COST MiMed Newsletter

ISSUE 4 APRIL 2018

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Message from the Action chairs

Dear all,

It seems like yesterday we were about to start this wonderful adventure: our COST Action TD1301, MiMed.

We cannot thank enough to everyone in COST for the amazing opportunity and for trusting us to lead a four-year networking project which gathered over 250 people from 30 countries: We will be forever grateful to our Science Officer, and all our Administrative Officers throughout the years, as well as the remaining staff in the COST office in Brussels, whom we met at several meetings and occasions. Your work and dedication is truly inspiring!

Also, I have so much to thank to everyone in our Action: WG leaders, STSM manager, Media officer, all of you involved in the newsletter, all participants, speakers, trainers, trainees – I could write all of your names, but the list of people would be too long to write in this message! You have all made our Action a success and we have so much to be proud for as a community.

A really special thank you goes to everyone in our grant holder institution, who have done an amazing work of keeping all accounts and logistics in order. It was a great pleasure working with you and becoming your friend in the past four years.

We have learnt so much from all of you, been involved in so many interesting talks, schools, projects and were really lucky to have made so many great friends in the process. We hope you can count on us with anything you may need in the future!

We still have a few things to look forward to within the context of this particular COST Action, and much more that is happening as a result of this COST Action. I cannot wait to see what we will do as a community in the area of Microwave Medical (MiMed) research!

Looking forward to meeting you all again soon,

Thank you all,

Regards,

Raquel and Martin

MiMed at a glance

Duration: 2013 - 2017

26 participating countries: AT, BE, BG, CH, CZ, CY, DE, DK, EL, ES, FR, HR, IE, IL, IT, MK, MT, NL, NO, PT, RO, RS, SE, SI, TR, UK

3 International Partner Countries: CA, CN, US

One Near Neighbouring Country: RU

"Development of a European-based Collaborative Network to Accelerate Technological, Clinical and Commercialisation Progress in the Area of Medical Microwave Imaging"

Working Group 1: Op. misation of microwave imaging prototypes
Leader: Dr Maciej Klemm (UK)
WG1.a – Software development subgroup
Co-Leader: Prof. Paul Meaney (USA)
WG1.b – Hardware development subgroup
Co-Leader: Dr Ferry Kienberger (Austria)

Working Group 2: New techniques and emerging applications for microwave imaging
Leader: Dr Lorenzo Crocco (Italy)
Co-Leader: Dr Irene Karanasiou (Greece)

Focus area 1: Microwaves to monitor brain diseases and functionality
Leader: Dr Claudio Pollo (Switzerland)
Focus area 2: Contrast Enhanced Microwave Imaging
Leader: Prof. Ovidio Bucci (Italy)
Focus area 3: Theranostics - Microwaves diagnostics for therapy
Leader: Prof. Luca Vannucci (Czech Republic)

Working Group 3: Establishment and management of the clinical trials of MWI prototypes
Leader: Dr Andreas Fhager (Sweden)
Co-Leader: Prof. Ibrahim Akduman (Turkey)

Working Group 4: Widespread adoption of microwave imaging devices in clinical practice and framework for their commercialization
Leader: Dr Panagiotis Kosmas (UK)
Co-Leader: Prof. Yifan Chen (China, recently moved to New Zealand)

Action positions

Chair and Vice Chair
Dr Raquel Conceição (Portugal)
Dr Martin O'Halloran (Ireland)

Financial Rapporteurs
Dr David Girbau (Spain)
Prof Gerard Van Rhoon (Netherlands)

Short-Term Scientific Missions Officer
Prof Jorge Rodrigues da Costa (Portugal)

Communications Officer
Dr Giuseppe Ruvio (Ireland)

Science Officer
Dr Mafalda Quintas (Belgium)

Administrative Officer
Ange Marie Ina Uwase (Belgium)

Grant Holder
Mafalda Basto (Fundação da Faculdade de Ciências da Universidade de Lisboa, FFCUL, Portugal)

Dissemination meetings

12th European Conference on Antennas and Propagation

London, UK, 9th—13th April 2018

http://www.eucap2018.org/

- Convened session #10: Imaging and diagnosing with microwaves – new findings covering dielectric studies, imaging algorithms and patient studies
- Convened session #13: Academic and Industrial Advances in Microwave Medical Technologies within European COST Action TD1301 - MiMed

Visit our stand number 314 at EuCAP 2018 in London!

In 2017...

11th International Symposium on Medical Information and Communication Technology

Lisbon, Portugal , 6th-8th February 2017

http://www.ismict2017.org

2 TPC co-chairs (Jorge Costa, Raquel Conceição), 1 Workshop co-chair (Antonio Sarolic), 1 Tutorial co-chair (Panagiotis Kosmas)

11th European Conference on Antennas and Propagation

Paris, France, 19th-24th March 2017

http://www.eucap2017.org

- Convened session #05 Advances in Electromagnetic Diagnostics and Biomedical Sensors
- Convened session #06: Advances in Microwave Breast Cancer Diagnosis and Treatment
- Convened session #12 with COST BM1309 EMF-MED: Developments in Electromagnetic Medical Interventions
- Convened session #16: European Academic and Industrial Advances in Microwave Medical Technologies
- Short course: Microwave imaging for medical diagnostics: from theory to implementation

2017 International Workshop on Antenna Technology, iWAT *

Athens, Greece, 1st—3rd March 2017

http://www.iwat2017.org

** Not an official MiMed dissemination meeting*

"Four Working Groups are active for the deployment of all Action's goals"

8th Meeting in Naples for WG2

The 8th MiMed meeting in Naples (February 2017) was dedicated to the focus area "Contrast Enhanced Microwave Imaging" of WG2 and specifically to "Synergies between nanocomposites and electromagnetic waves for contrast enhanced microwave imaging, therapy and theranostics". The meeting was a continuation of the WG2 workshop that was held in Prague (September 2014) and it aimed to contribute to the discussion on the adoption of contrast agents to improve performance and reliability of MWI.

The meeting included presentations on the selection and optimization of contrast agents, their biocompatibility and targeting, the design of preclinical tests, ethical issues, as well as the specific design and technological aspects related to imaging devices exploiting these concepts. From a clinicians' point of view, Dr. Johannes Woelfer (Klinikum University Muenster, Germany) showed how magnetic nanoparticles are currently used in brain tumour therapy. He also presented a video with the application of nanoparticles to a brain tumour of a patient during surgery, along with the initial positive results from the therapeutic process for the reduction of the tumour size.

