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**Report on the scientific activity of the
MTA SZTAKI
in 2009**

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I. Main tasks of the research institute in 2009

Information science is, at least, Janus-faced. Simultaneously can be observed, on the one hand, hardware of almost intangible complexity and efficiency (e.g., chips of several thousands of processors), complex distributed hardware and software systems due to the world wide web, the potential solvability of problems uncontrollable till now, and on the other hand, the rapid shift of the new tools in computer science towards bulk-products.

The institute, certainly, keeps track of the solution solely fruitful in the long run: mathematical and engineering biased basic research activity is strongly emphasized, since the ability demonstrated several times can be retained exclusively by the above effort, according to which, SZTAKI is able, almost immediately, to respond, often in a proactive way as well, to the novel challenges emerging almost day by day in information sciences. Underlining just some of these: sensing computers and remote presence, man-machine relations of new type, modelling, control, supervision and diagnostics of complex systems, distributed computing architectures, grid-systems, fast networks and their security issues, mobile communication, new WWW-technologies, informatics of globalized firms, but one could go on enumerating. In certain territories the accelerated world requires research attitude, organisation often different from those accustomed to in the past, and, based on the same, other type of evaluations of the results.

Informatics-based developments applicable in Hungary and also abroad, furthermore the high-level consulting activity at the institute are built on *results in basic research of international standard*, aiming at a center of excellence which ensures attractive themes and circumstances for talented young Ph.D. students starting their career.

The complex activity demands clusters of researchers of adequate size, composition and knowledge. In 2009 the management aimed to inspire the researchers to form units capable of spanning more substantial and wider tasks, by integrating the themes and suitably supporting the different activities, in accordance with their character. On the other hand, a natural way of creating research community suitable for major tasks is the establishment of national and international co-operations, consortiums, virtual laboratories, etc, ensuring their operation.

One must remember, at the same time, that quite often the home market is still not matured enough for accepting the latest results, and on the other hand, it is rather small in size. Consequently, the institute must necessarily consider international scale also with regard to the application of their results.

From among their traditional themes of great importance, successful at present as well, special emphasis is put on the following fields, in agreement with the European and inland research priorities:

- *Cellular wave computing and sensory computing systems, bionics*
- *Electronic vehicles and vehicle control.*
- *Complex systems (e.g., production networks) consisting of autonomous, co-operating units of individual intelligence.*
- *Informatics- and automation-related problems of traditional and renewable energy sources.*
- *Algorithmic problems of new computers of several thousands of processors.*
- *Distributed (e.g., grid) computing structures.*
- *The next generations of internet; mobile communication; data mining and information-retrieval.*

The areas dealt with at the institute can be grouped, according to the partially overlapping fields, as follows: 1.) *Mathematics and computer science*, 2.) *Information sciences*, 3.) *Automated control systems*. The aim is to integrate the results achieved in engineering, mathematics and computer science in problem-solving and system-development. The bridge between theoretical basic research, pilot model developments, applications and system-integrations is maintained through the traditional open intellectual substance of the institute.

The major results of the institute attained in 2009 will be enumerated according to the above threefold arrangement, also in the following part.

II. Outstanding research and other results, and their socio-economic impact in 2009

Mathematics and computer science

In the areas of mathematics and computer science, themes that can contribute to solving the still open problems got in the front of information sciences and automation are dealt with emphatically. Therefore, they concentrate, e.g., on modelling, analysing complex systems, including, for example, extremal graphs, data mining, stochastic systems, operations research, algebraic research, and biology-inspired computer science.

In the area of *symbolic computation* they have worked on structural properties of zero dimensional systems of polynomial equations. They studied the properties of the roots, which can be computed by global methods, without the need of actually calculating the roots themselves. Results of this type may be particularly important in the case when we have a system which is close to one with multiple roots. The systems of equations obtained from measurements often have this character. They have studied some combinatorial structures which are related to deterministic factoring algorithms for polynomials over finite fields. These structures can be interpreted as higher dimensional analogues of association schemes. The results obtained about these structures lead to improved factoring algorithms. They have worked on coverings of geometric structures with the exception of a single point. Some structural results have been obtained for these coverings which are similar to the Brouwer-Schrijver theorem for affine planes. They also considered linear space versions of theorems on set families. In this line of inquiry, with several co-authors, they have obtained a q -analogue of the Hilton-Milner Theorem.

In the field of *data mining* and *Web-search* the international reputation of the institute is raised by their outstanding ranking in the very strict competition titled *Knowledge Discovery and Data Mining (KDD) Cup 2009*. Also related to *Web Spam* filtering, the institute got into the circle of one of the strongest research institutes world-wide. The international acknowledgement of research is reflected in the fact that content related quality-forecast, provided for Internet archives, was defined as Discovery Challenge task of ECML/PKDD 2010 conference, and MTA SZTAKI was called upon to organize the conference.

Stochastic systems, financial mathematics: They made further advance in the statistical analysis of continuous time linear stochastic systems by establishing an accurate off-line approximation of the recursive maximum likelihood (RML) estimator. The convergence and asymptotic efficiency of the estimated parameter of ARX system under a certainty equivalence adaptive input design has been established. In the area of hidden Markov models a uniform law of large numbers for the log-likelihood function of a quantized Gaussian AR(1) system has been established. A significant improvement in the efficiency of a randomized EM method for establishing a Gaussian linear regression under quantization has been achieved. In

financial mathematics they established the viability of GARCH modelling to detect structural changes in financial markets. The micro-mechanics of arbitrage was studied, with surprising results on the prevention and the possibility of arbitrage.

