

PROCESS TOMOGRAPHY

Kostadin Brandisky, Andrzej Romanowski, Krzysztof Grudzień, Dominik Sankowski: **Electrostatic Field Simulations in the Analysis and Design of Electrical Capacitance Tomography Sensors** • Automatyka 2010, t. 14, z. 3/2

Electrical Capacitance Tomography (ECT) is used in many industrial processes for visualizations and determination of flow parameters. The analysis of the electrostatic field in ECT sensors and the computation of capacitances and sensitivities, are of key importance in designing better sensors. Especially analysis 3D measurements sensor space can give information in order to better interpret the capacitance changes during monitoring industrial processes using ECT system. In this paper the electrostatic field analysis of ECT sensors is considered and the opportunities it gives for the sensor design are outlined. The simulation results are compared to real measurements value obtain from 12-electrodes ECT system.

Keywords: *Electrical Capacitance Tomography, electrical field analysis, gravitational flow of granular material*

Henryk Fidos, Radosław Wajman, Robert Banasiak, Jarosław Sowiński, Dominik Sankowski: **Application of Electrical Capacitance Tomography System for Non-Invasive Phases Distribution Detection in Gas-Liquid Mixtures** • Automatyka 2010, t. 14, z. 3/2

The aim of this paper is to show the capabilities of the Electrical Capacitance Tomography (ECT) system as a technique for real-time three-dimensional examination of the parameters of the two phase flow structure. The main advantages of the ECT method over other techniques is a fact that this is a non-invasive, non-intrusive and, in addition, a very fast technique for investigation of the distribution of any dielectric materials. The ECT image provides the information about the flow fraction profile. Due to the high speed of ECT measurements it is possible to find out the velocity profile and mass flow rate.

Keywords: *Electrical Capacitance Tomography, two-phase flow, gas-liquid mixtures, raw data, image reconstruction*

Krzysztof Grudzień, Eric Maire, Jerome Adrien, Dominik Sankowski: **Analysis of Funnel Flow in Rectangular Silo Based on ECT Data** • Automatyka 2010, t. 14, z. 3/2

About 60% of solid state industrial products appear, at some stage of production, as powders or grains. Many of them are stored in containers, majority in silos. The most popular shape type of silo is cylindrical, but very often rectangular silos are used, mainly in mining or construction industry. One of the characteristic points of the bulk solids flow are dynamic volume changes during processes of receptacle unloading. The paper presents results of Electrical Capacitance Tomography application to monitoring sand concentration distribution inside model of rectangular silo. The silo construction causes a funnel flow of sand after opening the outlet. ECT allows in non-invasive way to track the changes of funnel size and sand concentration in funnel zone. Paper presents post-processing methods application for reconstructed image analysis in order to estimate the main parameters of funnel. Additionally the results of experiments allow to investigate the influence of wall roughness and initial sand density on the silo process discharging. The results are compared with data received from X-ray tomography system in order to determine the accuracy of ECT.

Keywords: *electrical capacitance tomography, gravitational flow, X-ray tomography*

Krzysztof Grudzień, Maciej Niedostatkiwicz, Jerome Adrien, Laurent Baobout: **Application of Particle Image Velocimetry Method for Monitoring the Volume Changes during Silo Flow on the Basis of X-Radiographs** • Automatyka 2010, t. 14, z. 3/2

Particle Image Velocimetry (PIV) technique, as an optical method of flow visualisation, is based on the numerical analysis of successive pairs of digital photographs (CCD camera). It is typically used to obtain the time dependent field of velocity distributions of flowing material. In case of silo flow PIV methods allows to analyse of the volumetric strain in sand during silo discharging process. Monitoring of granular materials volumetric strain in silos is crucial for construction site safety. Authors are presenting application of PIV method for analysis of a bulk solid deformation during silo

emptying to images obtained using X-ray, continuous exposure based radiographs. Analysis of radiograph images enables to gather the additional information, comparing to classical input data for PIV-digital photographs, about the volume changes, especially in the core of flow and above the outlet. Results are presented as volumetric strain changes for selected time points of the silo emptying process.

