Special Session Title: Biomedical Engineering in Latin America - Perspectives Towards EMBC 2021

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Theme: 12. Translational Engineering for Healthcare Innovation and Commercialization
(Actually, this special session spans across multiple EMBC themes)

Special Session Synopsis— Max 2000 Characters

Biomedical engineering development in Latin America has been growing in recent years with particular strengths and weaknesses that represent an opportunity for collaborations and contributions for researchers and entrepreneurs from all over the world. In this sense, knowing the specific context of the region in terms of healthcare management, political issues across the different countries and technology implementation process is of great relevance. It has been 10 years since EMBC took place in Latin America (Buenos Aires, 2010) in what became a significant milestone in the maturity of the regional biomedical engineering community. Therefore, it becomes significant to explore the regional aftermath of EMBC 2010 in preparation for EMBC 2021, which will take place in Guadalajara, México. This special session encompasses many aspects of the recent advancements in biomedical engineering in Latin America, including the design of updated academic curricula, an exploration of recent successes in innovation and entrepreneurship, and examples of research to the solution of prevalent health care problems in the region. Invited speakers from five different Latin American countries, including a mixture of seasoned EMBS leaders and promising young researchers, have all confirmed their participation and will discuss some challenges and opportunities for biomedical technology development in the region and provide context on what to expect from EMBC 2021.

Updating the Biomedical Engineering Curriculum in Latin America: Moving from Management and Maintenance to Design and Development of Medical Devices

Joaquin Azpiroz Leehan, Emilio Sacristán, Gerardo Urbina, and Fabiola Martínez, CI3M-Universidad Autónoma Metropolitana, México

The history of BME in Latin America is over 50 years old. Several well-known electrical engineers and physicians, returning to their countries from the US were the first BME "pioneers" in Mexico, Brazil, Argentina and Colombia. However, their legacy with regard to BME undergraduate education is not that important, since they concentrated mostly on promoting graduate programs. The Undergraduate programs in BME in the region started in 1973-1974 in Mexico as well as in the US. However, the aims of such programs were different. In the US the idea was to improve the support for the medical device industry, while in LA the most pressing needs were to manage and maintain the medical health technology infrastructure. Today, 45 years later, there are almost 100 institutions in the region that offer this degree. Our group at CI3M-UAM has analyzed these programs, and in conjunction with SOMIB has organized three meetings around the subject of curricular design where program coordinators from Latin America have participated. We have produced several publications (mostly in IEEE EMBC proceedings) that deal with these subjects, for example making the comparison of 90 LA programs with the 10 most highly rated undergraduate BME programs from the US. The main conclusions from these events (the latest was held in October 2019 at the LA Conference of Biomedical Engineering) are that:

1: the aims of the programs are still mostly linked to hospital engineering and the management of health technology

2: the programs are remarkably similar

3: there are very few (less than 10%) institutions dedicated to research

There is an enormous influence on it from the Electrical Engineering field (for example, there are up to 8 required courses from electrical circuits to digital filter design in a typical BME program in the region), to the detriment of presenting material on new and emerging trends. Also,, there is typically a one-year sequence of biochemistry and physiology courses which are taught by traditional physicians from the corresponding universities' medical school. This presentation proposes the development of a BME curriculum that is oriented towards promoting Research and Development in the field throughout the region. There is an opportunity for one or several institutions to distinguish themselves by doing real engineering research and development instead of following more technically oriented approaches.

The proposal includes the following changes: First, Engineering Design has to be taught throughout the 4 or 5-year curriculum. Second, a 1 year long capstone project must be obligatory. Third, the BME core of the curriculum must be carefully constructed and must include subjects in cell and molecular biology, tissue engineering, artificial intelligence and quantitative physiology, while reducing the excessive number of subjects in EE. We believe that these modifications will result in the strengthening of the industry-academia relationships, to improve the competitiveness of the countries with regard to R&D and to improve their outlook with regard to medical device manufacturing. This will help change the region (even if ever so slightly) from being technologically dependent to one that develops and manufactures medical devices.

Medtech Innovation in Latin America

Emilio Sacristán, CI3M-Universidad Autónoma Metropolitana, México

Historically, Latin America has developed very little innovation in the field of medical technologies. We have suffered from an over emphasis on import substitution, a murky regulatory environment and lack of support for genuine innovation. Nevertheless, researchers in the region have long had significant interest in the field and innovative ideas are constantly being proposed from academia. However, the path to successful commercial deployment has been rare. Nevertheless, over the past decade, an ecosystem for innovation is starting to emerge, and interest in medical technology is starting to explode in the region. We will present some of the region's latest success stories and describe what will be needed to consolidate this emerging trend and put Latin America in the world's map of medical innovation.

