Effective Prototype Algorithm for Noise Removal Through Gain and Range Change

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Abstract
This paper proposes an effective prototype algorithm using Audacity application software for noise removal to reduce noise from the sound signals similar to the noise removal algorithm of Audacity. The objective was to understand the overheads on the system resources and implement a mechanism to reduce the resources without obtaining a major shift in the final output. The experiments were conducted by designing a prototype with modifying the function of Noise Removal of the software. The gain and range are the major factors of noise removal. The novel code reduces the overhead processing of noise reduction with gain and range change. The quantitative analysis of plot spectrum of audio files represent the similarities of the different models implemented for the experiments.

Keywords
Noise, Gain, Range, Audio - real and recorded, Noise Removal

I. Introduction

Noise is the unwanted sound that gets recorded due to some environmental factors, technical limitations of recording equipment, and, alsonoise is a problem in all recording situations that caused by electrical circuit whisper, rolling magnetic tape whisper, errors in digital quantizing, poor screening, and amplifier ground loops and so on.

Any sound that doesn't allow listening the expected sound or sound effect is noise. Noise is generally louder in decibels than desired sound. It can be also termed as stain or impurity. This impurity disturbs the original sound and its effects to be played over output device. Noise reduction is one of the major applications of audio editors. As the audio recording and playing technology is developing, technical improvement is also happening with noise reduction technology. In video journalism, the audio must be taken care of the noise that occurs in playback of audio [1]. Journalists can take help of audio in expressing their fact based stories to the world. Text, video, and audio sources are increasingly integrated in storytelling [2].

Technically there are two types of audio; real audio and recorded audio. Recorded audio is the musical or verbal medium of communication. With the advent of technology audio recording, audio playback, audio broadcasting has grown at tremendous level. Audio downloading has become a heavy traffic over internet. The constraints of processing capacity, download speed and storage have gone past. The quality sound is needed. Users demand accurate and enjoyable audio tracks.

The gain value is directly related to the amplitude of the sound signal. It is the audio sound level. The amplification process deals with modification of the gain. Increase in gain increases the loudness of the sound.The noise removal portion of the audio editors modifies the gain values of the noise signal. In the noise reduction process, the noise signal pattern is identified. The relativity of the selected patch signal is compared with the overall sound signals. The gain values are changed with the code of the noise signals. The processing requires high speed and execution accuracy; otherwise, the original sound signal gets changed. The noise reduction programs take into consideration the noise signals and the range of the signals having noise for reduction.

II. Related Work

From the sound separation point of view noise reduction is significant task for civilizing eminence of recorded sound signals. While studying noise reduction algorithms, gone through various noise reduction theory. Related work carried out by author Tico proposed a noise and blur reduction method in HDR imaging. They used the property of LDRIs that LDRIs captured with under-exposure are noisy, whereas those with overexposure are blurred. They first photo metrically calibrated LDRIs using brightness transfer function between the longest exposure image and the remaining shorter exposure images, and fused calibrated LDRIs with noise estimation in the wavelet domain. In the fusion step, the weighted average is used, where the larger noise variance of the pixel neighborhood is, the smaller the computed weight of the pixel is [3]. Similarly, Akyuz and Reinhard has formed a method which reduced noise in radiance map generation of HDR imaging, in which input LDRIs captured at high sensitivity setting were used. They first generated the radiance map of each LDRI using an inverse camera response curve, and computed the pixel-wise weighted average of subsequent exposure images to reduce the noise. The weighting function depends on exposure time and pixel values. They gave more weight to pixels of LDRIs captured with longer exposure, but excluded over-saturated pixels from the averaging [4].

Theory proposed by T. H. Min, R. H. Park, and S. Chang selectively applies different types of denoising filters to motion regions and static regions in radiance map generation that is based on Debevec and Malik's method. In motion regions, a structure-adaptive spatio-temporal smoothing filter is used, whereas in static regions, a structure-adaptive spatial smoothing filter is used for each LDRI and then the weighted averaging for filtered LDRIs is performed. This filter is effective for low-light noise removal with edge preservation and comparably low computational load [5].

