IJTRET "Voice of Innovative Minds"
doi.org/10.54473/IJTRET.2022.6604
International Journal of Trendy Research in Engineering and Technology
Volume 6 Issue 6 December 2022
ISSN NO 2582-0958

AN AUDIO DENOISING APPROACH USING HYBRID MODIFIED FAST WAVELET TRANSFORM METHOD

[1]Dr.P.Senthilkumar[*], [2]Asha.V, [3]Dr.G.Ramesh,[4]M.Muthukumar,[5] Dr. Amairullah Khan Lodhi

*[1]Department CSE, Shadan Women's College of Engineering and Technology, Khairatabad,Telangana,India
[2]Department CSE,Anna University Affiliated College,Chennai,Tamilnadu,India
[3]Department of MECH, MEA Engineering College, Perinthalmanna, Malappuram District,Kerala,India
[4]Department CSE, SRM Institute of Science and Technology,New Delhi
[5]Department ECE, Shadan College of Engineering and Technology,Telangana,India
*Corresponding Author:psenthilmephd@gmail.com
ashamecse@gmail.com, principal@meaec.edu.in, mkumar7680@gmail.com,lakresumes@gmail.com

Received 29 August 2022 Received in revised form 31 August 2022 Accepted 02 September 2022
Available online 10 September 2022

ABSTRACT

Noise includes all unwelcome ambient sounds. If a sound is perceived as delightful music or annoying noise, it will be perceived as having the same decibel level. The fundamental drawback of noise in an audio signal is that it degrades the signal's quality during transmission over the communication system. Real-time audio signals are gathered for the present study using a microphone. The additive white Gaussian noise of AWGN is blended with a genuine audio source. The Median, Finite Impulse Response filter with Wavelet Transform approach is a hybrid filter for denoising audio signals that incorporates the Median Filter, FIR Filter, and Wavelet Transform techniques (MFWT).

In this study Peak Signal to Noise Ratio and Mean Square Error (MSE) are used to assess MFWT performance(PSNR). In terms of SNR (82.04) and RMSE score, MFWT performs better than the median filter, FIR filter, and Wavelet transform (0.055).

Keywords: MFWT, RMSE, PSNR

I. INTRODUCTION

Today, a wide range of industries use digital image processing [1], including satellites, medicine, face identification, UV sensing, pattern recognition, obstacle detection, machine or robot vision, and more. To improve image analysis, the noise that has been introduced into the digital signals from various sources is first removed. This noise is a result of transmission errors, compression techniques, thermally produced electrons at sensor sites, amplifier and quantization techniques, and other factors [2].

After removing noise or distortions from noisy photographs, a technique called image denoising [3] is used to preserve the original images. To remove noise from images, researchers [4] developed a variety of imagedenoising algorithms such as spatial filtering, transform domain filtering, and wavelet thresholding. In this situation, spatial filtering is a useful method for coping with images of additive noise. Linear filters and nonlinear filters are the two categories of spatial filtering methods. The performance of linear and nonlinear filters is poor when dealing with sharp edges and lines[5]. For reducing multiplicative or function-based image noise, nonlinear filters are helpful.

Low pass filters are used in transform domain filtering to remove noises by using a cut-off frequency and a frequency domain filter [6]. If the improper threshold is selected while using Wavelet-based calculations to reduce picture noise, the original image may become blurry [7].

Denoising for photos, audio, and videos is now the subject of several investigations. There are multiple sections to this work. The methods for denoising audio signals that have been developed are discussed in
Section II. The suggested technique for eliminating noise from audio streams is covered in Section III. Section IV reviews the MFWT's output at each level and evaluates how well it performs in comparison to other filter types.

International Journal of Trendy Research in Engineering and Technology
Volume 6 Issue 6 December 2022
ISSN NO 2582-0958

II. LITERATURE REVIEW

There have been numerous studies on denoising text, photos, audio, and video from various sources. The original image is not preserved by any of the denoising algorithms that have been created to eliminate different kinds of noise from the original image. Using such techniques, it is challenging to eliminate the noise connected to an image's texture and edge. Some of the research conducted by various research groups is covered in this section.

For the purpose of eliminating noise from 2D medical images, Somnath Mukhopadhyay et al.[8] suggested a wavelet-based thresholding technique based on a genetic algorithm. It offers the finest restoration outcomes when compared to other shrinking techniques.

