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ELECTROCARDIOGRAM BY MOBILE PHONE: A COMPRESSION METHOD FOR SMS

Cleonilson Protásio de Souza [1], Tiago Pontes Pereira[2], Raimundo C. Silvério Freire[3]

[1] Federal Institute of Education, Science and Technology of Maranhão, São Luís, Brazil, protasio@ieee.org
[2] Federal Institute of Education, Science and Technology of Maranhão, São Luís, Brazil, tiago.ic@dee.cefet-ma.br
[3]Federal University of Campina Grande, Campina Grande, Brazil, rcsfreire@dee.ufcg.edu.br

Abstract − The increasing development on mobile communication allows the design of new applications in different areas. Telemedicine is one of these areas and studies and researches on it are of extremely importance to the society. An important application in telemedicine is the use of electrocardiogram (ECG) to transmit ECG test remotely in a compact or portable way. However, ECG transmission technology available today is still expensive and is based on use of modems and, recently, PDAs. On this context, a portable ECG device based on mobile phone is welcome. A basic mobile service is the Short Message Service (SMS) that is present at all mobile phone at extremely low cost. To take advantage of SMS on design of a mobile ECG, it is need efficient compression methods to compress the ECG signal into a message. In this work is present a compression method that allows mobile phone to transmit ECG signal via SMS.

Keywords: telemedicine, electrocardiogram, mobile phone.

1. INTRODUCTION

Due to the mobile communication technology evolution, voice communication became just one of services offers by this technology. A lot of applications are available and new ones are in development due to its features that turns out to be interesting in different applications [1] [2]. Evidently, the possibility of wireless communication at any place covered by the system is the most import feature.

On the other hand, telemedicine comes up as a way to apply communication and information technologies in order to prevent and to treat ailments in isolated places [3]. One of successful applications is the use of portable electrocardiogram (ECG) device which is of very importance to care cardiovascular health of patients in hard access places.

Nowadays, portable ECG devices that allow ECG signal transmission directly to the doctor is still very expensive and is based on use of modems [4] and, recently, PDAs [5]. On this context, a portable ECG device based on mobile phone is welcome. A basic mobile service is the Short Message Service (SMS) that is present at all mobile phone at extremely low cost. To take advantage of SMS on design of a mobile ECG, it is need efficient compression methods to compress the ECG signal into a message. In this work is present a compression method that allows mobile phone to transmit ECG signal via SMS.

2. MOBILE ECG

Electrocardiogram (ECG) is the register of electrical activities that is created during cardio-activity by an instrument called electrocardiograph. A number of cardiopathies can be detected by it. The result of an ECG test is a voltage graph, as shown in Figure 1, which is analyzed in order to obtain a diagnosis.

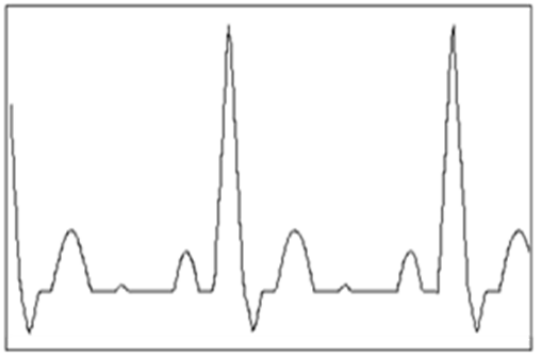

Figure 1. Example of Electrocardiogram (ECG) signal.

The intended mobile ECG is shown in Figure 2 and should be composed of an ECG signal acquisition system and microcontroller-based system to digitalize, to compress to an SMS and to interface the ECG signals with a mobile phone near the patient. After obtain the SMS-based ECG signal, the mobile phone will send it to another doctor's mobile phone with should be connected to a computer in order to show the original ECG signal visualization.

The main bottleneck of SMS-based mobile ECG is to achieve compression rates that allow a digitalized ECG signal to put into a SMS.

In the next section, it is present a method that is capable of achieving good compression rate that will be the base of the Mobile ECG that is being developed at Federal Institution of Education, Science and Technology of Maranhão – Brazil.