Operations research: A local search algorithm was proposed for the least squares problem of pair wise comparison (PC) matrices. The eigenvector method was extended for incomplete PC matrices, thus the estimation and quantification of the preferences of the decision makers are possible from significantly less number of PCs, too. The problem of optimization subject to orthonormality constraints was transcribed as a d.c. (difference of convex) programming problem, exploiting the possibility of representing the functions as difference of convex functions. A branch-and-bound method was proposed for solving the d.c. programming problem. An important class of continuous optimization is quadratically constrained convex problems which can be handled efficiently by interior point methods in large-scale cases. New techniques were presented that improve the efficiency of interior point methods when solving quadratically constrained large-scale problems. The progress in efficiency was confirmed by numerical experiments.

Important results were attained in their research in *biology-inspired computer science*, in the field of membrane computing belonging to the theory of biology-based computing, determining model classes of minimum size and functionality, but of computing power equal to the same of Turing machines. Their further essential result is determining the sub-classes of maximum computing power of generalized communicating membrane computer systems.

Combinatorial computer science, graph theory: Click-colouring problem was solved in claw-free graphs of small degree, both in theoretical and algorithmic sense. Given certain weights, estimations of lower and upper bounds were provided regarding the sum-free sets. Optimal algorithms were given for partitioning interval-systems under restricting conditions. Regarding the domination of set-systems and their complements, strong inequalities were proved.

Certain major areas overlap, both from thematic and personnel points of view, in the area of mathematics-computer science at the institute, the number of humans classified as researchers is 42 (see Act on Civil Service) and 22 without qualification in research. The estimated institute input was about 604MHUF, the 37% of which were grant resource. R&D tasks are carried out in co-operation with, among other partners, T-Online, Fornax, Econet.hu, Hungarian Telekom, AEGON, and national small- and medium enterprises.

Informatics

They traditionally have pioneering role in the field of cellular and sensory wave computing systems where, above algorithmic research, they contribute to the circuit-design of the new architectures, which is rather exceptional in our environment. Special emphasis is laid on research of distributed computing systems, new generation web development, furthermore, on the introduction of their theoretical results, putting those in real life applications.

The main results in the field of *cellular and sensory wave computing* in 2009 are as follows:

- New theoretical results in the area of spatio-temporal dynamical problems in the field of kilo-processor array computing and in the implementation limits of virtual and physical cellular machines:
 - New qualitative phenomena in 1D Cellular Automaton for Period 1, Period 3, and Period 6 rules;
 - New ways of computer assisted proofs in nonlinear dynamics;

- New algorithmic solutions for homogeneous big virtual and small physical machines were achieved in 4 different ways.
- Tera-Hz sensing and processing architectures were analysed and circuits were designed.
- The chip design of core circuits of the 3D VISCUBE architecture was completed to the vertical integrated 3 layer technology of MIT Lincoln Laboratory. The simulation and the test environment to the chip were also completed.
- In the FPGA model, the Virtual and Physical Cellular Architecture was identified and a special design method (via FIFOs) has been used to provide local control strategy. Principles regarding distributed, data driven local control of kilo-processor architectures were developed.
- The first part of *digital holographic microscope (DHM)* project was completed for quality control of drinking water and also the first tests on water samples were carried out. 3D DHMs of high resolution and enhanced field of view capture information from a volume of 1000 times larger by a single holographic image with the same size of resolution than the traditional microscopes. For hydro-biological applications the system is extended with a comprehensive morphological microbiological database which contains the injurious living organisms of indicator feature (alga, vermin, etc.) in potable water sources, water bodies. The software system including pattern recognition, classification, is built on this database. The manual microscopic examinations done only periodically at present are replaced by automatic, continuous inspection, which minimizes the water-based health hazard of biological origin.

Analysis of distributed events: A system has been developed for content-based video retrieval, having a complete tool chain for the annotation, indexing, retrieval and visualization of imported data with a modular infrastructure for descriptor handling, with an easy-to-use query-annotation-result visualization module in a web-based search interface. A continuous hidden Markov model has been developed for the analysis of urban traffic and to signal unusual traffic situations in a novel multilevel method; it learns the rhythm of the traffic in selected regions, while a global discrete model learns the interconnection among several regions. An automated procedure was provided for recognizing tiny objects, and detecting their unusual motions in aerial photos.

Research on Grid systems was mainly pursued in the framework of EU projects: EU FP6: CancerGrid, EU FP7: EDGeS (the coordinator of EDGeS is MTA SZTAKI), EGEE-III, ETICS-II, SEE-GRID-SCI, S-CUBE. Some results of the related comprehensive Grid research are as follows:

- Through the S-CUBE Network of Excellence MTA SZTAKI became a member of a software technology developer community having a Europe-wide reputation in this field. One of the outstanding results is the definition of an architecture that is capable of supporting SLA-based virtualized services integrating three major areas: SLA negotiation, broker and meta-broker technology and dynamic service deployment.
- Within the framework of the EDGeS project the institute has further developed the 3G Bridge (Generic Grid-Grid Bridge) service that enables the integration of any service grids with any desktop grids. The 3G Bridge was extended with a BES plugin that enables the direct usage of the 3G Bridge service for every grid system that supports the standard BES interface as recommended by the Open Grid Forum standardization body. The usability of the 3G Bridge is well demonstrated by the EELA-2 project (a joint project of the EU and Latin-America) where they integrated the European gLite and the Brazil OurGrid systems via the 3G Bridge service.

- The ETH Zürich research institute selected P-GRADE portal as the science gateway for SwissGrid. P-GRADE has been developed by SZTAKI in the recent years and by now it is intensively used in many countries of Europe as the science gateway of their national Grid system. As part of the collaboration with ETH Zürich the institute solved the integration of P-GRADE portal with local clusters (like PBS and LSF clusters) as well as with the ARC middleware that is used in SwissGrid. The joint work with MIMOS has also been continued in order to adapt P-GRADE portal for Grid Malaysia. In this collaboration the institute integrated P-GRADE with the grid accounting system developed in EGEE and extended P-GRADE with SLA support. These are unique features not available in other grid portals developed in Europe.