Keywords: *X-ray radiography, Particle Image Velocimetry, silo flow*

Paweł Kapusta, Michał Majchrowicz, Robert Banasiak: **Applying Parallel and Distributed Computing for Image Reconstruction in 3D Electrical Capacitance Tomography** • *Automatyka* 2010, t. 14, z. 3/2

The main goal of this article is to describe the set of solutions based on the OpenCL and Xgrid technologies that would accelerate image reconstruction calculation process in 3D Electrical Capacitance Tomography. The authors propose a new idea of performing the image reconstruction process by combining graphic cards and parallel programming techniques using OpenCL technology with distributed computing based on Xgrid clusters.

Keywords: *Electrical Capacitance Tomography, OpenCL, Xgrid clusters, high-performance computing*

Bartosz Matusiak, Andrzej Romanowski, Marco Jose Da Silva, Sebastian Thiele, Uwe Hampel: **Experimental Capacitance Planar Array Sensor Design for Flow Monitoring in Fluidized Bed** • *Automatyka* 2010, t. 14, z. 3/2

Many different methods can be used to monitor the process in the industry. However, the visualization of phase distributions in a wide range of processes is still a challenge. In this paper we would like to present the planar array design of capacitance sensor, which might be used for this purpose in fluidized beds. The developed sensor is 706 mm long, 86 mm wide and consists of 16×64 electrodes, what gives 1024 measurement points. It was placed inside an experimental fluidized bed column and applied to monitor flow regimes.

During the experiments the sensor was connected to a recently developed capacitance measuring apparatus, which was already evaluated with a wire-mesh sensor. Since the proposed design is expected to reveal changes only by the surface, due to its planar structure, we performed a numerical analysis of sensor sensitivity, as well.

Keywords: *capacitance planar array sensor, flow monitoring, fluidized bed*

Jacek Nowakowski, Erling Hammer, Dominik Sankowski, Dariusz Styra, Radosław Wajman, Robert Banasiak, Andrzej Romanowski:
Multimodality Measurement Data Fusion in Image Reconstruction for Multiphase Flow Measurements • *Automatyka* 2010, t. 14, z. 3/2

The multiphase flow measurements are very important tasks in many areas of industrial processes applications. The image reconstruction algorithms allow to visualize cross section of a flow (2D) reconstruction or 3D volumetric reconstruction. In many industrial applications for process control it is not necessary to perform image reconstruction resulting high-resolution image. The main goal is to offer method of accurate measurement and precise and robust calculation algorithm leading to phase fraction calculation. The submitted paper presents results of theoretical research and experiments performed both in the University in Lodz and University of Bergen using installed there multi phase flow rig. The paper shows possibilities of applying both image reconstruction algorithms for data obtained from electrical impedance and capacitance tomography and combining it with data obtained simultaneously from gamma sensors.. The experiments showed applicability of assumed approach and good concordance of data obtained from measurements with real parameters of a flow.

Keywords: *instruction, multiphase flow, ECT, gamma ray tomography*

Jacek Nowakowski, Erling Hammer, Dominik Sankowski, Dariusz Styra, Radosław Wajman, Robert Banasiak, Andrzej Romanowski:
New Concept of ECT/ERT/GRT Tomography for Multiphase Flow Measurements • *Automatyka* 2010, t. 14, z. 3/2

The multiphase flow measurements are very important tasks in many areas of industrial processes applications. One of them is

undersea exploration of oil in the petroleum industry. The submitted paper presents application of multi modality: capacitance, impedance and gamma ray tomography for performing measurements of a flow composed of sea water, oil and gas flow, theoretical principles applied to design multimodality tomograph and results of experiments performed in University of Bergen. The experiments were done using ECRT tomograph designed and built in Technical University of Lodz and combined measurements of signals acquired from all measuring modalities. Measurement confirmed that multi modality approach allows to give fast and reliable on-line results of measurements of composition of multi phase flow. Applied algorithm allowed to speed up on-line measurements and presented results in a form required in industrial applications. The derived conclusions can be used as a guidelines for preparation of industrial applicable construction of tomograph.

