



An Effective Method to Denoise EEG, ECG and PPG Signals based on Meyer Wavelet Transform

¹P.Thamarai, ²Dr.K.Adalarasu

¹Research Scholar/ECE, Bharath Institute of Higher Education and Research, Chennai.

²Associate Professor/EIE, SASTRA Deemed University, Thanjavur.

*Corresponding author Email: ¹thamaraitk@gmail.com, ²adalarasu@eie.sastra.edu

Abstract

In this analysis, the prevailing role of the wavelet transform in the interrogation of the ECG is discussed in detail, where both the constant and the discrete transform are considered in turn. A Wavelet denoising is functional on the original signal to eradicate high frequency noise, and then a process based on Meyer wavelet transform combined with adaptive filter is functional to eradicate the motion artifact. This approach uses Meyer Wavelet decomposition to extract the motion artifact, which is subsequently utilized as the reference input of an adaptive filter for noise cancellation. The technique diminishes the overhead of the circuit because it does not need a separate collection of reference input signal which link to noise. Testing results illustrate that this approach can efficiently remove motion artifact and make better the signal quality.

Keywords: EEG, ECG, PPG, wavelet transform, and wavelet decomposition tree, noise removal.

1. Introduction

The ECG signals are investigated wide for the diagnosis of the numerous cardiac diseases. The signals are sketched using non invasive electrodes that are positioned on the chest and limbs. The guts muscle cells that are positioned in atria and ventricles contract making electrical pulses that are then tracked by the ECG. The ECG signals of a normal heart beat enclose 3 portions: P wave, QRS superior and T wave. The P wave symbolizes the a test contractions. QRS problematical denote ventricle contractions. [1] The third wave in an ECG is that the T wave. This can be prepared once the ventricles are re polarizing. These waves illustrate ample vary of deformities within the ECG signal. Noise removal establishes a crucial pre-processing stage that should be addressed prior to resounding out more analysis on the EEG signals. Distinct wavelet transmutestuggestions an effectual result for noise removal non stationary signals such as EEG due to its shrinkage property. In this article, we investigated the appliance of wavelet noise removal approach to EEG indications acquired during various sleep stages confidential according to the RK rules, with the detached to recognize appropriate thresholding rules and threshold tenets. In real ecosystems PPG signals often get corrupted by non-stationary movement noise. To diminish such noise, we suggest assessing the desired signal from corrupted signals by utilizing a particle filter.

2. Methodology

2.1 Electroencephalogram: (Eeg)

A method for learning the electrical power supplies within the brain. Electrodes are connected to the scalp. Cables connect these electrodes to a mechanism, which records the electrical instincts. The consequences are whichever in print out or showed on a PC monitor. Diverse designs of electrical impulses can signify several types of epilepsy. Its short form in EEG.

An electroencephalogram (EEG) is a experiment utilized to assess the electrical movement in the brain. Brain cells interconnect with every other through electrical impulses. An EEG could be utilized to aid find probable troubles related with this motion. An EEG traces and records brain gesture patterns. Small level metal discs known as electrodes are connected to the scalp with cables [2]. The electrodes investigate the electrical impulses in the brain and throw signals to a PC that records the outcome.

The electrical impulses in an EEG recording look like curvy lines with peaks and vales. These lines permit general practitioners to rapidly evaluate assess whether there are strange patterns. Any abnormalities can be a indicate of seizures or other brain disorders.

The electroencephalogram (EEG) is a cassette of the electrical action of the brain from the scalp. The chronicled waveforms replicate the cortical electrical action [3]. Signal intensity: EEG action is fairly little, calculated in microvolts (mV). Acquiring EEG signals is more rapidly than acquiring pictures with a frontal viewing camera.