9th WG Meeting and MC Meeting in Valetta

The International Closing Meeting (WP & MC) of our Action was held in Valetta, Malta, June 2017.

Microwave tomography and radar-based algorithms for breast imaging along with the debate on the true dielectric contrast in microwave breast imaging and the development of dielectrically realistic breast phantoms were the main issues discussed by WG1 members. Prof. L. Vannucci's presentation about the role of animal models in the further development of microwave breast imaging and theranostics applications covered aspects of both WG1 and WG2.

WG2 meeting started with a recap by Dr. L. Crocco on the

10th Meeting in Prague for WG2

A workshop by WG2 on "Theranostics: options for implementing cancer imaging, diagnosis and treatment" was held in Prague, September 2017. Engineers, biologists, chemists and doctors participated with interesting presentations about the multidisciplinary research area of theranostics.

The workshop was divided into two main sessions: "Nanoconstructs and bioapplications" and "Electromagnetic (EM) fields". Session I involved nanoparticles and nanostructures for theranostics applications, materials and techniques used for their development and their main characteristics and properties, while Session II focused on the nanoparticle-EM radiation interaction, the electromagnetic properties of nanostructures and biomedical applications of diagnosis and therapy using EM waves.

The meeting finished with a smaller session for other biomedical applications of electromagnetic radiation and/or nanoparticles.

11th Meeting in Lisbon for EM therapeutics

A two-day meeting on "EM therapeutics: challenges and opportunities going forward" was organized at Lisbon, in October 2017.

The future of microwave biomedical applications was discussed. The challenges of dielectric properties measurement in living tissues and the accurate modelling of human organs has been drawning significant attention. Generally, the main focus of the meeting was the next steps towards electromagnetic biomedical systems for imaging and treatment, i.e hyperthermia and ablation.

Dr. L. Farrugia and Dr. M. O' Halloran introduced meeting participants to "MyWave" and to action scheduled for maximizing its impact by ensuring clinical and commercial translation of the outcome.

The meeting closed with a short workshop on dielectric data and metadata collection and a last conversation on the project conclusions.

activities and most significant results of the WG. The presentations that followed covered technical aspects of UWB and microwave brain imaging, microwave nanoparticles and contrast agents and the ongoing investigation of the dielectric properties of biological tissues.

Presentations and discussions within the WG3 meeting focused on the effort involved in preparing and performing clinical studies. Additionally, Dr Dingli, Mater Dei Hospital, Malta, gave an interesting presentation on the challenges in breast cancer surgery; Dr. K. Cassar, Mater Dei Hospital, Malta, also showed the results of thermography on limbs for assessing the success of endovascular revascularisation to diabetics. A review of the WG3 activities was also presented by Dr. A. Fhager.

The 9th WG meeting finished with an overview of the activities of WG4 and discussions over the efforts for commercialisation of microwave biomedical modalities and devices.

Additionally, a poster session with the work of the researchers that participated in last year's Short-Term Scientific Missions also took place.

The significance of this last MiMed meeting was noted by the speakers during their final presentations, and also by the special attendance of our Science Officer Dr. M. Quintas.

During round-table conversations regarding the following steps and "What next for MiMed?", MiMed's chairs, Dr. R. Conceição and Dr. M. O'Halloran, greeted all MiMed participants with port wine as a way of celebrating the successful 4-year course of the Action.

Training Schools

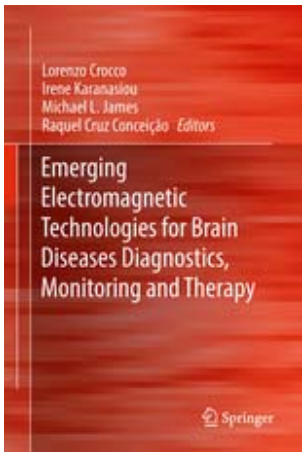
COST Actions can share knowledge and support collaboration through Training Schools. These Schools provide intensive training in emerging research topics within the laboratories and organisations involved in COST Actions. Training Schools also cover appropriate re-training as part of life-long learning. The MiMed Action co-organized 5 Training Schools and sponsored dozens of researchers, particularly PhD students and Early Career Investigators who work in the field of Microwaves in Medicine.

School name	Organizer(s)
"ESHO School on Clinical hyperthermia: Hyperthermia & Thermal Ablation in Cancer Therapy" — February 3-6, 2018 @ Huntsham, UK (link)	European Society of Hyperthermic Oncology (ESHO)
"Microwave Imaging and Diagnostics: Theory, Techniques, and Applications" — March 24-28, 2014 @ Madonna di Campiglio, Italy (link)	European School of Antennas (ESoA)
"European Training School on Clinical Trial Design and Management " — May 5-8, 2015 @ National University of Ireland Galway, Ireland (link)	MiMED COST Action TD1301 EMF-MED COST Action BM1309
"Health Technology Assessment" — March 21-23, 2015 @ Rome, Italy	Paediatric Hospital "Bambino Gesù", Rome, Italy
"Microwave Imaging and Diagnostics: Theory, Techniques, and Applications" — October 10-14, 2016 @ Taormina, Italy (link)	European School of Antennas (ESoA)

New MiMed Book

Emerging Electromagnetic Technologies for Brain Diseases Diagnostics, Monitoring and Therapy

Lorenzo Crocco, Irene Karanasiou, Michael L. James, Raquel Cruz Conceição (Eds.)
Springer International Publishing
https://www.springer.com/de/book/9783319750064



Congratulations to Lorenzo Crocco, Irene Karanasiou, Michael James and Raquel Conceição on the publication of their new book on Emerging Electromagnetic Technologies for Brain Diseases Diagnostics, Monitoring and Therapy, a significant milestone for the MiMed community. The book's 1st edition has been published by Springer in 2018. Most of the MiMed members who work in electromagnetic technologies for brain imaging and therapy have contributed as authors resulting in an important collective effort within our Action. In the following message by Dr. L. Crocco, book editor, the roots and course of this effort is explained along with the interesting areas of emerging electromagnetic brain technologies covered by this book.

