Research on the Detection of Vehicle Vibration and Noise Signal Based On Negative Entropy Detection Algorithm

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Abstract. As an important part of vehicle noise signal detection and processing, negative entropy detection algorithm can accurately reduce the number of speech coding bits, ameliorate the recognition accuracy, and establish the noise model in the process of noise reduction. Based on this, this paper first analyses the source and control of vehicle vibration and noise, then studies the principle of negative entropy detection algorithm of vehicle vibration and noise signal, and finally gives the vehicle vibration and noise signal detection method based on negative entropy detection algorithm.

Keywords: Vehicle Vibration, Noise Signal, Negative Entropy, Detection Algorithm

1. Introduction

With the iterative progress and maturity of computer tech, it has been widely and deeply studied and popularized in many fields, especially the utilization of computer tech represented by negative entropy detection algorithm in the field of vehicle vibration and noise signal detection, which greatly accelerates the detection and control of vehicle vibration and noise info. Various sensor device modules are used to separate, extract and recognize the collected vehicle noise signals, and sensors are used to process and make decisions on the collected noise signals. In this process, the use of negative entropy detection algorithm can better adapt to the changing environment, and can carry out more normal, reliable and stable work. The vehicle vibration and noise signal detection and recognition algorithm based on negative entropy adopts the approximate calculation method based on high-order cumulant, which has several typical advantages as shown in Figure 1 below, so it has stronger adaptability in the energy limited and random network utilization environment.

Traditional detection algorithms have more or less a variety of problems and shortcomings, for example, it is difficult to effectively use the prior info of noise, and it is difficult to meet the actual utilization environment. As an important part of vehicle noise signal detection and processing, negative entropy detection algorithm can accurately reduce the number of speech coding bits, ameliorate the recognition accuracy, and establish the noise model in the process of noise reduction. The use of negative entropy detection algorithm can effectively distinguish the characteristic parameters of vehicle vibration and noise signals, which can not only achieve good results under the...
condition of high noise ratio, but also adapt to the deterioration of noise environment, and adapt to a variety of special types of noise environment.

In addition, the vehicle will inevitably produce the changes of physical parameters such as vibration and noise in the process of running, and the complexity of its working environment will lead to the difficulty of detection of these noise signals. The traditional signal processing algorithm is difficult to accurately analyze process and identify [1]. Vehicle vibration noise is a kind of Gaussian signal, the utilization of entropy method to its research has high limitations, it is difficult to accurately determine the threshold of noise info, and it is easy to lead to the failure of the algorithm. As a non-Gaussian measure, negative entropy does not change with the amplitude of the signal, and it can pre-set the threshold through statistical info, so it can obtain better detection results of vehicle vibration and noise signal without posterior info adjustment.

In a word, the vehicle vibration and noise signal detection based on the negative entropy detection algorithm can effectively process multiple mixed vibration signals, realize the separation and extraction of multiple mixed vibration signals independently, and will not lose the weak feature info in the source signal. Vehicle vibration and noise signal detection is widely used in ground moving target recognition. The negative entropy detection algorithm is used to separate the collected signals, extract features and recognize patterns, so as to make correct decisions. Therefore, the study of vehicle vibration and noise signal detection based on negative entropy detection algorithm has important practical value.

![Figure 1. Advantages of noise signal detection and recognition algorithm based on negative entropy](image)

2. Sources and types of vehicle vibration and noise

2.1. Concept and model of vehicle vibration and noise

Vehicle vibration exists in many branches of science and engineering, which is a phenomenon that vehicle vibration oscillates around a specific reference point. The vibration is usually expressed by frequency, amplitude and phase angle. The models of vehicle vibration and noise can be divided into discrete system / lumped parameter system and continuous system / distributed parameter system. Secondly, according to the degree of freedom, vehicle vibration noise can be divided into single degree of freedom system vibration noise, multi degree of freedom system vibration noise and continuous system vibration noise. In addition, according to the excitation form, it can be divided into free vibration noise and forced vibration noise. According to the response of the system, it can be divided into harmonic vibration noise, periodic vibration noise, transient vibration noise and random vibration noise.

