63 (1995), 393-402 (i.f. 0.290)

[4] Fiedler M.: On a special class of generalized doubly stochastic matrices and its relation to Bézier polygons. - SIAM Journal on Matrix Analysis and Applications 16 (1995), 735-742 (i.f. 0.862)

[5] Fiedler M., Markham T.: Some results on the Bergström and Minkowski inequalities. - Linear Algebra and its Applications 232 (1996), 199-211 (i.f. 0.357)

[6] Fiedler M., Pták V.: A new positive definite geometric mean of two positive definite matrices. - To appear in Linear Algebra and Its Applications. (i.f. 0.357)

Number of citations: 200

4.5 International cooperation

1. Catholic University of Nijmegen, The Netherlands (O. Axelsson)
2. University of Bruxelles, Belgium (R. Beauwens)
3. Bulgarian Academy of Sciences, Bulgaria (P. Vassilevski)
4. Central Mining Research Institute at Dhanbad, India (B.B. Dhar)
5. Indian School of Mines at Dhanbad, India (V. Srivastava)
6. National Geophysical Research Institute at Hyderabad, India
7. University of South Carolina, South Carolina, USA (T.L. Markham)
8. Technical University Chemnitz, Germany (K. Rost)

4.6 Remarks — see 4.7

4.7 Additional remarks

- The papers presented by all working groups in the Department of Computational Mathematics are of a high scientific standard comparable to the leading scientific groups in the world. This fact can be illustrated by the Hans Schneider Prize which was awarded by the International Linear Algebra Society (ILAS) to M. Fiedler in 1993 and the SIAM Activity Group on Linear Algebra (SIAG/LA) Prize awarded to Z. Strakoš in 1994, or by the high acceptance of the papers and the large number of citations. The basic results have been developed especially in the matrix theory, graph theory and their applications. Another important field is the solution of large linear and nonlinear systems and its application to the problems described by partial differential equations. Significant results have been achieved in numerical optimization, especially in the theory of the convergence of methods for the solution of large and nonsmooth optimization problems.

- Four PhD. students are educated within the department and some of their papers have already been published in the important scientific journals. Some members work as lecturers at the Faculty of Nuclear Sciences and Physical Engineering of the Czech Technical University and the Faculty of Mathematics and Physics of the Charles University, including the work on the lecture notes. They are members of the editorial board of Numerische Mathematik, Linear Algebra and Applications, Linear and Multilinear Algebra, SIAM Journal on Matrix Analysis and Applications, Applications of Mathematics, Czechoslovak Mathematical Journal and Mathematica Slovaca. J. Nedoma has been the main organizer of the international conference "Modelling 94", held in Prague in 1994 and some members participate in the organization of the "Prague Mathematical Conference 1996". All working groups of the department have fruitfull international cooperation (see above), Z. Strakoš is taking the position of a visiting professor at the Emory University, Atlanta, USA. The research fellows and students monitor their fields of interest and the updating of the database NUM of references.

- The practical application of our research is mainly in the areas of the investigation of the underground water flow in the area of uranium leaching in Northern Bohemia, research of the geotectonics of the nuclear waste deposits, construction of endoprotheses and development of complex programming systems for the solution of numerical mathematics problems.

- Altogether in the years 1991–1995 the research fellows of the department submitted 12 grant proposals, most of which have been supported by the Grant Agency of the Czech Republic or by the Grant Agency of the Academy of Sciences. Besides that the department members take part in 3 international projects funded by foreign grant agencies.

- The department staff is kept to its minimum level. In the future we would like to hire one member of the technical support and at least one PhD. student. Due to the inadequate financial situation of the Academy of Sciences we will try to find external PhD. students who will be paid from the university budget.

- The Department of Computational Mathematics consists of three separate work-groups, which closely collaborate. The contacts with the workplaces outside the institute are both temporary and long-term. We consider to be the most important cooperating workplaces in the Czech Republic :

  - Faculty of Mathematics and Physics of the Charles University, Prague
  - Faculty of Nuclear Science and Physical Engineering,
    Czech Technical University, Prague
  - Faculty of Applied Sciences, University of Western Bohemia, Plzeň
  - Technical University Liberec.

Department of Knowledge-Based Systems

Head: **RNDr. Ivan Kramosil, DrSc.**

5 Department of Knowledge-Based Systems

Participants:

Doc. RNDr. Tomáš Havránek, DrSc. (till 1992)
RNDr. Milan Daniel, CSc.
RNDr. Zdeněk Fabián, CSc.
Prof. RNDr. Miroslav Fiedler, DrSc. (partially till 1993)
Doc. RNDr. Petr Hájek, DrSc. (since 1992)
prom. mat. Dagmar Harmancová (since 1992)
RNDr. Sylva Kočková (till August 1995)
RNDr. Ivan Kramosil, DrSc. (since 1992)
RNDr. Nina Ramešová (partially)
RNDr. Anna Sochorová
Doc. RNDr. Jana Zvárová, CSc. (till 1993)
Ing. Nguyen Hoang Phuong (1994–1996)

5.1 Main research projects

- Nonclassical logics, their metatheory and methodology, namely fuzzy logics, many-valued logics and modal logics
- Alternative mathematical models for uncertainty quantification and processing, in particular Dempster-Shafer theory and possibility theory
- Algorithms for adaptive learning
- Alternative numerical characteristics of random variables and statistical data processing based on them
- Theoretical and software tools for automated generation of statistically well-founded hypotheses based on large collections of statistical data (GUHA)
- Applications of these methods to the problems of medical and technical diagnostic and the development of software facilitating their usage by non-mathematically educated people

National grants

1. Grant Agency of the Academy of Sciences of the Czech Republic — Grant No. 11924: Mathematical foundations of inference in expert systems (1991–1992)
2. Grant Agency of the Academy of Sciences of the Czech Republic — Grant No. 23003: Model search techniques (1991–1993)
3. Grant Agency of the Academy of Sciences of the Czech Republic — Grant No. 17555: Non-numerical uncertainty quantification and processing in computer-aided systems for conclusion drawing and decision making (1992–1994)

4. Grant Agency of the Academy of Sciences of the Czech Republic — Grant No. 130108: Mathematical foundations of approximate inference (1993–1995)
5. Grant Agency the Czech Republic — Grant No. 201/93/0781: Building intelligent systems (1993–1995)
6. Grant Agency of the Academy of Sciences of the Czech Republic — Grant No. 130504: Alternative mathematical models for uncertainty quantification and processing
(1995–1997)

Foreign grants

1. European Union — Copernicus Project No. 10053 : MUM — Managing of Uncertainty in Medicine
2. COBASE, grant for a short visit and preparation of cooperation, U.S.A.

5.2 Relation to the previous research and goals for the future

The research in the domain of fuzzy logics naturally relates and continues several ongoing investigations in non-classical logics, in the theory of fuzzy sets in particular and fuzzy reasoning in general. It combines both of these fields in a qualitatively new and highly sophisticated way with the aim to suggest and develop new tools for uncertainty quantification and processing, meeting the classical demands of formal mathematical rigorousity, but also offering interesting and important applications in knowledge systems with data loaded with uncertainty, impreciseness, or vagueness. Extremely similar motivations and relations can be found as far as the research in mathematical calculi of the non-classical kind for uncertainty quantification and processing (like Dempster-Shafer theory, possibility theory and non-classical statistical characteristics) is concerned. In spite of the great merits of standard probabilistic and statistical tools, methods and results in this field, there are domains where either the uncertainty in question is of a different kind than that which is quantified and processed by probabilistic apparatus, or the conditions requested in order to apply these techniques are difficult to be met or verified. On the other hand, GUHA methods and procedures benefit from the classical hypothesis testing theory, but they qualitatively change the way in which they are applied. The contemporary research effort concerning GUHA methods and procedures continually relates to the ongoing investigations in this field, which are already about three decades old.

As all of the domains of research mentioned briefly above represent new, quickly developing and far from being closed fields of scientific investigation, it is quite natural and reasonable to declare the goals for the future as being the aim to enrich all of these domains with new, theoretically deep and applicationally useful and bountiful results.

5.3 The most important results of the last five years

1. Systematic metamathematics of fuzzy logic (in narrow sense, i.e. as a logical calculus — as opposed to fuzzy logic in a broad sense concerning many extra-logical matters): Some systems of fuzzy logic have been given an elegant complete axiomatization and their arithmetical complexity has been estimated. Many-valued modal systems formalizing fuzzy possibilistic theory have been developed ([1]–[4]).

2. New mathematical models for the Dempster-Shafer theory based on the tools of probability theory and theory of algebraic structures and other related probabilistic and algebraic models for non-additive numerical as well as boolean quantification of uncertainty ([5], [6]).

3. Theory and software for the GUHA method of automated hypotheses generation fitted for personal computers and oriented towards specialists in the field of possible applications of these procedures ([7]).

5.4 Number of publications

1.	journals	
	— international :	37
	— others :	15
2.	proceedings of conferences	
	— international (full texts) :	44
	— others (full texts) :	5
	— international (abstracts) :	6
3.	monographs or their parts :	5
4.	textbooks :	2
5.	dissertation :	1
6.	reports :	31

The most important publications of the last five years

[1] Hájek P., Havránek T., Jiroušek R.: Uncertain Information Processing in Expert Systems. - CRC Press, Boca Raton, Florida, U.S.A., 1993

[2] Hájek P., Harmancová D., Verbrugge R.L.: A qualitative fuzzy possibilistic logic. - International Journal of Approximate Reasoning 12 (1995), 1-19

[3] Hájek P.: Fuzzy logic and arithmetical hierarchy. - Fuzzy Sets and Systems 73 (1995), 359-363 (impact factor 0.655)

[4] Hájek P., Godo L., Esteva F.: Fuzzy logic and probability. - In: Proceedings of the Conference Uncertainty in Artificial Intelligence UAI '95, Editors : P. Besnard et al, Morgan-Kaufmann Publishers, San Francisco, 1995, 237-244

[5] I. Kramosil: Extensional processing of probability measures. - International Journal of General Systems 22 (1994), 2, 159-170 (i.f. 0.293)

[6] I. Kramosil: Believeability and plausibility functions over infinite sets. - International Journal of General Systems 23 (1994), 2, 173-198 (i.f. 0.293)

[7] P. Hájek, A. Sochorová, J. Zvárová: GUHA for personal computers. - Computational Statistics and Data Analysis 19 (1995), 149-153 (i.f. 0.412)

Number of citations: 225

5.5 International cooperation

The group has close scientific contacts with:

1. Institut d'Investigacio en Intel.ligencia Artificial CSIC (Bellatera, Spain)
2. University of Toulouse [prof. D. Dubois]
3. University of Manchester [prof. J. Paris]
4. State University of New York (Binghamton) [prof. G. J. Klir]
5. Florida State University (Tallahassee) [prof. L. Kohout]
6. representation of the CR in COST Cooperation — Action 15

5.6 Remarks

The level of results achieved is fully comparable with the top world level.
Members of the group are also active as far as the organizational and pedagogical activities are concerned.
They have participated in Organizing and Programme Committees of a number of important international scientific conferences (e.g. MFCS '95 Prague, Uncertainty in Artificial Intelligence 1994, 1995 (USA), ECSQUARU '95 Fribourg), workshops (e.g. WUPES 94 and 95) and other actions held either in the Czech Republic or abroad.
Another activity is the membership in boards of some international scientific organizations (Association for Symbolic Logic) and journals (Czechoslovak Mathematical Journal, Archive for Mathematical Logic, Computers and Artificial Intelligence and others).
Some members of the department hold regular courses within the framework of undergraduate and post-graduate studies and in individual tutorialship of post-graduate students. The pedagogical activities are oriented mainly towards mathematical logic including the non-clasical ones and logic programming, towards uncertainty processing in expert systems and towards probabilistic algorithms. They take place at the Faculty of Mathematics and Physics of the Charles University, Faculty of Nuclear Sciences and Physical Engineering and Faculty of Electrotechnics of the Czech Technical University at Prague, and also at foreign schools (University of Vienna, Austria).
The non negligible are also the participations in several boards of Grant Agencies, in committees for doctoral thesis and in scientific councils of a number of institutes and faculties.

Department of Neural Networks

Head: **Ing. Marcel Jiřina, DrSc.**

Research teams:

1. Neural Networks and their Applications
2. Mathematical Theory of Neural Networks
3. Biological Motivations of Artificial Neural Networks

6 Neural Networks and their Applications

Participants:

Ing. Marcel Jiřina, DrSc.
Ing. Stanislav Řízek, CSc.
Ing. František Hakl, CSc.
Ing. Dušan Húsek, CSc.
Ing. Petr Klán, CSc. (since 1994)
Ing. Josef Švanda, CSc. (till 1993)
Ing. Pavel Bitzan, CSc. (till 1994)
Ing. Jana Šmejkalová, CSc. (1994)
Ing. David Hrycej, CSc. (partially till 1994)
Ing. Pavel Růžička, CSc. (partially till 1993)

6.1 Main research projects

The group deals with new types of neural networks specifically designed for the solution of specific application problems.
There is a research project on nuclear particle detection which uses neural networks and is based on data from the ATLAS detector on Large Hadron Collider (LHC) in CERN, Geneva. The problems of adaptive control using neural networks were studied and mathematical relationships ensuring the convergence in learning of the neurocontroller were derived through the cooperation with the Institute of Higher Neural Activity in Moscow. The problems of the information capacity of selected types of neural networks were solved. The Control Expert Advisor has been designed so that it allows an optimal tuning of controller parameters. The principles of neural networks and artificial intelligence have been used for solving problems of information retrieval from textual databases.

National grants

1. Grant Agency of the Academy of Sciences of the Czech Republic — Grant No. 23005: Neural Networks with Neurons of a Limited Number of Synapses (1991–1992)

2. Ministry of the Economical Development of the Czech Republic — Grant No. G855: Education of Neural Networks and Computer Vision in a Postgraduate Study at the Faculty of Electroengineering of the Technical University in Prague (1991–1993)

3. Grant Agency of the Czech Republic — Grant No. 202/93/0178: Hadron Interactions in TeV Region (1993–1995)

4. Ministry of the Industry of the Czech Republic — Grant CERN RD-11: Cooperation of the Czech Republic with CERN (pernament)

5. Grant Agency of the Czech Republic — Grant No. 102/93/0912: Automatic Identification of Plants Grown in Rows (1993–1995)

6. Grant Agency of the Czech Republic — Grant No. 104/93/0227: Microcontroller Framed Innovative technology (1993–1995)

7. Ministry of the Education of the Czech Republic — Grant No. V 361/93: Education of Neural Networks and Neurocomputers (1993–1995)

8. Grant Agency of the Czech Republic — Grant No. 102/94/0728: Information Retrieval from Textual Databases Based on AI and NN (1994–1995)

9. Grant Agency of the Czech Republic — Grant No. 201/94/0729: Analysis of Information Capabilities of a Class of Artificial Neural Networks to Optimize their Structure (1994–1996)

10. Grant Agency of the Czech Republic — Grant No. 201/95/0979: Pattern recognition method based on univalence of neural network mapping (1995–1996)

Foreign grants

1. COPERNICUS CP 9630 : Microcontroller Framed Innovative technology

6.2 Relation to the previous research and goals for the future

The cooperation with CERN is a long-term project. The neural networks of a different kind will be used and modified appropriately for the tasks of particle detection. The neural network system for the detection of particles in events of B-physics is planned to be designed within the next three years. The problems of neurocontrol will be solved mathematically and will be verified by numerical experiments. The principles of a special coding in neural networks for sparse pattern learning and recall will be developed.

6.3 The most important results of the last five years

1. Design of high speed neural network with switching units for nuclear particle detection [1].

2. Method of learning of neural network based controller using neurophysiological analogies [4], [5].

3. Methodology for analysis of the behavior of Hopfield like neural networks with sparse coding and a large number of inputs [6].

4. Proof that the neural network can be effective in pattern matching even if applied on a standard Von Neumann machine [6].

5. An information approach to control and forecasting [2], [3].

6.4 Number of publications

1.	journals	
	— international :	27
	— others :	30
2.	proceedings of conferences	
	— international (full texts) :	29
	— others (full texts) :	6
	— international (abstracts) :	5
	— others (abstracts) :	2
3.	monographs or their parts :	1
4.	textbooks :	1
5.	dissertation :	2
6.	reports :	14

The most important publications of the last five years

[1] Bitzan P., Šmejkalová J., Kučera M.: Neural Network with Switching Units. — Neural Network World 4 (1994), No. 5, 515–526

[2] Jiřina M., Krayem M. S.: Convergence of the Learning with Small Learning Set in GMDH Neural Net. — Neural Network World 5 (1995), No. 3, 329–339

[3] Klán P., Maršík J.: Control Expert Advisor. — In: Proceedings of the International Conference on Signal Processing Applications and Technology, Dallas '94, October 18–21, 1994, Vol. II, 1103–1108

[4] Řízek S., Frolov A.: Differential Control by Neural Networks. — Neural Network World 4 (1994), No. 4, 493–508

[5] Frolov A., Řízek S.: Model of Neurocontrol of Redundant systems. — Journal of Computational and Applied Mathematics 63 (1995), 465–473 (impact factor 0.290)

[6] Húsek D., Frolov A.: Spreading Activation Methods in Information Retrieval — A Connectionist Approach. — Neurocomputing (Elsevier) 4 (1992), 31–34

[7] Růžička P., Hrycej D.: Topological Maps for Invariant Features Representation and Analysis of their Convergence. — In: Proceedings of 6th International Conference on Neural Networks and their Industrial & Cognitive Applications "Neuro Nimes '93", Nimes, France, October 25–29, 1993, 435–444

[8] Hakl F.: Basic Theory of Neural Network derived from the B-S-B Model. — Neural Network World 3 (1993), 3, 319–352

Number of citations: 6

6.5 International cooperation

1. CERN, Geneva, Switzerland,
   University of Jena and
   University of Mannheim, Germany, on problems of particle detection

2. Institute of Higher Neural Activity, Moscow, Russia, on problems of neurocontrol

3. University of Aleppo, Syria, on problems of the learning of the GMDH neural network

4. Catholic University Louvain, Belgium, and
   University of Strathclyde, Glasgow, Scotland, on problems of the information based approach to control and forecasting

5. Department of Physics, University of Linz, Austria, on problems of spin glasses in relation to the neural networks theory

6.6 Remarks

- P. Růžička and D. Hrycej were awarded the prize for the most outstanding contribution at the conference "Neuro Nimes '93".

- Members of the group are in close contact with the well known scientific centers CERN and IHNA Moscow.
  The activities in CERN are derived from the effort of the European Community to build a top research center of nuclear research in CERN.
  The work on neurocontrol with IHNA in combination with neuro-fuzzy control will be applicable to small automatic and semiautomatic devices.

- Contacts with other groups in the ICS are also organized in the form of seminar by department of neural networks and visited by guests from universities and other institutions.

- Dr. Hakl reads lectures at the Faculty of Nuclear Science and Physical Engineering of the Czech Technical University in Prague.
  Dr. Klán reads lectures at the Automatic Control Department of the University of Pardubice.
  Dr. Jiřina reads lectures on neural networks for doctoral students at the Faculty of Electrical Engineering of the Czech Technical University in Prague.

7 Mathematical Theory of Neural Networks

Participants:

RNDr. Věra Kůrková, CSc.
RNDr. Kateřina Hlaváčková, CSc.
Mgr. Roman Neruda (PhD student)
Mgr. Arnošt Štědrý (since 1992) — (PhD student)

7.1 Main research projects

Properties of the sets of functions computable by multilayer feed-forward neural networks are studied using techniques of approximation of functions and functional analysis. Constructive results achieved are applied to the design of neural network learning algorithms. The approximation properties of layered feed-forward networks are especially studied and upper estimates of the number of hidden units were set for some kernels, and universal approximation property was recently proven for cascade-type networks.

Further refinement of the theory of approximation of functions and neural network learning algorithms are the subject of a new project planned for the next three years. In this project new general incremental algorithms will be proposed, their convergence properties investigated, and program implementation will be tested for time series forecasting.

National grants

1. Grant Agency of the Academy of Sciences of the Czech Republic — Grant No. 23057: The approximation capabilities of multilayer neural networks (1992–1994)

2. Grant Agency of the Czech Republic — Grant No. 201/93/0427: Approximation of functions and neural network architectures (1993–1995)

3. Grant Agency of the Czech Republic — Grant No. 201/96/0917: Approximation of functions and neural network learning algorithms (1996–1998)

7.2 Relation to the previous research and goals for the future

The results obtained provide a characterization of the sets of functions that can be effectively computed by neural networks with various computational units and connections. Further, they compare the complexity of networks for various types of architectures, propose algorithms for the parameter setting and methods for speeding-up of some algorithms. The results show how the application of classical and more recent mathematical results contributes to the design of neural networks.

