TECHNICAL PROGRAMME

ICMWIA

INTERNATIONAL CONFERENCE ON MEDICAL MICROWAVE IMAGING APPLICATIONS

FEBRUARY 3-5, 2026

Version 2.4

Organised by:

3BAIwin MEDICAL MICROWAVE IMAGING

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Sponsorship:

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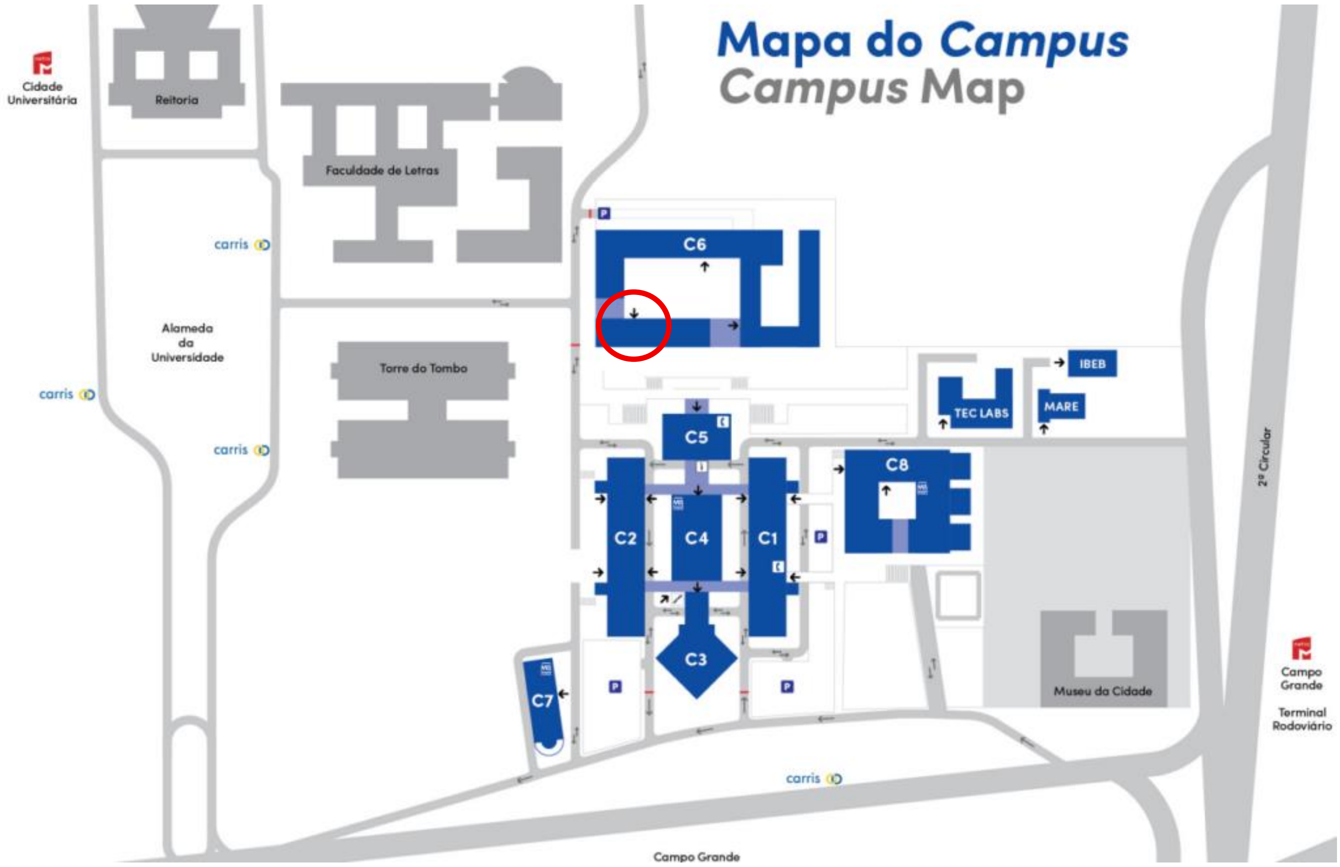
Conference Venue

The conference will take place in **Faculdade de Ciências da Universidade de Lisboa** (Faculty of Sciences of University of Lisbon), Lisbon, Portugal.

The registration area will be at the entrance of **building C6,** and all lectures will take place in **room 6.2.56**.

The entrance to the registration area is highlighted with a red circle in the *Campus* map below:



Available transportation:

Access to Ciências/ULisboa is quick and easy by bus, metro, train, car, or even bicycle (cycle paths).

Bus

- Carris: 701, 717, 731, 735, 736, 738, 747, 750, 755, 764, 767, 768, 778, 783, 796, 798
- Carris Metropolitana: see the *Carris Metropolitana - Schools platform*
    - Search results for 'University of Lisbon - Faculty of Sciences' and 'University of Lisbon'

Metro

- Cidade Universitária and Campo Grande stations

Train

- Entrecampos station

Car

- 2nd circular - Campo Grande / Cidade Universitária exit

Bicycle

- Gira 480 station

For most modes of public transportation, payment can be made by tapping a contactless bank card. In other cases, passengers may need to purchase a Navegante card (€0.50), which can be loaded with prepaid credit (the "zapping" option) and used across all public transport services, including the metro, buses, and suburban trains.