Message from Lorenzo Crocco, Book editor and WG2 leader

Brain related diseases nowadays represent an increasingly prominent societal challenge, owing to their significant incidence in an ageing population. Hence, the quest for new, minimally invasive and personalised technologies for monitoring, diagnosis and therapy is an active, multidisciplinary research field. In such a framework, electromagnetic technologies are receiving an ever-increasing attention, because of their non-ionising, minimal risk nature, relative low-cost and portability, and dual diagnostic - therapeutic nature. It is therefore almost natural that this topic has been one of the most important lines of development of the MiMed network activities.

The idea of this book emerged in 2015, during the Working Group 2 meeting of MiMed, hosted by Dr. Irene Karanasiou at the School of Electrical and Computer Engineering of the National Technical University of Athens, Greece. On that occasion, a number of scholars from various European countries and the US had the opportunity to get together to share their findings, views and perspectives on the application of electromagnetic technologies for brain disease diagnostics, monitoring, and therapy. Most importantly, thanks to the unique multidisciplinary nature of our network, the meeting offered a broad palette of expertise and experiences, ranging from neurosurgeons, immunologists, bio-chemists, engineers, physicists and nanotechnologists.

The success of that workshop brought forward the idea of making its interesting outcomes available to a broader community by means of a book made up of the participants' contributions. This proposal was eagerly embraced by our colleagues, who agreed to turn their presentations into a more structured form.

As a result, this eight chapters book presents, for the first time, an overview of the emerging electromagnetic technologies and their application to brain diseases diagnostics, monitoring and therapy. The first chapters of the book focus on microwave imaging for diagnostics and monitoring of cerebrovascular diseases (such as stroke, ischemia, haemorrhage, cerebral vasospasm), describing how this technology has the potential to address the current needs in neurointensive care. Then, the use of microwave radiometry is illustrated as a viable solution for non-invasive brain thermometry during surgery. Two chapters are dedicated to the treatment of brain tumors by means of the joint use of electromagnetic fields and nanotechnologies, due to unique therapeutic capabilities this combination offers. The final chapter addresses the perspective developments of multi-modal multi-spectral electromagnetic technologies, which exploit the different portions of the non-ionizing electromagnetic spectrum to improve the effectiveness of diagnosis and therapy, possibly even under a theranostics approach.

As editors, we have particularly appreciated the high quality of the material and the dedicated efforts of all the contributors, which we thankfully acknowledge, and we believe that, amongst the many important outcomes of MiMed, this book will be one of the most tangible legacies of our network.

Short-term scientific missions in 2016 - 2017 (GP4)

Name	Host — *Date*	Title
Irina Alborova, Bauman Moscow State Technical University, Moscow, Russia	Charles Sammut, University of Malta, Msida, Malta — *July 18-August 1, 2016*	A study of the biological tissues dielectric properties
Mohammed Rahman, King's College London, London, UK	Lorenzo Crocco, Istituto per il Rilevamento Elettromagnetico dell'Ambiente (IREA), Napoli, Italy — *September 1-22, 2016*	Phantom Study for Microwave Imaging
Saqib Salahuddin, National University of Ireland, Galway, Ireland	Charles Sammut, University of Malta, Msida, Malta — *September 3-October 1, 2016*	Preliminary Investigation of Temperature and Coagulation Effects on the Dielectric Properties of Blood
Syed Ahsan, King's College, London, UK	Francesca Vipiana, Politecnico di Torino, Turin, Italy — *September 4-25, 2016*	Development of Microwave Imaging Setup
Jorge Alberto Tobon Vasquez, Politecnico de Torino, Turin, Italy	Marko Helbig, Technische Universität Ilmenau , Ilmenau, Germany — *September 24-October 1, 2016*	Realistic skin realization for breast phantom
Martina Teresa Bevacqua, University Mediterranea of Reggio Calabria, Reggio Calabria, Italy	Rob Remis, Delft University of Technology, Delft, Netherlands — *November 13-December 14, 2016*	A novel, non invasive, methodology for mapping the dielectric properties of human tissue in vivo
Mina Bjelogrlic, École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland	Michael Mattes, Technical University of Denmark, Kongens Lyngby, Denmark — *January 1-31, 2017*	Computational Validation of a 3-D Microwave Imaging System for Brain Stroke Monitoring
Daniela Godinho, University of Lisbon, Lisbon, Portugal	Martin O'Halloran, National University of Ireland, Galway, Ireland — *March 18-26, 2017*	Data fusion algorithm for breast cancer classification with microwave imaging
Branislav Gerazov, Faculty of Electrical Engineering and Information Technologies, Skopje, Macedonia	Raquel Conceição, University of Lisbon, Lisbon, Portugal — *March 27-April 23, 2017*	Application of deep learning to breast cancer classification in microwave imaging
Tomislav Markovic, KU Leuven, Leuven, Belgium	Adrijan Barić, University of Zagreb, Zagreb, Croatia — *April 1-30, 2017*	Microwave Design and De-Embedding Techniques for Heating Devices for Life Sciences
Irina Alborova, Bauman Moscow State Technical University, Moscow, Russia	Panagiotis Kosmas, MediWiSe | Medical Wireless Sensing Ltd , London, UK — *April 10-30, 2017*	Antenna design by using specialist tool for the 3D EM simulation of high frequency components
Lorenzo Crocco, Istituto per il Rilevamento Elettromagnetico dell'Ambiente (IREA), Napoli, Italy	Ibrahim Akduman, Istanbul Technical University, Istanbul, Turkey — *April 13-17, 2017*	Participation to clinical trials and development of improved processing and acquisition strategies
Bárbara Luz Oliveira, National University of Ireland, Galway, Ireland	Raquel Conceição, University of Lisbon, Lisbon, Portugal — *April 15-30, 2017*	Validation of breast cancer classification systems for microwave imaging with experimental data

Short-term scientific missions in 2017 (GP5)

