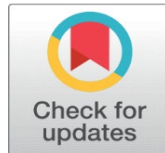
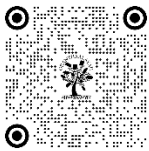


AN EFFECTIVE DCT AND HUFFMAN CODING SUPERVISING SYSTEM FOR CPMPRESSION OF MMG UTERINE SIGNAL

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DOI

[10.29121/shodhkosh.v5.i6.2024.3263](https://doi.org/10.29121/shodhkosh.v5.i6.2024.3263)

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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ABSTRACT

Globally, the rates of premature baby morbidity and mortality are increasing year. It is essential to use telemedicine and ambulatory monitoring to give these infants the right care at the right time. The strength of the uterine physiological signals limits the practical applicability. The study suggests a lossless compression strategy that combines Huffman coding with DCT. We estimated DCT components under 2 Hz frequency. A Huffman coder was utilized at the transmitter position to encode the quantized DCT coefficients. The DCT coefficients above 2 Hz are replaced at receiver position with a zero set. The reconstructed signal was obtained by applying inverse DCT. Uterine magnetomyography (MMG) signals were taken from Physionet database and utilized in this investigation. The outcomes show that suggested technique works well for lossless MMG signal compression.

Keywords: discrete cosine transform (DCT), Lossless compression, uterine MMG signals, signal to noise ratio (SNR), huffman coding, physionet, discrete wavelet transform (DWT), SQUID Array for Reproductive Assessment system (SARA)

1. INTRODUCTION

Predicting early labor is crucial since it raises the risk of morbidity and death for both moms and infants. The most concerning development is the rise in preterm births worldwide, as per the World Health Organization (WHO) report [1]. By giving critical care when it's needed, issues like infections in moms and babies are avoided, among other things. When health services and information technologies are combined, preterm symptoms can be effectively monitored. Telemedicine requires the transmission of physiological signals across a communication link. Since the long-term recordings of physiological signals placed an enormous strain on the channel, a lot of study has been done on lossless compression in recent years.

Presently, there are 2 techniques utilized to record uterine physiological activity: (i) magnetomyography (MMG), which records the magnetic fields that correlate to electrical fields, and (ii) electromyography (EMG), which records the activity using electrodes affixed to the abdomen. EMG/MMG can detect the myometrium's shift from a nonlabor to labor state. Myometrial characteristics could be revealed by uterine EMG/MMG measurements. These characteristics aid in distinguishing between the physiological contractions of preterm and term labor. The non-invasive method of measuring the action potentials' magnetic fields is called uterine MMG. Eswaran et al. [2] reported the first uterine MMG activity

recordings of uterine activity using a 151-channel sensor array.

Prior research on uterine EMG/MMG was restricted to analyzing the signals for the purpose of preventing preterm deliveries and forecasting labor. The surface EMG signals were the exclusive focus of the compression techniques. Norris et al. [3] used embedded zero tree wavelet to compress EMG signals. In [4], the wavelet transform is used for compression along with a dynamic bit allocation mechanism. The Filho et al. [5] multiscale multidimensional parser (MMP) technique is appropriate for compressing electroencephalogram (EEG) and magnetoencephalogram (EMG) signals. Surface EMG signals were subjected to picture reduction techniques in [6, 7]. For bit allocation, Trabuco et al. [8] used DWT with four distinct spectral functions. For the purpose of compressing EMG signals, vector quantization using SPIHT coding and arithmetic coding is used [9]. The DCT and DWT were compared using coding approaches. Different numbers of coefficients are taken into consideration when compressing EEG signals using the DCT approach [10, 11]. The most effective method for compressing multichannel EEG signals was a hybrid algorithm that incorporates Huffman coding and DCT, as reported in [12, 13].

Nevertheless, prior research was unable to demonstrate the application of compression approaches to uterine physiological information. Cho et al.'s research [14] is the only effort in this area to compress the uterine EMG signals dynamically. With this endeavor, monitoring pre-term delivery in medical information system was made easier and lossless through real-time transmission. The current study concentrated on compressing the uterine MMG signals using the technique utilized in [13]. It takes into account both Huffman coding and 1/f feature of the DCT frequency spectrum. Among the multichannel MMG signals (147–148 channels), a single channel with a high SNR was taken into consideration for the investigation.