Travel to and from the airport

Lisbon Airport is served by the metro (Red Line) and by a dedicated tourist bus service (Aerobus), which stops near the majority of hotels in the city centre. Taxi services are generally affordable, and ride-hailing services (TVDE), such as Uber and Bolt, are also widely available.

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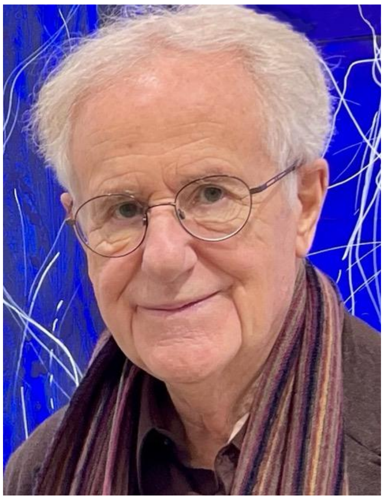

JEAN-CHARLES BOLOMEY

Jean-Charles Bolomey is currently Professor Emeritus of Paris-Saclay University, France (PSU). After earning a Radio Engineering degree from CentraleSupelec (CS), he became full-time professor at PSU in 1976, furthering his research in Laboratoire des Signaux and Systemes, a joint unit with the Centre National de la Recherche Scientifique (CNRS). Since the early 1980s, his work has focused on fast Near-Field (NF) methodologies, including antenna measurement, EMC/EMI testing, RF dosimetry, Industrial-Scientific-Medical (ISM) and NDE/NDT applications, with a strong emphasis on innovative developments and technology transfer. His major contribution, based on the Modulated Scattering Technique (MST), led to earliest convincing proofs-of-concept of rapid NF measurement and imaging systems using modulated probe arrays.

In 1986, he founded SATIMO, a company specializing in microwave imaging, whose advanced prototypes would leverage the launch of the Microwave Vision Group (MVG) ten years later. He actively participated in several European collaborative programmes on microwave imagery, ranging from medical diagnostics and hyperthermia therapy control to industrial tomography and material processing. He has also contributed to the scientific advisory boards of various European institutions and start-ups, engaging in technology transfer and prototype evaluation procedures in these fields.

Professor Bolomey is an IEEE Life Fellow, an AMTA Gilespie Fellow and a Fellow of the Electromagnetic Academy. He is also a member of the EurAAP and has received numerous awards for his pioneering contributions to fast electromagnetic near-field (NF) techniques, microwave imaging and related applications. He remained an active figure in these areas and was frequently invited to deliver keynote presentations and author review papers on the subject. He is currently broadening his interests to include multi-physics EM-Thermal visualization modalities for low-invasive NF characterization and diagnostic of wireless communication and sensing devices.

ELISE FEAR

Elise Fear is Professor in the Department of Electrical and Software Engineering at the University of Calgary, Alberta, Canada. Together with Jeremie Bourqui, Dr. Fear co-founded Wave View Imaging in 2020 with the goal of commercializing medical microwave imaging. Wave View Imaging was one of 3 Canadian companies selected for Pfizer's Healthcare Hub program in 2023.

Dr. Fear's research interests include microwave imaging and sensing for biomedical applications, including development of prototype systems and pilot feasibility studies with human subjects. She was the Alberta Innovates Technology Futures iCORE Strategic Chair in Multimodality Imaging and Sensing from 2013-2017. Her work has been recognized with the Outstanding Paper Award from the IEEE Transactions on Biomedical Engineering (2007), the Killam Interdisciplinary Research Prize (2012), the Killam Annual Professorship (2018), the ASTech Award for Innovation in Healthcare (2023), and a Fellowship in the Engineering Institute of Canada (2024).

Detailed Programme

Tuesday, 3rd of February

08:30 – 09:00	Registration
09:10 – 09:30	Opening Ceremony

09:30 – 10:30 **Session 1: Dielectric characterisation of biological tissues**
Chair: Daniela Godinho (Faculdade de Ciências da Universidade de Lisboa, Portugal)

09:30 ***Si CMOS Electronic Sensors for Terahertz Biomedical Characterization***

Dmytro B. But (CENTERA Laboratory, Institute of High Pressure Physics PAS, Poland); Adam Kowalczyk (Warsaw University of Technology, Poland); Cezary Kołacinski (CENTERA LAboratory, Institute of High Pressure Physics PAS, Poland); Valeri Mikhnev (CENTERA Labs, Institute of High Pressure Physics, Polish Academy of Sciences, Poland); Wojciech Knap (CENTERA - Center for Terahertz Technology Research and Applications, Poland)

Electrodynamic interactions between biological objects and electromagnetic radiation in the microwave and terahertz frequency ranges hold great promise for various medical applications. In this work, we discuss electronic sensors designed in silicon complementary metal-oxide-semiconductor technology and their role in advancing terahertz dielectric spectroscopy, based on our experience. Furthermore, we demonstrate the representative applications of these devices in the terahertz regime.