In the field of *distributed systems* they concentrated on web-based software technologies and experimental developments in 2009, such as digital library systems, groupware and ambient intelligence.

- Their R&D project of 3 years, common with the Japanese large enterprise *RICOH*, was closed with outstanding success. In course of its last year
 - New generation information-sharing systems (e.g., alternatives of e-correspondence) was developed, mainly for people with jobs in the field of creative knowledge-handling, who – working in several contexts in parallel – manage information greatly different from each other.
 - Technologies of context awareness and services of real-time, web-based group work assisting systems were integrated.
- In the frame of international EU FP6 project *BREIN (Business objective driven reliable and intelligent Grids for real business)* basic- and applied research results were attained in the fields of ontology building, developing service integration model and methodology. The SLA (service level agreement) management of web services, monitoring of agent-technology based grid/cloud services and source-adapt were solved primarily by help of semantic web-technologies.

The *Hungarian Bureau of World Wide Web Consortium* has been located in MTA SZTAKI since September, 2002. They carry on spreading the communication standards of Internet Web in Hungary and organizing scientific conferences and workshops related to the field.

Semantic integration: A new information-integration technology, based on virtual distributed database management, comprising concept-level as well, was developed, and they participated in experimental applications. The integration technology of web services in this environment was elaborated and applied in integrating digital library sources by using OpenURL technology.

The *Pocket Guide tourist software* was developed partially based on *eLearning* techniques. The product was widely recognized in Hungary (*Grand Prix for Hungarian Products, Special Prize of export- development by ITD Hungary Zrt., The Most Innovative Product" by INNOSTART National Business and Innovation Center Foundation.*). This innovative tool successfully integrates the functions of a city-guide, the audio-guide and navigation systems enabling tourists to have city-tours without special pre-studies.

In the field of *library informatics* two of their program-packages were further developed. *KisTéka* was developed for smaller libraries, and *HunTéka* – having the award of *Grand Prix for Hungarian Products* – for libraries of medium- and larger sizes. The ASP (Application Service Provider) or as it is called nowadays, *cloud-computing* version of the programs are

widely used at smaller libraries. HunTéka was introduced in 2009 in key educational institutions such as the Central Library of Semmelweis University or the Library of the University of Miskolc. As a whole, more than 245 libraries use the systems, in Hungary and abroad.

Marketing informatics: In the frame of a co-operation conducted from 2000 with an American firm, *Global Market Insite (GMI)*, a WEB-based NET-MR program-system using sophisticated mathematical methods and algorithms has been developed. The program is used by hundreds of marketing firms in 5 continents. Above the development, the institute takes share in supervising the program-system, running on American servers. The leading market and opinion research institute in Hungary is *Ipsos Zrt.* For them a software-system named *MédiaNavigátor 3 (MN3)* has been developed in a project of almost one and a half years.

Their activity is similarly highlighted in developments related to *network security systems and supervision*. In a project supported also financially by the Council of Internet Servicing Enterprises, the team, named *Hun-CERT (Computer Emergency Response Team)* performs network security tasks. (In 2009 they provided assistance in more than 150 network security incidents against the Hungarian network reported from abroad.)

The number of researchers in the area of informatics in a broader sense is about 40 at the institute (and further 23 employees without qualification in research.) The estimated institute input was 610MHUF, the 44% of which were grant resource. The economic exploitation and the exploitation capacity, according to broader areas, can be summarized as follows:

- *Cellular and sensory wave computing:* the fields of potential application (medical, industrial, space research, military, etc) are manifold.
- *Grid systems:* The institute takes part in application projects of different trends, most important in Europe and in Hungary. Also the utilization in *Malaysia* and the *Republic of Kazakhstan* must be emphasized, as well as the fact that *ETH Zürich* research institute chose P-GADE grid portal as Swissgrid user platform. In Hungarian relations R&D in co-operation with Econet NyRt and e-Group Kft is significant in the field of table grids and network services.
- *Distributed systems:* The first period of 3 years of R&D project SZTAKI -RICOH, mentioned earlier, is one of the success-stories of the institute. The extreme efficiency is shown by the 6 applications for common patents (4 in Japan, 2 in the USA)
- *Marketing informatics:* The know-how from GMI – Ipsos Zrt. co-operation is exploited in the development contracts with market and opinion research firms: Leyhausen GmbH (Germany), BrainJuicer (GB) and EMI (USA).
- *Analysis of distributed events:* Their video surveillance and retrieval systems and procedures to compare aerial photos contribute to increasing the safety of inhabited and natural environments.
- *Pocket Guide tourist-software:* The innovation awards won foretell that the possible sale of the product promises heavy economic benefit.
- In *library informatics* the product-scale of the institute is prominently successful, regarding the more than 245 users.

Utilizations are managed partly by the institute, partly by small enterprises in informatics field, based on contracts. The introduction of informatics-based solutions is associated with increasing the quality of life and intensifying competitiveness in all the fields enumerated in the detailed description.

Automated control systems

The theoretical and methodical backgrounds of automated control systems are provided by *systems and control theory*. Their R&D activity in continuous and discrete systems is grounded in their basic-research. Their results are exploited primarily by the energy- and vehicle industries, furthermore, by production-related firms and the networks of those, but their applications are successful, e.g., in medical spheres as well.

