Investigation of Diesel's Residual Noise on Predictive Vehicles Noise Cancelling using LMS Adaptive Algorithm

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Investigation of Diesel's Residual Noise on Predictive Vehicles Noise Cancelling using LMS Adaptive Algorithm

Sri Arttini Dwi Prasetyowati[1], Adhi Susanto[2], Ida Widihastuti[3]

[1,3] Electrical Engineering Dept, Islamic Sultan Agung University, Semarang, Indonesia
[2] Departement.of Electrical Engineering, Technology Faculty, Gadjah Mada University, Yogyakarta, Indonesia

[1] arttini@unissula.ac.id

Abstract. Every noise problems require different solution. In this research, the noise that must be cancelled comes from roadway. Least Mean Square (LMS) adaptive is one of the algorithm that can be used to cancel that noise. Residual noise always appears and could not be erased completely. This research aims to know the characteristic of residual noise from vehicle's noise and analysis so that it is no longer appearing as a problem. LMS algorithm was used to predict the vehicle's noise and minimize the error. The distribution of the residual noise could be observed to determine the specificity of the residual noise. The statistic of the residual noise close to normal distribution with = 0,0435, = 1,13 and the autocorrelation of the residual noise forming impulse. As a conclusion the residual noise is insignificant.

1. Introduction

Residual noise always appear after the execution of cancelling noise process. The correlation between residual noise and White Noise Gaussian (WNG) is important to be investigated, because WNG cannot be eliminated further. The previous proposal investigated that the noise cancelling process was still leaving the residual noise[1] while Ref. [2] examine about time-frequency domain methods for noise estimation and speech enhancement. The aims of this research are to analyze the statistic of residual noise and observe the distribution curve.

LMS Adaptive algorithm is the robust and simple algorithm so that it can be applied to the complex signal. The noise from the vehicles were quite complicated, because the noise change fluctuations or not static [1]. The simplest structure, Linear Combiner, can be executed simply. The Equation can be shown on the Equation (1).

$$y_k = w_{ok}x_k + w_{1k}x_{k-1} + w_{2k}x_{k-2} + \ldots + w_{Lk}x_{k-L} = \sum_{l=0}^{L} w_{lk}x_{k-l} \quad (1)$$

LMS Adaptive is one of the simplest adaptive algorithm that can solve the complex problem of vehicle's noise. The LMS Adaptive Algorithm can be shown on the equation (2).

$$\mathbf{W_{k+1}} = \mathbf{W_k} + 2\mu\mathbf{X}_k\ \varepsilon_k \quad (2)$$

Equation (2) is used to find the correct weight which used on equation (1). Besides two equation, needs to find the correlation of the error which is obtained from difference of noise that want to cancel and the output of the system [3].

The configuration in Figure 1 illustrates the most appropriate scheme for vehicle's noise cancelling and equation (1) and (2) are used in the block of that configuration [4].

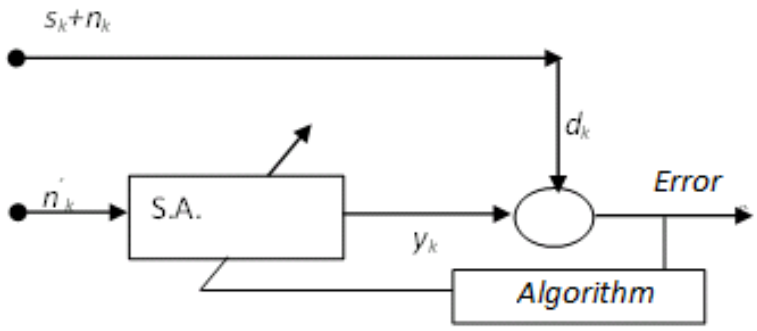

Figure 1. Configuration of Noise Cancelling

2. Method

Data from diesel vehicles were recorded. The collection of that data was processed by LMS predictive algorithm for minimizing the noise. Error that occur on the end of the process is called residual noise. The statistic of the residual noise was count. The grafic of the residual noise's statistic is shown in Figure 2. The horizontal axis shows the value of the signal, the vertical axis shows the amount of the each value.

