Abstract

According to recent reports, millions of workers suffer from dorso-lumbar pain due to their occupation. This problem affects people, who work seated in front of a screen, who have to stand up for long periods of time, who have to handle heavy weights, or who have to endure forced and awkward postures. In this paper, a system is proposed to allow the assessment of the muscular condition in any environment (at work, at school, in the house...), in a comfortable and simple way for the patient and using the advances in wireless communications. Only wireless electromyography and a handheld device (Personal Digital Assistant (PDA) or mobile phone) with wireless interface are needed. By the PDA or mobile phone, the user can configure the medical device and transmit online the electromyographic signals to a remote server.

Wireless networking is becoming more popular as telemedicine applications arise to accommodate the aforementioned flexibility to patients and specialists [3-8]. Wi-Fi is the most common wireless technology. It uses the 2.4GHz globally license free Industrial, Scientific and Medical (ISM) band. Wi-Fi requires a setup process and it is the suitable technology to Local Area Network (LAN). It is recommended for transfers that need a great bandwidth or for constant connections to the net or Internet.

This paper tries to take advantage of this kind of technology in benefit of the health care and especially in the use of electromyography techniques. Electromyography is the study of muscle function through the recording of the electrical activity associated with functioning muscle [9]. It describes and evaluates the neuromuscular response of the muscular contraction in subjects with and without pathologies of the musculoskeletal system from the bioelectrical information registered during specific activities. Specifically, surface electromyography (sEMG) is a non-invasive kinesiological technique used to study movement [10], during which pairs of surface electrodes are mounted directly on the skin. In most cases patients have to obtain signals data at regular intervals or several times a day. In these situations, they have to visit the health care centre or take the signals at home using complex and expensive devices. The aim of the system proposed in this paper is to avoid such displacement using wireless technologies, to widen the uses of the telemedicine applications and to generate automatic feedback reports. With this objective, the data captured by the electromyograph are sent online using wireless technology to a handheld device (PDA or mobile phone). Later, the data are relayed to a server placed in the sanitary centre accessible by Internet. A background application processes the information in real-time and it generates a feedback report which can be consulted and modified by the specialist and downloaded by the client using the PDA or mobile phone to visualize it.

The rest of this paper is organized as follows. In section 2 the background of this work is shown. Section 3 describes the handheld device-based telemedicine system. In Section 4, the system implementation is explained; this one is divided in three big phases. In Section 5, an example of the application is presented, and finally, in Section 6, the different conclusions which can be extracted are established.

2. Background

There have been important advances in wireless communications and network technologies in the last decades. These advances have had a significant impact on m-Health (Mobile Health) systems, defined as “mobile computing, medical sensor and communications technologies for health care” [2]. This impact is mainly due to an important growth in the use of handheld devices (PDAs and mobile phones). On the other hand, the use of wireless technologies represents a natural evolution of traditional telediagnostic systems. Among wireless medical applications, those related to home monitoring [11]-[13] and computer-assisted rehabilitation and therapy [14] should be highlighted. Both involve the monitoring of different parameters like heart rate, blood pressure or movement (for example, fall detection) [15].

There are several previous works which use PDAs for different aims: to have access to the patient’s information, data acquisition, processing and communication [3],[5],[16],[17], a proxy for medical devices [6], data integration from multiple sources [18], and a useful tool in high mobility environments [7],[19].

The use of handheld devices entails important benefits such as the possibility of having access to information from anywhere, sending immediate clinical orders to patients, or the opportunity to consult medical experts at any moment.

Integration into clinician’s workflow and work methodology: The success of the applications based on new technologies depends on their integration in the processes and methodology used by health professionals.

Technology: The evolution of communication networks reveals the need of developing applications that allow the use of different technologies: Internet, Wi-Fi, Bluetooth and cellular networks (2.5G, 3G and future 4G) and evaluating their performance to support the m-Health services. The development of the applications should also allow the user to select among the different available connection alternatives.

Mobile devices: Nowadays, there is a great variety of mobile devices available in the market (PDAs, smart phones, tablet PCs, laptops, etc.). Several studies consider PDAs and mobile phones as medical specialists’ favourite mobile devices. As computing standards and data format standards for m-Health do not exist, the interoperability between systems is even more complicated.