The goal of the future research is to explore the complexity of continuous models of neurocomputing to help formulate a methodology for the selection of a neural network architecture and an input and output data representation. The main objectives of the research are:

- characterization of the sets of functions that can be approximated with dimension-independent rates
- comparison of the complexity of networks with local, semilocal, and non-local types of units
- trade-off between the values of parameters and the number of units.

7.3 The most important results of the last five years

1. using classical theorems of functional analysis the universal approximation property and the best approximation property were proved for networks with various types of units ([1] and [2])
2. the kernel basis function networks were defined and upper estimates of the number of hidden units were derived for some kernels [2]
3. the universal approximation property for cascade-type networks and the convergence of incremental algorithms used in cascade correlation networks were proved
4. the functionally equivalent parametrizations for the perceptron-type and RBF networks were characterized [3]
5. estimates of the complexity of multilayered networks [4] and characterization of sets of functions that can be approximated with dimension-independent rates in terms of the variation with respect to half-spaces [5] were derived

7.4 Number of publications

1.	journals	
	— international :	15
	— others :	2
2.	proceedings of conferences	
	— international (full texts) :	24
	— others (full texts) :	1
	— others (abstracts) :	1
3.	dissertation :	1
4.	reports :	13

The most important publications of the last five years

[1] Kůrková V.: Kolmogorov's theorem and multilayer neural networks. — Neural Networks 5 (1992), 501–506 (impact factor 1.895)

[2] Kůrková V., Hlaváčková K.: Approximation of Continuous Functions by RBF and KBF Networks. — In: Proceedings of ESANN '94, Brussels, D facto, 1994, 164–174

[3] Kůrková V., Neruda, R: Uniqueness of functional representations by Gaussian basis function networks. — In: Proceedings of ICANN '94, London, Springer, 1994, 471–474

[4] Kůrková V.: Approximation of functions by neural networks with bounded number of hidden units. — Neural Networks 8 (1994), 745–750 (i.f. 1.895)

[5] Kůrková V., Kainen P. V., Kreinovich V.: Dimension-independent rates of approximation by neural networks and variation with respect to half-spaces. — Proceedings of WCNN '95, Volume I, INNS Press, 1995, 54–57

Number of citations: 44

7.5 International cooperation

1. University of Texas and El Paso, USA (V. Kreinovich) — dimension-independent estimates of the number of hidden units
2. NASA, Goddard Space Flight Center, Greenbelt, USA (J. J. Smid) — approximation of functions by cascade networks
3. Georgetown University, Washington, D.C. (P.C. Kainen) — complexity of neural networks
4. Politechnika Warszawska, Warsaw, Poland (B. Beliczynski) — incremental neural network algorithms
5. Catholic University of Louvain-la-Neuve, Louvain, Belgium (M. Verleysen) — approximation of functions by RBF networks
6. University of Reading, Reading, England (J. Mason) — approximation of functions by B-spline networks

7.6 Remarks

- The most effective cooperation has been developed with American universities, namely with the University of Texas and El Paso and with Georgetown University.
  The number of papers published in renowned international journals have been written with the scientists from these universities, dealing with the estimates of rates of approximation of functions by neural networks of various types. Neural network learning algorithms based on mathematical constructions were developed in

collaboration with the Warsaw Technical University and the Catholic University of Louvain-la-Neuve.

- V. Kůrková was awarded a prize for the best east-european contribution at ECAI '92 conference in Vienna.
- The results of the group were presented on major European conferences in the field of neural networks (V. Kůrková is a member of the programme committees of a number of European conferences : ICANN '95 and '96, ESANN '95 and 96, EANN '95).
- V. Kůrková is a member of the Editorial Board of the journal Neural Processing Letters (published by Kluwer).
- All the finished projects supported by the grant agencies in the Czech Republic have been highly evaluated.
- Mr. Štědrý and Mr. Neruda read lectures at the Faculty of Mathematics and Physics of the Charles University in Prague.

8 Biological Motivations of Artificial Neural Networks

Participants:

RNDr. Olga Kufudaki, DrSc.
RNDr. Ladislav Andrey, CSc.
Mgr. Martin Vojáček (PhD student)
Mgr. Přemysl Žák (PhD student)

8.1 Main research projects

The main goal of the group is to study new types of neural network models based on biological motivations. A general theory of such networks will allow the modelling of more complex biological systems, as well as more sophisticated applications of some ideas to, e.g., the immune system. Applications especially in psychiatry and in chronobiology are planned, as well.

National grants

1. Grant Agency of the Academy of Sciences of the Czech Republic — Grant No. 23011: The Analysis and Applications of New Neural Network Architectures (1991–1993)

2. Grant Agency of the Academy of Sciences of the Czech Republic — Grant No. 24453: Rules for the Creation of Conditional Reflexes and their Applications in the Field of Artificial Neural Networks (1992–1993)

3. Grant Agency of the Czech Republic — Grant No. 201/95/0992 : Extended Modular Model of Neural Networks and their Applications in Medicine.

Foreign grants

1. PENNEL — A grant of the Greek Government for a support of cooperation among Greek scientists at home and abroad :
   Project of a developmental study of neural networks at Greek universities

2. Project Biomed 2 (XII-E-1). Coordinator: P.J. Querinjean, Bioclub — Brussels, Ref. No. PL 95-1644 : Chaodynamics, Predictability and Decease Prevention.
   A proposal was acknowledged in 1995 with Dr. Andrey's participation.

8.2 Relation to the previous research and goals for the future

The above mentioned projects are a direct continuation of the previous research interests of Dr. Kufudaki and Dr. Andrey in the study of neural networks and nonlinear dynamics in general. Dr. Kufudaki introduced the problematics of neural networks in the former Czechoslovakia. Dr. Andrey was also engaged in chaodynamics with a possible application in the study of stability of learning in neural networks. They proved many original results in the field and published them in renowned journals.

The main goals of the group for the future can be classified into the following fields of interest:

a) the study of complex dynamics of a single biological neuron

b) the construction of new types of neural networks with neurons of a), closer to biological reality — so called $\lambda - \Theta$ neural networks

c) applications of some of the above mentioned ideas in a study of immune networks

d) applications of new types neural networks in medicine — especially in psychiatry and chronomedicine

8.3 The most important results of the last five years

1. The construction and development of a new type neural networks, so called $\lambda - \Theta$ neural networks.
   The detailed theoretical and experimental numerical study of such networks.

2. The proof that a sigmoidal transfer function for a single neuron (of biological nature) is sufficient for a potentiality of chaos of such neuron dynamics.

8.4 Number of publications

1.	journals	
	— international :	9
	— others :	3
2.	proceedings of conferences	
	— international (full texts) :	7
	— others (full texts) :	2
	— international (abstracts) :	15
	— others (abstracts) :	1
3.	monographs or their parts :	1
4.	reports :	8

The most important publications of the last five years

[1] Kufudaki O., Hořejš J.: PAB: Parameters Adapting Back-Propagation. — Neural Network World 1 (1991), 267–274

[2] Hořejš J., Kufudaki O.: Neural networks with local distributed parameters. — Neurocomputing 5 (1993), 211–213

[3] Andrey L.: Biological neural and stability criteria for equilibrium memories. — Neurocomputing 3 (1991), 221–230

[4] Andrey L., Kufudaki O.: Single Neuron Chaos Is Natural. — Proceedings of ENA Conference of European neuroscience, Amsterodam 1995, 53

Number of citations: 2

8.5 International cooperation

The group cooperates with the following foreign institutions:

1. The Institute of Informatics, The State Research Center Demokritos, Athens, Greece (Prof. J. Varufakis)
2. The Department of Computer Science, University of Crete, Greece (Prof. K. Papadurakis)
3. The Bioclub, Brussels, Belgium (Prof. P. Querinjean)
4. The Institute of Theoretical Physics, Academia Sinica, Beijing, China (Prof. Hao Bai-Lin)

8.6 Remarks

- The group has a close cooperation with the Department of medicine of Charles University in Prague.
- Dr. Kufudaki reads lectures at the Masaryk Institute of Higher Studies of the Czech Technical University in Prague.
- Mgr. Žák is a doctoral student supervised by Dr. Kufudaki.
- The members of the group often participate in "neuroseminars" organized by the department of neural networks. There is a close relation and common work with members of the group of Neural Networks and their Applications.

Department of Nonlinear Modelling

Head: **Ing. Emil Pelikán, CSc.**

9 Department of Nonlinear Modelling

Participants:

Ing. Emil Pelikán, CSc.
RNDr. Ladislav Pecen, CSc.
Ing. Mirko Novák, DrSc. (since 1995)
RNDr. Milan Paluš, CSc. (since 1994)
Ing. Hynek Beran (partially)
Mgr. Marek Sláma
Ing. Petr Matějka (since 1995 — partially)
Ing. Jana Šmejkalová, CSc. (1993)
Ing. Daniel Pfeffer (till 1995)
RNDr. Kryštof Eben, CSc. (till 1995)
Dr. Georges Darbellay (NSF, Switzerland) (since 1995)
Miguel Santos (Univ. of Porto, Portugal) (1994–1995)
Remo Schnidrig (ETH, Switzerland) (1994)

9.1 Main research projects

9.1.1 Design of Modular Artificial Neural Networks

The main goal of the proposed project is to study the principles leading to a design of neural network architectures with a high degree of modularity. The practical interest is focused on application areas, where complex data collected from various information sources are available. Using special strategies and optimizing techniques, the advantages of the developed modular complex systems are demonstrated on various artificial and real data from medicine, energetics and economy.

9.1.2 Application of modern mathematical methods in economic information processing

The main aim of this project is to investigate the applications of the most up-to-date methods of artificial intelligence in economy. The theoretical research is oriented towards artificial neural networks (ANN) and the knowledge-based systems (KBS). The integration of ANN and KBS results in the application of the developed methods in various economic areas (e.g. exchange rate forecasting, credit risk assessment etc.). The project provides a basis for combining research and educational activities in connection with a collaboration with the Faculty of Informatics and Statistics, Prague University of Economics.

9.1.3 New approaches to neural networks in digital signal processing

(Main investigator — Department of Computing and Control Engineering, Prague Institute of Chemical Technology)

The project goal is the interdisciplinary research of general signal processing methods and new architectures of neural networks, adaptive methods and discrete transforms. The basic interest is in the analysis and identification of nonlinear systems and nonstationary discrete signals.The proposed solutions are applied for the analysis and modelling of physiological signals and for the prediction of the power systems behaviour.