Name	Host — *Date*	Title
Mina Bjelogrlic, École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland	Michale Mattes, Technical University of Denmark, Kongens Lyngby, Denmark — *August 18-September 8, 2017*	Experimental Validation of Microwave Imaging for Brain Stroke Monitoring
Matilde Pato, University of Lisbon, Lisbon, Portugal	Martin O'Halloran, National University of Ireland, Galway, Ireland — *September 4-15, 2017*	Development of a robust technique for skin removal artefact in numerical phantom for different skin's layer
Gennaro Bellizzi, Università Mediterranea Di Reggio Calabria, Reggio Calabria, Italy	Maarten Paulides, Erasmus University Medical Center-Daniel den Hoed, Rotherdam, Netherlands — *September 4-October 13, 2017*	Microwave hyperthermia: optimal treatment planning & theranostic potential of applicators
Álvaro Fernández Vaquero, University Of Oviedo, Gijón, Spain	Jorge Costa, Instituto Superior Técnico, Lisbon, Portugal — *September 6-November 6, 2017*	Design of a Bessel broadband lens for skin cancer
Julian Bonello, University of Malta, Msida, Malta	Martin O'Halloran, National University of Ireland Galway, Ireland — *September 14-October 4, 2017*	Characterising the temperature dependence of dielectric properties of biological tissue samples
Michele Ambrosanio, Università Degli Studi Di Napoli, "Parthenope", Napoli, Italy	Panagiotis Kosmas, Medical Wireless Sensing Ltd, London, UK — *September 14-October 4, 2017*	Testing of Novel Microwave Imaging Inversion Approaches
Laura Farina, Sapienza Università di Roma, Rome, Italy	Charles Sammut, University of Malta, Msida, Malta, — *October 2-31, 2017*	Characterization of the dielectric properties of biological tissues and their correlation to tissue hydration
Alessandra La Gioia, National University of Ireland, Galway, Ireland	Ferry Kienberger, Keysight Technologies, Linz, Austria — *October 2-13, 2017*	Evaluation of Keysight VNA software for automatic calculation of dielectric measurement uncertainty

Short-term scientific missions in 2016 (GP3)

Name	Host — *Date*	Title
Giuseppe Ruvio, Dublin Institute of Technology, Dublin, Ireland	Vanni Lopresto, ENEA, Rome, Italy — *February 1-7, 2016*	High-accuracy dielectric properties measurements
Raquel Conceição, University of Lisbon, Lisbon, Portugal	Edward Jones, National University of Ireland, Galway, Ireland — *February 28-March 18, 2016*	Microwave Imaging-based breast cancer classification
Marija Stevanovic, University of Belgrade, Belgrade, Serbia	Andrea Massa, ELEDIA Research Center, Trento, Italy — *March 29-April 10, 2016*	Sparse microwave imaging using wavelet transform
Declan O'Loughlin, National University of Ireland, Galway, Ireland	Milica Popovic, McGill University, Montreal, Canada — *April 4-22, 2016*	Hardware Development for Microwave Breast Imaging
Laura Farina, Sapienza Università di Roma, Rome, Italy	Luca Vannucci, Institute of Microbiology Czech Academy of Sciences, Prague, Czech Republic — *April 10-17, 2016*	Characterization of dielectric properties of in vivo breast tumor model

Subset of journal publications within the MiMed framework

2014

Breast phantoms for microwave imaging
Nadine Joachimowicz (FR), Christophe Conessa (UK), Tommy Henriksson (UK) & Bernard Duchêne (FR)
IEEE Antennas and Wireless Propagation Letters, 2014, 13:1333-6

Targeting Mitochondria for Cancer Treatment—Two Types of Mitochondrial Dysfunction
Jiří Pokorný (CZ), Jan Pokorný (CZ), Jitka Kobilková (CZ), Anna Jandová (CZ), Jan Vrba (CZ) & Jan Vrba Jr (CZ)
Prague Medical Report, 2014, 115:104-119

Development of anatomically and dielectrically accurate breast phantoms for microwave imaging applications
Martin O'Halloran (IE), Giuseppe Ruvio (IE), Jennifer Browne (IE), Raquel Conceição (PT), Edward Jones (IE) & Martin Glavin (IE)
Proceedings of SPIE, May 2014, 9077:90770Y

Breast cancer detection using interferometric MUSIC: experimental and numerical assessment
Giuseppe Ruvio (IE), Raffaele Solimene (IT), Antonio Cuccaro (IT), Domenico Gaetano (IE), Jacinta Browne (IE) & Max Ammann (IE)
Medical Physics, Oct 2014, 41(10):103101

Microwave radar imaging of heterogeneous breast tissue integrating a priori information
Jochen Moll (DE), Thomas Kelly (DE), Dallan Byrne (UK), Mantalena Sarafianou (UK), Viktor Krozer (DE) & Ian Craddock (UK)
International Journal of Biomedical Imaging, Nov 2014, 2014:943549

2015

Satellite symposium: Emerging role of microwave imaging technology
Martin O'Halloran (IE)
New Horizons in Translational Medicine, Jan 2015, 2(2):62

Other applications of medical microwaves – Breast tumour classif cation
Raquel Conceição (PT)
New Horizons in Translational Medicine, Jan 2015, 2(2):62-63

Wavelet-based regularization for robust microwave imaging in medical applications
Rosa Scapaticci (IT), Panagiotis Kosmas (UK) & Lorenzo Crocco (IT)
IEEE Transactions on Biomedical Engineering, Apr 2015, 62(4):1195-202

Focused ultrasound for treatment of bone tumours
Dario Rodrigues (US), Paul Stauffer (US), David Vrba (CZ) & Mark Hurwitz (US)
International Journal of Hyperthermia, May 2015, 31(3):260-71

A touch-communication framework for drug delivery based on a transient microbot system
Yifan Chen (CN), Panagiotis Kosmas (UK), Putri Anwar (CN) & Limin Huang (CN)
IEEE Transactions on Nanobioscience, Jun 2015, 14(4):397-408

Development of Clinically Informed 3-D Tumor Models for Microwave Imaging Applications
Bárbara Luz Oliveira (IE), Martin O'Halloran (IE), Raquel Conceição (PT), Martin Glavin (IE) & Edward Jones (IE)
IEEE Antennas and Wireless Propagation Letters, Jul 2015, 15:520-523

Subset of journal publications within the MiMed framework

2015

Preliminary investigations of magnetic modulated nanoparticles for microwave breast cancer detection
Sebastian Ley (DE), Marko Helbig (DE) & Jürgen Sachs (DE)
Current Directions in Biomedical Engineering, Sep 2015, 1(1):302-305

