ECG Steganography for Protecting Patients Confidential Information

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Abstract: ***With the growing number of aging population and a significant portion of that suffering from cardiac diseases, it is conceivable that remote ECG patient monitoring systems are expected to be widely used as Point-of-Care applications in hospitals around the world. Therefore, huge amount of ECG signal collected by Body Sensor Networks (BSNs) from remote patients at homes will be transmitted along with other physiological readings such as blood pressure, temperature, glucose level etc. and diagnosed by those remote patient monitoring systems. It is utterly important that patient confidentiality is protected while data is being transmitted over the public network as well as when they are stored in hospital servers used by remote monitoring systems. The proposed method allows ECG signal to hide its corresponding patient confidential data and other physiological information thus guaranteeing the integration between ECG and the rest. To evaluate the effectiveness of the proposed technique on the ECG signal, two distortion measurement metrics have been used: the Percentage Residual Difference (PRD) and the Wavelet Weighted PRD. It is found that the proposed technique provides high security protection for patients data with low (less than 1%) distortion and ECG data remains diagnosable after watermarking (i.e. hiding patient confidential data) and as well as after watermarks (i.e. hidden data) are removed from the watermarked data.***

Keywords: ECG, Body Sensor Network, Confidential Information.

1. Introduction

Monitoring and recording of physiological parameters of patients outside the clinical environment is becoming increasingly important in research as well in applied physiology and medicine in general. Instrumentation developed especially for application in extreme environments is the key for rapid advances in environmental physiology. Technical solutions enabling the field of Telemedicine promise to mediate the impact of changing population statistics. Most important is the field of on-line monitoring and analysis of vital parameters. Different kinds of wireless technologies promise to ensure patient compliance. Especially Body Area Networks (BAN) coupled with these wireless technologies allows the setup of a comprehensive telemedical infrastructure. Depending on the environment two different subsystems are central to a BAN: 1) An embedded system as a sensor platform. 2) A Wireless Network (WSN) tailored to the specific task. The IEEE 802.15 Task Group 6 (BAN) is developing the communication standard optimized for low power devices and operation on, in or near the human body.

Smart phones and Tablet PCs take over tasks of the traditional PC, once again changing the hardware base of computer science. Therefore it is a natural development to use smart phones as mobile sinks, and integrate them as central modules of a telecare system. In addition to a BAN a typical smart phone features around a dozen internal sensors, some of them may be used in a medical application.

2. ECG Based Information Transmission

Presently very little is known about acute adaptation mechanisms, and especially about long term changes in physiological function, e.g. in professionals which are regularly exposed to extreme environmental conditions such as divers, astronauts or pilots. The main obstacle to the assessment of physiological changes in extreme environment is the fact that most findings have been collected during laboratory conditions with frequently bulky instruments. In field measurements outside laboratory are not feasible, simply as suitable instrumentation that can withstand such harsh environments was not available. Thus research is far away from the real field conditions when different environmental factors could act synergistically or vice versa an individual response to environmental stimuli is complex. How age and gender influence these adaptations is also largely unknown. A sound understanding of human physiology in such environments is however the basis for being able to give recommendations and draft guidelines on how and to what extent exposures to extreme environments can be tolerated in a safe way with minimized health risks considering short, medium as well as long term effects. Literature reports the clear and effective advantage of specific patient monitoring well tuned to the patients clinical condition. Reported results of a met analysis on 5000 patients by Alister point out that specific assistance programs like a phone hotline to medical staff (for example a nurse) or by outpatient medical follow-up assure both a reduction of re-hospitalization and also mortality. Hence efforts are taken develop Android Based Body Area Network for the Evaluation of Medical Parameters.

