



Praise of the “Honoris Cause” PhD Professor Dr. Leif Sörnmo by the University of Zaragoza

Rector Magnífico of the University of Zaragoza
Academic Authorities
Distinguished Guests and Doctors
Ladies and Gentlemen

It is our honor, and above all, a great pleasure to introduce Professor Dr. Leif Sörnmo for this investiture as Doctor Honoris Causa of the University of Zaragoza.

The proposal of Professor Sörnmo as Doctor Honoris Causa have arisen from the Centers in the field of Engineering at University of Zaragoza (both the School of Engineering and Architecture, EINA, and the Aragón Institute for Engineering Research, I3A), where a number of professors and students have had the privilege to work together with him and his research group for more than 20 years. When this proposal was presented, all of his direct collaborators during these years unanimously and enthusiastically supported the initiative. The proposal was also very well-received by the steering boards of the Department of Electronics Engineering and Communications (DIEC) and the Aragón Institute for Engineering Research (I3A), whose directors, Dr. Ignacio Garcés and Dr. Javier Mateo, both have good knowledge of the fruitful collaboration history that supports the nomination. This support was ratified unanimously by the boards of both the DIEC and I3A. Subsequently, Dr. Rafael Bilbao, director of the EINA, and the EINA Board expressed again support for the proposal, which was finally ratified by the Government Council of the University of Zaragoza.

There are several professional and social profiles that make a particular person qualified to receive the recognition as Doctor Honoris Causa. In Professor Leif Sörnmo we have a dual profile which combines scientific excellence in a branch of knowledge with a special proactive relationship to our University. Professor Sörnmo is known as an international reference in the field of Biomedical Engineering, in particular with regard to the processing of biomedical signals of cardiac origin. On the other hand, his continued support of the research line on biomedical signals at the Communications Technologies Group (GTC), is far from anecdotal when considering the achievements of the group,



recently renamed as Biomedical Signal Interpretation and Computational Simulation (BSICoS).

We now turn to the merits of Professor Sörnmo corresponding to the two already mentioned profiles. This task will be difficult to do with descriptive neutrality – and we do not wish to do this – since the personal appreciation that has been woven over the years of working closely together are inseparable from the collaborative merits to which we will later refer. We have, moreover, the firm conviction that it is not only possible, but also desirable, to have an interaction between professional and personal aspects which will make our professional objectives come to fruition. We believe that the cooperation with Professor Sörnmo is a good example of this.

Leif Sörnmo was born in Nässjö, a town in Southern Sweden in 1955, where his father worked as railwayman at the train station and his mother as an assistant at different stores. Later he moved to Lund where, in 1978, he was awarded the Electrical Engineering degree at Lund University. To Leif Sörnmo, this was the chance to approach the discipline of Biomedical Engineering, which, since his teens at high school, had attracted his interest as it combines two of his personal concerns: the challenges of engineering and its application to human health. Later, in 1983, he received the Bachelor in Telecommunication Theory (signal processing), and in 1984 the PhD degree of the same branch. Upon completion of his studies, Dr. Sörnmo worked for several years as a research engineer at the Department of Clinical Physiology, University of Lund, gradually combining his dedication with that of Associate Professor in signal processing in the Department of Telecommunication Theory at the university. In 1995 he left the medical faculty to fully devote himself to research at the engineering faculty. In 2000 he was appointed Professor in Biomedical Signal Processing by the same university.

This track record, which provides good knowledge of the daily life and clinical needs in a hospital setting, shaped, no doubt, his professional profile. For him, it will always be obvious that the performance of an engineer working in medical applications must go through direct knowledge of the clinical problem, being addressed by closely working with those who develop his profession on the healthcare side at hospitals.

In his early research, in the 1980s, Professor Sörnmo devoted his efforts to the problem of detecting heartbeats as a necessary step for the analysis of electrocardiogram (ECG) during exercise testing. He pioneered the introduction of statistical processing techniques and the development of the theories of detection and estimation in the field, truly new technologies at that time. Some of his seminal works on the subject became the structural basis of many QRS detection systems that have been developed in the coming decades.