An unsupervised consensus network has been created by Dufan Wu et al [9] for the elimination of noise from medical images. For this, they analyze the MRI and Low-dose CT Challenge datasets, and they contrast the consensus network and Noise to Noise frameworks. Using this method, the microscopic lesion's structure and textures are kept in the medical photos. The RMSE and the Structural Similarity Index Metric are used to gauge performance (SSIM). This study shows that the suggested method has an SSIM score of 87.7 and an RMSE score of 4.7.

To reduce noise, Graps et al [10] used FFT-based audiosignal analysis.Using periodic functions of various scales, the structure of audio signals is examined. To eliminate noisefrom audio signals, Radhika Bhagat et al. [11] employed a number of filters, including low-pass and high-pass filters. To facilitate the effective design of time-varying filter applications, they created a number of built-in filters. A quick FFT-based method was utilised by Harpal Singh et al. [12] to examine temporal and frequency domain data.

Butterworth and Chebyshev filters have been employed by Mannu Singla et al. [4] to minimize the noise in signals with various frequency and ripple factors. In their research, Seema Rani et al. [13] used the FIR and IIR filters to denoiseaudio signals. The FIR filter has a
error than the IIR filter, its output is extremely close to the target value, and it is more stable than the IIR filter, according to the performance analysis.

The Least Mean Square (LMS) technique was developed by C Mohan Rao et al. [14], in which the AWGN is added to the message signal to reduce noise with little to no mistakes. It is nevertheless sensitive to the input's scale used to denoise audio signals. The wavelet transformation was utilized by Jai Shankar et al. [15] to separate audio signals into several blocks, protecting the distinctive and important properties of each block while displaying the finest information offered by the combined collection of blocks.

A discrete wavelet approach has been used by Ola Ratelli et al. [16]. They draw attention to the value of wavelet transformation. For their performance investigation, Priyanka Khattar[17] used hybrid wavelet transformations, specifically the Daubechies and Haar.

The advantages of the Median filter, FIR filter, and wavelet transform approach are combined in this suggested methodology -MFWT to remove noise from audio sources.

III. METHODS

Noise theory and fundamentals of audio theory are used to evaluate the audio signal. A noisy signal is created by concatenating the audio signal with the AWGN. This noisy signal is transformed from the time domain to the frequency domain using the Fast Fourier Transform method (FFT).

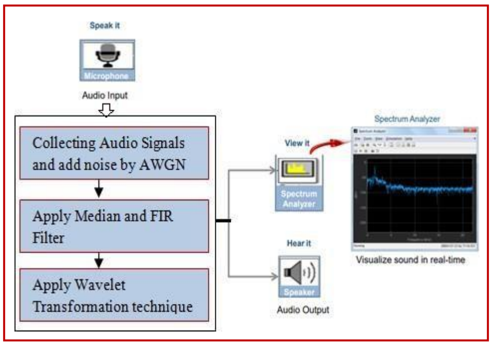

Fig.1. Flow of MFWT Technique-based audio noise removal

In order to implement the suggested filter, MFWT, a number of filters, including the median filter, FIR filter, and Discrete Wavelet Transform (DWT), would need to be created while taking into account various filter design criteria, such as system order and cut-off frequency. Signal normalization, a decomposition mechanism, and the actual reconstruction procedure are all included in the MFWT filtering technique. The audio signal is recreated during the decomposition stage, and the Inverse Fast Fourier Transfer (IFFT) is used to convert the frequency domain to the time domain.
The following are the different phases of MFWT

- Collection of audio signals and production of noisy signals
- Median Filter Approach
- FIR filter
- DWT transformation method

Audio signals and production of noisy signals

Acquiring real-time audio signals is the initial step in the denoising process. After assembling the audio signal, add AWGN to produce the noise signal. A median filter, an FIR filter, and a DWT are used by FFT to filter the signal.

IJTRET "Voice of Innovative Minds"
International Journal of Trendy Research in Engineering and Technology
Volume 6 Issue 6 December 2022
ISSN NO 2582-0958

Median Filter Approach

The median filter is a nonlinear filter that is effective at removing salt-and-pepper noise and speckles from a signal. By using a dynamic windowing approach, it also keeps all signal regions.

FIR filter

A linear phase symmetric filter with inherent stability is the Finite Impulse Response (FIR) filter. It doesn't need to respond to any input signals with a limited length or provide feedback. The median filter is a nonlinear filter that is effective at removing salt-and-pepper noise and speckles from a signal. By using a dynamic windowing approach, it also keeps all signal regions.

