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Empirical Mode Decomposition And Data Hiding In ECG Signal

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Abstract - An electrocardiogram (ECG) is the graphical representation of electrical impulses due to ideal activity in the cardiac muscles of human heart. ECG provides useful information that helps in analyzing the patient's heart condition. But different noises may cause wrong interpretation of the ECG signals. So proper diagnosis of the heart , ECG signals must be free of noises. These noise which can be reduced by using the method signal processing. The major objective of this work is to denoising the ECG signal and hiding the details of the patient into the ECG. For this purpose use the technique Empirical Mode Decomposition (EMD) followed by moving average filter.EMD is based on a decomposition derived from the data and is useful for the analysis of nonlinear and nonstationary time series signals. For denoising, the ECG signal is initially decomposed into a set of Intrinsic Mode Functions (IMFs), then high frequency noises are eliminated using lower order IMFs followed by the reconstruction of the ECG signal and it is found to be free of noises with a high degree of Signal to Error Ratio(SER).

Key Words*: ECG, EMD, IMF, *STEGANOGRAPHY, ENCRYPTION

1.INTRODUCTION

Heart disease is one of the main causes of deaths worldwide. Doctors use electrocardiogram (ECG) to sense abnormal heart rhythms and to examine the cause of chest pains. This test detects and records the heart's electrical activity. ECG signals are recorded from patients for diagnostic purposes. An ECG is nothing but a record of the potency and timing information of electrical signals as they pass through the heart. A common problem in ECG analysis is the removal of unwanted artifacts and noise. There are various artifacts which get added in these signals and change the original signal therefore the need to remove these artifacts from the original signal is significant. Typically an ECG signal consists of P wave, QRS complex; T wave and any deviation in these parameters predict and justify the abnormalities present in heart. This signal could be measured by electrodes from human body in typical engagement. Signals from these electrodes are brought to simple electrical circuits with amplifiers and analogue – digital converters.

The major crisis of digitalized signal is intrusion with other noisy signals like power supply network 50 Hz frequency and breathing muscle artefacts. These noisy elements have to be removed before the signal is used for next data processing like heart rate frequency detection. Digital filters and signal dispensation should be designed very effective for real-time applications in embedded devices. Heart rate frequency is very important health status information. The frequency measurement is used in many medical applications like stress tests or life treating condition prediction. One of possible ways how to get heart rate frequency is compute it from the ECG signal.

Hiding patient's mystery facts and other physiological information in ECG signal is the main intention. provide secrecy, integrity, and accessibility to personal records. the primary branch of cryptography is steganography that includes hiding statistics in different secondary facts. Hiding the facts lower the risk of the statistics being detected. clinical pics has smaller size were the ECG signal has extra size. consequently in preference to medical photograph ECG sign is utilized in steganography manner. The ECG sign of the sufferers is used to hide physiological facts of affected person like temperature, glucose stage, blood stress, role, etc., that are accumulated through the usage of body Sensor Networks (BSNs) at domestic and stored on clinic server by transmitted through network. On the same value that the affected person privateness is included towards intruders whilst records navigate in open network and stored in medical institution servers. This technique allows hiding the personal records of the patient in to ECG signal and consequently offers ensures the patient's privateness and discretion records hiding.

2. DENOISING OF ECG SIGNAL

The existing work is devoted closer to the EMD primarily based denoising of ECG signals and in addition improvements are made to the prevailing set of rules [1]that indicates true stepped forward effects for the denoising of the ECG indicators. diagram of the proposed set of rules is proven in Fig. 1 .

A. *Decomposition of noisy ECG sign in to IMFs*

The EMD is applied to the Noisy ECG sign to get a series of IMFs representing distinct oscillations.

B. *Addition of 1st 3 IMFs and finding the width of QRS*

To maintain the QRS complex, we want a delineation of the QRS complicated. Experiments display that sum of 1st three IMFs
(im=imf1+imf2+imf3) preserves the morphology of the QRS complicated. the width of the QRS lie within the zero crossing factors, with one zero crossing factor in the left hand side of the nearby absolute minima and another one at the right hand facet of the neighbourhood absolute minima.