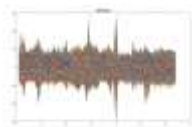


Fig. 1: EEG signal

Electroencephalography (EEG) is an electrophysiological looking at approach to document electrical movement of the brain. It is generally noninvasive, with the electrodes positioned alongside the scalp, though invasive electrodes are brief times secondhand consisting of in electrocorticography. EEG gauges voltage vacillations resultant from ionic modern-day within the neurons of the brain.[4] In clinical circumstances, EEG represent to the cassette of the brain's natural electrical motion over a phase of time, as chronicled from manifold electrodes located on the scalp. Analytical appliances usually listen whichever on occasion- related potentials or on the spectral satisfied of EEG. The previous inspects capacity vacillations time inaccessible to an event like incentive onset or switch press. The concluding assay the kind of neural oscillations (typically known as "mind waves") that can be monitored in EEG signals within the occurrence subject.

In general, EEG is acquired using electrodes positioned on the scalp with a conductive gel. An EEG signal normally ranges from about 1 uV to 100 uV in a usual adult, and it is around 10 to 20 mV when calculated with subdural electrodes such as spine electrodes.

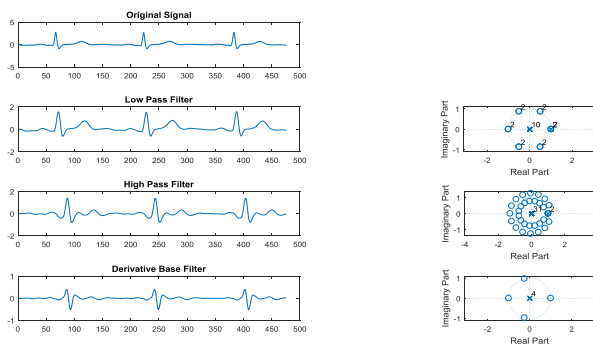
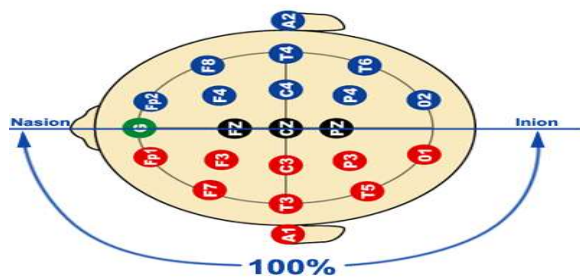


Fig. 2: EEG waves



Here the systems are meant in a broad sense embracing observing, diagnostic and therapeutic systems, whose running relies in one way or another on the assay of electrocardiograms. In common we will be referring to Them as ECG systems. An assay of ECG signals necessitates their preprocessing and a appropriate representation so that depending upon the character of the ECG system, it helps reveal the necessary diagnostic information.

2.3. PPG Signals:

A photoplethysmogram (PPG) is an optically acquired plethysmogram, a volumetric quantity of an organ. A PPG is regularly received by way of utilising a pulse oximeter and is the reason the pores and skin and gauges adjustments in light immersion.[6] A conventional pulse oximeter video display units the perfusion of blood to the epidermis and intravenous tissue of the pores and skin.

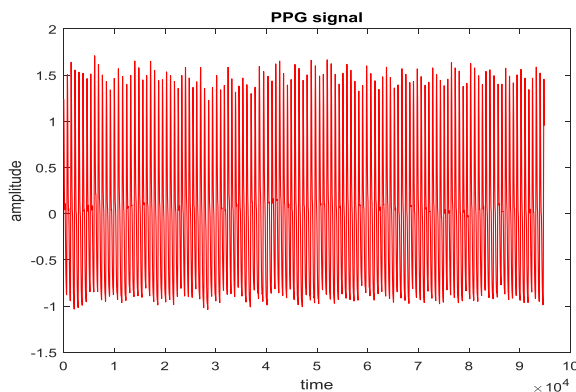


Fig.6: PPG waves

With each cardiac cycle the coronary heart pushes blood to the periphery. Nevertheless this pressure pulse is really checked by the point it arrives at the skin, it's far enough to inflate the lines and arterioles within the intravenous tissue. If the heart beat oximeter is connected with out squeezing the skin, a stress pulse will also be seen from the intravenous plexus, as an unimportant consequential height.