Keywords: *multiphase flow, ECT, gamma ray tomography*

Zdzisława Rowińska, Jarosław Gocławski, Joanna Sekulska-Nalewajko: **The Perspectives of Applying OCT Technology to the Investigations of Selected Biological Materials and Processes** • *Automatyka* 2010, t. 14, z. 3/2

Optical Coherence Tomography is 3D imaging technology, which can produce high resolution cross-sectional images of biological issues in vivo and in real time. OCT perfectly fills apparent gap in depth/resolution feature space existing between confocal microscopy and ultrasound methods. The paper explains the concept of OCT method and presents the review of some measurement systems currently offered by most advanced producers and some existing applications used in medicine and biology. The authors suggested the new proposals of applying OCT to some biological investigations e.g.: the estimation of topological changes of wheat roots cultivated in the presence of heavy metals, the evaluation of spatial changes of plant tissues caused by biotic and abiotic stressors.

Keywords: *OCT, optical coherence tomography, polarization, interferometer, confocal microscopy, noninvasive imaging, Swept-Source OCT*

Mariusz R. Rząsa: **Influence of Quality of the Sensitivity Map and the Reconstruction Method on the Result of Concentration Measurement in the Gas-Liquid Flow** • *Automatyka* 2010, t. 14, z. 3/2

The paper presents the results of tests on influence of quality of the sensitivity map generation on the image reconstruction. The sensitivity maps were generated with use of the methods of solution of the Poisson's equation for different numbers of the network nodes for the finite element method. The sensitivity maps generated in such a way were applied for determination of the volume fraction of some chosen structures of the gas-liquid flow. The optimum selection of a number of nodes of the finite element network for determination of sensitivity maps was considered. The results were also related to analysis of influence of the image reconstruction methods and influence of these methods on the measurement results. The paper contains many experimental data shown as the graphs.

Keywords: *capacitance tomography, gas-liquid flows, volume fraction*

NEURAL NETWORKS

Lidia Jackowska-Strumiłło: **Analytical and Neural Correctors of Temperature Sensors Dynamic Errors** • *Automatyka* 2010, t. 14, z. 3/2

The paper presents comparison of analytical and neural correctors of temperature sensors dynamic errors. Classical serial correction method using convolution equation is described and also ARX (*AutoRegressive with eXogenous variables*) model of the corrector is developed. A new correction method by means of *Artificial Neural Networks* (ANNs), in which an inverse dynamic model of the sensor is implemented by a neural corrector is proposed. Feedforward multilayer ANNs and a moving window method are applied. The described correction techniques are evaluated experimentally for two platinum resistance temperature detectors in sheath, immersed in water. In these working conditions, i.e. for which sensor's dynamic properties can be approximated by linear model the best corrector's performances and the shortest correction time $t_{0,05}$ are

achieved for the ARX corrector with digital moving average filter after the corrector. The results for the neural correctors are only slightly worse, but comparable. However, for the systems without filtering the best corrector's performances are achieved for the neural correctors. Obtained results indicate that the ANN-based method is less sensitive to noise interferences.

Keywords: *temperature sensors, dynamic errors correction, artificial neural networks*

Przemysław Korohoda, Joanna Grabska-Chrząstowska: **Application of Neural Networks in Kinetic Urea Modelling** • *Automatyka* 2010, t. 14, z. 3/2

In the paper an experiment aimed at verification of the thesis that the multilayer perceptron network may be successfully used to assess the intercompartmental clearance and the volumes of both compartments has been described. The results with satisfactory precision were obtained when data simulating measurements of urea in blood concentration every 10 minutes, accompanied by other numerical data available via measurement were applied. In the experiment a set of ten thousand simulated hemodialysis sessions were utilized. Additionally, it has been shown, that the high precision of assessed parameters drops rapidly while reducing the number of measurements of the concentration values to 5 and 2 during each session.