09:50 ***Investigating the Tolerance of Coaxial Cable Movement in Dielectric Property Measurement***

Eoghan Dunne, Shaun McCormack, Bilal Amin, Icaro V Soares, Marcin J. Kraśny and Adnan Elahi (University of Galway, Ireland)

Cable movement is a well-known confounder of dielectric property measurement. In fact, the literature has strongly avoided any cable movement or even, having any cable at all. However, this practice is not always possible, e.g., in in-vivo testing. Hence, in this study, we assessed whether any cable movement can be tolerated in both phase-stable and non-phase-stable cables. We apply a linear translation of an experimental setup, so the coaxial cable is the only moving factor. We assessed what the dielectric property errors are on the test sample of physiological saline relative to the baseline height that the calibration and validation were performed. We assessed what error occurred with small and large cable displacements. The results show a maximum relative error of under 1.8% across frequency, relative permittivity and conductivity, and small and large cable displacements. The phase-stable cable out-performed the non-phase-stable cable, with the phase-stable cable showing a similar small relative error of less than 0.3% across small and large cable displacements. The results from this study indicated that the error envisioned with cable movement in cable and open-ended coaxial probe dielectric property measurement may be less than expected, particularly when using phase-stable cables.

10:10 ***Broadband Complex Permittivity Sensing of Biological Tissues Up to 20 GHz Using a Low-Cost Open-Ended 0.047-Inch Semi-Rigid Coaxial Probe***

Raúl Moreno-Merín and Andrea Martínez-Lozano (University Miguel Hernández of Elche, Spain); Paula Viudes-Pérez (Miguel Hernández University, Spain); Concepción Parejo-Prados (Miguel Hernández University of Elche, Spain); Hector Garcia Martinez (University Miguel Hernàndez of Elche, Spain); Germán Torregrosa-Penalva (Universidad Miguel Hernández, Spain); Ernesto Ávila-Navarro (Miguel Hernández University, Spain); Julia Arias-Rodriguez (University Miguel Hernández of Elche, Spain)

A low-cost open-ended coaxial probe using a 0.047" semi-rigid coaxial cable was developed for dielectric characterization up to 20 GHz at a cost below EUR 20. Validation with ethanol and methanol showed normalized errors below 7% when compared with established reference data. Ex vivo biological tissues (egg white, yolk, chicken breast, pork loin, liver, and fat) were also characterized, with results in agreement with values reported in the literature. Repeatability analysis yielded relative standard deviations below 5% for most samples, with larger variability only in pork fat. The system was additionally benchmarked against a commercial Slim Probe, showing comparable accuracy across the full frequency range while maintaining reliable performance down to 100 MHz, below the specified operating limit of the commercial device.

10:30 – 11:00	Coffee Break

11:00 – 11:40 **Session 2: Phantoms and tissue mimicking materials**
Chair: Matteo Savazzi (Politecnico di Torino, Italy)

11:00 ***Precision Characterization of Graphite-Based RTK Silicone Compounds for Repeatable Microwave Imaging Phantoms Manufacturing***

Nadim Conti (Politecnico di Milano, Italy & Rilemo Srl, Italy); Valentina Lidoni (Rilemo Srl, Italy); Pablo Giaccaglia (Politecnico di Milano, Italy); Alessia Rosa (Rilemo Srl, Italy); Luca Maria Sconfienza (Università degli studi di Milano, Italy)

The development of emerging medical imaging technologies, such as microwave imaging, requires precise phantoms and models to replicate realistic human conditions. These human phantoms require stable materials with dielectric properties close to those of biological tissue. However, there is heterogeneity in phantom recipes, materials, and fabrication methods. The aim of this study is to define a low-cost and easily reproducible formulation for human phantoms based on silicone and graphite for microwave imaging. An open-ended coaxial probe was used to measure the dielectric properties of each material sample as a function of internal composition, and an empirical formula was derived to ensure reproducibility.

11:20 ***Comprehensive Repository of MRI-Derived Breast Models for Microwave Imaging Research***

Ana Catarina Pelicano (Universidade de Lisboa, Instituto de Biofísica e Engenharia Biomédica & FCiencias ID, Portugal); Maria C. T. Gonçalves (Universidade de Lisboa, Portugal); Tiago Castela and M Lurdes Orvalho (Departamento de Radiologia, Hospital da Luz Lisboa, Luz Saúde, Lisbon, Portugal); Nuno Araújo (Centro de Física Teórica e Computacional, Fac. Ciências Un. Lisboa, Portugal); Emily Porter (McGill University, Canada & RI-MUHC, Canada); Daniela M Godinho and Raquel C. Conceição (Universidade de Lisboa, Portugal)

Breast cancer has the second highest incidence rate of all cancers worldwide. While the incidence rate has seen a slight increase over the years, the mortality rate has sharply decreased. This decline is primarily due to improvements in screening methods, earlier diagnoses, and advancements in management and treatment options. Therefore, the development of new technologies for cancer detection and diagnosis, as well as treatment, remains essential to further reducing mortality rates associated with this disease. In recent decades, microwaves have been explored for both the detection and treatment of cancer. Breast models are paramount for the design, test and validation of new imaging and treatment equipment. Additionally, realistic breast models are crucial for creating effective treatment planning tools. In this paper, we present an update to our open-access repository of MRI-derived and anatomically and dielectrically realistic breast models, which now includes data from 117 patients with single and multiple benign and malignant tumours. In addition to increasing the number of available models, we have incorporated clinically relevant information such as volume density, body mass index (BMI), age, diagnosis, biomarkers (when available), menopausal status, and family history.

