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**Report on the scientific activity of the  
MTA SZTAKI  
in 2012**

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## **I. Main duties of the research unit in 2012**

Research areas dealt with at the MTA SZTAKI are in harmony with the majority of big challenges the world is facing. Information science can be one of the driving motors of answers the challenges need, but R&D areas highlighted by the institute, such as mechatronic research (electric vehicle and vehicle control) related to vehicle industry, or automation and informatics problems of traditional and renewable energy sources are directly connected to the challenges. Mobility, vehicle industry and logistics; information sciences and the new energy and environment protection developments R&D&I themes are considered by the New Széchenyi Plan with priority from the entire aspect of economy. Naturally, the areas of themes are in accordance with the major R&D programs of the EU, particularly with programs Information and Communication Technologies; Materials and New Production Technologies; Factory of the Future; Energy; Transport (including Aeronautics).

One of the most significant directions in the development of computer science and information and communication technologies is represented by cyber-physical systems (CPS). By this notion a new interaction and integration of virtual and real worlds is meant, which is of significantly higher rank and, simultaneously, deeper than in the foregoing. These systems are computational structures which are in intensive connection with the surrounding physical world, physical processes, serving and using, at the same time, data-accessing and data-processing services available in the internet. From this point of view, they surpass the embedded systems approach, since they integrate the computational abilities present in the embedded systems with the data-access- and processing abilities of cyber-world, they operate in heterogeneous environment, and ensure the intensive interactive connection with the physical world.

CPS creates considerable challenges in basic research. Here cooperative, but – at the same time – autonomous elements, sub-systems are meant, getting into connection with each other depending on the situation, and by this having emergent behaviour. Modelling their operation and also forecasting their behaviour raise a line of basic research tasks, not to mention the control of any level of these systems. Integration of analytical and simulation-based approaches can be projected to become more significant than previously. The fundamental question is to explore the relations of autonomy, cooperation and optimization. Research of sensor-networks may get fresh impulses due to sudden advance of cyber-physical systems. One must face the questions of handling big bulks of data, the questions of information retrieval, representation, and interpretation, not to mention security aspects. A newer level of man-machine communication is needed and can be realized in course of establishing CPS.

The application fields are almost endless: air- and ground-traffic; discrete and continuous production systems; logistics; medical science, energy production, infrastructure surrounding us, entertainment, and we could keep on enumerating. Through cyber-physical approaches, they could result in „smart” cities, production-, communication-, logistic- and energy systems; furthermore, they could contribute to creating new quality of life. In the latter case we may either talk about cyber-physical society, which already includes human, social, cultural spheres as well, above the physical- and cyber spaces.

The two keywords figuring in the name of institute (automation and computer) duly indicate that their objectives and activity are in harmony with the challenges the cyber-physical systems raised. In 2012, as their major goal, the institute focused on creating the infrastructure (laboratories of 3D-internet, control, SmartFactory, cloud-computing) necessary for CPS research, and establishing efficient organizational units – either of international dimension – which are capable of performing R&D activity, based on basic research results, at least up to the pilot model stage.

## **II. Outstanding research and other results in 2012**

### **a) Outstanding research and other results**

In the following part, above the description of their four major domains of basic research (computer science, systems- and control theory, engineering and business intelligence, machine perception and human-computer interaction), five sub-sections contain a summary on how their basic research results support the R&D activities which aim at fields considered as particularly important both on EU-level (Horizon 2020) and in Hungary (New Széchenyi Plan). Consequently, their application-oriented results achieved in the fields of vehicle industry and transport, production informatics and logistics, energy and sustainable development, security and surveillance, furthermore, networks, distributed computing structures and next generations of internet are detailed in separate sub-sections.

### BASIC RESEARCH – MAIN DOMAINS

#### Computer Science

Their research in Computer Science leverages on the synergies of several interrelated fields, including the theory of algorithms and databases with emphasis on new parallel hardware architectures, data mining, information retrieval, machine learning, and graph theory. Business intelligence, e-science and Web mining are rapidly growing sources of extreme large scale information processing problems. Their goal is to provide efficient solutions to distil knowledge from “big data”.

Selected most important results in 2012:

- Advanced machine learning techniques over GPGPU graphical coprocessors were used for content-based image classification. Their team made second place with tight margin at ImageCLEF 2012 Photo contest by using their open-source Gaussian Mixture Modelling and Fisher vector toolkit.
- Their team won the prize for the “Good Support for the Data Preparation, Analysis, and Presentation Process” at the IEEE Visual Analytics Science and Technology Challenge 2012.
- In the area of graph algorithms, the disjoint paths problem for directed planar graphs was studied. The classical algorithm of Schrijver gives a polynomial-time algorithm for fixed number of terminal pairs. This algorithm was significantly improved by making the running time uniformly polynomial.
- Interval graphs are appropriate models of several problems in application areas such as biology and scheduling. Thus, measuring the distance of a given graph from the class of interval graphs is a natural question. In the case of vertex-deletion distance, a uniformly polynomial algorithm was given for this problem.
- They have achieved significant improvement of their algorithm for the explicit isomorphism problem for full matrix algebras. The new method works in small dimensions important in the practice. In addition to being much simpler, it is faster than the earlier algorithm.
- New lower and upper bounds on the communication complexity (in the deterministic, the classical probabilistic and the quantum setting) of certain graph properties were given. These properties include connectivity, possessing perfect matching, and being Eulerian.
- They developed new algorithms and FPGA architectures to speed up computation over two and three-dimensional unstructured grids by reordering the grid-points to find optimal refresh strategies.