Comparing Two Approaches for Point-Like Scatterer Detection
Angela Dell'Aversano (IT), Giovanni Leone (IT) & Raffaele Solimene (IT)
International Journal of Antennas and Propagation, Oct 2015, 2015:139235

Progress in Microwave Imaging: From Theoretical Developments to Cutting-Edge Applications - Guest Editors Editorial
Ibrahim Akduman (TR), Lorenzo Crocco (IT) Amélie Litman (FR) & Ali Yapar (TR)
International Journal of Antennas and Propagation, Nov 2015, 2015:960927

2016

An introduction to microwave imaging for breast cancer detection.
Editors: Raquel Conceição (PT), Johan Mohr (DK), & Martin O'Halloran (IE)
Biological and Medical Physics, 2016

Higher Order Sparse Microwave Imaging of PEC Scatterers
Marija Stevanović (RS), Lorenzo Crocco (IT), Antonije Djordjević (RS) & Arye Nehorai (US)
IEEE Transactions on Antennas and Propagation, Mar 2016, 64(3):988-997

Metamaterial Antenna Arrays for Improved Uniformity of Microwave Hyperthermia Treatments
David Vrba (CZ), Dario B. Rodrigues (US), Jan Vrba (CZ) & Paul R. Stauffer (US)
Progress In Electromagnetics Research, Apr 2016, 156:1-12.

Microwave bone imaging: a preliminary scanning system for proof-of-concept
Giuseppe Ruvio (IE), Antonio Cuccaro (IT), Raffaele Solimene (IT), Adriana Brancaccio (IT), Bruno Basile (IT) & Max J. Ammann (IE)
Healthcare Technology Letters, May 2016, 3(3):218-221

Analysis of on-Body Transponders Based on Frequency Selective Surfaces.
Javier Lorenzo (ES), Antonio Lazaro (ES), David Girbau (ES), Ramon Villarino (ES) & Ernest Gil (ES)
Progress In Electromagnetics Research, Nov 2016, 157:133-143

Evaluation of a tumor detection microwave system with a realistic breast phantom
Maria Koutsoupidou (EL), Irene Karanasiou (EL), Constantine Kakoyiannis (EL), Evangelos Groumpas (EL), Christophe Conessa (FR), Nadine Joachimowicz (FR), Bernard Duchêne (FR)
Microwave and Optical Technology Letters, Nov 2016, 59(1):6-10.

Numerical investigation of novel microwave applicators based on zero-order mode resonance for hyperthermia treatment of cancer
David Vrba (CZ), Jan Vrba (CZ), Dario Rodrigues (US) and Paul Stauffer (US)
Journal of The Franklin Institute, 2016

Differential Evolution Optimization of the SAR Distribution for Head and Neck Hyperthermia
Grazia Cappiello (IE), Brian McGinley (IE), Adnan Elahi (IE), Tomas Drizdal (NL), Margarethus Paulides (NL), Martin Glavin (IE), Martin O'Halloran (IE) & Edward Jones (IE)
IEEE Transactions on Biomedical Engineering, 2016

Microwave Broadband Characterization of a Diluted Water-Based Ferrof uid in Presence of a Polarizing Magnetic Field
Ovidio M. Bucci (IT), Gennaro Bellizzi (IT) & Gennaro G. Bellizzi (IT)
IEEE Transactions on Magnetics, 2016

Subset of journal publications within the MiMed framework

2017

Minimum information for dielectric measurements of biological tissues (MINDER): A framework for repeatable and reusable data.
Emily Porter (IE), Alessandra La Gioia (IE), Saqib Salahuddin (IE)., Stefan Decker (DE), Atif Shahzad (IE), Adnan Elahi (IE), Martin O'Halloran (IE) & Oya Beyan (DE)
International Journal of RF and Microwave Computer Aided Engineering, 2017

Optimised analytical models of the dielectric properties of biological tissue.
Saqib Salahuddin (IE), Emily Porter (IE), Finn Krewer (IE) & Martin O'Halloran (IE)
Medical Engineering & Physics, 43, pp.103-111, 2017

Effect of logarithmic and linear frequency scales on parametric modelling of tissue dielectric data
Saqib Salahuddin (IE), Emily Porter (IE), Paul Meaney (US) & Martin O'Halloran (IE)
Biomedical Physics & Engineering Express, 3(1), p.015020., 2017

Effects of Standard Coagulant Agents on the Dielectric Properties of Fresh Human Blood
Saqib Salahuddin (IE), Martin O'Halloran (IE), Lourdes Farrugia (MT), Julian Bonello (MT), Charles V. Sammut (MT) , P. Schembri Wismayer (MT) & Emily Porter (IE)
IEEE Transactions on Dielectrics and Electrical Insulation, vol. 24, no. 5, pp. 3283-3289, 2017

Focal quality metrics for the objective evaluation of confocal microwave images.
Declan O'Loughlin (IE), Finn Krewer (IE), Martin Glavin (IE), Edward Jones (IE) & Martin O'Halloran (IE)
International Journal of Microwave and Wireless Technologies, pp.1-8., 2017

MRI-based electric properties tomography with a quasi-Newton approach
Anar Rahimov (FR), Amélie Litman (FR) & Guillaume Ferrand (FR)
Inverse Problems, 33(10), p.105004, 2017

Adaptive artifact removal for selective multistatic microwave breast imaging signals
Adnan Elahi (IE), Martin Glavin (IE), Edward Jones (IE) & Martin O'Halloran (IE)
Biomedical Signal Processing and Control, vol. 34, pp. 93-100, 2017

Modelling of the Dielectric Properties of Biological Tissues within the Histology Region
Emily Porter (IE), Alessandra La Gioia (IE), Adam Santorelli (IE) & Martin O'Halloran (IE)
IEEE Transactions on Dielectrics and Electrical Insulation, vol. 24, no. 5, pp. 3290-3301, 2017

Investigation of Histology Region in Dielectric Measurements of Heterogeneous Tissues
Emily Porter (IE) & Martin O'Halloran (IE)
IEEE Transactions on Antennas and Propagation, vol. 65, no. 10, 2017

