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**Report on the scientific activity of the
MTA SZTAKI
in 2013**

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I. Main duties of the research unit in 2013

The institute realised in due time that their main research focus and the scopes of new laboratories (3D-internet, control, SmartFactory, cloud-computing) should be determined by taking the most important directions of information and communication technology into account, joining this way the world-wide research of *Cyber-Physical Systems (CPS)*.

The Cyber-Physical Systems are systems of collaborating computational entities which are in intensive connection with the surrounding physical world and its on-going processes, providing and using, at the same time, data-accessing and data-processing services available on the internet. The potential of CPS to change every aspects of life is enormous: concepts such as autonomous cars, robotic surgery, intelligent buildings, smart electric grid, smart manufacturing, and implanted medical devices, but the list could be extended. Cyber-physical approaches 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 speak of cyber-physical society, which already includes human, social, cultural spheres as well, above the physical- and cyber spaces. The *Cyber-Physical Production Systems (CPPS)* – according to the Federal Ministry of Education and Research, Germany (BMBF) – may lead to the 4th Industrial Revolution, frequently noted as Industry 4.0.

The expectations towards CPS are versatile and enormous: robustness, autonomy, self-organization, self-maintenance, self-repair, transparency, predictability, efficiency, interoperability, global tracking and tracing, to name only some of them. Though there are very important developments in cooperative control, multi-agent systems (MAS), complex adaptive systems (CAS), emergent systems, sensor networks, data mining, etc., even a partial fulfilment of these expectations represent real challenges for the research community.

II. Outstanding research and other results in 2013

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 distill knowledge from “big data”. Unique to the institute is the strong collaboration of engineers and mathematicians: while their results are always experimentally validated over real data, due to the huge size of the problems, their algorithms are based on deep theory of algorithms, probability and algebra.

Selected most important results in 2013:

- In the area of quantum computing their generalization of the famous hidden subgroup problem leads to novel connections to a seemingly unrelated algorithmic problem.
- Their results on error protection methods in optical networks were published at leading international conferences and journals.
- Their paper "List H-coloring a graph by removing few vertices" voted Best Paper at the European Symposium on Algorithms (ESA 2013). Based on graph homomorphisms, they find a unified handling of several classical graph algorithms that they investigate with the techniques of parameterized complexity theory.
- They developed a new FPGA-based foveal image processing architecture for UAV (unmanned aerial vehicle) collision avoidance.
- Their FPGA architecture for parallel non-Boolean pattern recognition leads to simulations of the future quasi-optical wave equation processors.

Research grant "Momentum – Big Data" gave new impulse for their research. By following the publication standards in computer sciences, first they presented their new results at leading conferences, and submitted the extended versions to journals. In the first year of the grant, they published 3 journal and 6 conference papers with an additional three extended journal versions in preparation.

Their basic research awarded by ERC- and Momentum grants as well, leads to research and development projects in cooperation with Hungarian Telekom, AEGON Hungary, Vodafone Hungary, and several Hungarian SMEs. AEGON is their partner in customer relation management and fraud detection projects. Hungarian Telekom, Vodafone and AEGON rely on their search technology as well as provide research testbed for their research in text mining in cooperation with Hungarian SMEs.

Systems and Control Theory

The theoretical and methodical backgrounds of automated control systems are provided by mathematical systems- and control theory. The research provides firm theoretical basis for other R&D activities carried out at the institute in the field of automated control systems. The basic fields of activity are system modelling and identification, theory of adaptive and robust control, signal processing and filtering, distributed and networked control systems, moreover, 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.