11:40 – 12:40 **Open session: Current Challenges and Emerging Needs in Research**

Moderator: Daniela Godinho (Faculdade de Ciências da Universidade de Lisboa, Portugal)

12:40 – 14:00 Lunch

14:00 – 15:00 **Keynote 1: *Updated viewpoints on the journey of microwaves in the medical imaging landscape***

Jean-Charles Bolomey (Professor Emeritus of Paris-Saclay University, France)

15:00 – 16:00 **Session 3: Antenna development for medical microwave applications**

Chair: Francesca Vipiana (Politecnico di Torino, Italy)

15:00 ***Sensitivity of Two Substrate-Integrated Waveguide Probes for Skin Cancer Detection to Dielectric Changes Using Skin-Mimicking Phantoms***

Nicolas Treier and Benedicta Fofo Doku (University of Applied Sciences Offenburg, Germany); Marlene Harter (Offenburg University, Germany)

This paper presents experimental measurements taken with two substrate-integrated waveguide (SIW) probes to detect skin cancer with skin-mimicking phantoms. The goal of the paper is to evaluate the probes for their ability to detect skin cancer, taking into account the real-world variability of the tissues. Three skin phantoms with different relative permittivities are used to measure across a range of dielectric properties. The properties have been selected to reflect the variety that can be found in skin. The results show that changes in dielectric parameters have a significant impact on the probe's sensitivity. This can reach the point where reliable cancer detection is not possible. The findings demonstrate the importance of accounting for tissue variability during the early stages of probe design and development, especially for medical imaging applications.

15:20 ***Preliminary Experimental Assessment of a Fractal Antenna-Based Multi-Static Radar System for Breast Tumor Detection***

Matteo Bruno Lodi and Elisabetta Orrù (University of Cagliari, Italy); Simona Di Meo and Marco Pasian (University of Pavia, Italy); Giacomo Muntoni, Andrea Melis and Alessandro Fanti (University of Cagliari, Italy)

In this paper, an imaging prototype for breast cancer detection composed of newly designed fractal antennas in the 3-11 GHz band is proposed. A multi-static radar architecture composed of 8 Tx antennas and 7 Rx antennas in a circular configuration was synthesized using two fractal antennas and tested on a phantom emulating medium-density healthy breast tissue with tumor-like inclusion. All measurements were made in air, i.e., in the absence of a coupling medium. The Delay-And-Sum beamforming algorithm was used, both in the presence and absence of the air-phantom interface. The results show that the target is visible in both cases, with a significant improvement in target visualization in the absence of background.

15:40 ***Evaluating Conformal Antenna Arrays for Microwave Head Imaging***

Anja Kovačević, Darko Ninković, Branko Kolundzija and Marija Stevanovic (University of Belgrade, Serbia)

This paper aims to compare two different layouts of a helmet-like antenna system mounted onto a head phantom. The helmet surface is parameterized using a spherical harmonic approximation derived from the outer surface of the head. The position of each patch antenna is defined by the spherical coordinates of its mass center and a rotation angle within the plane tangential to the helmet surface. Two distinct, non-overlapping helmet layouts are presented. Their performance is evaluated in the presence of a brain stroke, whose position is varied along one axis. For each stroke position, the scattering matrix is computed, and the corresponding Fisher information is calculated for both layouts. The results indicate that, although the two layouts contain the same number of antennas, one exhibits greater sensitivity to changes in stroke position.

16:00 – 16:30 Coffee Break

16:30 – 17:30 **Session 4: Hardware for medical microwave applications**
Chair: David Rodriguez-Duarte (Politecnico di Torino, Italy)

16:30 ***A Metric-Based Framework for Microwave Breast Imaging Array Design***

Eleonora Razzicchia, Carlos Ramos Flores, Yunxiao Zhang and Alan Poisot Palacios (McGill University, Canada); Emily Porter (McGill University, Canada & RI-MUHC, Canada); Lorenzo Crocco (CNR - National Research Council of Italy, Italy); Rosa Scapaticci (CNR-National Research Council of Italy, Italy)

Microwave imaging has shown promise for breast cancer detection and monitoring, yet the absence of standardized metrics for evaluating array configurations limits systematic design and comparison of prototypes. In this work, we propose the use of two quantitative metrics-spatial coverage and spectral coverage-that provide design-oriented insight into antenna placement. Their application is demonstrated on a simplified breast phantom model, with validation provided through an example of 3-D radar image reconstruction. Two array configurations were investigated: (i) a circular arrangement of eight uniformly spaced antennas in a single ring and (ii) a 16-element array composed of two rings of equally-spaced eight antennas. To further assess the role of spatial arrangement, two subsets of eight antennas were extracted from the 16-element array. The results show that the proposed metrics effectively capture the impact of geometry on image reconstruction, with the 16-element dual-ring configuration and the uniformly spaced 8-antenna ring both achieving broader and more uniform coverage than the other 8-antenna subsets. These findings lay the foundation for a reproducible framework to assess microwave imaging prototypes, representing an important step toward clinically practical imaging systems.

