Multimode Monitoring of Electromyographic Signals with USB interface

Prof. Sushil Kumar
Dept. of Electrical & Electronics, Pragati College of Engineering&Management Raipur CG, INDIA
Email Id sk1_bit@rediffmail.com

Abstract:
Electromyography (EMG) is a muscle examination method which tracks and interprets electrical activity that provides to muscle contractions. Surface electromyography (SEMG) is widely used as a diagnostic tool in estimation of muscle strength, calculation of muscle fatigue and ergonomics, sports physiology and rehabilitation. Obtaining and examining carefully EMG signals provide valuable information in determining and examining abnormalities in the muscle and motor system. In this research we detect abnormalities in the muscle.

Keywords: Surface electromyography (SEMG), Motor System, Matlab.

INTRODUCTION: Chronic conditions are becoming the first problem of public health in western countries. This situation is the result of changing demographic trends and population aging, changes in consumption patterns and risk behaviors, rapid urbanization and social disintegration and the globalization of health issues. The economic costs associated to the treatment of these patients are a burden that not only threatens the sustainability of health systems but also imposes challenges to the patients and their families.

Our current health care structures, too focused in the healing of acute conditions, do not facilitate the management of chronic patients. There is little or no co-ordination among different health care levels, patient empowerment is a priority, prevention and regular follow-up are not frequent and community support is not considered. New emerging models of health care provision for chronic patients take all these components into account to achieve productive interactions between informed activated patients and proactive practice teams.

There are experiences demonstrating the feasibility and benefits of such model. The Hospital Clinic (CSC, Barcelona) has implemented such a model in the case of patients with Chronic Obstructive Pulmonary Disease (COPD). The results in two different programs (home hospitalization of patients with an exacerbation of their disease and prevention of exacerbation in stable patients) showed benefits in clinical outcomes, quality of life and economic costs.

The IT platform used in these programs is a starting point for the integration of the URSAFE products. Within the project, the chronic patient model will correspond to either Chronic Pulmonary Obstructive Disease or Congestive Heart Failure or both. The focus will be set in the monitoring facilities of the different vital signs to ensure adequate follow-up at a distance.

To this end, the URSAFE system includes sensors (ECG, Oxygen saturation and fall detection) linked to a Portable Base Station (PBS) through UWB (Ultra Wide Band) techniques. Each sensor will include software for signal processing and alarm management; it has been agreed that a regular poll coming from the UWB associated to each sensors will regularly check if an alarm has been set at the sensor SW module.

In case an alarm has been effectively raised, the UWB module then initiates the transmission scenario between the local monitoring network (including all the monitoring devices) and the medical service center (using different transmission bridges that are the PBS and either indoor or outdoor dedicated networks).

Two modes of operation are foreseen for the transmission. In indoors mode, a UWB interface will communicate with the UWB interface of a Gateway, located at the patient's home. From here, data will be forwarded over various Access Networks (terrestrial or satellite) to the Medical Data repository. In outdoors mode, the PBS will use a GSM/GPRS interface to transmit the data over the available mobile network of the service provider; the future UMTS will be used when it will be available and fully deployed.

Additionally, the Personal Base Station will also support a Voice Recognition module to send basic voice messages to the patient or to receive and analyze alarm/emergency voice messages from the patient. Finally GEO satellite use will be considered in the design of the gateway through an interface with DVB-RCS systems.

The use of the DVB-RCS technology will be explored because it's potential cost-effectiveness (home equipment, healthcare center deployment)) and its potential for further extension of home care services.

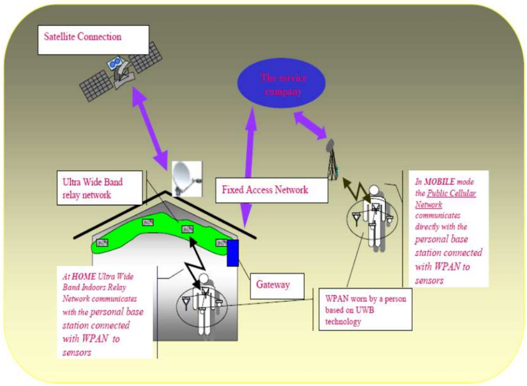

Figure 1 : Involved networks and transmissions links

At the server side, dedicated servers will receive the monitored medical data, process them (cleaning and restoration process) and display them in the appropriate format (cf. D5 part from WP5.6). The following features summarize the URSAFE nominal scenario including:

1. Real time Monitoring of biomedical data
2. Alarm management at "sensor" level (it implicitly includes the alarms that could be raised by the patient, through the voice recognition or push button interfaces).
3. Automated medical expertise (automated questions/answers recording) between the PBS and the patient
4. Transmission scenarios of the medical data (biomedical signals (last recorded data), answers to the questions…); including the network(s) adapted to the location of the patient
5. Medical expertise at the center level.

