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VOLUME I

Session 1 - Systems Engineering and Intelligent Systems

Session 2 - Advances in Control Theory and Control Engineering

Session 3 - Optimisation and Management of Complex Systems and Networked Systems

Session 4 - Intelligent Vehicles and Mobile Systems

Session 5 - Robotics and Motion Systems

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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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K. Shaposhnikov / V. Astakhov

The method of ortogonal projections in problems of the stationary magnetic field computation

ADVANCES IN CONTROL THEORY AND CONTROL ENGINEERING

We consider the problem of stationary plane magnetic field computation in the presence of infinitely long cylindrical ideal magnetics which have piecewise-smooth Lipschitz's boundaries Γ_k of cross-sections Ω_k. Let's introduce the following notation: Ω^-, Γ are the unions of the cross-sections and the boundaries of magnetizing bodies accordingly, $\mu = const$ is magnetic conductivity of the medium that is denoted as $\Omega^+, \Omega = \Omega^- \cup \Omega^+ \cup \Gamma$.

We have the following boundary problems for magnetic field computation:

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

$$H_\tau = 0 \text{ on } \Gamma, \qquad \varphi^* = C_k - \varphi^0 \text{ on } \Gamma_k,\ k = \overline{1,N},$$

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

where φ^* is scalar potential of intensity of reaction field $\mathbf{H}^*$, φ^0 is a potential of non-perturbed field intensity $\mathbf{H}^0$, $\mathbf{H} = \mathbf{H}^* + \mathbf{H}^\mathbf{0}$, $C_k = const$, $k = \overline{1,N}$.

We use a Hilbert space $\mathrm{H}(\Omega)$ that is introduced and studied in [1]. The inner product and the norm in $\mathrm{H}(\Omega)$ are the following:

$$(\psi_1, \psi_2)_\mathrm{H} = \int_\Omega \nabla\psi_1 \nabla\psi_2 d\Omega,\ \|\psi\|_\mathrm{H} = \sqrt{(\psi,\psi)_\mathrm{H}}.$$

According to [1], there is the orthogonal decomposition for this space: $\mathrm{H}(\Omega) = \mathrm{H}^*(\Omega) \oplus \mathrm{H}^0_\sigma(\Omega)$. The subspace $\mathrm{H}^*(\Omega)$ consists of the functions with constant value on Γ_k. $\mathrm{H}^0_\sigma(\Omega)$ consists of the functions that are represented by the potentials of simple layer with the zero mean of densities on Γ_k. We have shown that if φ^0 is in the $\mathrm{H}(\Omega)$ then φ^* belongs to $\mathrm{H}^0_\sigma(\Omega)$ and the potential of the resulting field $\varphi = \varphi^* + \varphi^0$ is in $\mathrm{H}^*(\Omega)$. Thus, the solution of the problem is reduced to φ^0 projection to subspace $\mathrm{H}^0_\sigma(\Omega)$ that can be found by the calculation of φ^0 coordinates in some basis for $\mathrm{H}^0_\sigma(\Omega)$. The coordinates is defined by the following SLAE solution:

$$\begin{bmatrix} (\varphi_1,\varphi_1)_\mathrm{H} \dots (\varphi_1,\varphi_n)_\mathrm{H} \\ \cdots \quad \cdots \quad \cdots \\ (\varphi_n,\varphi_1)_\mathrm{H} \dots (\varphi_n,\varphi_n)_\mathrm{H} \end{bmatrix} \begin{bmatrix} c_1 \\ \cdots \\ c_n \end{bmatrix} = -\begin{bmatrix} (\varphi^0,\varphi_1) \\ \cdots \\ (\varphi^0,\varphi_n) \end{bmatrix}.$$

We denote $\Gamma_j = \Gamma'_j \cup \Gamma''_j$ where Γ'_j is cross-section of this body and Γ''_j is its

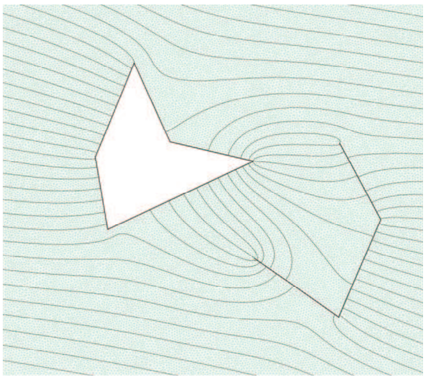

Fig. 1

closure to Γ_j in case if the cross-section of j-th magnetizing body is singular. We define that the density of φ^* is zero on Γ_j''. We have shown that the potentials with such densities form a subspace in $H_\sigma^0(\Omega)$ and all proofs are right with the change Γ_j to Γ_j'.

It is convenient to use the potentials of simple layer with finite step densities with zero mean on Γ_k as the coordinate functions. We have proved that sush system of functions is complete in $H_\sigma^0(\Omega)$ in sence of Ritzs's approximate sequence convergence. In this case the elements of SLAE are defined by the following formulas:

$$(\varphi_i, \varphi_k) = \frac{1}{2\pi}\int_\Gamma \sigma_i \int_\Gamma \sigma_k \ln\frac{1}{r} d\Gamma d\Gamma,\ (\varphi^0, \varphi_i) = \int_\Gamma \sigma_i \varphi^0 d\Gamma .$$

The computing algorithm and its software realization are developed. This package computes magnetic field faster and more effectively than the famous software packages. The example of the developed software package usage is show on Fig. 1.

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