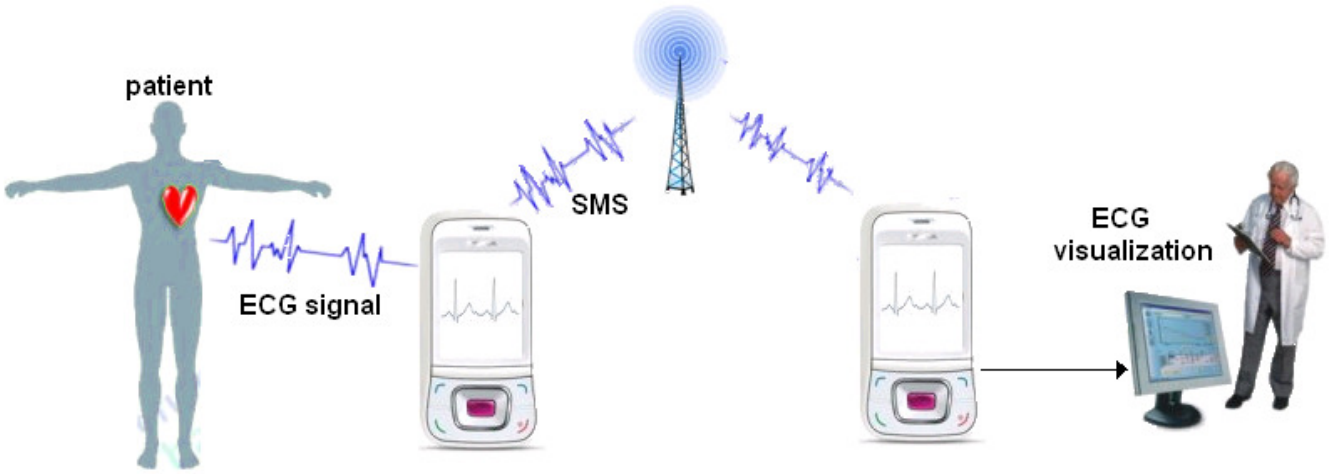

Figure 2. Mobile ECG Scheme.

3. COMPRESSION ALGORITHM

In general, compression methods can be classified as lossy compression and lossless compression. Lossy compression methods get to better values of compression, but allow information losses. This method is specially used in pictures, movies or sounds, because the small losses are not important. In other cases, as in computer data, methods of lossless compression must be used [7]. In our case, lossless compression was intended.

Figure 2 shows a typical ECG voltage signal against time. The first step of the proposed compression method is based on to convert voltage points to characters. It was used a predefined table relating 90 ASCII characters to each 0.01 volts that cover 1 volt of the range of ECG voltage signal, i.e, from -0.1 to 0.9 volts as shown in Figure 3.

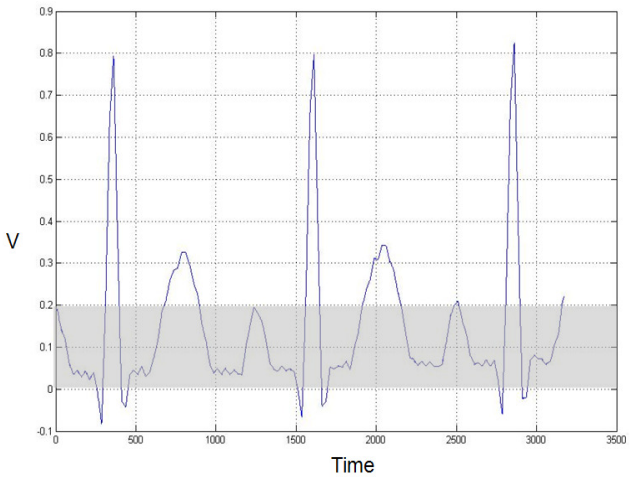

Figure 2. Typical ECG voltage signal. Darkest areas indicate the concentration of information.

