Different Encoding and Decoding Techniques of ECG Signal for Efficient Transmission - A Survey

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Abstract - *In the present scenario hearts abnormal condition shows a threat to human beings. This signal contains information about the heart. The disease that affects the heart is identified by the P-QRS-T wave shape, size and their time intervals between its various peaks. ECG signal is degraded by dissimilar noises of high and low frequencies which causes wrong interpretations. This paper presents a survey of how signal is aimed to its transmission using different coding and decoding techniques. ECG signal is considered as a major issue and loss of data transmission occurs frequently. However, their inadequate computational power carry out the use of several encoding techniques grounded on a lesser number of digital computations. Therefore this paper focuses on certain encoding and decoding techniques of ECG signal for resourceful transmission.*

Key Words: **Types of ECG, ECG diagnoses, noises in ECG Signal, QRS detection, denoising techniques, wavelet transform, encoding and decoding techniques, IIR-FIR-adaptive filters.**

1. INTRODUCTION

From the observation it is said that one should make ECG diagnoses more accurate in some diseases and to evaluate other diseases with an acceptable probability. Nowadays with the help of ECG signal he hearts activity is monitored for weeks to months while the individual is performing the day to day activities of daily living at work or home. There are several types of electrocardiogram signals simply called ECG signal. When the body is at rest the hearts activity is monitored frequently, which can be taken as resting ECG signal. In exercise ECG the hearts activity under conditions of physical exercise is monitored. This signal is used for coronary disease detection, evaluation of exercise capacity and its assessment of severity. Signal averaged ECG signal is performed for about 15-20 minutes. Information which is received from this signal is being processed by a computer to detect cardiac abnormalities and also used in arrhythmias suspicion.
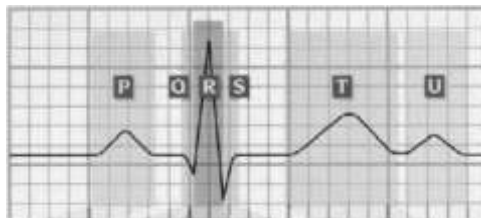

Fig. 1. An electrocardiogram waveform

With the help of electrodes heart signals are taken in arms, chest and leg of our body. Analysis and readings of ECG signal are carried out from signal transmission. [24]In today's world signal transmission plays a crucial role in ECG signal interpretation and analysis. In various situations ECG signal has noise present in it and also the signal gets affected if the electrodes are not properly placed on the body. Noise occurs by means electrodes, instruments and power interference. Hence, noise reduction is the most important constraint of signal transmission.[24]

In order to obtain diagnosis telemedicine uses the transmission of medical information (recordings, images etc.) by telecommunication means for a remote patient monitoring. In real time, technological developments have helped remote transmission which involves voice and image transmission. The data transmission physical supports are coaxial cables, telecommunications, twisted pair cable, optical fiber and satellite links network.

2. LITERATURE SURVEY

Various encoding and decoding techniques are taken out by many researchers to find efficient transmission of ECG signal. Wavelet transforms are used to remove the noise in ECG signal. Because of its good temporal localization property dyadic wavelet transform provides best output and it has a very good accuracy. [4, 7-9] This paper gives the survey for ECG signal. Variable stage differentiation is used to extract the ECG feature. SNR is achieved in this paper using non-linear amplification and also feature extraction is done in a fast manner.[24]

To overcome various types of noise enormous methods are developed. The noises such as power line interferences, contact electrodes and baseline drift occurs during transmission. By using advanced adaptive filtering technique along with LMS algorithm these noises are reduced. [15] An effective wavelength transforms and genetic algorithm is used to reduce noise and also a noise which arises in acquisition time is reduced by adaptive filters. During transmission of ECG signal, baseline noise is produced and it is eliminated by using filter banks such as IIR and FIR filters. When compared to FIR filter IIR acts as the best approach.[16-18]

For multiple lead ECG baseline drift suppression filter which have minimal calculation power, minimal non-linear phase shift, maximum signal to noise ratio and minimum delay is used to remove noise during transmission of ECG signal. [12] Median and FIR filter together is used for ECG signal preprocessing. It preserves edges and rejects the baseline drift while removing noise. Using wavelet transform ECG signal is retrieved with the help of QRS complex detection. [19, 22]