DWT transformation method

The usage of DWT can help reduce noise in digital communications. This approach is used to compute the Signal to Noise ratio and the root means the square of a noisy signal. The signal threshold value is determined using the wavelet thresholding algorithm. Using the related wavelet coefficients, it breaks down the incoming signal intobanks of analytical filters. It loops over each subband individually. Apply the level-dependent and global thresholdvalues to the decomposed wavelet coefficients across all scales and subbands. For wavelet denoising, a soft threshold is employed. The audio signal is then reconstructed using a filter bank and threshold wavelet coefficients. The DWTalgorithm serves as an example of this procedure.

Algorithm 1: Audio denoising using the DWT algorithm
Input : Noisy audio signal
Output : Denoising audio signal

Step 1: Read a noisy signal r(i) and an input signal s(i)

Step 2: Calculate the noise-related signal's SNR and RMSE using equations (2) and (3).

$$SNR = 10\log_{10}\left(\sum_{i=1}^{n} x_j^2 \,\middle|\, \sum_{i=1}^{n}(r_i - s_i)^2\right) \quad (2)$$

$$\text{RMSE} = RMSE = \sqrt{\frac{\sum_{i=1}^{n}(r_i-s_i)^2}{n}} \quad (3)$$

Step 3: Make a decision on a threshold value for the decomposition phase using the wavelet transform technique. The threshold point T_{new} is derived from number of samples N and Noiseintensity σ . Equation can be used to explain this (4)

$$T_{new} = \sqrt[\sigma]{2\log N} \quad (4)$$

Step 4: Utilize a filter bank to divide the received signal into wavelet coefficients.

Step 5: Apply a threshold value to the decomposed wavelet coefficients.It uses the Soft threshold, which has an equation defining it (5).

$$r = \text{sign}(s)(|s| - T_{new}) \quad (5)$$

Step 6: Use a filter and threshold wavelet coefficients to rebuild the signal.

IV. PERFORMANCE ANALYSIS AND RESULTS

The denoising audio signal tests are performed in Matlab, and the filter's performance is assessed using SNR and RMSE, as shown by equations (6) and (7), respectively.

SNR: The signal-to-noise ratio (SNR) measures the relationship between the necessary output signal strength and the noise power that distorts the quality of the input signal.

$$SNR = 10\log\frac{\text{Required output signal power}}{\text{sigal power of distorting noise}} \text{ dB} \quad (6)$$

RMSE: A statistic known as the Root Mean Square Error (RMSE) assesses the degree of error in statistical models. It assesses the average squared difference between the actual and anticipated visual output.

$$RMSE = \sqrt{\frac{1}{N} \times \sum_{n} |x(n)|^2} \quad (7)$$

An audio recorder with Fs = 8500 is used to capture an audio signal at first. It captures real-time audio for up to 5 seconds and stores the finished recording as a.wav file with a minimum file size of 78.1 kilobytes. Figure 2 shows the frequency of the input audio signal, and Figure 3 shows the input audio signal's noise analysis.

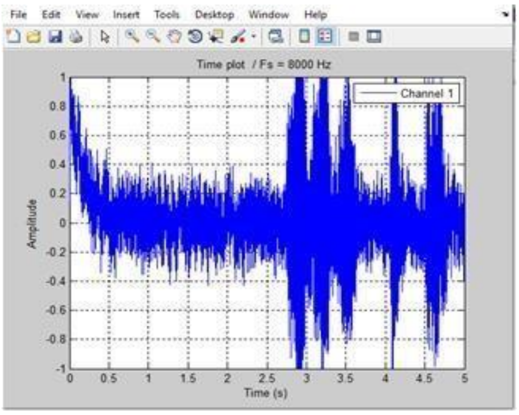

Figure 2: signal after AWGN

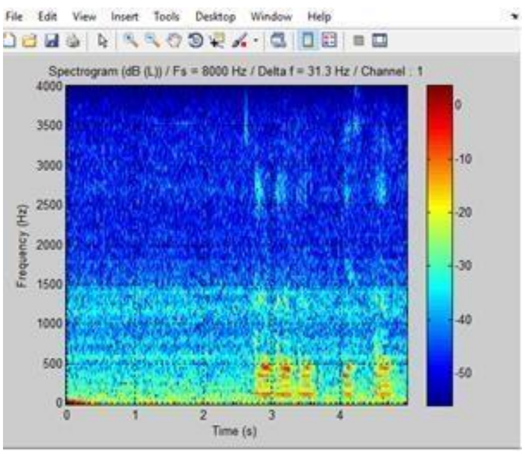

Figure.3 Noise Input Signal

International Journal of Trendy Research in Engineering and Technology
Volume 6 Issue 6 December 2022
ISSN NO 2582-0958

Figure 4 depicts the input audio signal's averaged FFT spectrum.