An additional algorithm, wavelet based for audio de-noising is discussed by the authors, in which, they focused on audio signals corrupted with white noise. The authors used Discrete Wavelet Transform (DWT) to transform noisy audio signal in wavelet domain. It was assumed that signal is represented by high amplitude DWT coefficients and noise is represented by low amplitude coefficients. To get audio signal with less noise, thresholding of coefficients are used and they are transformed

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back to time domain [6].
Similarly, there is a method i.e. Speech enhancing method based on improved spectral subtraction algorithm. For effective noise reduction with minimal distortion spectral subtraction algorithm takes in account perceptual aspects of human ear. Improved spectral subtraction algorithm effectively reduces background noise in comparison with commonly used spectral subtraction type algorithms [7].
Band filters on a speech signal allows cancellation of stationary noise with a narrow frequency band. However, in most cases the noise is not stationary, and occurs in a wide frequency band along with speech, where the application of band filters does not provide satisfactory results. This is why other noise cancellation techniques are used that can filter the speech signal according to certain speech and noise properties [8].
Lowerre, J.M. proposed a method for cancelling noise in a multi-microphone situation which uses the estimate-maximize (EM) algorithm in the time domain. The development in the time domain of its use with a signal processing problem is presented. Two approximations are presented. The time-domain method will permit smaller data blocks to be used since no assumption of stationarity and estimates of the spectrum are used [9].
Guoshen Yu and Stephane Mallat proposed the audio denoising by using time-frequency block thresholding method. This system removes noise from audio signals requires a non-diagonal processing of time-frequency coefficients to avoid producing "musical noise." State of the art algorithms perform a parameterized filtering of spectrogram coefficients with empirically fixed parameters. A block thresholding estimation procedure is introduced, which adjusts all parameters adaptively to signal property by minimizing a Stein estimation of the risk. Numerical experiments demonstrate the performance and robustness of this procedure through objective and subjective evaluations [10].

III. Experimental Setup

Ubuntu is easy-to-use Linux desktop operating system. Ubuntu is appropriate OS for setup and configuring Audacity application software rather than MS-Windows.Audacity is free, open source, cross-platform software for recording and editing sounds for Windows, Mac OS X, GNU/Linux and other operating systems (http://audacity.sourceforge.net/). wxWidgets is a C++ library that lets developers create applications for Windows, Mac OS X, Linux and other platforms with a single code base. wxWidgets gives applications a truly native look and feel because it uses the platform's native API rather than emulating the GUI. It's also extensive, free, open-source and mature (https://www.wxwidgets.org/). A system with hardware configuration 2GB RAM, i3 processor, 3.08GHz and 350GB HDD was used for experiments. Experiments were conducted on "Dream a sleepless dream.mp3", "It only feels like something.mp3" and "Virtual hair cut.mp3" these files. The desired output for the said files is shown in Snapshots and results and discussion section of this paper. The prototype algorithm as used for the study of noise reduction. Used prototype algorithm is discussed as follows.

IV. Prototype Algorithm

Noise removal function
1. Get the noise profile
2. Raise the gain
3. Qualify the gain for selection of noise level indication
4. Select the range of gain change to the next occurrence
5. Decay the gain in both directions
6. Apply frequency smoothing to output gain
7. Implement output to the frequency-amplitude spectrum

V. Plot Spectrum Analysis

The plot spectrum analysis of frequency (Hz) and the Model wise dB values (sample values of a song "It only feels like something. mp3")