2. METHODS AND MATERIALS

A. DATA ACQUISITION AND PREPROCESSING

The Physionet database, which is a part of the MMG database (mmgdb), is where the MMG records used in this study were obtained [15, 16]. Uterine MMG signals captured by 151-channel SARA [2] at UAMS are included in the database. Little Rock, USA. SARA is $a(2)x(n) = \sum \omega(k) X(k) \cos(\pi(n-0.5)(k-1)/N)$

The mother sits and rests her abdomen on concave surface of the floor-mounted passive device, which houses the sensor array. The sensor array has a surface area of 1300 cm^2 , measuring 33 cm in width and 45 cm in height.

where $X(k)$ and N are DCT and length of original signal $x(n)$ correspondingly.

Enclosed within a magnetically shielded room (MSR), the entire system is prepared with high-order synthetic gradiometer noise cancellation that efficiently reduces noise that subject transmits.

The DCT frequency spectrum of signal with a Twenty-five participants in third trimester of pregnancy provide MMG signals for recording. The signals were captured for almost twenty minutes. With 15 participants delivering fewer than three days after the SARA recording, the subjects' gestational ages (GAs) vary from 37 to 40 weeks. Channel names and clinical data are contained in the database:

- Body Mass Index
- Days to delivery after SARA recording
- Race
- Gestation Age (weeks+days)
- Cervical dilation (dilation cm) / (effacement%) / (station)

A 250 Hz sample rate was used to digitize the unprocessed signals. Down sampling was used to sample the original data at 32 Hz. A bandpass filter (0.1–1 Hz) was used to attenuate the cardiac signals from the mother and fetus. I eliminated the mother breathing (0.33 Hz) using a notch filter (0.25–0.35 Hz). To produce the final MMG signals, segments exhibiting maternal movement were removed from these signals. Every recording has between 147 and 148 channels and lasts for about 20 minutes. In this work, the channel with a high SNR is used. The MMG signal for subject 202's single sensor is displayed in Figure.

B. COMPRESSION USING DCT

The closeness between the sign and cosine functions is measured by DCT. Any function can be expressed using the DCT as infinite series of oscillating cosine functions at various frequencies. Equations (1) and (2) define the DCT and inverse DCT transforms.

$$X(k) = \omega(k) \sum x(n) \cos(\pi(n-0.5)(k-1)/N)$$

The frequency step in Figure 2 is approximately 0.00049 Hz. It depicts the signal's DCT transform as shown in Figure 1. For the DCT, the frequency step is $f_s = F_s/2L = 32/(2 \times 32640) = 0.00049$. The sampling frequency (F_s) and the MMG signal length (L) are the respective values. We can see from the figure that DCT frequency spectrum has a characteristic of $1/f$. For this reason, the frequency components over 2 Hz are minuscule and nearly nonexistent. These high frequency components can be deleted for lossless compression.

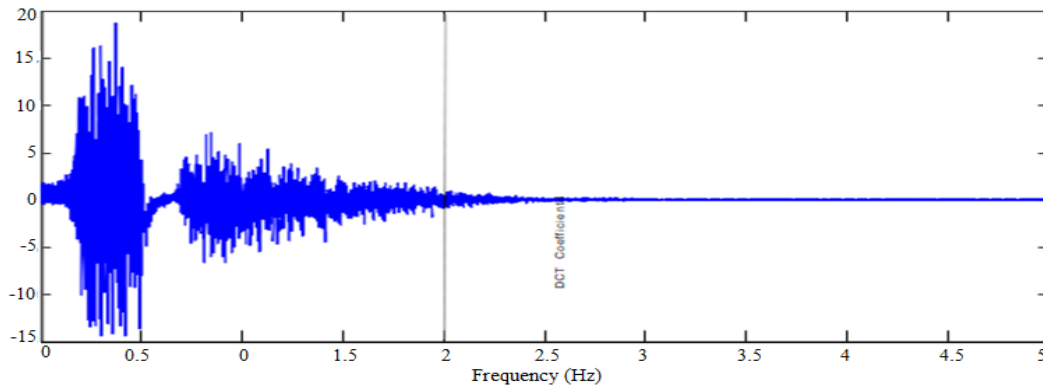


Fig.1: DCT sample of single channel's MMG signal from subject 202

Compression with use of Huffman coding and DCT

The most popular technique for coding text, signals, and images is called Huffman coding. It is an entropy-based technique that calculates the amount of bits needed to code the symbols based on probability. For lossless compression, it is preferable to employ Huffman coding because DCT coefficients of the MMG signal have a Gaussian distribution. The MMG signals were quantized uniformly in 20 levels using the formula $Y = f([N(X-X_{min})]/[X_{max}-X_{min}])$. Here, X stands for DCT coefficients and N for number of quantization levels. The elements are rounded to nearest integer by the function f . These DCT coefficients are effectively compressed using an appropriate codebook based on Huffman's technique. A presentation and check were made of Huffman's codebook, which is appropriate for compressing the DCT coefficients.