Their basic research awarded also by an ERC Starting Grant and a Momentum Grant of the Hungarian Academy of Sciences leads to research and development projects in co-operation with Hungarian Telecom, AEGON Hungary, Vodafone Hungary, and several Hungarian SMEs (Schibsted Media Group, Glia, Petabyte, Universitas Press). They developed customer relation and fraud detection systems for AEGON. Hungarian Telecom, Vodafone and AEGON rely on their search technology as well as provide research test bed for their research in text mining in co-operation with Hungarian SMEs.

### Systems- and control theory

The methodical background of automated control systems is provided by the research of mathematical systems- and control theory, which offers firm theoretical basis for other R&D activities carried out by the institute. The scope of activity includes system modelling and identification, theory of adaptive and robust control, signal processing and filtering, distributed and networked control systems and process control systems. Linear and nonlinear systems, both in continuous and discrete time approaches, moreover, deterministic and stochastic views are equally considered for both synthesis and analysis.

The extension of the results achieved for the geometrical description of linear time invariant systems to linear time varying (LTV) and/or state dependent varying parameter model structures (LPV and quasi-LPV systems) makes up a coherent strategy for further research of robust controllers. These results were successfully applied to indefinite geometries that facilitated the understanding of the role of Möbius transformation in the analysis of various types of control theoretic problems.

Design of a fundamental control problem in the time domain over a closed set of solutions was successfully formalized and parameterised embedding the related design methods in linear algebra. Conditions for the proper selection of the scheduling variables of the quasi-LPV system in question were given. The mathematical method of TP-tau model transformation was matured, which is capable to transform dynamical system models with time delay to non-delayed quasi-LPV model in polytopic form. In this type of LPV model the time delay appears as external parameter that can be already treated by the standard methods of Linear Matrix Inequalities (LMI) of modern control theory. In this way the non-delay type system descriptions, including quasi-LPV, polytopic and LMI based techniques could be extended to dynamical systems with delay. The usefulness of the method was demonstrated by the experiment in which the control of the force-feed-backed robotic manipulator arm over the internet could be solved in great efficiency. There were no known references for the solution of this control problem in the literature earlier.

Research along the extension of rational orthogonal basis functions in signal processing towards hyperbolic wavelets opened the way to the development of novel parametric system identification methods, and also to the description of systems in indefinite metrics. This allows the construction of a new hyperbolic systems theory. The newly developed identification method lets determine the unknown poles of the system in a revolutionary new way by extending the original frequency domain description of the system with time domain measurements.

There have been new results in the field of geometric modelling of optical surfaces. Beyond the traditional surface representation techniques, based on the Zernike and Chebisev approaches, there has been a definite movement towards the use of the methods originated in mathematical system theory. The new approach is conformant with realistic methods of measurement technology that makes use of indefinite number of measurement points and surface segmentation.

Principal end users of the results of systems and control theory are from the energy-, and the vehicle and transportation industries. There have been a number of important projects, performed both in national and international horizons, whose main objective was the industrialization and analysis of practical applicability of the developed theories. There have been research and development projects (ADDSAFE-FP7, TRUCKDAS-NFÜ), carried out in close cooperation with Airbus, Bosch and Knorr-Bremse. As a direct consequence of industrial cooperation, there appeared results in the field of the design of fault tolerant vehicle on-board control systems, and in coordinated control and supervision of platoon systems for commercial road-vehicles. The integrated control of braking and steering systems together with new algorithms for intelligent unmanned vehicle control and sensor fusion solutions got new approaches in the applied research.

### Engineering and business intelligence

Globalised technical and business systems of our days are characterized by distributed decision centres, abundance of incomplete and uncertain information, as well as extraordinary complexity. The fundamental goal of the R&D activities in this field is the research and elaboration of techniques applicable for handling complex production and business systems working in an uncertain, changing environment, balancing the aspects of optimisation, autonomy and co-operation. The research necessitates an interdisciplinary approach with special emphasis on computer science, operation research, manufacturing science and knowledge-based techniques.