9.1.4 Theory and methods of synthesis of systems with improved reliability

The main goal of this project is to develop a new approach to the design of complex systems, the operation reliability and life-time of which will be significantly higher than the standard. This approach is based on the analysis of the most sensitive parameters of the system under consideration (so called markers), on the analysis of the shape and size of the regions of acceptability in the multidimensional system parameter (or marker) space, on the analysis of the system life-curve in this space and of its prediction for the near future of expected system operation. If such a prediction signals the danger of the life-curve approaching or breaking the boundaries of the region of acceptability, the correction of some selected system parameters is started. The focus of this project is concerned with the forming of the concept of such predictive diagnostics and restorations and to the development of basic design methods.

9.1.5 New methods for prediction and optimization in Czech energetic network

The goal of this project is to investigate new nonlinear methods for time-series prediction and optimization, adapted for application in the energy production and distribution of the Czech Republic. A special interest is given to the medium and long time predictions and to complicated optimization problems when dealing with limited and nonstationary input data. Besides the medium and long prediction horizons, the interest is also given to the ultra short time predictions dealing with very high frequency data.

9.1.6 (Non-linear) Mathematical processing of tumor marker measurements in oncology

The main tasks could be divided into the following categories which have common mathematical methodology.

Early diagnostic of the recurrence of cancer disease
Mathematically it is a problem of change point detection in time series.

Primary diagnostic — detection of a type of the primary tumor
This problem can be solved by using Bayesian probabilities net.

National grants

1. Grant Agency of Czechoslovak Academy of Sciences — Grant No. 23010 : Analysis of the generalization properties of layered neural networks for signal processing (1991–1992)

2. Czech Ministry of Research and Technology — Grant No. Z-192 : Prediction of some risk factors of the cancer and its metastases using neural networks (1991–1992)

3. Grant Agency of the Academy of Sciences of the Czech Republic — Grant No. 230106: Mathematical modelling of metastatic activity of tumor cells (1993–1995)

4. Grant Agency of the Czech Republic — Grant No. 101/93/0430 : Theory and design methods of systems with improved reliability (1993–1995)

5. Power Distribution Company in Pilsen, Czech Republic — Grant No. 466 : Neural network applications in power systems (1993–1996)

6. Grant Agency of the Academy of Sciences of Czech Republic — Grant No. 230404 : Design of modular artificial neural networks (1994–1996)

7. Grant Agency of the Czech Republic — Grant No. 201/94/0130 : New approaches in digital signal processing (1994–1996)

8. Grant Agency of the Czech Republic — Grant No. 201/94/1327 : Application of modern mathematical methods in economic information processing (1994–1996)

9. Grant Agency of the Czech Republic — Grant No. 102/95/1311 : New prediction and optimization methods for applications in the Czech energetic network (1995–1997)

Foreign grants partial participation (Dr. L. Pecen, Dr. K. Eben)

1. Copernicus project : MUM — Managing Uncertainty in Medicine

2. Tempus-Phare project : EuroMISE — European Education in Medical Informatics, Statistics and Epidemiology

9.2 Relation to the previous research and goals for the future

The main research projects follow the successful former grants:

1. Grant Agency of Czechoslovak Academy of Sciences — Grant No. 23010 : Analysis of the generalization properties of layered neural networks for signal processing (1991–1992)

2. Czech Ministry of Research and Technology — Grant No. Z-192 : Prediction of some risk factors of cancer and its metastases using neural networks (1991–1992)

9.2.1 Goals for the future

The future activities will be oriented into the following areas:

- Development of new methods and algorithms for nonlinear time series forecasting
- Development of new methods for the design of complex systems with modular architectures
- Development of a new concept and of a general theory of artificial technical, social, economical or medical systems of which the operation reliability can be significantly improved by the application of principles of complex predictive diagnostics and the restoration procedure optimization or failure prophylactics
- Application of the developed methods in energetics and banking
- Algorithm of evaluating a response to a therapy
- Organization of the scientific workshops, seminars and conferences (e.g. NEURO-FUZZY 96, PASE 97, ECSAP-97 etc.)

9.3 The most important results of the last five years

1. The original approach for the combination of different neural networks [2] was developed by Emil Pelikán (co-authors Diethelm Würtz and Class de Groot, IPS ETH Zürich) [8]. This approach is based on a decorrelating combination, when new neural networks learn to be "decorrelated" with respect to the previous models. This approach can be generalized to any "nonlinear models" and can be applied in many application areas. The application of this approach in the electric load forecasting problem improves the quality of prediction of about 30 percent. Remarkable improvement was also obtained in the foreign exchange rate forecasting problem [4] and [7].

2. The mathematical model proposed by L. Pecen, K. Eben for the early diagnostic of recurrence of cancer disease realized with the help of the long-term monitoring of tumor markers which takes into account time dependence of the covariates [6].

3. The development of Bayes network for fixing an unknown location and a type of primary tumor, where the inputs are results of some of the serum tumor markers measurements, patient sex and age. Authors had to solve the problem of reconstruction of a multidimensional distribution of tumor marker concentrations from partial less dimensional distributions [6].

4. Formulation of the general theory of ultra-reliable systems based on the use of the tolerance theory and the system life-curve prediction by Mirko Novák (prepared for publication).

9.4 Number of publications

1.	journals	
	— international :	40
	— others :	32
2.	proceedings of conferences	
	— international (full texts) :	19
	— others (full texts) :	15
	— international (abstracts) :	14
	— others (abstracts) :	6
3.	monographs or their parts :	4
4.	dissertation :	1
5.	reports :	24

The most important publications of the last five years

[1] Novák M., Pelikán E. (Editors): Theoretical Aspects of Neurocomputing. — Selected papers from the Symposium on Neural Networks and Neurocomputing NEURONET'90, World Scientific, London, 1991, 289 pages

[2] Pelikán E., de Groot C., Würtz D.: Power Consumption in West-Bohemia: Improved Forecasts with Decorrelating Connectionist Networks. — Neural Network World 2 (1992), 6, 701–712

[3] Pelikán E., Šebesta V.: Neural Network Learning Algorithms for Electric Load Forecasting. — In: Proceedings of the SPIE 94 Conference on Application of Artificial Neural Network V., Volume 2243, Orlando, USA, 1994, 2243–2257

[4] Pecen L., Pelikán E., Ramešová N., Beran H. : Application of the GUHA method on financial data. Neural Network World Journal 5 (1995), 4 (Special Issue on PASE '95), 565–572

[5] Pecen L.: Electrical Signal Processing. — International Journal of Electronics 73 (1992), 5, 1085–1087 (impact factor 0.238)

[6] Nekulová M., Šimíčková M., Pecen L., Eben K., Vermousek I., Stratil P., Černoch M., Lang B.: Early Diagnosis of Breast Cancer Dissemination by Tumor Markers Follow-Up and Method of Prediction. — Neoplasma 41 (1994), 2, 113-118 (i.f. 0.352)

[7] Paluš M., Pecen L., Pivka D.: Estimating predictability: Redundancy and surrogate data method. Neural Network World 5 (1995) , 4 (Special Issue on PASE '95), 537–552

[8] Novák M., Beran H, Pelikán E.: Time Series Prediction by Artificial Neural Networks. — In : Frontier Decision Support Concepts — Help Desks, Learning, Fuzzy Diagnoses, Quality Evaluation, Prediction, Evolution, Editors : Plantamura V.L., Souflorinek B.,

Visaggio G., Sixth-Generation Computer Technology Series, John Wiley & Sons, 1994, 221–239

Number of citations: 29

9.5 International cooperation

1. IPS ETH Zuerich, Switzerland
2. TU Delft, Netherlands
3. National Oncology Institute, Hospital Sv. Alžběty, Bratislava, Slovakia
4. University Hospital, Erlangen, Germany

9.6 Remarks

- Results on a good scientific level can be documented by the second award in the poster section (from 49 presentations) at the 12th International Conference on Human Tumor Markers in New York, June 11–14, 1995 (L. Pecen, K. Eben, M. Sláma), and 1.–3. award (from 45 presentations) at the 2nd International HSBCR Congress, Kos, Greece, October 25–28, 1995 (L. Pecen, K. Eben).

  Basic theoretical results are :

  - original approach for the combination of different neural networks and its generalization for any nonlinear models
  - multidimensional survival analysis model with undirectly diagnosed failure realized with the help of long-term monitoring of selected parameters
  - reconstruction of multidimensional distribution from partial less dimensional distributions
  - formulation of the general theory of ultra-reliable systems based on the use of the tolerance theory and system life-curve prediction.

- In last year, three foreign visitors were in the department.
- The members of the group organize international conferences (PASE 92, NEURONET 93, partially PASE 93, PASE 95, NEURO-FUZZY 96, PASE 97, ECSAP-97) and national seminars (three 3–5 days seminar about Mathematical methods of data processing in oncology).

- Most projects mentioned above have interdisciplinary character. Some of the theoretical results proposed by the department have been used for the practical application of:
  - decision support systems for oncology
  - systems for energetic systems prediction
  - methods of artificial intelligence for exchange rate forecasting, credit risk assessment, etc.
- The members of the department participated in ten projects supported by the Grant Agency of the Academy of Sciences or the Grant Agency of the Czech Republic, and partially participated in two other projects.
- Because interdisciplinary applications are time consuming, the personal equipment is minimal for realization of the running project and should be extended.
- Instrumental equipment came mostly from grant projects and is sufficient for their realization.
- The organization of seminars is coordinated in collaboration with other departments of the institute.
- Besides the international cooperation mentioned in the previous section, the department collaborates with the following national institutes :
  - Masaryk Memorial Cancer Institute, Brno
  - Faculty Hospital of Charles University, Plzeň
  - University of Economics, Prague
  - Institute of Chemical Technology, Prague.

Department of EuroMISE (European Center for Medical Informatics, Statistics and Epidemiology)

Head: **Doc. RNDr. Jana Zvárová, CSc.**

10 Department: EuroMISE (European Center for Medical Informatics, Statistics and Epidemiology)

Participants:

(since 1993 :)
Doc. RNDr. Jana Zvárová, CSc.
Mgr. Karel Hrach
Mgr. Martin Štefek
Mgr. David Švejda

The department is a joint department of the Institute of Computer Science AS CR and the Faculty of Mathematics and Physics of Charles University. The department is of a broad interdisciplinary nature, cooperating closely with several medical faculties of Charles University and hospitals.

