# 52. IWK

Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium

**PROCCEDINGS** | **10 - 13 September 2007**

## FACULTY OF COMPUTER SCIENCE AND AUTOMATION

## COMPUTER SCIENCE MEETS AUTOMATION

## VOLUME II

- Session 6 - Environmental Systems: Management and Optimisation
- Session 7 - New Methods and Technologies for Medicine and Biology
- Session 8 - Embedded System Design and Application
- Session 9 - Image Processing, Image Analysis and Computer Vision
- Session 10 - Mobile Communications
- Session 11 - Education in Computer Science and Automation

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Andrea Schneider
Tel.: +49 3677 69-2520
Fax: +49 3677 69-1743
e-mail: kongressorganisation@tu-ilmenau.de

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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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52nd Internationales Wissenschaftliches Kolloquium
Technische Universität Ilmenau
10 – 13 September 2007

Matthias Hamsch, Claudia H. Igney, Marko Vauhkonen

# A Magnetic Induction Tomography System for Stroke Classification and Diagnosis

## Abstract

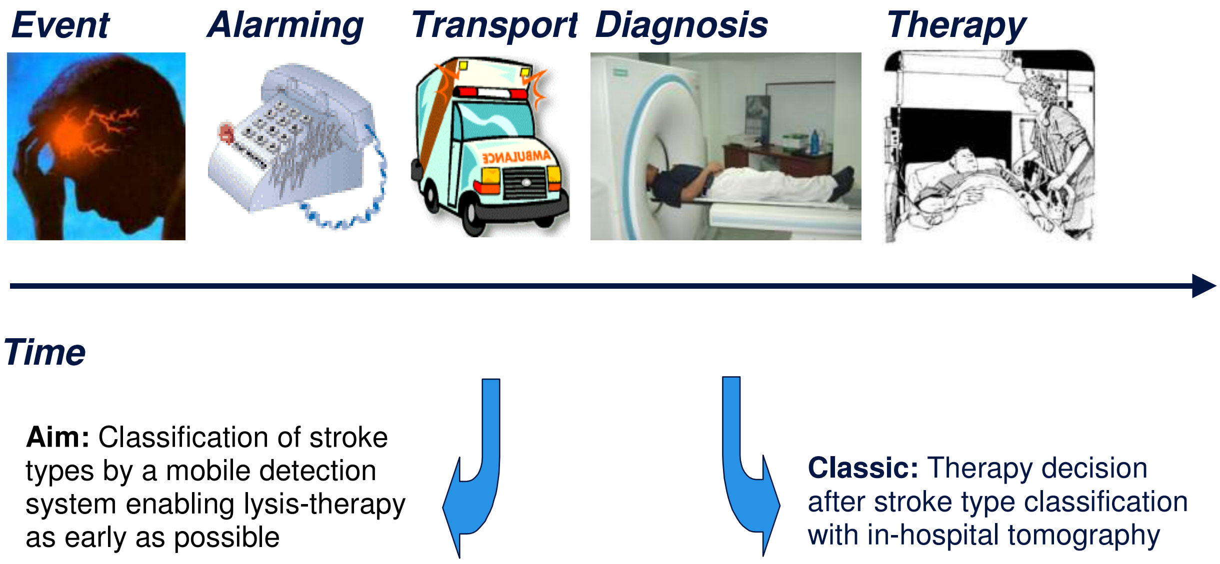
About 15 million people worldwide suffer a stroke every year. 5 million people die as a consequence of the stroke and another 5 million people become permanently disabled. While an ischemic stroke can be treated by a thrombolytic drug therapy within some hours after the stroke, the therapy would be lethal for a patient who had suffered a hemorrhagic stroke. Therefore a fast and reliable diagnosis is necessary to provide the patients with an adequate therapy.

One of the promising technologies for the fast classification of strokes is magnetic induction tomography (MIT). Magnetic induction tomography allows the reconstruction of conductivity distribution images for a wide variety of industrial and medical applications. In a medical application the MIT technique is used for acquiring information of conductivity distributions and conductivity changes in human tissue. The advantage of this technique is the contactless and non-invasive way of data collection. It is therefore also applicable for collecting information about the brain tissue.

The paper presents the setup of a 16 channel MIT system for analysis of conductivity distributions in human tissue. In addition to the description of the system measurement results of phantom objects and first reconstructed images are presented.