In the field of systems and control theory the following results achieved in 2009 are first to mention:

- Regarding nonlinear system theory, the invariant subspace concept of linear time invariant (LTI) systems was extended to linear parameter varying (LPV) and quasi linear parameter varying (qLPV) frameworks. A method was given to the dynamical inversion based controller design of certain qLPV systems. The results were successfully applied in the control systems of nuclear power plants and in the control design task related to vehicle system dynamics. New results were obtained concerning the controllability of specific classes of switching systems. The relation of controllability to stabilizability for these systems was also clarified.
- By the dualization of the design algorithms related to the LPV and qLPV classes significant results were obtained for filtering and detection problems, too.
- Progress in the mathematical theory and modelling of signals and systems based on non-standard orthogonal bases has been made in an attempt to develop new methods and applications such as wavelet processing. The achievements have significant contribution to the extension of advanced image processing in medical imaging.
- There have been activities in the establishment of a new research laboratory dealing with the control and navigation of unmanned land and aerial vehicles (UAVs). The research program of the laboratory is laid down in close cooperation with the Aerospace Department of the University of Minnesota. The research is partially supported by US grants.
- The principles of *programming robots through the internet* were elaborated. Accordingly, the base of system VirCa (Virtual Robot Collaboration Area) that can be regarded the first application of 3D Internet was completed. It serves as the core of the world-net named iSpace LaboratoryNetwork, initiated by the institute, and founded in co-operation of almost 15 institutes of high rank. VIRCA uses de facto standards such as RT Middleware and the Internet Communications Engine (ICE), together with TP model transformation based system control methods, as well as cognitive info-communication (the implementation of the latter elements has recently begun).
- The research activity in project TRUCKDAS provides new results in the field of intelligent vehicle control systems. The main directions of research include the design of fault-tolerant vehicle architectures, the control of coordinated platoon systems and intelligent unmanned vehicle systems, the design of sensor fusion and network-based communication solutions and the integration of active vehicle control components of the suspension, steering and braking systems. Control design methods are developed for a platoon system in order to achieve two main performance goals, i.e., to improve safety compared to that of the individual transport and to reduce the total fuel consumption.
- In project CORNEA new results were attained in the elaboration of new, high precision topographic examination methods of cornea, applicable in the practice of clinical ophthalmology. The sample system proving the accuracy and reliability of the method has been completed. The co-operation with Semmelweis University, Ophthalmology

Clinic, in the long run, is of vital importance also in the future in the further development of the measurement principle and experimental method, clinical tests.

- Based on the scientific relations the institute has earned in earlier activities with key players of space and avionic system and technology developers, companies, universities and research institutions, the research project in FP7 Framework, code-named *ADDSAFE*, came into existence by the support of 8 European partners. The project aims to develop advanced methods and technologies for the detection of faults and system malfunctions in airplane structures and onboard control systems in an attempt to enhance flight safety and airplane reliability, significantly.

From among the 2009 results in *process control research*, the following ones are to be emphasized:

- An optimization-based procedure was elaborated, which is suitable for determining the realization of reaction-kinetical networks, subject to different conditions, as an important category of nonlinear positive systems. By this procedure the realization independent dynamic structural properties (e.g., stability) of the above category can be determined easily.
- By applying the theoretical results attained in the field of modelling and control of nonlinear process systems, the simplified dynamic model of the primary circuit of Pask Nuclear Power Plant was further developed, which, now describes the temperature-dependent reactivity and xenon poisoning phenomena of the plant. By help of data measured during the load change transients between day and night periods, parameter estimation, too, was done. This model can be the base of the joint re-design (reconstruction) of the primary circuit controls.

In the field of *geometric modelling and computer vision* the following results are to be stressed:

- A new precise method was developed for multiview variational 3D reconstruction.
- New video based perspective autocalibration method was developed that calculates camera parameters and obtains 3D reconstruction.
- It was shown that bundle adjustment could be efficiently applied to photometric stereo.
- A method was developed for the detection and correction of irregularities of engineering surfaces.
- A new type of knee prosthesis was designed by using novel geometrical principles and the prototype was manufactured.

In the field of *computer integrated manufacturing* they concentrated mainly on the relationship of extended/virtual enterprises and “extended products”, furthermore, “life-cycle engineering” and “service engineering” taking also environmental criteria and social expectations into consideration. Their research results derive from important projects:

- In project eMULT EU they participated in the development of a multi-agent software system to support car dismantling and used part commercialization SMEs. They implemented and introduced an experimental multi-agent network to serve some SMEs.
- In EU project SCULPTOR control algorithms were developed to support completely novel (dieless) sheet forming.

The main objective of research in the field of *engineering and business intelligence* is to research and elaborate techniques applicable for handling *complex* production and business systems working in an *uncertain, changing* environment, in a real-time manner, with special

emphasis on *informatics, operation research* and *knowledge-based* approaches, balancing the aspects of *optimisation, autonomy and cooperation*. Their major results in 2009 are:

- By joint application of mixed integer programming and taboo search, they provided a solution regarding *production scheduling* problems of *large-scale industrial practice*.
- The tools of *mathematical* and *constraint programming* were widened with general methods particularly suitable for solving mixed integer linear and hierarchical (bilevel) problems and for optimization based on criteria of sum-type. New results were obtained in applying bilevel programming for scheduling tasks.
- *Stochastic programming* method of rolling horizon of flexible production systems design was developed.
- In the field of *production networks* co-ordination mechanisms were developed for sharing risks due to uncertainties in demands.
- A *complexity model* of production networks was elaborated in the framework of an international co-operation.
- Informatics solutions were elaborated which make it possible for SMEs to use *active identifiers* (e.g., RFIDs) in production-logistics systems for ensuring visibility both within and beyond the organisational borders.
- New approaches were developed for the diagnostics of wind turbines (and their farms) and scheduling repairs and maintenance.