Subsequently, the research of Professor Sörnmo focused on obtaining relevant clinical information from signals recorded during the stress test, a noninvasive test that is used to quantify the severity of coronary artery blockage which can cause ischemia in the heart muscle, while also developing the necessary stages to automate this processing (as, for instance, the design of systems to cancel interferences which inevitably appear in the ECG signal, of either technological or physiological origin). An example is his pioneering work on the cancellation of baseline wander using time-variant signal processing.

However, the rather poor sensitivity and specificity of the stress test became increasingly evident, and therefore, guided by the power of information technology, Professor Leif Sörnmo embarked on the search for information not visible even for the experienced expert eye. This meant taking one step beyond computerization of the cardiologist's task, to address tasks involving the challenge of finding and extracting new sources of clinical information of transient origin, or related to sudden changes in heart rate and other circumstances. In the 90s, a series of papers on late potentials estimation appeared, again applying techniques of optimal signal processing.

In the late 90's he began with what we believe can be considered the more fruitful and elegant stage of his research career, which is devoted to the the management of atrial fibrillation, a very common arrhythmia, with different therapeutic lines of action, whose choice is often given, or guided, by the support of information extracted from surface ECG. Professor Leif Sörnmo is definitely the indispensable international reference in this field. His contributions on the cancellation of ventricular activity, including techniques compensating the variability introduced by respiration, and characterization of atrial activity and its correlation with the properties of the underlying arrhythmia, are recurring references in any research addressing this field. Even today this is a subject of great interest in the scientific community, and Professor Sörnmo is currently deeply involved with the task of characterizing the atrioventricular conduction as a way to better understand and control the ventricular rate resulting from atrial fibrillation.

This predominant dedication to the ECG signal has been extended to other applications where he has made significant contributions, including the study of otoacoustic emissions, derivation and study of respiration from the ECG, heart sounds detection, detection of hypotension during hemodialysis, analysis of heart rate turbulence, study of photoplethysmography as an alternative to ECG to extract heart-rate-related parameters, and other applications.



In some of the lines I just mentioned, we have established significant collaboration between University of Zaragoza and Lund University, but it is in ischemia studies where the richer and more fruitful part of our collaboration has taken place. This project began thanks to the invaluable leadership of Professor Galen Wagner at Duke University (Durham, North Carolina), who successfully brought together a number of experts from different areas into a clinical study analyzing the changes in ECG characteristics induced during acute ischemic coronary angioplasty interventions. The study began in the present era when Stafford Warren (who has given name to the "STAFF" studies) performed long coronary occlusions, up to 9-minute duration, as an alternative to performing several shorter occlusions, thus seeking better protection against restenosis. The ECGs recorded during such interventions represent a valuable model of severe and transient ischemia in humans. Professor Sörnmo was the one who provided, through the company Siemens-Elema, a high performance acquisition equipment that was taken to Charleston Area Medical Center (West Virginia) for signal acquisition, carried out with the help of a medical student from the University of Lund. Subsequently there have been many groups in different countries and institutions that have contributed to the analysis of the data obtained from these experiments, but the collaboration between Lund and Zaragoza has been one of the most successful, if not the most, to contribute to this study. These collaborations, reinforced by the biannual Symposium of the STAFF Studies, bring together groups that have contributed to the analysis of this database, and have established what Galen Wagner has labelled as "University without walls" – a successful international multidisciplinary collaboration. It is here fair to recognize the powerful and indefatigable leadership of Galen Wagner.

All these activities have not been solely developed through research in collaboration with the clinical partners, but the third leg of Biomedical Engineering – industry – has also always been present. Partnership with Siemens, St Jude Medical, Gambro, etc. are clearly intertwined in his research results, which is particularly reflected in his 11 patents.