## I. Introduction

Annually, worldwide 15 million people suffer a stroke. Five million of these people die as a consequence of the stroke and another 5 million people become permanently disabled, placing a burden on family and community [1]. Beside reducing the major modifiable risk factors for stroke, like high blood pressure and tobacco use, it is important to provide a patient who suffered a stroke with an adequate therapy as fast as possible. While an ischemic stroke can be treated by a thrombolytic drug therapy within some hours after the stroke, the therapy would be lethal for a patient who had suffered a hemorrhagic stroke. Therefore a fast and reliable diagnosis is necessary before providing the patient with the therapy.



**Aim:** Classification of stroke types by a mobile detection system enabling lysis-therapy as early as possible

**Classic:** Therapy decision after stroke type classification with in-hospital tomography

*Fig.1 Care chain after a stroke event.*

Figure 1 presents the classic care chain after a stroke event. After alarming the ambulance the patient is carried to a hospital for diagnosis and treatment. Depending on the distance to the next hospital and the availability of CT or MRI machines in the hospital several hours are lost before the first diagnosis. A mobile stroke diagnosis system could reduce the time from alarming the ambulance to the first diagnosis dramatically. The reduced time to therapy increases the probability of a complete recovery from the stroke and reduces costs for rehabilitation. Magnetic Induction Tomography (MIT) offers a new contactless technique for a decision support system inside the ambulance by enabling the mapping and imaging of the electromagnetic tissue properties.

## II. System Description

### *A. Measurement Principle*

The multi-coil system consists of excitation and receiver coils. A sinusoidal current flows through the excitation coil and generates a primary alternating magnetic field. Typical frequencies of the sinusoidal current are in the range from 1 MHz to 10 MHz. In a conductive medium, the alternating field induces eddy currents, which are proportional to the conductivity of the medium. The eddy currents generate a secondary alternating electromagnetic field that is also proportional to the conductivity. If the skin depth is large compared to the thickness of the sample, which is generally true for biological tissues, the secondary field is nearly 90º phase shifted to the primary field [2] and can be detected by a receiver coil or a gradiometer. The measured secondary magnetic field gives an indication for the conductivity of the sample. If multiple coils are used for measuring the signal a conductivity distribution can be reconstructed.

A multi-frequency magnetic induction tomography system using planar gradiometers for the detection of the secondary magnetic field was introduced in [3]. The measurement system presented in this paper uses planar detection coils similar to the systems shown by Watson [4] or Korjenevsky [5], but improves the measurement speed by enabling a parallel readout of the 16 measurement channels.

### *B. Mechanical setup*

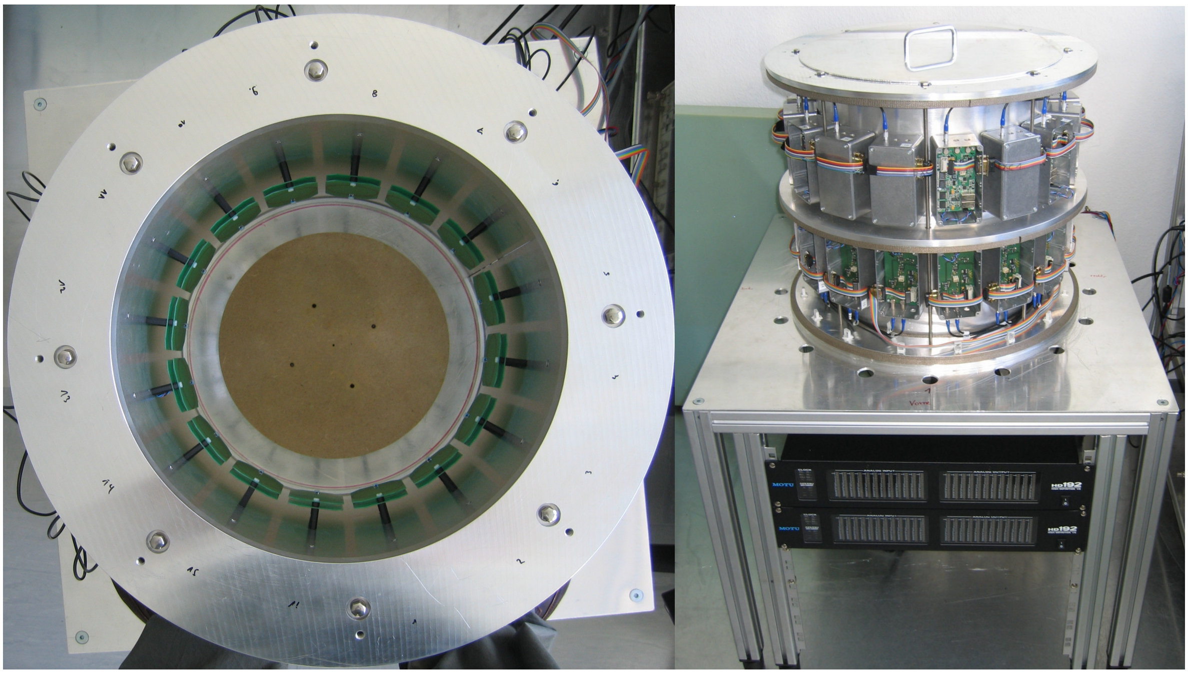


*Fig.2 MI-Tomograph: top-view (left)and side-view with electronic modules (right)*