The main results of basic research activities achieved in 2012 are as follows:

- They generalized the Gomory mixed integer (GMI) cuts for solving mixed integer programs with binary variables. It was shown that the seemingly stronger cuts can be derived as GMI cuts.
- They generalized the scheduling problem with inventory releasing jobs to take into account delivery due-dates. The computational complexity of several special cases has been studied, and a fully polynomial time approximation scheme was provided for obtaining approximate solutions.
- A new, non-asymptotic system identification method, called Sign-Perturbed Sums (SPS), was developed which can build exact, finite-sample confidence regions for parameters of general linear systems (e.g., Box-Jenkins), under minimal statistical assumptions, with arbitrary user-chosen confidence probabilities.
- Efficient stochastic methods have been developed that, departing from binary quantified measurements, approximate the estimates in case of ARX systems with strong consistency.
- A new model and a solution method have been developed for solving the computer assisted process planning (CAPP) problem of complex products with free-form surfaces. This method is based on the combination of geometric reasoning and large-scale combinatorial optimization.
- A methodology was devised for applying the conceptual apparatus of mechanism design (so-called inverse game theory) to the analysis and design of coordination protocols for supply networks. In this way, generic properties (like efficiency, truthfulness, budget balance) of the widely applied Vendor Managed Inventory (VMI) protocol could be investigated.
- Numerical investigations and real-life applications showed that relaxation techniques are efficient tools to overcome the most common numerical drawbacks of interior point methods. The existing relaxation techniques were extended to handle a wider class of optimization problems. This was done by generalizing a convergence theorem for which a new, more general proof was derived.

- Novel results have been received on the convexity issues of the approximation of nonreciprocal pairwise comparison matrices by consistent matrices in the least squares, and sufficient conditions have been given for finding the global optimum of the problem by using local search technique.

The research activities are partly pursued in the framework of EU-supported projects – some of them coordinated by the institute. The theoretical results achieved in 2012 have been published – among other forms – in journals with impact factors, led to industry-oriented applied research and innovation activities (see the sections on Production informatics and logistics and on Energy and sustainable development).

### Machine perception and human-computer interaction

Detection and recognition in the world of sensors around us is an increasing challenge: the fusion of the different sensors in space and time, discovering the interaction among the different machine perception methods call for a developing demand for higher level modelling. It covers the geometrical analysis of the surrounding scene structure, data mining of measurement and classification data, static and dynamic reconstruction of scene geometry in indoor and outdoor scenes, making virtual presence in fused environments.

Most outstanding results in 2012:

- A dynamic scene model (e.g., four dimensional, 4D model) including pedestrians and vehicles has been generated from point clouds' series of three dimensional laser scanner (LIDAR). Multi-view fusion methods have been developed for detecting and positioning moving pedestrians, based on geometric and stochastic optimization.
- A new type of image feature representation has been introduced for remote sensing, resulting in a high precision automatic detection of urban area. The new scientific achievements make the image based indexing and retrieval more suitable for surveillance and terrestrial data classification tasks.
- In cooperation with Hitachi Co., new 3D image analysis algorithms have been developed for the surveillance of building sites, based on laser scanning (LIDAR) point clouds.
- Microwave and THz methods and detectors have been developed and patented, which are, according to scientific literature, the most sensitive detectors based on standard (affordable) CMOS technology. This is the only detector, which is capable of in-phase and quadrature-phase signal reception with proper antenna arrangement without moving delay stages.
- A digital holographic (volumetric) microscope (DHM) has been developed to detect, classify, and count worms (helminths) in drinking water. The microscope operates in real-time even in case of very low concentrate of worms, which makes the continuous monitoring of drinking water possible with the accuracy required by the applicable standards. Production and sales of the device are done by a Hungarian small enterprise.
- A many-channel deep brain electrode amplifier array has been developed and implemented on analog ASIC. The noise and other parameters of the circuit surpass the similar solutions found in international scientific literature. In-vivo animal experiments run at MTA TTK with the new chip.

## R&D ACTIVITIES

### Vehicles and transportation systems

Research performed for intelligent vehicle and transportation systems has been structured by the distinguishing technologies applied to road- and air-vehicles.

Regarding intelligent vehicle and transportation systems research, the integrated solution to combined braking and steering control solutions of cars and heavy vehicles, the advanced sensor fusion and control over network methods, the fail-safe design of on board vehicle control systems, the cooperative control and advanced drivers assistance systems (ADAS) are highlighted as the most important achievements (project TRUCKDAS).

The basic objective of the new cooperative vehicle and traffic control methods is to enhance the safety and efficiency of transportation of goods and passengers while keeping the environmental footprint of the road transportation on a minimum level.

The recognition that the driver is an inherent part of the control loop of every man controlled vehicles, a specific control method has been developed and tested that considers a human behaviour model in the algorithm.

A successful communication system demonstration that was part of the official demo program of World Congress of Intelligent Transportation Systems (ITS) in Vienna made the benefits of the use and integration of the most recent wireless communication technologies, clearly visible. The communication scenarios developed for this demonstration were realistic and fully compliant with the use of IPv6 communication protocol and other advanced mobility technologies applicable both in vehicle and the roadside infrastructures. A deployment view of the ISO/ETSI ITS Station Reference Communications Architecture was presented. The scenario focused on the implementation of Roadside and Vehicle communication stations, with a multitude of communication links (i.e., sensor access, 3G, 802.11p, WiFi) based on native point-to-point IPv6 data transfer. The presentation of the integration of low-power road sensors in the standardized architecture concept was one of the main objectives of demo highlights.