University teaching has also had a marked significance in the professional trajectory of Professor Sörnmo, alternating teaching of core subjects in the curriculum of Electrical Engineering, with the design of new courses in the growing field of Biomedical Engineering either as elective subjects within the curriculum of the mentioned Engineering degrees, or as part of the Degree in Biomedical Engineering, for which Professor Sörnmo is responsible, and whose first class will graduate in 2016 at Lund University. In addition to teaching, his interests for deploying academic knowledge has led him to write several books, among which we would like to highlight the one entitled "Bioelectrical Signal Processing in Cardiac and Neurological applications" published by Academic Press, in collaboration with the University of Zaragoza, in response to an



identified common concern of our two universities in teaching biomedical signal processing. This concern was to have a teaching reference which would pool technical rigor and perspective, guided by the knowledge of the underlying physiological systems generating the biomedical signals of interest. The challenge of writing this book, whose magnitude we ignored, maybe fortunately, at the time of its conception, has allowed us, over almost 10 years, to deepen in debate and scientific discussion. It has also allowed us to share with the honored doctor a good gastronomic knowledge of our respective environments, a love of nature (concretized in many occasions in our near and dear Pyrenees), and, as a valuable by-product, has allowed us to develop a personal relationship in addition to what we think is a valuable textbook on the processing of bioelectric signals.

Besides these highlights on the activity of Professor Sörnmo, we should add endless other aspects, as a fruit of its devotion towards University (in its “universal” sense) as his stays as a visiting professor at the Northeastern University, in Boston, at Indianapolis University Purdue School of Engineering, Indianapolis, at Kaunas University, Polytechnic Universities of Catalonia and Valencia, and University of the Basque Country, in addition, of course, to our Alma Mater. We must also add to this his contribution to a large number of advisory committees, his editorial activity in several international scientific journals, emphasizing his role as Associate Editor for the IEEE Transactions on Biomedical Engineering, Medical & Biological Engineering & Computing, and as Guest Editor in several special issues on Biomedical Signal Processing. He has also been Chairman of the Organizing Committee of several international conferences such as the Computing in Cardiology (CinC), and the International Conference on Electrocardiology (ICE). He currently serves on the Board of Directors of the CinC. He received the "Erna Ebeling Award" from the Swedish "Physics and Medical Engineering" society and a long list of other mentions which reflect the commitment of Professor Sörnmo with the University community and the international promotion of a standard of excellence and quality inextricably linked to universality.

Finally, we would like to list, more closely, the some of the fruits of the collaboration between the research groups in Lund and Zaragoza, in addition to those already mentioned. His participation in multiple collaborative initiatives, sometimes with yet other research groups, often fostered by Professor Leif Sörnmo, allows us to say, without any reservation, that he has had and has a role in what is now the activity and experience in biomedical signal processing of our group at the University of Zaragoza. We can highlight the following collaboration results:

- The authorship of the aforementioned book and three more chapters in other books.
- 23 joint publications in international journals and 40 papers at scientific conferences.



- Development of five research projects funded by national research agencies.
- Hosting of eight long stays of University of Zaragoza researchers at the University of Lund.
- Two sabbaticals of Professor Sörnmo at University of Zaragoza.
- Participation in several international, scientific cooperative initiatives.
- Completion of two projects of technological development and transfer to companies plus a joint patent.
- Teaching of four one-week courses, both at the Master and the Doctorate in Biomedical Engineering at University of Zaragoza, in the framework of the mobility programs of the Excellence PhD.
- Four participations at PhD thesis juries at the University of Zaragoza.
- Development and creation of two databases of ECG signals

Therefore, it is a privilege and an honor for the University of Zaragoza, to recognize Professor Sörnmo among its faculty of doctors. We know and appreciate all that we have had from him over these years, and we wish to continue to count on him, with renewed commitment, sharing his support, wisdom, advice, knowledge, passion for the profession and friendship. We firmly believe that collaboration and complementarity of groups and individuals in research is the key to successfully addressing more ambitious challenges, where the frontiers of any kind are to become a simple footnote.

Thank you very much.

Pablo Laguna Lasaosa and Juan Pablo Martínez Cortes