Preface

The IV Latin American Conference on Bioimpedance (CLABIO 2021) were carried out in November 10–13, 2021, in San Luis Potosí, SLP, Mexico. The conference was hosted by the Autonomous University of San Luis Potosí. Plenary conferences, lectures, mini-courses, tutorials and workshops were developed in both on-site and on-line modes. We are proud to present in this proceedings book a selection of papers from Latin America and all over the world, reporting on the latest findings and technological outcomes in the bioimpedance field. The content is organized to reflect outstanding scientific research lines in bioimpedance, innovative topics on tissue and molecular engineering, biosensors on the basis of bioimpedance, novel devices and clinical applications are discussed in this book. Content innovation and academic quality have been warranted by a careful peer-reviewing process, which was coordinated by an expert Scientific Committee and involved academic reviewers. With a final acceptance rate of 95%, this book is the result of a great effort involving more than 100 scientists, both professors and students, participating as authors, reviewers, and Scientific Committee members. We are sure that the contributions presented in this book will give you a deep overview of the leading edge in bioimpedance area. On behalf of Scientific and Organizing Committees, we thank authors, academic reviewers as well as sponsoring societies such as the Mexican Society of Biomedical Engineering (SOMIB)-Mexico, for their contribution. Moreover, we encourage readers to enjoy this amazing piece of scientific literature as a breadth of knowledge in the bioimpedance and biomedical engineering fields. We hope that all of you had enjoyed the outstanding opportunity we had during CLABIO 2021—a tremendous experience and expertise throughout the length and breadth of wide range of fields under one roof—generating a wave of motivation and diversity spreading across the Americas to the world.

Editors

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Distinguished Lecturer Message

It is my great pleasure and honor to welcome you all in reading the proceedings of the IV Latin American Conference on Bioimpedance (CLABIO 2021). The conference was held in San Luis Potosí, México as a combination of a physical and online meeting. After nearly two years with the Corona pandemic, the situation is fortunately improving around the world and physical meetings are again possible. Bioimpedance as a research field is roughly 150 years old and has experienced different periods in activity and progress. The 60s and 70s saw a huge increase in basic research with studies on the electrical properties of different biomaterials and an important development in measurement technology. Unfortunately, shortly thereafter a period started where bioimpedance based instruments were pushed to the market for clinical use, without proper research foundation. To some extent, this led to the whole field into discredit and the negative effects of this can sometimes still be sensed. However, the last two decades or so have again seen a very positive development in the bioimpedance field, with an increase in excellent research, high-quality instruments launched on the market and a growing interest from the industry. We see new trends where state-of-the-art from areas such as microelectronics, advanced materials, artificial intelligence, and new methods for data analysis are implemented in bioimpedance research and technology, creating breakthrough developments and innovations in our field. The CLABIO 2021 showed many examples of this and hence confirmed the importance of such meeting arenas also in the future.

Ørjan G. Martinsen
Distinguished Lecturer CLABIO 2021
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Plenary Lectures

Prof. Ørjan G. Martinsen
Distinguished Lecturer CLABIO 2021
Department of Physics, University of Oslo.

Bioimpedance from mHz to GH
My research is mainly on the passive electrical properties of biological materials (bioimpedance). Since these properties are highly influenced by the anatomy and physiology of the tissue, bioimpedance measurements can be used for characterization or diagnostication of the tissue. It is e.g. possible to use bioimpedance measurements to classify cancerous tissue, to separate between different qualities of meat, to assess the moisture content of the skin or the stress level of a person. These are just a few of numerous possible applications of bioimpedance technology in medicine, biology, sports, cosmetics and psychology. My particular expertise is within bioimpedance basic theory, instrumentation, electrode systems, non-linear phenomena, and modeling.
Medical Engineering and Electrical Bioimpedance: a promising future