2.2. Research status of vehicle vibration and noise detection methods

Vehicle vibration and noise monitoring, testing and testing play an important role in the design, implementation, maintenance and repair of vehicle engineering system. Common vibration and noise control methods include vibration source reduction, resonance avoidance, vibration reduction and isolation. The main noise source is the flywheel of the press and the protective cover of the drive belt, which is made of solid sheet metal [2]. In addition, the vehicle vibration noise can be divided into structural vibration radiation noise and fluid dynamic noise according to the sound source formation mechanism, and can be divided into air noise and structural noise according to the sound transmission.
medium. The first step to establish the differential equation of vehicle noise is to establish the
generalized coordinates, as shown in the following formula 1 and 2, where V represents kinetic energy,
V, u represents potential energy, and P represents dissipative energy. Then, the force analysis diagram
of the isolator used as the mass element is established. Finally, the vibration differential equation is
established and sorted into the standard form.

\[ U = \sum_{i=1}^{n} \int_{0}^{x} F_i dx = \sum_{i=1}^{n} \int_{0}^{x} k_i x_i dx = \sum_{i=1}^{n} \frac{1}{2} k_i x_i^2 \]  
(1)

\[ P = \sum_{i=1}^{n} \int_{0}^{x} C_i x_i dx = \sum_{i=1}^{n} \int_{0}^{x} C_i x_i^2 dt \]  
(2)

3. Principle of negative entropy detection algorithm for vehicle vibration and noise signal

3.1. The concept and principle of negative entropy

Non Gaussian is independent. The key of estimating ICA model is non Gaussian. The classical non
Gaussian measurement is kurtosis or fourth-order cumulant. The kurtosis value of Y is defined as
follows equation 3.

\[ kurt(y) = E(y^4) - 3E(y^2)^2 \]  
(3)

\[ H(y) = -\sum_{i} P(Y = a_i) \log P(Y = a_i) \]  
(4)

Under some simple assumptions, entropy is the coding length of random variables. According to
the basic conclusion of info theory, Gaussian variable has the maximum entropy among all random
variables with the same variance [3]. In order to make the non-Gaussian measurement always be non-
negative, a method of modifying the form of micro entropy is called negative entropy. Negative
entropy J is defined as:

\[ J(y) = H(y_{gauss}) - H(y) \]  
(5)

\[ y_{gauss} \] is a Gaussian random variable with the same covariance matrix as \( y \). It can be seen that the
negative entropy is always nonnegative if and only if \( y \) is Gaussian and the distribution is zero.
Another significant property of negative entropy is that it has no change to reversible linear
transformation. The classical method of approximate negative entropy is to use higher order moments.

3.2. Mutual info minimization

Mutual info is an independent natural measurement among random variables. In fact, it is equivalent to
the famous Kullback-Leibler dispersion between the joint density \( f(y) \) and the edge density product
[4]. It is zero if and only if the variables are statistically independent. The mutual info of scale m
random variables is defined by the concept of micro entropy:

\[ I(y_1, y_2, ..., y_m) = \sum_{i=1}^{m} H(y_i) - H(y) \]  
(6)

Since mutual info is an info theory measurement of the independence of random variables, it can be
used as a judgment to find ICA transformation. In addition, the estimation method of ICA model is
closely related to the info maximum principle [5]. If properly selected, this framework can also
estimate ICA model. It can be proved that the principle of maximum entropy or maximum info is
equivalent to maximum likelihood estimation. Obviously, the principle of maximum likelihood
estimation ICA is to solve the maximum entropy of neural network output, which is also an optimization problem.