Regarding nonlinear system theory, new results were obtained to the robust controller design problems concerning linear parameter varying (LPV) and quasi linear parameter varying (qLPV) systems. Related results are those that highlight the role of Krein spaces and the geometry of indefinite spaces in control problems. The results concerning the qLPV modeling framework provide new methods for the performance analysis of the control algorithms. A basic result of the robust controller design was extended to multivariable case (*cf.* multivariate S-procedure). These results were used to the formulation of the so-called quadratic separator framework, which is the starting point to robust controller design in the time-domain. Conditions were given to the proper choice of the scheduling variables of the qLPV design in order to enhance performance properties of the designed controller. Relying on operator theoretic methods the state space design conditions and the parametrisation of the solution set of the robust control design problem were appropriately given. The above constructive result proved to be useful in the satisfaction of various additional specifications required by a given particular control. Based on the previously developed TP model transformation, a numerical

relaxation scheme was developed for qLPV polytopic models. These results are listed in various publications.

Focusing on the demands imposed by problems of practical interests, new results were obtained concerning the analysis and design of fault-tolerant, reconfigurable hybrid control systems. It was shown how to apply the switching and qLPV model based reconfiguration strategies in a combined way to obtain guaranteed performance. The results were successfully applied to the global control of vehicle dynamics.

In signal processing the research along the extension of rational orthogonal basis functions towards hyperbolic wavelets opened the way to the implementation of a novel nonparametric system identification method, which is unique in how the original frequency domain data are extended with data obtained from time domain measurements.

The main target fields of the application of results in systems and control theory are in the energy sector, moreover, in the vehicle and transportation industry. Advanced vehicle control methods and solutions suitable for on-board implementation featuring fault-tolerant behavior were developed. They were integrated in complex transportation applications, such as in control of commercial vehicle fleets and unmanned autonomous light vehicles. Methods were made available for sensor fusion and integrated solutions developed for coordinated braking and steering actions in an attempt to alter vehicle dynamics in a performance optimized way. Industrial partners in the exploitation of the results were Airbus, Bosch, Knorr-Bremse, etc., just to mention a few.

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 cooperation. 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 2013 are as follows:

- Generic methods were developed to match the CAD model of complex, large-scale engineering objects to point cloud data taken by measuring the surface of objects. Thanks to the new methods, the model can be adapted to reality and its missing elements can also be recognized.
- Models and methods were elaborated for integrated task sequencing, path planning and collision avoidance that optimize the cycle time of robotic remote laser welding operations.
- The aggregate demand prediction problem relevant in smart grids was studied, and by using the apparatus of (inverse) game theory a mechanism was elaborated which does not only make the agents interested in reporting truthfully, but also inspires them to achieve the socially optimal forecast precision. This system as a whole is efficient, i.e., is able to optimize the total expected cost of the electricity supply.
- They provided a polynomial time approximation scheme for single machine scheduling with non-renewable resources and the makespan objective. The best approximation algorithm for this problem had a performance ratio of two.
- They studied the connections between variants of the knapsack problem and single machine scheduling problems with non-renewable resources, and provided

approximation preserving reductions between various problem classes. The new reductions led to new approximability results (both positive and negative).

- They provided a new problem formulation for the bilevel lot-sizing problem. This is a two-level optimization problem where the second level optimality criteria are usually described by the Karush-Kuhn-Tucker (KKT) conditions, but in the new mixed-integer mathematical programming formulation the optimality of the second level is expressed by a single equation.
- A robust controller was developed which can predict energy- production and consumption and, based on these predictions, can optimize the energy flow in renewable energy systems. Predicting the energy production is obtained by a wavelet-based nonlinear autoregressive model, while the consumption forecast is based on a Box-Jenkins type time-series model. The controller works on a rolling-horizon by solving a linear program in each time-step that takes the probability of power-outages into account, as well.
- An outer-approximation algorithm was developed, for the previously proposed Sign-Perturbed Sums (SPS) system identification method, which can build ellipsoidal covers for the constructed non-asymptotic confidence regions, under minimal statistical assumptions. This method can be used, for example, to construct guaranteed confidence ellipsoids for the celebrated least-squares point estimate, even in case of only finite samples and without assuming the knowledge of the particular noise distributions.