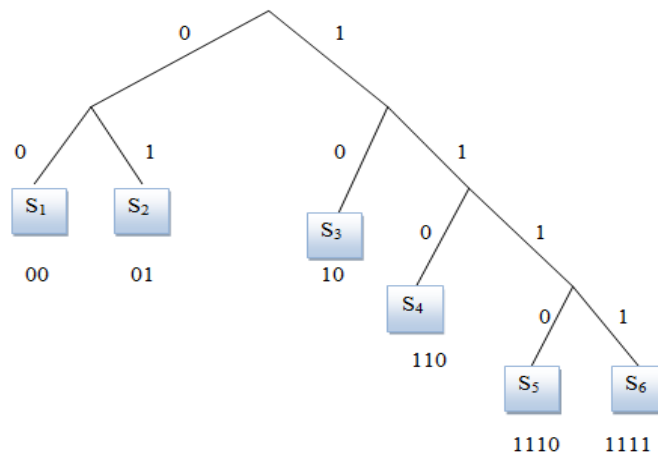


Figure.2. Algorithm

The study employed several performance measurements, including correlation rate, compression ratio, percentage root-mean-square difference (PRD), mean squared error (MSE), and SNR. The suggested algorithm's parameters as shown the figure 2.

The block diagram (Figure 3) illustrates the compression strategy used in this work, which combines Huffman coding and DCT.

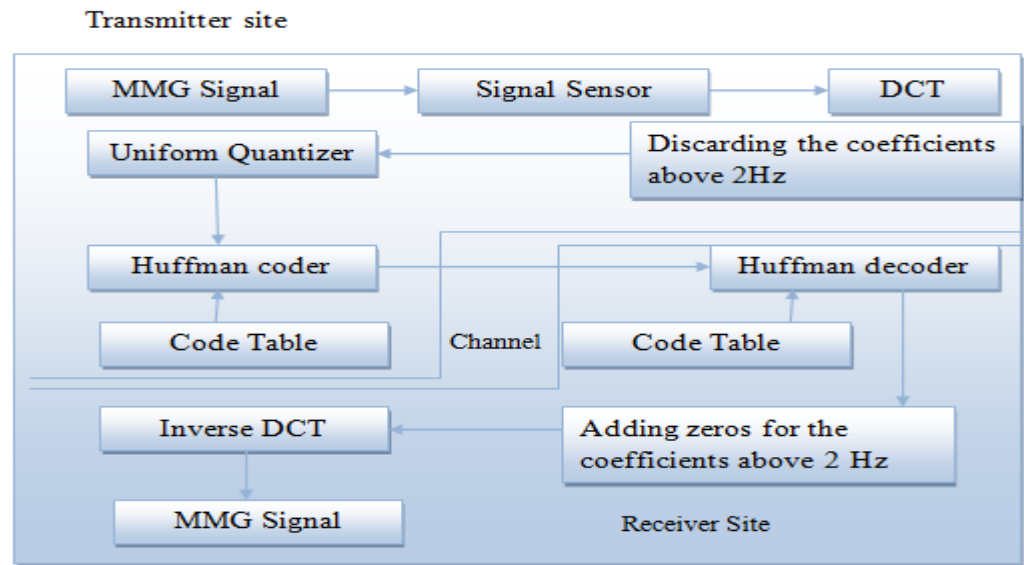


Fig. 3: Block diagram of compression process with use of Huffman coding and DCT

3. RESULTS AND DISCUSSION

The DCT of original MMG signal was calculated at transmitter location. Above 2 Hz, the DCT coefficients were eliminated. After that, quantized DCT coefficients were sent via Huffman coder. A Huffman decoder was used at the receiver location to decode the DCT coefficients. The high frequency coefficients (above 2 Hz) were then replaced with a zero-set appended to decoded signal. To obtain the reconstructed signal, these coefficients were subsequently subjected to inverse DCT. An example of both reconstructed and original MMG signals is shown in Figure 4.