16:50 ***Assessment of Skin Contact for Ultra-Wideband Microwave Breast Scanner***

Alexandra Prokhorova and Marc-Patrick Heppner (Technische Universität Ilmenau, Germany); Ingrid Hilger (University Hospital Jena, Germany); Marko Helbig (Technische Universität Ilmenau, Germany)

A breast fit assessment procedure for microwave breast imaging is presented in this paper. Since poor or uneven contact between patient's skin and measurement mold can significantly decrease the quality of the resulting images, methods for detection and localization of the air gaps are needed. Three algorithms, which primarily analyze the crosstalk component of the ultra-wideband signals, are proposed, implemented and validated based on a comprehensive phantom study. Initial results show that each of the methods can successfully detect different types of air gaps and that the choice of a specific algorithm mainly depends on the clinical scenario.

17:10 ***Broadband Quarter-Wavelength Impedance Matching for Microwave Bone Health Monitoring Applications***

Amra Mehboob, Bilal Amin, Martin O'Halloran and Adnan Elahi (University of Galway, Ireland)

The performance of non-invasive microwave medical technologies such as microwave imaging, microwave hyperthermia, and microwave sensors is directly related to the penetration of microwave signals into the human body. The impedance mismatch at the skin surface causes most of the microwave signals to be reflected, hence reducing the penetration depth. This study presents the implementation of a quarter-wavelength impedance-matching dielectric layer to reduce the reflection at the antenna-skin interface, thereby increasing the penetration depth of microwave signals for bone health monitoring applications. The analysis is performed over the frequency band of 1-12 GHz, proposing the values of relative permittivity and thickness of the impedance matching dielectric layer across the considered frequency band. The full-wave near-field simulation results showed an average decrease of 2.8 dB (47.5 % reduction) in reflected power at the antenna-skin interface and an average increase of 6.9 dB (390 % increase) in transmitted power to the trabecular bone compared to the case when an impedance-matching layer is not used. These results suggest that implementing a quarter-wavelength impedance-matching dielectric layer enhances signal penetration depth in the calcaneus, thereby improving the effectiveness of microwave-based bone health monitoring.

17:30 – 19:30	Welcome Reception

Wednesday, 4th of February

09:10 – 10:30 **Session 5: Radar medical microwave imaging**
Chair: TBC

09:10 ***Non-Invasive Microwave-Based Imaging System for Breast Cancer Screening***

Andrea Martínez-Lozano (University Miguel Hernández of Elche, Spain); Roberto Gutierrez Mazon (University Miguel Hernàndez of Elche, Spain); Julia Arias-Rodriguez (University Miguel Hernández of Elche, Spain); Concepción Parejo-Prados (Miguel Hernández University of Elche, Spain); María José Moscardó-Domenech (University Miguel Hernández of Elche, Spain); Hector Garcia Martinez (University Miguel Hernàndez of Elche, Spain); Enrique Bronchalo (Miguel Hernández University of Elche, Spain); Ernesto Ávila-Navarro (Miguel Hernández University, Spain)

Microwave medical imaging (MWI) systems are becoming increasingly important in the detection of various diseases, particularly in the early detection of breast cancer. This paper presents a breast tumor detection system using microwave signals based on 16 broadband antennas that transmit and receive narrow time-domain pulses. Realistic synthetic breast models have been developed to test the capabilities of the system. The results obtained demonstrate the ability of the system to detect and locate breast tumors.

09:30 ***Comparison of 3-D Direct Microwave Imaging Algorithms Applied to Brain Stroke Follow-Up***

Alex Ramiro Masaquiza-Caiza, David O. Rodriguez-Duarte, Martina Gugliermino and Francesca Vipiana (Politecnico di Torino, Italy)

This paper presents features and performance comparison of two non-iterative inversion approaches used for microwave-imaging-based monitoring of after-onset stroke infarct migrations, utilizing 3-D realistic full-wave twin numerical experiments that mimic a controlled progressing hemorrhage scenario. Specifically, it considers two well-established approaches with the potential for real-time operation and low computational demand: a tomographic approach based on a truncated singular value decomposition and the Born approximation, a frequency-domain method; and the Delay-Multiply-And-Sum, a time-domain method. The setup and implications of both approaches are discussed, and their performance is assessed using various metrics, which indicate the fidelity of the retrievals.

