SMART CARE

BIR&D

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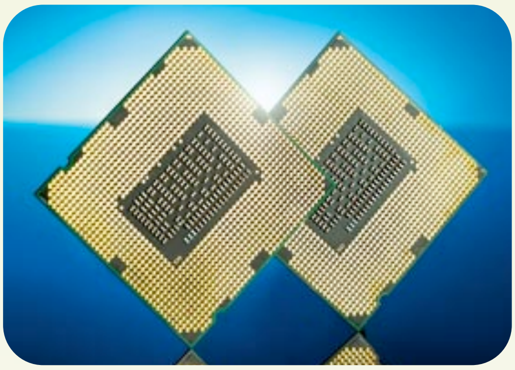
MASTER OF SCIENCE

THESIS

COMPACT WIRELESS DATA TRANSFER



SMART CARE

TEAMS

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- Promotor: prof. dr. Annie Cuyt
- Copromotor: dr. Wen-shin Lee
- Master student: Sem Peelman
- Master thesis: “Sparse signal processing techniques”

Katholieke Universiteit Leuven – ESAT

- Promotor: prof. dr. ir. Sabine Van Huffel
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- Master thesis: “Compressive sampling and reconstruction of biopotential signals”

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- Promotor: prof. dr. Diana De Graeve
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- Master thesis: “Telemonitoring and its socio-economic impact on healthcare”

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SPARSE SIGNAL PROCESSING

The first new resource crisis of the millennium may be the bandwidth crisis. Technically, bandwidth is best defined as the capacity to move information through a channel. The more information you move through the channel, the more bandwidth you use. Hence video uses much more bandwidth than for instance e-mail. A bandwidth shortage occurs when the demand to move information exceeds the capacity of the channel.

The real bandwidth shortages will be in wireless, where demand is growing and supply is weak. The industry cannot keep up with the wireless demand. We're already seeing more and more slow connections. Jams will become the norm instead of the exception. If we want the pleasure and convenience of a high-bandwidth society, someone will need to figure out a solution to the bandwidth dilemma soon [1].

Throughout computational science and engineering, several attempts have been made to represent data in a parsimonious or sparse way. A representation is considered sparse if it accounts for most or all information in the data with a combination of only a few generating elements or atoms. Because of the bandwidth issue, sparsity has become a true priority. A sparser model means higher compression, less data collection, storage or transmission, and a reduced model complexity. The ultimate goal is to determine a sparse representation of a digital signal directly from only a few data samples, rather than first acquire a massive amount of data which are then compressed (as in JPEG-2000 for instance).

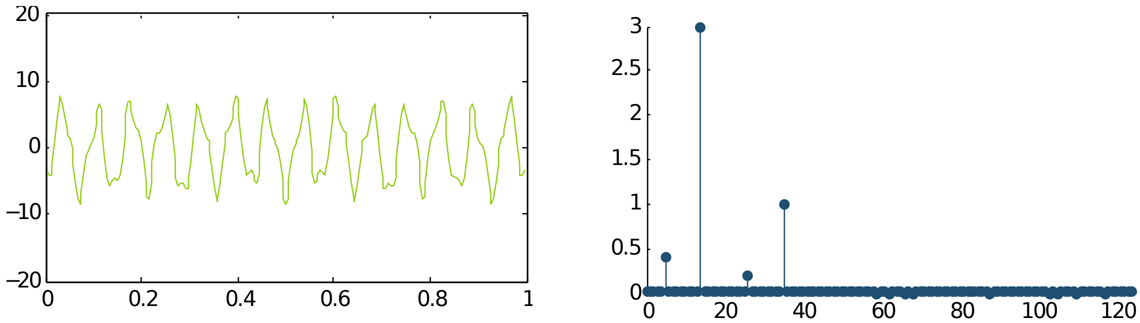

Figure 1. Sparse power spectrum (right) of **SmartCare** project logo (left).
Note the large number of zero values in the power spectrum.