Research in the field of Aerospace Guidance, Navigation and Control yielded many new exciting results. In the framework of ADDSAFE FP 7 project the detection filter developed by the institute staff was one of the best performing algorithms for the detection and identification of specific actuator faults occurring in commercial aircraft structures. The algorithms have been successfully validated on test facilities of Airbus.

Research of electromechanical actuators commercialized mainly by the air industry revealed new problems and provided novel results. The development of the small, electromechanical actuator subjected to the application in the control system of autonomous air vehicles was carried out, successfully. In collaboration with UTC Aerospace, new mathematical models and controller algorithms for use in commercial aircrafts have been developed in the frame of the ACTUATION 2015 FP7 project.

The laboratory tests of a small sized, dependable avionic system controller for use in unmanned air vehicles approved usability of the hardware. Flight tests of the controller are projected for the first part of 2013. The avionic system will help the deployment and integration of small sized robotized aircrafts in National airspace, based on its unique sense-and-avoid machine vision based technology in an attempt to safely separate flying objects of a variety of flight licenses, in the common airspace. The vision-based avionic system is capable of identifying airplane patterns over cloudy backgrounds on a variety of cloud structures. As a consequence, the small unmanned air vehicles (UAVs) are now capable of flying over a

prescribed flight trajectory, autonomously, relying solely on their on-board navigation systems.

Research supported by the Office of Naval Research of the US (ONR) subjects advanced trajectory estimation and collision avoidance methods based on real time simulation and processing of sensory data. The hardware in the loop (HIL) validation of the navigation system, including image processing and decision-making functionality of the system have been successfully demonstrated in presence of the delegates of US Air Forces and ONR.

#### Production informatics and logistics

The R&D activity of the institute in this field aims at designing and modelling production, servicing and logistic systems, together with the digitalization, control and optimisation of their operation, on shop floor-, enterprise- and network levels alike. In 2012, MTA SZTAKI made efforts to develop solutions of world class quality well applicable both at globalized large companies and also at SMEs co-operating with them. Most of the applied R&D activities, such as consulting, system development and deployment have been carried out within the frame of Fraunhofer-SZTAKI Project Center for Production Management and Informatics, established at the institute in 2010.

Major R&D results achieved in 2012 are as follows:

- A new flexible and reconfigurable assembly system concept has been elaborated for the new assembly plant of Knorr-Bremse in Kecskemét. The system warrants required production capacities on considerably less floor space.
- Within the project RLW Navigator supported by the European Commission, a new model and appropriate solution algorithms have been developed for task sequencing, path planning and generation of inverse kinematics for remote laser welding (RLW) robots. The method has been tested in collaboration with a carmaker (Jaguar LandRover) and RLW robot producer (Comau) company. In terms of cycle time, the method surpasses the robot programming methods known from the literature or applied in the industrial practice.
- As an answer to the need of industry for internal logistics solutions, a hierarchical milkrun planning and vehicle routing system has been developed that complies well with the engineering practice and generates solutions by efficient local search.
- Within the VFF project supported by the European Commission, the technology of semantic web was exploited for integration of factory planning, production planning and control applications running on various computational platforms. As a breakthrough solution, discrete event-driven simulation was tailored to various functions of production informatics, like product design, process planning, factory planning cost calculation, etc. by means of a common ontology.
- In order to support networked companies in improving their information collecting and processing infrastructure, as well as to enable strategic planning coupled with instant decision making, an open-source Java-based platform has been developed in the frame of the EU project ADVANCE.
- Through an industrial contract, they have started to work out the planning and sequencing decision support system for Audi Hungary Motor factory. In the fall of 2012, the requirements analysis was carried out. The project proceeds with implementation, testing and evaluation in 2013.
- Novel methods have been developed for sheet metal forming operations performed by robots. The main results – that make bending without pressing tools possible – have been patented.

Most of the above results have been devised for, or are already in application at large, world-class manufacturing companies such as Audi Hungaria Motors Ltd, GE Hungary, Knorr-Bremse Braking Systems Ltd, Bosch Rexroth Pneumatics Ltd., Hitachi, Gamesa, Jaguar-LandRover, and Palletways. Of special importance is the long standing R&D cooperation between SZTAKI and HITACHI that, going back to six years, has already resulted in several joint patent applications. The collaboration that started in semiconductor manufacturing and continued in power systems industry is now driven by problems in power plant construction business of the company.