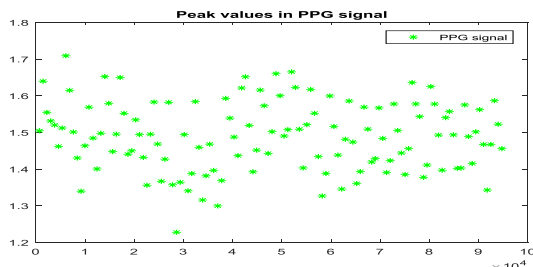


Fig. 7: peak value in PPG signal

The trade in extent as a result of the strain pulse is found with the aid of explaining the skin with the bright from a mild-emitting diode(LED) after which determining the quantity of mild whichever broadcasted or reflected to a photodiode. Every cardiac cycle emerges as a peak, as uncovered inside the photograph. Because blood pour to the skin can be moderated through manifold other physiological strategies, the PPG can also be hired to check breathing, hypovolemia, and different circulatory circumstances. Moreover, the form of the PPG waveform be at variances from situation to theme, and differs with the position and approach wherein the heartbeat oximeter is constant.

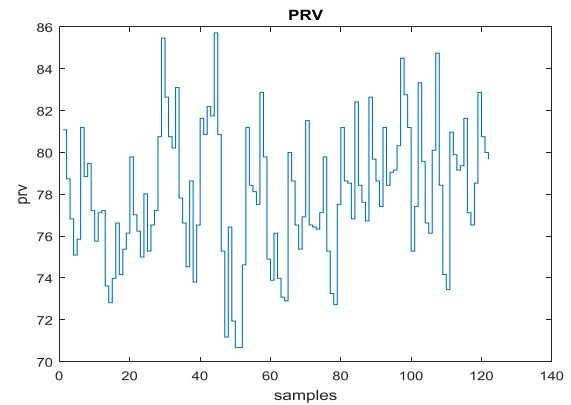


Fig.8: PRV

Representative PPG in use from an ear pulse oximeter. Dissimilarity in amplitude are from Respiratory Induced Change.

3. Classifications of Signals

3.1 EEG Denoise

Noise eradication Wavelets typically used to de-noise biomedical indicators together with orthogonal meyer wavelet and Daubechies, 'db8' 'db6' and 'db2' wavelets. These are usually decided on from the structures analogous to those EEG alerts [7]. A wavelet decays a sign in numerous multi decision sections in accord with a key occupation. This is called wavelet characteristic. The most lengthily used signal dispensation features are strainers. The sieving operations clarify the resolution of the sign, that's a computation of complete records within the sign. The gauge is steadied by down sampling or sub sampling and the up sampling procedures. DWT is predicted with successive high bypass and occasional skip distinct time domain signal filtering, that's established in diagram 10.

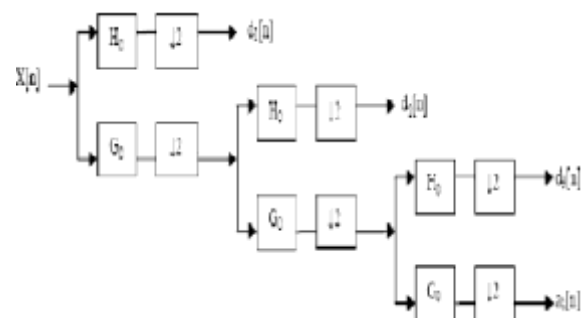


Fig 9: Three-level wavelet decomposition tree.

In this study, a discrete wavelet-based totally noise removal is finished to dispose of relics from EEG sign. In de-noising physiological indicators, Wavelet de-noising is powerful because it has a propensity for keeping sign distinctiveness whilst diminishing noise that is favorite over sign frequency area riddling [2]. The motive is that the brink approaches are accessible which allows recuperation based totally on selected numbers Daubechies (db8, db6, db2), Meyer (dmey) and wavelet occupations (WF) are used on this studies for the segment of the wavelet remodel for noise eradication. These WFs are decided on primarily grounded on mom wavelet shapes [3,8]. Figure 11. Suggests the meyer wavelet. Using these wavelets, RMS variant was labored out to assess the noise deletion efficiency.