Unlike Nuclear Medicine or Radiology, Electrical Bioimpedance diagnostic technology is simple, cheap and safe. Despite these characteristics, Bioimpedance receives a lot less research funding and is used in a fraction of the diagnostic and follow up opportunities associated to ionizing radiation procedures. A review of available clinical applications of Bioimpedance shows the potential for further development. From Electrical Impedance Tomography to tissue characterization, plethysmography and wearable devices, a number of ongoing prototypes under development are part of the promising future Bioimpedance offers in the XXI Century.
Fundamentals of electrodes

About twenty years ago, as a recently graduated electrical engineer, I initiated my research career in biomedical electronics with the assumption that the electrical behavior of electrodes was little bit more complicated than that of a resistor. I was naive. Experience, and literature, has taught me that electrodes can behave as a seemingly chaotic combination of a non-linear resistance, a pseudo-capacitance and an unstable voltage source. Furthermore, toxic chemical species can be generated at the surface of the electrode, even if made of noble and biocompatible metals. Through an overview of my past research, particularly focusing on bioimpedance, electroporation and stimulation, I will summarize some facts I have learnt about the behavior of biomedical electrodes and how those facts must be taken into account when developing systems for measuring bioimpedance.
Insights on wearable bioimpedance meters

Medical wearable technologies have been growing since the last two decades with the launch of new generation diagnostic devices, due to its mobility and low cost. Bioimpedance technique has been widely used for being considered one of such innovative technologies, contributing for lowing costs and time in the characterization of biological materials. It is considered an intelligence support tool in medical and biological applications, such as: detection of cancerous tissues, body composition, blood glucometer, water and bovine milk quality meter. Such devices have promising advantages, such as simplicity, sensitivity, selectivity, low detection limit, low cost, low power consumption and miniaturization. However, in some cases, the diagnostic feature with impedance measurements requires a mathematical model to reduce possible uncertainty values, as well as an accurate hardware for working wireless at low power supply. This talk presents the main required characteristics for a wearable bioimpedance meter, but also reviews some medical wearable case of success.
Prof. César Antonio González Díaz  
Instituto Politécnico Nacional-Escuela Superior de Medicina, México  

**Biosensors on the basis of Bioimpedance.**  
In the last two decades biosensors at micro and nanoscale levels have been developed on the view of *lab-on-a-chip device* designing worldwide. Detection of biological analytes such as cancer cells, DNA, virus and proteins, on the basis of Bioimpedance measurements has been highlighted as a potential technique for biosensors development because its simplicity and inexpensive characteristics. This talk represents a mini-review of the new approach to design biosensors on the basis of bioimpedance, documented in the last five years. An analysis of the functionality surface, transducer and bioinstrumentation is developed, results are organized in the view of sensitivity and specificity accordingly experimental results. Preliminary results of the author’s work regarding DNA biosensor design is discussed.
The broad scope of electrical bioimpedance spectroscopy in human medicine
The conference aims at giving the attendants a glimpse on basic biological and medical concepts that underpin the enormous amount of possibilities out there for the present and future applications of EBIS in human medicine
Cole model: numerical applications.

In the field of bioimpedance, Cole model is widely used by doctors, engineers, physiologists, physicists, among many others. This is very useful to be able to characterize different situations of biological systems: normal conditions, pathological conditions or singularities of each system. The parameters of this model must be calculated from a geometric approximation to a semicircle of the measured experimental data. In this presentation, different numerical methods will be approached to calculate the characteristic parameters of the Cole model regardless of the origin of the experimental data measured: configuration of measurement electrodes, brand / model of the device, biological system tested, among many. Basic concepts of mathematics and physics will be covered so that the scope of the talk is not only for professionals with prior technical knowledge. Undergraduate student Tomás Villanueva (IDEI-UNTDF) will participate, presenting his multi-device application on this electrical bioimpedance data processing.
Electrical Bioimpedance Measurement: Electronic Instrumentation.

