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Annual scientific awards of the Division IV Technical Sciences of the Polish Academy of Sciences in 2008

For many years it has been a great tradition of the Division IV of Technical Sciences of the Polish Academy of Sciences to recognize the outstanding achievements of young scientists with several Awards related to various fields of technology. The awarded candidates have to satisfy the requirements specified in suitable Regulations. In 2008 the Scientific Award Fund of the Division IV was supported by the well known international Siemens company which significantly augmented the status of the Awards. The list of Awarded Winners and the brief description of their achievements prepared by the authors are as follows.

In the field of Mechanics:

Discrete model of dynamics of grain collisions in granular material flows

Jacek Leszczyński
Częstochowa University of Technology

Fractional calculus is a natural extension of classical integer-order calculus. At present fractional operators offer the physics and engineering communities a useful tool for mathematical modelling many hyper-complex processes in nature. In a mathematical point of view, unlike derivatives of integer order, which depend only on the local behaviour of the function, derivatives of fractional order accumulate the whole history of the function in weighted form. Sometimes the operators are so called operators with memory or operators with history. Within this background my first experience focuses on elaboration of numerical schemes for ordinary differential equations where a mixture of integer and fractional derivatives are included. Going step forward I dealt with numerical solutions of fractional differential equations where initial and boundary conditions are considered. Therefore, I am coauthor of the Fractional Finite Difference Method (FFDM) and its application to numerical solution of anomalous diffusion. Extending my scientific activity I tried to apply fractional calculus in mechanics. Using the Discrete Element Method (DEM) I focused on mathematical modelling of a collision process in granular flows. I elaborated a model of the repulsive force, acting between a pair of colliding particles, in general form called the fractional interaction law. Within this activity I have published the monograph which developed my scientific career. At present I try to apply fractional calculus in mathematical modelling of hyper-complex processes, e.g. for continuous description of granular dynamics.

In the field of Electrotechnics:

Application of artificial intelligence methods and adaptive techniques for improvement of power system protection operation

Waldemar Rebizant
Wrocław University of Technology

The subject of Scientific Prize awarded to Dr. Waldemar Rebizant (Ph.D., D.Sc., Assc. Prof.) was a set of publications under the general topic of "intelligent methods and techniques for solving contemporary problems in power system protection and control". Within the period of assessment (2004–2008) the Laureate published 40 scientific works, i.e. one habilitation monograph issued in 2004, 12 papers in Polish and international journals (6 Polish, 6 abroad) as well as 27 papers in conference proceedings (9 Polish, 18 abroad). For a part of developed solutions a number (6) of patent applications have been prepared to gain protection of intellectual property rights. The following are the most significant achievements of the Laureate:

- development and thorough testing of a series of adaptive algorithms for power system protection criteria measurement, being insensitive to signal frequency changes in a wide range,
- development of adaptive decision-making procedures and neural classification units for synchronous generator protection against out-of-step and protection stabilization for the cases of generator-close external faults,
- development of new methods for correction of secondary current of saturated current transformers, with use of both algorithmic approach and artificial neural networks,
- development and optimization of the method for high impedance faults detection in power transmission lines with use of the wavelet transform,
- application of genetic algorithms for structure optimization of artificial neural networks, being utilized for solving of selected classification tasks in power system protection.

In the field of Electronics:

Bases of the automated design of reprogrammable parallel processing units for real-time systems on a chip

Oleh Masliennikov
Koszalin University of Technology

The monograph is devoted to the development of methodological bases for design of parallel processing units with VLSI processor array architectures destined to implementation in reconfigurable devices like as FPGAs (Field Programmable Gate Arrays). A special attention in this research directs to development and improvement of methods, which: allow to design these architectures together with the processor element control units (or executing programs for all processor elements in the array) in an nearly automatic way; provide a tolerance of the target processor units to transient faults in the algorithm level; allow to use (in a mixed analogue-digital system on a chip) the processing units based on the current-mode gates, which guarantees the high level noise immunity of chips which contain both analogue and digital circuits.

The main author achievement is the introduction of two conceptions of the target parallel architecture control, named autonomic control and local control. Based on these conceptions, the method for systematic generation of executing programs for processor elements of the parallel ASIC or FPGA-based processing units has been designed, as well as the automated procedure for realization of the local control conception has been proposed. Moreover, the approach to decomposition of the processor array structure into several substructures with nearly equal hardware overheads has been proposed, which is destined to effective implementation of fixed-size processor arrays in dynamically programmable FPGAs.

