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# Noise Reduction In ECG Signal by Various Filters

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***Abstract:-*** **In this project we have done a comprehensive work and research done for this type of field of project that we have covered. We have done the project line in field of bioelectric signal that is ECG signal which is been recorded from a human body then we have analyze that signal and we found that various types of interference occurred from different aspects present in surroundings ,that is we have covered. for filtrations process and that filtrations are done by four different filters Gaussian filter, median filter, FIR filter, Butterworth filter and then we will compare all those filters results in form of data recorded from simulation and produce a factual result from metrics like MSE, PSNR, SNR, CORRELATION.**

***Keywords— ECG Signal, Gaussian filter, FIR Filter, Median Filter, Butterworth Filter.***

## I. INTRODUCTION

In This work we are talking about ECG signal which a bio-electric signal which is characterized by PQRS wave form, the PQRS wave form are segmented in different parts which show the bio-electrical function of heart. These types of signal are taken from human body from the patients in hospital. These signals are often used to analyze the heart rhythm. This signal is taken with the use of cord and leads attached to the body which is called a surface electrode, if the electrode are not placed correctly on the body then there is a variation in signal in the form of noise, if the skin is not good enough then we clean the skin with the help of surgical sprit, and we also apply gel to get to match the impedance, mean while taking signal make sure the patient is not moving or he in warm condition, there is one more type of noise which is called PLI noise (Power Line Interface) which is also responsible to create the noise in the signal, Baseline Wander(BW) is a low-frequency artifacts in Electrocardiogram(ECG) signal recordings of a subject. BW removal is an important step in processing of ECG signals because BW makes the interpretation of ECG recordings difficult. The main cause of the BW in ECG signal is movement and respiration of the patient. The presence of motion artifacts in ECG signals can cause misleading interpretation of cardiovascular status. Recently, reducing the motion artifact from ECG signal has gained the interest of many researchers. Due to the overlapping nature of the motion artifact with the ECG signal, it is difficult to reduce motion artifact without distorting the original ECG signal. However, the application of an adaptive noise canceller has shown that it is effective in reducing motion artifacts if the appropriate noise reference that is correlated with the noise in the ECG signal is available. Unfortunately, the noise reference is not always correlated with motion artifact. Consequently, filtering with such a noise reference may lead to contaminating the ECG signal.

It consists of four filters Butterworth Filter, Median Filter, Gaussian Filter, FIR Filter for removing high frequencies followed by for eliminating the 50/60Hz power line interference, and the adaptive noise canceller for removing baseline wandering. Industrial environment can be a source of radiation generated by high voltage power lines, transformers, welders, electric motors, induction furnaces, degaussing coils, etc. Thus, in the first part, the ECG signals are digitally filtered with a zero-phase Butterworth filter (0.05–130 Hz). We see the capability of all four filters is used as stopband to suppress the 50/60Hz power line interference. In this paper we showed the comparison on four different aspect metrics of noise ratios available.

## II. TYPES OF FILTERS

***MEDIAN FILTER:***

In this paper the filters that makes possible for the elimination of a divergent value by changing the divergent value in a finite series with the medium value in the same series. When it is of two dimensions, the MF for images would be developed as follows $\mathrm{m}\,(\mathrm{k}) = \{\,\mathrm{med}\ \mathrm{w}\,(\mathrm{k}) = \ \mathrm{med}\ \mathrm{x} - \mathrm{n}\,(\mathrm{k}), \ldots\,..,\mathrm{x} - 1\,(\mathrm{k}\,), \mathrm{x0}\,(\mathrm{k}), \mathrm{x1}(\,\mathrm{k}), \ldots\,.., \mathrm{xn}\,(\mathrm{k})\}$

***GAUSSIAN FILTER:***

Gaussian filter is one of the crucial important for both the theory and application compared to other linear filters. In two dimensional this filter is given.

$$g_\sigma(x) = \frac{1}{2\pi\sigma^2}\, e^{-\frac{x^2}{Z\sigma^2}}$$

$\sigma$ Denotes the scale level

$$\hat{u} \ = g_\sigma * Z$$

From this relation, the heart equation also suggests a convenient way to calculate the Gaussian filter. For digital image.