The research activities are partly pursued in the framework of EU-supported projects – some of them coordinated by the institute. The theoretical results led to industry-oriented applied research and innovation activities (see the sections of 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 between 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 2013:

- A CMOS THz detector array was designed and built. The detector array is sensitive in the region of 0.2 - 0.7 THz. The device can capture an image by using its integrated analog and digital circuits. A new theory was developed for plasma resonance phenomenon, which provides explanation for wider operation range than the previous ones. The silicon based THz detectors are based on plasma resonance phenomenon.
- A FET based detector array was designed for THz imaging, which makes it possible to integrate a large number of detector elements with their low noise pre-amplifiers. This flexible arrangement allows the fast controlling of the resolution vs. signal-to-noise ratio tradeoff. This made the high resolution, compact and easy to integrate THz sensors available, which can be used with both continuous and pulsed illuminators.
- By optimising of the applied algorithms, they were able to considerably increase the screening speed of the lensless digital holographic microscope when it was applied to inspect rare samples.
- A numerical method was developed that can be used in coherent imaging to measure and compensate the optical aberrations of the applied lens. This method increases the achievable resolution considerably, and ameliorates the quality of the gained images.

Thanks to this method, in digital holographic microscopes that aim at measuring rare samples (like water samples), the applied intricate microscope objectives can be replaced with much simpler ones along with the proper modification of the applied reconstruction algorithms.

- A digital holographic microscope system was designed for the automatic size and shape analysis of the component particles in different powders in cooperation with Gedeon Richter Pharmaceutical Company.
- Experiments were pursued to develop zero optical path difference interferometry based fluorescent digital holographic microscope by applying diffraction type multi-focal lens.
- A chip of 1424 channel filter and buffer circuits was designed and built for the distortion and noise-optimized pre-amplification of thalamic recordings in cooperation with IMEC research institute. The in-vivo experiments are made in cooperation with the Institute of Cognitive Neuroscience and Psychology Faculty of the Hungarian Academy of Sciences.
- A novel method was developed for the 3D reconstruction of non-rigid, symmetric objects. The method was successfully applied for precisely computing the gaze direction of a human face. A related result was the development of a new algorithm for eye corner detection.
- In cooperation with the University of Szeged, a novel procedure for the optimal estimation of surface normal vector was proposed. In the case of a calibrated stereo image pair, the algorithm provides the minimal least squares solution to the problem, given the affine transformation between the images.
- A novel method was proposed for the motion tracking of deformable 3D objects.
- A new mixed reality system was developed that can visualize 4D models on mobile devices (phones, tablets) in real time and as a part of a real environment.
- They developed a system for remote sensing and remote surveillance where, based on optical and TerraSAR satellite images and Lidar measurements, hierarchical urban and non-urban scene interpretation tasks are implemented, considering 4D data representation (3D spatial and 1D temporal dimension).
- They proposed a multi-layer segmentation approach of multi-temporal remote sensing image series for region classification and change detection.
- They introduced an approach for multi-level urban traffic analysis, based on remotely sensed data.
- They introduced novel image description techniques based on image databases, which can be used in aerial reconnaissance and classification of ground regions.
- A graph analysis based approach, focusing on giant components, was proposed for selecting and ranking various features, in particular regarding parameter vectors of multimedia databases in a geometric graph based representation.

R&D ACTIVITIES

Vehicles and transportation systems

Technology development in the fields of vehicles and transportation systems was structured by systems of aerial and road vehicles.

One of the main focuses of vehicles and transportation systems research is represented by the enabling technology field of cooperative intelligent transportation systems (C-ITS). New methods shown up in the modelling, control and filtering of cooperative systems, for the integrated methods of the design of large-scale vehicle and traffic control systems, for advanced vehicle communications technologies and for drivers assistant systems supporting the principle of autonomous drive. Fault-tolerant operation and failsafe behavior were always prevailing issues in the control systems design of aerial and road vehicles.

