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COMPUTER SCIENCE MEETS AUTOMATION

VOLUME I

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Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

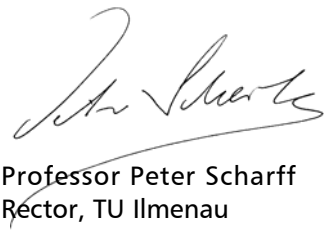
- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.
I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.



Professor Peter Scharff
Rector, TU Ilmenau

Professor Christoph Ament
Head of Organisation

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T. Kochubey/ V. Astakhov

The computation of magnetic field in the presence of ideal conductors using the integral-differential equation of the first kind

ADVANCES IN CONTROL THEORY AND CONTROL ENGINEERING

Statements of many engineering problems include necessity of mathematical modelling and computation of stationary magnetic fields in the presence of ideal conductors.

The problem of stationary plane magnetic field computation in the presence of N infinitely long cylindrical ideal conductors has been considered. Cross-sections Ω_k^- of the ideal conductors have piecewise-smooth Lipschtz's boundaries Γ_k. The following notation is used here: Γ is the union of Γ_k, Ω^- is the union of Ω_k^-, Ω^+ is an exterior domain to Ω^- with magnetic conductivity $\mu^+ = const$.

The problem of magnetic field computation has been reduced to the following plane boundary problem which in vector and scalar statement looks like:

$$\mathrm{rot}\mathbf{H} = \boldsymbol{\delta}\,,\ \mathrm{div}\mathbf{B} = \mathbf{0}\,,\ \mathbf{B} = \mu^+\mathbf{H} \text{ in } \Omega^+, \qquad \Delta\varphi^* = 0 \text{ in } \Omega^+,$$

$$B_n = 0 \text{ on } \Gamma, \qquad \frac{\partial\varphi^*}{\partial n} = B_n^0 \text{ on } \Gamma,$$

$$\mathbf{B}(M) \xrightarrow[M\to\infty]{} \mathbf{0}, \qquad \varphi^*(M) \xrightarrow[M\to\infty]{} 0,$$

$$\mathbf{B} = \mathbf{B}^* + \mathbf{B}^0,\ \mathbf{B}^* = -\mathrm{grad}\,\varphi^* \text{ in } \Omega^+ \cup \Omega^-$$

where $\mathbf{B}^0$ is an induction of non-perturbed magnetic field, $\mathbf{B}^*$ is an induction of magnetic field of reaction, φ^* is a scalar potential of magnetic field of reaction. The balance of magnetic field sources is also taken into account.

The φ^* can be represented in the form of potential of double layer. The boundary problem has been reduced in this case to the integral-differential equation of the first kind for scalar density:

$$K_{\tau\sigma}\tau = f_\tau$$

where

$$K_{\tau\sigma}\tau = -\frac{1}{\pi}\frac{\partial}{\partial n}\int_\Gamma \tau\frac{\partial}{\partial n}\ln\frac{1}{r}\,d\Gamma, \qquad f_\tau = -2B_n^0.$$

It is necessary to introduce Γ_k'' that is a closure to closed $\Gamma_k = \Gamma_k' \cup \Gamma_k''$ in case if k section is singular.

It was shown that the operator of the equation is linear, self-adjoint and positive in $L_2^0(\Gamma)$ that is Hilbert space of square-integrable functions with zero average value. It allowed to prove the availability, uniqueness and stability of the solution of the equation in the operator's energetic space [1] by applying the

variational principle and Riss's theorem.

The numerical solution of the equation is carried out by constructing the minimizing Ritz's sequence $\tau^{(1)}, \tau^{(2)}, ..., \tau^{(n)}, ...$ on the base of system of continuous piece-polynomial coordinate functions. This approach reduces the equation to the SLAE with the real positive-definite matrix.

The software package for the numerical realization of the developed theory has been created. The comparing of the results of the software package with the results of similar packages has shown that the developed software package has higher accuracy and shorter time of computation. Examples of the developed package usage are shown on Fig. 1.

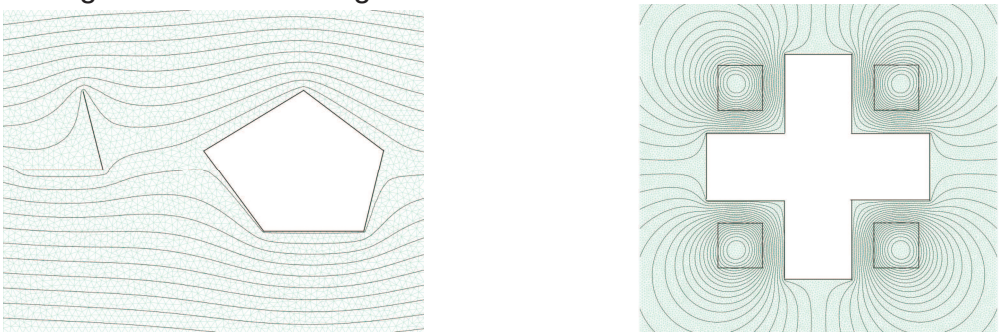

Fig. 1

References:

[1] Astakhov V. I. Surface potentials and operators of potential's theory in Dirichlet's spaces // Electromechanics. 2000. #2. p.1-18. (in Russian language)

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