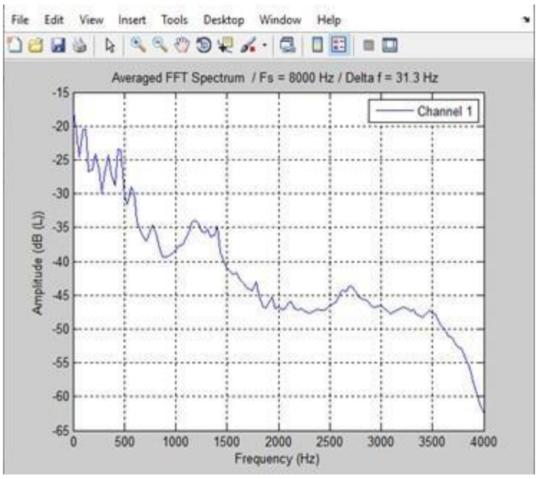

Figure.4 Averaged FFT Spectrum

The median filter, FIR filter, and Wavelet transform are then applied to the noisy input signal after adding noise (salt, pepper, and white Gaussian noise). The output of the median low pass filter is shown in Figure 5.

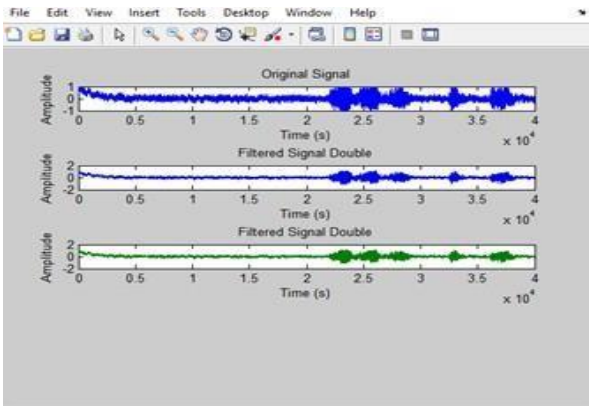

Figure.5 Outcome of Median Low Pass Filter

Figure 6 depicts the FIR low pass filter's output.

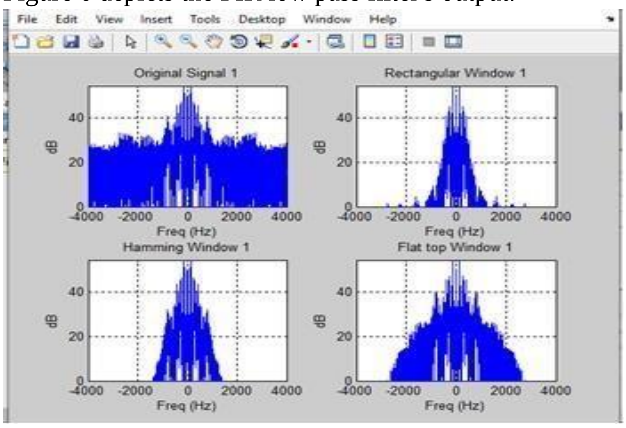

Figure .6 Outcomes of FIR Filter

Figure 7 depicts the Wavelets low pass filter's output.

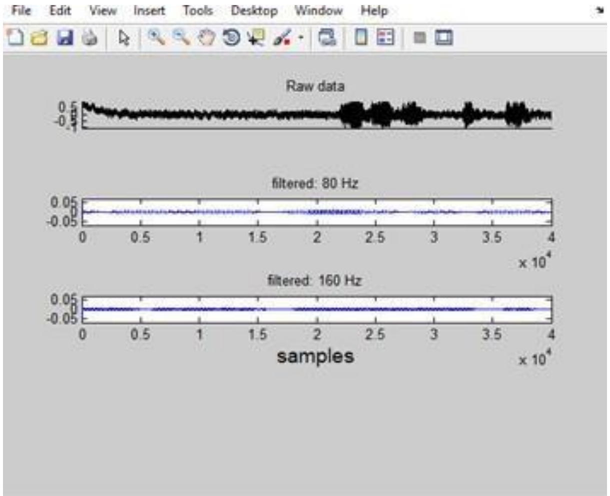

Figure.7 Outcomes of Wavelet filter

MFWT's magnitude and phase response are depicted in figure 8.

