Design and Implementation of a Portable ECG Signal Transmission Prototype

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Introduction: Telemedicine techniques not only reduce morbidity and mortality but also lower the total cost of monitoring, provide healthcare to people who have limited access to or are far from healthcare centers. Current signal transmitters can be quite expensive and are not easy or convenient to use for non-technical patients. Hence, we designed a low-cost, portable and user friendly vital signal transmission device which could send the patients' health status information to respective healthcare centers even when they are occupied with their daily activities. Cardiovascular diseases are the number one killer throughout the world. Hence, monitoring the cardiovascular activities in emergency conditions and/or certain intervals could prevent sudden mortalities. ECG is one of the most important biological signals which must be recorded in patients with cardiovascular diseases. In our previous study [1], we demonstrated how to transmit a biological signal through the GSM voice channel with reliable transmission accuracy (98%). In this study, we designed a low-cost and reliable transmission prototype using a GSM voice channel communication platform which provides a real-time vital data link between the patient and health care provider. Real-time transmission of ECG and other low-frequency-range signals (below 75 Hz) with considerable accuracy, lowered cost and convenience for users are the benefits of the proposed system. Besides, using any type of cell phone would be possible for transmission, not just the smart devices.

Materials and Methods: The prototype consists of two devices; a portable transmitter and a stationary receiver. The portable transmitter is a light-weight biomedical data acquisition unit which captures the signal and sends the data stream over GSM channel using a GSM modem. The stationary receiver unit is an interface between a GSM modem and PC. And finally a software is designed (using Microsoft C# 2010) to receive, store and plot the vital signal. ECG signal is gathered and passed through analog and digital filters using a high precision instrumentation circuit and a 16-bit microcontroller unit (ATMEGA128, AVR microcontroller). Each sample, before being transferred over GSM voice channel, is converted to a speech-like signal using a mapping method and at the receiver. The software would have contact information of all registered patients in database and whenever it is necessary, would establish a connection to the portable device. Additionally, the patient also has the ability of sending alarm signals by pushing the emergency buttons placed on the device.

Results and Discussion: The biomedical instrumentation amplifier had an amplification gain of 1000 and cutoff frequencies 0.1 and 75 Hz, and a feedback electrode captured the ECG signal and the microcontroller was used to: 1-convert the amplified signal to digital; 2-generate the transmission symbols; 3-communicate with a GSM modem; and 4-read the commands and prompt the information to patient. The amplifier captured the signal using two Ag/AgCl skin electrodes placed at right and left upper chest and bellow right armpit towards the abdomen. At the receiver side, an application opens the serial port to communicate with GSM modem through RS-232 link. Moreover, it saves all received data and notations made by specialist in an online database. Results showed a proper level of transmission accuracy and no delays in transmission.

Conclusions: A prototype design integrating ECG signal tranmission over GSM channel was implemented based on our previous algorithm. This device is not limited to ECG signal transmission only and can be used for transmission of other vital signals such as EEG, PPG and SpO_2, etc. (<75 Hz). In conclusion, we propose a low-cost, portable, reliable and convenient device with emergency controls for monitoring the cardiovascular health status. Further studies will be conducted to make the system more compact and convenient to use.

(A) (B)

Figure 1. (A) Transmitter device; (B) Receiver device

References:

1. Seyedmohsen Dehghanojamahalle, B.L.P., Mehmet Kaya, *ECG Signal Transmission Through GSM Voice Channel*. 2014, BMES 2014. p. 114.