### Energy and sustainable development

A fundamental requirement of sustainable development is the adaptation of the energy production, -transfer, and -transformation systems to the changing needs and possibilities. One of the keys to renewal in the control and supervision of electrical power systems is the increased data processing, storage, and transfer capacity of the available information technology toolset, which opens new prospects in the areas of automation and efficiency increase, however, generates new problems as well. The institute gives much emphasis to the following topics in the field of energy management and sustainable development:

- The strategic collaboration with Paks Nuclear Power Plant (NPP) continued. The institute provided support of expertise, consulting for the preparation of the refurbishment of the instrumentation and control (I&C) systems equipment. This activity fits in the global service life extension strategy of the plant. The conformance review and reliability analysis of the Unit Computers, as well as the Universal Test System (was developed and implemented by the institute years ago) have been carried out from the viewpoints of life-cycle management and longevity. A concept for standardization and harmonization of use of the variety of I&C systems applied in the NPP on the basis of the OPC Unified Architecture recommendation was proposed and elaborated. They took part in the preparatory work aiming at the modernization of the Reactor Power Controller system, and in collecting requirement specifications for the new system functions to be supplied. Work on the computer security scanning of computerized systems connected to the Technological Computer Network (TCN) continued. Technology survey and analysis of the effects of the introduction of data diodes in the TCN was performed in an attempt to create optimal architecture capable to defend critical infrastructures of the plant. The institute's staffs provide a stable background for the planned technology extension of Hungarian nuclear power generation facilities in the future.
- In a case study, by using methods of mathematical programming, basic principles, organizational as well as planning methods of production informatics have been suggested for application to increase the performance of maintenance capacity management at E.ON, the leading energy provider in Hungary.
- In the frame of project VERYSchool supported by European Commission customised energy savings strategies and related ICT solutions have been developed for schools throughout Europe, by integrating smart LED lighting technologies, smart meters, and building energy management systems.
- Solutions developed by MTA SZTAKI for the supervision and maintenance planning of wind turbines and wind turbine farms have been transferred ready for application at company Gamesa. Special algorithms have been developed to assess non-conform states, as well as to detect and predict failures of wind turbines.

## Security and surveillance

The importance of security and surveillance applications and areas has been rising in recent years. Computer systems can notably contribute to raising security awareness. Cyber security has been a key issue by now, which acquires importance in the domain of critical infrastructure protection (e.g. energy production, traffic).

The goal of remote monitoring and remote sensing research is the introduction of a new scientific methodology for the automatic interpretation of remotely sensed 4D (space and time dimensions) data from various sources. This, through the separation of certain areas and the perception of defined objects and samples, will allow complex, multilevel description of surveyed sites. Analysis is performed by using air photos, satellite imagery, infrared and radar images, and ground-mounted and airborne LiDAR sensor data. The central tasks are the examination, registration and intelligent fusion of multiple data sources, 3D/4D representation of samples, and machine learning methodologies.

Main results achieved in 2012:

- Multi-sensor equipped tactical support network: In the project APIS funded by the European Defence Agency (EDA), Research and Technology Contract Joint Investment Program on ICET, a new object recognition method, based on Marked Point Process stochastic optimization, has been tested with success for estimating the silhouette of the objects on passive radar images, even in the case of very noisy and incomplete source data. In force protection research activity cooperation has been started with the Universität der Bundeswehr München, Fakultät für Luft- und Raumfahrttechnik, Institut für Flugsysteme for joint publications and current and future cooperative projects. UAV based remote sensing methods have been tested and investigated in relations with the DLR's (German Aerospace Center) laboratory in Oberpfaffenhofen with the goal of dynamic modelling of ground structures based on aerial data (e.g., for disaster management applications) and traffic analysis.
- New methods have been developed for the effective real-time segmentation of 3D moving objects and the background.
- Their colour digital holographic microscope (DHM) with its algae classification system developed for automatic monitoring of drinking water was introduced in multiple areas. At the waterworks in Kecskemet (BÁCSVIZ) worm detector DHM was successfully applied. Algae monitoring DHMs were utilized at Budapest Waterworks and at Lake Balaton (DRV) for monitoring surface water. The DHM based inspection of the frozen Balaton has generated significant media interests.
- Upon the request of the National Atomic Energy Authority, instructions were put in place regulating the computerized safety of process control systems of nuclear facilities, the industrial use of which is expected in course of establishing the defence architecture of the Hungarian nuclear facilities' computer controlled system.

## Networks, networking systems and services, future internet technologies

The importance of this field is unquestionable. A new program, Horizon 2020 is in preparation. This program emphasizes basic research in the fields of information and communication technologies: the next generation of internet. The above subject covers the issue of the management of large-scale, connected systems. It requires the handling of extremely large amounts of data, and has to support the information exchange and collaboration of smaller or bigger, heterogeneous or ad-hoc communities by creating a context-oriented knowledge base for their common knowledge.