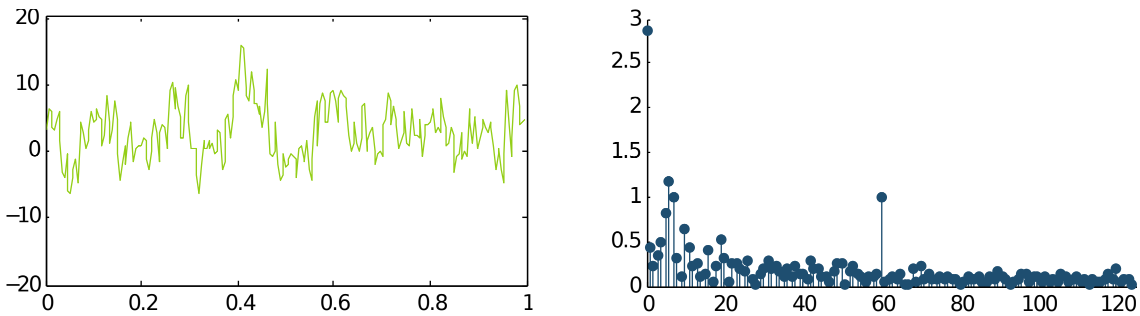

Figure 2. Typical power spectrum (right) of an unfiltered adult EEG signal (left).
Note the small number of dominant values in the power spectrum.

Currently, non-sparse data sampling still underlies nearly all signal acquisition used in modern consumer electronics, biomedical monitoring and medical imaging devices. But many signals are sparse or compressible when expressed using the proper atoms [2]. Sparse representations are being investigated in power systems, sonar, electrical and electronic engineering, astronomy, signal processing, hyperspectral imaging, MRI, telecommunication, telemonitoring, sensor networks, ambient assisted living, high-frequency radar, econophysics, and so on. There is almost no area in modern technology that is not impacted by digital signal processing!

SPARSITY AND BIOMEDICAL SIGNALS

With the trend in medical monitoring devices to become smaller and wireless, the demand for ever more sophisticated techniques to acquire and process data is high. The technical goal of the **SmartCare** project is to implement efficient methods to process biomedical signals. The focus is on the compression and minimization of data to extend battery life and reduce storage in a wireless and wearable medical monitoring device, and its possible socio-economic impact on healthcare. The technology offers a new opportunity to face the challenge of an aging society and the alarming situation of our **health insurance**.

Today's wireless monitoring devices still transmit uncompressed EEG signals which is very power consuming. Therefore acquisition and compression schemes are needed that require a smaller amount of data to represent the same biomedical information. This will allow for smarter and smaller medical monitoring devices and resolve the power supply problem, which is mainly dominated by the amount of data being transmitted and the computationally expensive compression schemes.

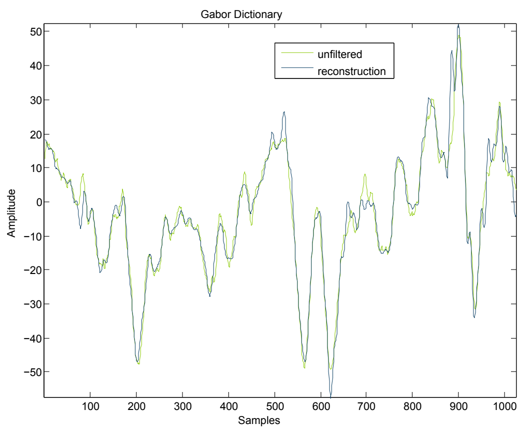

Figure 3. Compressed sensing reconstruction of an unfiltered 4 second EEG signal using only 11% of the data collected at 256 Hz.

It is still unclear how to represent EEG signals compactly. Also, it is most unlikely that there exists one formula that fits the entire signal. The representation is expected to change in different segments of the signal. Therefore current compression techniques resort to approximating these signals based on a number of assumptions. In this project we investigate the available technology of **compressed sensing** and some newly developed technology (of the Universiteit Antwerpen) using a **smart sampling** scheme. Compared to the traditional techniques, compressed sensing constructs a sparse data model from fewer samples but at the price of a high computational complexity, while smart sampling works with even fewer samples at the complexity of the traditional methods. So, using the latter, one can enjoy the best of both worlds: few data samples, no increased computational complexity. The displayed graphs are typical of what can be achieved.