Gadolinium-based nanoparticles for targeting the tumor microenvironment.
Lucca Vannucci (CZ), Lenka Rajsiglová (CZ), Dmitry Stakheev (CZ), Daniela Lehutova (CZ), Vladimir. Havlicek (CZ), Dominika Luptaková (CZ), Tomas. Pluhacek (CZ), Pierpaolo Ceci (IT), Elisabetta Falvo (IT), Michal Babic (CZ), Uliana Kostiv (CZ), Daniel Horak (CZ), Jiri Krizan (CZ), Jan Vrba (CZ), Jan Vrba JR (CZ), David Vrba (CZ), Laura Farina (IT), Vanni Lopresto (IT), Giuseppe Ruvio (IE), Pavol Makovicky (SK), Peter Makovicky (CZ) & Radislav Sedlacek (CZ)
Invited Lecture in International Journal Molecular Medicine, 40 (S1):S38-S38, 2017

Microwave Breast Imaging: Clinical Advances and Remaining Challenges
Declan O'Loughlin (IE), Martin O'Halloran (IE), Brian Moloney (IE), Martin Glavin (IE), Edward Jones (IE) & Adnan Elahi (IE)
IEEE Transactions on Biomedical Engineering, vol. PP, no. 99, pp. 1–1, 2018

Microwave Breast Imaging: experimental tumour phantoms for the evaluation of new breast cancer diagnosis systems
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Tangible output/impact produced by the COST Action

"Overall, the MiMed Action (via the enthusiasm and drive of each and every member) has exceeded our initial ambitious objectives, and delivered some really inspiring outputs. Our aim going-forward is to maintain this momentum, and to continue to expand our network of MiMed friends."

Raquel Conceição and Martin O'Halloran, chairs of the MiMed Action

Several short term scientific missions (STSMs) were funded to support the refinement of existing microwave medical devices. These STSMs facilitated the significant acceleration of microwave hardware for both diagnostic and therapeutic applications. Working group 1 (WG1) also produced the following: i) standard phantoms activity launched; ii) launch of Centres for Experimental Microwave Imaging (CEMI) activity; iii) establishement of formal collaboration between small and medium-sized enterprises (SMEs), supported by a EUROSTAR grant.

During the four years, microwave imaging prototypes within the MiMed Action have converged into two clear categories (fixed multistatic antennas and movable monostatic antenna systems). Research groups have adopted the best features of each category, have largely moved beyond prototype development and are more focused on gathering early first-in-man clinical data, which was one of the key goals of the Action.

Several funded STSMs allowed researchers to evaluate and optimise their algorithms on reliable advanced prototypes. A dedicated Training School was organised twice for that purpose: "Microwave Imaging and Diagnostics: Theory, Techniques, and Applications". An acceleration of the refinement of microwave imaging software has been achieved and the MiMed community have converged to a small set of image reconstruction algorithms that have shown to be most robust and effective for image formation. Review and comparison papers have been published, highlighting the best options within each category. The most recent papers are now focused on comparing these algorithms on real patient data, as the final step in algorithm validation.

MiMed participants chaired and presented their research at numerous medical forums, in an effort to better educate and inform clinicians of the value and potential of microwave imaging and therapeutic technologies. Several new projects involving microwave imaging/therapeutics have been proposed and submitted for funding. Four focus areas have been identified:

1) Application of Microwaves for Brain diseases monitoring and diagnostics
2) Exploitation of Contrast Agents for Microwave diagnostics
3) Theranostics
4) Microwave ablation.

Microwave ablation in particular has emerged during the lifetime of the Action and has shown significant promise with a number of projects being funded through national funders.

At each WG meeting, works involving initial clinical trials were presented, and the non-technical practical challenges in running a trial were discussed. Additionally, a dedicated training school on Clinical Trial Design and Management was organised. Many groups are now rapidly moving to clinical trial, or redesigning their existing trials based on the training school. One industry partner (Microwave Vision Group) is now planning the clinical evaluation of their microwave imaging system at a COST partner institution (National University of Ireland Galway), after testing their system with breast tumour models provided by another partner (University of Lisbon).

At each WG meeting, invited speakers were organised to host workshops on research commercialization and address the intellectual properties concerns, health technology evaluation, and securing non-exchequer funding. As a result, all MiMed participants are now much more informed about the commercialisation process, including the importance of identifying unmet clinical needs, measuring the impact of their technologies to the improvement of health, evaluating the target market, protecting their intellectual property, and securing non-exchequer funding. Several MiMed participants have submitted patent applications over the course of the Action.

Tangible output/impact produced by the COST Action

At the beginning of the MiMed COST Action, microwave imaging and therapeutics was often described as a set of technologies with significant "future potential". During the duration of the MiMed Action, members were trained in technology refinement, clinical evaluation and commercialisation. Based on these trainings, and increased interaction, the technology grew significant momentum, resulting in an increase in the number of clinical trials being completed in Europe, an increase in the number of start-up companies being formed, and a growing number of collaborative projects between MiMed Partners. The success of MiMed can be illustrated with three significant examples (see box below).

1. **Microwave Vision Group** (France) are completing their first clinical trial of their microwave breast imaging system at NUI Galway (Ireland) in early 2018. NUI Galway have a dedicated Clinical Trials Facility and have a large medical device research team who helped Satimo secure regulatory and ethical approval at zero cost. This collaboration was formed within the MiMed COST Action and shows the potential for close collaboration between industry and academia to ensure new technologies get to the clinic as soon as possible.

2. A **radio-frequency medical device spin-out** company from NUI Galway has secured circa €10 million in investment in 2017 for the development of their novel therapeutic technology. It should be noted that this investment is one of the largest ever investments in a university spin-out company in Europe, and really validates the investment from the COST Office four years ago in the MiMed Action. The company is now seeking to hire ~25 engineers/scientists, and hopes to draw on the MiMed network for candidates. It should be noted that a number of MiMed participants are co-inventors of the technology.

3. A sub-group of companies within the MiMED Action secured very significant funding under the **H2020 EuroStars Programme**. That funding allowed the partners to develop a core piece of common hardware technology that could be shared across all of their medical devices, to improve performance and reduce development costs. While Eurostars funded the development, the consortium formation and co-operation was driven solely through the MiMed Action. Importantly, that spirit of cooperation between the MiMed industry members has remained and they continue to collaborate to address common hardware challenges as they progress towards the market and the clinic.

