Scholar Publishing Group
International Journal of Multimedia Computing
https://doi.org/10.38007/IJMC.2022.030304
ISSN 2789-7168 Vol. 3, Issue 3: 47-62

Image Processing Technology in Emission of Intelligent Traffic Diesel Vehicle

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Keywords: Intelligent Transportation, Image Processing, Exhaust Gas Monitoring, Wavelet Transform

Abstract: Traditional smoke measurement methods for diesel vehicles mainly include Lingman blackness telescope and smoke meter. The Lingman Blackness Telescope uses a binocular prism telescope system. On the telescope partition board, a gray scale step block with corresponding Lingman smoke concentration of 1-5 level is made, and the transparent part is O level. The observer compares the smoke target with the gray gradient block through the left eyepiece of the telescope to determine the standard grade of smoke blackness. Smoke is divided into sampling part and measuring part. In the sampling part, the sampling cylinder extracts a certain volume of smoke from the exhaust pipe so that it passes through a certain area of white filter paper, so the particulate matter in the exhaust gas adheres to the filter paper and makes the filter paper black. Then, the smoke traces on the filter paper are measured by photoelectric detection device to evaluate the exhaust smoke of diesel engine. The above method can measure the smoke level of diesel vehicle exhaust to a certain extent, but it has great application limitations in practice, or cannot be applied in practice. For example, (I) Although the level of diesel vehicle exhaust smoke can be measured with the Lingman blackness telescope, it cannot record the level of diesel vehicle exhaust smoke and the relevant information of the vehicle; (2) The Lingman blackness telescope must be measured manually. It is time-consuming and laborious, and it is impossible for traffic police to observe every vehicle 24 hours with Lingman blackness telescope; (3) Smokemeter can only measure static diesel vehicles, but cannot measure driving vehicles. In view of the above problems, this paper introduces digital image processing technology, through the analysis of digital image of diesel vehicle exhaust, realizes the dynamic detection of diesel vehicle exhaust.

1. Introduction

In 2014, China's car ownership has reached 140 million vehicles. With the continuous growth of car ownership and the increasingly serious environmental pollution, vehicle exhaust emissions have become the focus of attention. Implementing strict exhaust emission detection of in-use motor vehicles can effectively reduce the emission of automobile pollutants and reduce the impact on the environment [1-3], which is the driving force to promote the rapid development of emission control technology [4].

Therefore, the research on data acquisition methods of automobile exhaust emission is of great significance in the formulation of emission control strategies in China. In 2015, the Ministry of industry and Commerce confirmed that the four emission of [5] will be fully implemented. This means that China's emission standard has officially entered the fourth stage. On the basis of the existing three countries, NOX should be further reduced by 30%[6], and particulate matter emissions from diesel engines should be reduced by more than 80%. Country three upgrade country four is not simply a digital upgrade, but a technical standard of the overall upgrading of [7]. Just like Guo 1L Guo 2L, pressurization technology should be adopted; Guo 2L Guo 3L, in addition to pressurization, should also add intercooling technology; while Guo 3L Guo 4th, pressurization intercooling has been unable to meet the requirements [8], we must add aftertreatment devices. With the increasingly stringent emission regulations, its exhaust detection technology and processing equipment are constantly upgrading.

Since the 1970s, there have been a variety of data collection methods for vehicle exhaust emissions, including chassis dynamometer test method, "outdoor remote sensing detection method" vehicle exhaust detection method, etc. [9].

1) Chassis dynamometer test is a traditional vehicle exhaust detection method. Its working principle is in the room, using a chassis dynamometer and a gas analyzer combined in preset vehicle condition, the measured emissions [10] accurately. The utility model has the advantages of low equipment cost "easy to use, widely used in automobile use station maintenance industry and automobile test line", is currently the main source of $disadvantages data acquisition vehicle exhaust is the test must be carried out in fixed driving conditions. It cannot reflect the real-time emission of road exhaust, which limits the method cannot meet the current and future needs of exhaust detection [11].

2) After 1990, remote sensing technology, a relatively advanced vehicle exhaust monitoring technology, began to be applied in the United States and other countries and regions [12]. Its working principle is to use infrared and ultraviolet spectroscopy technology to test the mixing ratio of each component in exhaust emissions [13]. Its advantage is that it can complete the fixed-point detection in the normal driving process of the car, with a high degree of automation. This method has a special role in strengthening emission regulations. The disadvantage of this method is that it has strict requirements on traffic conditions and location, and can only measure the concentration of exhaust gas, so it cannot be widely used [14].