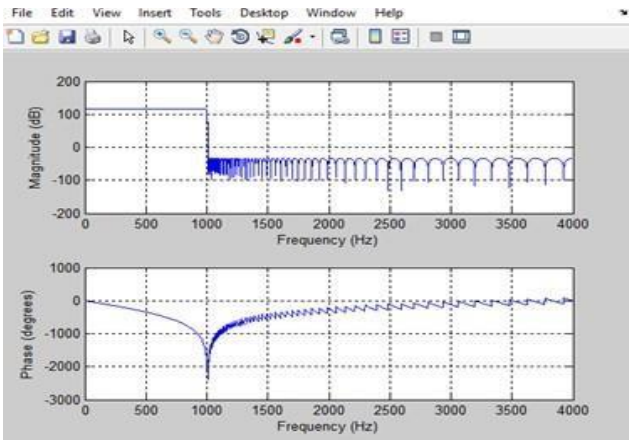

Figure.8 Magnitude, the Phase response of MFWT

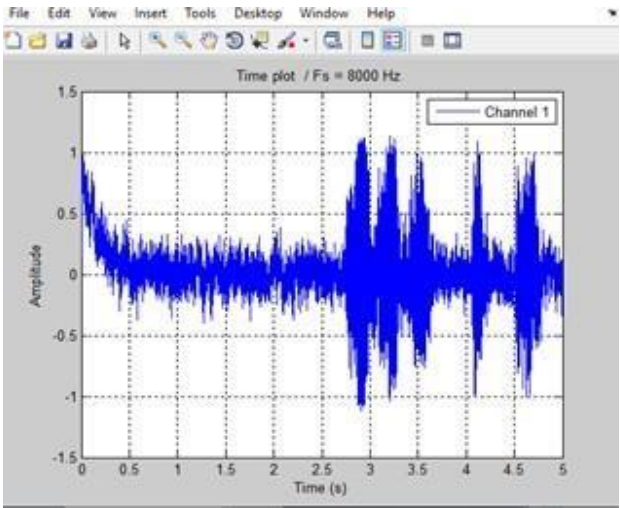

Figure.9 Outcome Signal

IJTRET "Voice of Innovative Minds"
International Journal of Trendy Research in Engineering and Technology
Volume 6 Issue 6 December 2022
ISSN NO 2582-0958

The final audio signal's output signal is depicted in figure.9. figure 10 depicts the averaged FFT spectrum signal for the output audio signal. The output audio figure's spectrum analysis(figure11).

Table 1: Performance assessment of Filters

S.No	Actual Metrics	Median Filters	FIR filters	Wavelet Transformation	MFWT filter
1	SNR	57.08	64.03	73.2	83.08
2	RMSE	5.02	2.98	0.87	0.056

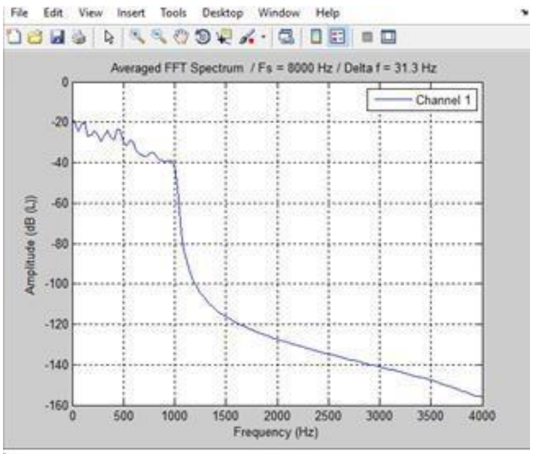

Figure.10 Averaged FFT Spectrum

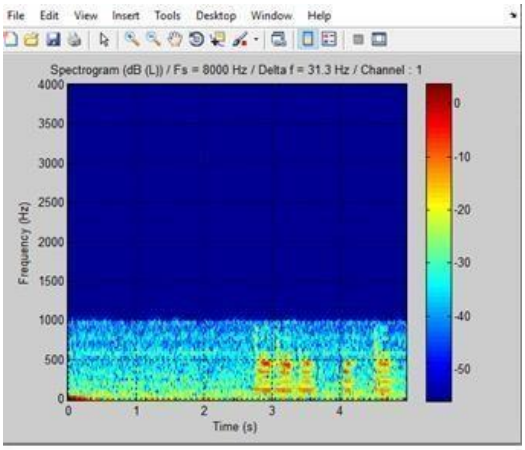

Figure.11 Outcomes of spectrum

Each filter's performance is shown in Table 1.This study shows that MFWT outperforms individual filtering algorithms in terms of RMSE score and signal-to-noise ratio.