The Philips MI-Tomograph consists of a cylindrical shaped tank made of aluminum with excitation and receiver coils mounted on the inner wall of the tank. The inner diameter of the tank is 35 cm. In the current setup 16 excitation coils are arranged circularly, shaping the outer ring of coils. The inner circle of coils is formed by 16 receiver coils (see Fig. 2 left). The coils are made of PCB material (FR4, 1 mm thick). In the current setup coils with two windings of 50 mm in diameter are used, one winding on the top layer and the other on the bottom layer of the PCB. The electronic modules that are driving the excitation coils and processing the signals coming from the receiving coils are mounted on the outer wall of the tank. Each of the electronic modules is placed in a separate metallic case for shielding purposes (see Fig. 2 right). A removable coping provides a secondary electrical shielding between the receiver and the excitation modules and reduces perturbations from the outside.

### *C. Electrical Setup*

Figure 3 shows a block diagram of the measurement setup. Two synchronized generators are used for signal generation. Signal generator 1 provides the reference signal for the excitation circuits. The signal is split up by a power splitter and is then distributed to the excitation modules. The excitation modules contain a switch to turn the excitation signal on or off. The switch is controlled by a USB converter interface box. The excitation modules amplify the reference signal to a level of about $V_{RMS} = 1.7$ V and $I_{RMS} = 50$ mA at the excitation coil.

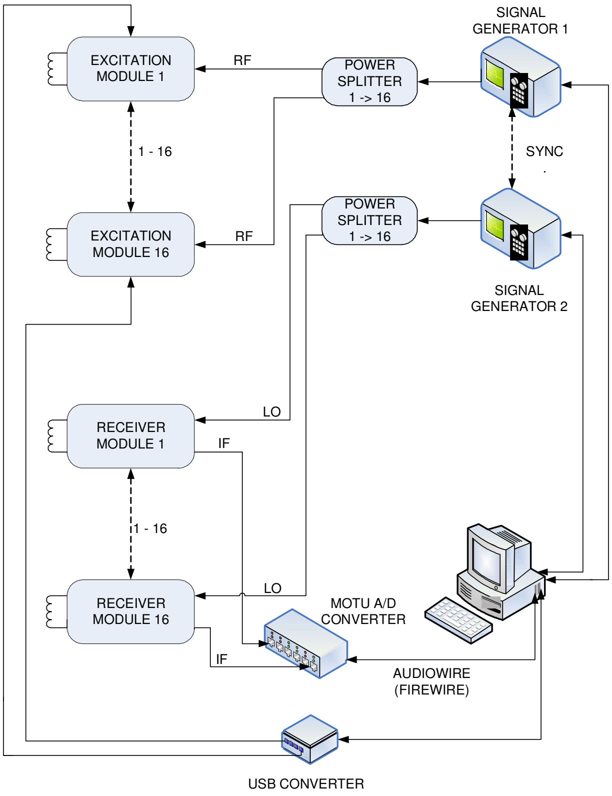


Fig.3 Block diagram of the measurement setup (RF=radio frequency, IF=intermediate frequency, LO=local oscillator signal)

The second signal generator provides the sinusoidal signal (LO) for the downconversion of the measurement signal in the receiver module. It is split up by a power splitter and then distributed to the receiver modules, too. These modules include fixed gain amplifiers for the measured signal received by the receiver coil. The receiver modules implement a downconversion of the received radio frequency (RF) signal to a lower intermediate frequency (IF). The current setup uses an RF signal of 1 to 10 MHz and an IF signal of 10 kHz. The IF outputs of the receiver modules are connected to an A/D converter device. In the current setup an audio sampling equipment is used. It allows the parallel and synchronized sampling of up to 48 channels. In addition to the possible parallel sampling of the channels it features low noise (0.0005% THD+N) and 24-bit resolution of the sampled values at a sampling rate of 192 kHz. The sampled values are transferred to a PC for further signal processing. The PC also controls the entire measurement setup. The control software is written in National Instruments Labview, a commonly used graphical programming language for measurement automation. Beside controlling the signal generators and the excitation modules it also processes the sampled data. By using pre-calculated matrices the Labview software is capable of creating images of the conductivity distribution based on the measured data set directly.