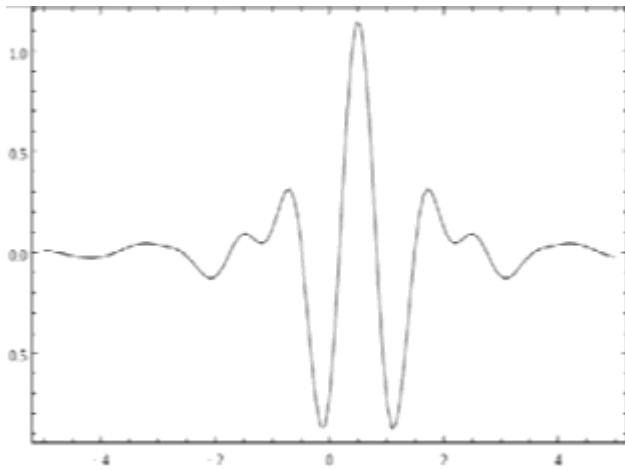


Figure 10: Meyer wavelet.

From the outcome it can be found that the WFs db8 gives the maximum high-quality noise removal from raw EEG sign of a strong difficulty, WF orthogonal meyer gives excessive RMS departure in assessment to other three WFs for epileptic topics. These final consequences improve noise abolition for the EEG signal.

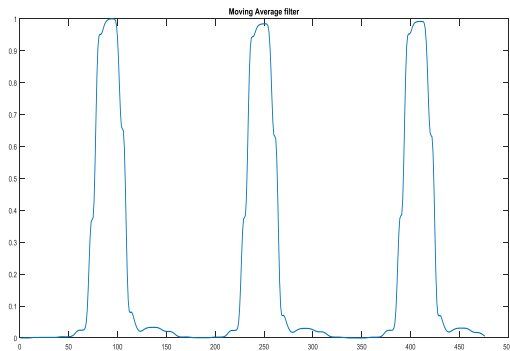


Fig.11: Moving Average filter in EEG

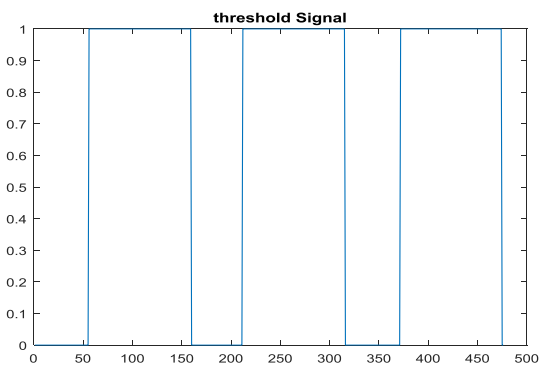


Fig.12: Threshold signal

In Fig 11. The sign is exact by means of series $x[n]$, in which n is an integer. G_0 denotes the low bypass clear out and H_0 factor to the high pass filter. The high skip clear out engenders complete statistics $d[n]$ at each level. Coarse guesstimates $a[n]$ is produced by way of the low authorization clear out associated to scaling feature. The time decision turns illogically awesome with this tactic at excessive occurrences, where at low occurrences, the frequency decision cracks arbitrarily. A threshold is unwavering for the raw EEG signals which is useful on

the wavelet constants ($d_1[n], d_2[n], d_3[n], d_4[n], a_4[n]$) after the WT. The WT coefficients used are to assessment the noise and compute the threshold. Calculate the median absolute deviation, δ_{mad} on the largest coefficient spectrum by

$$mad = \text{median}(|x - \text{median}(x)|) = 0.6745 \tag{1}$$

where $|c_0|, |c_1|, \dots, |c_n|$ are the wavelet coefficients and 0.6745 in the denominator rescales the numerator so that it is an appropriate estimator for the standard deviation for Gaussian whitenoise.

The noise threshold, t is determined by,

$$\text{Threshold}_{mad} = \sqrt{\ln N} \tag{2}$$

where δ is the assessed noise. N is the totality no of samples. Presuming raw EEG signal (f) is alike to original EEG signal (s) and noise (n). The threshold technique mechanisms under the subsequent expectations, where T_s is the signal threshold and T_n (threshold, t) is the noise threshold. The threshold technique that has been functional in this research is explained underneath.