V. CONCLUSION

One of the most prevalent issues in real-time image processing is denoising. During the real-time audio acquisition process, random noise taints the actual signal. The original audio stream is degraded and the transmission quality is changed as a result of the random noise. The importance of denoising techniques in audio signals was highlighted in this study. The wavelet transform method,along with linear and nonlinear filters, are all included in the hybrid MFWT filter that is discussed here. In the presence of significant background noise, MFWT outperforms individual filtering methods thanks to its high SNR ratio (82.04) and low RMSE score (0.055).

REFERENCES

[1] YUE, ZhongQi. "Digital image based numerical methods for mechanical analyses of geomaterials with actual meso- heterogeneity." Chinese Journal of Geophysics 1(2022)108-118.

[2] Pouyani, Mozhde Firoozi, Mansour Vali, and Mohammad Amin Ghasemi. "Lung sound signal denoising using discrete wavelet transform and artificial neural network." Biomedical Signal Processing and Control, 72(2022)103-129.

[3] Li, Zhixiong, Xihao Liu, Atilla Incecik, Munish Kumar Gupta, Grzegorz M. Królczyk, and Paolo Gardoni. "A novel ensemble deep learning model for cutting toolwear monitoring using audio sensors." Journal of Manufacturing Processes 79 (2022)233-249.

[4] Venkata Lavanya, P., C. Venkata Narasimhulu, and K. Satya Prasad. "Image Denoising Using an Artificial Neural Network and Genetic Optimization Algorithm Based Dual-Tree Complex Wavelet Transform." In Soft Computing and Signal Processing, pp. 393-401. Springer, Singapore, 2022.

[5] Ihza, Muhammad Yaumil Ihza, Satria Mandala, and Miftah Pramudyo. "Study of Denoising Method to Detect Valvular Heart Disease Using Phonocardiogram (PCG)." Indonesia Journal on Computing (Indo- JC) 7, no. 1 (2022): 31-38.

[6] Gong, Tao, Jianhua Yang, Songyong Liu, and Houguang Liu. "Non- stationary feature extraction by the stochastic response of coupled oscillators and its application in bearing fault diagnosis under variable speed condition." Nonlinear Dynamics 108(2022): 3839-3857.

[7] Ramya, A., Sudha Rajesh, and G. Karthick. "Prediction Analysis of Noise Component Using Median-Based Filters Cascaded with Evolutionary Algorithms." In Prediction and Analysis for Knowledge Representation and Machine Learning, pp. 55-79. Chapman Prediction and Hall/CRC, 2022.

[8] Mukhopadhyay, Somnath, and J. K. Mandal. "Wavelet based denoising of medical images using sub-band adaptive thresholding through genetic algorithm." Procedia technology 10 (2013)680-689.

[9] Wu, Dufan, Kuang Gong, Kyungsang Kim, Xiang Li, and Quanzheng Li. "Consensus neural network for medical imaging denoising with only noisy training samples." In International Conference on Medical Image Computing and Computer-Assisted Intervention, pp. 741-749. Springer, Cham, 2019.

[10] Graps, Amara. "An introduction to wavelets." IEEE computational science and engineering 2 (1995)50-61.

[11] Bhagat, Radhika, and Ramandeep Kaur. "Improved audio filtering using extended high pass filters." Int. J. Eng. Res. Technol 2 (2013)81-84.

[12] Singla, E. M., & Singh, M. H., Paper on frequency based audio noise reduction using butterworth, Chebyshev & Elliptical filters. Int. J. Recent Innov. Trends Comput. Commun, 3(2015) 5989-5995.

[13] Rani, S., Kaur, A. and Ubhi, J.S., 2011. Comparative study of FIR and IIR filters for the removal of Baseline noises from ECG signal.

[14] Rao, C. Mohan. "of LMS Algorithm for Noise Cancellation" International Journal of Advanced Research in Computer and Communication Engineering Vol. 2." (2013).

[15] Shankar, B. J., and K. Duraiswamy. "Wavelet-Based Block Matching Process: An Efficient Audio Denoising Technique." European Journal of Scientific Research 48, (2010)16-28.

[16] Bratteli, O., Jørgensen, P.E. and Jørgensen, P.E., 2002. Wavelets through a looking glass: the world of the spectrum. Boston: Birkhäuser.

[17] Khattar, P., Rai, A. and Tripathi, M.S., 2016. Audio De-noising using Wavelet Transform.