For the analysis and compression of ECG signal various techniques such as DCT, SAPA, AZTEC, and Fourier transform and KLT is used to process the signal. [1-3, 5, 6] For an advanced telemedicine applications an expensive and sophisticated communications infrastructure is used. Huffman coding is used for data compression which allows to reduce the average length of an alphabet. [24] Linear prediction and variable length coding and decoding in this paper to evaluate the performance of the compression system. Two encoding schemes optical zonal wavelet coding and wavelength transform higher order statistics based coding are used in this paper. [11] However, the fault of this algorithm is due to LPC filtering. Adaptive LPC filtering which is based on optimal segmentation will improve the performance of algorithm but this LPC filtering practice lowered. The algorithm is complex and subsequently it take time for processing.

Based on electromagnetic interference noise is produced. This happens because of improper grounding of the patient or ECG machine. From the electrical cavity of the muscle EMG noise is generated. In this paper it has a maximum frequency of 10KHZ. Baseline under noise have frequency greater than 1 HZ. Detection and analysis of peak is not an easy job to find. Channel noise occurs due to poor channel conditions and electrode contact noise occurs and it has duration of 1seconds. [26]Several denoising techniques such as IIR notch filter, FIR filtering and adaptive filter is used to remove power line interference. PLI is removed at 50Hz frequency with the help of notch filter. FIR filter, HPF and LPF's are designed with cut-off frequency 3Hz and 100 Hz. [21]

DSC scheme is used in the encoding stage in order to encode the signal whereas in decoding side stage sparsity promoting optimization algorithms is used. [14, 26] Distortion rate performance are sub-optimal when compared to traditional transform coding. [10] Random encoding matrix is applied to the signal, so as to optimize the attained code rates and SNR performance. [20, 23, 26] Because of lossy DSC, CS achieves low code rates with low computational complexity at the encoder side. In this paper, the ECG signal is measured with the help of instrumentation amplifier and the signal gain is appeared as 1000. Transmission is done with the help of FM transmitter around 90 Hz and the transmission distance is acquired around 300 meters. [13]

With the help of Ag/Cl electrodes, noiseless ECG signal is measured. The signal is converted into digital data using pulse code modulation (PCM) and by using FSK technique the data was sent to the receiver with a power of 100mW, 433MHz and speed 9.6Kps. Sonic Foundry forage 6.0 program is send to record the reconverted signal on PC.

3. CONCLUSION

By this survey the idea is gained how an electrocardiogram is transmitted by using different encoding and decoding techniques. Various types of ECG and the noise that affects them were studied and gathered some knowledge about how to overcome that noise while transmitting form one end to another. Some of the filtering techniques were studied to denoising the signal. Thus a survey has been done to check the performance of ECG signal under various conditions.

REFERENCES

[1] Cox J R, Nolle F M, Fozzard H A, Oliver G C "A preprocessing program forreal-time ECG rhythm analysis ", AZTEC, vol. 15, pp.128-129, 1968.

[2] Ahmed N, Milne P J, Harris S G, "Electrocardiographic data compression viaorthogonal transforms", vol.22,   pp.484-487, 1975.

[3] Ishijima M, Shin S B, Hostetter G H, Sklansky J,"Scan along polygon approximation for data compression of Electrocardiograms", vol.30, pp. 723-729, 1983.

[4] Pan, J. and Tompkins, W. J, "A real-time QRS detection algorithm", IEEE Transactions Biomedical   Engineering, vol. 32, pp. 230–236, 1985.

[5] Philips W and Jonghe G D, "Data Compression of ECG's by High-Degree polynomial approximation", vol. 39, pp. 330-337, 1992.

[6] Madhukar B and Murthy I S N ECG Data Compression by Modeling AMIA, Inc. 586-591.

[7] Hu, Y.H., Tompkins, W.J., Urrusti, J.L and Afonso, V.X., "Applications of artificial neural networks for ECG signal detection and classification, J .Electro cardiology", vol. 26 (Suppl.), pp. 66-73, 1993.

