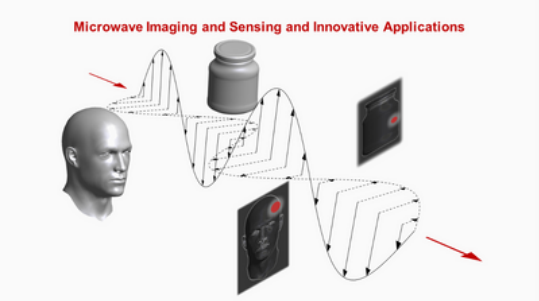
SC10-Microwave Imaging and Sensing and Innovative Applications



Abstract

Microwave imaging technology exploits the differences in dielectric properties of the objects under test to reconstruct an image of its inner parts in a contactless and safe way. Due to microwave technology's low cost, availability, and flexibility, MWT is increasingly considered a complementary diagnostic tool for medical imaging and quality control in industrial environments.

The short course aims to give the students the tools to understand and design MWT systems, select the best application approach and propose new techniques. The course structure covers a general introduction and applicability of the method, the theoretical concepts, and the already existing devices.

Recommended prerequisites

- Basic knowledge on electromagnetism
- Basic notions on antennas
- Basic notions on linear algebra

Learning objectives

After the course the students will be able to:

1. Recognize pros and cons of Microwave techniques in comparison to imaging and detection assessed technologies.
2. Find the situations where microwave techniques can complement those assessed techniques
3. Recognize each of the sections of a complete Microwave Tomography system, knowing their limitations, risks and challenges in the design process.
4. Distinguish and recognize the different imaging technique types (qualitative, quantitative) and their most important algorithms.
5. Decide which kind of technique or algorithm will be suitable for a specific problem they will face.
6. Start the implementation of some of the most known algorithms.
7. Recognize the main problems of numerical models of realistic situations and their role in the inversion algorithms.
8. Differentiate linear inversion problems from iterative inversion problems.
9. Recognize the nature of an inverse scattering problem (non-linearity and ill-posedness)

Course outline

This short course summarizes the developments in the Microwave Imaging techniques on real-world applications, going from the theoretical and design steps to the description of already implemented devices, highlighting the strengths and limits of each approach. The increasing interest in this topic can be seen in the number of publications and workshops available, reflecting the high development of this technique that arrives to implemented and working devices.

The Antenna and Propagation Community is already a leading actor in this technology development, as Microwave and RF applications in different areas are always on the community radar. The course summarizes the efforts to develop devices, explaining the bases to a broader public that could exploit these techniques in different applications not yet studied.

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Course outline

The course is planned as a 3-hour lecture going from an introductory review in other techniques to the implemented devices, passing through the theoretical background of inverse scattering problems and algorithms. No laptop required by the students.

Part I: Introduction & Theoretical Background

1. Overview of possible applications
2. Background theory
    a. Review of Electromagnetism Scattering
    b. Fundamentals of Inverse Scattering Problems

Part II: From theory to implementation

1. Linearized Inverse methods
2. Non-linear Tomography methods
    a. Gauss-Newton methods
    b. Contrast Source Inversion
    c. Other approaches III. Emerging techniques.

Part III: Experimental implemented devices

1. Devices for biomedical applications
    a. Breast Cancer detection
    b. Brain stroke follow-up
    c. Other biomedical applications
2. Devices for food monitoring applications

Rosa Scapaticci (Member, IEEE) received the Master Degree (summa cum laude) in Biomedical Engineering from the "Federico II" University of Naples, Naples, in 2010, and the Ph.D. degree in information engineering from the "Mediterranea" University of Reggio Calabria, Reggio Calabria, Italy, in 2014. From December 2013, she has been working with the Institute of Electromagnetic Sensing of the Environment, National Research Council of Italy, Naples, first as a Research Fellow, as a researcher from September 2017 to December 2022 and as a Senior Researcher since January 2023. She has co-authored more than 80 papers on international journals and conference proceedings. Her scientific interests include electromagnetic scattering problems, imaging methods for non-invasive diagnostics and they are mainly focused on the development of innovative microwave imaging approaches in the framework of biomedical applications, as well as therapeutic applications of electromagnetic fields. She received the best Student Member Paper Award from the IEEE Antennas and Propagation Society Central and Southern Italy Chapter in 2013 and the Italian Society of Electromagnetics, the Barzilai Award and the Latmiral Award in September 2014 and in September 2018, respectively. In 2021, she received the Associate Professor Qualification in Electromagnetic fields, by the Italian Ministry of Research and University. She is an Associate Editor of the IEEE Transactions on Medical Imaging.

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Jorge A. Tobón Vasquez received the Degree in electronics engineering from the Universidad de Antioquia, Colombia, in 2010, in a double degree program; the master's degree in electronic engineering and the Ph.D. degree in electronics and telecommunication engineering from the Politecnico di Torino, Italy, in 2010 and 2014, respectively, where he was an Assistant Professor until 2023. Since 2024 he works in Wavision (Politecnico di Torino spin-off). His main research activities correspond to modelling, designing, and analyzing systems for microwave imaging applications, specifically in the biomedical and food industry fields, and the numerical modelling of complex and nonhomogeneous media propagation. He received the "Premio Latmiral," an award granted by the Italian Society of Electromagnetism in 2018 and the URSI General Assembly Scientific Symposium Young Scientist Award and the Sorrentino URSI Italy National Meeting Young Scientist Paper Award in 2020. He teaches the course "Microwave sensing and imaging for innovative applications in health and food industry." At the PhD School at Politecnico di Torino. In 2021 he received by the Italian Ministry of Research and University the Associate Professor Qualification in Electromagnetic Fields.

Bibliography

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Contact: shortcourses-workshops@eucap2025.org