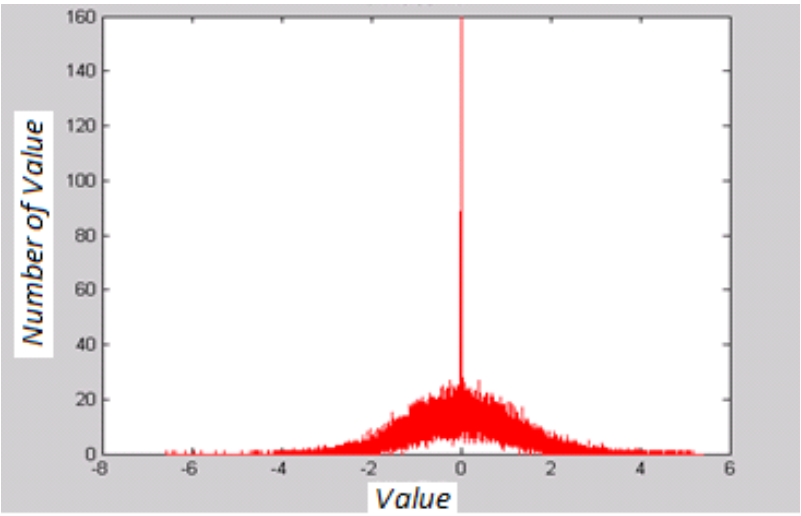

Figure 2. the statistic of the residual diesel's noise

It was called the statistic of the residual noise. The fitting curve of Figure 2 after taken the logarithm would be compared with the logarithm of the normal distribution. The analysis is as follows:

At the first time, scrutinized the autocorrelation. If there was still forming impuls, its shows that there was a noise. The autocorrelation of the residual noise shows in Figure 3.

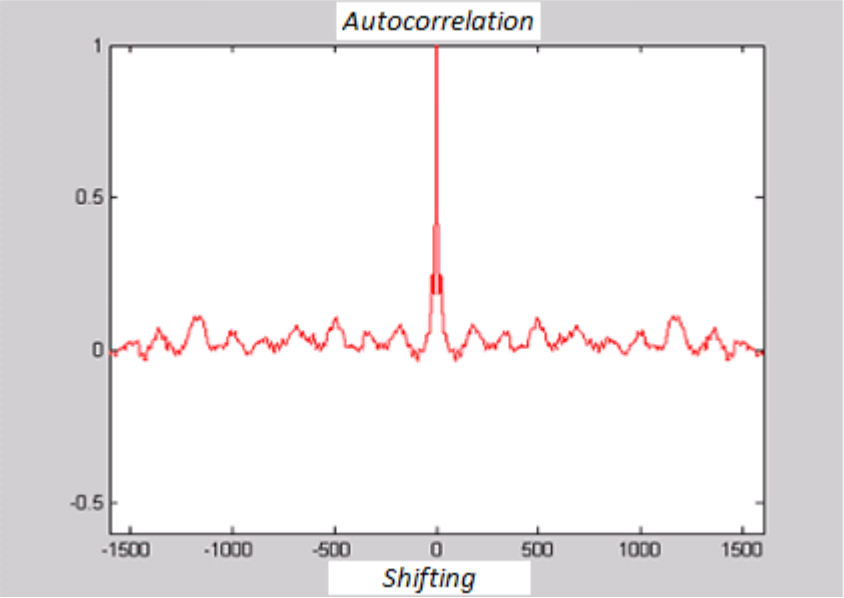

Figure 3. Autocorrelation of the residual Diesel's noise forming impuls

The condition that autocorrelation of the residual noise forming impuls confirm that there was a noise.

The next process is to analyse the distribution function of diesel's residual noise. It will be investigated if the distribution close to normal distribution or not.

The Normal distribution: $N(x,\mu,\sigma)=\frac{1}{\sigma\sqrt{2\pi}}\exp\left[-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2\right]$

$$\ln[\,N(x,\mu,\sigma)\,]=\ln\frac{1}{\sigma\sqrt{2\pi}}\exp\left[-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2\right]$$

$$=\ln\,(\sigma^2 2\pi)^{-1/2}\exp\left[-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2\right]$$

$$=-\frac{1}{2}\ln(2\pi\sigma^2)-\frac{1}{2}\left[\frac{x-\mu}{\sigma}\right]^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$\text{y\_diesel} = -0{,}39x^2-0{,}034x+2{,}6=-\frac{1}{2}\frac{(x+0{,}0435)^2}{1/0{,}78}-(0{,}39)(-6{,}67) \quad \ldots\ldots\ldots\ldots \quad (4)$$

From Eqs. (3) and (4) the result were

$$\sigma^2=\frac{1}{0{,}78}$$

$$\sigma=\sqrt{\frac{1}{0{,}78}}$$

$$\sigma=1{,}13$$

So, the first result is $\mu=-0{,}0435$ and $\sigma=1{,}13$.

