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Gear Classification

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Abstract: ***This paper explains how we can replace a human being in a factory create small pump for pumping water who check the quality of the gear inside motor to find out whether they are good or damaged. Human tend to hear some kind of noise which are already notified that one of them is good noise and another one is bad noise, so he judges the gear according to the sound made by the gear on the motor. The system proposed is going to replace a human by giving out the results whether gear is good or bad by checking the sound produced and make a comparison between the good gear sounds with the new gear sound that has been produced.***

Keywords: cross-correlation, convolution, autocorrelation, sample difference.

1. Introduction

In this paper, we are going to go through the classification of good gear and bad gear based on sound from the gear after connected the external motor. After the gear manufactured it was realized that some of the gear were malfunction so the study was conducted. Study show that when the gear connected to the motor tends to gives different sound. Then the sound of the gears was collected and the gears were tested, then after the good ones their sounds were stored different with the bad ones. This make us know the sound for the good gear and the sound of the bad ones. For this job one man should stay at the end of the process of gear manufacture and hear the sound of the gears then choose which are good and which one are bad. For this part job is tough since the man has to stay the whole manufacturing period to make the checkup, also its easy for the man to make mistakes and confuse the good gears and bad gears.

Therefore, the purpose of this paper is to design a system that will take place the man position and do the work with minimum supervision. This means the system will receive the sound made by gears decide whether the gear is good or bad. This is the best way because the system will never get tired also system always follow instructions so there will be no mistakes of its own.

2. Proposed System

The proposed system will use MATLAB software to handle the task, which means the classification of good gear and bad gear based on sound produced from the gears. We will be having the good sound gear which was obtain before from the person listening and deciding the performance of the gears. Then from that good sound we will use that as a reference sound, in which other gear will be compared to. The other sound gear will be extracted from real time during operation using microphone. Here there is a challenge since during recording of the second, we have to avoid getting other noise mix up with our original sound. We have to record these sounds in quite place where other sound cannot affect the sound must be smart since other hardware can also be the source of noise. So, after obtain the real-time sound which is the one we intend to judge whether it's good or bad sound we have to use some of the ways to make the classification. In MATLAB, there are some ways used to check the similarities between the signals. First let discuss way used in MATLAB to check the similarities between signals.

2.1 Cross correlation

In signal processing, cross-correlation is a measure of similarity between two series as a function such as audio in our case. Can be named as a sliding dot product or sliding inner-product. It is widely used for searching a long signal for a shorter, known feature. It can be used in pattern recognition, single particle analysis, electron tomography, averaging, cryptanalysis, and neurophysiology.

This is a formula definition of continuous function of f and g:

$$(f * g)(\tau) \stackrel{def}{=} \int_{-\infty}^{\infty} f*(t)g(t+r)dt,$$

Where,

f*= complex conjugate of f.

τ = displacement, also known as lag.

Positive value of τ means that g (t+ τ) leads g(t).

For discrete functions, the cross-correlation is defined as:

$$(f * g)[n] \stackrel{def}{=} \sum_{-\infty}^{\infty} f*[m]g[m+n].$$

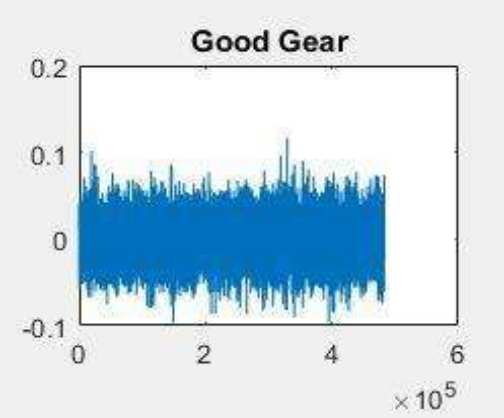
Let see the comparison of convolution, cross-correlation and autocorrelation. The cross-correlation is similar to the convolution of two functions. In an autocorrelation, which is the cross-correlation of a signal with itself, there will always be a peak at a lag of zero, and its size will be the signal power. In probability and statistics, cross-correlations can be used to refer the correlations between the entries of two random vectors X and Y, while the autocorrelations of a random vector X are considered to be the correlations between the entries of X itself, those forming the correlation matrix (matrix of correlations) of

X. This is analogous to the distinction between autocovariance of a random vector and cross-covariance of two random vectors. One important thing is that in probability and statistics the definition of correlation always includes a standardizing factor in such a way that correlations have values between −1 and +1. If X and Y are two independent random variables with probability density functions f and g, respectively, then the probability density of the difference Y-X is formally given by the cross- correlation (in the signal-processing sense) f*g; however, this terminology is not used in probability and statistics. In contrast, the convolution f*g (equivalent to the cross- correlation of f(t) and g(−t) gives the probability density function of the sum X+Y.