The achievements in 2012 can be summarized as follows:

- Grid and cloud computing:
  - In the frame of project EDGI (European Desktop Grid Initiative), FP7, the Cooperation of different types of grid and cloud systems was generally solved.
  - In the frame of project SHIWA, FP7, the cooperation of European scientific workflow systems of different kinds was made possible
  - In the frame of project SCI-BUS, FP7, WS-PGRADE/gUSE portal frame system was further developed and extended to support cloud systems gaining ground fast. The profitableness of the system is characterized by the more than 6000 downloads from the sourceforge, from more than 40 countries, within a year. It was, furthermore, used by several national grids and large international projects for establishing their own portal.
  - With the aim of maintaining their achieved position outstanding on international level as well, furthermore, of meeting the increasing national requirements – supported partly by the Hungarian Academy of Sciences – significant steps were made for establishing a cloud-system.
- 3D-internet: VirCA (Virtual Collaboration Area) platform supporting fast knowledge-sharing and collaboration among institutions has been further developed. The platform is able to integrate the real and virtual tools of different laboratories, and it visualizes the same in common 3D immersive virtual space.
- Application of data of extreme quantities: SZTAKI gave solutions to index and retrieve of billions of Web pages and classify terabyte-scale data by using scalable machine learning techniques. They also gave solutions to entity resolution in customer databases consisting of more than 100 million records. The industrial applications in this field are also remarkable: customer relations (AEGON), Web analytics (archives, surveys, and market research), social media (Hungarian Telekom, Vodafone), city design and navigation (NavNGo). They provided large scale Web data and scalable search technologies for the SZTAKI plagiarism detection system (kopi.sztaki.hu).
- Social intelligence and mobile internet applications: Delay Tolerant Networking (DTN) based on Pocket Switched Networking (PSN) network technology, an adaptive, context-oriented collaboration platform, supporting „emergent interoperability” has been developed for chaos/crisis management. A solution built in an experimental mobile application (PhotoFlood) performs the P2P presentation of digital pictures and short video shots in the direction of retraceable mobile users in the vicinity.

## **b) Relationship between science and society**

The 18-year old SZTAKI Dictionary (SZTAKISzótár) is the most frequently visited Hungarian internet-based, on-line multilingual dictionary service. Day by day 1-1,2 Million searches are performed by 100-140 thousand people. Its 4.0 version has been developed, and the cloud infrastructure of suitable capacity, allowing the operation start of the new system has been installed. The updated dictionary service was awarded the life-work award at „eFestival 2012 Outstanding Hungarian Contents”.

The institute service named KOPI plagiarism detection system has been gaining a widening interest. The further developed version meets also the new demands of the higher educational institutions regarding plagiarism-filtering.

The next generation mobile tourist guide of the institute, named GUIDE@HAND is applied with success at most different fields. Some examples of the system application: based on a novel by Géza Ottlik, titled „Hajnali háztet k” (Rooftops at Dawn), an interactive walk in

literature, designed for smartphone, which is the first Hungarian service established in cooperation with Moholy-Nagy University of Art and Design and the Petőfi Literary Museum; digital guiding in Kosice and in the country (e.g. Tokaj wine region, the Zemplén Mountain, the town of Eger, etc.); supporting visitors with information on the spots at the Museum Nights, lecture at Danube Museum, the presentation of the planned events at the Researchers' Night, Vodafone Picnic in May.

In the frame of the XIII. eLearning Forum an opportunity was provided for experts in curriculum development and for experts dealing with education and training to get them acquainted with up-to-date eLearning systems and learning materials, to a widening extent.

Different target-groups visited the VirCA platform, 3D immersive virtual system and the 4D Studio more than 40 times.

The institute contributed to the event-series Researchers' Night 2012 to an extent more significant than earlier. The openness of science towards the society was deepened by their researchers' reporting on the institute results on the television and the radio upon a great number of occasions, and taking all the opportunities of publishing those through the medium of the press.

### **III. A presentation of national and international relations**

#### **International relations**

Their activity in EU FP7 was prominent, with their participation in 39 granted projects and in 7 cases acting as the head of consortium (they participate in further 11, EU-financed projects, as well). Within the frames of the programs, they work in collaboration with the most distinguished companies in Europe, in the area of information sciences, automobile- and aircraft manufacturing and energy production.

In the field of vehicle technology research and development MTA SZTAKI has been the most competent academic research centre in Hungary. Based on this invaluable knowledge background, the multipolar technology collaboration between leading research and development companies, operating in Hungary in the field of the vehicle industry, such as Bosch and Knorr-Bremse, has come into existence, recently. The collaboration aims to industrialize the theoretical results obtained in the academic research, and the utilization and capitalization of the science in technology development. With the strategic involvement of the institute Robert Bosch Research and Technology Center in Budapest, and the Vehicle Research Center at Széchenyi University in Győr have been established.

Fraunhofer-SZTAKI Project Center for Production Management and Informatics opened in 2010 has been successfully operating, due partly to which, they have major partners from the industry. Based also on the cooperation, their connections in Germany have strengthened further.

One of their outstanding partners is Hitachi Yokohama Research Laboratory.

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

From among the conferences organized by the MTA SZTAKI in 2012 the following ones are to be highlighted:

- AIM 2012: Conference of the European Academy for Industrial Management: DET – Digital Enterprise Technology: Tools and Learning Factories, Sept. 20–23, Budapest;

- MITIP 2012: The 14<sup>th</sup> Int. Conf. on Modern Information Technology in the Innovation Processes of Industrial Enterprises, Oct. 24–26, Budapest (in the frame of the conference EU-officials of high rank organized a „Proposers’ Day);
- CogInfoCom 2012: IEEE International Conference on Cognitive Infocommunications, December 2–5, Kosice.