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***BUTTERWORTH FILTER:***

The function Nth-order transfer function of analog low-pass Butterworth filter $H(s) = \frac{1}{\sum_{n=0}^{N} A_n s^n}$
Through the mapping between the analog and digital domain, its corresponding digital low-pass and highpass filters are in the form

$$H(Z) = \frac{(1 + b_{01}Z^{-1})(1 + b_{11}Z^{-1} + b_{12}Z^{-2})}{(1 + a_{01}z^{-1})(1 + a_{11}z^{-1} + a_{12}z^{-2})}$$

$$\frac{(1 + b_{K1}Z^{-1} + b_{K2}Z^{-2})}{(1 + a_{K1}Z^{-1} + a_{k2}z^{-2})}$$

***FIR FILTER:***

Desired frequency response specification $H_d$ (w) and the corresponding unit sample response $h_d$ (n) is determined using inverse Fourier transform. Showing relation between $H_d$ (w) and $h_d$ (n)

$$H_d(w) = \sum_{i=0}^{\infty} h_d(n)e^{-jwn}$$

$$h_d(n) = \int_{-\pi}^{\pi} H_d(W)e^{jwn}dw$$

Impulse response $h_d$ (n) obtained from the above equation is of infinite duration. Truncated at some point, say n=M-1 to yield an FIR filter of length M (i.e. 0 to M-1). Truncation of $h_d$ (n) to length M-1 is done by multiplying $h_d$ (n) with an window. Design considering the “rectangular window”, define as

$$w(n) = \begin{cases} 1 n = 0,1,2, \dots \dots M-1 \\ 0 \ otherwise \end{cases}$$

## III. EXPERIMENTAL RESULTS

Thus we have taken the input ECG signal from MIT-BIH arrhythmia database, this signal what we are putted for simulation is for noise removal process in ECG signal. The ECG signal is illustrated in one recorded from MIT-BIH database and the signals are present in the form of (.hea), (.dat), (.atr), the other miscellaneous information like the what type of leads attached and how many electrodes and leads attached are stored in the binary type of file. The data is present in the vast scale so we have taken one record of ECG signal and processed for simulation the sampling frequency we have used in the simulation is 2000 sample per mV.

### PERFORMANCE MATRICS

The noise removal process is done by using four different types of filters, Median Filter, Gaussian Filter, Butterworth Filter, FIR Filter(Finite Impulse Response Filter), for proposing the result in this type process we have updated the results of performance metrics by showing comparison.

The means of MSE, PSNR, SNR, CORR (Correlation) from which filter is showing the best results for reduction of noise the ECG signal.

FOR MSE,

x=Double (Input Image)
y=Double (Filtered Image)

$$z = abs(x - y)$$

MSE=$\sqrt{mean(mean(z^2))}$)
MSE is denoted as Mean Square Error

The largest value of MSE input ECG signal is mean that signal quality is poor.

FOR PSNR,

$$\text{PSNR}=20 * log10(\frac{255}{\sqrt{MSE}})$$

PSNR means peak to signal to noise ratio,
The result is quite inverse of MSE the small result value means it does not perform the noise removal process better.

FOR SNR,

$$\text{SNR (db)} = 2log_{10}(\frac{Vinput\ signal}{Vnoise})$$

Where, v input signal is original input voltage
v noise is noise voltage

FOR CORRELATION,

$$r = \frac{\sum(x_i - \bar{x})(y_i - \overline{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

Where,
r = correlation coefficient
$x_i$= value of x variable in sample
$y_i$ = value of y variable in sample
$\bar{x}$ = mean value of x variable
$\bar{y}$ = mean value of y variable

TABLE-I

***Table (I). Is a comparison between all the results evaluated by performance metrics by MSE, SNR, PSNR, CORR.***

| Input Signal | FILTERS | MSE | SNR | PSNR | CORR |
|---|---|---|---|---|---|
| MIT-BIH Data Base | MEDIAN FILTER | 0.0010415 | 30.25 | 68.67 | 0.9765 |
| | GAUSSIAN FILTER | 0.034474 | -4.74 | 33.67 | 0.21211 |
| | BUTTER--WORTH FILTER | 0.0016746 | 25.50 | 63.92 | 0.96171 |
| | FIR FILTER | 0.0016133 | 25.87 | 64.29 | 0.96361 |