1. Original signal energy s is competently acquired at a higher percentage. This is done by transforming standards where magnitudes are larger than threshold ($T_s > 0$).
2. Transform values of raw signal have magnitudes. These lie under a raw threshold T_n satisfy $T_n < T_s$.

Noise in f can be removed by thresholding transform. Entire transform values which magnitude is less than the noise threshold (T_n) are put equal to 0.

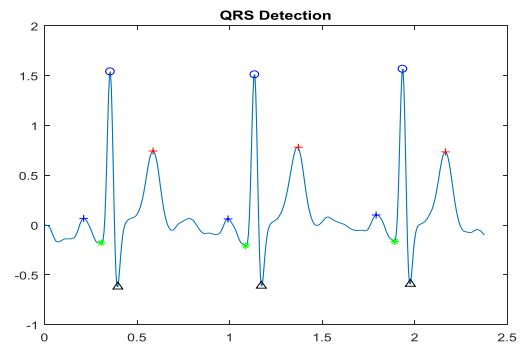


Fig.13: QR s Detection

An appropriate estimate of f has been delivered thru implementing an converse redesign. Reconstruction is the other manner to decomposition. Feature coefficients and approximation at every diploma are upsampled with the useful resource of 2, handed by way of excessive and low pass synthesis filters and brought subsequently. To get the particular sign, the method is sustained via comparable quantity of ladders like decay method.

Equation 1 describes the RMS alteration of raw EEG signal (f) associated with EEG (noise free) signal (s)

$$\sqrt{\frac{(f-s_1)^2 + (f-s_2)^2 + \dots + (f-s_N)^2}{N}}$$

RMS Difference =

RMS difference was computed for 4 WFs. Where N is samples

number, s is de-noised signal and f is noisy EEGsignal.

3.2 ECG Denoise

Wavelet de-noising Wavelet signal decay can be seen has an iterative method whereby a signal is decayed into finer decision indicators in clock and regularity. Initially, symmetric filters are formed from a “mom” wavelet and a climbing meaning linked to that wavelet. These filters will have the funds for an orthogonal base separating the sign fiequency spectrum and making excessive and occasional frequency indicators in every iterative level. These alerts are destroyed by way of earlier than the after that iterative step. Particulars on wavelet decomposition may be determined someplace else [1]. Figure three display this wavelet decomposition tree of an ECG sign, wherein the A approximations) contains symbolize the low frequency components received by way of the low pass filter (LPF), and the D Uetails) boxes signify the high frequency machineries received through the symmetric high skip filter out (HPF)

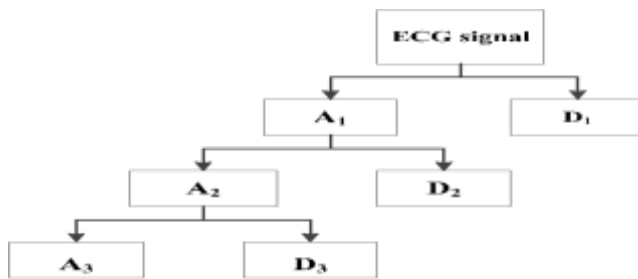


Fig.14: wavelet decomposition tree.

The de-noising purpose is to degree the coefficients noise price in the sign sub-bands within the decay tree. To obtain this, evaluation strategies are recycled affording a threshold level for coefficient diminution. Both noise dropping processes create rent of the gentle thresholding technique which is usual practical to the details components (D) of the decay tree. The aspect degree behavior the noise varies in line with the noise type and selection frequency: for white noise the general public a part of the noise coefficients are in the D1 sign while, in the electricity line case, and for a sampling price of 500 Hz, they're placed in degree three (D3). In the accurate element sign the coefficients are administered in keeping with the following rules: if the sign amplitude is lesser than a threshold stage it is considered a noise coefficient and, consequently, is about to 0; if the cost is advanced than the edge degree, then it's far portion of the ECG waveform and its cost will only be diminished by way of the noise assessed degree. Diagram 15 illustrates an example of this method:

After referring to the gentle-thresholding operation the signal is restructured by way of mountain climbing up the decomposition tree[2]. For example, recuperation filters could be purposeful to D3 and A3 main to the A2 sign. Iterating this maneuverpending the top stage will result inside the last, drinkable, ECG sign.