[8] Bahoura, M., Hassani, M. and Hubin, M., "DSP implementation of wavelet transform for real time ECG waveforms detection and heart rate analysis, Comput. Methods Programs Biomed, vol. 52, no. 1, pp. 35–44, 1997.

[9] Afonso, V.X., Tompkins, W.J., Nguyen, T.Q and S. Luo, "ECG beat detection using filter banks", IEEE Trans. Biomed. Eng., vol. 46, pp. 192–202, 1999.

[10] V.Goyal, "Theoretical foundations of transform coding," IEEE Signal Process. Mag., vol. 18, no. 5, pp. 9–21, Sep. 2001.

[11] Istepanian R S, Leontios J Hadjileontiadis and Stavros M Panas, "ECG Data Compression Using Wavelets and Higher Order Statistics Methods", IEEE Transactions on Information Technology in Biomedicine, 5(2) 108-115, 2001.

[12] Harting, L.P., Fedotov, N.M and Slump, C.S, "On Baseline Drift Suppressing in ECG Recording" IEEE Benelux Signal Processing Symposium, 2004.

[13]NihalFatma G¨uler · UgurFidan, "Wireless Transmission of ECG signal", J Med Syst, Springer Science + Business Media, PP: 231–235, 2006.

[14] A. Fletcher, S. Rangan, and V. Goyal, "On the rate-distortion performance of compressed sensing," in IEEE Int. Conf. Acoustics, Speechand Signal Processing, , vol. 3, pp. III-885–III-888, Apr. 2007.

[15] Tareen, S.G., "Removal of Power Line Interference and other Single Frequency Tones from Signals", 2008.

[16] El-Dahshan, "Genetic algorithm and wavelet hybrid scheme for ECG signal denoising", Telecommunication Systems, vol. 46, pp. 209-215, 2010.

[17] Seema Rani, Amarpreetkaur and Ubhi, J.S., "Comparative study of FIR and IIR filters for the removal of Baseline noises from ECG signal", International Journal of Computer Science and Information Technologies Vol 2 (3), 2011.

[18] Dutta, "SSDM Optimized Noise Canceller for ECG Signals", International Conference on Intelligent Systems and Data Processing, 2011.

[19] Priyanka Mehta and Monika Kumari, "QRS Complex Detection of ECG Signal Using Wavelet Transform", International Journal of Applied Engineering Research, Vol.7 No.11, 2012.

[20] M. Mangia, R. Rovatti, and G. Setti, "Rakeness in the design of analog-to-information conversion of sparse and localized signals," IEEE Trans. Circuits Syst. I, vol. 59, no. 5, pp. 1001–1014, 2012.

[21] ChinmayChandrakar, M.K. Kowar, "Denoising ECG Signals Using Adaptive Filter Algorithm", International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-2, Issue-1, March 2012.

[22] Karnewar, J.S and Sarode, M.V. 2013. The Combined Effect of Median and FIR Filter Pre-processing of ECG Signal using Matlab, International Journal of Computer Applications (0975 – 8887), 2013.

[23] V. Cambareri, M. Mangia, F. Pareschi, R. Rovatti, and G. Setti, "A rakeness- based design flow for analog-to-information conversion by compressive sensing," in IEEE Int. Symp. Circuits and Systems, pp.1360–1363, IEEE, 2013.

[24] R. Kavitha, T Christopher, "A Study on ECG Signal Classification Techniques", International Journal of Computer Applications, vol. 86, no. 14, 2014.

[25] Valerio Cambareri, Mauro Mangia, Fabio Pareschi, Riccardo Rovatti, GianlucaSetti, "A Case Study in Low-Complexity ECG Signal Encoding", IEEE signal processing letters, vol. 22, no. 10, pp. 1743-1747, 2015.

[26] AswathyVelayudhan, Soniya Peter, "Noise Analysis and Different Denoising Techniques of ECG Signal - A Survey", IOSR Journal of Electronics and Communication Engineering (IOSR-JECE), pp. 40-44, 2016.