This minicourse describes each stage of the electronic instrumentation used in electrical bioimpedance measurement, including the current injection system, electrodes, and the voltage measurement system. During the minicourse, the main characteristics of electronic circuits will be studied in order to reduce some measurement errors and the contribution of some interference signals. The application will be oriented to electrical impedance plethysmography to detect cardiac and respiratory activities.
Mini-courses

Prof. Pedro Bertemes-Filho
Universidade do Estado de Santa Catarina, Brazil

A 8-channel differential bioimpedance meter using AD5933
The interest on bioimpedance measurements has been growing up in the area of tissue characterization for cancer diagnosis and of monitoring organs functions, as it is in the electrical impedance tomography (EIT). This type of measurements requires the use of many electrodes connected to the body site, then requiring multi-channels for either current excitation and voltage measurements. There are some commercial development boards for a bioimpedance meter, such as AD5933, ADuCM350, MAX3001 and AD5940. None of them perform a multi-channel task if a sweep between electrodes is needed. The AD5933 development kit is a low cost and straight forward solution for bipolar measurements. However, it contains only one channel and also is highly dependent on load variations. We are proposing to build an extra circuit board containing a current source, a multiplexer and an instrumentation amplifier in order to obtain a multi-channel bioimpedance meter with the advantage of having all the signal processing done by the AD5933.

Designing an effective bioimpedance meter (Tutorial)
Over the last 50 years, bioimpedance technique has been widely used as a promising, low cost and effective tool for medical and clinical diagnosis. The quality of data obtained from bioimpedance measurements is highly important to get an accurate and trustable diagnosis. Bioimpedance meter accuracy depends on many factors, such as electrode setup and both exciting and measuring devices. The design and performance of an effective bioimpedance meter is of great importance in order to avoid noise, interference and degradation due to stray capacitances. This tutorial presents the main anomalies usually encountered in bioimpedance signals and then brings the main solutions in terms of circuit topologies and new trends for the area.

Prof. Carlos-Augusto González-Correa
Universidad de Caldas – Colombia

Clinical applications of electric bioimpedance spectroscopy (EBIS) in humans: present and future. The mini-course aims at giving the participants a glimpse on some of the most common clinical applications of EBIS in humans, from the study of very small areas for the detection of pre-cancerous or cancerous lesions, through segmental measurements to study either structural or functional conditions of specific areas of the body, to whole body studies for body composition. It will cover basic biological and medical concepts necessary for understanding why and how EBIS can be used in medicine, as well as to motivate the participants to explore new applications of this techniques in the medical field. Among these concepts are: electrical model of cells and biological tissues, the concept of chronicopathology (development of chronic diseases), body composition and the carcinogenic field effect. Depending on the conditions (time, logistic, and number of participants), part of the time assigned to the course will be allocated to a practical activity, either as a demonstration or as a small workshop.
Prof. Antonio H. Dell'Osa & Gerardo Ames Lastra

*Universidad Nacional de Tierra del Fuego, Antártida e Islas del Atlántico Sur (Ushuaia, Argentina)*

**EIS and EIT: low cost applications with AD5933EBZ and EIDORS (Workshop)**

In the Bioimpedance field, Electrical Impedance Spectroscopy (EIS) is a technique that is commonly used in a wide variety of applications regardless of whether the biological system to be analyzed is on a microscopic or macroscopic scale. Also, Electrical Impedance Tomography or Bioimpedance Tomography is commonly used for ventilatory perfusion monitoring in humans, however, applications in other biological systems already exist or are being explored.

This course will have a leveling theoretical approach to then strongly address EIS applications with the Evaluation Board AD5933 (AD5933EBZ) that is widely used for its low cost and ease of use, providing applications on food and human beings after making a technical focus on all the necessary knowledge on the AD5933EBZ so that the performed measurements are valid. An introduction to EIT will also be made with a practice on the EIDORS app on the computer to provide the first steps in the reconstruction of the measured bioimpedance data to a 2D image.

The Workshop will be jointly directed by Antonio H. Dell'Osa with the assistance of Gerardo Ames-Lastra as in the course "Low-cost applications of BIA, EIS and EIT: theoretical and practical bases of bioimpedance" (Faculty of Engineering of the University of Buenos Aires, March 2020). Essential requirements: Personal Computer (in face-to-face modality) and AD5933EBZ (in virtual modality).
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