3. Experiment

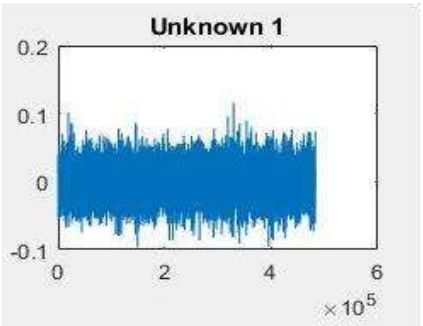
In this part we are going to show the plot of each signal, first the plot of the good gear sound which we already know and then we take two unknown signals. After that we going to use cross correlation concept to check the similarities between two signals. At first, we take good signal which we know and compare it with the first unknown signal, and we plot its graph. Then we take the good signal with the second unknown signal, and we plot its graph. After finishing plotting we have to judge the outputs of the graphs drawn and decide whether there are good ones. In this point it come to our attention that still we will need someone to check the graph and make a decision, in which case we will be not solving our original problem. Because as I said in introduction the purpose of this paper is to replace that person who make the decision by hearing the gear sound. So, to solve this we introduce sample difference as I said before. What sample difference does is comparing the sample difference value which we already set the threshold value from the good gear sound. And that value will be the reference of the good gears and bad gears. If the sample difference doesn't match with our threshold value automatically the system will give the output as bad gear, and if the sample difference does match our threshold value then the output will be good gear.

i) Good gear graph



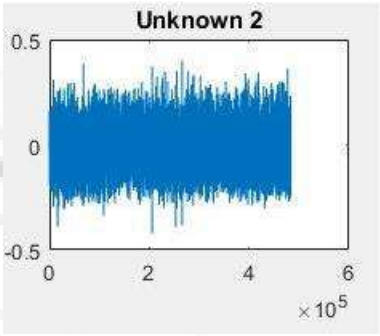
The above graph is the plot of the good gear sound signal alone.

ii) Unknown 1 gear graph.



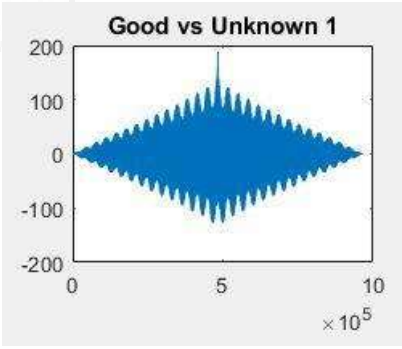
Previous graph is the plot of the unknown gear sound signal.

iii) Unknown 2 gear graph.



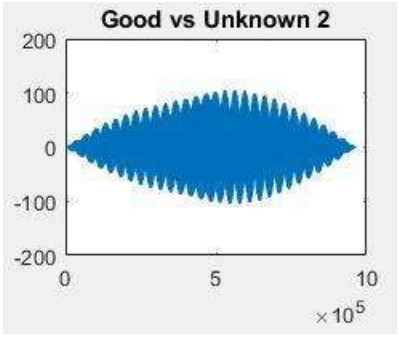
This is another graph of unknown gear sound. So, after this we have to take the comparison between the good gear signal and the two unknown's signals, in which the cross-correlation technique will take place. Furthermore, we will judge the graph obtained and decide whether the signal correspond with the good gear, since the cross-correlation always be a peak at a lag of zero. From those two comparisons, we will check this effect.

iv) Good gear sound signal versus Unknown 1 gear sound signal.



The above is the output graph of the good gear signal and unknown 1 gear signal. Then let's take a look on next graph and see the difference.

v) Good gear sound signal versus Unknown 2 gear sound signal.



The above is the output signal between good gear signal and unknown 2 gear sound. From here we can see that the iv) graph contain a peak value which is absence in the last graph. From cross-correlation concept that peak value shows the close similarities between those two signals. In conclusion, we can say the good gear signal is more related compared to unknown 2. This means the unknown 1 is a good gear while the unknown 2 is a bad gear. To make this clear we extract the sample difference value and make a decision for us. So, in generally this is the whole concept of the system operation.

4. Conclusion

In concluding the output where promising good but still more effort has to be applied to make the system more applicable and efficiency. For example, instead of using one feature to make decision (i.e. Sample difference) other features should be added to the system make it more stable. Some features like normalization of signal before process them, and also feature like root mean square technique. These features can help more the results to be more accurate since sample difference approach is not quite hundred percent perfect.

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John Mkhomoi received Bachelor Degree in Electronics and Communication engineering from St. Joseph University in Tanzania in 2013.Currently pursuing M.E in Signal and Information Processing from Tianjin University of Technology and education. He was working at Aglex Company Limited. During 2014 – 2015 and his research areas are computer vision, artificial neuro network, pattern recognition and biomedical image processing.

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