3) Real-time vehicle exhaust detection method appeared after 2000. Its working principle is based on portable exhaust detection technology, and real-time measurement of vehicle exhaust and driving characteristics and other parameters [15]. The advantage of this method is that it can simulate real-time road conditions, and also can quickly obtain exhaust emission data of different sections of "different types of vehicles" in different periods [16]. On the premise of ensuring the accuracy and reliability of detection, it can also save a lot of time and samples [17]. Moreover, after the three of the country's new cars must be equipped with OBD automatic diagnostic system [18].

However, due to the early implementation of emission regulations in Europe, their testing equipment and technology are very advanced [19]. In 2000, Imperial College of Technology studied the remote monitoring system of vehicle operation and emission status [20]. Through the use of advanced data acquisition technology and vehicle positioning technology, remote detection of vehicle exhaust emissions [21]. In 2001, the College of Engineering, University of Manchester, UK, conducted a study on remote monitoring of diesel exhaust emissions [22-23]. The exhaust gas of automobile diesel engine can be detected remotely to minimize the emission of automobile polluted gases. Nowadays, small-value measuring instruments have been installed in many roads, toll stations and other places in Europe to achieve the goal of low-cost vehicle emission status factual detection [24].

At present, some testing equipments abroad have the functions of intellectualization and expert system. Compared with the automobile testing equipment in our country, it needs further optimization and strengthening, and there is still a big gap. Before 2003, China's automobile exhaust emission monitoring system basically relied on imported foreign equipment, but there is no independent research and development of the complete set of equipment in China. However, after so many years of continuous development, domestic enterprises have been able to produce equipment that basically meets the requirements of the simple transient working condition test of diesel vehicles in use. General diesel engine exhaust detection equipment such as ordinary chassis dynamometer, etc., are more and more diversified, and can meet the domestic demand [25]. Remote sensing technology of diesel exhaust has been applied in many cities in China, but the results are greatly affected by driving conditions. With the increase of vehicle ratio equipped with ternary catalytic converter, it is gradually ignored [26]. At present, combined with computer and vehicle automatic identification technology, some mobile devices which can be placed on the roadside for real-time monitoring have been developed, but have not been widely used. Comparing with the research on vehicle emission testing technology abroad, the main theoretical research aspect in our country is [27].

At present, more stringent emission parameters have been worked out with the introduction of the national laws and regulations. In order to adapt to the new detection parameters and methods, more advanced monitoring methods will also be developed. In this paper, digital image processing technology is introduced. Through the analysis of digital image of diesel vehicle exhaust emissions, dynamic detection of diesel vehicle exhaust emissions is realized [28].

(1) The camera records the relevant information of diesel vehicle status on the road by video, and gives it to the exhaust recognition and processing module in the form of continuous frame images. The exhaust recognition and processing module receives 10 consecutive frames of images from the video measurement part and preprocesses the images. Then, according to the static, dynamic and color characteristics of diesel exhaust, the target exhaust in the image is checked, segmented and extracted, and the best five frames of images are selected. Its static characteristics include: (I) there is a kind of "thin yarn" effect after diffusion, which can obscure the background and blur [29]; (2) because the smoke particles continue to diffuse around, they are large in front and small in the image. Its dynamic characteristics include: (I) During the emission process, the exhaust gas has the characteristics of internal rolling and changing, alternating changes between the exhaust gas and the background will occur, and the gray value changes in the image [30].

(2) The tail gas has a constantly changing shape, which can be used as a basis for distinguishing the tail gas from the general moving objects [31]. The best five frame target area extracted is subtracted from the background area by [32]. After filtering and filling the subtracted target, the average gray value of the target area is calculated (the maximum [33], the minimum gray value can also be calculated and extracted as a reference). The calculated result is compared with the blackening level in the standard library, and the corresponding blackening level is given. The data is uploaded to the central data processing unit. The central data processing unit receives the

information from the vehicle detection unit [34], and determines whether there is a vehicle entering the detection area.

2. Proposed Method

2.1. System Composition

A detecting system is composed of mechanical parts of digital image processing hardware is mainly composed of a base, lights, cameras, video card, PC machine based on transmission for not compressed video stream. In this system, we use the high pixel CCD camera, video capture area of diesel exhaust. After entering the computer, video signal is transformed into video data for programming by video capture card. We will video signal directly displayed on the PC, and at the same time for image processing, the real-time data processing results to the PC machine. The processing of its video stream is shown in Figure 1.