Here, the R&D cooperation of the SZTAKI and *HITACHI* is to be stressed, in the frame of which colleagues from the institute take part in the development of the production control systems of the Japanese firm's factories in California and Japan, producing hard discs, in the field of *adaptive forecast of production system behaviour*. Based on the model elaborated by the SZTAKI and the system built on it in co-operation with *HITACHI*, a joint application for patent took place in Japan. The success of the project is proved by the plan of *HITACHI* according to which they intend to adapt the results in their other factories, in cooperation with the SZTAKI.

Another outstanding success of the scientists in the area is that in 2009 a decision was made according to which – based on German initiative – the “*Fraunhofer-SZTAKI Project Center for Production Management and Informatics*” will start operation in 2010, within the frames of the institute. The areas already agreed upon (production planning and –optimization, design and management of co-operative production logistics structures, informatics of plants and servicing firms) belonging to the targeted main line of the Project Center (digital, real time firms and their networks) make it unquestionable that the activity of the Project Center will be tightly connected to the great part of the economic and related R&D priorities in Hungary.

The number of researchers in the area of automated control systems is about 49 at the institute (and further 25 employees without qualification in research.) The estimated institute input was 744MHUF, the 51% of which were grant resource. The economic exploitation and the exploitation capacity can be summarized as follows:

- *Systems- and control theory*: Paks Nuclear Power Plant is to be referred to as the outstanding partner of the institute. It is of vital importance that application results in Hungary were attained based on high-level theoretical work in the field, and the know-how is available which contributes to the power plant's safer and more efficient operation, ensuring reducing dependence of foreign partners. The institute takes part in control, technical expertise activity related to the life-cycle prolongation of the 4 available blocks of the power plant. Their fundamental task is the examination of the

process control systems of the plant with respect to the prolongation of the life-cycle and the requirements of safe and economic operation. In one of the prominent fields of the expert work, they co-operate in the project aiming at preventing events endangering the computer- data and network-security of the plant's process control system.

Research in intelligent vehicle-control is highly important from the points of view of the national automotive industry and logistics of gaining importance. With regard to future, their participation in project ADDSAFE FP7 started in conformity with the real development requirements of AIRBUS is of fundamental importance.

- *Informatics of engineering and business intelligence, computer integrated production, digital enterprises, production networks:* The systems realized, proved by everyday use, are not specialized for certain branches of industry, they can be utilized at several national firms, either installed, or as an electronic service. Major firms in Hungary applying the R&D results: GE Hungary Zrt, Paks Nuclear Power Plant Zrt, AUDI Motor Hungaria Kft, Robert Bosch Kft, Knorr Bremse Braking Systems Ltd. In the frame of European research projects they work with leading industrial enterprises (Bosch, BMW, VW, Siemens, Continental automotive, Finnish PTT). Also in this respect is to be stressed the R&D co-operation with Hitachi Production Engineering Research Laboratory (PERL) and the establishment of “*Fraunhofer-SZTAKI Project Center for Production Management and Informatics*”.

III. Presentation of national and international relations

International relations

Worthily of their distinguished *Centre of Excellence* title granted by the EU, the institute played a role in the V. and VI. Frame Projects of the EU, participating in more than 30 projects, and networks of excellence, each, providing project-manager tasks as well. They participate in 13 winning projects of the EU VII. Frame Project (considering the projects awarded up to the end of 2009, only), in several cases they act as consortium leaders. In the frame of the programs they work with the most outstanding European firms in the fields of information sciences, energy, car- and aircraft production.

MTA SZTAKI – as the first institute from the region – has been a member of *ERCIM* (*European Research Consortium for Informatics and Mathematics*) for 16 years. This organization was established for promoting European scientific co-operation in information technology. The bureau of global WWW Consortium in Europe was taken charge of by ERCIM, and the office of WWW Consortium in Hungary is located in MTA SZTAKI.

In accordance with the efforts aiming at the development of the European research area, the institute carries on establishing and operating *international virtual institutes and laboratories*. As a result of several-year-long preparatory work and research co-operation, in 2009 a decision was made, according to which – based on German initiative – the “*Fraunhofer-SZTAKI Project Center for Production Management and Informatics*” will start operation in 2010, within the frames of the institute. The parties' R&D and consulting potential partially overlapping, partially complementing each other, provide unique opportunity both for doing R&D of required efficiency and for adapting the results in real life applications in Hungary and abroad alike. It must be admitted that the expansive recognition of Fraunhofer Institute renders help to MTA SZTAKI – and through the Project Center to other research institutes of the Academy, and universities as well – in forming connection with Central-European firms, particularly in German ownership, furthermore, in entering into R&D co-operation. The

establishment of the *Central European Grid Consortium*, aiming at the harmonization of Grid research and infrastructure developments in Central-European countries, was initiated also by the institute.

In the recent past of the institute R&D co-operations with the Japanese firms *RICOH* and *HITACHI* were uniquely successful. During three years, the former resulted in 6, the latter, during one year, 1 application(s) for a patent, common with the contracting partners, in the USA and Japan.

Researchers at the institute take part in the management and working groups of the most significant international scientific organizations (CIRP, IEEE, IFAC, IFIP, etc). Several of their colleagues are members of Editorial Boards of leading international journals.

Several researchers of the institute were invited to co-operate in the evolving of the main trends in the VII. Framework Programme, and to participate in the elaboration of the co-operation issues between the EU and the USA (National Science Foundation). Journeys in the frame of bilateral agreements, Hungarian Academy of Sciences, and the S&T relations are very advantageous, especially in basic research, therefore, researchers take these opportunities.