10.1 Main research projects

The research of the department is interdisciplinary, concentrated in the field of medical informatics, statistics and epidemiology. Research in medical informatics is mainly promoted by the Institute of Computer Science, and in medical statistics by the Faculty of Mathematics and Physics. The epidemiology part is carried out by the physicians cooperating in the interdisciplinary research projects. The EuroMISE department is involved in research grants connected with cardiology, oncology, genetics and epidemiology. From a theoretical point of view we are involved in decision support systems, managing uncertainty problems, data analysis, measuring association, information theory approaches and statistical multivariate methods (survival analysis, regression analysis, discriminant analysis) and mathematical models in genetics.

National grants

1. Grant Agency of the Czech Republic — Grant No. 313/93/0616 : Development of new methods for data analysis in epidemiological studies, detection of risk factors and disease risk modelling (1993–1995)

Foreign grants

1. European Union — Copernicus Project No. 10053 : MUM — Managing Uncertainty in Medicine

2. European Union TEMPUS-PHARE Project No. JEP 4358 : Education in the Methodology Field of Health Care — EuroMISE (European education in Medical Informatics, Statistics and Epidemiology).
   In this project J.Zvárová has worked as the coordinator for the entire project involving 12 EU Universities and Health Research Institutions, 5 faculties of Charles University, Faculty hospital and Institute of Computer Science

3. Fourth Framework Programme of European Union : Project InTeMe EDUCTRA, as Associated Partner

10.2 Relation to the previous research and goals for the future

The research in the field of information theory is connected with previous work of J. Zvárová in this field in the Czech School of Information Theory directed by A. Perez. There is a close connection between this research and the research in statistics, especially on measuring association. The interdisciplinary research is based on J. Zvárová's experience in the field of medicine and health care. This research is concentrated in the field of medical informatics and statistics, i.e. decision support in medicine, extraction of relevant information and data analysis, and research considering epidemiologic and genetical problems. During her lectures at the Faculty of Mathematics and Physics, Dr. Zvárová brought attention to this field to the students of informatics and statistics. Some of them are now actively developing the new interdisciplinary research approaches, continuing as doctoral students at the Institute of Computer Science or at the Faculty of Mathematics and Physics. The main goals for the future work are to develop new methods and algorithms for data reduction and constitution problems or decision support in medicine; to develop new methods and tools for analysis of data in epidemiology, genetics and for selected medical disciplines; application of developed methods in the field of medicine and health care; development of new methods and tools for the estimation of models for disease risk assessment; to promote interdisciplinary studies, organize interdisciplinary courses, postgraduate and continuing education using modern information technology; to organize scientific workshops, seminars and conferences (e.g. EuroMISE international workshops in 1995 and 1996)

10.3 The most important results of the last five years

1. Research in information theory approaches for extraction of relevant information for decision support realized in the prototype program CORE (COnstitution and REduction of data).

2. Research in methods for support of research in epidemiology realized in the prototype program EPITOOLS.

3. Papers on genetic models and application to concrete medical problems, practical tools for medical care, prototype program HYPERTENSION

4. Educational activities in the field of medical informatics, statistics and epidemiology on an international scale, organization of courses in English and Czech languages within the TEMPUS project.

5. Research on the association of risk factors and diseases.

10.4 Number of publications

1.	journals	
	— international :	6
	— others :	21
2.	proceedings of conferences	
	— international (full texts) :	16
	— others (full texts) :	1
	— international (abstracts) :	7
3.	monographs or their parts :	5
4.	textbooks :	1
5.	reports :	7

The most important publications of the last five years

[1] Zvárová J.: Education in methodology for health care — EuroMISE.
— Methods of information in Medicine 33 (1994), 3, 315–317 (impact factor 0.917)

[2] Zvárová J., Jedličková A., Zvára K.: Computer based evaluation of antibiotic therapy predictions. — International Journal of Biomedical Computing 29 (1991), 207–213 (i.f. 0.410)

[3] Zvárová J.: Detecting rick factors of diseases. — Biocybernetics and Biomedical Engineering 15 (1994), 204–212

[4] Zvárová J., Dostál C., Jirků P., Kasal P.: Expertní a konzultační systémy v medicíně. Textbook. Univerzita Karlova, Praha 1992

[5] P. Hájek, A. Sochorová, J. Zvárová: GUHA for personal computers. - Computational Statistics and Data Analysis 19 (1995), 149-153 (i.f. 0.412)

Number of citations: 7

10.5 International cooperation, remarks

Within the European projects we have cooperated with the following universities and research institutes:

1. University of Heidelberg, Faculty of Medicine (Prof. R. Haux)
2. University of Rotterdam (Prof. J.H. van Bemmel)
3. University of Dublin (Dr. M. o'Regan)
4. Limburg University (Prof. A. Hasman)
5. University of Leuven (Prof. J. Albert)
6. Free University of Brussels (Prof. J. Lagasse)
7. University of Manchester, UMIST (Prof. B. Richards)
8. University of Thessaloniki (Prof. B. Katsouyannopoulas)
9. University of Bordeaux (Prof. R. Salamon)
10. University of Marburg (Prof. O. Rienhoff)
11. MEDIS Institute Neuherberg (Dr. R. Engelbrecht)
12. University of Wroclaw (Dr. M. Lubicz)
13. University of Barcelona (Dr. F. Esteva)
14. Institute of Medical Informatics and Statistics Bucharest (Dr. I. Moisil)
15. Centre of Biocybernetics Warszawa (Prof. J. Doroszewski)

- Within the TEMPUS project we have organized two international conferences (with proceedings edited by J. H. van Bemmel, J. Zvárová: Medical Informatics Education and Research, 1994, and by J. Zvárová, I. Malá: Information, Health and Education, 1995) and two international workshops within the COPERNICUS project.
  In 1995 we also organized international one month courses on medical informatics, statistics and epidemiology. And in 1994, we organized one week courses every month. We hosted more than 50 professors and health scientists from EU countries as teachers or lecturers for courses and conferences.
  Moreover, we supported the participation of health researchers from Poland, Hungary and Romania in the courses and conferences.
  In EuroMISE courses we educated more than 70 attendees from the Czech Republic, Hungary, Poland and Romania and issued them certificates.

- J. Zvárová has presented invited lectures at seminars and conferences, e.g. in Romania, Hungary, Morocco, England, Greece and Poland.
  At all of these and other conferences she chaired scientific sessions.
  She participated as a member of the Word Congress on Medical Informatics MEDINFO 95 in Vancouver and was chairman of the Scientific session.
  She is the representative of the Czech Republic in International Medical Informatics Association (IMIA) and European Federation for Medical Informatics (EFMI).

- In pregraduate education, the EuroMISE department has participated in teaching students of the Faculty of Mathematics and Physics, the First Faculty of Medicine and the Third Faculty of Medicine.
  Moreover we held courses for doctoral medical students of the Medical Faculty in Pilsen (two weeks course in 1995) and we organized a one week course Medical Informatics for Oncology.

- J. Zvárová is a supervisor of 3 doctoral students (Mgr. Pikhart, Mgr. Rosendorfská and Mgr. Štefek) and she was supervising 3 diploma theses.
  She is on the editorial board for the International Journal for Biomedical Computing and the National Journal Physician and Technology, and she is the reviewer of IMIA Yearbooks.

- All young scientists of the department had the opportunity to take part in retraining/updating stays which lasted about 3 weeks at some of the cooperating EU Universities through the TEMPUS grant (Hrach — University of Heidelberg, Švejda — Limburg University, Štefek — Trinity College Dublin).
  The finances from the project COPERNICUS enabled Švejda to attend the workshop in Manchester and Štefek to attend the conference MEDINF 95 in Bucharest.
  All of these young scientists elaborated on a final thesis of EuroMISE courses and received the certificate.
  During the year 1995 all of them had to lecture at a seminar or an international conference. All of them participated in teaching courses held for doctoral students of the Medical Faculty in Pilsen and presented their thesis on EuroMISE courses. The other two doctoral students of J. Zvárová (Mgr. Pikhart, Mgr. Rosendorfská) are presently in Great Britain for interdisciplinary research studies.

11 An Outline of the Future Research

11.1 Introduction

As mentioned previously in the introduction, the history of ICS as being purely a research institute only began only in the 1990s. Therefore, it is understandable that its first research conception has mostly been based on the existing research streams that existed in the early days of ICS . The priority was given to the stabilization of the institute's research potential and to its adjustment to a new research climate after the velvet revolution in 1989. The most profound change, due to the previous statement, was the introduction of the granting system into the financing of science in the Czech Republic. Some time was necessary for research teams to be acquainted with the new granting system and to develop habits and mechanisms for successful existence within this system. Nowadays, this transition and accommodation phase seems to be approaching its end and the time has come to develop a new conception, other than one mostly based on bottom-up approach, declaring the existing status-quo as its goal.

A new conception should be based on a vision that should be both credible and motivating, and, of course, achievable with the institute's research potential. Although it should be rooted in existing research results and the previous experience accumulated by the institute, it must focus the future research effort towards a coherent research field. This field should not only be conformed to the prevailing world-wide research development, but should also anticipate this development, and be pro-active in its formulation. The ultimate goal should be the promotion of the institute among the leading institutes in that field on an international scale.

To achieve these objectives we propose a research conception targeted towards the heart of computer science — towards new computing paradigms.

11.2 Towards New Computing Paradigms

For the first time in the history of science, we now collectively have a substantial amount of experience with standard computing on a large scale, and, more significantly, we have had a few decades to reflect on its principles, possibilities and limitations. Along with this experience we also have a substantial body of the respective theory. Both our experience and the respective theory point to the fact that we have probably achieved the inherent limits of the prevailing "traditional" ideas, and ways of computing. The traditional thinking about computing goes back to Turing and von Neumann and can be characterized by precision, rigor, certainty at the level of reasoning about computing, and by its deterministic, mostly sequential, realization. Recent results and trends, especially in logic and related areas of complexity theory, and practical experience from parallel computing, clearly reveal the drawbacks of such an approach in all the areas where human-like style in problem solution is required. Therefore, new ideas, new computational paradigms are needed in order to push the computing onto a qualitatively higher level.

It appears that now it the time when we may have an unprecedented opportunity to

make progress along these lines. Of course, in different areas of computer science the magnitude of this opportunity, as well as ways of its realization, are different.

Undoubtedly the emergence of new computational paradigms presents a great challenge to pure theory. It is especially logic and complexity theory that, both, thanks to their very nature, possess the most vigorous and the most flexible formal tools, methods and methodologies to cope with such intellectual task. In fact, the signs announcing the advent of a new philosophy of computing are clearly to be recognized in these two fields, at the border of mathematics and computer science. Here, the progressive research trends are directly inspired namely by the ability of human mind to effectively employ modes of reasoning/learning or problem solving that are approximate rather than exact[1], and by the ability of the human brain to realize the underlying computations effectively, using massive parallelism, randomness and probabilism rather than sequential determinism, and also by the robustness of the underlying computational processes and devices. In complexity theory a good deal of attention is also paid to the search of new computational models based on new computational mechanisms related to neural, quantum, genetics, molecular, and other phenomena.