As driver's behavior is an inherent part of the vehicle control loop, methods were developed for modelling human behavior in the control algorithms.

A notable result of intelligent vehicles research and C-ITS applications was related to the showcase event held for the demonstration of the operation and integration of the networks of low-power road sensors in the standardized vehicle communication architecture, and as such, in the intelligent and autonomous drive. The demonstration made the benefits of the integration of the most recent vehicle communication technologies and mobility concepts in the vehicle and transportation systems applications clearly visible. It was shown how the principle of cooperation and advanced networking concepts may contribute to the sustainable development of future traffic and transportation systems.

Distributed and hierarchical control strategies were developed to improve the operational efficiency of hybrid and electrical road vehicles. In these approaches fault-tolerant control and communication methods applying reconfiguration strategies and novel topologies play a central role. Design methods were elaborated for control tasks based on smart sensors, sensor fusions and communication networks in order to improve road stability and safety and ensure economical operation. These solutions are related to research and development activities in Robert Bosch Knowledge Center and the Research Center of Vehicle Industry within Széchenyi István University, Győr.

Significant progress was achieved in the research of Electro Mechanical Actuators (EMA). A small size actuator was developed, suitable for Unmanned Aerial Vehicles (UAV), which is considered as a smart unit with its self-contained control and fault detection algorithms, hosted onboard the actuator. In project ACTUATION2015 FP7 they also developed modern, optimization based servo control and force-fight mitigation control techniques with their corresponding mathematical modelling aspects.

A novel safety-critical avionics architecture able to remain operational in the event of single component failures was developed for light-weight Unmanned Autonomous Vehicles (UAVs). This capability is essential for the future integration of flying UAVs into the common airspace. A vision based sense-and-avoid (SAA) crash avoidance detection system was developed for the same purpose, which provides the necessary information for the autopilot about the surrounding air traffic. By means of automatic visual detection, the aircraft is able to mitigate the risk of collision by fusing information from the actual motion information and the predicted path of the intruder aircrafts. The first flight test results with the system were promising. Advanced reconfigurable flight control algorithms were researched and developed, which facilitates the automated handling of off-nominal events and optimize the aircraft status and flight while keeping its safety level in compliance with current regulations. The algorithms developed make automatic reconfiguration of the aircraft recover its optimal flight conditions after any disturbing events. The institute works in close collaboration with Airbus, who provides the assessment of advanced methods and oversees the potential future adoption of the methods developed.

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 2013 they 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 were 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 2013 are as follows:

- In the RLW Navigator EU project, with special regard to the requirements of industrial partners such as Jaguar Land Rover and Comau, methods were elaborated for configuring and planning, programming and simulating the operation of robotic remote laser welding workstations. All the methods were integrated into an interactive planner and decision support system.
- In the frame of international cooperation a manufacturing capability model was developed that makes it possible to select, coordinate and realize different services in the design and manufacturing life cycle phases of the product by applying cloud computing technology.
- They completed the initial specification of the planning and sequencing software for Audi Hungária Motorgyár, and they also developed the first solvers.
- Within project ADVANCE EU FP7, coordinated by them, an advanced predictive-analysis-based decision support system was developed, especially targeting deployment in logistics. The solution uses data mining, machine learning and optimisation techniques to aggregate structured but locally constrained data, as well as obtaining information for local operative decisions to minimise deadheading traffic, issue early warnings for unfulfilled requests or anticipate changes in data supplied by business partners.
- New sheet forming technologies without die application were developed, solving in parallel the connected CNC and robot control problems. Additional new results were achieved in the field of heat-assisted sheet forming by shaping thermoplastic polymer plates by using local dynamic heating.
- ETL processes of data warehouses were built up on NoSql-base, and the resulted Big DATA solution proved to be quicker than the classical, Sql-based technology, with orders of magnitude. The results were demonstrated through business intelligence models of wind farms in a prototype application.
- In international cooperation, innovative and integrated quality, production logistics and maintenance design, management and control methods as well as advanced technological enablers were surveyed with special emphasis on their impact on overall production quality. New interactions were highlighted, together with main challenges and opportunities for manufacturing industries in this context.