In the field of Material Engineering:

Influence of mechanical static and dynamic stresses on durability and anticorrosive properties of passive layers

Juliusz Orlikowski
Gdańsk University of Technology

Tensile process of aluminium alloys and stainless steel exposed to electrochemical environment is accompanied by numerous electrochemical phenomena, the reasons of which depend on both mechanical and electrochemical factors. Identification and description of these phenomena is of fundamental importance. During investigation the impedance investigations carried out during a tensile test of aluminium alloys and stainless steel till rupture. The impedance measurements were performed using a dynamic electrochemical impedance spectroscopy (DEIS) technique. It was found that a phenomenon of mechanical cracking of a passive layer occurs in the elastic range which results in significant breakdown of barrier properties of the layer and thus in an initiation of corrosion processes on the samples' surface. In the plastic range oscillatory changes of electrochemical properties of the samples were identified. The DEIS measurements were conducted under different electrochemical (various levels of anodic polarization) and mechanical (various strain rates) conditions in order to identify and evaluate the factors influencing a dynamics of changes of electrochemical properties of the alloys.

In the field of Informatics:

Late work scheduling in shop systems

Małgorzata Sterna
Poznań University of Technology

The series of works by Małgorzata Sterna contains theoretical and experimental results for some selected scheduling problems with dedicated machines and the late work criterion. These problems involve assigning in time some restricted resources, such as specialized machines, to the set of tasks in order to complete them under the imposed constraints minimizing the size of their late parts. Such models represent many practical problems in a natural way. "Machines" and "tasks" may correspond to different real-world objects such as industrial machines, specialized workers, customer orders or stages of software development project. The series of works can be considered as monographic one, since it is devoted to some specific scheduling problems. On the other hand, it contains various scientific results. They include theoretical results concerning the complexity status of some selected scheduling problems as well as experimental results involving different optimization methods: exact and heuristic ones. The research on classical theoretical models was completed with an example of a practical application of the late work criterion in optimizing production plans in a real flexible manufacturing system. The works present the proofs of NP-hardness for some problems and of optimality features for other ones. They contain the proposals of dynamic programming algorithms, branch and bound methods as well as metaheuristic strategies such as: genetic algorithm, simulated annealing, tabu search or variable neighborhood search, together with the analysis of extended computational experiments. As the scheduling theory itself, the research reported in the presented series of works was strictly related to other scientific domains such as: operational research, complexity theory and graph theory.

In the field of Building Engineering:

Non-linear analysis of pounding-involved response of equal height buildings under earthquake

Robert Jankowski
Gdańsk University of Technology

Earthquake-induced structural pounding between buildings may result in considerable damage or even lead to collapse of colliding structures. The aim of the work is to conduct a detailed non-linear investigation on pounding-involved response of two equal height buildings with different dynamic properties. First, a verification of the effectiveness of different pounding force models is conducted by comparing the results of numerical and experimental analyses. Then, theoretical and experimental approaches are employed to determine the parameters of the non-linear viscoelastic model. The idea of impact force response spectrum for earthquake-induced structural pounding is considered in the next part. Then, the non-linear analysis is conducted for pounding of buildings modelled as elastoplastic multi-degree-of-freedom lumped mass systems. Finally, a detailed three-dimensional pounding-involved study is carried out under uniform and non-uniform earthquake excitation using the FEM with the non-linear model of material behaviour. The results of the study indicate that the proposed non-linear viscoelastic model is the most precise one in modelling the pounding-involved response of structures. The analytical approach has led to derivation of a formula describing the relation between the impact damping ratio and the coefficient of restitution for the model, whereas the experimental investigation has shown a wide range of model's parameters for different building materials. Further analyses show that collisions have a significant influence on the lighter building, whereas the behaviour of the heavier building has been found to be influenced only negligibly. The results of FEM study indicate that the non-uniform ground motion excitation may considerably influence the pounding-involved behaviour.

In the field of Metrology:

Indirect measurements using techniques of mathematical modelling to investigate the respiratory system

Adam Polak
Wrocław University of Technology

The monograph shows new possibilities of planning and performing indirect measurements of complex object properties that result from the development of mathematical and computer modelling techniques, the advance in the techniques of mathematical model transformations and their use in indirect measurements, as well as from the computational potential of microprocessor-based measuring instruments. The monograph includes: theoretical fundamentals of direct and indirect measurements, issues of the assessment of their accuracy and the role that electronic microprocessor-based meters play in non-invasive medical measurements, principles of the elaboration and validation of physico-mathematical models and their role in solving the forward and inverse problems, methodology of the transformation of complex forward models into inverse ones with the use of computer simulations, model reduction and sensitivity analysis techniques, and problems of the non-invasive measurements of complex object properties consisting in the estimation of the inverse model parameters together with the ways of their accuracy evaluation. All theoretical considerations were illustrated by the examples of investigations with one of the most complex human physiological structures, i.e. the respiratory system. The primary cognitive issues, complex forward models, their reduction, inverse models used in indirect measurements and chosen measurement methods of respiratory mechanics were described.

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The suitable procedure aiming at the determination of the Award'2009 Winners has just started.