Although altered, it remains a fact that the new or changing approach to computing can be observed in more applied parts of computer science that are directly related to software production. The corresponding part of computer science, being tightly coupled with the existing computing machinery, must not only function within the limits of this machinery, but must also react to the steadily growing needs of practical use. Increasingly better software is required, in every sense of the word 'better'. Thus, more reliable and/or more robust software is required; it should operate faster. It should not only be produced faster, but should also be more easily modifiable, and should be reusable, scalable, portable, etc. It is a formidable task which computer science has not yet mastered satisfactorily. It is not only because of our relatively short period of time that we are confronted with such needs, but also because it is primarily the intellectual complexity of the underlying problems, especially in the parallel and distributed environment, and the necessity to verify the proposed solutions in real life, which make the progress in this field slow and difficult.

Nevertheless, simultaneously with the progress in computing technology (parallelism, distributed computing, high speed networking), the influence of human-like style, especially in the engineering approach to problem solving, can be observed one again. Contemporary software production strives, to the best of its abilities, for achieving the same engineering mastership as the one that the technical or civil engineering has been enjoying for decades and perhaps centuries. Tools and methods that are based mostly on algebra of processes and object-oriented decomposition and that would lead to software production technologies guaranteeing all the above mentioned desirable properties of software are being sought after.

[1] Along these lines the term *fuzzy logic* is used very often. In fact, it has become a fashion and one can find publications claiming to belong to fuzzy logic yet they are actually logically (and mathematically) poor. This undeniable fact must not be allowed to close the door to serious investigations of logics of vagueness and their applications. There is an ongoing theoretical investigation on this both in the foreign literature (cf. works by Gottwald, Kruse et al., Dubois–Prade, Takeuti–Titani, etc.), and in the literature of the Czech Republic (see the references by P. Hájek in previous parts of this report).

Similar development is present in the field of high performance technology where the convergence between the trends in practice and theory is to be observed. On one hand, there seems to be kind of a weak consensus about the prevailing architectures of real parallel computers. On the other hand, based on this consensus in theory, there is a vibrant field of investigation of the so-called *realistic machine parallel models* that would enable a uniform theoretical and programming (i.e., machine independent) treatment of existing parallel machines.

The announcing of a new computing era takes a special form in a scientific computing. The main difference between scientific computing and 'computing *per se*' seems to be that the former has been confronted with well formulated tasks from the very beginning. Also, the search space for finding the respective algorithms is usually well defined being represented in terms of mathematical spaces with known properties that should be exploited to design algorithms that are in some way efficient. What makes the problems difficult is usually the size of problems to be solved which implies the need of fast algorithms of which the correct and precise solution is guaranteed despite the speed. This requires coupling of modern mathematical tools with advanced programming optimization techniques, carefully designed data structures, and appropriate programming models and tools, and, last but not least, suitable high performance computing platforms. Except of some simple cases, the mechanical exploitation of parallelism could lead to algorithms that do not give correct results due to the lost of stability of the underlying numerical processes, or the lost of precision of underlying computations. In the massively parallel environment, also problems related to the reliability of individual processors, transformed into a fault-tolerant algorithms, must be also solved. Thus the acceptance of new computational paradigms leads to problems specific to this kind of computations.

Finally, some of new computing paradigms, related directly to brain-like computing and based on recent ideas treated in the theory, have quickly found their ways to practice. It is the case of neurocomputing in particular. Data mining methods, knowledge-based systems, neuro-fuzzy, and other systems based on multi-agent cooperation start to present viable alternatives to the classical systems based on standard methods. The primary practical fields of their exploration cover, besides other fields, economy, medicine, computational biology and chemistry, etc.

11.3 Intelligent Computing

It seems that the approach to computing we have in mind will be becoming increasingly known as *intelligent computing*. In the field of logic, this became apparent at the last international conference IMPU '94 in Paris. In fact, one of the most prominent, invited lectures, by Professor M. Sugeno, had the title *"Intelligent Computing"* and the speaker applied the term in a very similar way as we do. Moreover, the book of selected papers read at the conference (including, by the way, two papers from ICS Prague) is being published under the title *"Advances in Intelligent Computing"*. The term *intelligent computing* has been also used in the recent prestigious monograph "Computer Science Today " (Jan van Leeuwen editor) that has appeared as a 1000th anniversary volume in the LNCS of Springer

Verlag, Berlin (including, by the way, also one paper from ICS Prague).

Thus, for the further purposes and for the sake of brevity, we shall denote the relevant style of (thinking and reasoning about) computing as *intelligent computing*.

11.4 The Research Conception of ICS for the Next Decade

The above mentioned ideas of intelligent computing present a conceptual framework for the research conception of the ICS for the next decade.

When formulating our long-term perspective using the words "intelligent computing" we are well aware of the fact that paradigms emerge and disappear and that a particular paradigm may seem fruitful and promising but later may fail to fulfill original expectations (let us mention e. g. the original expectations related to Artificial Intelligence, Fifth Generation machines etc.). Stressing this we wish to make explicit that our approach to the term "intelligent computing" is not and must not be a matter of fashion (even if the term itself is fashionable); our aim is *critical inspiration* as we are trying to take the term (program, paradigm) as seriously as possible, distinguishing deep insight from short-term popularity. In particular, the new paradigm will *not* mean any resignation to exact mathematical methods; on the contrary, a profound theoretical analysis should also show (among other things) how to extend the mathematical approach to domains inherently dealing with impreciseness, vagueness and various sorts of uncertainty.

In order to achieve the desired effects described in subsection 11.1 the conception is centered around three complementary research streams that spread across the computer science and at the same time build upon the current research structure of the ICS. These three basic research streams make the conception interdisciplinary within the framework of computer science. They are tightly coupled by the manifestation and application of paradigms of intelligent computing:

- *theoretical foundations of intelligent computing:* theoretical basis of approximate, nondeterministic or uncertain, and of other non-standard reasoning will be continually reviewed and expanded especially by new solutions based on fuzzy approaches to logics. With respect to these results, and with due regards to recent trends in the field of complexity theory and neural-network theory, models of massively parallel, distributed, cooperating and randomized systems will be developed. For these models, efficient algorithms for problems originating in the area of intelligent computing will be designed and analysed, too;

- *programs and software tools for the efficient realization of intelligent computations:* Progressive distributed and parallel programming systems and environments will be designed and prototyped with an emphasis put upon the employment of new paradigms, such as object-oriented and fault-tolerant software in distributed environment, tightly cooperating processes based on loosely coupled computing power, and efficient sharing of physically distributed resources. These programming systems will be built with hopes to achieve reusability, portability, and interoperability of software components in heterogeneous environments.

- *intelligent scientific computing and experimental applications in intelligent information processing:* new high performance numerical algorithms and software systems for the solution of optimization and nonlinear prediction problems, and problems of linear algebra stressing robustness, stability, precision, efficiency and other non-traditional approaches will be designed and implemented. Pilot applications of selected results from the previous two research fields, especially in economics, banking, energetics, and medicine, will be realized and their efficacy will be evaluated.

Thus we believe that the explicit formulation of the idea of intelligent computing, being that of an emerging research conception of the ICS, will help to speed-up the process of introducing ideas based on new computing paradigms not only into our ways of thinking about computing, but also into the computing itself. At the applied end it will help in promoting the utilization of our computing devices to a qualitatively higher level.

We expect the ICS to contribute to this process not only through its intramural research, but also via its taking part in the corresponding international cooperation.

12 Enclosures

12.1 List of grants

12.1.1 International grants

Duration	*Grant Agency*	*Name*	*Principal Investigator in ICS AS CR*	*Title of the Project*
92–95	COPERNICUS	ALTEC	Wiedermann	Algorithms for Future Technologies
93–96	NSF		Strakoš	Iterative Methods for Non-symmetric Linear Systems and Eigenvalue Problems
93–96	TEMPUS	EuroMISE	Zvárová	European Education in Medical Informatics, Statistics and Epidemiology
93–96	MHNL/CR	AMBI/CR	Šebesta	EXIN/ČR — Examination Institute of the International Education Program in Informatics AMBI for the Czech Republic
94–96	COPERNICUS	MUM	Hájek	Managing Uncertainty in Medicine
95–97	COPERNICUS	HIPERGEOS	Nedoma	High Performance Computing in Geosciences; Safety of Constructions with Respect to Rock Deformation and Movement

12.1.2 Grants of the Ministry of the Education of the CR

Duration	*No.*	*Coordinating Institution*	*Principal Investigator in ICS AS CR*	*Title of the Project*
93–95	V 361/93	FEE CTU	Jiřina	Education of Neural Networks and Neurocomputers

12.1.3 Grants of the Ministry of the Economical Development of the CR

Duration	*No.*	*Coordinating Institution*	*Principal Investigator in ICS AS CR*	*Title of the Project*
91–92	G192	ICS AS CR	Pelikán	Prediction of some risk factors of cancer and its methastasis using neural networks
91–93	G855	FEE CTU	Řízek	Education of neural networks and computer vision in a postgraduate study at the Faculty of Electroengineering of the Technical University in Prague

12.1.4 Grants of the Grant Agency of the CR

Duration	*No.*	*Coordinating Institution*	*Principal Investigator in ICS AS CR*	*Title of the Project*
93–95	201/93/0427	ICS AS CR	Kůrková	Approximation of functions and architectures of neural networks
93–95	101/93/0430	ICS AS CR	Novák	Theory and methods of ultra reliable systems synthesis
93–95	201/93/0429	ICS AS CR	Lukšan	Research of optimalization methods and development of an interactive system for universal functional optimalization
93–95	201/93/0067	TU Liberec	Tůma	Mathematical models of underground water flow and of the transport of dissolved substances for the purpose of remediation of the consequences of uranium mining in Northern Bohemia
93–95	201/93/0781	PUE Praha	Kramosil	Building intelligent systems
93–95	313/93/0616	1st FM CU	Eben	Construction of methods for data analysis in epidemiological studies, detection of risk factors and disease risk modelling
93–95	202/93/0178	IP AS CR	Jiřina	Hadron interaction in the TeV region and their fast triggering for quark-physics
93–95	102/93/0912	FEE CTU	Jiřina	Automatic identification of plants growing in rows by means of neural nets
94–96	102/94/0728	ICS AS CR	Húsek	Information retrieval from textual databases based on AI and NN methodology
94–96	201/94/0729	ICS AS CR	Húsek	Analysis of the informational capabilities of a class of artificial neural networks for the optimization of their structure

