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# An Overview of Noise Cancellation Techniques

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**Abstract**
Noise are the unwanted signal or disturbance in the network, there are many sources form where we can get the disturbance in the signal due to with the fidelity of the signal gets low and hence we are not able to understand the message or actual inputs from the speaker.
In the paper we try to elaborate the techniques to mitigate the nose signal or noise channel so as to capture the original signal with high fidelity.
On the contrary the noise channel may cause several health issues such as loosing the hearing ability hence we need such system which ensures the protection to human system damages from noise.

**Keywords**
Noise, SNR, Fidelity, Channel, Signal Path, Active Noise Control, Least Mean Square, Adaptive Filtering

**Introduction**
Today, we are living in the era of communication where we have lot of signals besides us, the sources of signals are almost infinity and hence we came across the noise which is the undesired to us due to its nature of disturbing the original signal. Thus to avoid the noise channel and achieve the high fidelity we need a mechanism know as Noise cancellation techniques.
The Noise cancellation is also known as Active Noise Control, in this process we try to reduce the amount of unwanted noise from entering an audio system or channel or signal path.
Noise cancellation techniques has wide range of application ideally for almost all the type of electronic and communication devices / gadgets we need this system to get the best fidelity.
Since the human hearing system can only recognize the frequencies in the range from 20Hz to 20Kz. i.e if we get the sound wave with in this range then only we can hear also at a time human can understand or process only one sound signal this limitation of human definitely directs to developed such systems with is free from noise.

**Important terminologies:**
**Sound Signals:** The sound wave can have Lower and higher frequencies lower frequency sound signals possess a longer wavelength, as they complete fewer cycles per second, where as higher frequencies complete faster cycles and carry a shorter wavelength. The sound signal is measured in Decibels (dB).

**Phase**: The Phase is the relationship between two or more audio waveforms. If two identical audio signal or waveforms are played with one another(in Phase), they create a louder sound – known as phase reinforcement. This means we can have very strong signal or high fidelity signal.

Similarly If one of the waveforms is reversed(Out of Phase) before the waveforms are played together, they interact negatively and result in the listener only hearing the difference between them. This means that we can have noise signal.

**Reinforcement or Amplification:** It is process by which we can amplify the original sound signal so that we can get a loud or amplified sound, the devices used here are known as amplifiers.

**Attenuation:** It is the process by which we can we get the losses of signal strength during transmission or reduction in the intensity or amplitude – to make a sound signal softer

**What is Noise Cancellation?**

Noise cancellation in sound system, an approach by which we try to reduce or eliminate or mitigate unwanted ambient noisy signals.

**Noise Cancellation Techniques**

As Noise are the unwanted signal introduced at the output so as to attenuate the original signal and mix with the signal to get the disturbance at the output. Hence to mitigate this signal we have to apply the noise cancellation techniques.

With the help of noise cancellations we can simple reduce (attenuate) the unwanted noise from the original signal so that the it does not appear at the output. There are many sources of such unwanted noise such as wind, noise from other systems, external factors such as generator or machinery etc. causes interferences in the original signal.

**There are following techniques for Noise cancellation**

a) Passive Noise Cancellation (PNC)
b) Active Noise Cancellation (ANC)
c) Hybrid Noise Cancellation (HNC)
d) Environment Noise Cancellation (ENC) and
e) Advanced Noise Cancellation(AdNC)

**a) Passive Noise Cancellation (PNC)**

This techniques base on modification of the physical features of handsets. We can
Modify the physical structure of handset such as adding extra thick padding around the ears to increase the isolation between the listener and the surroundings. The use of sound-absorbing materials with cushioning absorbs and dampens external noise, mitigate its impact on the user's listening experience.
This can be implemented at industries where workers are working near to the loud machinery or at Mines or at Construction sites where they preserve their ears by using the sound proffer into their ears.
Here, we tried to isolate the sound by introducing physical separation of a noise source from a receiving environment, such as using earplugs or earmuffs to block external noise.

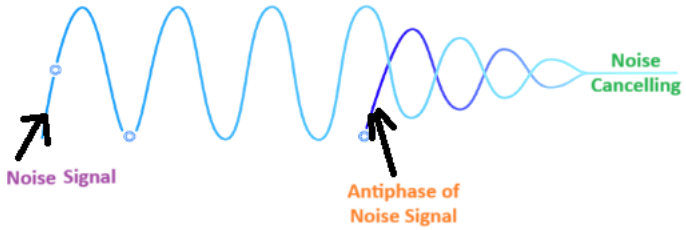
**b) Active Noise Cancellation (ANC)**

In these techniques we use the phase cancellation techniques which can mitigate the unwanted signal such as background noise to get mix with the original signal.