3.3. Detection and recognition of vehicle vibration and noise signal based on negative entropy
Because the probability density of sub Gaussian distribution is different from that of super Gaussian distribution, the former has flat peak, long tail and low negative entropy, while the latter has sharp peak, relatively short tail and high negative entropy [6]. As an important statistic to measure the non-Gaussian property of vehicle vibration noise signal, it can be used to measure the outlier degree of total outlier data. As a kind of intermittent pulse signal, vehicle vibration and noise signal has typical characteristics of outlier data. The utilization of negative entropy detection can identify, collect and analyze vehicle vibration and noise info well [7]. The negative entropy result of vehicle vibration and noise signal is far less than 1. In addition, if the target is far away from the vibration sensor at the beginning and end of the collected signal, the signal is pure Gaussian white noise. In this case, the negative entropy will be far less than 1.

4. Vehicle vibration and noise signal detection based on negative entropy detection algorithm

4.1. Principle of vehicle vibration and noise signal detection based on negative entropy
As a non-Gaussian measure, the entropy of a random variable is related to the info given by the observed value of the variable. The entropy of a Gaussian signal will increase with the increase of the randomness of the variable, and its unpredictability will also increase [8]. The negative entropy function of vehicle vibration signal can replace the negative entropy function of vehicle noise. In addition, due to the long-term stationary characteristic of noise, the variance normalization of random variables can be realized by using this characteristic of noise. Since the negative entropy can only detect the Gaussian noise signal of vehicle vibration, it will cause the stationary noise signal to be ignored, which limits the extraction of time-domain features. This requires further extraction of Gaussian sequence from the amplitude spectrum of stationary noise.

4.2. Analysis of negative entropy characteristics
According to the linear invariance of negative entropy, the negative entropy feature of vehicle vibration and noise section has strong stability, which is mainly reflected in that it is not affected by noise amplitude and signal-to-noise ratio [9]. Using the disorder of Gaussian signal and the long-term stationarity of stationary noise, the stationary noise signal with negative entropy can be established. Secondly, because the negative entropy of colored noise has no spectral entropy feature, it is only suitable for Gaussian white noise detection. By dynamically estimating the variance of random sequence in noise segment, the approximate negative entropy feature of vehicle vibration noise segment can be closer to the theoretical value of zero. In addition, the vehicle will produce a certain amount of stationary noise in the process of running, but these noises often contain peak values, which need to be set through statistics to realize the effective detection of its signal.

4.3. Negative entropy detection algorithm of vehicle vibration and noise signal
The negative entropy detection system of vehicle vibration and noise signal is mainly composed of noise adjustment, acquisition and analysis modules [10]. The adjustment system of vehicle vibration and noise mainly includes the related components of vehicle running vibration, which can effectively simulate and adjust the vibration and noise in the process of running. The acquisition module of vibration and noise signal mainly consists of sensors and modules for signal conditioning and acquisition. The noise processing system includes various analysis modules to achieve efficient and accurate analysis of noise data. Through the collection of vibration and noise signals in the process of vehicle operation by negative entropy, and the simulation analysis of the results, it can be found that the negative entropy detection algorithm has high efficiency and accuracy.
In addition, in the process of vehicle vibration and noise signal detection, the fuzzy logic classifier based on negative entropy and wavelet features is used to identify the vibration and noise signal of personnel vehicles, and the result has high accuracy. Moreover, the calculation of the negative entropy detection algorithm is very small, which makes the energy consumption of the whole system small, so it has high utilization value.

5. Conclusion
In summary, vehicle vibration and noise signal detection is widely used in ground moving target recognition. The negative entropy detection algorithm is used to separate the collected signals, extract features and recognize patterns, so as to make correct decisions. This paper analyzes the concept and model of vehicle vibration and noise based on the research on the source and control of vehicle vibration and noise. Through the analysis of the principle of vehicle vibration and noise signal detection algorithm based on negative entropy, the concept and principle of negative entropy are studied. Through the research of vehicle vibration and noise signal detection based on negative entropy detection algorithm, the negative entropy detection algorithm of vehicle vibration and noise signal is analyzed.

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