Keywords: *multilayer perceptron network, hemodialysis modelling, two-pool model*

Robert Nowotniak, Jacek Kucharski: **Building Blocks Propagation in Quantum-Inspired Genetic Algorithm** • *Automatyka* 2010, t. 14, z. 3/2

This paper presents an analysis of building blocks propagation in Quantum-Inspired Genetic Algorithm, which belongs to a new class of metaheuristics drawing their inspiration from both biological evolution and unitary evolution of quantum systems. The expected number of quantum chromosomes matching a schema has been analyzed and a random variable corresponding to this issue has been introduced. The results have been compared with Simple Genetic Algorithm. Also, it has been presented how selected binary

quantum chromosomes cover a domain of one-dimensional fitness function.

Keywords: *genetic algorithms, optimization, quantum-inspired evolutionary algorithms, building blocks propagation*

BUSINESS INFORMATION SYSTEMS

Wojciech Chmiel, Piotr Kadłuczka, Stanisław Jędrusik: **Supervised English Text Classification** • Automatyka 2010, t. 14, z. 3/2

Text classification is a growing area of research at the intersection of information retrieval (IR) and machine learning. The goal of text classification systems is to attach automatically labels to previously unseen electronic documents. These labels may indicate topics discussed in the document, the relevance of the document for a given user, the mailbox or newsgroup into which the document should be filed. Text categorization presents unique challenges due to the large number of attributes present in the data set, large number of training samples, and attribute dependencies. In this paper we present a supervised classification algorithm based on centroids method and decision trees. This paper presents comprehensive computational experiments examining the efficiency of proposed classification algorithms.

Keywords: *classification, supervised classification, decision tree, machine learning, information retrieval*

Wojciech Chmiel, Piotr Kadłuczka, Konrad Wala, Stanisław Jędrusik: **Heuristic Algorithm for Three-Dimensional Packing Problem** • Automatyka 2010, t. 14, z. 3/2

In this paper we examine the problem of optimal packing of a three-dimensional container with rectangular boxes such that the volume of the packed boxes is maximized. We investigate fast constructive procedures and an approximation algorithm based on simulated annealing. In all developed algorithms solutions are represented in a form of four sequences. Extensive computational results involving various test instances up to 400 boxes, are presented.

Keywords: *three-dimensional knapsack problem, constructive algorithm, discrete optimization, simulated annealing*

Lidia Dutkiewicz, Katarzyna Grobler, Patryk Orzechowski, Dariusz Pałka, Cezary Piskor-Ignatowicz, Marek Zachara: **Research on Automation of Web Service Building Process** • Automatyka 2010, t. 14, z. 3/2

The article presents description of a methodology and experiments concluded in order to develop a semi-natural language that can be used to describe the layout of web pages. The language is developed with the final goal of automatic web interface generation in mind. The guidelines for the construction of such language presented in this paper are drawn from the results of a real life scenario experiment when a web page layout is produced on a basis of the requirements description prepared by a group of non-professionals.

Keywords: *quasi(semi)-natural language, web interfaces*

Lidia Dutkiewicz, Edyta Kucharska: **Route Planning Algorithm for Multiple Traveling Salesman** • Automatyka 2010, t. 14, z. 3/2

The aim of the article is presenting a heuristic algorithm for NP-hard problem of planning delivery routes to multi-branch firms. This problem is a modification of well-known multiple TSP problem with additional constraints related to need of visiting some cities to make other ones available. The algebraic-logical model of the given problem is presented in the article. The proposed algorithm is based on the optimization task substituting method which uses general scheme of an algebraic-logical model. Characteristic elements of the algorithm are described: transitional goals, its priorities and way of choosing in each state a number of the goals to be accomplished. Results of experiment are also presented.