Merging Medical Humanism and Cardiovascular Technology

Ricardo Armentano, Universidad Tecnológica Nacional, Argentina

IEEE Region 9 hosted the EMBS Annual International Conference (EMBC 2010) in Buenos Aires, Argentina. As the Conference Chair, I promoted the conference theme as "Merging Medical Humanism and Technology", a tribute to the life and work of Dr. Rene Favaloro (July 12, 1923 – July 29, 2000) an Argentinean cardiovascular surgeon that revolutionized the field with his pioneering contributions, among which the most remarkable is the standardization of the coronary artery bypass surgery, performed for the first time in 1967. He thought that individualism had to be replaced by collective interests and realized that teachers could cooperate in his plans through daily preventive education. He assumed that the technological universe should be designed to fit and serve the human dimension, as Michael Dertouzos, the former director of the Laboratory for Computer Science, stated at the Massachusetts Institute of Technology: "We made a big mistake three hundred years ago when we separated technology and humanism. It's time to put the two back together".

Given that poverty, malnutrition and environmental degradation may increase the propensity to cardiovascular diseases, I focused my work towards modeling cardiovascular dynamics in these high-risk groups. My goals were (1) to promote screening for subclinical atherosclerosis, (2) to develop a centralized database to store information obtained non-invasively from anywhere, (3) to develop a bio-mathematical model integrating values for arterial structure and function into traditional cardiovascular risk assessment, (4) to generate a detailed and comprehensive report for the specialist comparing patient data with reference data from the healthy population, (5) to generate a similar report (using a Structural and Functional Arterial Age Calculator) for the patients assessing the state of their arteries. To this end an integrative complimentary approach was designed to evaluate arterial structure and function, after medical interview and laboratory measurements. Qualitative and quantitative information obtained/stored in portable (ambulatory) units was transferred (electronically) to a Data Center in order to cluster it by using automatic learning algorithms.

The implementation of the vascular age approach and the use of the informatics tool developed, give a unique opportunity to positively impact in the management of the atherosclerotic disease in our population. The personalized risk estimation and cardiovascular diagnosis provided allows designing and implementing individualized strategies of prevention and treatment. The multiparametric approach improves risk estimation and vascular diagnosis since the dissimilar distribution, impact or manifestation of vascular changes associated with cardiovascular risk or ACVD are considered.

Diffusion and universal access are secured or facilitated by:

a) mobile evaluation units and b) possibility of loading remote studies to be analyzed in the central unit

During these years, we have been prepared and qualified an interdisciplinary team of young students, engineers, medical doctors, physicists, mathematicians and other specialists, emphasizing the importance of humanistic concepts, since they are playing an important role in the research, development and management of medical technologies under a new paradigms that tend to accomplish the celebrated complementarity statement by Dr. Favaloro "I would like to ask especially the younger people to understand that material things are temporary: only ideals last forever, and within this context, the battle-cry should be: education and scientific development for a society in which social justice is top priority.

Motor Control and Sleep Deprivation – A Study in a Latin American Metropolis

Arturo Forner Cordero, Universidad de Sao Paulo, Brazil

One of the major problems in Latin America is related to the uncontrolled growth of cities that led to major problems of traffic and long commutation times. The impact of sleep quality on diurnal sleepiness is a crucial aspect of human health. Moreover, this is reflected in the performance of daily tasks such as postural balance. It seems that life in large cities, and especially in the megalopolis of emerging countries, compels people to sleep less than needed. We registered by means of actigraphy the sleep habits of 54 volunteers (28 of them from a small town and the rest from São Paulo, the largest city in South America). The actimeter we recorded accelerometry, light and body temperature and the subjects filled questionnaires to assess sleep quality (Pittsburgh Sleep Quality Index - PSQI), sleepiness (Epworth Sleepiness Scale - ESS) and chronotype (Morningness-Eveningness Questionnaire – MEQ-HO). The metropolitan group had worse sleep parameters: lower sleep time and sleep efficiency. These results could be attributed to the social and work characteristics imposed in the metropolitan environment. In order to assess the impact on motor control of the different sleep conditions we performed motor experiments under both chronic and acute (1 night) sleep deprivation with 12 volunteers. The three motor tasks consisted on: 1. standing on a low-cost force plate (with eyes open and closed); 2. performing a coincident timing task that consisted of hitting a virtual target falling on the screen with the hand; and 3. walking while following subliminal rhythm changes of a metronome. There were differences in the motor performance of the tasks that could be related to the different sleep conditions. For instance, the group that were sleep-deprived for one night, had larger anterior-posterior sway while standing without visual information. In addition, the group with better sleep parameters learnt quicker converging rapidly to a high level of performance, while the worse sleepers needed more trials to learn the task reaching a slightly lower level of performance. In general, the influence of sleep conditions on motor control performance is very important. While this was well-known for cognitive tasks or postural control, the effect of sleep deprivation on gait or motor learning was not clear.