Most of the above results were 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 seven 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:

- Control and supervision of energy production systems: one of the strategic collaborations of the institute with the industry was the traditional cooperation with Paks Nuclear Power Plant for more than two decades. The institute provides consulting and other project specific support for the refurbishment of the existing instrumentation and control (I&C) systems and in the preparation of other related future projects. The main tasks in 2013 were related to the upcoming refurbishment of the Rod Control System (RCS) that basically influences the safety features of the reactors. The preparatory work for the reconstruction of the Reactor Power Control System (RPCS), the design update of the Universal Test System (UTS), moreover, the formulation of the protocols ensuring interoperability between the connected control systems of the Nuclear Power Plant are ongoing. The delegated experts participated in the investigation of failures occurred in the instrumentation and control systems, occasionally, and also in the repair of the faulty equipment. They were invited to participate in the I&C expert tasks for the preparation of the new reactor unit innovation project.
- In assignment of the multinational energy service provider company E.ON, the nationwide maintenance planning and scheduling practice of the company was reviewed and modelled. A new planning method was suggested whose benefits – lower costs and higher service levels – were demonstrated via computational studies on a detailed mathematical program.
- In the E+GRID project, in cooperation with GE Hungary, the controller of an intelligent, energy-positive public lighting system was implemented. The controller and all other elements of the IT architecture passed the factory tests. Field deployment is underway; the full system will be operational at the premises of MFA in 2014.
- In a joint research with Hitachi Corp., methods of model recognition out of large-scale point cloud data were applied to recovering the 3D model of a European power plant.
- Within the VERYSchool EU project, the comprehensive integrating platform VSNavigator was developed, with the main purpose of supporting the energy efficiency assessment of public school buildings, and building up functionalities facilitating energy management decisions.

Security and surveillance

The CERT (Computer Emergency Response Team) activity has been performed since January 2000. The "Hun-CERT" activity is partly financed by the Council of Hungarian Internet Providers. Network security related tasks are carried out for more than 40 Hungarian Internet Service Providers (e.g., NIIF, Hungarian Telekom, UPC, GTS-Datanet, etc.). The webpage www.cert.hu is maintained as part of this activity. In 2013 more than 200 network security incidents relating to Hungarian computer networks – but reported from outside Hungary – were handled.

They developed the integrated 4D (i4D) pilot system for the reconstruction and visualisation of complex spatio-temporal scenes by integrating two different types of data: outdoor 4D point cloud sequences recorded by a car-mounted Velodyne HDL-64E LIDAR sensor, and 4D models of moving actors obtained in an indoor 4D Reconstruction Studio. The main purpose of the integration is to measure and represent the visual world at different levels of detail. Innovative solutions are offered in various application areas, among other things 4D virtual city reconstruction, protecting collective properties in urban environment, 4D video surveillance, augmented reality and telecommunication.

Novel results were achieved in the field of sensor networks by fusing multiple cameras and imaging modalities:

- Registration of depth, infra- and optical camera images for improved target localization and tracking.
- Proposing multi-camera based procedure, for accurately localizing people walking on arbitrary non-flat ground in 3D.
- Processing images of distributed ad-hoc sensor networks for location-dependent visualization and panoramic image reconstruction.

The WaterScope microbiological monitoring device, based on the digital holographic microscope with increased speed was applied at the Budapest Waterworks and BACSVIZ Waterworks in 2013. Thanks to the continuous monitoring, a new water filter cleaning protocol was developed at BACSVIZ, which guarantees wormless filters.

“Chaoster: Context-aware collaboration platform for crisis/chaos management based on the concept of emergent interoperability” the in-house project combines exploratory and applied research in the field of crisis management. In the project PSN basic network technology was established and built into three specific experimental mobile applications. A simulation system with reality integration that serves as the research infrastructure basis to develop distributed crisis management algorithms was created.