Concerning the transmission of the monitoring data, it has been agreed that the last recorded 30sec (cf. deliverable D1 section 8.1.2.2) of the ECG (since event detection has occurred) will be send to the medical center (MC). In the same time the post event ECG recordings shall store the recorded data to be later transmitted to the MC. This functional description already gives some specifications concerning the SW processing activities:

1. The biomedical signal processing and the associated alarms management will be implemented at sensor level. So the SW computing needs will have to be in line with the sensor hardware capability.
2. The monitoring shall operate in real time, so that all the technical solutions must be compliant with real time application constraints.
3. The ECG monitoring software shall operate in a memory loop mode continuously detecting and analyzing the ECG signal, and update a short portion of the signal in a looping memory buffer.

To be fully completed, the specifications of the SW processing modules have to be supported by the medical requirements within the URSAFE field of activities. Regarding this point, it is important to mention that we do not intend to provide a clinical validation of the whole URSAFE demonstrator. Indeed, it is not in the scope of URSAFE to perform a clinical test on actual chronic population, but is limited to be run in the well-defined demonstrator. The aim of the final demonstrator is to illustrate the potentiality of the whole **"conceptual"** chain; ***"real time monitoring- alarm management - transmission – medical expertise in a medical center"***. But as the aim is also to demonstrate the medical support of such a health care solution, it is very important to describe the medical applications supported with such means. So the first part of this document will be dedicated to clearly describe the medical field(s) of application of the URSAFE concept.

We do not intend to review all the medical scenarios that could be supported by the URSAFE platform. But the detailed description of some of them will illustrate the advantages of the concept in specific medical cases and its usefulness for home health care.

It will also help to further define and understand some requirements regarding the signal processing SW modules. Then we can detail the SW module functionality and architecture to answer those requirements. Finally the efficiency of the adopted solution will be illustrated by some simulation and validation results obtained on available biomedical signals. This latter point will be further completed by test reports concerning the three aspects of the SW study:

1. Signal pre-processing
2. Signal analysis: event detection and pre-diagnosis
3. Signal Compression and Restoration

MEDICAL REQUIREMENT CONSTRAINT

The present document focuses on the definition of the signal processing needs for the development of telemonitoring applications. This task shall include in a complementary way, both medical requirements as well as technical feasibility.

The following sections adopt a medical point of view and provide basis for drawing the technical system specifications. It has particularly led to some adaptation of the initial system architecture and has orientated the signal processing application SW.

The medical aspects of the context (it will be updated and completed throughout this document), it will help to define a first stage for the signal processing activity specifications. The sensors of interest and the associated biomedical data in the scope of this study are the baseline-selected devices:

The processing associated to each device has to be considered. But as we will further underline, the most demanding signal from both medical and technical points of view (medically full of information and most complex to analyze) is the ECG. First we will highlight the "medical" objectives of an automated monitoring, that is to say what kind of events have to be analyzed, detected, and recognized. Then with the clarified medical objectives in the scope of URSAFE we will present the steps followed for the signal processing activity study. This part will finally help support the technical specification of the software modules dedicated to biomedical data monitoring.

MEDICAL SUPPORT PROVIDED THROUGH THE USE OF WEARABLE AND CONTINUOUS MONITORING DEVICES

The efficiency of the whole URSAFE concept from medical cost reduction as well as patient way of life improvement has been proved in deliverable D1. Particularly focusing on the signal processing activities, we have to detail some fields of application of the system. This section recalls in which situations this system could be required to satisfy the two initial objectives of the project: hospitalization costs reduction and patient quality of life by avoiding visits to the hospital.

Case 1: After a by-pass heart operation, the (usually elderly) patient comes at home after some days and earlier than she/he would have been back without the use of the U-R-Safe platform. The continuous monitoring at home allows during the initial dates the rhythm of the evolution to be continuously monitored. A nurse comes from time to time to the home of the person to assure her/him. When the person does not feel comfortable a first contact is established with the voice processing system. A series of simple but critical questions is set by the machine and answered by the person. This information is transmitted to the Hospital or other Medical Service and the Medical doctor in charge of the case decides either to send the emergency or to settle the case by phone. After some days of home follow-up the person can quit her/his home and drive a normal life: visit family, shopping, travelling. The whole system is following her/him: the communication is conducted outdoors via the GPRS system. To avoid excess transmission of data, automatic transmission is triggered on events or manually when the person feels less comfortable. The same procedure based on voice processing is also followed in the outdoors case. By doing so for the first several weeks after the operation the person is better followed up (continuously) with lower cost (the hospital bed cost for 2-3 days versus monitoring for several days – presently precursor services come with costs of the less than 2 Euro per day, that even for weeks of monitoring is considerably lower than the cost of a hospital bed for 2-3 days).