Participation in higher education in Hungary

Gradual and postgradual education is henceforward regarded at the institute as an important attribute of research activity, and an indispensable condition of future-shaping. Regular education is in progress at the following universities in Hungary: Budapest University of Technology and Economics (BME), Eötvös Loránd University (ELTE), Corvinus University of Budapest, University of Pannonia, University of Pécs, University of Miskolc, Pázmány Péter Catholic University (PPKE), Central European University (CEU). The form of co-operation is manifold: secondary or full-time employment of researchers, common chairs run at the institute, employment as the head of a department, co-operation in establishing information science faculties.

In the fields of electrical engineering-information sciences and biological sciences (particularly, of neurobiology), the *Hungarian Research Center in InfoBionics* is run by 6 research institutes of the Hungarian Academy of Sciences and 6 university research laboratories. Also the establishment of the *Hungarian Grid Competence Center* (MGKK) was initiated by the SZTAKI. Co-operating partners are: BME, ELTE and the National Information Infrastructure Development Institute (NIIFI), later KFKI Research Institute for Particle and Nuclear Physics (RMKI) joined.

As a sign of a many-year-long co-operation, in the frame of “*Regional University Knowledge Centers*”, the institute participates in the project *Advanced Vehicles and Vehicle Control Knowledge Center*, led by the BME. Similarly is outstanding the role of the institute in the National Office for Research and Technology (NKTH) project titled *Mobile Innovation Center*, headed also by the BME.

On the average, about 30 Ph.D. students do research at the institute, under the scientific supervision of leading researchers. Doctoral schools in Hungary have colleagues from the institute as collaborators in 25 cases, and as permanent foundation members in 5 cases.

Besides following the traditional educational methods, steps were taken towards the application of *multimedia tools* and *distance education*.

Major scientific events organized by the institute

The *European Control Conference* in 2009 (*ECC'09*), as an event of the conference-series by the EUCA (European Union Control Association) was organized this time in Budapest, by MTA SZTAKI, between 23-26. August, 2009. The ECC conference organized biyearly is the forum of highest rank in control sciences. The lectures held presented the most recent results in control theory and their industrial applications which are in the centre of interest world-wide. The most actual issues of the area were highlighted at the conference, such as the control of distributed systems, highly reliable autonomous systems, and their control problems. The high professional standard of the event was guaranteed by an international program committee of high professional reputation, and a traditionally high standard peer-review system. 8 plenary sessions were in the focus of the professional program and in further 24 invited sessions, selected specifically, presentations written by altogether 120 invited lecturers were made. The number of all the scientific contributions presented at the conference totalled up to 730. Lecturers represented 57 countries from 5 continents.

Nearly 700 researchers took part in the *Eighth International Conference on Autonomous Agents and Multiagent Systems (AAMAS)* held in Budapest, between 10-15. May, 2009. This conference-series started in 2002 by uniting the following three highly recognized conferences: The aim of the combined conference was to provide a unique forum highly acknowledged internationally, for research in autonomous agents and multi-agents from all theoretical and practical aspects.

IV. Brief evaluation of successful national and international grants

In 2009 considerably many EU-supported projects were started at the institute. In these projects they work, for the most part, with prominent universities, research institutes and, on several occasions, with firms of world-wide fame. Hereunder, besides some projects started in 2009, further running projects are presented, together with several, home-supported ones (with the names of the project-leaders from the SZTAKI in parentheses):

- **ADDSAFE**: *Advanced Fault Diagnosis for Safer Flight Guidance and Control* (Andras Edelmayer, FP7, 2009-11)

Recent airliner accident and incident statistics show that about 16% of the accidents between 1993 and 2007 can be attributed to Loss of Control In-flight (LOC-I), caused by a piloting mistake, technical malfunctions or unusual upsets due to external disturbances. LOC is intrinsically related to the guidance and control (G&C) system of the aircraft, and includes sensors and actuators faults. The early detection and localization of these faults is absolutely important, therefore. ADDSAFE tries to overcome this technological gap by facing the following two challenges: i) helping the scientific community to develop the best suited fault detection and diagnosis (FDD) methods capable of handling the real-world challenges raised by industry; and ii) ensuring acceptance and widespread use of these advanced theoretical methods by the aircraft industry. The overall aim of the project is to develop and apply model-based FDD methods for civil aircraft in order to increase aircraft safety and reduce development/maintenance costs. The use of these advanced FDD synthesis and tuning methods in conjunction with reliable software verification & validation (V&V) tools will also reduce the costs for development and certification.

- **TRUCKDAS**: *Innovation of distributed driver assistance systems for a commercial*

vehicles platform (Péter Gáspár, NKTH, 2009-11)

The TRUCKDAS project is led by Knorr-Bremse Braking Systems Ltd. with MTA SZTAKI, Advanced Vehicles and Vehicle Control Knowledge Center and the TRIGON Ltd as partners. The primary aim of the project is the research and development of active safety and driver assistance systems. In these systems the vehicle functions are achieved via intense communication amongst the individual intelligent components. With a view on this communication aspect, several tasks were identified to contribute to the safe operation of commercial vehicles. In the tasks of steering actuation and drive mechanism development steering torque and additional steering were used to create a practically applicable vehicle control. By the appropriate control of the drive mechanism, it is possible to achieve an adaptive cruise control and to establish effective collision mitigation. The project also included the development of a camera-based traffic lane departure warning system and of an automatic lane keeping assistant. By the same approach, an integrated steering and braking system for electronic stability control for cargo vehicles was also developed. Probably, the main contribution of the whole project is the method of platoon control, which relies on the fusion of signals coming from on-board sensors, on fast network-based communication solutions and on the integration of active vehicle control components situated on the individual vehicles. Another important aspect of the project is to decrease the number of related accidents, even under the demanding economic criteria and operating circumstances characteristic to the transport industry, by making use of the new driver assistance functions.

