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Analysis of Best Algorithm for Noise Reduction in Podcasting

Siya Sadashiv Naik, Gouri Bhatikar, Ugam Gaude
Department of Computer Engineering, Don Bosco College of Engineering, Margao, Goa, India

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ABSTRACT

Podcast allows recording of audio file on any topic. It is like an interview where one person questions and another person replies back to that question. Podcasting requires both the people to be present physically at one location. But recently, due to the pandemic, it is conducted online which most of the time results in poor quality of the audio. One of the reasons for the same is the presence of noise in it. This paper compares various noise reduction algorithms and also states the best algorithm to solve the above problem. We carried out our experiment on various audio files. Results were compared against various noise reduction methods and best ratio was obtained for Spectral Gating Algorithm.

Keywords: Podcast, Noise Reduction Methods, LMS Filter, Kalman Filter, Spectral Gating.

I. INTRODUCTION

Podcasting [1] word is derived from combining the word iPod with broadcasting. This does not mean that it can be used to broadcast only iPods. It can be used for any audio player which will allow the user to upload and download the files from the internet. Podcasting [2] is a process of capturing audio event like a song or a speech or any mix of sounds and posting that digital file to a web site or may be a blog. Podcast users called poddies can than download these files and listen on their systems at home.

The current system used for creating podcasts in one-to-one seating, is either through physical or online mode using platforms such as Google Meet, teams, etc. The online system used currently is based upon the continuous recording of the podcast from the creator's end, which sometimes fails or reduces the quality of the audio due to network issues. The online mode which has more scope is lacking behind by the method used as it significantly reduces the audio quality of the podcast. The audio quality of the podcast is what interests more listeners and content creators apart from the content.

So, the idea is to use noise reduction algorithms to eliminate noise from audio files and make the podcasting process more interesting to a larger group of people.

So, instead of recording the podcast as a single audio file, the plan is to divide the audio files into individual clips called nodes. These nodes will be recorded from both creator’s and guest’s devices separately and will significantly reduce the noise. To do this, noise reduction algorithms will be applied to each node which will enhance the audio quality by reducing the noise from it.

Since the recent pandemic, everything has been shifted to online mode but the online method for conducting podcasts was very inefficient. As a result, the quality of the podcast decreased significantly. So, therefore we have come up with noise reduction algorithms which will reduce the noise in the recorded podcast files.

The paper is organized as follows: Section II explores the various noise reduction methods. Section III shows the implementation of noise reduction algorithms. Section IV states the results analyzed and finally, section V shows the conclusion and future scope.

II. NOISE REDUCTION METHODS

Natural audio signals [3] are never available in pure noiseless form. Every signal experiences some distortion due to background noise. Therefore, every speech signal must be treated with noise reduction tools before storage or transmission.

There are several noise reduction algorithms available. But many of the algorithms have two major drawbacks. Firstly, some algorithms are really complex and hard to implement for real world scenarios. Secondly, some algorithms remove noise but alter the characteristics of the original audio signal in the process. Therefore, the audio signal after the treatment of noise is distorted and has different characteristics.

The algorithm chosen must be less complex and may cause minimum to no distortion to the audio signal. There are several algorithms for the said purpose as follows:

1. Kalman Filter

The Kalman filter [3] takes the input signal consisting of the noise and required signal and gives the unknown quantities that are close to the true value which is necessary. It uses positioning and velocity. It picks out the signal of interest from inaccurate observations.

Kalman filter [4] is used in various industrial applications including sensor less controls, diagnosis, robotics, vision and sensor fusion techniques, signal processing, instrumentation, distributed generation and storage systems.

2. Boll Spectral Subtraction

Boll Spectral Subtraction algorithm [3] enhances the audio signal by using spectral averaging and the leftover noise is removed. The spectrum of a noise signal is found by Fast Fourier Transform and subtracted from the spectrum of the spectrum of the mixed noisy signal. Hence the new signal is denoised and an inverse Fourier transform is applied to get the clean signal. This method involves subtraction of spectra of the given signal and noise signal.

This method [5] partitions the original audio signal with noise into frames. Each segment is later multiplied by using a Gaussian window function. These segments are later applied to the algorithm which results into reconstruction of the enhanced speech signal in time domain. This Subtraction Algorithm is simple to implement and hence it is used widely.

