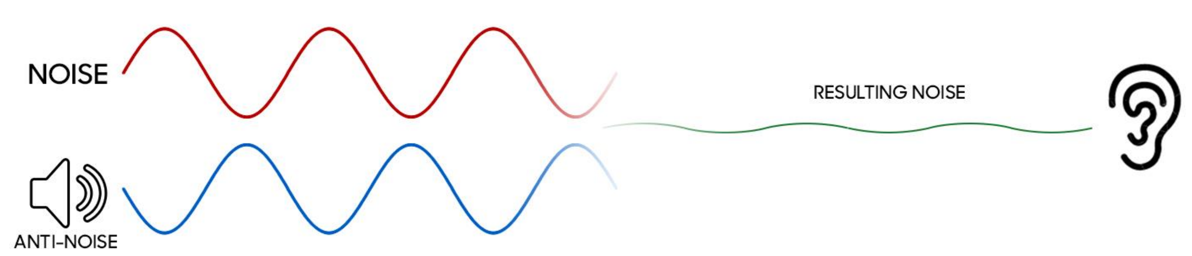
An Audio Integrated Noise Control system

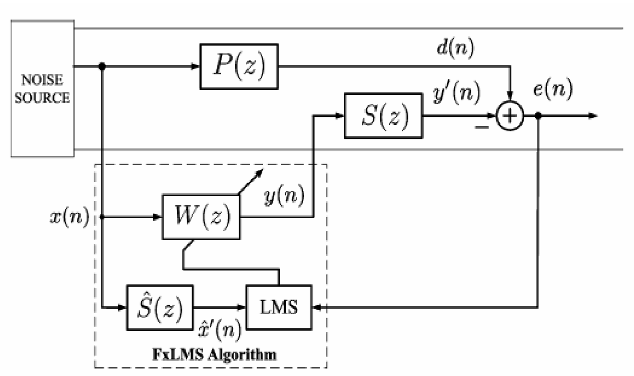
Yang Lu
Department of Electrical and Computer Engineering
University of Rochester

Introduction

This paper introduces a noise canceling approach by using modified FxLMS Algorithm with online secondary path modeling and variable step size. Different from the noise canceling system on the market, the desired audio signal is injected into the ANC system and being output with the cancelling noise.



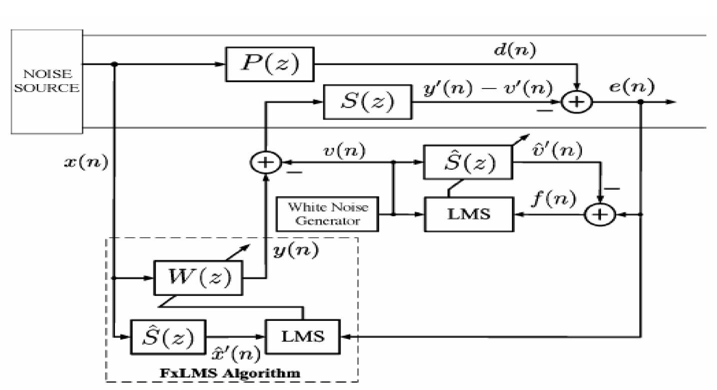
FxLMS Algorithm



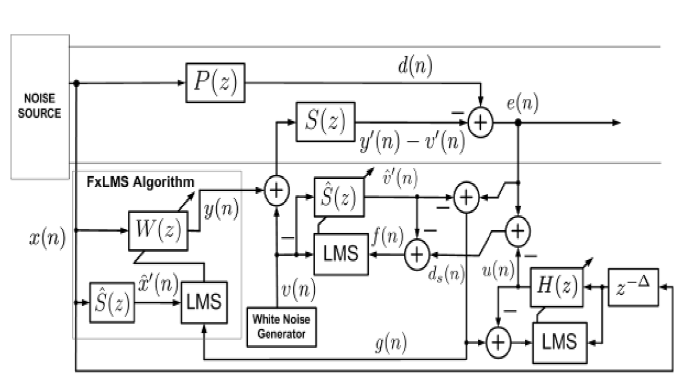
For real-time applications, the secondary path is consisted of amplifier, DAC, reconstruction filter and the loudspeaker, etc. And will not always be stationary. Therefore, updating secondary path is required and critical for some ANC systems.