Case 2: A diabetic person is in rural area. A satellite communication system is the means to establish the contact to the home of this person. In a normal case the personal base station is measuring diabetes. At a certain moment a case of hypoglycemia appears. Then the Satellite Communication is activated. According to the position of the home either a confident neighbor is invited to come or the emergency service (that can be in this case the rural medical doctor or helicopter help). Again information gained through the voice processing before collapse and glucose automatic measurements are fed to the Service center. Electromyography is a muscle examination method which tracks and interprets electrical activity that provides to muscle contractions. Surface electromyography (SEMG) is widely used as a diagnostic tool in estimation of muscle strength, calculation of muscle fatigue and ergonomics, sports physiology and rehabilitation. Obtaining and examining carefully EMG signals provide valuable information in determining and examining abnormalities in the muscle and motor system.

In this research, a computer based, instrumentation system has been designed for EMG signals which are taken from the patient's arm muscle. The aim of the hardware is to provide, transfer to computer and view the EMG information of the patients received over the USB port.

The essential hardware and software was created to perform the system. On the phase of obtaining the signal, EMG signals that were received from the surface electrodes over the patient's arms have been subjected to various filtering and amplification processes to transport from the transmission channel to the environment that the signal will be displayed.

The EMG signal was translated from analogue to digital and was transferred to the computer with USB. After transforming analogue signal to digital, obtained data was filtered with MATLAB in the digital media and provided to display in the computer with the prepared software interface.

According to my research:

1. Facial expression and human emotion analysis
2. Eye movement and gaze tracking
3. Speech recognition and synthesis
4. Virtual reality (VR) and augmented reality (AR) interaction
5. Driver assisted multimodal interface
6. Multimodal interface for disabled and elderly people

PROPOSED PLAN OF RESEARCH WORK

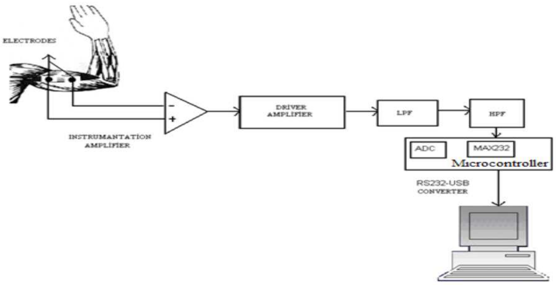

Figure 3.Block diagram of Designed System

The paper represents work on the challenge of real time, non-invasive simultaneous acquisition and wireless transmission of human physiological parameters using easy and cost effective approach. Electromyography (EMG) signal detection and analysis is utilized in various clinical and biomedical applications including generation of control signal for prosthetic tools. However, better solutions to obtain noise free signal using compact detection arrangement and wireless communication technologies are being upgraded. In this work, surface EMG signal is acquired under various levels of bicep muscle contractions using simple computer interface and processed using MATLAB based Filter algorithm for online clean display and wireless transmission. EMG and Carotid artery pulsation are then acquired in time coherence to analyze the effect of rectus abdominals muscle contractions on carotid pulse wave and developed into a stand alone MATLAB executable file. The effect manifests as raised amplitude in the Carotid pulse wave form. Hence, a clear correlation is established between surface EMG signal and Carotid artery pulsation to give a compact, cost efficient solution to physiological signal monitoring.