3.3PPG Denoise

For numerous signals, the low-frequency content is the in particular extensive element as it offers to the signal its uniqueness. The excessive-frequency content, on the opposite component, imparts nuance[3]. Think approximately the human voice. If high frequency materials are eliminated, the voice sounds atypical, but the phrases are nonetheless audible and absolutely.

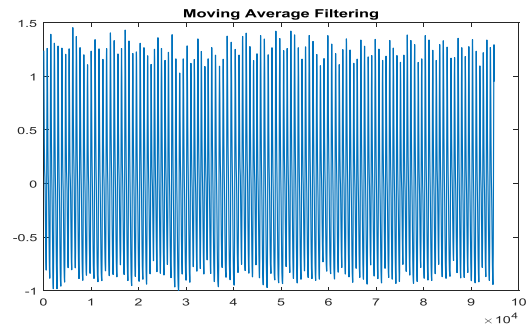


Fig .15: Moving Average Filtering in PPG denoise

However, if enough low- frequency materials are eliminated, the consequent audio sign is not clean. In wavelet assay, guesstimates are the excessive-scale, low-frequency factors and the specifics are the low-scale, high-frequency elements of the signal. Picture 18 illustrates the stairs for sign putrefaction.

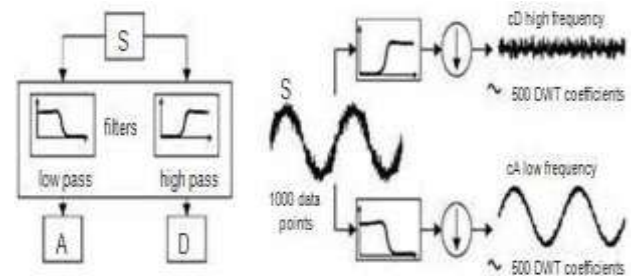


Fig.16: Denosing – PPG filter

3.4Multiple-Level Decomposition

The decomposition procedure can be reiterated, with succeeding guesstimates being decayed return, in order that one sign is fragmented down into various lower resolution machineries. This is christened the wavelet putrefaction tree this is exposed on picture 19.

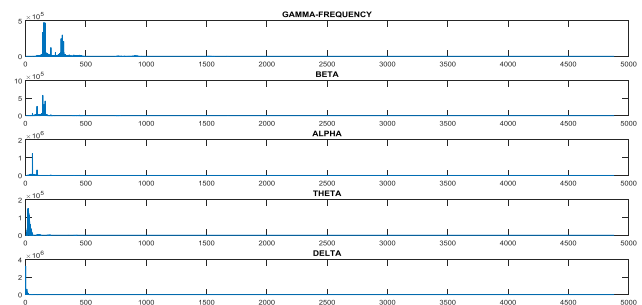


Fig. 17: Gamma frequency

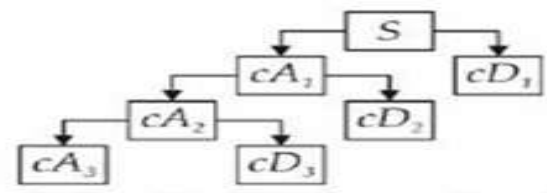


Fig.18: illustrates the procedure of performing, the manifold decomposition, which it is called wavelet decomposition tree.

Number of levels: Ever because the assay manner is iterative, in speculation it may be continuous indeterminately. Practically, the decay can advance most effective pending the unique detail incorporates a single pattern or pixel. Additionally, the tactics include picking a apposite integer of degrees grounded at the character of the signal, or on a appropriate criterion which includes entropy [4].

3.5 Wavelet Reconstruction

Discrete wavelet rework can be labored to research, or decay, indicators and images in a manner known as decomposition or assay. Equally, rebuilding or fusion is the approach of gather hose basics returned into the particular sign with out lack of records. While being this alteration, it's miles attractive to establish its asset, i.E. To go back to the authentic sign from the output tree. This line of attack follows logic inside the opposite direction, i.E. From the coefficients at the same time as relying on the digit of stages and allowing the excessive frequency (H') and low (L') bands that need to be acquired from the modernized signal S , exposed in diagram 21. The arithmetical managing that impacts combination is called: the inverse discrete wavelet transforms (IDWT). In order to synthesize a sign by way of using Wavelet Toolbox software program, we rebuild it from the wavelet constants.