- **EOARD: Switching Systems: Controllability and Design.** (Air Force Office of Scientific Research, Air Force Material Command), (Zoltán Szabó, 2008-09)

The research investigated some controllability properties of hybrid systems, focusing on the controllability questions of bimodal linear systems. Conditions for controllability were given in matrix algebraic terms and the stabilizability problem was also investigated. The applicability of the theoretical results was demonstrated through practical control design examples, i.e., control of a High Speed Supercavitating Vehicle (HSVV).

- **EDGeS: Enabling Desktop Grids for e-Science** (Péter Kacsuk, FP7, 2008-09)

The objective of the project is to integrate the EGEE service grid with BOINC and XtremWeb desktop grids, and in this way, the establishment and operation of an extremely large grid infrastructure in which new, grand-challenge applications can be executed. This project is coordinated by the MTA SZTAKI.

- **S-CUBE: Software Services and Systems Network** (Péter Kacsuk, FP7, 2008-12)

The aim of the project is to investigate SOA and grid technologies, and particularly, their possible integration. The task of the institute is to do research on brokering, monitoring issues and virtualization. Based on these technologies, SZTAKI has to develop an automatic service for deployment service.

- **ETICS-2: eInfrastructure for Testing, Certification and Integration of Software – Phase 2** (Péter Kacsuk, FP7, 2008-10)

The goal of this project, led by the CERN, is to develop a comprehensive testing methodology and technology for grid middleware and complex software systems. Part of the work is the establishment of a testing infrastructure that makes the fast and efficient testing and certification of various grid services possible. The task of the

institute is the further development of WS-PGRADE portal to provide high-level testing support.

- **EGEE-III: Enabling Grids for E-Science-III (EGEE-III)** (Péter Kacsuk, FP7, 2008-10)

This project is a continuation of project EGEE-II. The role of SZTAKI has been significantly increased in EGEE-III compared to EGEE-II. Meanwhile, SZTAKI continued the training activity started in EGEE-II. A new service called as GASuC (Grid Application Support Center) (<http://www.lpds.sztaki.hu/gasuc/>) was also established. Five other similar centres have been established in EGEE-III, and SZTAKI coordinates the work of these centres.

- **SEE-GRID-SCI: SEE-GRID eInfrastructure for regional eScience** (Péter Kacsuk, FP7, 2008-10)

This project is the continuation of project SEE-GRID-2. The role of SZTAKI in SEE-GRID-SCI is the development of meteorology and seismology grid applications, as well as to support grid training activities.

- **Supporting new generation WEB services and applications by secure, business-oriented GRID platform** (Péter Kacsuk, NTP, 2009-11)

The goal of this NTP project is merging the benefits of WEB2 services and desktop grid systems as well as to adapt the results of FP7 EDGeS project for Hungarian applications and grid systems. Special attention is paid in the project to the business exploitation of research achievements.

- **Energy efficiency in large scale distributed systems** (Péter Kacsuk, Róbert Lovas, COST, 2009-13)

This COST action deals with research on alternative solutions for increasing energy efficiency in the field of large-scale computing systems, since those systems integrate more and more computing and storage resources and hence, their energy consumption grows exponentially. Within the COST action SZTAKI further develops its grid application development tools and brokering solutions for supporting technologies that are needed for reducing energy consumption.

- **AC/DC Five Days Car projekt** (Váncza József, Monostori László, FP7, 2007-10)

The AC/DC project is aimed at increasing the competitiveness of European car manufacturers by establishing and running a production network that is able to meet demand for customized cars within extremely short, even five-day-long delivery time. This challenge involves almost all the key problems of production informatics, from product design up to the organization of production networks. Main industrial partners in the 4-year project are leading German carmakers (BMW, Volkswagen), as well as 1st tier suppliers who themselves have global supply networks (Continental, ZF Friedrichshafen). One track of research is the development of modular and configurable product structures that facilitate the late, order-dependent configuration of cars. MTA SZTAKI is involved in the second research track, in particular, in the development of so-called “dynamic supply loops” that promote a highly responsive supply logistics at increased service level and reduced inventories. Specifically, the institute contributed to the communication protocols, an underlying computerized ontology, as well as to methods of risk and profit sharing within the dynamic supply loops.

- **LiWA: Enrichment tools for Web archive** (András Benczúr, FP7, 2008-10)

Web content plays an increasingly important role in the knowledge-based society, and the preservation and long-term accessibility of Web history is of high value (e.g., for scholarly studies, market analytics, intellectual property disputes, etc.). There is strongly growing interest in its preservation by library and archival organizations as well as emerging industrial services. Web content characteristics (high dynamics, volatility, contributor and format variety) make adequate Web archiving a challenge.

LiWA looks beyond the pure “freezing” of Web content snapshots for a long time, transforming pure snapshot storage into a "Living" Web Archive. "Living" refers to a) long-term interpretability as archives evolve, b) improved archive fidelity by filtering out irrelevant noise and c) considering a wide variety of content.

LiWA extends the current state of the art and develops the next generation of Web content capture, preservation, analysis, and enrichment services to improve the fidelity, coherence, and interpretability of web archives. By developing methods, which improve archive fidelity, the project will contribute to preparing the adequate preservation of complete and high-quality content. By developing methods for improved archive coherence and interpretability, the project contributes to ensuring its long-term usability.

LiWA RTD will focus on innovative methods for content capturing, filtering out spam and other noise, improving temporal archive coherence, and dealing with semantic and terminology evolution. Two exemplary LiWA applications - focusing on audiovisual streams and social web content, respectively, will show the benefits of advanced Web archiving to stakeholders interested.