Methods Overview

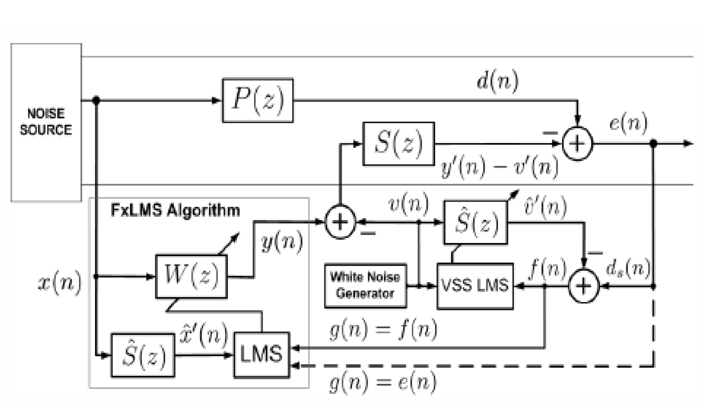
Three well-known methods for ANC system with online secondary path modeling have been tested and compared in the paper.



Eriksson's method:
Baseline for ANC system with online secondary path modeling.
Pros: Low computation complexity.
Cons: Slow rate of convergence and system can be unstable.



Zhang's method:
Three adaptive filters are used in this method.
Pros: Faster convergence rate and more stable.
Cons: High computation complexity.



Akhtar's method:
Variable step size is implemented in this method.
Pros: Better overall performance than Zhang' s method and has lower computation complexity.
Cons: Convergence rate varies with the input signal.

Variable Step Size

The canceling noise $y'(n)$ is zero in the initial stage of the modeling process, and disturbance of the system is given as

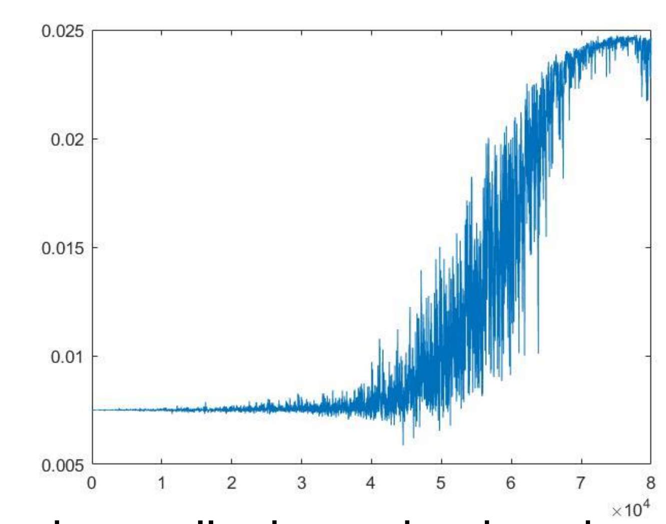
$$u_m[d(n) - y'(n)]v(n)$$

This component will decrease as $y'(n)$ gradually converges to $d(n)$. Therefore, in order to improve the convergence rate and maintain a stable system, we should apply a small step size us at the beginning of the modeling process and switch it to a large step size uL in the later stage of the modeling process.