Networks, networking systems and services, future internet technologies

The importance of this field is unquestionable. Horizon 2020 also 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.

Results achieved in 2013 are summarized as follows:

- *Grid and Cloud computing:*
 - In the framework of project FP7 SCI-BUS the so-called Data Avenue service was developed. The basis of this service is a high-level grid/cloud middleware that allows the efficient transfer of even very large data files between different kind of grid and cloud storages, no matter what kind of data access protocol they support. Many different grid storages are supported at production level and the S3 cloud storage protocol is supported at prototype level. All these provide a uniquely flexible data transfer service compared to the other existing similar services.
 - In the framework of the Hungarian CLAKK project tools and methods were developed for the accreditation of IaaS cloud service providers. Research related to this service includes the investigation of performance analysis methods and tools for cloud infrastructures by applying a hierarchical fuzzy rule system.
 - The SZTAKI Cloud project was continued, and preparation work was done towards the creation of the MTA Cloud. Within the SZTAKI Cloud project possible solutions of the autoscaling problem were investigated. If the application running in the cloud requires more resources than available in the applied cloud, a newly developed method can be used that makes the automatic extension of the applied cloud capacity with new resources taken from other clouds possible.
 - A breakthrough in the usage of Desktop Grid technology for EGI (European Grid Initiative) user communities was achieved in the framework of project FP7 IDGF-SP (International Desktop Grid Federation Support Project).

- New, efficient algorithms were developed for task scheduling issues in heterogeneous distributed systems. As a follow-up investigation, a systematically created set of models were introduced and tested for task scheduling problems.
- Scaling techniques for clouds and cloud federations were investigated and integrated into a newly developed scaling strategy in order to reduce response time and improve QoS (Quality of Service) as well as minimizing the costly usage of cloud systems.
- 3D-Internet: the VirCA (Virtual Collaboration Arena) platform was further developed in several directions. The platform supports rapid knowledge sharing and collaboration, and is now capable of integrating physical and virtual devices in different laboratories and displaying them in an immersive virtual space.

b) Relationship between science and society

The PR activities of the institute can be characterised by social responsibility and the harmonisation of research and marketing attitudes. As to 2013, the institute can report on 50 news releases and 110 publications in the media. The information for the social media was refreshed in a daily manner. The most important innovations were demonstrated at Researchers' Night 2013 by 9 divisions, on 10 sites, with 11 programmes.

Among the services provided by the institute, SZTAKIDictionary (SZTAKISzótár 2.0) – available for users for 19 years now - has the widest application in the Hungarian society. In 2013 KOPI Online Plagiarism Search Portal was enhanced by creating a web database which now enables this service to meet the new plagiarism search requirements coming from higher education and it also gives the opportunity to process various targeted fields of the web.

The next generation mobile tourist guide of the institute, named GUIDE@HAND is applied with success at most different fields. Some examples of applying the system are as follows: event recommender (the Long Night of Museums, Researchers' Night, International Opera Festival in Miskolc, Wrestling World Championships in Budapest, CSIT'2013 conference in Yerevan, Armenia, DIPP'2013 conference in Veliko Tarnovo, Bulgaria) and tourist applications (Duna-Gerecse region, Balaton Highlands, towns of Győr, Vác, etc). Current release of GUIDE@HAND application maintains extended QR code service for art exploring and learning. This service can be easily applied in churches, monasteries, museums, collections, etc. where the GPS signal cannot be relied upon.

The aim of Sign Language Interpreter Glove project is to create an innovative, intelligent tool that helps speech- and hearing-impaired people to contact non-disabled people in everyday life in a way that is intuitive for both parties. In the project an "alpha" prototype of the interpreter glove has been developed, which contains a network system of 12 inertial sensors attached to the fingers of the glove, the accompanying central signal processing unit and a software system running on mobile phones for gesture identification and natural language processing.