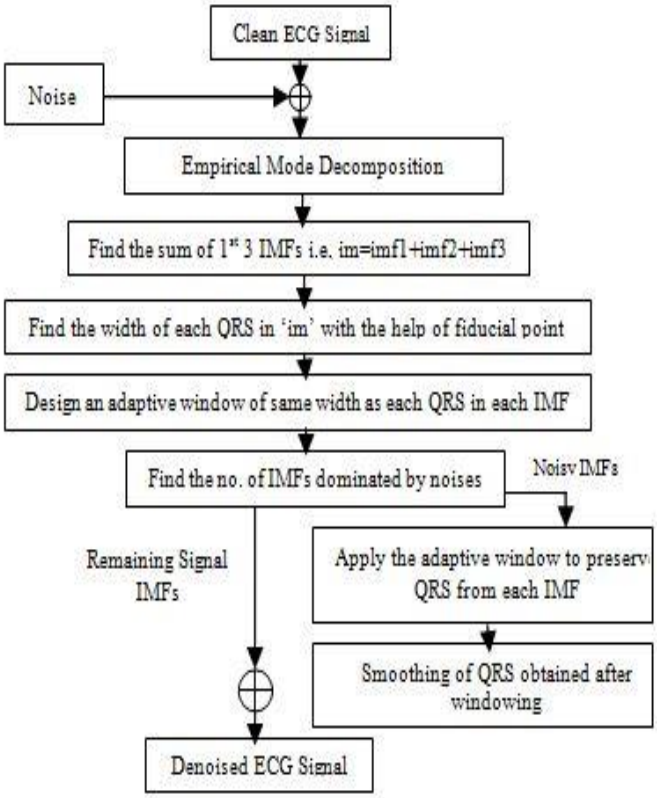

Fig. 1: Block diagram of modified EMD based algorithm for denoising of the ECG signal[1]

Now again in the case of noisy ECG signal the nearby minima can also lie just close to the R-peak (fiducial point). As noise adjustments the form of the actual signal, and could create a huge misinterpretation for the actual width of the QRS complex. subsequently to keep the QRS complicated we must discover the width of it and it may be found by means of following steps:

1) identity of the R-peaks (fiducial factors)
2) Addition of 1st 3 IMFs to get 'im' after applying EMD to the noisy ECG sign three) finding of two neighbourhood absolute minima on both aspects of the fiducial factors
four) Detection of the zero crossing points on the LHS of the left absolute minima and on the RHS of the right absolute minima (here in case of absence of genuine 0 crossing point the just above the 0 crossing point is to be considered),which makes the entire width of the QRS complex.

C. *Designing of an adaptive Window for the QRS complex*

Now to keep the QRS complicated from the noisy IMFs an adaptive window is designed and width of window is various in keeping with the width of each QRS complicated in the IMFs . The magnitude of the window is stored harmony inside the width of the QRS complex. The window is selected because the Tukey window (tapered cosine window).

D. Finding of the number of Noisy IMFs

Now we have to apply the above window to preserve the QRS complicated, for which we should realize the number of IMFs that make a contribution to excessive frequency noises, as QRS is also excessive frequency content material of the ECG sign and particularly stays in the beginning lower order IMFs that is already corrupted with the noises. For the ECG signals, the corrupting noise is normally of 0 suggest whereas the ECG sign is usually of nonzero imply. This reality makes it easy to split the noise and ECG signal inside the EMD domain. As noises are specifically infected within the decrease order IMFs for that reason here statistical test can be carried out to a particular mixture of IMFs for his or her noise trying out through checking for the 0 suggest. A number of the whole statistical check, the t-test is frequently used for locating the noise order.

E. *preservation of QRS complicated with the aid of making use of Window to the noisy IMFs*

After finding the quantity of noisy IMFs, to hold the QRS complex from them the window is implemented to these IMFs. For every IMF to keep the every QRS complex, the window feature is hooked up by means of the concatenation of window fashioned in such that it is centred at the fiducial factor of each QRS in the IMF.

F. *Smoothing of QRS complexes acquired after windowing*

After making use of the window to the noisy IMFs the QRS complexes are preserved inside their boundary. however because of noises the shape of the QRS complex is modified and some peaks get embedded inside it, that make modifications within the biphasic or triphasic shape (the actual function) of the QRS complex .as a result to get a noise loose ECG signal, smoothing of the QRS complex is executed. Smoothing of the QRS complicated is carried out after the partial reconstruction of the sign i.e, with the aid of including the windowed IMFs collectively so that the

QRS complicated is reconstructed after the removal of noises.

3. STEGANOGRAPHY:

The sender side steganography technique containing of four stages and receiver steganography side consists of three stages. In this technique to decompose ECG signal discrete wavelet transform is used. Then data hide inside that decomposed signal. The two main part of this method are sender steganography and receiver steganography.

1) Encryption:

This stage has main aim to provide security to the confidential information of the patient by encrypting data in like the way that prevents illegal persons to accessing the private information. For this stage the main part is XOR ciphering which involves the technique for share key in security purpose. Because of simplicity XOR ciphering is selected. Additionally, XOR ciphering can be implemented easily within a mobile device.

a) Confidential Information:

For Security purpose, Public key cryptosystem is used to encrypt the patient's data first. The confidential information of the patient is encrypted like the way that prevents illegal persons to accessing the private information to which share key is unknown. In open network communication, the initial security is given by Encryption. Data hacking does not prevent by encryption but it prevents from modify or reading the encrypted data content.

b) XOR Ciphering:

Exclusive-OR encryption is not like RSA, is roughly unbreakable through brute force methods. Exclusive-or encryption requires share key for both Encryption and descriptor algorithm, while is simple and unbreakable. Exclusive-OR encryption depends on the Boolean algebra function, exclusive-OR (XOR). XOR is a binary operator (meaning that it adds two arguments). By its name, exclusive-OR, it returns true if one operator is true out of two operators. XOR ciphering method is used with a shared key which is an ASCII coded. Here first security is provided with a shared key which is an ASCII coded.