## III. Reconstructed image

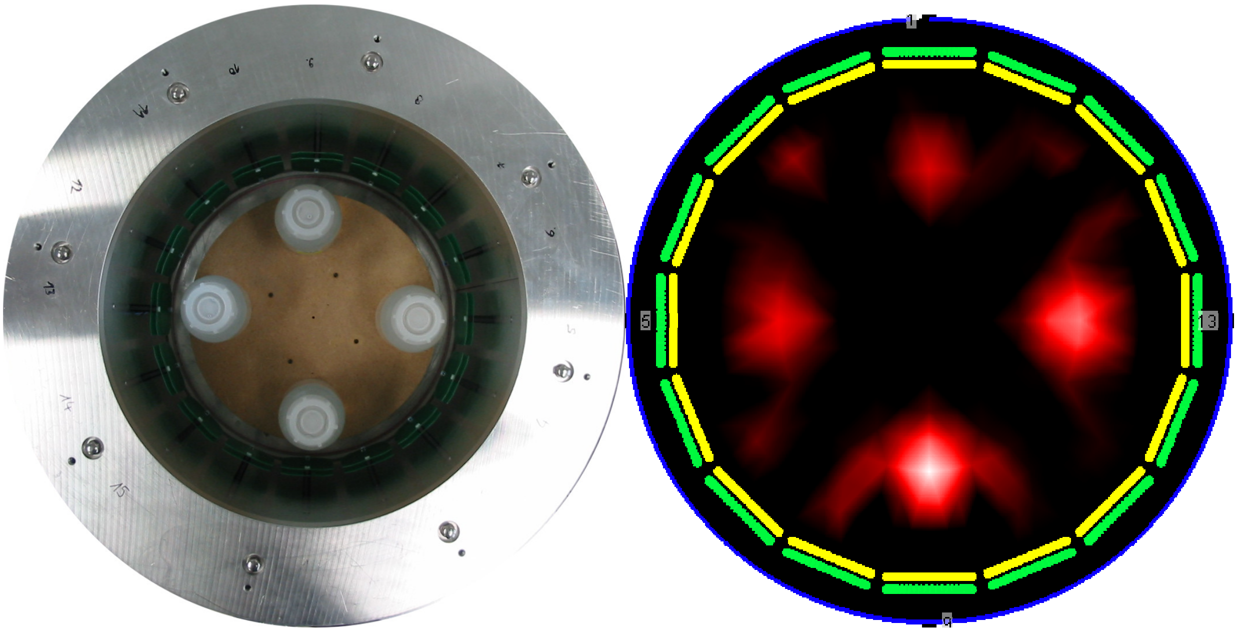


*Fig.4 Measurement setup (left) and reconstructed image (right) of 4 plastic bottles filled with saline solution (conductivities 0.5, 0.75, 1 and 1.25 Sm$^{-1}$)*

Figure 4 shows the result of an experiment with four plastic bottles, each filled with 250 ml saline solution of different conductivities. The upper bottle was filled with 0.5 $Sm^{-1}$ saline solution, the left one with 0.75 $Sm^{-1}$, the right one with 1 $Sm^{-1}$ and the lower one with 1.25 $Sm^{-1}$ solution. The left picture shows the arrangement of the plastic bottles in the tank. The right picture shows the reconstructed conductivity distribution. Details on the image reconstruction algorithm can be found in [6]. The rising conductivity from the upper to the lower bottle is clearly visible by the increasing intensity of the color.

## IV. CONCLUSIONS

Magnetic induction tomography has the potential to enable a faster stroke diagnosis in the future. A prototype of an MIT system was presented in the paper. The prototype offers the possibility to analyze phantom objects and calculate conductivity distributions from the measured values. A reconstructed image of four phantom objects was shown. Compared to other excisting MIT systems the parallel readout of all 16 measurement channels enables faster measurements. The measurement cycle needs only one-sixteenth of the time of a sequentially working system, which also leads to more reliable measurement results. Main focus of future work will be the reduction of temperature drift as well as phase noise in the system.

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**Authors:**

Dr. Matthias Hamsch
Dr. Claudia H. Igney
Dr. Marko Vauhkonen
Philips Research Europe, Weisshausstrasse 2
D-52066 Aachen, Germany
Phone: +49 241 6003754
Fax: +49 241 6003518
E-mail: Matthias.Hamsch@philips.com