III. A presentation of national and international relations

International relations

Their activity in EU FP7 was prominent, with their participation in 44 granted projects and in 8 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.

They have invaluable knowledge in the research of commercial aircraft systems and other enabling technologies of road vehicles. There were joint efforts in the research of avionic

systems relying on the cooperation with the Department of Aerospace Engineering and Mechanics at University of Minnesota, the US Office of Naval Research (ONR), European Space Agency (ESA), German Aerospace Center (DLR), moreover, with Laboratoire de l'Intégration du Matériau au Système at University of Bordeaux.

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 institute in 2013 the following ones are to be highlighted:

- *4th IEEE International Conference on Cognitive Infocommunications*, December 2-5, 2013. Budapest, with about 200 presentations;
- *International Workshop on Towards Cyber-Physical Production Systems*, October 11, 2013. Budapest, Hungarian Academy of Sciences.

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.

In the field of vehicle technology research they became the most competent academic research center in Hungary in the past decade. Based on this invaluable background of knowledge, the multi-pillar technology platform relying on the collaboration with the industry represented by the multinational R&D companies working in the field of vehicle industry, such as Bosch and Knorr-Bremse, came into existence, recently. The collaboration aims at industrialising the theoretical results obtained in the academic research, and capitalising the advances of the new technologies. The strategic involvement of the institute in the Robert Bosch Research and Technology Center in Budapest, moreover, the collaboration with the Research Center for Vehicle Technologies at Széchenyi István University, Győr, created the opportunity to conduct research for emerging vehicle technologies and applications, such as for hybrid and electric vehicles, smart sensors and visual detection.

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 2013

In 2013 new 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):

RobustPlanet Shock-robust design of plants and their supply chain networks,
(*László Monostori, Botond Kádár, FP7, 495 960 €, 2013-16*)

In the project coordinated by the institute, novel production planning, scheduling and execution technologies and business models will be developed which will change the current rigid supply chain mechanisms and the current product-based business models into collaborative and robust production networks able to timely deliver innovative product services in very dynamic and unpredictable global environments.

CloudSME Cloud based simulation platform for manufacturing and engineering,
(*Péter Kacsuk, FP7, 326 716 €, 2013-15*)

The goal of the project is to further develop the WS-PGRADE/gUSE portal framework as a cloud simulation platform service according to the needs of manufacturing industry in order to assist the development and execution of simulation packages on cloud systems.

VIALACTEA The milky way as a star formation engine,
(*Péter Kacsuk, FP7, 120 750 €, 2013-15*)

In the framework of the project the WS-PGRADE/gUSE portal framework will be adapted for astrophysics to assist the investigation of Via Lactea. Special emphasis will be put on improving the edition and debugging of astrophysics workflows and their access to large data sets.

HEXAA Higher educational external attribute authorities,
(*István Tétényi FP7, 132 872 €, 2013-15*)

The project aims at widening the application of e-infrastructures.

ChaosFIRE ChaosNet experiment in Fed4FIRE testbed,
(*László Kovács, FP7, 80 000 €, 2013-14*)

During the Future Internet Research Experiment (FIRE) joining the Fed4FIRE EU project the capacity and usability of specialised peer to peer mobile technologies of the institute are evaluated as an alternative to central service based solutions to collect and distribute sensor information in smart space urban environment.

DUSIREF Dynamic urban scene interpretation and reconstruction through remotely sensed data fusion,
(*Csaba Benedek, ESA, 150 000 €, 2013-15*)

The project is coordinated by the institute and funded by the European Space Agency (ESA) under the PECS-HU framework. The main objective of the project is high-level urban scene recognition and change interpretation based on heterogeneous Remote Sensing (RS) data sources (mainly optical and TerraSAR satellite images and LIDAR data).