Keywords: *algebraic-logical model, discrete decision process, optimization task substituting method, heuristic algorithms*

Bogusław Filipowicz, Wojciech Chmiel, Piotr Kadłuczka, Konrad Wala: **Convex Contour for 3D Bin Packing Problem** • Automatyka 2010, t. 14, z. 3/2

The paper presents an universal method for describing of contour and insertion points that can be applied do wide class

of packing problems including two and three dimensional problems with a fixed central point. The central point specifies a place of insertion of a first package. This gives the opportunity to create several greedy algorithms acting differently from the standard algorithm, which starts packing from the left, bottom, rear corner of the container. Moreover it allows to solve container balancing problem.

Keywords: *3D bin packing problem, convex contour*

Bogusław Filipowicz, Joanna Kwiecień: **Application of Selected Algorithm Based on Swarm Intelligence in Combinatorial Optimization Problems** • Automatyka 2010, t. 14, z. 3/2

Nature-inspired metaheuristic algorithms are successfully applied to combinatorial optimization problems. They incorporate particle swarm optimization inspired by the behaviors of bird flocks. This paper presents the applying of binary particle swarm optimization to the multidimensional knapsack problem. The results of computational experiments for standard test problems have been also presented.

Keywords: *particle swarm optimization, knapsack problem*

Radosław Klimek, Paweł Skrzyński, Michał Turek: **Verification of Activity for SOA-Based Systems – Carried Out on a Use-Case Diagrams Requirements** • Automatyka 2010, t. 14, z. 3/2

The article discusses the issue of formal requirements verification for so-called “business systems” – expressed through an UML Use-Case model and Use-Case scenarios. A methodology for transformation of UML Use-Case diagrams to Activity diagrams has been described. To specify advanced system requirements a temporal logic notation was used. These requirements (encoded in such way) could be verified with a deductive inference based on semantic tables. The methods for obtaining temporal logic formulas directly from Use-Case scenarios stored in the UML Activity diagrams have also been introduced.

Keywords: *verification, temporal logic, SOA architecture, UML diagrams, Use-Case, UML Tools, UML Diagram Translation*

Radosław Klimek, Paweł Skrzyński, Michał Turek: **Automated Process Verification with a Semantic Tables Approach** • *Automatyka* 2010, t. 14, z. 3/2

This paper describes the results of work on stabilizing the methodology for formal correctness verification of processes recorded in a process model with BPMN notation. The main path of a solution is to carry out the conversion of BPMN model to set of specially designed logic formulas. Afterwards – to formal verify the correctness of formulas using the calculation provided by the authors. A semantic table method has been applied in the verification process. The approach could provide interesting alternative to the traditional approach, allowing relatively easy errors identification in the specification process.

Keywords: *verification, BPMN notation, deduction, semantic tables method, procedural patterns, extraction of formulas*

Radosław Klimek, Paweł Skrzyński, Michał Turek: **A BPQL Language Extension for Interactive Modeling and Formal Validation of UML Activity Diagrams** • *Automatyka* 2010, t. 14, z. 3/2

The article describes the results of up study on business processes modeling with semi-formal and formal methods. A new method for transformations of activity diagrams to set of formulas has been proposed in a previous work. That enables designer tools to automatically evaluate process models correctness. It could also be possible to dynamically modify process flow structure in an interactive way – with a “on the run” validation. To achieve that point a new language has been developed and described in this article.