09:50 ***Clutter-Based Metrics for Radar-Based Breast Imaging: Clutter Region Selection***

Stacey Torres and Declan O'Loughlin (Trinity College Dublin, Ireland)

Results from first-in-human and later trials of microwave breast imaging continue to be reported with a variety of quantitative and qualitative findings in the literature. Clutter-based metrics are very widely reported, however, small differences in the implementations and definitions are common and restrict the ability to compare these values across findings. Using idealised images and experimental validation, two common versions of the signal-to-mean ratio (SMR) are compared and the maximum and typical differences in the final values examined. For the largest signal regions, difference of up to 10 % could be expected, with the largest differences observed in homogeneous breast phantoms. Based on these findings, not including the signal region in the clutter region for SMR is recommended to match the only practical definition of the signal-to-clutter ratio (SCR).

10:10 ***Repeatability in Medical Microwave Imaging: Mapping Current Approaches***

Henrique V. Lopes, Daniela M. Godinho and Raquel C. Conceição (Universidade de Lisboa, Portugal)

Medical microwave imaging (MMWI) has been proposed for several medical applications. However, for its successful integration into clinical practice, it is crucial to ensure the repeatability of the signal or imaging outputs. This work synthesised the current approaches used to assess repeatability in MMWI. The findings underscore the need for standardised protocols and metrics to evaluate repeatability in MMWI, as well as a broader exploration of applications beyond breast imaging.

10:30 – 11:00	Coffee Break

11:00 – 11:40 **Session 6: Microwave tomography for medical applications**
Chair: Eoghan Dunne (University of Galway, Ireland)

11:00 ***Effect of Patient Movements on Non-Invasive Microwave Temperature Monitoring During Head and Neck Hyperthermia: Numerical Study***

Barbora Šmahelová and Jakub Kollár (Czech Technical University in Prague, Czech Republic); Jan Vrba (Faculty of Biomedical Engineering, Czech Technical University in Prague, Czech Republic)

Cancer treatment often requires multimodal approaches, where hyperthermia (HT) is an adjuvant therapy to radiotherapy and chemotherapy. Accurate temperature monitoring of HT is essential for both safety and efficacy. Differential microwave imaging (MWI) has been proposed as a non-invasive monitoring method, but it relies on the assumption of a static background between the reference and monitoring phases. In clinical practice, however, patient movement and device displacement are inevitable and may compromise reconstruction quality. In this study, numerical simulations were performed to evaluate the effect of patient and applicator movements on differential MWI during head and neck HT. Two scenarios were tested: positioning differences relative to the reference electric field model and movement occurring during the differential monitoring phase. The results showed that even minimal positioning differences substantially degraded reconstructions, with ultra-wideband (UWB) antenna rotation of only 5° reducing the Dice similarity coefficient (DSC) to 23% of the reference value. Movements of the HT applicator had a weaker effect, confirming that misalignments of the imaging antennas are more critical to MWI than applicator displacements. Most critically, any movement during the monitoring phase resulted in complete reconstruction failure (DSC = 0), eliminating the ability to detect the heated region. These findings highlight that precise patient positioning, robust immobilization, optimized antenna placement, and motion-robust system design are essential prerequisites for successful clinical translation of differential MWI in HT monitoring.

11:20 ***Two-Step Measurement Strategy for Improved Axillary Lymph Node Microwave Tomography: A Frequency Dependent Assessment***

Matteo Savazzi (Politecnico di Milano, Italy & Politecnico di Torino, Italy); David O. Rodriguez-Duarte, Jorge Tobon and Francesca Vipiana (Politecnico di Torino, Italy); Olympia M Karadima (Kings College London, Italy); Panagiotis Kosmas (National Centre for Scientific Research Demokritos, Greece); Carlos A. Fernandes (Instituto de Telecomunicacoes, Instituto Superior Tecnico, Portugal); Joao M Felicio (Instituto Superior Técnico, Portugal & Instituto Telecomunicacoes, Portugal); Raquel C. Conceição (Universidade de Lisboa, Portugal)

Axillary lymph node (ALN) microwave tomography (MWT) presents significant challenges related to the limited angular view and the limited space for antenna placement in the underarm region, which restricts the measurement domain and, consequently, the information available for image reconstruction. In this context, we assess a strategy to enhance information retrieval by performing two consecutive measurements, with the antenna set rotated by half the angular antenna spacing. Our MWT system consists of six monopole antennas (0.8-2.5GHz) immersed in a glycerol bath and surrounding a CT-derived axillary region phantom mimicking fat tissue with one ALN embedded. Our reconstruction algorithm employs the distorted-Born iterative method combined with the two-step iterative shrinkage/thresholding for the inversion. Our numerical results compare single-step acquisitions and two-step acquisition reconstructions, and demonstrate reliable target detection in the 0.8-1.0GHz band with improved performance using two-step acquisition. The 1.1-1.9 GHz range proved unsuitable due to clutter presence, while clear improvements in the detection are observed in the 2.0-2.5GHz band when employing the two-step measurements strategy. Our experimental results, obtained with the two-step acquisition method, confirmed stable detection at 0.8-1.0GHz, while presenting clutters in the 2.0-2.5GHz band, suggesting that the two-step acquisition method is not sufficient to overcome the instability associated with higher frequencies.