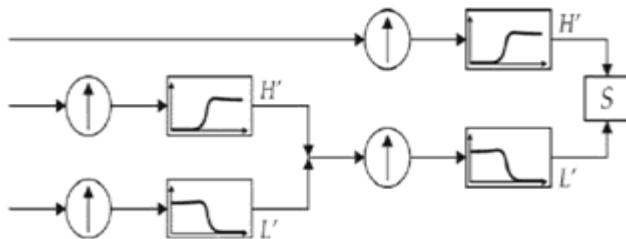


Fig 19: Show how to reconstruct a signal using wavelets

4. Result and Discussion

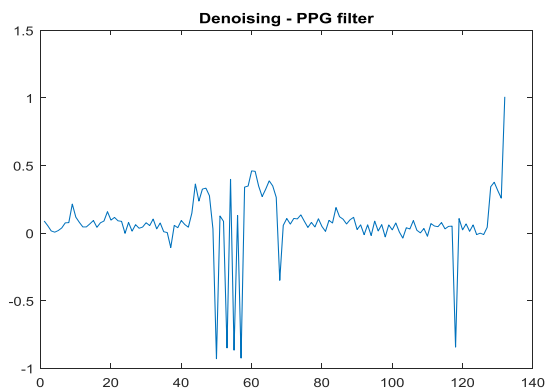


Fig 20: output image

In this section, the presentation of the experimental estimation will divide into the following subsections. Section 3.1 describes the EEG dataset signals which is used in this work. Section 3.2 explain the ECG results of the various mother wavelet functions. Lastly section 3.3 provides the discussion of the PPG experiments outcome. The results exposed that the selected mother wavelet purpose has successful realized the effectual EEG signal denoising grounded on whole determine factors EMG noises. In this paper, various

mother wavelet functions for EEG signal has been used to find the capable EEG signal denoising. Concurrently analytic & prognostic worth of wavelet techniques in various field of ECG needs to be familiar in large clinical studies. moreover the work can be further expand by disease diagnostic schemes for ECG signal. For appraising the presentation of the projected de-noising method, it is administered in few stages as exposed in Fig. 3. The database consists of PPG signals transferred. Then, 60 Hz noise signal is auxiliary to the PPG signal as a birthplace of interfere.

5. Conclusion

We have obtainable in this articles a review on dissimilar methods that intention at eliminate different types of noise humiliating ECG, EEG, PPG signal. We find that Equiripple notch filter is the best excellent to eliminate power line interfering while to eliminate motion artifact and EMG noise we should select discrete Meyer wavelet and smear the enhanced thresholding function which merge structures of firm and soft thresholding. To eliminate baseline wander we recommend to use empirical mode decay established method.

References

- [1] B.Keerthiveena; S.Esakkirajan, Denoising of PPG signal by wavelet packet transform : 2017
- [2] Harender; R.K.Sharma,EEG signal denoising based on wavelet transform Year: 2017
- [3] M. K. Diab. Masimo Corporation "Plethysmograph Pulse Recognition Processor ".U.S. Patent Application US 044 918 B2 May 2006.
- [4] D. B. Swedlow. Nellcor Inc " Oximeter with Motion Detection for Alarm Modification".World Intellectual Property Organization WO 94/22360 Oct. 1994.
- [5] Joydeep Bhattacharya Partha Pratim Kanjilal and V.Muralidhar " Analysis and Characterization of Photo-Plethysmographic Signal" IEEE.
- [6] Transaction on BioMedical Engineering vol 48 No.1 pp 5-23 January 2001.
- [7] Metin Akay "Wavelet Applications in Medicine " IEEE Spectrum pp 50-56 May 1997.
- [8] Robi Polikar " The Wavelet Tutorial " Second Edition.