Duration	*No.*	*Coordinating Institution*	*Principal Investigator in ICS AS CR*	*Title of the Project*
94–96	201/94/1327	ICS AS CR	Pelikán	Application of modern mathematical methods in economic information processing
94–96	201/94/0130	UCT	Pelikán	New approaches to neural networks in digital signal processing for applications to system identification and modelling
95–97	102/95/1311	ICS AS CR	Novák	New methods of prediction and optimalization of the applications in the electric power network of the Czech Republic
95–97	201/95/0976	ICS AS CR	Wiedermann	HYPERCOMPLEX: Complexity issues in high performance computing
95–96	201/95/0979	ICS AS CR	Hakl	Pattern recognition method based on univalence of neural network mapping
95–97	201/95/0992	ICS AS CR	Kufudaki	Extended modular models of neural networks and their applications in medicine
95–97	201/95/1484	FMP CU	Fiedler	Linear problems with approximate data
95–97	308/95/0304	FH Vinohrady	Nedoma	Mathematical models of a hip joint, total endoprothesis of a hip joint based on the stress analysis
96–98	201/96/0918	ICS AS CR	Lukšan	Development of methods for solving large-scale problems of nonlinear analysis
96–98	201/96/0917	ICS AS CR	Kůrková	Approximation of functions and networks learning algorithms

12.1.5 Grants of the Grant Agency of the Academy of Sciences of the CR

Duration	*No.*	*Coordinating Institution*	*Principal Investigator in ICS AS CR*	*Title of the Project*
91–92	23005	ICS AS CR	Jiřina	Neural networks with neurons of a limited number of synapses
91–92	23010	ICS AS CR	Pelikán	The analysis of the generalization abilities of layered neural networks used for signal processing
91–92	11924	ICS AS CR	Hájek	Mathematical foundations of inference in expert systems
91–93	23003	ICS AS CR	Šebesta	Model search techniques
91–93	23007	ICS AS CR	Strakoš	Convergence and stability of conjugate gradient type methods for solving linear systems and computing eigenvalues in finite precision arithmetic
91–93	23011	ICS AS CR	Kufudaki	The analysis and applications of new neural network architectures
91–93	23012	ICS AS CR	Lukšan	Research of optimization methods and the development of an interactive system for universal functional optimization
92–93	24453	IFR AS CR	Andrej	Rules for the creation of conditional reflexes and their applications in the field of artificial neural networks
92–94	17555	ICS AS CR	Kramosil	Non-numerical uncertainty quantification and processing in computer-aided systems for conclusion drawing and decision making
92–94	23057	ICS AS CR	Kůrková	The approximation capabilities of multilayer neural networks
93–95	130108	ICS AS CR	Hájek	Mathematical foundations of approximate inference
93–95	230106	ICS AS CR	Eben	Mathematical modeling of metastatic activity of cancer cells
94–96	230404	ICS AS CR	Pelikán	Design of modular artificial neural networks

Duration	*No.*	*Coordinating Institution*	*Principal Investigator in ICS AS CR*	*Title of the Project*
94–96	130407	ICS AS CR	Fiedler	Structured matrices
94–96	230401	ICS AS CR	Strakoš	Numerical methods for linear algebraic systems with application to nonlinear problems
95–97	1030504	ICS AS CR	Kramosil	Alternative mathematical models for uncertainty quantification and processing
96–98	A1030601	ICS AS CR	Hájek	Mathematical foundations of inference under vagueness and uncertainty

12.2 International Conferences since 1991

- International Workshop on Decision Making on the Basis of Data and Knowledge Integration, Prague 1991 (26 participants from 5 countries)
- International Summer School on Computational Aspects of Model Choice, Prague 1991 (59 participants from 15 countries)
- PASE'92 — 3rd International Workshop on Parallel Applications in Statistics and Economics, Prague 1992 (93 participants from 15 countries)
- NEURONET'93 — 2nd International Conference on New Information Technologies and their Applications in Trade, Industry, Banking, Energetics, Ecology and Medicine, Prague 1993 (88 participants from 12 countries)
- SOFSEM'93 — 20th Annual International Winter School on Theory and Practice of Software Systems, Hrdoňov, Czech Republic 1993 (141 participants from 7 countries)
- MODELLING'94 — International Symposium on Mathematical Modelling and Computational Methods, Prague 1994 (83 participants from 12 countries)
- WUPES'94 — Workshop on Uncertainty Processing in Expert Systems, Třešť, Czech Republic 1994 (57 participants from 9 countries)
- SOFSEM'94 — 21st Annual International Winter School on Theory and Practice of Software Systems, Mílovy, Czech Republic 1994 (136 participants from 9 countries)
- ICDT'95 — International Conference on Database Theory, Prague 1995 (139 participants from 19 countries)
- MFCS'95 — 20th International Symposium on Mathematical Foundations of Computer Science, Prague 1995 (146 participants from 18 countries)
- PASE'95 — 5th International Workshop on Parallel Applications in Statistics and Economics, Trier-Mainz, Germany 1995 (88 participants from 20 countries)
- SOFSEM'95 — 22st Annual International Winter School on Theory and Practice of Software Systems, Mílovy, Czech Republic 1995 (152 participants from 8 countries)
- NEURO'95 — NEURO-WORKSHOP 95 International Workshop on Neural Networks, Brno, Czech Republic 1995 (79 participants from 9 countries)

12.2.1 International Conferences in preparation

- NEuroFuzzy'96 — IEEE European Workshop on Computational Intelligence, Prague 1996
- GOEDEL'96 — International Conference on Logical Foundations of Mathematics, Computer Science and Physics, Brno, Czech Republic 1996
- SOFSEM'96 — 23rd Annual International Winter School on Theory and Practice of Software Systems, Mílovy, Czech Republic 1996
- ECSAP'97 — 1st European Conference on Signal Analysis and Prediction, Prague 1997
- IFSA'97 — Congress of International Fuzzy Sets Association, Prague 1997

12.3 International Cooperation

There are several international cooperations that have been established within the past and current international grants. Moreover, there are many formal and informal cooperations with research institutions and universities:

- Computer Center of the Russian Academy of Sciences (V. Zhadan)
- University of Leipzig, Germany (G. Rex).
- Courant Institute of the Mathematical Sciences, New York University (A. Greenbaum)
- Stanford University (G.H. Golub)
- Linköping University (A. Björck, T. Elfving)
- University of Bologna, CERFACS Toulouse (M. Benzi)
- University of Bergamo, Italy (E. Spedicato)
- Rechenzentrum Universität Karlsruhe (R. Weiss)
- Catholic University of Nijmegen, The Netherlands (O. Axelsson)
- University of Bruxelles, Belgium (R. Beauwens)
- Bulgarian Academy of Sciences, Bulgaria (P. Vassilevski)
- Central Mining Research Institute at Dhanbad, India (B.B. Dhar)
- Indian School of Mines at Dhanbad, India (V. Srivastava)
- National Geophysical Research Institute at Hyderabad, India
- University of South Carolina, South Carolina, USA (T.L. Markham)
- Technical University Chemnitz, Germany (K. Rost)
- Institut d'Investigacio en Intel.ligencia Artificial CSIC (Bellatera, Spain)
- University of Toulouse [prof. D. Dubois]
- University of Manchester [prof. J. Paris]
- State University of New York (Binghamton) [prof. G. J. Klir]
- Florida State University (Tallahassee) [prof. L. Kohout]
- CERN, Geneva, Switzerland — on problems of high energy particles detection
- University of Jena, Germany — data flow in high energy particles classification
- University of Mannheim, Germany — high energy particles triggering
- Institute of Higher Neural Activity, Moscow, Russia — on problems of neurocontrol
- University of Aleppo, Syria — on problems of learning the GMDH neural networks
- Catholic University Louvain, Belgium — on problems of information based approach to control and forecasting

- University of Strathclyde, Glasgow, Scotland — on problems of information based approach to control
- Department of Physics, University of Linz, Austria — on problems of spin glasses in relation to neural networks theory
- University of Texas and El Paso, USA (V. Kreinovich) — dimension-independent estimates of the number of hidden units
- NASA, Goddard Space Flight Center, Greenbelt, USA (J. J. Smid) — approximation of functions by cascade networks
- Georgetown University, Washington, D.C. (P.C. Kainen) — complexity of neural networks
- Politechnika Warszawska, Warsaw, Poland (B. Beliczynski) — incremental neural network algorithms
- Catholic University of Louvain-la-Neuve, Louvain, Belgium (M. Verleysen) — approximation of functions by RBF networks
- University of Reading, Reading, England (J. Mason) — approximation of functions by B-spline networks
- The Institute of Informatics, The State Research Center Demokritos, Athens, Greece (Prof. J. Varufakis)
- The Department of Computer Science, University of Creta, Greece (Prof. K. Papadurakis)
- The Bioclub, Brussels, Belgium (Prof. P. Querinjean)
- The Institute of Theoretical Physics, Academia Sinica, Beijing, China (Prof. Hao Bai-Lin)
- IPS ETH Zuerich, Switzerland
- TU Delft, Netherlands
- National Oncology Institute, Hospital Sv. Alžběty, Bratislava, Slovakia
- University Hospital, Erlangen, Germany
- University of Heidelberg, Faculty of Medicine (Prof. N. Victor)
- University of Rotterdam (Prof. J.H. van Bemmel)
- University of Dublin (Prof. M. o'Regan)
- Limburg University (Prof. A. Hasman)
- University of Leuven (Prof. J. Albert)
- Free University of Brussels (Prof. J. Lagasse)
- University of Manchester, UMIST (Prof. B. Richards)
- University of Thessaloniki (Prof. B. Katsoupuylanos)

- University of Bordeaux (Prof. R. Salamon)
- University of Marburg (Prof. O. Rienhoff)
- MEDIS Institute Neuherberg (dr. R. Engelbrecht)
- University of Wroclaw (Dr. M. Lubicz)
- Institute of Medical Informatics and Statistics Bucharest (Prof. I. Moisil)
- Centre of Biocybernetics Warszawa (Prof. J. Doroszewski)
- Stichting EXIN, Utrecht, The Netherlands (A. van der Niet)

Since 1994 the Institute has been active in approaching the prestigious European Research Consortium in Informatics and Mathematic (ERCIM) which is an international consortium of the leading computer science institutes in Europe. Currently, the Czech Research Consortium in Informatics and Mathematics (CRCIM) is being established. It consists of the Faculty of Mathematics and Physics, the Charles University, Prague; the Faculty of Informatics, Brno; the Institute of Theory of Information and Automation, AS CR, Prague; the Institute of Computer Science, AS CR, Prague.
CRCIM will become a member of ERCIM in the near future.