2.1. Android Smartphone

A. Android Smartphone: An Android based Smartphone has been chosen because of its powerful and Java-based development kit, Android SDK, its excellent documentation and library including classes like Bluetooth Health, and the possibility to develop on many platforms, like Linux, Mac Os and Windows . For development different smart phones are being used with Android 2.3.5 and 4.03.
B. Android Apps: As mentioned in the System Architecture

the smart phone should manage not only data acquisition from the W (BAN), but also synchronization and provide a Graphical User Interface (GUI), among other tasks. In order to do so an Android application is necessary, this application Should feature several functions, among these are: Data acquisition from the (W)BAN via Bluetooth; data analysis, i.e. comparison with medical norm values; GUI for configuration, data visualization, and communication; data transfer (synchronization) to a medical server via WiFi or cellular network

Monitoring Unit:

Figure 1: Monitoring Unit

2.2. BAN with LPC2138 ARM7 Board

In terms of the sensor nodes and the gateway, Atmel solutions promise to provide an ideal platform for Tele care devices, reliable communication together with power efficiency, in a compact design. For this a high-performance, low power 32-bit LPC 2138 Microcontroller is available. It features a 32-bit CPU, a maximum operating frequency of 60 MHz, 512KB In-System Self-Programmable Flash, 32KB internal SRAM, 2 Universal Asynchronous Receiver Transmitters (UART),1 Serial Peripheral Interface (SPI) and 14 channels ADC with a resolution of 10 bits and DAC with a resolution of 10 bits.

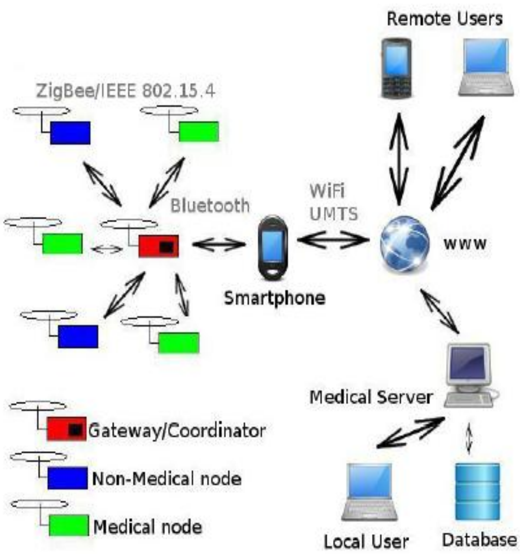

Figure 2: WBAN architecture

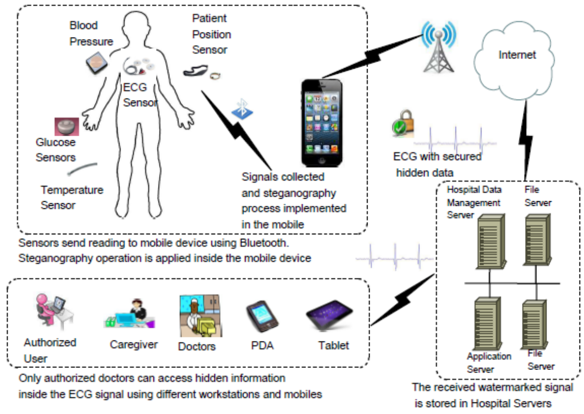

Figure 2: ECG as a transmission carrier where body sensors collect different readings

3. Future Scope and Further Enhancement

Security on all levels of the layered system must be further investigated, especially to define trade-offs with respect to performance and comfortable use. Certification according to medical safety standards is currently impossible due to the different components used, e.g. the Android operating system. The first version of the proposed system will therefore be used in different research applications of environmental physiology, i.e. HRV measurement, heart rate, breathing rate, etc.

4. Conclusion

The first design approach, a WBAN, fulfills the basic requirements. Reliability and range are sufficient. Due to fears with respect to transmission power of wireless systems the upcoming standard IEEE 802.15.6 will be considered for future designs. The combination of the WBAN with an Android Smartphone offers a large functionality. Vital parameters can be stored, analyzed and visualized with GUIs designed for the end-user.

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