Hindawi Publishing Corporation
International Journal of Antennas and Propagation
Volume 2013, Article ID 589598, 2 pages
http://dx.doi.org/10.1155/2013/589598

*Editorial*

# Inverse Scattering and Microwave Tomography in Safety, Security, and Health

**Rocco Pierri,[1] Jean-Charles Bolomey,[2] Qing Huo Liu,[3] and Francesco Soldovieri[4]**

[1] *Dipartimento di Ingegneria dell'Informazione, Seconda Università di Napoli, 81031 Aversa, Italy*
[2] *Electromagnetic Research Department, University Paris-Sud XI, 91405 Paris, France*
[3] *Department of Electrical and Computer Engineering, Duke University, Durham, NC 27708-0291, USA*
[4] *Istituto per il Rilevamento Elettromagnetico dell'Ambiente, CNR, 80124 Napoli, Italy*

Correspondence should be addressed to Rocco Pierri; rocco.pierri@unina2.it

Received 8 October 2013; Accepted 8 October 2013



Electromagnetic diagnostics and radar systems are of increasing interest in many application domains when the aim is to characterize in a qualitative and quantitative way the targets in electromagnetically complex scenarios. The exploitation of usual data processing approaches, despite their simplicity of use, does not allow the results to be fully interpretable even in simple cases. Therefore, the necessity of developing electromagnetic inverse models arises, which account accurately for the physics of the sensing and can achieve more reliable and stable solutions when qualitative reconstructions are performed. The availability of accurate modeling is necessary when the aim is the quantitative characterization of the targets where, besides the mathematical difficulties of the local minima and the ill-posedness, a need arises to achieve accurate evaluation of the key factors playing in the inverse scattering (incident field, Green's function). Lastly, the diversity in the data is useful for solving the inverse scattering problem and this pushes towards nonconventional measurement configuration and antenna arrangements, where still the necessity of a modeling arises.

Most part of the papers contained in this special issue are concerned with the advances in the inverse scattering approaches with a focus on the above-mentioned necessities.

The paper by R. Solimene et al. is concerned with the investigation of the effect of the spatial diversity on the reconstruction performance of the radiation operator. This topic is of great importance because the so-called number-of-degrees of freedom concept represents a key parameter in inverse source problems. Analytical arguments are developed to estimate the pertinent singular value behavior in the 2D case; this allows highlighting the way observation domain features affect spectrum behavior. Numerical examples are provided in order to support the analytical results.

E. A. Marengo presents an approach based on the multipole expansion to solve the inverse problem of estimating the smallest region of localization (minimum source region) of a source or scatterer from the radiation or scattered field. The effectiveness of the proposed method is illustrated with an example relevant to inverse scattering.

E. A. Marengo and F. K. Gruber present a new approach for the detection of scatterers embedded in reciprocal media. This new method is rooted on the optical theorem applicable to wavefields (e.g., acoustic, electromagnetic, and optical). The proposed approach is ideally suited for target detection in complex, highly reverberating unknown environments such as indoor facilities, caves, tunnels, and urban canyon.

S. Meschino et al. present a technique for the localization of buried metallic and dielectric objects, which is based on a subarray processing (SAP) approach. A comparison of the proposed technique with several direction of arrival algorithms is performed in different operative conditions. The proposed procedure can be usefully deployed for ground-penetrating radar applications, near-surface probing, and more generally for the detection and localization of targets in a host media.

The paper by A. Diaz-Bolado et al. compares the microwave tomography measurement setups for different configurations based on breast compression with the classical circular measurement setups. Configurations based on compression allow measuring the evanescent component of the scattered field and lead to more compact measurement setups. The performance of the proposed measurement setups is investigated thanks to numerical simulations at a single frequency of operation.

The paper by V. Picco et al. describes the application of the Radio Frequency tomography to 3D free space scenarios; the approach is based on a dyadic Green's function and a novel inversion scheme exploiting the algebraic reconstruction technique is presented. The proposed method is after improved by introducing physical bounds on the recovered solution. The results from three experimental case studies are presented and discussed.

R. K. Amineh et al. propose a three-dimensional microwave holographic imaging method for the transmission mode. In the proposed method, one transmitter and multiple receivers perform together a two-dimensional scan on two planar apertures on opposite sides of the inspected domain. The ability to achieve three-dimensional imaging without back-scattered waves enables the imaging of high-loss objects, for example, tissues, where the back-scattered waves may not be available due to low signal-to-noise ratio or nonreciprocal measurement setups.

The paper by A. Galli et al. deals with the development and application of a 3D inverse scattering approach, based on a linear model of the scattering and the capability to account explicitly the half-space geometry. Therefore, the approach is suitable for ground penetrating radar surveys, where the system is placed at a ground interface. Challenging test cases are considered where the scatterers have size comparable to the resolution limits and are located in the antenna near field.

C. Estatico et al. present the extension of a microwave imaging method, previously developed for tomographic inspection of dielectric targets, to the three-dimensional case. The approach is based on the full vector equations of the electromagnetic inverse scattering problem. The ill-posedness of the problem is faced by the application of an inexact Newton method. Preliminary reconstruction results are reported.

The two papers by M. Alekhin et al. are concerned with the use of the microwave signals in order to detect and characterize vital signs, with a focus to the breathing activity characterization in medical applications. The focus is on the development of advanced data processing with the end of using this noncontact screening technique in real medical problems as sleep apnea syndrome.

The paper by I. Arnedo et al. gives a review of different synthesis techniques for the design of passive microwave components with arbitrary frequency response. The authors provide the theoretical foundations based on inverse scattering and coupled-mode theory; several applications are shown, where the devices designed following those techniques have been successfully tested with a focus on advanced UWB radar and communications and on novel breast cancer detection systems.

The paper by F. Soldovieri et al. deals with the recent advances in the field of the passive imaging at millimeter wavelengths. In particular, first the paper describes the design and the realization of two systems working in 3 mm and 8 mm wavebands, respectively. Secondly, the measurements collected by the two systems are enhanced by means of simple data processing strategies so to improve the interpretability of the images.

These thirteen papers represent an exciting and insightful snapshot of the current research for a reliable and effective use of microwaves in the complex scenarios encountered in the very timely fields of safety, security, and health. State-of-the-art, existing challenges, and emerging future topics are highlighted in this special issue, which may inspire the reader and help advance the research.

## Acknowledgments

We would like to thank all authors, reviewers, for making this special issue possible.

*Rocco Pierri*
*Jean-Charles Bolomey*
*Qing Huo Liu*
*Francesco Soldovieri*