A personalized and reconfigurable cyberphysical system to handle multi-parametric data acquisition and analysis for mobile monitoring of epileptic patients

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***Abstract*—This poster proposes a personalized and reconfigurable cyberphysical system to handle multi-parametric data acquisition and analysis for mobile monitoring of epileptic patients.**

Keywords—epilepsy; multi-parametric monitoring; EEG; ECG; GSR; Home Gateway

I. INTRODUCTION

Epilepsy is one of the commonest and most serious of the incurable neurological disorders, affecting at least 50 million people in the world [1]. Epileptic or non-epileptic seizures interfere with the life of affected people dramatically. E.g. every day activities like driving a car or riding a bike can become severely dangerous when having a seizure.

Clinical state-of-the-art in monitoring epileptic patients is inpatient video-EEG recording, but this method suffers from some serious disadvantages as it is rather expensive and with low availability due to limited numbers of places for whole night recordings. In addition to this the number and type of epileptic seizures during in hospital recording could differ from normal behavior and the equipment used in clinical practice is rather inconvenient for patients.

The best solution would be to enhance out-of-hospital monitoring for diagnosis and management of epilepsy and related brain disorders. Recent research has shown that ECG monitoring can also be used for real-time epileptic seizure detection [2], and that activity monitoring via accelerometry and GSR monitoring can be used as extra context parameters [3-4], while monitoring epileptic patients.

Depending on the type of epilepsy, different brain and body parameters need to be assessed in order to monitor the patient's state of health at best and to adapt the medical treatment accordingly.

Different solutions for multi-parametric assessment of physiological signals have been developed during the last years. However, none of them were able to provide an integrated platform for the assessment of all the parameters needed or the proposed system was not appropriate for use in everyday life. That's why this poster proposes a personalized and reconfigurable cyberphysical system to handle multi-parametric data acquisition and analysis for mobile monitoring of epileptic patients.

II. SYSTEM ARCHITECTURE AND COMPONENTS

Fig. 1 is giving an overview of the whole system architecture which can be divided in 3 main parts the sensors, the Home Gateway and the Personal Health Record (PHR).

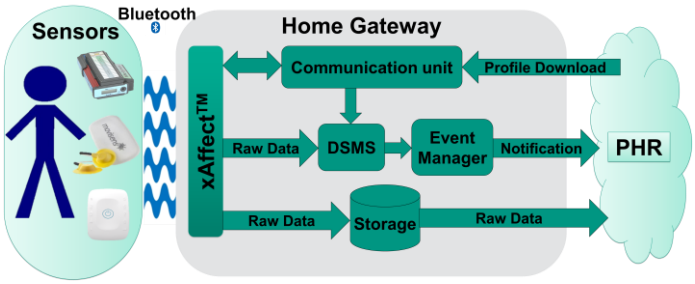

Fig. 1. System archetecture

A. Sensors

In order to achieve the main requirement, the multi-parametric monitoring, different sensors should be integrated in the system. This includes not only the most relevant bio-signal for epilepsy monitoring, the EEG but also ECG, GSR and a push button that have be proven to be important in mobile epilepsy monitoring. For this system the following sensors were selected.

The EEG module (TrackitTM, Lifelines Ltd, Over Wallop, UK) is a mobile ambulatory device that can measure up to 32 channels with a sampling rate of 256 Hz.

The ECG module (ekgMove, movisens GmbH, Karlsruhe, Germany) is a single channel ECG recorder with a 12 bit resolution and a sampling rate from 256 Hz to 1024 Hz. The electrodes are integrated into a wearable chest strap, which is light, small and comfortable.

The galvanic skin response (GSR) module (edaMove, movisens GmbH, Karlsruhe, Germany) measures the skin conductance with a sampling rate of 32Hz.

The push button module (bioPLUX, PluX, Arruda dos Vinhos, Portugal) is actually a device that collects up to 8 signals from various sensors and transmits the signals via Bluetooth to a computer, where they can be viewed in real time. For this system only one push button sensor is used.

B. Home Gateway

The Home Gateway consists mainly of three parts. The first part is the data fusion unit that collects all the data from the sensors and fuses it to a synchronized data stream. The second part is the communication unit, it communicates with sensors, the PHR server and the third part the Data Stream Management System (DSMS). Finally, the DSMS and the Event Manager use the data stream to perform online analysis and with it the detection of events of special interest.

1) Data Fusion Unit:

To connect all the data, synchronize them and handle the data stream a lean and open framework, which can be personalized and reconfigured for each patient, is needed. xAffect is a software framework developed by the Research Center for Information Technology, Karlsruhe, Germany. It was developed in Java to fulfill real-time data processing, easy integration of different data sources, easy integration of algorithms and data logging of raw as well as derived data [5]. Libraries for some common sensors already exist in xAffect. To use a broad spectrum of biosignals, additional libraries for bioPlux and TrackIT devices from the companies bioPLUX and lifelines had to be implemented.

The data format which is being used is the unisens-format. This is a universal and generic format suitable for recording and archiving sensor data from various recording systems and with various sampling frequencies [6].

2) Communication Unit:

The Communication Unit handles the communication with all components. It connects to the PHR server to download the profile for a measurement. It uses the downloaded profile to setup the Sensors and it stores the data stream received from the sensors and uploads it to the PHR server. Furthermore it configures the DSMS with a custom set of algorithms also described in the profile downloaded from the PHR server.

3) DSMS and Event Manager:

The main objective of the DSMS is to be able to detect alarms and warnings for pre-defined events. The module that will communicate events to the PHR is called the Event Manager. One of the simplest but most imported events detected by the online algorithms is the push button. This event is triggered by pressing the marker button in the bioPLUX™ device.

The DSMS canalize the push button raw data to the StreamInsight™ core. The Framework contains a developed query to detect alarm signals, if it successfully detects an alarm condition; it notifies the Event Manager which builds and sends an XML message to the PHR. Also if the user has defined more queries to detect alarms they would produce appropriate output that would be handled within a defined observer.

C. Personal Health Record (PHR)

The PHR server is an online server were the clinicians can access all the patient related data.

A customized set of sensors and also a customized set of algorithms can be defined for each patient. Furthermore all data acquired by the system will be uploaded to the PHR server continuously. Hence the Data can be downloaded and viewed by the clinicians almost instantly from any point where they have an internet connection. In case of events the PHR server set a marker for the time of interest and can notify immediately by sending an email or a SMS.

III. CONCLUSION

Different sets of sensors can be used customized to the needs of clinicians and patients to acquire the necessary data from a specific patient to handle his epilepsy. Furthermore the system does not acquire unnecessary data that is useless for the clinicians by reducing the hardware to a minimum set of sensors personalized for the patient.

The first tests under clinical conditions showed that the developed system is not only more comfortable for the patients since they can move more freely but also easy usable for the clinicians who were in charge of the data acquisition. In the future the System should be tested not only in clinical environment but also in patients' homes to verify the reliability of the system. Furthermore the Home Gateway which is running on a laptop at the moment should be replaced with a smartphone for providing an even more comfortable monitoring.

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