2) Wavelet Decomposition:

For the correct evaluation it takes multistage wavelet decomposition. Wavelet remodel is a manner that decomposes the given sign into excessive frequency and coffee frequency coefficients. Time area and frequency area can be combining in a single remodel the usage of wavelet transform. For greater variety of programs discrete indicators are used. Consequently, in preference to non-stop wavelet remodel it uses Discrete Wavelet rework (DWT). The decomposition of DWT may be finished by way of applying wavelet remodel to the signal with band filters.

3) The Embedding Operation:

For the high information security the technique is applied which entails embedding operation. There are two parameters in scrambling operation. First parameter is shared key. Sender aspect and the receiver facet ought to understand the proportion key which identical for each sides. second parameter is scrambling matrix. The transmitter and the receiver each stores same scrambling matrix inside in, thus for each pair of transmitter/receiver has a same scrambling matrix defined by Eq. four [2]

$$S = \begin{pmatrix} S_{1,1} & S_{1,2} & \cdots\cdots\cdots & S_{1,32} \\ S_{2,1} & S_{2,2} & \cdots\cdots\cdots & S_{2,32} \\ \cdot & \cdot & \cdots\cdots\cdots & \\ \cdot & \cdot & \cdots\cdots\cdots & \\ S_{128,1} & S_{128,2} & \cdots\cdots & S_{128,32} \end{pmatrix} \quad (4)$$

We're scrambling matrix S has size 128×32. The detail S is more than a few that is in between 1 and 32.
The first step in embedding matrix is changing the shared key into ASCII coded price, therefore the result in ASCII code variety is in among 1 to 128 for each individual. the primary function of scrambling collection fetcher is, study the corresponding row for every character code from the given scrambling matrix. For data hiding the embedding operation plays according to fetched row end result that is sub-band collection

$$S = \begin{pmatrix} 32 & 22 & 6 & 3 & 15 & 11 & 30 & 7 \\ 28 & 17 & 14 & 8 & 5 & 29 & 21 & 24 \\ 31 & 26 & 27 & 19 & 16 & 1 & 23 & 2 \\ 4 & 18 & 25 & 13 & 9 & 20 & 10 & 12 \end{pmatrix} \quad (5)$$

For example, in eq. 5 if the fetched row is gift, then from 32 sub-bands the wavelets coefficients are study and trade its LSB bits by using the embedding method. Then, it'll study the primary wavelet coefficients from the 32 sub-bands and trade the LSB bit in 32 variety sub-band. Then it'll trade the LSB bit of 22 wide variety sub-band and so forth. According to degree vector it comes to a decision the steganography level. the principle paintings of degree vector is to maintain the document of sub-bands and the LSB bit changed numbers. as an instance it'll modified 6 bits for 32 sub-band per sample while for the 1 sub-band it's going to trade five LSB bits.

4) Inverse Wavelet Decomposition:

The first step in inverse wavelet decomposition is restoring the signal from decomposed signal. As a signal is decomposed in multilevel sub-bands then that signal is recomposed from the decomposed signal. In practical, there is multistage reconstruction technique is used for small waves. For accurate analysis signal should be reconstructed.

B) Receiver Steganography:

The receiver side includes watermark decomposition, extraction & decryption process. The received ECG watermarked signal is extracted with the help of shared key.

1) Watermarked Extraction Process:

In the watermarked secret bit extraction, the receiver side should know the following information. 1) The shared key value 2) Scrambling matrix 3) Steganography levels vector.

The shared key value and the scrambling matrix should be same at both side. The first steps is to get the extracted information from the watermarked ECG signal. To generate the 32 sub-bands signals it applies 5-level wavelet packet decomposition to ECG signal. Then the main step to extract hidden data or secret data from stego signal is to apply known scrambling matrix value to signal. Then that secret data is fetched sequentially according to scrambling matrix using row fetched sequencer. Finally, to decrypt the extracted secret bits apply the shared key value which is same at both sender and receiver side.

4. CONCLUSIONS

The method explicated on this work deliberates that on making use of empirical mode decomposition to the noisy ECG sign, IMFs include both, the content of the signal as well as noise components, for that reason only renovation of the useful content material of the signal i.e the real ECG sign is being taken into consideration as the principle intention. The proposed approach is melioration toward the prevailing EMD based denoising processes. This approach of denoising includes the adaptive window method observed through the smoothing of the preserved QRS complex inside the detailed QRS period so that the reconstructed sign achieved is very an awful lot much like the actual ECG signal. The qualitative as well as quantitative results acquired for diverse experiments display that the proposed set of rules could be very a great deal efficacious and promising one for the denoising of the ECG sign without converting the actual characteristic of the signal. Also the private records of the affected person is hiding inner ECG signal and as a consequence ensures the patient's confidentiality and privacy the use of Discrete Wavelet remodel. The proposed algorithm offers secrecy, integrity, and accessibility to personal facts. three tier of security is supplying. . Any medical doctor from the medical institution can get admission to the watermarked ECG sign but most effective licensed docs can extract the secrete facts from ECG watermarked sign. also the accredited man or woman can best get right of entry to to the confidential affected person's information as well as different physiological records of affected person which is stored within the host ECG signal. The distortion can be much less.

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