$$P_e(n) = \lambda P_e(n-1) + (1-\lambda)e^2(n)$$

$$P_f(n) = \lambda P_f(n-1) + (1-\lambda)f^2(n)$$

$$u(n) = p(n)u_{min} + (1 - p(n))u_{max}$$

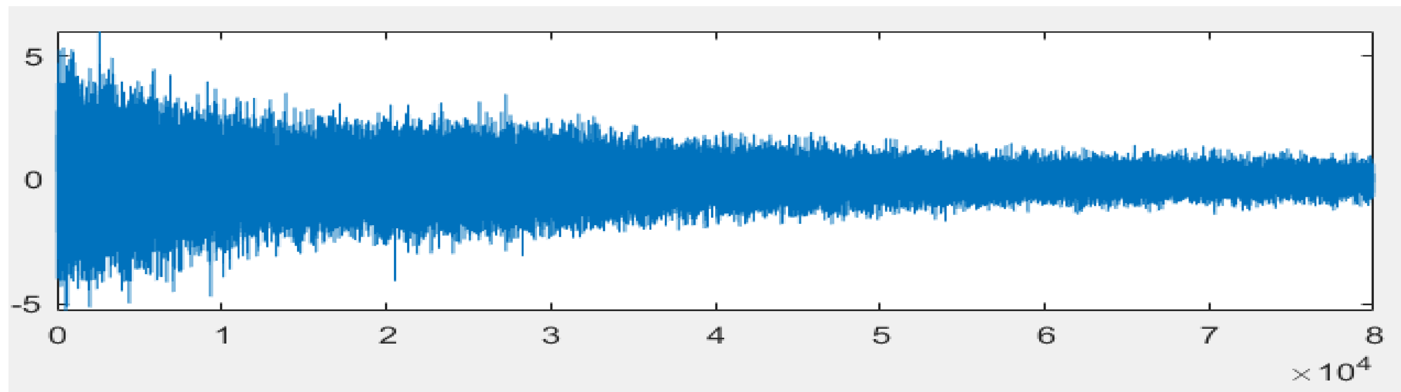


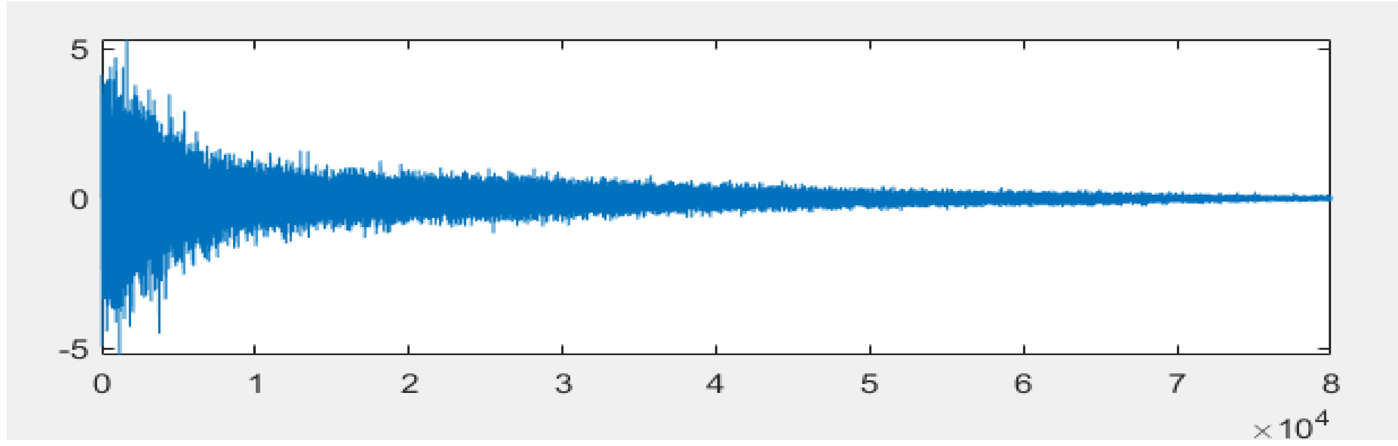
The upper and lower boundaries are experimentally determined so that the convergence rate is neither too slow nor unstable.