11:40 – 12:40 **Round-table: Aligning Research Priorities with Patient Needs**

Moderator: Nuno Matela (Faculdade de Ciências da Universidade de Lisboa, Portugal)
Speakers: Tamara Milagre (EVITA, Portugal) and Diana Wong Ramos (Portugal AVC, Portugal)

12:40 – 14:00 Lunch

14:00 – 15:00 **Keynote 2:** ***Breast Imaging with Microwaves: A Summary of Recent Work with Patients and Participants***

Elise Fear (University of Calgary, Canada)

15:00 – 16:00 **Session 7: Patient studies in microwave applications**

Chair: Declan O'Loughlin (Trinity College, Ireland)

15:00 ***Initial Assessment of a Patient Study Using a Breast Microwave Imaging Prototype***

Daniela M. Godinho and Henrique V. Lopes (Universidade de Lisboa, Portugal); Mónica Alfaiate (NOVA University of Lisbon, Portugal); Afonso Simões. Inês Correia, Gonçalo Canastra, Joana Saraiva and Rodrigo Dias (Universidade de Lisboa, Portugal); Luís Ramos and Arymar Andrade Junior (ULS do Estuário do Tejo, Portugal); Raquel C. Conceição (Universidade de Lisboa, Portugal)

This paper presents a new Medical Microwave Imaging (MMWI) prototype to screen the breast and the axillary region and an analysis of the first results of a patient study. Twenty-two healthy volunteers were examined in a first assessment and five breast cancer patients were examined to perform a preliminary benchmarking of our prototype. Initial analysis shows promising results.

15:20 ***Exploiting Phase Information from Microwave Imaging for Breast Density Classification: A Deep Learning Approach***

Mehran TaghipourGorjikolaie (School of Engineering, London South Bank University (LSBU), London, UK. & London South Bank University (LSBU), United Kingdom (Great Britain)); Bilal Khalid (LSBU, United

Kingdom (Great Britain)); Banafsheh Khalesi (Researcher & Clinical Trials Support at UBT & Researcher at LSBU, United Kingdom (Great Britain)); Navid Ghavami (Umbria Bioengineering Technology (UBT), Italy); Mario Badia (UBT - Umbria Bioengineering Technologies, Italy); Mohammad Ghavami (London South Bank University, United Kingdom (Great Britain)); Gianluigi Tiberi (London South Bank University, United Kingdom (Great Britain) & UBT - Umbria Bioengineering Technologies, Italy)

Dense breast tissue can cause problems mainly in breast cancer detection and risk assessment. It can reduce sensitivity of conventional imaging such as mammogram and may promote tumour development due to higher amounts of fibroglandular tissue. Moreover, it is a big challenge for AI-based models to detect breast cancer in dense breast samples, reducing the accuracy of such models. In this paper, phase information of microwave imaging has been used to develop an optimum deep learning-based model to classify breast density. Phase information is sensitive to variations in tissue composition and permittivity, making it a reliable indicator of breast density. Our obtained results show that a three-layer convolutional model can provide an accuracy of approximately 70% in both high- and low-density breast groups.

15:40 ***Microwave Imaging for Breast Cancer Screening: Interim Analysis Results from MammoScreen Clinical Trials***

Mehran TaghipourGorjikolaie (School of Engineering, London South Bank University (LSBU), London, UK. & London South Bank University (LSBU), United Kingdom (Great Britain)); Navid Ghavami (Umbria Bioengineering Technology (UBT), Italy); Daniel Álvarez Sánchez-Bayuela (Servicio de Salud de Castilla - La Mancha, Spain); Lorenzo Papini (UBT - Umbria Bioengineering Technologies, Perugia, Italy); Mario Badia (UBT - Umbria Bioengineering Technologies, Italy); Renier Perez (Umbria Bioengineering Technologies, Italy); Arianna Fracassini (UBT - Umbria Bioengineering Technologies, Italy); Teresa López-Brea Alarza (Servicio de Salud de Castilla - La Mancha, Spain); Alessandra Bigotti (UBT - Umbria Bioengineering Technologies, Perugia, Italy); Banafsheh Khalesi (Researcher & Clinical Trials Support at UBT & Researcher at LSBU, United Kingdom (Great Britain)); Mohammad Ghavami and Sandra Dudley (London South Bank University, United Kingdom (Great Britain)); Letizia Pontoriero (Fondazione Toscana Life Sciences, Italy); Cristina Romero Castellano (Hospital Virgen de la Salud, Toledo, Spain); Gianluigi Tiberi (London South Bank University, United Kingdom (Great Britain) & UBT - Umbria Bioengineering Technologies, Italy)

We present here the interim results from a large prospective, multicentre, open-label, non-randomized clinical trial evaluating the breast cancer detection capabilities of MammoWave microwave imaging device on an asymptomatic population across five European countries. This study will conduct a comparative analysis between reference standard, defined as the outcome of the conventional breast examination pathway, and MammoWave's AI model classifications. The reference standard will be classified as 'positive' for histology confirmed breast cancer, and 'negative' otherwise. The algorithm will assign each breast to one of two categories: 'With suspicious finding' or 'No suspicious finding'. We report results from the first 3,000 volunteers enrolled in nine hospitals. This interim analysis allowed us to evaluate the performance of the AI model, with a sensitivity of 42% and a specificity of 75%. Subsequently, as indicated in the clinical protocol, we updated the AI model by fusing the information from machine learning and statistical models. The updated AI model allowed us to retrospectively reach a sensitivity of 67% (80% in dense breast) and a specificity of 81% (80% in dense breast).