3. White Gaussian Noise Filter

White Gaussian Noises [3] are disturbances that naturally occur and this filter removes them considering an average case. This kind of noise has uniform power distribution and is distributed normally throughout the time domain. The filter characteristics are changed in the algorithm due to which the band pass filter and band stop filter are used to allow or stop different sets of frequencies depending upon the noise. Hence, using tenable filters the Gaussian noise can be removed.

White Gaussian noise [7] spread over the frequencies and therefore they are hard to remove. So, this method uses discrete Fourier transform to convert signal with noise to wavelet form. The wavelet form makes it easy to separate noise and audio based on coefficient ranges. After the noise removal, it is converted into time domain form which gives us the audio without noise.

4. LMS Adaptive Filter

LMS Adaptive Filter [8] stands for least mean square algorithm. It filters noise by calculating least mean square of the error signal. Error signal is the difference between actual signal and the desired noise less signal. It restores the desired audio signal by passing the noisy speech through a FIR filter whose coefficients are estimated by minimizing the mean square error between the clean signals It is easy to implement and can also be described in the frequency domain.

The method [3] comprises of two basic components including a digital filter and an adaptive algorithm. Adaptive algorithm has the major responsibility of adjusting the coefficients of the digital filter while the digital filter is responsible for producing an output in response to an input signal. The filter becomes more effective when the carrier frequency of the band interference is balanced from the carrier of the spectrum signals.

5. SDROM

SDROM [6] stands for signal dependent rank order mean algorithm. It is highly efficient in removing noise from highly corrupted audio signals. It also preserves data characteristics of the audio signal. It improves SNR at a greater extent. It is one of the best and effective noise reduction algorithms available. It has advantage of being a fast, robust and well effective. It can also be used in a recursive fashion.

The rank order function [3] runs a rank-order order of N. It computes the percentile window of size N. The samples are sorted in the difference and called as rank order. When the rank ordered differences are considered than the threshold value, it indicates the p. Every noise impulse detected is replaced by mean (r2+r3)/2. It is a recursive algorithm.

The applications [6] of this algorithm include in restoring of gramophone discs and scratches. It is also used in telecommunications.

6. Spectral Gating Algorithm

Spectral gate [9] is an uncommon filter effect that is used as a tool for creating sound design. It divides the incoming signal into two frequency ranges one above and another below a centre frequency band that you specify with centre frequency and bandwidth parameters. It should be specified with a centre frequency and bandwidth parameters. The signal ranges which are above and below the defined band can be individually processed with the low level and high-level parameters.

The algorithm [10] requires two inputs:

1. A noise audio clip containing prototypical noise of the audio clip.
2. A signal audio clip containing the signal and the noise intended to be removed.

Steps:-

1. Calculate the FFT over the noise audio clip.
2. Perform statistics over the FFT of the noise.
3. Calculate threshold based on the statistics of the noise.
4. Calculate the FFT over the signal.
5. Determine the mask by comparing the signal FFT to the threshold.
6. Smoothen the mask with a filter over frequency and time.
7. Apply the mask to the FFT of the signal and invert it.

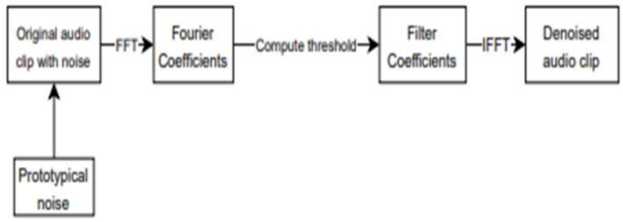

Figure 3: Spectral Gating Flow

III. IMPLEMENTATION

Experiments were carried out on Intel Core i5 processor, 64-bit OS and 4GB RAM. Programming Language used was MATLAB and Python.