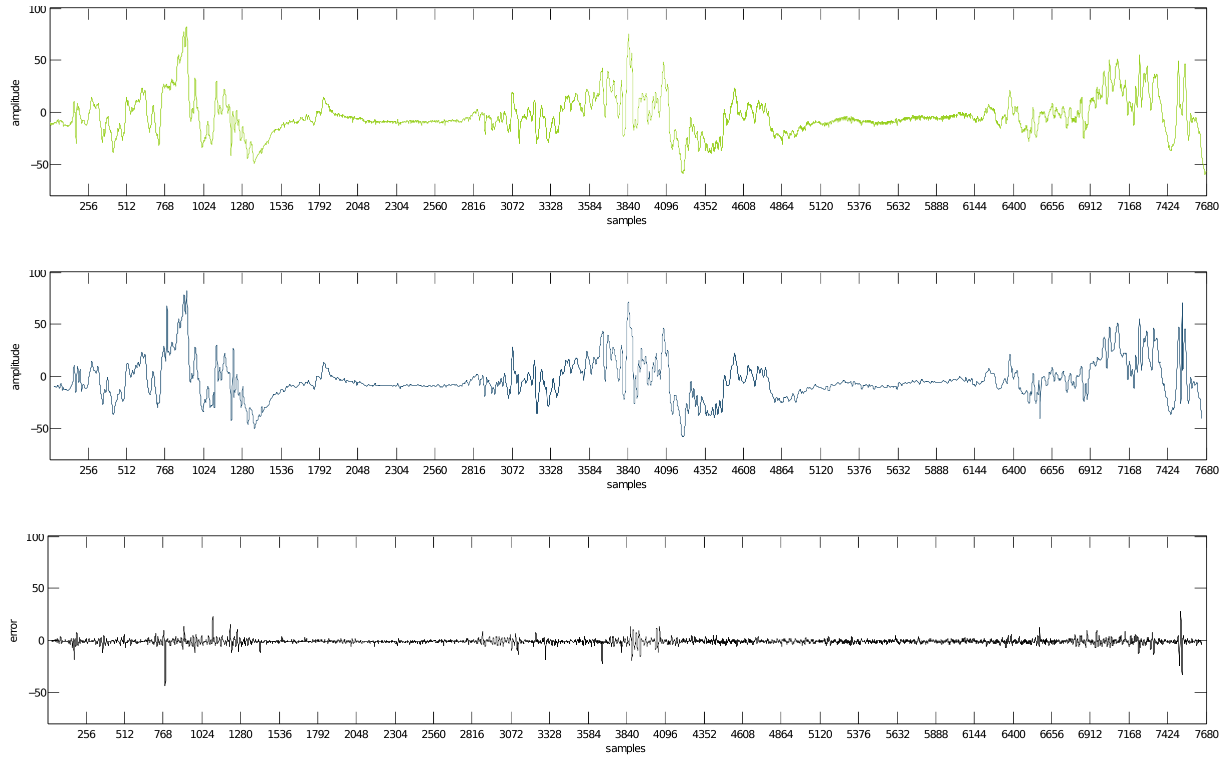

Figure 4. Smart sampling reconstruction (middle) of an unfiltered 30 second EEG signal (top) from 11% of the data, with accompanying error plot (bottom).

The new technology clearly solves some unmet needs: better data compression, reduced acquisition and transmission, low power sensing, real-time analysis, continuous wireless home-based or ambulatory monitoring, reduced model complexity, less archive storage, ... Its socio-economic impact goes well beyond healthcare.

REFERENCES

[1] Tim Wu, “Bandwidth Is the New Black Gold”, Time Magazine, Thursday, March 11, 2010.

[2] Emmanuel J. Candès and Michael B. Wakin, “An Introduction To Compressive Sampling”, IEEE Signal Processing Magazine, Volume 21, March, 2008.

PROF. DR. ANNIE CUYT

"Several challenging problems in industry can be solved using advanced mathematical techniques. It is a matter of bringing the right people together in an interdisciplinary team. Over the past 12 years we've obtained astonishing results in different engineering applications, financial mathematics, bio-informatics and graphics."

SEM PEELMAN

Sem Peelman obtained in 2011, summa cum laude, his Master in Financial Mathematics from the Universiteit Antwerpen, where he is currently a teaching assistant. His interests lie in applied mathematics in general and in numerical approximation theory in particular, especially in the fact that an abstract mathematical formalism can find its way to real-life applications and shed light on unsolved problems.

JORGE SANCHEZ MEDINA

Jorge Sánchez Medina studied at the University of Las Palmas of Gran Canaria in Spain, where he received in 2011 his Telecommunications Engineering degree, with awards. For his master thesis on biomedical signal processing he spent a year at the Katholieke Universiteit Leuven in Belgium as Erasmus student. His main interest is in bio-engineering and new technologies in biomedicine.

STEFANIE TURELINCKX

Stefanie Turelinckx obtained her Master of Applied Economic Sciences in 2011 from the Universiteit Antwerpen. She also participated in the 2011 Econometric Game, organized by the University of Amsterdam, and made it to the finals (team of five players). Currently she is working as a project consultant at TriFinance in the Middle Office Capital Markets Operations Department.

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