CONCLUSION:

The most important problem in project has appeared during obtaining EMG signal from muscle. Signals obtained from muscles with two electrodes have been similar to noise than EMG signals. When we deal with a laboratory equipped with electrical materials, this difficulty has been resolved by using third electrode even though it is quite difficult to distinguish a signal having low amplitude of 5mV from environmental noise absorbed by human body. EMG signal has been obtained by using reference electrode, a pair of electrodes as well. In this point, the other problem is that EMG signals have been over 50 Hz network noise in case a system has been fed from the network. This condition has been destroyed by using 9V batteries instead of feeding system from the network. Following transmission of signal wanted to computer, changing EMG signals have been observed in the case of muscle contraction with hardware prepared, but signal has been disappeared as a result of lack of contact between connected cables and electrodes. To prevent this, a gel has been dripped between electrodes and cables, so contract problem has been resolved. Frequency interval of EMG signal has been known as 5-500 Hz. Cut-off frequencies of filters designed as analog have been chosen to this interval. Cut-off frequency of numeral AGF designed has been limited as well. The reason of this is not to have a value for sampling frequency over 120 Hz due to serial communication with PIC.It has been clear that amplifiers and folds work separately from each other in this system. EMG signals obtained have been transmitted to computer in only a system. With an interface program prepared, patient electrodes contract biceps muscle they based on, here as simultaneously signals have been followed; they have been made more understandable after processing with Matlab program.

REFERENCES:

[1] Dixon, A. M. R. , Allstot, E. G. ; Gangopadhyay, D. ; Allstot, D. J. /Compressed Sensing System Considerations for ECG and EMG Wireless Biosensors/ Product Type: Journals & Magazines/ April 2012/ Volume: 6, Issue: 2 / On Page(s): 156 – 166.

[2] Hari Garudadri and Pawan Baheti / Application of Compressed Sensing to Sensing and Processing of Biomedical Signals.

[3] Catalina Monica Fira, Liviu Goras , Constantin Barabasa, Nicolae Cleju/ECG COMPRESSED SENSING BASED ON CLASSIFICATION IN COMPRESSED SPACE AND SPECIFIED DICTIONARIES /Product Type: conference EUSIPCO-2011/ August 29-september 19,2011.

[4] Sungho Hong, Erik De Schutter /Efficient estimation of phase response curves via compressive sensing /Product Type: conference EUSIPCO-2011/ From Twentieth Annual Computational Neuroscience Meeting: CNS-2011 Stockholm, Sweden. 23-28 July 2011.

[5] Amir M. Abdulghani・Alexander J. Casson・Esther Rodriguez Villegas/Compressive sensing scalp EEG signals: implementations and practical performance.

[6] R. M. Rangayyan. Biomedical signal analysis: A case study approach. IEEE Press Series in Biomedical Engineering, 2002.

[7] A. Hyvarinen, J. Karhunen, and E. Oja. Independent Component analysis. Wiley, 2001

[8] Wisbeck JO, Barros AK, Ojeda R. Application of ICA in the Separation of Breathing artifacts' in ECG

Signals. International Conference on Neural Information Processing, (ICONIP’98), Kyushu, Japan, 1998

[9] T.-P. Jung, S. Makeig, T.-W. Lee, M. McKeown, G. Brown, A. Bell, and T. J. Sejnowski. Independent component analysis of biomedical signals. In Proc. Int. Workshop on Independent Component Analysis and Blind Separation of Signals (ICA'00), pages633, Finland, 2000.

[10] Molegedy, H. Schuster, “Separation of independent the Signals using Time delayed Correlations” Physical Reviews letters .Vol72pp.

[11] R Batch, Michael Jorden, “Kernel Independent Component Analysis,” Journal of Machine Learning Research, Vol.3 pp-1-48, 2002.

[12] Hyvarinen, A. and Oja, E. (1997) “A fast fixed- point algorithm for independent component analysis”. Neural Computation, 9:1483-92.

[13] Yi Zhu, Amirali Shayan,, Wanping Zhang, Tong Lee Chen, Tzyy-Ping Jung,, Jeng-Ren Duann, Makeig, and Chung-Kuan Cheng Analyzing High-Density ECG Signals Using ICA ,IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, VOL. 55, NO. 11, NOVEMBER 2008.

[14] Benesty J., Chen J., Huang Y., A generalized MVDR spectrum, IEEE Signal Processing Letters, 12 (12), pp. 827–830, 2005.

[15] Benesty J., Chen J., Huang Y., Estimation of the coherence function with the MVDR approach, Proceedings of IEEE ICASSP 2006, 3, pp. 500–503, 2006.

[16] Capon J., High resolution frequency-wave number spectrum analysis, Proceedings of the IEEE, 57 (8), pp. 1408–1418, 1969.

[17] Challis R. E., Kitney R. I., Biomedical signal processing (in four parts). Part 3: the power spectrum and coherence function, Medical & Biological Engineering & Computing, 29, pp. 225–241, 1991.

[18] Clayton R. H., Murray A., Coherence between body surface ECG leads and intracardiac signals increases during the first 10s of ventricular fibrillation in the human heart, Physiological Measurement, 20, 159–166, 1999.