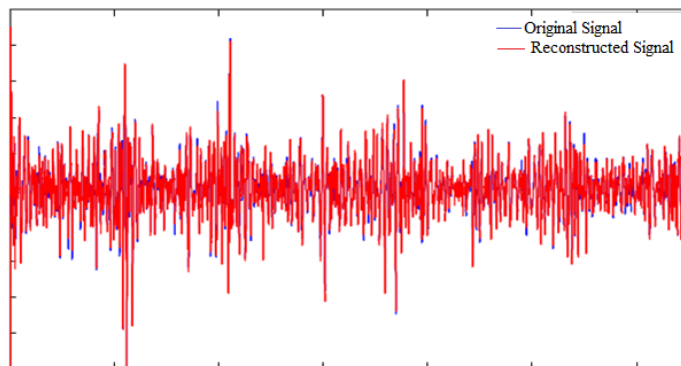


Fig. 4: A sample of reconstructed and original MMG signal with 20 levels of quantization (subject202)

The choice of quantization settings for this MMG signal compression can be wise. Among reconstructed and original signal, compression ratio was 3.61 and correlation rate was 95.02%, respectively. Please take note that, regardless of the number of quantization levels, the values shown in Figure 5 represent the greatest and lowest values that may be obtained using the suggested method.

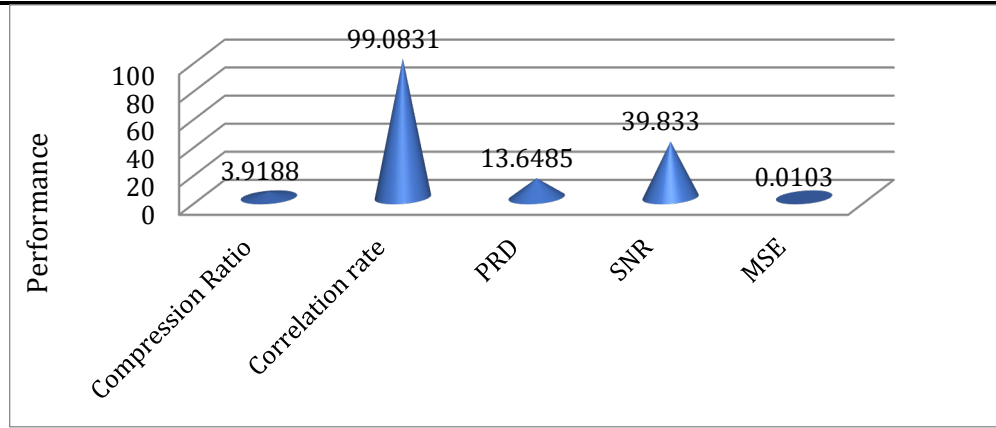


Figure.5. Performance metrics of suggested method

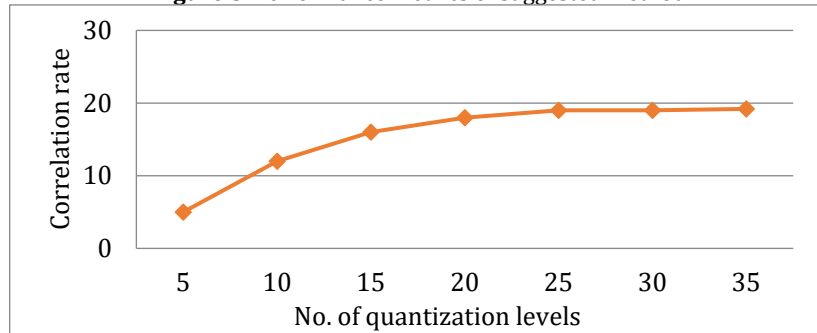


Figure.6. The quantization effect on correlation and compression rate of MMG signal (subject202)

When DCT coefficients above a given frequency are excluded for various signals, the reconstruction of more information is possible for the DCT components of MMG signals below 2 Hz. Therefore, as Figure 6 illustrates, eliminating DCT coefficients could considerably compress the content of MMG signals. This study ignored 2 forms of errors: the quantization error and the error resulting from the deletion of the DCT coefficients. Rather of focusing on exact values, we examined the trade-off between performance indicators to offset the implications of these mistakes on those metrics. Since signals other than uterine MMG have distinct qualities, the findings of this survey were not compared to those of other signals. Given that the signals taken into consideration in both cases were uterine physiology signals, the compression ratio shown here is comparable to that seen in [14].

4. CONCLUSION

Physiological signals utilized in remote health care services require excellent correlation rates and compression ratios. Since the mother's health is indicated by the uterine EMG/MMG signals, any loss of data can result in serious clinical errors. The suggested approach works well for lossless multichannel MMG signal compression when it combines the DCT with Huffman coding. Even though the current study is focused on term records, any signal with a $1/f$ characteristic in frequency spectrum can use it. When combined with the suitable technology, the suggested algorithm can help medical practitioners make the best choices during the postnatal period, or "Golden Time".

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

None.

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