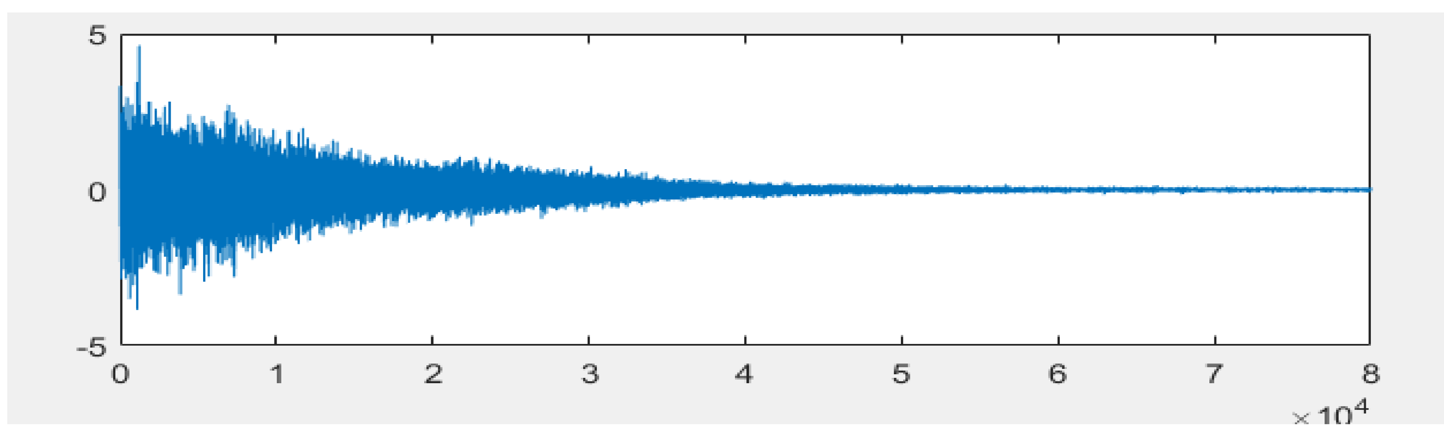
$$u_{max} = 2.5 \times 10^{-2} \qquad u_{min} = 7.5 \times 10^{-3}$$

Performance Simulation

White noise is used as the noise signal in the performance simulation, and the sound of running water is used as the audio signal.