NeuroCogSpace Virtual Neuro-Cognitive Space for research and development of the immersive media technologies of the future,
(Péter Baranyi, KTIA_AIK, 70,956 MHUF, 2013-15)

The goal of this project coordinated by the institute is to develop and deploy a professional neuro-cognitive virtual laboratory system, which will allow the various participating institutions to integrate their infrastructure into a single virtual space and thus conduct unique, interdisciplinary experiments.

Fraunhofer II Basic financing of further two-year operating cost of SZTAKI-Fraunhofer Project Center for Production Management and Informatics
(László Monostori, ED, 200 MHUF, 2013-15)

The main objective of the project is, on the one hand, to convey basis research related to factory of the future, and, on the other, to prove the demand for Fraunhofer-type R&D&I activities in Hungary, and in accordance with this, the preparation of a German-Hungarian common establishment, namely, Fraunhofer Hungary.

V. List of important publications in 2013

Books

1. Baranyi P Yam Y Várlaki P: Tensor product model transformation in polytopic model-based control. CRC Pr. - Taylor and Frances Group, 262 (2013)
2. Bauer P: Optimal tracking solutions applied to unmanned aerial vehicles. Lambert Academic Publishing, 241 (2013)
3. Bokor J Gáspár P Szabó Z: Robust control theory with automotive applications. Typotex Kiadó, 278 (2013)

Journal-publications

4. Benedek Cs Krammer O Janóczki M Jakab L: Solder paste scooping detection by multilevel visual inspection of printed circuit boards. IEEE T Ind Electron, 60 (6): 2318-2331. (2013) <http://eprints.sztaki.hu/7504/>
5. Doumiati M Sename O Dugard L Martinez-Molina J Gáspár P Szabó Z: Integrated vehicle dynamics control via coordination of active front steering and rear braking. Eur J Control, 19 (2): 121-143. (2013) <http://eprints.sztaki.hu/7289/>
6. Egri P Váncza J: A distributed coordination mechanism for supply networks with asymmetric information. Eur J Oper Res, 226 (3): 452-460. (2013) <http://eprints.sztaki.hu/7549/>
7. Földesy P: Current steering detection scheme of three terminal antenna-coupled terahertz field effect transistor detectors. Opt Lett, 38 (15): 2804-2806. (2013) <http://eprints.sztaki.hu/7649/>
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12. Kocsis L György A N. Bán A:

- BoostingTree: parallel selection of weak learners in boosting, with application to ranking. Mach Learn, 93 (2-3): 293-320. (2013) <http://eprints.sztaki.hu/7562/>
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 14. Kornai A: Digital language death. Plos One, 8 (10): 1-11. Paper e77056. (2013) <http://eprints.sztaki.hu/7564/> OA: <http://www.plosone.org/article/fetchObject.action?uri=info%3Adoi%2F10.1371%2Fjournal.pone.0077056&representation=PDF>
 15. Kovács A Egri P Kis T Váncza J: Inventory control in supply chains: Alternative approaches to a two-stage lot-sizing problem. Int J Prod Econ, 143 (2): 385-394. (2013) <http://eprints.sztaki.hu/7557/>
 16. Marosi A Kovács J Kacsuk P: Towards a volunteer cloud system. Future Gener Comp Sy, 29 (6): 1442-1451. (2013) <http://eprints.sztaki.hu/7509/>
 17. Marx D: Tractable hypergraph properties for constraint satisfaction and conjunctive queries. J ACM, 60 (6): 1-51. Paper 42. (2013) <http://eprints.sztaki.hu/7531/>
 18. Mészáros Cs: On sparse matrix orderings in interior point methods. Optim Eng, 14 (4): 519-527. (2013) <http://eprints.sztaki.hu/7543/>
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 26. Zsedrovits T Zarándy A Vanek B Péni T Bokor J Roska T: Estimation of relative direction angle of distant, approaching airplane in sense-and-avoid. J Intell Robot Syst, 69 (1-4): 407-415. (2013) <http://eprints.sztaki.hu/7288/>