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LCM – Center for Symbiotic Mechatronics

Programme: COMET – Competence Centers for Excellent Technologies

Programme line: K2 - COMET-Centre

Multifirm Project:
Integrated and embedded Sensors
Part of the Research Area Sensors and Communication

A MEASURING DEVICE FOR FAST AND ACCURATE DATA ACQUISITION FOR APPLICATIONS OF ELECTROMAGNETIC TOMOGRAPHY

APPLICATIONS LIKE ELECTROMAGNETIC TOMOGRAPHY DEMAND FOR MEASUREMENT INSTRUMENTS WITH HIGH ACCURACY ON LOTS OF PARALLEL MEASUREMENT CHANNELS IN A VERY SHORT TIME FRAME.

Introduction

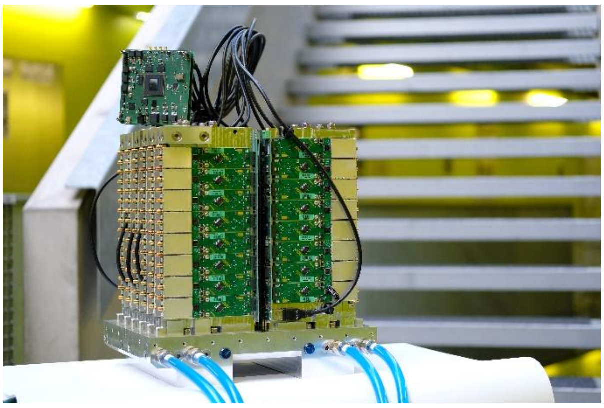
Electromagnetic tomography is a sectional image technique, which complements the known methods of computed tomography or ultrasound. In contrast to these methods, electromagnetic tomography does not depict density ratios, but the influence of the examined material or tissue on electromagnetic waves.

For measuring data which is used to obtain images, it is necessary to capture the signals from multiple antennas of a measurement setup. For this purpose, commercially available measuring devices, such as network analyzers, are only partially suitable. They are designed to measure signals with a high bandwidth, but usually have only two or four ports to connect a device under test. These instruments are very accurate, but the limited number of ports limits the use for electromagnetic tomography. In addition to that, certain targets, such as the human head, introduce significant attenuation to the measurement signal and therefore require very highly sensitive sensors and advanced shielding. This is the only way, to reconstruct the information, which is hidden in signals with power levels right above thermal noise. For this purpose, a novel measuring instrument has been developed that meets the requirements of electromagnetic tomography.

Description of the measurement system

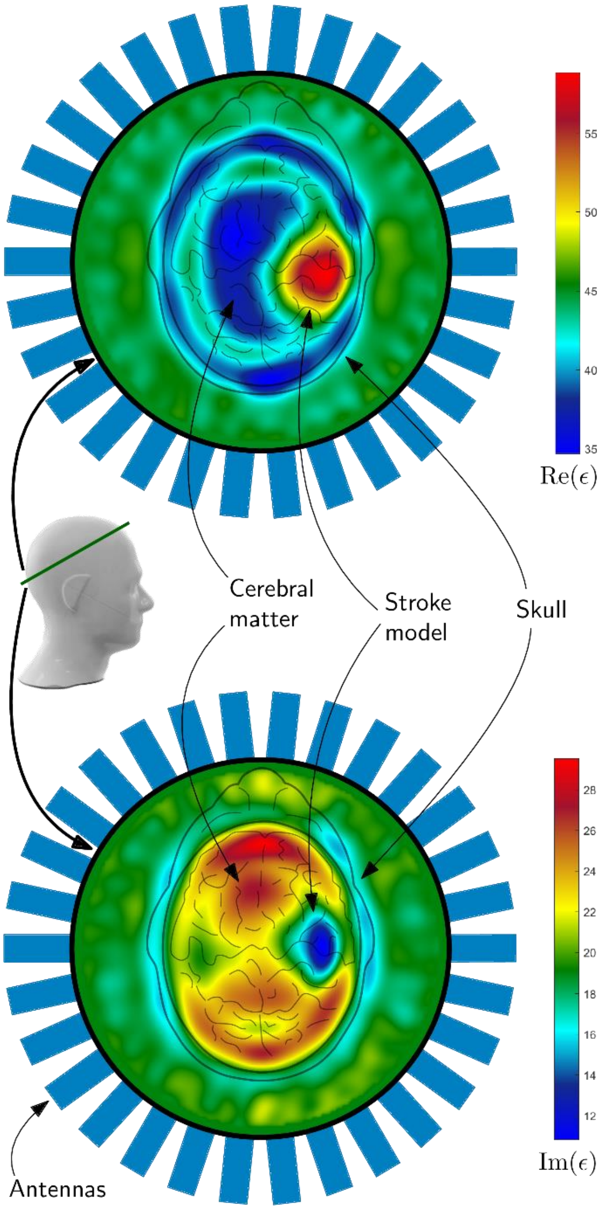
The system architecture provides distributed sensor units, which are connected by a synchronization infrastructure. The system collects data about the attenuation and phase shift of an electromagnetic wave at a signal frequency of 1 GHz from around 200 spatially distributed antennas.

Due to the architectural independence of the measurement units, individual measurements can be parallelized, which reduces the overall duration of a measurement sequence considerably.



Front view of the multiport network analyzer prototype electronics.

The system can complete an entire measurement sequence within seconds, while it can take up to hours for commercially available systems to collect the same amount of data.



Early simulation result of a phantom including a stroke model.

Impact and effects

The measurement signals used in electromagnetic tomography are, as far as known today, noninvasive and are therefore suitable for long-term monitoring applications. In addition, the described system can also be realized in a compact way in the future, to be able to be used on the move. This can significantly

Austrian Research Promotion Agency
Sensengasse 1, A-1090 Vienna
P +43 (0) 5 77 55 - 0
office@ffg.at
www.ffg.at

reduce the time to medication when used e.g. in an ambulance, for patients affected by stroke and thus save lives.

In order to achieve a correctly interpretable result for clinicians, which should uncover the location and the type of stroke, it is necessary to apply a reconstruction algorithm that converts the measurement data into a graphical representation.

The reconstruction is a very time-consuming and computationally intensive process, which should be made available for automated use from the project partner emtensor for test purposes. An automated evaluation of the measured data is currently not possible. This additional step of a fully automated reconstruction of measurement and simulation data, would make it possible to find out details about the systems hardware requirements in order to fit the application best.

Currently, a prototype of the measuring system is tested in a clinical trial.

The work was honored at the EUMW 2017 in Nuremberg with the EuMC Young Engineer Award for Sebastian Poltschak.

Project coordination (Story)
Sebastian Poltschak, Dr.
Research Engineer
Institute for Communications Engineering and RF-Systems
T +43 (0) 732 2468 0
Sebastian.poltschak@jku.at

LCM / Symbiotic Mechatronics
Linz Center of Mechatronics GmbH
Altenbergerstr. 69
4040 Linz
T +43 (0) 732 2468 6002
office@lcm.at
www.lcm.at

Project partner

- Emtensor GmbH, Vienna