- **JUMAS: Judicial Management by Digital Libraries Semantics** (Tamás Szirányi, András Benczúr, FP7, 2008-10)

Public administration forms the broadest information-bound sector. Using modern Content Management approach, it is possible to improve efficient data access and effective information retrieval. The potential increase in content production and consumption, considering the growing trans-national cooperation also among several national law systems, highlights the need to adapt the technological profiles of new member states. In this context JUMAS is the leverage able to converge to an actionable knowledge starting from content revolution. In particular, JUMAS envisages a system for the embedded semantic extraction from multimedia data that join an advanced knowledge management system. Moreover, JUMAS is tailored to managing situations in which multiple cameras and audio-source are used to record assemblies which people debates on and event sequences need to be semantically reconstructed for future consultations.

- **TEXTREND: Intelligent application platform for text mining** (András Benczúr, Jedlik 2008-10)

The major and interconnected objectives of the project are (1) to create an integrated TEXTREND Platform toolkit and service basis, and (2) to elaborate some demonstrative applications of the toolkit in various fields of business and governmental decision support, based on partner use cases. The goal of TEXTREND Platform is the in-depth analysis of the enormous amount of dynamic information to be found on the Web from the aspect of a particular field of science of business. In-depth analysis means in contrast to the usual extraction and indexing services we aim at retrieving an

essentially new type of information that would otherwise be impossible to gather manually. Trend analysis is an example with the aim to determine and predict the characteristics of public opinion or interest along with their changes in time based on mass document analysis (blogs, Web documents etc.). As another example, we explore and exploit the latent, e.g. social, structures by automatic text processing, network analysis and visualization in order to estimate the power and the impact of a certain field. We aim to gain information to support policy, business or final decision makers.

- **MEDUSA**: *Multi sEnsor Data fusion grid for Urban Situational Awareness (Levente Kovács, European Defence Agency, 2009-11)*

The goal of MEDUSA project is to realize an integrated, intelligent and versatile multi-sensor data fusion grid to improve situational awareness. Tasks include adapting semantic sensor analysis methods for a distributed urban surveillance architecture, with the goal of aiding tactical decision making and creating an alert signalling framework. A 3D GIS Environmental Service will also be included for visualization and supporting decision making process.

- **TRASER**, *Identity-Based Tracking and Web-Services for SMEs (Angyalka Zudor, László Monostori, FP6, 2007-09)*

The primary goal of EU FP6 TraSer project coordinated by MTA SZTAKI was to develop a free, open-source software package offering affordable item-centric tracking and tracing solutions for SMEs which can transcend company or organizational borders. TraSer package relies on a Java-based open-source web service framework. Publicly available interface specifications will allow users to easily implement their own special building blocks, such as clients tailored to specific purposes, or re-implement a TraSer solution in a developmental environment of their choice. This feature is of special importance for small enterprises which are suppliers in multiple production networks and have to conform to multiple communication and track-and-trace specifications.

- **RELIAWIND**: *Reliability-focused research on optimizing wind energy systems design, operation and maintenance (Zsolt János Viharos, László Monostori, FP7, 2008-11)*

The main goal of the project is to increase the reliability of wind turbines and wind turbine farms, with special emphasis on off shore ones where the repair and maintenance tasks bear significant cost. In cooperation with the leading European companies (GAMESA, HANSEN, ABB, SKF, etc.), SZTAKI leads the development of intelligent monitoring and diagnostic systems within the project.

- **VFF**: *Holistic, extensible, scalable and standard Virtual Factory (Botond Kádár, László Monostori, FP7, 2009-12)*

The project uttermost objective is to foster and strengthen the primacy of Future European Manufacturing by defining the next generation Virtual Factory Framework. VFF will result in major time and cost savings, while increasing performance in the design, management, evaluation and reconfiguration of new or existing facilities, supporting the capability to simulate dynamic complex behaviour over the whole life cycle of Factory, approached as a complex long living Product. Thus, the project will research and implement the underlying models and ideas at the foundation of a new conceptual framework designed to implement the next generation Virtual Factory, also meant to lay the basis for future applications in this research area. MTA SZTAKI works with Audi Hungary in cooperation on the integration of the event-based simulation into

the VFF framework, and on the development of and test of the module for logistic optimization.

- ***EJTT: Advanced Vehicles and Vehicle Control Knowledge Center (Péter Gáspár)***

MTA SZTAKI plays a determining role in the *Advanced Vehicles and Vehicle Control Knowledge Center* led by Budapest University of Technology and Economics. The institute's related research activity involves control over communication networks, cooperative fleet control of vehicle systems, moreover, the control of active vehicle components such as advanced suspension systems. Research and development of advanced architectures of on board vehicle electronic information and control systems relying on the C-By-Wire concept is pursued.

The participation of the institute in the organization *Mobile Innovation Center* also reflects the good co-operation between the institute and the BME.

It follows from the above enumeration that information and other sciences (material, life, and social science, mathematics, artificial intelligence, systems- and control science, automation, operations research) and the fields of application (sensing computers, vehicle industry, transport, production-automation and management, health care, information society, data security, medical science), all concentrate on interdisciplinary research and development, which may lay the institute's future foundations in the long run.

Based on the above, the relations of the institute with remarkable major enterprises such as GE, Audi, Hungarian Telekom, MOL, Paks Nuclear Power Plant, Knorr Bremse, Bosch get deeper and stronger. At the same time, the participation of small enterprises guarantees that the institute's results should keep spreading in the widest possible spheres. Their co-operation with overseas countries (USA and Japan) opens completely new perspectives.

The list of grant-supported projects and their financial data are incorporated in a separate table.

V. The most important publications and patents in 2009

Publications

1. Bacsó, G. - Tuza, Z.: Clique-transversal sets and weak 2-colorings in graphs of small maximum degree.
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