16:00 – 16:30 Coffee Break

16:30 – 17:30 **Session 8: Emerging electromagnetic-based medical applications**
Chair: Matteo Bruno Lodi (University of Cagliari, Italy)

16:30 ***Vital Sign Parameter Estimation Using Millimeter Wave OFDM Radar***

Benjamin Nuss (Technical University of Munich, Germany); Simon Ruhnau (Race Result AG, Germany); Christian Maximilian Karle (Karlsruhe Institute of Technology, Germany); Thomas Zwick (Karlsruhe Institute of Technology (KIT), Germany)

Contactless measurement of breathing and heartbeat is playing an increasingly important role in everyday medical practice, as it allows vital signs to be recorded quickly and easily. The advent of new digital radars and integrated sensing and communication systems is opening up new possibilities for measuring vital signs. This paper uses a 60 GHz millimeter wave OFDM radar to demonstrate how breathing rate and heartbeat can be recorded over the air. The setup of the demonstrator and the signal processing steps are described in detail, and finally, radar-based measurements of a human's vital signs are presented, along with a comparison of the radar measurements with an optical sensor for recording blood pressure.

16:50 ***Recent Advancements on Bone Healing Monitoring via Microwave Imaging and Magnetic Scaffolds***

Ehsan Akbari Sekehravani (Institute for the Electromagnetic Sensing of the Environment, CNR, Italy); Agostino Gervasio (Università Degli Studi Mediterranea di Reggio Calabria, Italy & IREA-CNR, Italy); Roberta Palmeri (Università Mediterranea of Reggio Calabria, Italy); Lorenzo Crocco (CNR - National Research Council of Italy, Italy); Rosa Scapaticci (CNR-National Research Council of Italy, Italy)

The growing integration of magneto-dielectric composite materials is playing an increasingly significant role in advancing both therapeutic and diagnostic biomedical applications. A prominent example is represented by magnetic scaffolds (MaS), in which a biocompatible matrix is impregnated with magnetic nanoparticles. Such scaffolds can be externally controlled by applying a magnetic field to induce or monitor biological processes. In this contribution, we investigate the feasibility of employing implanted magnetic scaffolds as in vivo probes for monitoring bone healing and regeneration. By exploiting the characteristic electromagnetic response of the MaS to an external magnetic field, we show that changes in scaffold integrity (degradation) can be tracked through the analysis of their microwave response. Preliminary imaging results are presented that support this approach.

17:10 – 17:30	Closing Ceremony
19:30 –	**Social Dinner** Entrecopos, R. de Entrecampos 11, 1000-151 Lisboa (https://maps.app.goo.gl/joG6ALfijVuKSutd9)

Thursday, 5th of February

09:10 – 10:30	**Tutorial: *Accurate and Repeatable Dielectric Measurement of Biological Tissues*** Instructor: TBC
10:30 – 11:00	Coffee Break
11:00 – 12:20	**Tutorial: *Medical Microwave Imaging: basic principles and data processing strategies*** Instructor: Rosa Scapaticci (CNR-National Research Council of Italy, Italy)

Microwave Imaging relies on the solution of an inverse electromagnetic scattering problem, which is well known to be nonlinear and ill-posed. After recalling the basic features of inverse electromagnetic problems, the tutorial will focus on a hands-on session aimed at providing participants with the basic skills required for their solution, with particular emphasis on linear inverse EM problems. Attendees will experience firsthand the importance of key theoretical concepts such as the “degrees of freedom” of electromagnetic fields, the “ill-posedness” of the inverse scattering problem, and “regularization strategies,” by analyzing their impact on the solution of the inverse EM problems for medical applications.

12:20 – 12:40	**Talk: IEEE AP/ED/MTT-S and IEEE Opportunities for Young Researchers** Speaker: Ricardo Figueiredo (IEEE MTT/AP/ED Portugal Joint Chapter) & João Pedro Oliveira (IEEE Portugal)
12:40 – 14:00	Lunch
14:00 – 17:30	**Visit to two laboratories of NOVA School of Science and Technology** (transportation from and to the conference venue will be provided)

- **3D Printing Center for Health** is a center which aims to develop devices for healthcare using 3D printing technology, promoting innovation, research, and social responsibility in healthcare.
- **CENIMAT|i3N** is a national scientific research center devoted to developing radical new approaches in the area of structural materials, electronic and optoelectronic materials, polymeric and mesomorph materials, dielectric and electroactive materials, involving nanofabrication and micro/nanotechnologies tools.

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