The value of σ also can be taken from

$$-\frac{1}{2}\ln(2\pi\sigma^2)=(0{,}39)(-6{,}67)$$

$$-\frac{1}{2}\ln(2\pi\sigma^2)=-2{,}6013$$

$$\ln(2\pi\sigma^2) = 5{,}2$$
$$2\pi\sigma^2 = e^{5{,}2}$$
$$\sigma^2 = \frac{e^{5{,}2}}{2\pi}$$
$$\sigma = \sqrt{\frac{e^{5{,}2}}{2\pi}}$$
$$\sigma = 5.373$$

There were two result for σ: σ = 1,13 and σ = 5,373. Because σ or standard deviation, measured how the data values are spread. Standard deviation (σ) could also be defined as the average of the difference of data measured by the mean of data. In addition to mathematical calculation, the fitting curve of statistic of the residual noise is in Figure 4 and be enlarged at Figure 5.

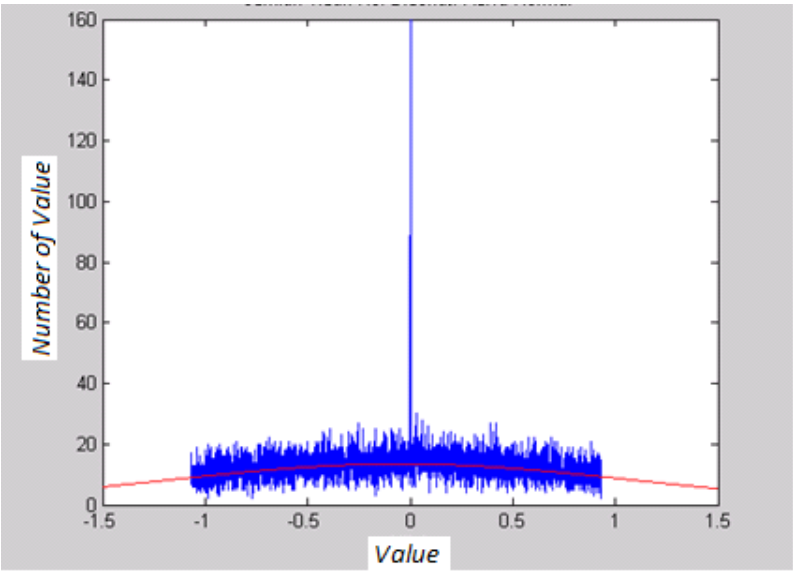

Figure 4. Fitting curve of the residual noise's statistic

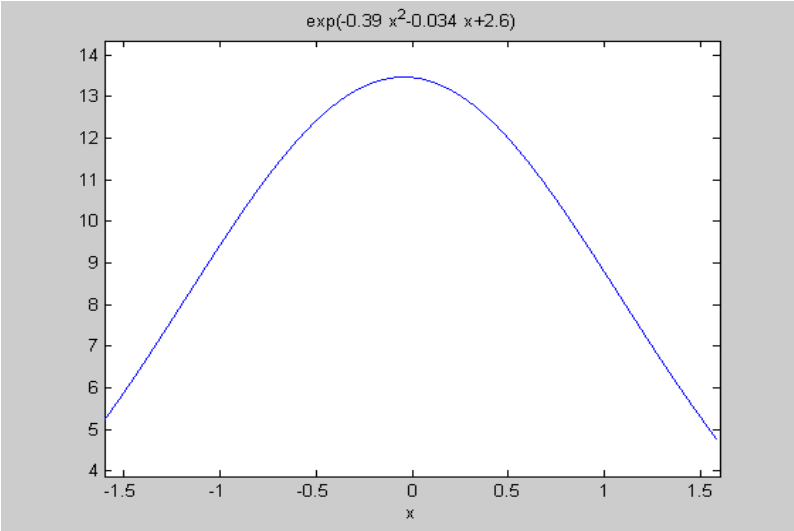

Figure 5. Enlarge of Figure 4

Figure 5 is close to the normal distribution (with $\mu = 0$ and $\sigma = 1$). Therefore, the diesel's residual noise was a white noise Gaussian. Based on the mathematical calculation and Figure 5 it is found that $\mu = -0{,}0435$ and σ close to1,13 than 5,373.

3. Conclusion

From the description above, it can be concluded that the statistic of the residual noise close to normal curve with $\mu = -0{,}0435, \sigma = 1{,}13$ and the autocorrelation of the residual noise forming impulse. That confirms the noise is no longer appear as a problem or no longer disturb.

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