Part of this paper is focused on the aspects related to problems in the integration and implementation of mobile and medical devices and also mobile networks. In our opinion, the most interesting and motivating point of the paper is, in fact, demonstrating that the objective of m-Health can be achieved “to utilize health care application written on mobile devices that are connected through the wireless networking and communication technology to improve safety and outcomes, whereas reducing costs”. Most of the studies related to m-Health consider the following challenges:

- Healthcare professionals: Most of healthcare professionals haven’t experienced the new technologies and are even reluctant to use them if that usage entails a hard and long learning process. In this context, aspects such as user-friendliness are essential, as well as lightness and functionality in application design, even at the cost of realizing less attractive user interfaces.

- Integration into clinician’s workflow and work methodology: The success of the applications based on new technologies depends on their integration in the processes and methodology used by health professionals.

- Technology: The evolution of communication networks reveals the need of developing applications that allow the use of different technologies: Internet, Wi-Fi, Bluetooth and cellular networks (2.5G, 3G and future 4G) and evaluating their performance to support the m-Health services. The development of the applications should also allow the user to select among the different available connection alternatives.

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Most health care systems have their own medical devices. Most previous works have not taken into account the fact that these devices use their own proprietary configuration protocols. Our system has been developed to use commercially available hardware and software components. We have designed a scalable and modular software which allows us to include new technologies as they appear in the market.

Configuration: In the proposed system, the handheld device is not only used as a data acquisition and communication platform but also as a configuration interface of the medical device.

Gateway: In our system, the handheld device can act as a gateway between multiple devices (electromyography (EMG), electrocardiogram (ECG), video, audio, etc.) and the Internet. The fact that medical devices do not need to have a direct access to the Internet has some advantages. For example, medical devices just need to implement wireless technologies with short ranges, saving power and costs. In addition, medical devices are manufactured by different vendors and use incompatible configuration protocols, but our system can translate proprietary protocols and integrate data from heterogeneous sources.

• Offline and OnLine mode: The system can be configured in either offline or online way. If the online mode is chosen, the measurements are transmitted in real time. Therefore, permanent Internet connection is necessary for the whole exercise length. However, the offline mode allows the movement assessment regardless of whether the user has or not a permanent connectivity. With the aim of checking that 3G network is suitable to support our m-Health service, we analyze the impact of the wireless network in the communication between the mobile device and the server.

3. Handheld-based telemedicine system

The system platform allows therapists to obtain health records from patients at their homes, avoiding visits from patients to a medical center or visits from therapists to patients’ homes. Moreover, the medical reports, diagnosis and subsequent treatment steps are available on patients’ interactive PDAs or mobile phones. Figure 1 shows a diagram of the system under development with three differentiated domains: the smart home domain, the service provider domain and the therapist domain. The following list summarizes the steps involved in the operation of the application:

1. The therapist draws the therapy work plan, which will be stored in the server database. Each work plan consists of questionnaires and multimedia content describing medical advices and therapy exercises. The questionnaires are used to create and update user profiles.

2. The patient receives the work plan on his handheld device as an interactive service. It is necessary that users login to the service and fill in the initial questionnaire in order to access their personalized work plan.

3. When needed, the sensor equipment undergoes a remote configuration to prepare for the activities. Also, users receive (video) configuration instructions for the positioning of sensors or the execution of exercises.

4. Once the patients are ready, they perform the exercises and the data (biometric signals, weight, blood pressure) capture starts. The application sends the data back to the server, which implements the Electronic Health Record (EHR). The data can be captured and sent to the server in real time.

5. The server processes the raw EHR data to detect anomalies and assess a preliminary diagnosis. Together with the questionnaire, the EHR data is used to create user profiles that describe the state of patients and their health habits.

6. Therapists access the data in the server to follow up the progress of each patient. The server user interface presents therapists a comprehensive summary of the results of the tests and questionnaires, the preliminary diagnosis and a list of media items related to the patient profile. Then, the therapists generate the pertinent medical reports.

7. Again, patients receive the results of the tests, together with the medical reports, the updated work plan and the media recommendations on their handheld device.

3.1. Medical and Handheld Devices

The medical device used for the work is the ME6000 Biomonitor System (Figure 2). It is an 8 or 16 channels electromyograph, which carries out surface measurements of electrical potential of 8 or 16 muscles simultaneously. This device can be used in laboratory or in field tests, because it is a small, light and portable surface electromyograph. Besides sEMG, it allows using other types of sensors, both physical and environmental (goniometers, meters of cardiac frequency, etc.). It has trigger in/out connections which facilitate a simple synchronization with other medical equipments.

It allows on-line records using Universal Serial Bus (USB) cable or telemetry to Personal Computer (PC) (optional) and off-line without computer, using a compact flash memory card (256MB extendable). The electromyograph uses a PCI-MCIA (Personal Computer Memory Card International Association) adapter Cardbus D-Link AirPlus to 2.4GHz, which establishes one WLAN (Wireless Local Area Network) interface using IEEE 802.11b technology.