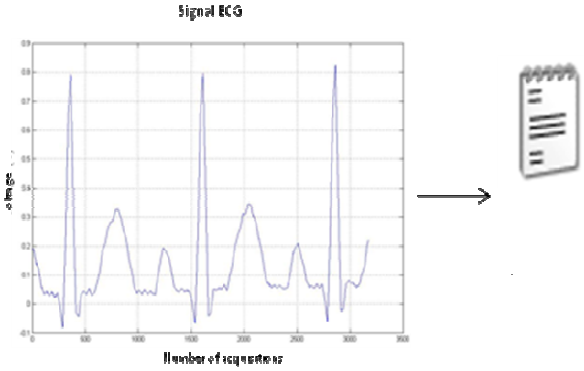

Figure 3. ECG Signal to ASCII characters conversion.

The initial conversion from ECG voltage signal to characters is necessary since the aim of to adapt the ECG signal to be able to be sent by SMS which is based on ASCII characters. The resulting characters form a file that will pass by the compression method shown as follows.

As shown in Figure 2, it is observed that the darkest area has a concentration of information. Such concentration can be used in order to compress the original set of characters using Huffman-ASCII coding.

Based on Huffman-ASCII coding, the characters which appear more (or in the darkest area), will use fewer characters than in other areas. In this way, the more frequent is the voltage value (or the correspondent character), smaller is the quantity of characters. The resulting character sequence is a complete coding and compressed one which is suited to be sent by a mobile service as SMS.

The steps of the proposed compression algorithm are:

1. Convert the CGC voltage value → ASCII characters.
2. Comprise them using Huffman-ASCII coding
3. Send by SMS

4. EXPERIMENTAL RESULTS

The algorithm has been developed on MATLAB® since it is user-friendly and has specific functions to work on images and to show results. To generate ECG signal was used NI LABVIEW®.

The experimental results using Huffman-ASCII coding are shown in Figures 4 and 5. Figure 4 is the original ECG signal which was sampled at different rates.

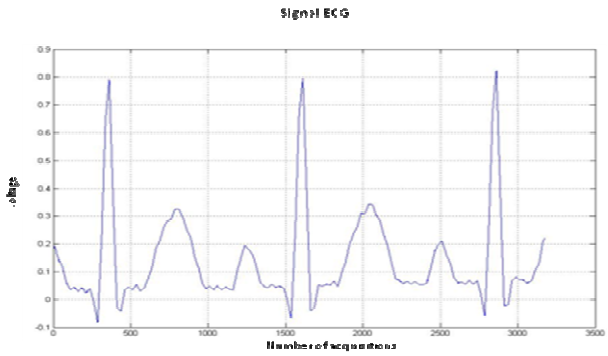

Figure 4. ECG signal.

Figure 5 shows the number of characters obtained after the sampled ECG signal is coded and compressed using the proposed method. Logically, the less is the sample rate, the less is the number of characters.

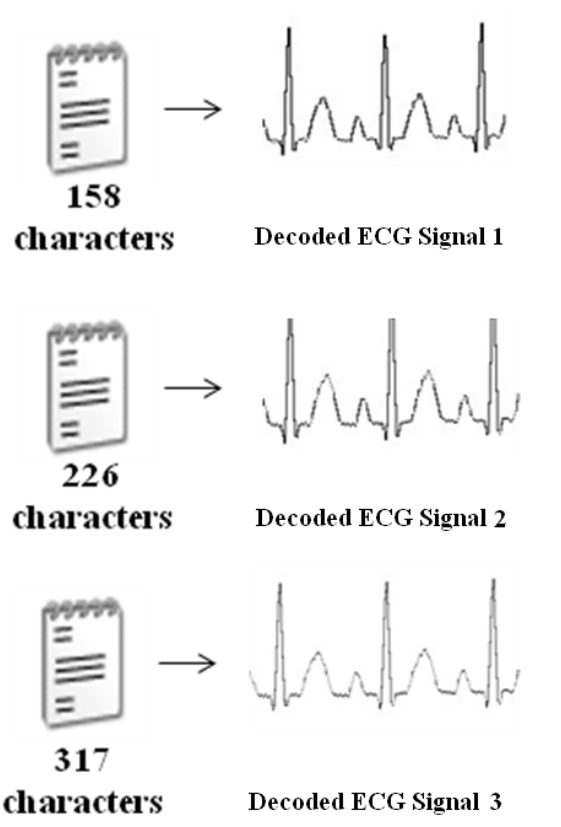

Figure 5. Doctor Side decoded ECG signals.