Frequency (Hz)	Model 1	Model 2	Model 3	Model 4
86.13281	95.15706	492.9424	389.9457	298.6145
172.2656	335.0929	911.4543	776.0123	709.6312
258.3984	393.7891	1189.206	960.1916	797.0611
344.5313	562.0909	1393.128	1197.43	1003.217
430.6641	492.7586	1309.018	971.1404	980.4698
516.7969	510.0842	1197.535	1314.239	1191.087
602.9297	632.6603	1406.585	1559.858	1368.737
689.0625	739.1496	1914.332	1410.408	1382.302
775.1953	815.1994	1560.449	1751.333	1582.645
861.3281	813.3393	1743.926	1522.393	1437.411
947.4609	861.0559	1896.838	1581.776	1570.106
1033.594	930.1023	2008.576	1996.914	1812.892
1119.727	948.4412	2056.682	1886.424	1769.187
1205.859	1078.604	2005.985	2115.962	1916.138
1291.992	1244.366	2363.147	2171.155	2005.253
1378.125	1159.806	2199.942	2011.172	1925.644
1464.258	1171.802	2263.634	2218.001	2070.228
1550.391	1147.737	2103.218	2111.14	1997.687
1636.523	1181.186	2337.934	2170.591	2209.665

VI. Snapshots

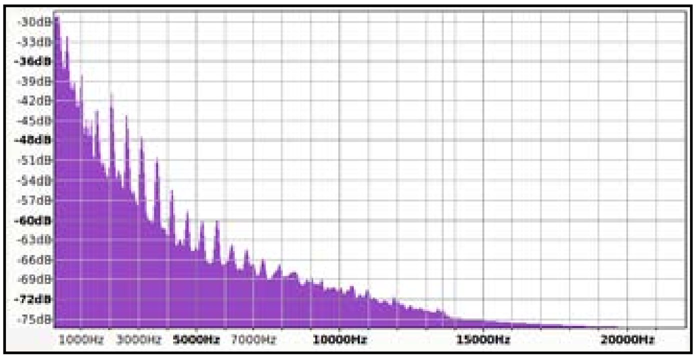


Fig. 1: Screenshot window of Frequency Analysis original noise removal function (Model 2) Song: Dream a sleepless dream. mp3

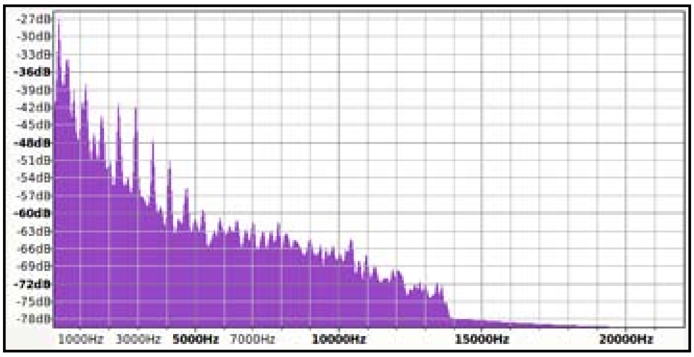


Figure 2: Screenshot window of Frequency Analysis with noise removal using prototype (Model 4) Song: Dream a sleepless dream.mp3

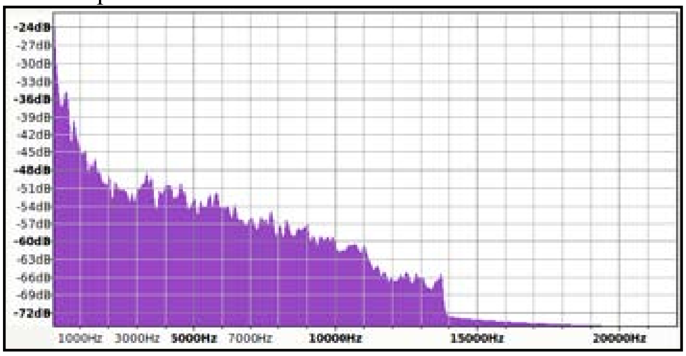


Figure 3: Screenshot window of Frequency Analysis original noise removal function (Model 2) Song: It only feels like something.mp3

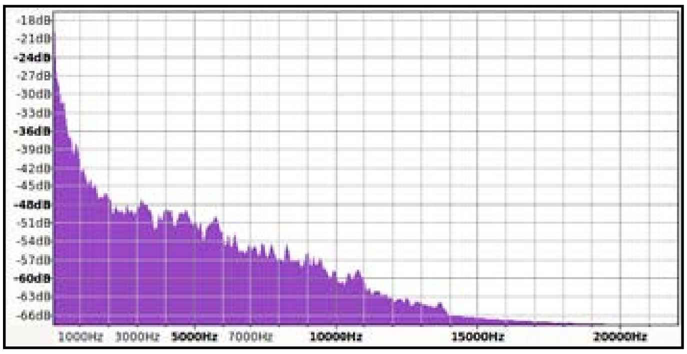


Figure 4: Screenshot window of Frequency Analysis with noise removal using prototype (Model 4) Song: It only feels like something.mp3