For the MiMed Management team, the best method for dissemination was through education, enabled by the COST STSM tool. We wanted "best practice" within Action-members to become "normal practice" within the network. Therefore, in each and every year, we prioritised the support of STSMs between partners, where ECIs in particular could spend time in the leading labs and learn what was required to translate an idea out of the lab and into the clinic. At the start of the Action, only a handful of groups had completed clinical trials. By spending time at these leading labs, the translational knowledge was shared, and the numbers of clinical trials started to grow year-on-year. Clinical studies and the commercialisation of technology was demystified greatly, and the barriers to translation were overcome. We also organised dedicated sessions at international conferences yearly (e.g. APS-URSI, EuCAP, PIERS) where new discoveries in the area could be presented and discussed. By having several dedicated "MiMed" sessions at conferences, the value and significance of the meetings became ever more important. The MiMed members received training on the formation of spin-out companies, IP protection, securing finance, health technology assessment, and many other topics relevant to technology exploitation. The spin-out companies supported by the MiMed COST Action include Medfield Diagnostics, Mediwise, Micrima, and Microwave Vision Group, amongst others. Other research groups have patented their concepts and licenced their ideas to medical device companies, to shorten the development timeline. Their technologies have been licensed to European companies including Kite Medical (kidney imaging device for children) and Neurent Medical (therapeutic technology company in Ireland). In summary, there has been significant and continued exploitation of results from the MiMed COST Action in the form of spin-out companies or license deals.

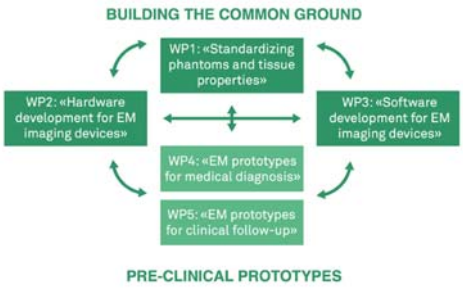
EMERALD: a new MSCA Training Network on EM medical devices

EMERALD (ElectroMagnetic imaging for a novel genERAtion of medicAL Devices) is a Marie Skłodowska-Curie Innovative Training Network (MSCA-ITN) recently funded by the European Union's Horizon 2020 Research and Innovation Programme. The EMERALD Training Network has been prepared and proposed by European engineering groups, part of the MiMed COST Action, involved in electromagnetic (EM) technology for medical imaging. The EMERALD consortium includes academic institutions, industrial partners, hospitals and university medical centers (as partner organizations); all these different institutions are part of the MiMed COST action that allowed to establish solid connections and collaborations among them.

The main aim of EMERALD is to form a cohort of highly-skilled researchers capable of accelerating the translation of this technology "from research bench to patient bedside". Nowadays, medical imaging technologies play a key role to face the ever-growing number of challenges due to ageing populations, as they are the essential clinical tool to deliver accurate initial diagnosis and monitor the evolution of disease over time. For this reason, a whole range of new imaging modalities is currently being developed to supplement and support current modalities; the EMERALD network will focus its research activities on EM imaging technologies.

The scientific objective pursued by the EMERALD action is to accelerate translation of research in EM medical imaging into clinical prototypes. To this end, EMERALD will establish a group of 13 outstanding early stage researchers who will be the European leaders in this field, through a unique scientific and training programme. The EMERALD trained researchers will drive the future developments of EM imaging technology, thanks to the targeted skills, they will attain, and their established connections with clinicians and stakeholders. The success of EMERALD will ensure that all achieved innovative technological developments will be translated into benefits to the end user community and potentially taken to market, with an impact on both the European society and scientific community.

Dr. Francesca Vipiana



Vacancy No.	Host Institution	Location	Starting date	Main research topic
1	Centre National de la Recherche Scientifique / Sorbonne University	Paris (FR)	Oct. 2018	Standard phantoms for EM device testing
2	National University of Ireland, Galway	Galway (IE)	Oct. 2018	Characterization of the tissue dielectric properties
3	Politecnico di Torino	Torino (IT)	Oct. 2018	Hardware acceleration for imaging algorithms
4	Keysight Technologies Austria GmbH / Johannes Kepler University Linz	Vienna (AT)	Oct. 2018	Development of customized radiofrequency front-end systems
5	King's College London	London (UK)	Oct. 2018	Metamaterial technology for improved EM medical devices
6	WIPL-D d.o.o. / University of Belgrade	Belgrade (RS)	Oct. 2018	Full wave modeling for EM medical devices
7	King's College London	London (UK)	Oct. 2018	Imaging algorithms for medical diagnosis devices
8	National Research Council of Italy, IREA / University of Trento	Napoli (IT)	Oct. 2018	Imaging algorithms for clinical follow-up devices
9	Politecnico di Torino	Torino (IT)	Oct. 2018	EM device for cerebrovascular diseases imaging
10	FCIENCIAS.ID Associação para a Investigação e Desenvolvimento de Ciências / Faculdade de Ciências da Universidade de Lisboa	Lisbon (PT)	Oct. 2018	EM device for axillary lymph node diagnosis
11	MITOS Medical Technologies A.S. / Istanbul Technical University	Istanbul (TR)	Jan. 2019	EM device for chemotherapy monitoring
12	Technical University in Ilmenau	Ilmenau (DE)	Jan. 2019	EM device for hyperthermia treatment monitoring
13	National Research Council of Italy, IREA / University of Rome Sapienza	Napoli (IT)	Oct. 2018	EM device for imaged guided microwave ablation

Currently the EMERALD network is looking for brilliant and highly motivated young scientists who will form a critical mass of top experts in electromagnetic technology for medical imaging in Europe and become leader candidates for future employment in related industry and academia. 13 positions are available on fixed-term contracts for 36 months with a start date in either October 2018 or January 2019, depending on the host institution. All candidates must comply with the Marie Sklodowska-Curie Actions eligibility requirements, and, in summary, candidates:

- must be within the first four years (full-time equivalent) of their research career;
- must not yet have been awarded a doctoral degree;
- must carry out transnational mobility and not have resided or carried out their main activity (work, studies, etc.) within the host country for more than 12 months in the three years immediately prior to recruitment (short stays such as holidays are not taken into account).

Salary will be within the range: approximately € 26,000 to € 40,000 gross per annum (depending on location and family status). Successful candidates are expected to enroll on a PhD programme at the host institutions (or at the partner Universities if the host institution does not award the PhD title).