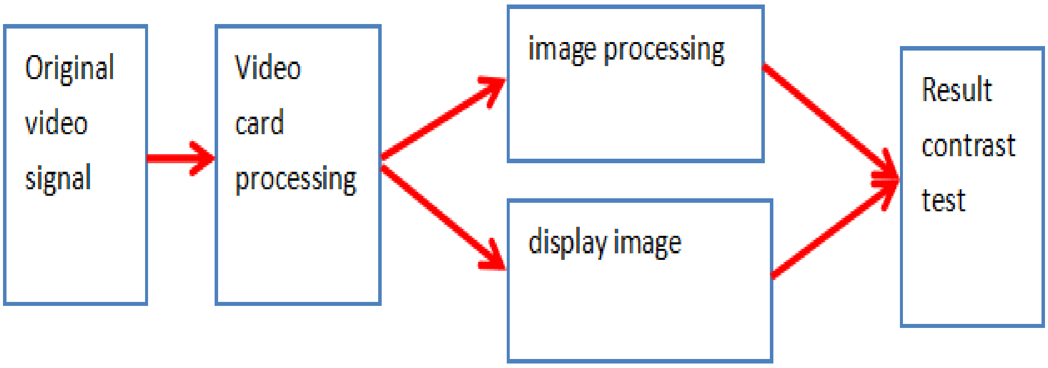


Figure 1. Processing of video process

The software of this system is mainly composed of two parts: one is image processing software, which displays, preprocesses, detects and recognizes the collected images; the other is interface software, including video switching, camera control, operation interface design, test result indication, etc.

2.1.1. Image Processing Part

After the video signal is collected by CCD camera, it is converted into programmable video data by video acquisition card. After image preprocessing, edge detection operator, contour curve positioning and other algorithms, we can compare the actual contour curve with the standard curve and obtain the deviation data. And then judge whether the exhaust emission is qualified. The software flow of image processing is shown in Figure 2.

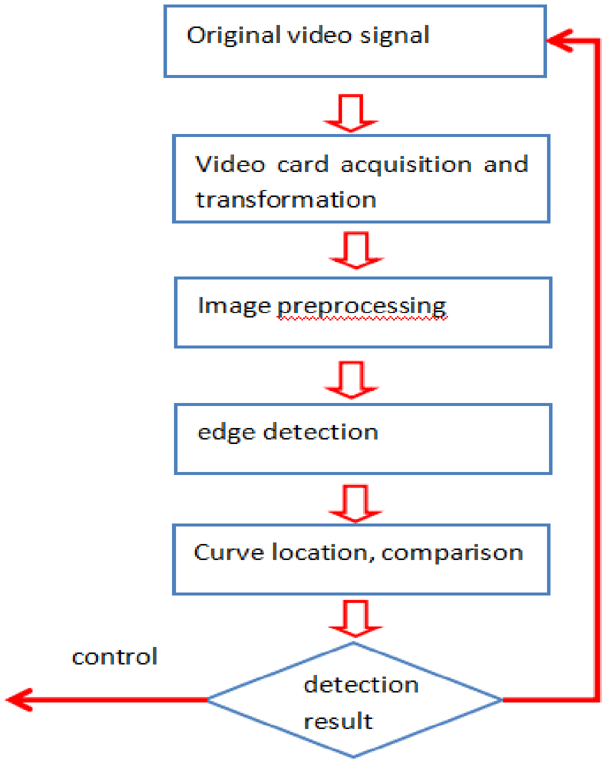


Figure 2. Image processing flow chart

2.1.2. Image Enhancement

In the process of image capturing, due to the influence of environmental factors such as insufficient exposure, the brightness distribution of the image will suffer from different degrees of non-linear distortion, which is manifested in the overall dark brightness and low contrast of the image. This distortion can be improved by adjusting the contrast by means of image enhancement. The purpose of image enhancement is to improve the contrast and visual effect of the image by modifying the gray level of the image. Because the shooting background is set artificially, the gray level of the digital image of the object under test in the input computer is relatively concentrated compared with other images, and most of the pixels are distributed in the background and target areas. Gray level histogram is a function of gray level, which represents the number of pixels with each gray level in the image, and reflects the frequency of each gray level in the image. It is an important research content in image processing and analysis to adjust the contrast of image by changing the shape of histogram. It enhances image contrast by changing the gray value of the image or indexing the color value of the image. The one-dimensional discrete form of the histogram is:

$$s_r(r_k) = \frac{n_k}{n} \begin{cases} 0 \le T_k \le 1 \\ k = 0, 1, \ldots, L-1 \end{cases} \quad (1)$$

In the formula, nk is the number of pixels of the k-level gray level, Sr (rk) is the frequency of the occurrence of the gray level, and L is the gray level of the image, n is the total image prime number.

The essence of image enhancement technology using gray histogram trimming is to select appropriate transformation function to modify the gray level probability density function Sr (rk), so as to obtain the required gray scale form, which increases the dynamic range of the gray value of the pixel, so as to achieve the purpose of enhancing the overall contrast of the image. There are two forms of histogram modification: gray scale linear transformation and nonlinear transformation.