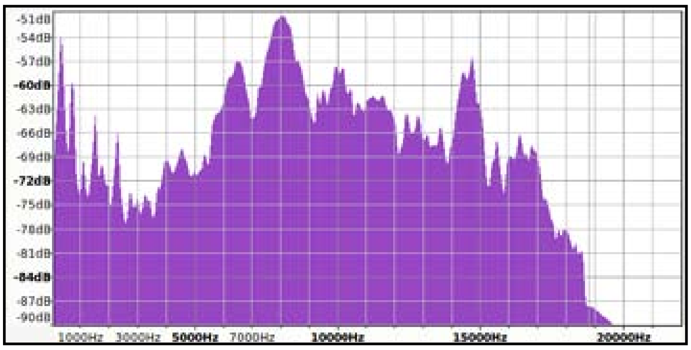


Figure 5: Screenshot window of Frequency Analysis original noise removal function (Model 2) Song: Virtual hair cut.mp3

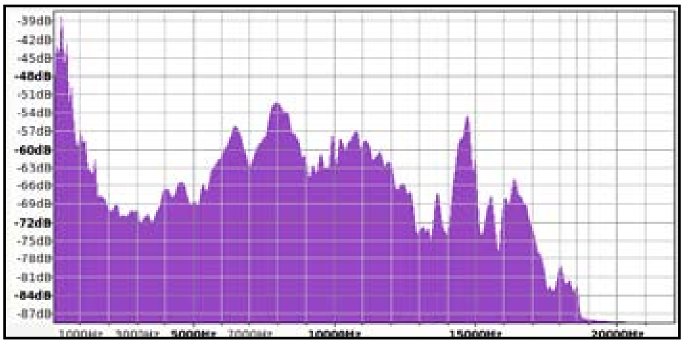
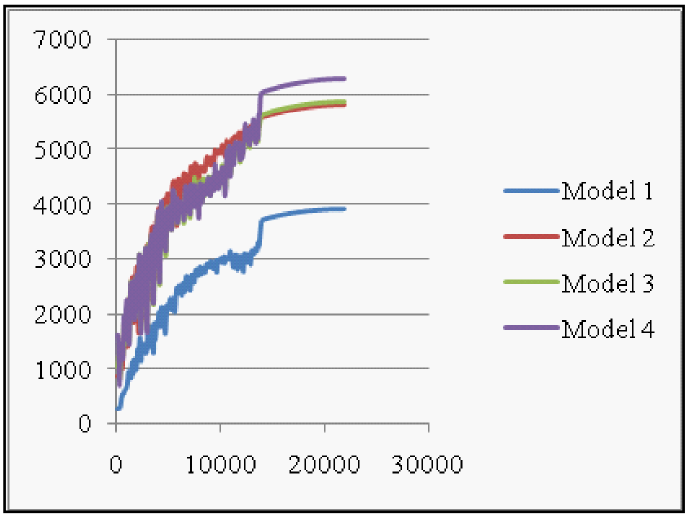


Figure 6: Screenshot window of Frequency Analysis original noise removal function (Model 4) Song: Virtual hair cut.mp3

VII. Result And Discussion

Model 1: The original plot spectrum of the original song
Model 2: The plot spectrum of song after Noise removal
Model 3: The plot spectrum of song after Noise removal having gain change
Model 4: The plot spectrum of song after Noise removal having gain and range change

In the Graphs shown below; X-axis is the frequency values and Y-axis is the sound signals in dB.