Solution assumes an expansion for a business processes language, referred to the acronym BPQL (*Business Process Query Language*). This language syntax is very basic, and can only be used for variables definition and processing (inside a basic process symbols). It is not possible to use BPQL formulas for interactive modification of an existing process structure or a control flow between processes. Proposed high-level extension for BPQL will allow these modifications to be made – also in a scripting or an interactive mode. The main goal for a solution development is to reduce a set of language statements – only to those possible for interactive pro-

cessing. Each statement should also have a proper processing algorithm established. Each query, defined with an analogy to a typical Structured Query Language component is executed and must leave a BPMN process model intact – with validation constraints fulfilled. BPMN diagram is possible to express through a set of temporal logic formulas for validation purposes. Any execution of BPSQL query will result in a modification of these formulas. The procedure for validating the modifications to the formula remains unchanged, thus enabling the validation methods achieved as a result of earlier work. A scripting language, composed from SQL and BPSQL statements will enable quick and concurrent data structure and process behavior modeling and for future system – with a common interpreter and very similar validation system. Proposed approach will open a way to design tools enabling interactive modeling of business processes with simultaneous validation of the processes correctness. Implemented control procedures will be similar to referential database integrity checking applied by Database Management Systems while processing classical SQL data definition queries.

Keywords: *BPMN notation, process modeling, process flow validation, Database Management Systems*

Marcin Pietroń, Paweł Russek, Kazimierz Wiatr: **Prototype of Loop Profiling Tool for HPC Code Inspection as an Efficient Tool for FPGA Based Acceleration** • *Automatyka* 2010, t. 14, z. 3/2

This paper presents the research on FPGA based acceleration of HPC applications. The most important step to achieve this goal is to extract code that can be sped up. A major drawback is the lack of a tool which could do it. The HPC applications usually consist of a huge amount of complex source code. This is one of the reasons why the process of acceleration should be as automated as possible. Another reason is to make use of HLL (*High Level Languages*) such as Mittrion-C and Impulse-C. Loop profiling is one of the steps to check if the insertion of HLL to existing HPC source code is possible to gain acceleration of these applications. Hence the most important step to achieve acceleration is to extract the

most time consuming code and data dependency, which makes the code easier to be pipelined and parallelized. Data dependency also gives information on how to implement algorithms in an FPGA circuit with the minimal initialization of it during the execution of algorithms.

Keywords: *HPC, HPRC, loop profiling, Mitrion-C, DFG (data flow graph), FPGA*

Maciej Wielgosz, Ernest Jamro, Paweł Russek, Kazimierz Wiatr:
Hardware Implementation of the Polynomial Part of the Orbital Function • Automatyka 2010, t. 14, z. 3/2

The hardware acceleration module for generating the polynomial part of the orbital function in quantum chemistry calculation is presented. Both implementation and acceleration results are provided in the paper along with the comparison tests (against Itanium 2 processor). The implementation described can be regarded as a milestone on the way towards introducing an efficient hardware implementation of the exchange-correlation potential. The FPGA-based SGI RASC accelerator was used to offload a processor in the most exhausting computations of the SCF routine. The paper also covers issues regarding an integration of the PP (polynomial part) module with the rest of the computational system.

Keywords: *FPGA, quantum chemistry, Custom Computing, HPC*

WIRELESS TECHNOLOGIES AND DATABASES

Radosław Adamus, Tomasz Marek Kowalski, Kamil Kuliberda, Jacek Wiślicki, Michał Bleja: **Tools Supporting Generation of “Data-Intensive” Applications for a Web Environment** • Automatyka 2010, t. 14, z. 3/2

The article is an attempt to describe the current state of development tools whose purpose is building web applications. The article is focused on applications that rely on a relational database as a mechanism for data persistence, covered by an object-oriented application working in a client-server architecture (this should be

considered rather as a functional simplification to more complex architectures) available to end users by a web interface. The leitmotif is a thesis that the fundamental element of complexity of such applications is the impedance mismatch between data models used in storage and business logics. The thesis also claims, that a commonly accepted direction of development of such solutions does not lead to any elimination of this inconsistency, but rather tends to hide it inside a mapping layer, which may, in certain cases, lead to a counterproductive effect.

Keywords: *web, framework, database, application, development*