We have worked with a PDA Hewlett Packard iPAQ H54700 Pocket PC and with a mobile phone Nokia E61. It requires two necessary features: WLAN Wi-Fi 802.11b wireless standard and JAVA MIDP 2.0 (Mobile Information Device Profile) profile with CLDC 1.1 (Connected Limited Device Configuration) configuration.

Wi-Fi technology will be used for the communication between the ME6000 Biomonitor System and the mobile unit, but also for sending data to the server. The ME6000 network configuration must be established previously. The wireless mode is a connection in ad-hoc, the authentication is open and an extended 128-bit WEP protocol with a 104-bit key size is used.

The aforementioned profile and configuration have been installed, and the .jar and .jad files created have been downloaded in order to run the application in the mobile device. A Java Application Descriptor (JAD) file contains a predefined set of attributes, which allows application management software to identify, retrieve, and install the MIDlets. A MIDlet is an application written for a Mobile Information Device (MID) Profile. All attributes appearing in the JAD file are made available to the MIDlets. A Java Archive (JAR) file contains Java classes for each MIDlet in the suite (a suite is a group of MIDlets that can share resources at runtime), Java classes shared between MIDlets, resource files used by the MIDlets (for example, image files) and a manifest file describing the JAR contents and specifying attributes used by application management software to identify and install the MIDlet suite.

As a server, a computer waits for service requests from other devices on the network (in this case an application running in a PDA or mobile phone). It receives the medical data and stores it. The server is used to locate the web page, too. It allows the user to know how to use the Biomonitor System and to locate the electrodes, among other information.

4. Development of the system

The Figure 3 describes the sequence of actions to be followed by both participant actors (specialist and user) in the telemedicine system proposed for the back care.
Two applications have been developed using Java in order to materialize the presented system: one to be running in the handheld device and another to be executed in the handheld device.

**Step 1:** A web page has been developed to include the information that the professional considers necessary about the correct execution of a specific movement to evaluate. The kind of information included can be text describing the sequence of steps of the activity, images showing the right placing of the electrodes on the skin or video explaining the complete exercise. Figure 4 shows an example of this kind of information. This kind of data is displayed in a web page on a computer, which can be accessed through a network connection with the mobile device.

**Step 2:** The application running in the handheld device provides the user with three possible actions: the first action (Start, in Figure 5) is the collection of sEMG measurements while the user is executing the proposed movement. This information is sent online by the electromyograph to the mobile device, which stores the raw data using the Record Management System (RMS) (23).

The application allows selecting between three different protocols whose parameters of configuration have been defined and stored previously. The most important parameters are the duration of the exercise and the sampling frequency. With both parameters, the number of measurements is calculated. In this way, when all values have been received, the mobile device sends a message of end of connection. Then, the electromyograph stops the measuring and sends its last message.

The wireless connection established between medical device and mobile device sets five specific phases: Connection, to establish the wireless connection; Medical Device Configuration, to define the kind of signal, number of active channels, etc.; Registered Measurements, to send the packets with the sEMG values; End, to define the end of the registration; and, Disconnection, to finish the wireless connection.

The wireless connection established between medical device and mobile device works through an ad-hoc network (24). It can be identified as a network without infrastructure where all the nodes are connected through wireless links, and there is no central or dominant node.

The second action (Update, in Figure 5) is the transmission of the information stored in the record stores using a simple wireless connection by Internet. Among the information sent are the username of the patient and the protocol name.

Finally, the third action (Exit, in Figure 5) allows exiting the application when the measurement is finished, or aborting it. Therefore, the MIDlet which is being executed in the mobile device is destroyed.

Figure 6 describes the main processes of the application developed for the mobile device and the relationship between the different objects which have been programmed.

**Step 3:** An application developed in Java is running at the server. It is waiting to receive information across a socket and it creates an ASCII file with a specific format compatible with Electromyograph software from the received information.

One way to assess the behaviour of the spine in pain-free and low back pain subjects is through the test of trunk forward bending. During trunk flexion and extension took four seconds each, resting for a second at maximum flexion. Each cycle was distributed as follows: seconds 1-2, neck and trunk flexion, until the hands reach the knees; seconds 3-4; further trunk flexions, until second 5, when the subject kept a position of maximum non-forced flexion. Extension was performed inversely during seconds 6 to 9 (see Figure 7).