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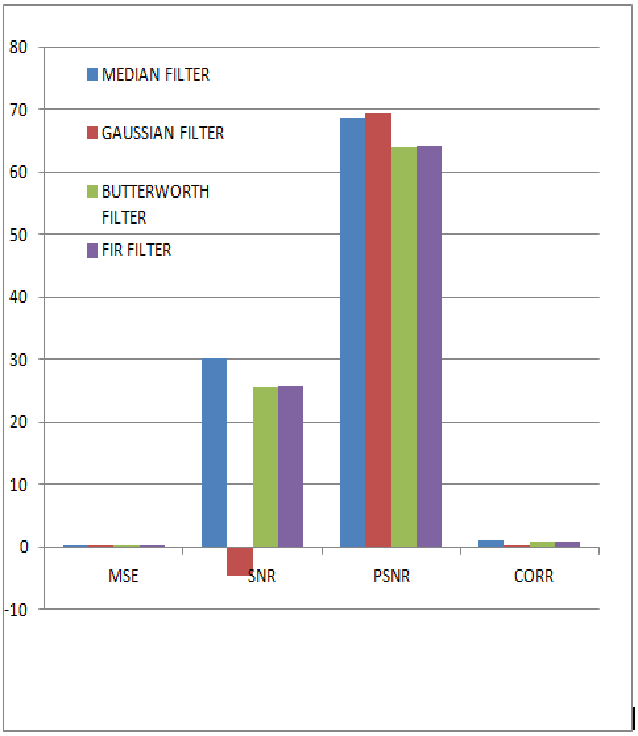


*FIGURE (1). Comparison of MSE, SNR, PSNR, CORR.*

In this fig (1). we shown the comparison of value of MSE,PSNR,CORR in the form of bar chart comparison clear states that the Gaussian filter and median filter has better results than the other filters.

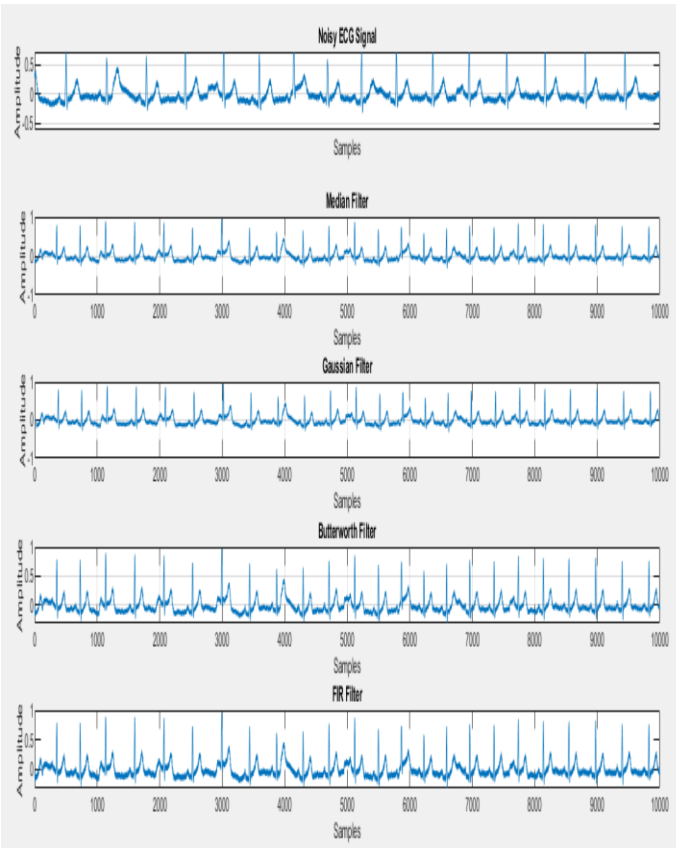


*FIGURE (2). Noise Reduced by (a) Median Filter, (b) Gaussian Filter, (c) Butterworth Filter, (d) FIR Filter.*

In this fig(2). shown above is results output of simulation run as per the input ECG signal values we get from MIT-BIH Database has showed the comparison of the filtered signal out in the form of graph plot for different filters.

## IV. CONCLUSION

In this paper we have taken the input ECG signal values from MIT-BIH Arrhythmia database and analyze that, and many times there is chance of occurrence of noise comprises with the original signal so we have use different filters so removing the noise from the ECG signal because in the field of biomedical we saw that many hospitals run the various tests like recording ECG signal or for (Ex. recording of EEG signal of brain waves), the interference of noise is happens all the time in hospital premises or in test centers premises so, we have run the simulation on ECG signal and the result are **Gaussian filter and Median filter is giving the best result** for noise reduction as compare to other two filters Butterworth filter , FIR filter you can see in performance metrics table I and also in the Bar chart comparison the of all filters for MSE , PSNR, SNR, CORR of all filters output.

## V. REFRENCES

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