#### National relations, participation in higher education

At the institute interdisciplinary research and development in information sciences and other branches of science (materials-, life- and social sciences, mathematics, artificial intelligence, systems- and control sciences, automation, operations research) and in application areas (sensory computers, vehicle industry, transport, production engineering, production management, cultural heritage, information society, data-security) are concentrated on, which may determine the conditions of the institute in the longer run.

In their projects the institute co-operates with remarkable major enterprises such as GE, Audi, Hungarian Telekom, MOL, Paks Nuclear Power Plant, Knorr Bremse, Bosch, E.ON. At the same time, the participation of small enterprises guarantees that the institute’s results should keep spreading in the widest possible spheres.

Gradual and post gradual 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). They make efforts to strengthen their strategic partnership, and to establish new ones.

On the average, 20 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.

#### **IV. Brief summary of national and international research proposals, winning in 2012**

In 2012 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 (with the most important data of the projects, including also the amount of the support won by the institute related to the *entire length* in parentheses):

RLW Remote laser welding system navigator for eco & resilient automotive  
Navigator factories, (FP7, 295 400 €, 2012-2014)

Objective: Design and operation of robot-based laser welding systems, based on technical, economic and environmental criteria, motivated by European car-manufacturers’ demands.

PARAMTIGHT Parameterized complexity and the search for tight complexity results,  
(FP7, 1 150 000 €, 2012-2016)

Objective: More exact understanding of the complexity of algorithmically difficult problems, with tools of parameterized complexity. Partly, the exact determination: how the different parameters of the task influence the time necessary for solving the problem. Partly, creating algorithms where the dependence of the operation time from the parameters is optimal.

INARMERA- Integrating Armenia into Era: Information and Communication,  
ICT Technologies, (FP7, 80 678 €, 2012-2014)

Objective of the project co-ordinated by the Informatics and Automation Institute, Armenian Academy of Sciences, primarily, joining the research activities of the institute, (and through them Armenia's) the research programs by the EU.

**PROACTIVE** Predictive reasoning and multi-source fusion empowering anticipation of attacks and terrorist actions in urban environments,  
(FP7, 313 240 €, 2012-2015)

Objective of the consortium: Elaboration of a sensor-fusion decision support system predicting terrorist actions, reliable also in urban environments.

**NADINE** New tools and algorithms for directed network analysis,  
(EU FP7, 290 000 €, 2012-2015)

Objective of the data mining algorithms to be developed in the project is to support search systems, to rank the information retrieved and to state the stages of confidence.

**ER-flow** Building a European research community through interoperable workflows and data  
(EU FP7, 88 917 €, 2012-2014)

Objective: Making the workflow cooperation technology elaborated in project SHIWA (EU FP7) available for four different scientific user communities.

**KOPFire** Multi-layer, federated, elastic environment for plagiarism search service (BONFire subproject)  
(EU FP7, 97 000 €, 2012-2013)

Objective: Research in multi-spot cloud federation - next generation internet network applications, services, systems R+D in whole life-cycle.

**IDGF-SP** International Desktop Grid Federation - Support Project  
(EU FP7, 359 575 €, 2012-2014)

Objective of the project coordinated by the institute: Supporting the world-wide spread of Desktop Grids.

**RECONFIGURE** REconfiguration of CONTROL in Flight for Integral Global Upset Recovery  
(EU FP7, 469 300 €, 2013-2015)

The goal of the project is to conduct research in the field of guidance, navigation and control technologies for commercial aircraft uses, for the development of methods for automatic handling of unanticipated events, for the optimal treatment of aircraft flight conditions in an attempt to enhance flight safety levels.

**LUDUS** European network for the sharing and dissemination of technologies and knowledge in the innovative field of game based learning  
(EU SEE, 61 471 €, 2012)

Objective: Development of serious games, mainly for economic and teaching purposes.

**MTA - LENDÜLET** "Big Data" Search Group  
(204 900 eFt, 2012-2016)

Objective: Analysing the big data of info-communication technologies, mobile tools with sensors, combining bulks of users, forming the entirely new attitude necessary for breaking through the dividing line between physical and digital worlds.

**NFÜ-KMR** E+GRID – Developing embedded information system for optimizing energy- positive public lighting  
(119 715 eFt, 2012-2014)

Objective: The system to be developed, based on renewable energy source, controls public lighting – meeting the environmental conditions and traffic needs – in a way that the network energy balance should be positive.

NFÜ-KMR            Sign language interpreter glove  
(90 000 eFt, 2012-2014)

Objective: Creation of an innovative intelligent device with the help of which handicapped people (speaking- and hearing deficiency) are able to make contacts in every-day life with healthy people in a way that both parties act intuitively.

NFÜ-KMR            Starting cloud accreditation service  
(87 120 eFt, 2013-2014)

Objectives: Elaboration of new methods and a marketable service.

Algorithmic analysis of bog data  
(69 728 eFt, 2012-2016)

Objectives: Research and development of efficient algorithms which rely on deep theoretical basis and exploit distributed architectures.