Proposed COST Action: MyWAVE

European network for advancing electromagnetic hyperthermic medical technologies

Building on the remarkable success of COST Actions MiMed and EMF-MED, the proposed MyWAVE networ aims to support innovation and research connections for the next generation of researchers. Bringing together engineers, scientists, medical professionals, and industry experts, the Action will focus on advancing electromagnetic (EM) thermal-based techniques for the treatment of disease. Within the context of an ageing population in Europe and an exponential growth in healthcare costs, EM therapeutics are promising and very attractive solutions - they are low-cost, non-ionising and largely non-invasive. EM hyperthermic technologies specifically hold great potential in the treatment of diseases, especially for cancers that are resistant to standard regimens. These technologies modify tissue temperature; for example, hyperthermia heats the diseased tissue above normal physiological levels to make it more susceptible to other treatments, and ablation heats the targeted tissue until it is destroyed (while simultaneously preserving the surrounding healthy tissues). Hyperthermia has been demonstrated to be particularly effective in the treatment of cervical and breast cancer, head and neck cancers, sarcoma in adults, and germ cell tumours in children; while radiofrequency and microwave ablation offer promise for treating liver, kidney, and lung cancers. Overall, these therapeutic techniques have shown significant potential and there is considerable opportunity to solidify their use clinically and to apply them to a wider range of medical conditions. However, in general these technologies are unfortunately not reaching patients in a timely manner. While research into EM thermal technologies is becoming increasingly popular, the translation of this technology has not kept pace. Without commercialisation of a medical device, the device cannot be used in the clinic and therefore does not provide any benefit to patients. However, the high level of risk involved in the commercialisation process limits investment interest. Furthermore, there is a large gap between scientific advances and the regulatory science needed to predict and evaluate product performance. As such, assessment of the value of medical devices is challenging due to the shortage and reliability of data, both in terms of the clinical benefits of the device and associated costs.

The key technical challenge underpinning EM therapeutics is the need for reliable, accurate knowledge of the dielectric and thermal properties of human tissues and how these parameters change with time, temperature, hydration, and blood perfusion. These parameters provide the foundation for EM thermal

The challenges and topics MyWAVE will address in order to advance EM hyperthermic medical device development for existing and novel clinical applications. Progress in EM thermal therapies offers substantial promise for improving patient outcomes.

therapies, and knowledge of them would de-risk the technical as-pects of commercialization. Further-more, contributing to the stagnant market of EM hyperthermic medical devices is the fact that, researchers working on the development of these devices often have specific fields of expertise, and are not trained to address the comprehensive clinical and commercialisation challenges facing novel medical devices. To address this series of challenges, among others, the proposed MyWAVE Action will take a holistic approach by bringing together key players in the field of dielectric spectroscopy, translational research, and medicine. Joining these diverse communities into one collaborative network will be critical in advancing the design, development, and commercialisation of EM hyperthermic technologies, so that they can reach patients faster and improve treatment outcomes. Notably, EM hyperthermic therapies have the potential to include patient-specific treatment planning and treatment guiding, resulting in optimised, individualised treatment. As such, these modalities offer substantial promise in terms of improving patient outcomes through more effective and more efficient treatment strategies. The MyWAVE network aims to support researchers to deliver on this promise.

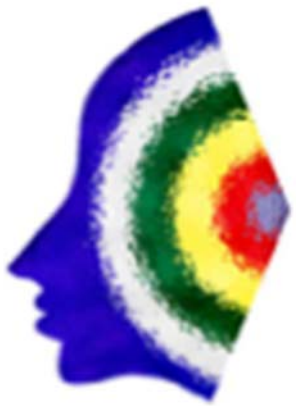
The MyWAVE COST Action is envisioned to have three working groups, each of which address key challenges facing the design, development, and translation of EM hyperthermic technologies today.

MyWAVE will, for the first time, bring dielectric and thermal data generators and end-users together, to address critical challenges faced by the thermal-based EM medical device community. Overall, this COST Action will advance treatment protocols, planning, and monitoring, towards better healthcare, with progress beyond the state-of-the-art achieved by bringing together all relevant stakeholders to define standards and pave the way to advancing these technologies in the right direction.

The main proposer of the MyWAVE network is Dr. Lourdes Farrugia, University of Malta. Along with secondary proposer, Dr. Emily Porter (National University of Ireland Galway), Dr. Farrugia has built a strong and diverse network, which currently includes 18 COST Countries, including 7 ITCs, 1 Cooperating State, and 1 International Partner Country (IPC). The group consists of researchers from electrical engineering, medical engineering, clinical medicine and health services, as well as industry partners who are developing hardware and software tools, and commercial thermal-based EM medical technologies. This blend of expertise will be crucial to the success of MyWAVE. The MyWAVE network is currently composed of almost 30% Early Career Investigators, which will foster a dynamic network that is receptive to new ideas, and for whom this network will be instrumental to building the next stages of their careers. Overall, the MyWAVE network has the potential to significantly, and positively, impact the field of EM therapeutic technologies.

The MyWAVE proposal was submitted in September 2017, and we expect a result this April.

If you are interested in receiving updates about MyWAVE, please email Dr. Lourdes Farrugia at lourdes.farrugia@um.edu.mt



MyWAVE: Electromagnetic waves for individualized therapies.

Contacts

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Who are we?

One of the most promising emerging medical imaging modalities is Microwave Imaging (MWI), which is a low-power, low-cost, non-ionising imaging modality and also has therapeutic capabilities. Most of this MWI research to date has been accomplished in simulation and laboratory studies, with only limited translational research into the clinical environment.

European researchers have been at the forefront of the development of MWI. With respect to medical applications, these (mostly independent) efforts have lead to the design of several microwave-based imaging devices, most of which are currently undergoing or poised for clinical trials. Such a reserve of knowledge constitutes a unique opportunity for European researchers to leverage existing experience and expertise to streamline the transition from simulation/phantom testing to full clinical trials and clinical adoption of MWI devices.

Collaboration will provide a valuable non-competitive framework which will provide European researchers with the necessary structure and support to overcome common challenges and bring MWI from "research bench to patient bedside" in a much shorter period of time, boosting the European Research Area (ERA) and its excellence in a worldwide context. Experience in the commercial evaluation of MWI devices will also be shared amongst COST participants.

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