Real-Time Biosignal Acquisition and Telemedicine Platform for AAL Based on Android OS

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Abstract. Among other strategic action points, the Ambient Assisted Living Joint Programme framework has defined telemedicine and remote monitoring as major applications for improved quality of care. With the advent of novel, game-changing mobile platforms, the technological basis is now in place to provide more capable and usable systems for this practice. In this paper, we present a real-time biosignal acquisition and telemedicine platform based on Android OS, as both the system and the available handsets present highly desirable features for the field. The proposed platform was used in the context of a continuous real time monitoring of ECG signal showing one simple example of its applicability.

1 Introduction

Telemedicine and mobile monitoring of health, and other related parameters, are referred as one of the major applications toward improved quality of care and independent living in an Ambient Assisted Living (AAL) framework [Steg et al., 2006]. This is a rapidly growing field within clinical medicine, and modern Information and Communication Technologies (ICTs) are providing new opportunities, through the introduction of innovative ways of monitoring wellbeing and conveying information both to health-care professionals and users [Yamauchi et al., 2005; Zheng and Ni, 2005; Wang et al., 2007; Wan et al., 2009].

In this paper we present a telemedicine platform for real-time biosignal acquisition, display, and transmission based on Android OS. Within the existing mobile platforms landscape, Android OS is gaining particular attraction due to its hardware interoperability, versatility, and usability characteristics. The proposed platform was devised as a tool for ambulatory and/or home-care within an AAL framework, providing: a) interface with measurement instrumentation through Bluetooth; b) local data acquisition and visualization; c) local data compression and storage; and d) data transmission to a remote server over TCP/IP.

The rest of the paper is organized as follows: Section 2 provides an insight on the motivation behind the use of Android OS; Section 3 details the proposed platform; Section and finally, 4 outline the main results and discussion.

2 Mobile Platforms

In all platforms, except Android and Windows Mobile, applications must either be digitally signed or undergo a thorough approval process by the manufacturer prior to their deployment or for being made available to end-user. Still, after these processes, the access to core resources is typically restrained or sand-boxed, limiting the functionality of the applications and/or requiring a great deal of attention from the end-user to grant permission in the operations considered most sensitive in terms of resource access. In either case, the user experience, functionality, and attainable automation levels are, in general, highly restrained.

Android however, is an open source platform, currently supported by a wide range of devices[Vergne et al., 2010], it is hardware independent, and greatly focused on interaction via touch reducing the learning curves. As of 2010, over 70 devices from different makers can be found on the market with a wide price range and most of them with large touchscreen displays; these allow users with different cognitive and motor skills to use the device as screens can be easily adapted to the end-users needs.

Given this scenario, our research found the Android platform to be the most versatile in an AAL framework. Among other advantages regarding its competition, Android provides: a) Advanced UI with touch-driven interaction; b) Portability; c) Exposed APIs for Bluetooth radio access; d) Unrestrained hardware access through unified APIs to access the different services; e) Multihoming over WiFi or cellular network (2G/3G); and f) Unprecedented security and application permissions management policy.

3 Proposed Approach

3.1 System Overview

Figure 1 presents an overview of the global architecture for the proposed approach. Sensors (A) are applied to the subject with the purpose of simultaneously monitoring one or more parameters. An end-device (B), the acquisition unit, performs the analog-to-digital conversion and data encoding of the biosignals coming from the different sensors. Furthermore, the end-device (B) provides Bluetooth wireless connectivity to the smartphone (C) based on the Serial Port Profile (SPP).

The data streamed by the end-device (B) is continuously collected and decoded in real-time on the smartphone (C) which performs storage, instant display, and transmission to a remote database (D) where the data becomes available for observation by healthcare professional and other designated caregivers. In the smartphone, algorithmic transformations are also performed over the signals, which include data compression (based on deflate algorithm), and signal processing operations consisting of transfer functions computation and automated biosignal modeling.

Local real-time monitoring of incoming data is shown in the smartphone (C) screen to provide local feedback to the user, based on our UI screen architecture; also, the data is stored in standard ASCII format on the local memory. When a connection to the remote database (D) is available, the stored data is then compressed for network payload optimization, and streamed in real-time to the remote database (D) using an atomic transaction model.

For data transmission at distance, our platform uses the multihoming capabilities of Android OS. A connection to the remote database (D) for data transmission is performed through standard TCP/IP protocol over an established WiFi, 2G/3G cellular network connection. Since current devices and associated mobile providers data plans are designed in an always-on, always-connected approach, our platform is able to provide near-real time continuously updated data at the remote server. The remote server (D) is able to handle incoming concurrent connection from multiple smartphones.

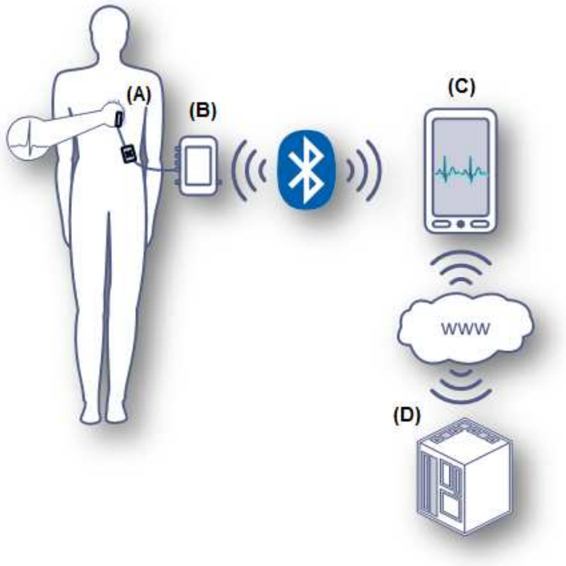

Fig. 1. Global system architecture overview.

3.2 Mobile Application

The mobile application requires Android OS version 2.0 or above, a handset with SD card storage capabilities, and WiFi or 2G/3G cellular network connectivity. It has been deployed and tested in the HTC Hero, Google Nexus One, and Samsung SPICA handset; the application runs in all devices, and has been tested successfully for all features in the first two devices. In the case of Samsung SPICA, an unresolved firmware problem with the Bluetooth interface prevents the application from executing with all features, namely the connection to Bluetooth wireless end-devices.

For the mobile client, the user interface takes advantage of the advanced features provided by the Android platform. Figure 2 depicts an oscilloscope-like screen for real-time signal visualization, that allows the monitored channel selection and besides the raw signal is able to provide instant on-screen measurements of the computed parameters for local feedback to the user, in this case the Heart Rate of the subject in beats per minute(BPM).

(a) Real-time visualization screens

Fig. 2. User interface examples.

4 Conclusions

Other platforms have been proposed in the past that either use dedicated hardware or conventional mobile platforms that, by design, are limitations and high permissions restrictions that are preventing the faster evolution of telemedicine systems in terms of functionality and usability. In this paper we have presented a real-time biosignal acquisition and telemonitoring platform for AAL based on Android OS.

This paper presents an approach which takes advantage of the novel capabilities of that mobile platform and of the compliant handsets. We've provided a brief discussion on the current mobile platform landscape, and why Android OS is ahead of the competition in this field, and we've described our proposed approach.

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