An Asynchronous Tele-Ultrasound Model for Rural Areas

Benjamín Castañeda, Pontificia Universidad Católica del Perú, Perú

Millions lack access to adequate diagnostic imaging services in rural areas worldwide. As a low-cost and portable imaging modality, ultrasound will play a key role in correcting these disparities. However, access to ultrasound technology is limited due to the lack of trained sonographers and readers. Even though, telemedicine appeared as a solution to bring specialized medicine to the remote areas, in the case of ultrasound, only a synchronous model has been widely implemented (by streaming 3 live feeds simultaneously). Although in countries with access to an advanced telecommunications infrastructure this model may be helpful, its application to developing countries has been minimal. For example in Peru, only few capitals of provinces have been connected to major hospitals in the country capital. To overcome this situation, we propose the implementation of an asynchronous tele-ultrasound model in which connectivity is not required at the moment of acquisition. Therefore, Asynchronous Ultrasound (A-US) can be used to provide imaging capabilities even in the most remote areas with low telecommunications capacities. In this model, ultrasound naïve rural health workers perform volume sweep imaging (VSI) protocols based only on external body landmarks for diagnosing obstetrical, gallbladder, and thyroid pathologies. The VSI protocols are complemented by the use of a tablet that connects to a commercial ultrasound scanner encapsulating all the complexity of maneuvering it. The tablet has a friendly-user interface that guides the rural operator during the whole operation. Our telemedicine ultrasound system was piloted in an academic setting at the Pontifical Catholic University of Peru (Lima, Peru) and in the different regions of Peru (highlands, rainforest and desert). Health workers were trained on VSI protocols, image capture, labeling, and electronic transmission. Trainees then obtained images from patients requiring obstetrics, gallbladder, or thyroid scans. Images were uploaded to a cloud-based system and then downloaded and read by radiologists all using a customized software. The radiologists filled in a structured report that was then sent back to the operator in the rural area. Every report had an indication to the rural health-worker clearly stating the action to perform in a grading system: 0 – repeat examination, 1 – no findings, 2 – follow up examination in a month, 3 – Some findings but they are not of concern, 4 – findings of concern, patient should go to the main hospital, 5 – findings of concern, patient need to go to hospital urgently. Overall, more than 800 have been read in Peru using A-US. The pilot in the academic setting helped to improve the usability of the system as well as the manual procedures to be performed by the rural health-worker. In this stage 21 thyroid and 26 gallbladders were scanned. The rest of the cases were acquired from 8 health posts in remote areas in different regions of Peru. Findings include thyroid cysts, cholelithiasis, nephrolithiasis, and obstetric information including the number of fetuses, fetal position, placenta position and amount of amniotic fluid. Among these cases, one of placenta previa and one case of twins were found. Both pregnant women were immediately transported to a hospital in Lima. One of the main identified problems on the large scale deployment of ultrasound was training of the rural operator. This training would usually last 6 months and once trained, the rural health-worker would quickly get a job in closed-by town earning more money thanks to the new skill. Our methodology only requires that the rural health-worker is trained on the movements to follow the VSI protocols. Trainees learned VSI protocols in the span of 9 hours within 3 days. This capacity for rapid training means that the A-US model is scalable and could be easily deployed in remote areas. Overall, we believe our asynchronous telemedicine system could provide a low-cost and scalable diagnostic service suitable for deployment in rural areas.

Methods for the study of brain connectivity based on Diffusion MRI

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Introduction: Psychiatric and neurological disorders are in general progressive diseases that generate several difficulties in daily life and affect millions of people in Latin-American and worldwide. In most of the cases, their early diagnosis is still a challenge. Hence, the discovery of better biomarkers is required for diagnosis and treatment evaluation. Diffusion Magnetic Resonance Imaging (dMRI) is an in-vivo and non-invasive technique that estimates the structure of white matter (WM) through the measurement of water molecules diffusion [1]. From dMRI images, the main trajectories of WM can be reconstructed using tractography algorithms. Several methods have been proposed for the analysis of tractography datasets to study brain connectivity, contributing to a better understanding of these diseases and their correlation with different clinical scores. Tractography datasets are very complex and variable across subjects, and can contain millions of fibers, making its analysis a difficult task. We will describe the main developments in this area and some examples of their application to the study of psychiatric and neurological disorders.

Methods: We present several methods for the analysis of tractography datasets, to study brain connectivity: Fiber clustering: regroups fibers based on a similarity measure. Exploratory algorithms aim to reduce the dimensionality of the datasets, remove noise and get a better representation of the main white matter structure. WM bundle atlases: Through the use of fiber clustering methods and anatomical data, it is possible to construct atlases of white matter fiber bundles, created from a population of subjects.WM automatic segmentation: Automatic methods applied to identify anatomical bundles on a new subject tractography. Diffusion-based cortical parcellation: The cortical surface can be parcellated based on the connectivity given by tractography data, to study the Human Brain Connectome.

Results: We have developed efficient methods for the fiber clustering (Fig. 1) and the segmentation of anatomical bundles based on a multi-subject atlas (Fig. 2). We have also created WM bundle atlases of deep and superficial WM.

Fig 1. An efficient fiber clustering method [2].

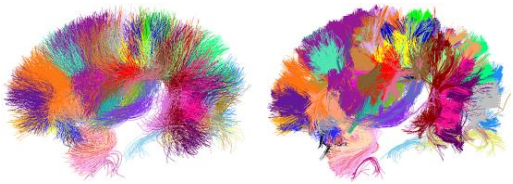

Fig 2. A segmentation method based on a multi-subject atlas [3,4]

Conclusion: The developed tools have been used for the study of several psychiatric disorders like Bipolar Disorder, Autism and Schizophrenia [5]. Similar tools have been used by the community to study neurological disorders.

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