Noise Reduction Algorithms were implemented and it was seen that best SNR ratio was obtained for Spectral Gating Method. SNR ratio is given as follows:

SNR = Power of the signal/ Power of the noise

Noise Reduction Algorithms	SNR Value
LMS filter	2
Kalman filter	6
Spectral Gating	14

TABLE I: COMPARISON OF SNR VALUES

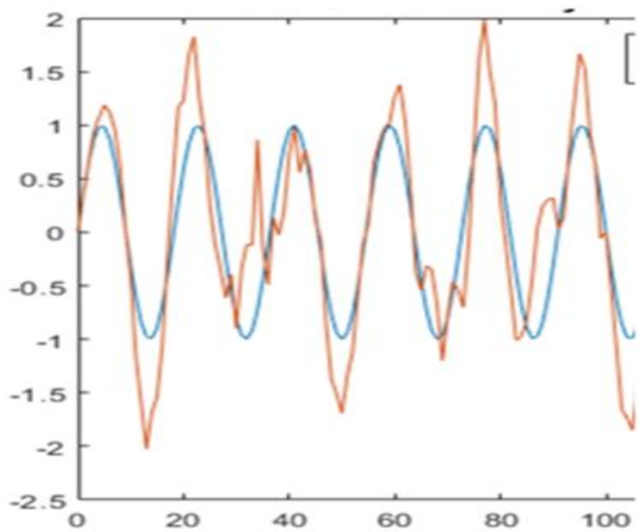

Figure 2: Graph for LMS Filter

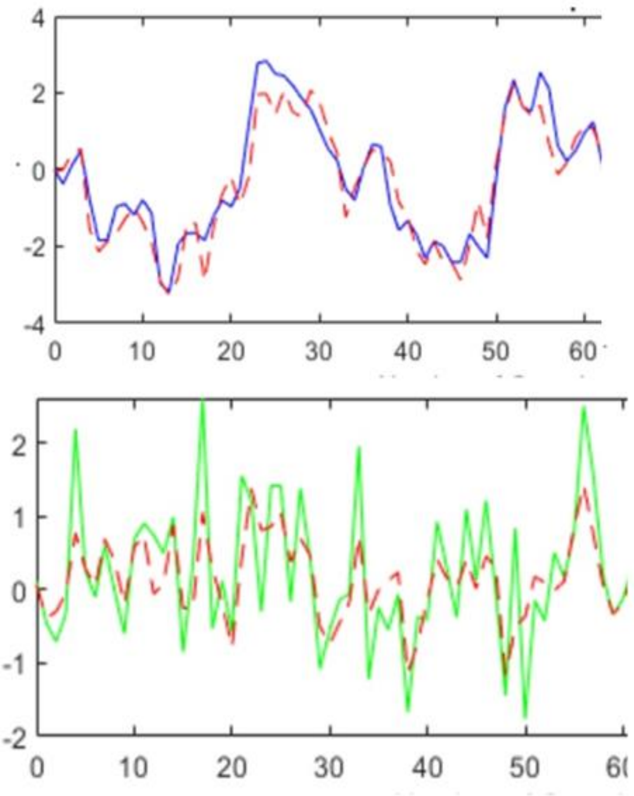

Figure 3: Graph for Kalman Filter

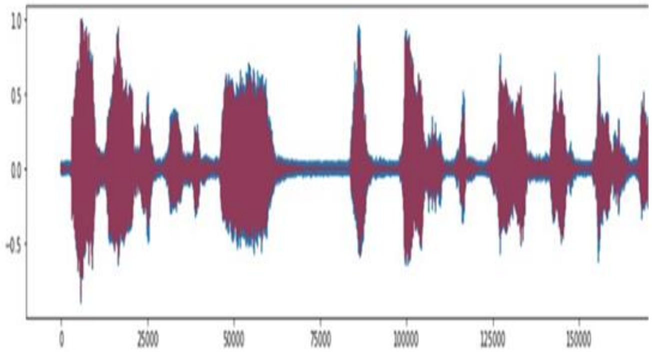

Figure 4: Graph for Spectral Gating

IV. CONCLUSION AND FUTURE WORK

A podcast is series of spoken words digital audio files that can be downloaded by the user for listening. It was seen from the results of implementation that the spectral gating method gives the highest value of signal-to-noise ratio. Therefore, it is an effective method of noise reduction for recorded podcast audio file.

As a future work, this method can be applied with other methods to increase the accuracy of the result.

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