12.4 Types of Employees

Type	Scientific workers	Supporting staff
Full time	42	32
Part time	18	7
Total equivalent number	50.31	34.36

12.4.1 Age Categories

Age	–30	31–40	41–50	51–60	61–
Full time scientists	10	12	8	10	2
Part time scientists	5	3	3	4	3
Full time all	12	14	19	18	11
Part time all	6	3	4	8	4

12.4.2 Degrees of Qualification

Qualification	RNDr., Ing.	CSc.	DrSc.	Doc.	Prof.
Full time	46	22	9	2	–
Part time	18	3	4	4	3

12.4.3 List of PhD students and their advisors from ICS AS CR

PhD student	home institution	tutor	degree granting institution
Novický	FMP KU Bratislava	Wiedermann	FMP KU Bratislava
Hegedus	FMP KU Bratislava	Wiedermann	FMP KU Bratislava
Kelemen	FMP KU Bratislava	Wiedermann	FMP KU Bratislava
Štědrý	ICS AS CR	Wiedermann	FMP CU Prague
Vovsová	FMP CU Prague	Wiedermann	FMP CU Prague
Strupl	FMP CU Prague	Wiedermann	FMP CU Prague
Beran	ICS AS CR	Novák	UCT Prague
Nikolič	FEE CTU	Novák	FEE CTU
Žáček	FEE CTU	Novák	FEE CTU
Dvořák	ICS AS CR	Nedoma	FMP CU Prague
Kestřánek	ICS AS CR	Nedoma	FNSPE Prague
Fadljevič	ICS AS CR	Plášil	FMP CU Prague
Kleindienst	ICS AS CR	Plášil	FMP CU Prague
Drkošová	ICS AS CR	Strakoš	FNSPE Prague
Rozložník	ICS AS CR	Strakoš	FNSPE Prague
Švejda	ICS AS CR	Hájek	FMP CU Prague
Černovský	FSV CTU	Kramosil	FEE CTU Prague
Žák P.	ICS AS CR	Kufudaki	FMP CU Prague
Neruda	ICS AS CR	Kůrková	FMP CU Prague
Matějka	FNSPI CTU	Pelikán	FNSPE CTU Prague
Valach	MI Prague	Řízek	ICS AS CR
Pech	PhI AS CR	Šebesta	ICS AS CR
Štefek	ICS AS CR	Zvárová	FMP CU Prague
Zapletal	FMP CU Prague	Šíma	FMP CU Prague
Vojáček	ICS AS CR	Hořejš	FMP CU Prague
Sláma	ICS AS CR	Procházka	UCT Prague

12.5 Pedagogical activities in 1995

12.5.1 List of Semestral Lectures in Summer Semester

Name	*University*	*Hours*	*Topic*
Fiedler	FNSPE CTU Prague	2+0	Theory of matrices
Hájek	TU Vienna	2+0	Foundations of logics
Hakl	FNSPE CTU Prague	0+2	Basic course on linear algebra
Hamata	FEE CTU Prague	3+0	Diploma seminar
Jiřina	FEE CTU Prague	2+0	Neural networks and neurocomputers
Klán	Univ. Pardubice	3+0	Automatic control theory - lecture
Klán	Univ. Pardubice	0+2	Automatic control theory - seminar
Klán	Univ. Pardubice	0+3	Automatic control theory - laboratory
Klán	Univ. Pardubice	2+0	Information engineering
Kramosil	FEE CTU Prague	2+0	Probabilistic algorithms
Nedoma	WBU Plzeň	1+0	Problems of mathematical modelling in biomechanics and geodynamics
Novák	MIHE CTU Prague	2+0	Foundations of artificial neural networks
Rozložník	FNSPE CTU Prague	0+2	Linear algebra and geometry
Savický	FP CU Prague	2+0	Computing complexity
Savický	FP CU Prague	0+2	Use of computers
Šebesta	FNSPE CTU Prague	2+0	Parallel architectures and their programming
Šíma	FMP CU Prague	2+0	Theoretical issues of neural networks
Šíma	FMP CU Prague	0+2	Programming seminar
Šíma	FMP CU Prague	0+6	Disk sorting algorithms - software project
Štědrý	FMP CU Prague	2+0	Text processing - lecture
Štědrý	FMP CU Prague	0+2	Text processing - seminar
Štuller	FNSPE CTU Prague	4+0	Database systems
Tůma	FNSPE CTU Prague	2+0	Sparse matrices
Wiedermann	FMP CU Prague	2+0	Models of parallel and distributed computers
Wiedermann	FMP CU Prague	0+2	Hora informaticae seminar

12.5.2 List of Semestral Lectures in Winter Semester

Name	*University*	*Hours*	*Topic*
Drkošová	FNSPE CTU Prague	2+0	Advanced numerical linear algebra
Fiedler	FNSPE CTU Prague	2+0	Theory of matrices
Hájek	FMP CU Prague	2+0	Mathematical logic
Hájek	FNSPE CTU Prague	2+0	Reasoning under uncertainty and vagueness
Klán	Univ. Pardubice	2+0	Automatic control theory
Klán	Univ. Pardubice	2+0	Information engineering
Kleindienst	FNSPE CTU Prague	2+0	Operating systems
Nedoma	WBU Plzeň	1+0	Problems of mathematical modelling in biomechanics and geodynamics
Novák	MIHE CTU Prague	2+0	Advanced theory and applications of artificial neural networks
Savický	FP CU Prague	2+0	Formal languages and automata
Savický	FP CU Prague	0+4	Basic computer course
Šíma	FMP CU Prague	2+0	Theoretical issues of neural networks
Šíma	FMP CU Prague	0+2	Programming seminar
Šíma	FMP CU Prague	0+6	Disk sorting algorithms - software project
Štědrý	FMP CU Prague	2+0	Text processing - lecture
Štědrý	FMP CU Prague	0+2	Text processing - seminar
Tůma	FNSPE CTU Prague	2+0	Numerical software
Wiedermann	FMP CU Prague	2+0	Models of parallel and distributed computers
Wiedermann	FMP CU Prague	0+2	Hora informaticae seminar

12.5.3 Diploma Works in 1995

Student	*University*	*Advisor*	*Theme*
Harad	PUE Prague	Pecen	Application of probabilistic and causal networks in medicine
Hrinko	FMP CU Prague	Kleindienst	COBRA lifecycle service
Koubková	FMP CU Prague	Lukšan	Interior point methods for linear and quadratic programming problems
Végh	FNSPE CTU Prague	Hakl	Conditions of univalence of threelayer neural net
Hrušková	FAS WBU Plzeň	Nedoma	Mathematical modelling of a function of a hip joint in a 3D approximation
Cobanová	FAS WBU Plzeň	Nedoma	Numerical modelling of a fracture of the femur in a 3D approximation
Lukeš	FMP CU Prague	Nedoma	Numerical solution of 2D parabolic equations for the quasi-steady-state electromagnetic field
Baštová	FMP CU Prague	Nedoma	Numerical solution of nonlinear string equation
Novický	FMP CU Prague	Nedoma	Numerical solution of the 2D dual contact problem in elasticity
Krejčí	FMP CU Prague	Nedoma	Graphical pre- and post-processing for FEM
Krauz	FMP CU Prague	Nedoma	Numerical solution of 2D magnetodynamic equation
Mazný	FMP CU Prague	Šíma	Integrating rule-based and neural approaches to the expert system design
Červenka	FMP CU Prague	Šíma	A constructive learning of multi-layered neural networks
Franěk	FNSPE CTU Prague	Pelikán	Analysis of nonlinear dependences in time series
Pivka	FNSPE CTU Prague	Pelikán	Nonlinear prediction of financial time series
Jedličková	UCT Prague	Pelikán	Evaluation of time series prediction in real life
Svačina	FEE CTU Prague	Fabián	Criterium of entropy minimum for neural networks

12.6 Institute Library

The Institute library had on 31st December 1995 in its funds 8 268 bibliographical units and 87 titles of journals.

12.6.1 The List of Incoming Journals in the Institute Library in the Year 1995 (Purchase and Donation)

1. Communication of the ACM, USA (since 1995)
2. Parallel Computing, Holland (since 1986)
3. ACM Transactions on Database Systems, USA (since 1984)
4. ACM Transactions on Mathematical Software, USA (since 1977)
5. Advances in Computational Mathematics, Holland (since 1995)
6. Numerische Mathematik, Germany (since 1986), *Donation*
7. BIT, Sweden (since 1995)
8. BYTE, USA (since 1993)
9. Fuzzy Sets and Systems, Holland (since 1993)
10. International Journal of Approximate Reasoning, Holland (since 1992)
11. Expert Systems with Applications, USA (since 1990)
12. Neural Networks, USA (since 1989), *Donation*
13. Neural Computation, USA (since 1990)
14. International Journal of Neural Systems, GB (since 1991)
15. Neurocomputing, Holland (since 1992)
16. Neural Processing Letters, Belgium (since 1995)
17. Neural Network World, CR (since 1991), *Donation*
18. International Journal of Circuit Theory and Applications, GB (since 1972), *Donation*
19. Hewlett-Packard Journal, USA (irregularly), *Donation*
20. Scientific American, USA (since 1995)
21. La Recherche, France (since 1991), *Donation*
22. Aplikace matematiky, CR (since 1969)
23. Kybernetika, CR (since 1977)
24. Computers and Artificial Intelligence (Počítače a umelá inteligencia), SR (since 1982)
25. Computer Echo, CR (since 1990)
26. Computer World, CR (since 1990)
27. PC World, CR (since 1991)
28. CHIP, CR (since 1991)
29. LAN COM, CR (since 1992)
30. Softwarové noviny, CR (since 1990)
31. Elektronika, CR (since 1987)
32. Business Central Europe, Austria (since 1994)

12.7 Institute Budget

Year	*1991*	*1992*	*1993*	*1994*	*1995*
Basic budget (from AS CR)	11,659	12,023	11,124	13,176	13,487
Final budget (with grants & cooperations)	15,860	16,507	16,201	19,875	24,555
Labour costs	7,346	7,656	7,873	9,055	11,111
Durable equipments	2,650	3,975	1,084	1,810	2,847

Note : Amounts are in thousands of Kč.