**Working of ANS System:**

With ANS system we actively counter the noise by generating an anti-noise signal with the help of electronic circuits. The anti-noise signal so produced is then mixed with the original sound signal or audio content. Once it get mixed with the original signal with noise because of its anti – phase with noise signal effectively it cancels our or rather reduces the unwanted background noise which causes the listener to get the desired sound frequency or desired sound with amplification, this all process happens in real time and very faster with accuracy to get the high fidelity signal at the listener allowing the listener for seamless and uninterrupted original / desired signal frequency sound.

The ANS system are designed to become more adaptive in nature that means it continue monitor the environment in real time and when and where needed produces the anti-noise signal accordingly, ensuring optimal cancellation even if the noise phase or characteristic changes. The adaptive nature of ANS makes it perfect system to reduce a wide range or frequencies of background noises.

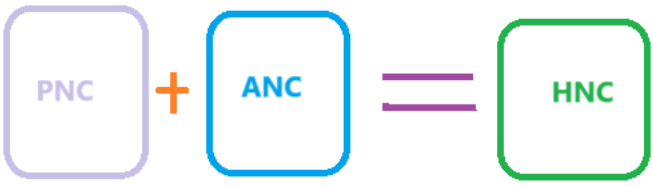



Active Noise Cancellation (ANC)

Thus, by using the noise canceling headphones we can mitigate the background noises – such as noise or car, train, machinery etc. thereby getting the original amplified signal at output. The example of active noise cancellation is headphones or earplugs.

**c) Hybrid Noise Cancellation (HNC)**

In hybrid nose cancellation utilizes both the techniques of PNC and ANC so that we can get best noise cancelling system.




Hybrid Noise Cancellation (HNC)

**Following are the benefits achieved**

• Increased Noise Isolation: By using physical barriers to block low-frequency noise and active cancellation for high-frequency noise, hybrid systems can provide more comprehensive noise cancellation for the channel.

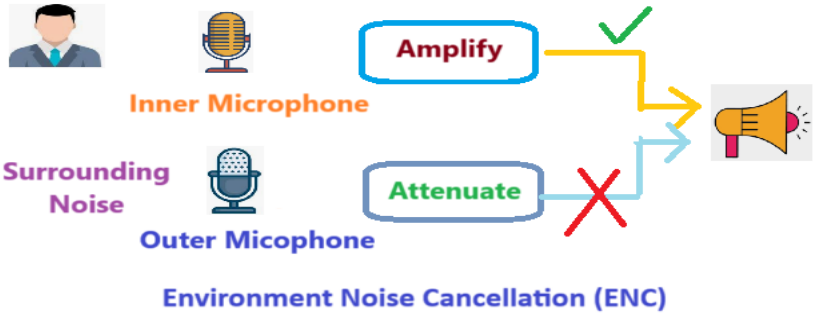
• High Versatility: HNS system can be designed to adaptive and programmed for working with different environments and noise channel sources.

• Optimize Costing: By leveraging the strengths of both the techniques such as PNS and ANS in HNS, we can have hybrid systems which is capable for more effective noise cancellation at a optimized cost compared to that of standalone ANC or PNC systems.

**d) Environment Noise Cancellation (ENC):**

As the name suggests the ENC techniques actively work in the real time environment where the user is working. In this technique we require use of two microphones inner and outer, the inner microphone is for the user i.e. it captures and converts the voice of user (desired voice signal) and further amplify it, on the other hand the outer microphone captures the surrounding noise signals and attenuates it. Then, both the sound so capture from the microphones are optimized and sent through channel by so that the receiver will get the more clarity of the desired sound signal.

ENC can effectively cancels out ambient noises present in the environment like background chatter, traffic, or wind.




**e) Advanced Noise Cancellation(AdNC):**

The AdNC techniques are categorized further as discussed below

**i) Clear Voice Capture (CVS)**

This techniques of Noise cancellation are more advanced and complex in implementation comparative to other noise cancelling techniques . CVS requires software and hardware combination for its functionality. This techniques uses advanced algorithms and signal processing techniques to identify and suppress unwanted noise there by preserving the integrity of the user's voice. This techniques have capability to adjust in the dynamic environment, CVS system continuously monitors the changing acoustic environment, dynamically adjusting the noise reduction parameters to provide optimal voice clarity.

