Readability of physiologic data and detection of specific activity using TEMIS system

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Abstract— Physical inactivity has a negative influence on health and increases the risk factors of developing many diseases such as cardiovascular diseases, diabetes and depression. Measurements to quantify and qualify physical activity could be very useful.
The goal of the TEMIS project was to evaluate the capacity of an ambulatory system to qualify and quantify the physical activity level but also to provide objective physiological measurements to qualify the physiological adaptation to the lifestyle of a person.
For that we recruited 65 adult healthy volunteers to test the system that includes a smart t- shirt and ECU (CETEMMSA), an external accelerometer and a smartphone with a specific application (MEDES).
In order to define the readable physiologic data and due to the huge quantity of data collected from TEMIS database, this data firstly needs to be imported and processed to be readable. Another objective was to analyze the capacity of the system to identify specific activity performed by the volunteer. Therefore an algorithm was developed by Anger's CHU in order to estimate an activity minute by minute when the subject was wearing the TEMIS system. The results showed that the system was able to characterize physical activity with a good performance (80,9 %).

Keywords: TEMIS system, physical activity, Fisiosinal, physiologic data processing, smart t-shirt

I. INTRODUCTION

Physical inactivity significantly increases the risk of numerous chronic diseases, including cancer, diabetes, hypertension, obesity, coronary and cerebrovascular diseases, all associated with high rates of mortality [1]. For that reason, over recent years, physical activity has been prescribed by healthcare professionals as a way to improve general health [2].

Normally patients' physical activity evaluation is based on an interview and questionnaires that are highly subjective and badly quantified [3]. However, medical research is currently moving towards a greater personalization of healthcare, but that is only possible if precise information about the patient is available, in particular the type and quantity of physical activity [4].

The TEMIS project (co-financed by the SUDOE territorial cooperation programme) seeks to build a long-term cooperation network to supply innovative technology in order to measure a person's lifestyle, particularly their physical activity, for personalized medicine and medical research [4].

The TEMIS system is compounded by different equipments developed by the partners of the project: a smart garment (smart t-shirt and ECU) developed by CETEMMSA, an external accelerometer, a smartphone with a specific application and an integrative platform developed by MEDES. The T-shirt had different sensors which collected some physiological parameters (heart rate, respiratory curve, body temperature). Accelerometers and GPS recorded the movements and the position of the body [4].

II. METHODS

A. Volunteers recruitment and physical activity assessment protocol

After signing the informed consent form, 65 healthy adult volunteers were recruited. The volunteers used this system at home during four days and one night. Each subject had to indicate which type of physical activity they were performing by a marker on the smartphone application. The different activities were: standing, walking, sitting, lying, running, standing in a vehicle, sitting in a vehicle and cycling.

During two and a half days, the subject had to do four of the activities previously mentioned. Each activity had to be performed for at least 5 minutes. Our main objective was to analyze the reliability of the software to automatically detect each activity. The volunteers were asked to be as precise as possible when indicating the start and the end of each activity.

An algorithm developed by Anger's CHU estimated an activity minute by minute when the subject was wearing the TEMIS system in order to analyze the capacity of the system to identify specific activity performed twice during the week (walking, sitting vehicle, running, cycling). This was designed to identify human physical activities from accelerometers and GPS sensors. This algorithm was accessible on the web server and could analyze automatically all the TEMIS data. A Kappa test was applied to assess the success rate of the algorithm (correspondence between the estimated activity by the algorithm and the physical activity reported by the volunteers).

B. Signal acquisition and processing

Signals from the T-shirt were wirelessly sent to a smartphone application that through integration with the software

(MEDES, Toulouse) ensured that the collected data was available for remote evaluation. ECG data was acquired at 1 kHz and the R-R intervals were computed using a proprietary algorithm (CETEMMSA, Spain). RR intervals were sampled at 25Hz.

C. Readability of physiologic data

Data was downloaded and exported in a file readable by a software dedicated to biomedical signal analysis (Labchart, AD Instruments in Toulouse, FisioSinal in Lisbon). All heart rate curves were analyzed using FisioSinal [5]. We analyzed separately the 24 hour period, the night period and the daily period. Due to the huge quantity of data (100 Mb per file and 500 Mb per subject), this data was imported and processed with the following steps:

Pre-processing. Data was collected from the TEMIS database using the on-line platform (http://ext.temis-project.eu). For a chosen patient/volunteer all parameters were marked and a period was selected using the date and time boxes. Output file was then sent to the e-mail administrator using a download link. Downloaded file was a compressed .csv text file, with more than 500 MB when decompressed, for 40 hour sessions (4 day sessions of 8 hours and 1 night session). The files presented the recordings of 20 parameters distributed in several columns. All other variables were decimal numeric data. Data had a 25 Hz sampling rate, which corresponds to a 40 ms interval between each recorded point.

Data importing and filtering. File importing was performed with Matlab in-house algorithms. When NaN values were present a processing was done, in which the last numerical value was repeated until the next decimal value.

RR interval extrapolation and algorithm validation. For Heart Rate Variability analysis, the RR peak interval from ECG signal is needed. Peak detection and processing is supposed to be done in real time in the garment unit, but information on that processing is not available to us. The RR determination algorithm was written using HR wave as raw data. To validate the algorithm, the extrapolated RR signal was visualized and overimposed on the original data.

III. RESULTS

A. Physical activity assessment

Physical activity assessment was obtained according to the Angers CHU algorithm: the percentage of concordance between the activity performed by the subjects and the activity estimated by the algorithm during scheduled activities was good (80.94 %) in healthy volunteers (n=33). However, according to Angers analysis, some different activities were sometimes declared as identical by the algorithm. That was the case of the running and walking states. Indeed, some volunteers did not run fast enough and with too ample movements to see a difference between running and walking. If the algorithm was asked to differentiate walking and running, the concordance for healthy subjects decreased to 78.40 %.

B. Algorithm validation

To validate the algorithm, extrapolated RR signals were visualized and overimposed on the original data (Figure 1). In detail it is possible to see that each RR peak is located within the original signal.

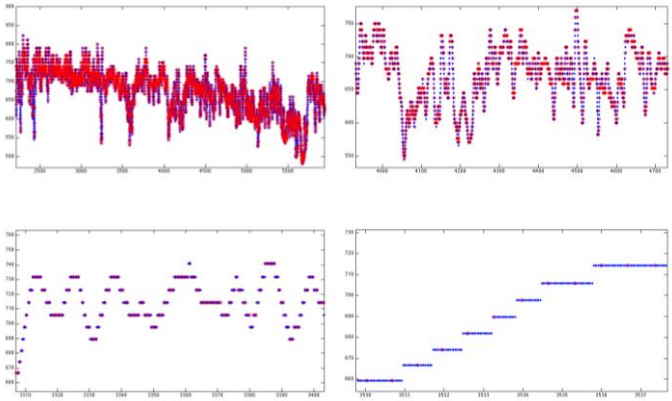

Figure 1: Original data over computed R-R intervals.

IV. DISCUSSION

The TEMIS wearable device and data collection platform showed to be able, under some technical and environmental requirements, to collect physical and physiological data. By using physical data (GPS and accelerometer data), the system was able to characterize physical activity with a good performance.

However, according to Angers analysis, the algorithm had difficulties differentiating between walking and running. When this was taken into account, the performance dropped slightly from 80.94 % to 78.40 %. This means that, even though there is still room for improvement, the TEMIS system is a viable option for recording both physical activity and physiological parameters. More research in this area is necessary in order to create new accessible technologies to measure physical activity, needed for personalized medicine and medical research.

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