From Figure 5, the ECG signals beside each set of characters are the decompressed and decoded ECG signal at the Doctor side. Moreover, these character set lengths are suited to be sent by SMS. Figure 6 shows the decoded ECG signal, as red points, using 158 characters SMS and from this can be observed the correct reconstruction of ECG signal in the Doctor Side apparatus.

Figure 7 and 8 show the decoded ECG signal, as red points, using 226 and 317 characters SMS, respectively.

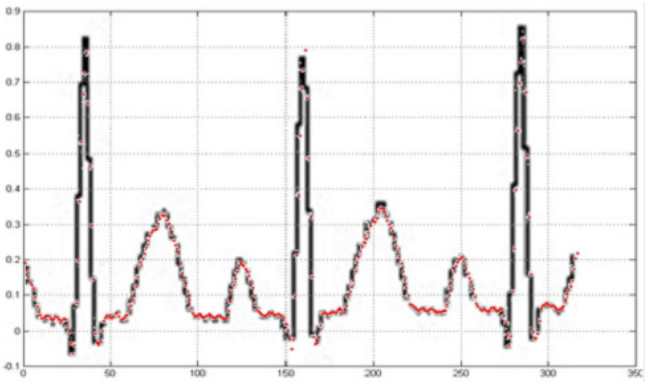

Figure 6. Doctor Side decoded ECG signals using 158 characters SMS.

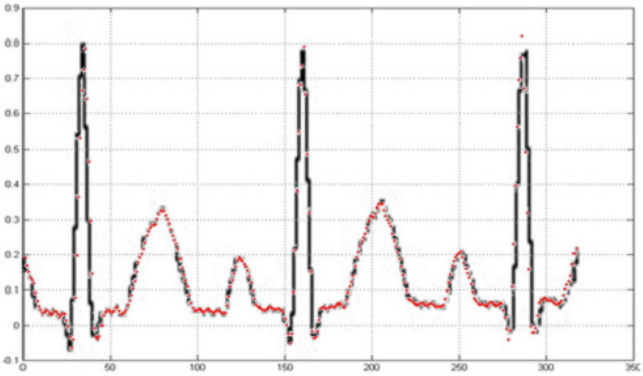

Figure 7. Doctor Side decoded ECG signals using 226 characters SMS.

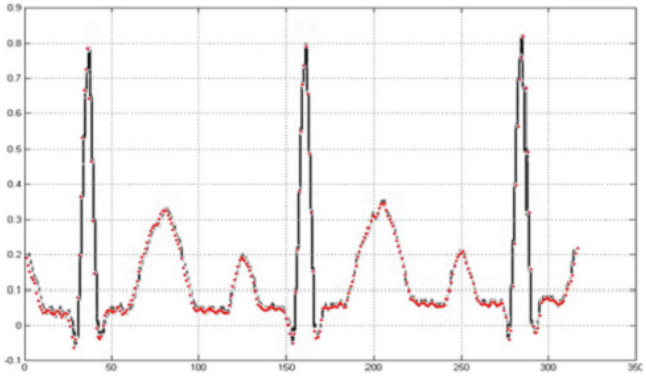

Figure 8. Doctor Side decoded ECG signals using 317 characters SMS.

5. CONCLUSIONS

In order to develop a mobile ECG instrument based on SMS and take advantages of its extremely low cost, in this work was present an efficient compression method to compress the ECG signal into a SMS message. The compression method is based on Huffman-ASCII coding and the experimental results shown that with it is possible to allows mobile phone to transmit ECG signal via SMS. Additionally, it was shown that the Doctor side SMS received signals matched precisely with the original SMS.

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