CVS ensures enhanced voice quality, automatic gain controls, use of adaptive equalizers, comfort noise, howling control, nonlinear processing, power savings techniques, auxiliary stream mixing and frequency-enhanced speech intelligibility which can be possible with the use of software. Example of a CVC device is an earphone-TRANYA T6

**ii) Digital Signal Processing (DSP):**

DSP utilizes the DSP processor for its functioning, it collects the ambient sound with the help of microphone and process with the help of algorithms. It can apply powerful techniques by which signals can be analyzed, filtered and also increases the quality. For

noise reduction, DSP uses techniques such as noise shaping, spectral subtraction, or adaptive filtering etc. as per the requirement of the user.

With DSP invokes operations on signals such as used such as noise reduction, signal filtering, signal compression, signal enhancement, signal synthesis, and signal analysis etc.

**Example**: Speakers Sonos One, or JBL Flip 5, Bose SoundLink Revolve+

**Implementation**

We can have several techniques of implementation of Noise Cancellation System. We can use the optimum algorithms and filters for its implementation. Here, we have the adaptive filtering algorithms like LMS and NLMS algorithms used for active noise cancellation.

a) Least Mean Square (LMS) algorithm and
b) Normalized Least Mean Square (NLMS) algorithm
c) Adaptive Filters

**a) LSM**

The Least Mean Square algorithm was introduced by Stanford Professor Bernard Widrow and Ted Hoff in 1960. It's a type of adaptive filter known as the stochastic gradient-based algorithm since it uses the gradient vector to coverage on the optimal wiener solution.

It has been used due to its computational simplicity.

**b) NLMS**

Another algorithm is called the Normalized Least Mean Square algorithm. The NLMS algorithm is a modification of the LMS algorithm aiming to overcome LMS's computational disadvantages. NLMS algorithm is better in terms of simplicity and performance.

**c) RLS**

The recursive least squares (RLS) algorithms, are known for their excellent performance and greater fidelity, but they come with increased complexity and computational cost.

Compared to the LMS algorithm, the RLS approach offers faster convergence and smaller error with respect to the unknown system at the expense of requiring more computations.

**d) Adaptive Filters**

As we can think of Noise is random process and adaptive filters have the capability to adjust their impulse response to filter out the correlated signal in the input. Further, they require modest or no a priori knowledge of the signal and noise characteristics. In addition adaptive filters have the capabilities of adaptively tracking the signal under non-stationary conditions. The usage of adaptive filters is one of the most popular proposed solutions to reduce the signal corruption / interferences caused by predictable and unpredictable noise.

Adaptive Noise Canceller (ANC) is used removes or suppresses noise from a signal using adaptive filters.

**Following steps illustrate the process to remove the Noise signal from the corrupted signal:**

Step 1: Record : a speech signal via MATLAB software

Step 2: Add Noise: white noise or random noise to the recorded speech signal and plot their respective graphs.

Step 3: Choose Filter: between LMS and NLMS and RLS adaptive filter for active noise cancellation of the corrupted Speech signal.

Step 4: Vary the variables which are associated with the adaptive noise cancellation filters such as filter length and step size.

Step 5: Plot the de-noised speech signal obtained as the output of the adaptive noise cancellation filter.

Step 6: Calculate SNR (signal to noise ratio), Correlation coefficient and MSE (mean squared error).

Step 7: Repeat the same procedure for the other adaptive noise cancellation filters.

Thus, we can implement the LMS, NLMS and RLS adaptive noise cancellation algorithms.

**Applications**

Noise cancellation has become an essential feature in various industries and consumer products, providing a more comfortable and focused user experience.

- Ear buds and Headphones
- Aviation and Transportation
- Industrial and Construction Environments
- Personalized listening experience
- Call center and customer service operations
- Offices
- Hospitals
- Study Centers (School and Collages)

**Conclusion**

This paper highlights today's technology for getting the high fidelity system with reduced distortions. Thus it became important for the individuals to understand its specific need, preferences, costs and the environment to choose right technique to mitigate the noise.

We have also discussed Least Mean Square (LMS), Normalized LMS, recursive least squares (RLS) algorithms are the adaptive filter based de-noising techniques.

ANC, PNC, HNC, ENC and AdNC are the modern technology to increases the user experiences and getting the best audio content at the output. User can become choose whether to go for simple noise reduction, or an active noise cancellation or may have hybrid approach so that they can use the technology and acquire the maximum benefit with minimum damage to the human acoustic system.

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