OTKA                Analysis of polynomial nonlinear systems and their control by help of  
optimisation methods  
(50 576 eFt, 2012-2016)

Objective: Development of new model-analysis, identification and control design methods for nonlinear dynamic systems by making use of the special algebraic properties of quasy-polynomial (QP) and deterministic kinetic systems.

OTKA                Finding focal-field of attention in random sensor network  
(32 994 eFt, 2013-2016)

Objectives: To demonstrate that in an environment with dense sensors organized in network, for gathering and analysing information, it is enough to have sensors which observe directly something of important. In case this is done by many, with a part of them concentrating on the same spot/event, then, there must be something important of which a model or a detailed observation can be carried out.

## V. List of important publications in 2012

### Books

- [1] Kecskeméti, G.: Foundations of Efficient Virtual Appliance Based Service Deployments: New Techniques for Virtual Appliance Delivery and Size Optimization in Infrastructure as a Service Clouds. LAP Lambert Academic Publishing, Saarbrücken, 208p. (2012)
- [2] Keviczky, L., Bányász, Cs.: Két-szabadságfokú irányítási rendszerek. Gy r: Universitas-Gy r Nonprofit Kft, 420p. (2012)
- [3] Rödönyi, G.: Structured uncertainty modelling for robust control: iterative design for linear systems. LAP Lambert Academic Publishing, Saarbrücken, 172p. (2012)

### Journal-publications

- [4] Balló, G. - Hangos, K.M. - Petz, D.: Convex optimization-based parameter estimation and experiment design for Pauli channels. **IEEE Transactions on Automatic Control** 57 (8) : 2056-2061. (2012)
- [5] Benedek, Cs. - Descombes, X. - Zerubia, J.: Building development monitoring in multitemporal remotely sensed image pairs with stochastic birth-death dynamics. **IEEE Transactions on Pattern Analysis and Machine Intelligence** 34 (1) : 33-50. (2012)
- [6] Bulatov, A.A. - Dalmau, V. - Grohe, M. - Marx, D.: Enumerating homomorphisms, **Journal of Computer and System Sciences** 78 (2) : 638-650. (2012)
- [7] Egri, P. - Váncza, J.: Channel coordination with the newsvendor model using asymmetric information. **Int. J. of Production Economics** 135 (1) : 491-499. (2012)

- [8] ElMaraghy, W. - ElMaraghy, H. - Tomiyama, T. - Monostori, L.: Complexity in engineering design and manufacturing. **CIRP Annals-Manufacturing Technology** 61 (2) : 793-814. (2012)
- [9] Farkas, Z. - Kacsuk, P.: Evaluation of hierarchical desktop grid scheduling algorithms. **Future Generation Computer Systems** 28 (6): 871-880. (2012)
- [10] Földesy, P.: Terahertz single-shot quadrature phase-shifting interferometry. **Optics Letters** 37 (19) : 4044-4046. (2012)
- [11] Gáspár, P. - Szabó, Z. - Szederkényi, G. - Bokor, J.: Design of a two-level controller for an active suspension system. **Asian Journal of Control** 14 (3) : 664-678. (2012)
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- [13] Hangos, K.M. - Szederkényi, G.: The underlying linear dynamics of some positive polynomial systems. **Physics Letters A** 376 (45) : 3129-3134. (2012)
- [14] Ivanyos, G. - Karpinski, M. - Rónyai, L. - Saxena, N.: Trading GRH for algebra: Algorithms for factoring polynomials and related structures. **Mathematics of Computation** 81 (277) :493-531. (2012)
- [15] Ivanyos, G.: Finding hidden Borel subgroups of the general linear group. **Quantum Information & Computation** 12 (7-8) : 661-669. (2012)
- [16] Kacsuk, P. - Farkas, Z. - Kozlovsky, M. - Hermann, G. - Balaskó, Á. - Karoczkai, K. - Márton, I.: WS-PGRADE/gUSE generic DCI gateway framework for a large variety of user communities. **Journal of Grid Computing** 10 (4) : 601-630. (2012)
- [17] Kim, H. - Sah, M.P. – Yang, C. – Roska, T. – Chua, L.O.: Memristor bridge synapses. **Proceedings of the IEEE** 100 (6) : 2061-2070. (2012)
- [18] Kis, T. - Kovács, A.: A cutting plane approach for integrated planning and scheduling. **Computers and Operations Research** 39 (2) : 320-327. (2012)
- [19] Kovács, A. - Szirányi, T.: Harris function based active contour external force for image segmentation. **Pattern Recognition Letters** 33 (9) : 1180-1187. (2012)
- [20] Mészáros, Cs.: Regularization techniques in interior point methods. **Journal of Computational and Applied Mathematics** 236 (15) : 3704-3709. (2012)
- [21] Nonaka, Y. - Erdos, G. - Kis, T. - Nakano, T. - Vancza, J.: Scheduling with alternative routings in CNC workshops. **CIRP Annals-Manufacturing Technology** 61 (1) : 449-454. (2012)
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