After the exercise, the medical data were sent to the server using the developed application. The specialist downloaded the ASCII file created and represented the EMG signals. The results of the pain-free patient are shown in Figure 8. It represents the raw signal in the 8 channels used to place the electrodes. They were attached bilaterally on the upper and lower rectus abdominis, rectus spinar, and biceps femoris muscles.

Five repetitions of the trunk flexion-extension cycle were performed. Both trunk flexion and extension took 4 seconds each, resting for a second at maximum flexion. Each cycle was distributed as follows: seconds 1-2, neck and trunk flexion, until the hands reach the knees; seconds 3-4; further trunk flexions, until second 5, when the subject kept a position of maximum non-forced flexion. Extension was performed inversely during seconds 6 to 9 (see Figure 7).

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and with the five periods of flexion and extension marked. The results show that the muscles stimulation of both sides is coordinated in time and amplitude.

But in order to assess the behaviour of the spine in both subjects, a processing of the signal is necessary. The raw EMG data were full-wave rectified, averaged over 500 samples (Root Mean Square) and normalized as a percentage of their maximum value to make easier the interpretation and evaluation of the results. The duration of each cycle of movement was divided into 18 equal time intervals. Then, the mean of the five repetitions was calculated, getting only one EMG pattern of trunk flexion-extension movement (Figure 9).

6. Conclusions

The telemedicine system offers telediagnosis and televigilance services using efficiently miniaturized equipments, allowing the detection of abnormalities in the esophageal movements, and lasts until the beginning of extension time, when an abrupt decrease of the electrical activity takes place. Muscle activity shows values below the initial baseline (myoelectrical silence) during the whole flexion–extension cycle: in the patient with low back pain myoelectrical silence during the whole flexion–extension cycle: in the subject with low back pain myoelectrical silence of the ES was absent. This is a well-known sign of low back pain [26], which is clearly shown using this application.

Figure 8. Raw signal registered in the 8 channels.

Figure 9. Results in a pain-free subject and a low back patient.

References


ability of PMfES: A Mobile Phone Application for Monitoring Real Time Caloric Balance, Mo-


[4] Nazeran H, Setty S, Haltiwanger E, Gonzalez, ME4 Isolation Unit,


[8] Stanford V., Using pervasive computing to deliver elderly care, IEEE Pervasive Comput-


[9] Kotronen I, Parkka J, and van Gils M, Health monitoring in the home of the fu-


[10] Warren S. Beyond telemedicine: Infrastruc-
tures for intelligent home care technology, in Pre-ICADI Workshop Technology for Ag-


[12] Guerri J.C., Esteve M., Palau C., Montfort M. and Sarti M.A., A software tool to acquire,

synchronise and playback multimedia data: an application to kinesiology, in Computer Methods and Programs in Biomedicine, pp. 51-58, Elsevier, 2000.


[15] Nazeran H, Setty S, Haltiwanger E, Gonzalez, ME4 Isolation Unit,


[17] Guerri J.C., Esteve M., Palau C., Montfort M. and Sarti M.A., A software tool to acquire,

synchronise and playback multimedia data: an application to kinesiology, in Computer Methods and Programs in Biomedicine, pp. 51-58, Elsevier, 2000.

[18] Stanford V., Using pervasive computing to deliver elderly care, IEEE Pervasive Comput-


[19] Kotronen I, Parkka J, and van Gils M, Health monitoring in the home of the fu-


[20] Warren S. Beyond telemedicine: Infrastruc-
tures for intelligent home care technology, in Pre-ICADI Workshop Technology for Ag-


[22] Guerri J.C., Esteve M., Palau C., Montfort M. and Sarti M.A., A software tool to acquire,

synchronise and playback multimedia data: an application to kinesiology, in Computer Methods and Programs in Biomedicine, pp. 51-58, Elsevier, 2000.

[23] Kotronen I, Parkka J, and van Gils M, Health monitoring in the home of the fu-


[24] Bangrjan Xu, Hsichie S, Walke B. The role of ad hoc networking in future wireless com-

munications. In Proceedings of International Conference on Communication Technol-


[25] Borenstein DG, Wiesel SW, Boden SD. Me-

chanical disorders of the lumbo-sacral spine. In Low Back Pain: Medical Diagnosis and Comprehensive Management. Phila-


[26] Paquet A, Malouin F, Richards CL. Hip–spine movement interaction and muscle activa-

tion patterns during sagittal trunk movements in low back patients. Spine 1994, 19:

596-603.

[27] Mohomed I, Belling M. R., Jerome W. and Misra A, HARMONIC: Motivation for a Health-

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Waves 2010 · year 2 / ISSN 1889-8297