Graph1 Plot Spectrum analysis of song 'Dream a Sleepless Dream.mp3'

Table 1: Correlation Matrix (R) analysis of song 'Dream a Sleepless Dream.mp3'			
	Model 1	Model 2	Model 3
Model 2	0.971		
Model 3	0.981	0.967	
Model 4	0.978	0.950	0.995

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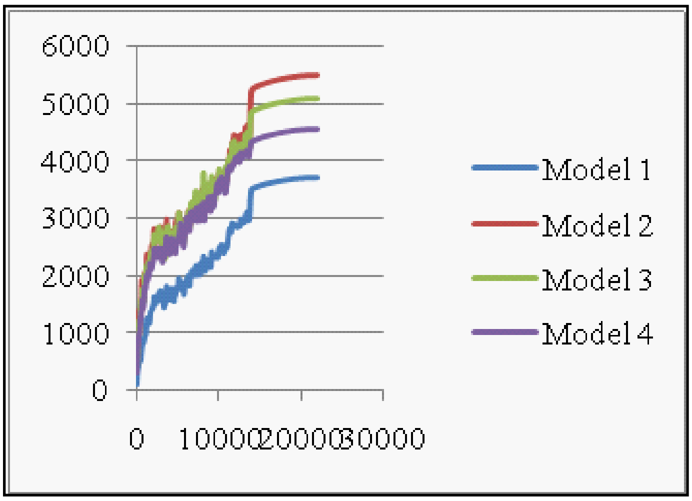
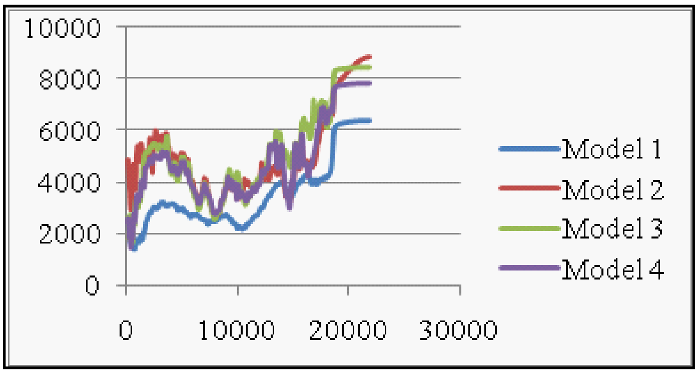


Graph 2 : Plot Spectrum analysis of song 'It only feels like something.mp3'

Table 2: Correlation Matrix (R) Spectrum analysis of song 'It only feels like something.mp3'

	Model 1	Model 2	Model 3
Model 2	0.998		
Model 3	0.996	0.993	
Model 4	0.988	0.981	0.992



Graph3 : Plot Spectrum analysis of song 'Virtual hair cut.mp3'

Table 3: Correlation Matrix (R) analysis of song 'Virtual hair cut.mp3'

	Model 1	Model 2	Model 3
Model 2	0.871		
Model 3	0.940	0.896	
Model 4	0.924	0.935	0.965

From the correlation matrices, the deviations among the model 1,2, 3and 4 are significant. The observed outputs are correlated. The significant difference is not observed within the model 2 and model 4. The original noise removal algorithm and the prototype noise removal algorithm with gain and range factors altered doesn't have major deviations in the plot spectrum analysis.
As shown in Table 1, Table 2 and Table 3 the correlation matrix values for plot spectrum analysis of different songs are correlated. The Model 2 and Model 4 values are significantly similar as compared to Model 1 and Model 2.

VIII. Conclusion

In this noise removal paper, using Audacity application software and Noise removal algorithm noise was removed. We present here a prototype algorithm, which also reduces noise from the sound signals similar to the noise removal algorithm of Audacity. The tabular results shown express that there is significant difference between Model 1 (Before noise removal - plot spectrum) and Model 2 (After Noise Removal - plot spectrum). And, model 2 is not significantly different than model 4 (After Noise Removal by gain and range change – plot spectrum); that means, the prototype algorithm is reducing the noise from sound and producing the same quality output by reducing processing overhead of the system.In this paper a novel algorithm prototype for noise reduction with altering gain values and range values is presented. Proposed algorithm prototype features Dynamic Range Control mechanism for selection of frequency instance. The overhead processing of noise reduction with gain and range change feature can be minimized.

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