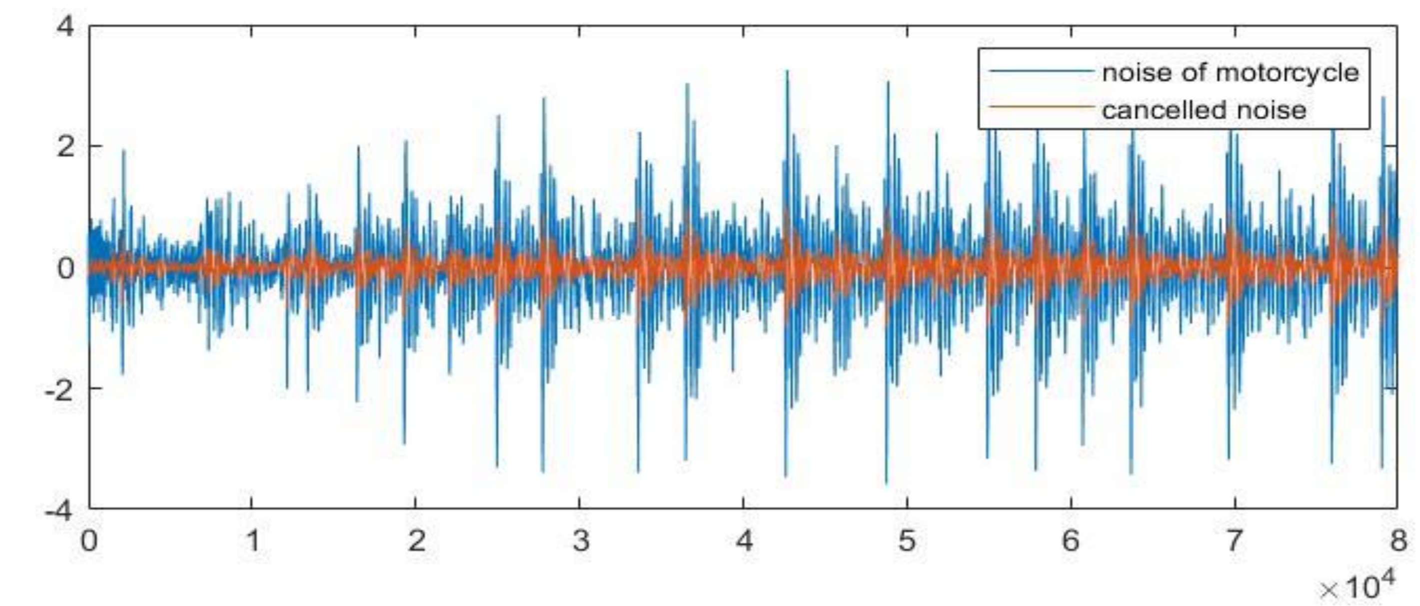


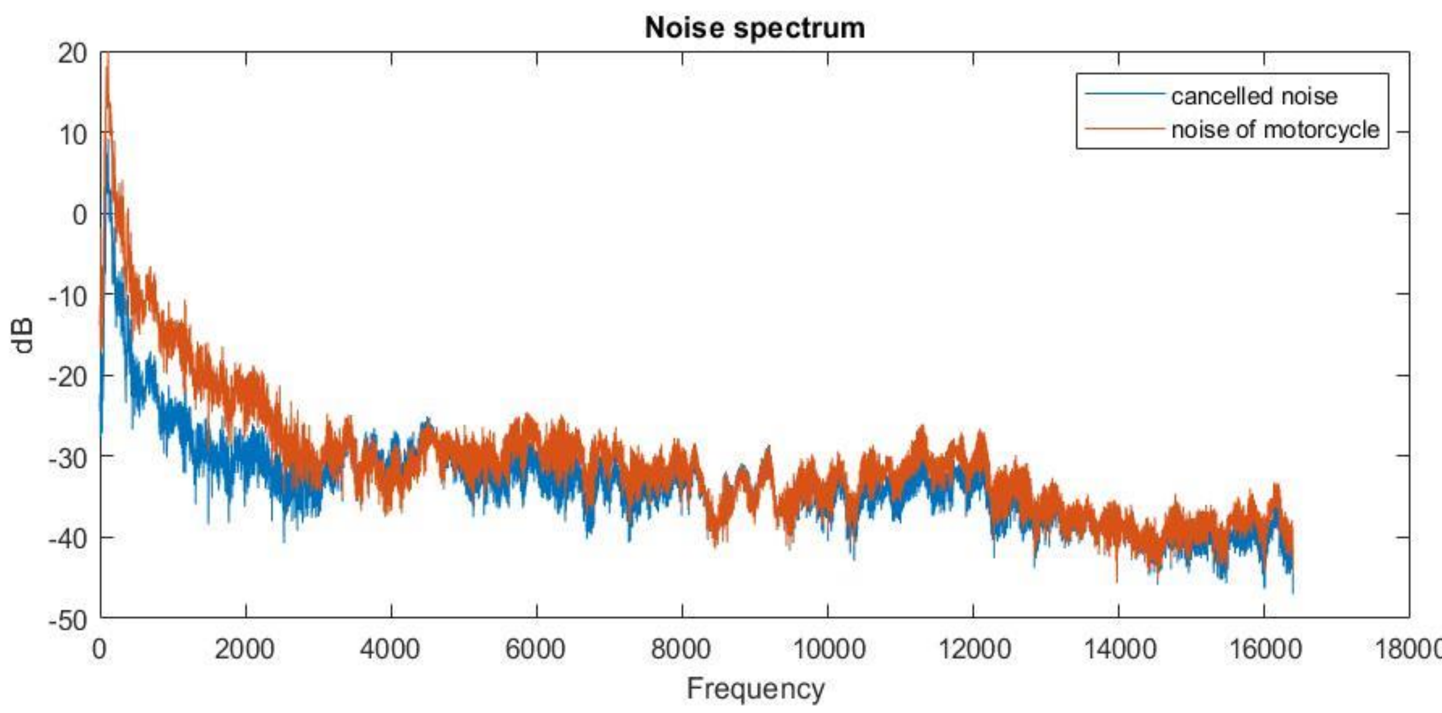




Audio Integrated Results

Noise of motorcycle is used as the noise for the system, and random music is used as the audio signal.





Conclusion

- The audio integrated noise control system can effectively cancel the low frequency noise signal below 1000Hz while playing the desired audio signal.

Future Work

- More research will be conducted on the improvement of the convergence rate and the stability of the overall ANC system.
- More research and data collection should be done on the selection of audio signal in a more psychoacoustic way.