1, gray scale linear transformation

It is a method of transforming the gray level of all pixels in an image according to a certain linear function. To transform the gray range of image f (x, y) from [a, b] to [c, d], the following transformation can be used to achieve the gray transformation effect.

$$g(x,y) = \frac{(d-c)\left[f(x,y)-a\right]}{b-a} + c \tag{2}$$

2, gray scale nonlinear transformation

Gray level non-linear transformation refers to logarithmic transformation. It is often used to expand low-value gray level, compress high-value gray level, and make the image of low-value gray level clearer. The expression is:

$$g(x,y) = K\log[f(x,y)+1] \tag{3}$$

K is a constant factor and is determined according to the specific image content.

2.2 Adaptive Iterative Two Valued

The main purpose of image binarization is to effectively separate target from background by threshold processing, so that only interested targets can be identified, processed and measured afterwards. The simplest way is to set a threshold T and divide the gray image data into two parts: the set of pixels larger than the threshold and the set of pixels smaller than the threshold according to the set threshold T. For example, the input grayscale image function is f (x, y) and outputs the two valued image function g (x, y), and

$$g(x,y) = \begin{cases} A, f(x,y) \geq T \\ 0, f(x,y) < T \end{cases} \tag{4}$$

By solving the threshold T, the gray image f (x, y) is divided into two regions: the target feature and the background feature. Threshold is a ruler to distinguish image from background. The principle of selecting threshold is to keep image information as much as possible, and to reduce the interference of background and noise as much as possible. At present, there are many threshold selection methods, which can be divided into global threshold method, local threshold method and dynamic threshold method according to the application scope of threshold, and have been applied in various fields. Image detection is carried out on the premise of guaranteeing image quality, and image targets are often single. In theory, simple global binarization can be used. However, due to the influence of uneven illumination and ambient noise, the gray distribution of the exhaust image is not uniform, so it is not suitable to simply use a single threshold. In order to ensure the effect of binarization and take into account the time consumption, the image can be segmented by iterative binarization. The threshold based on iteration can distinguish the main areas of the object and background of the image, which meets the requirement of segmentation effect.

The adaptive iteration method is based on the idea of approximation. Firstly, two variables Fmax and Fmin are defined to find the highest and lowest gray values of gray images respectively. The specific process of the algorithm is as follows:

1, establish the grayscale histogram of the image. The maximum gray value and minimum gray value Fmax and Fmin are searched, and the initial threshold is calculated.

$$T_k = | f_{\max} - (f_{\max} - f_{\min}) / 3 | \tag{5}$$

2. The image is divided into foreground and background by initial threshold Tk, and the average gray value F0 and fB of the two parts are obtained respectively.

3, further find out the new threshold:

$$T_{k+1} = | f_0 - (f_0 - f_B) / 3 | \tag{6}$$

If the condition is satisfied: TK = TK + 1, the result TK is the best threshold; otherwise, turn to 2, and continue to iterate until the condition is satisfied.

2.3 Threshold

With a threshold T as the bound, the operation of converting the whole gray level of the image into 0 or 1 (usually 0 as the background, 1 as the object) is the threshold processing. In order to obtain threshold reliably, various thresholds automatic decision method has been proposed. If the threshold T is fixed to the whole image, it is called fixed threshold processing. In addition, when the background gray level changes due to non-uniform illumination, a fixed threshold cannot be applied to the whole image, but a dynamic threshold should be adopted. Threshold T is often determined by user debugging while observing the 2-valued results. If the state and shooting conditions of the object image remain unchanged, the threshold determined at one time can be applied to all images. But sometimes it automatically determines the threshold of each image. The commonly used automatic threshold determination methods are P-parameter method, Otsu discriminant analysis method, Kittler method, Laplace histogram method and differential histogram method. The dynamic threshold method mainly includes moving average method and part image segmentation method. Each method has its applicability and should be reasonably chosen according to the needs of the image processing system.

P-parameter method is the simplest automatic threshold determination method, but the premise of applying this method is the area ratio of the known object in the image, so its application is also limited. Otsu discriminant analysis method is to use the gray histogram of image to determine the optimal threshold of statistical significance. Its principle is that when a threshold divides the histogram into two groups, it can make the variance between the two groups.

$$\sigma^2{}_B(t) = \omega_0 (u_0 - u_T)^2 + \omega_1 (u_1 - u_T)^2 \tag{7}$$

Becoming the largest t is selected as threshold t*. When ni is the number of pixels of gray level i, L is the number of gray levels of images, N is the total number of pixels and when Pi is ni/N,

$$\omega_0 = \sum_{i=0}^{k-1} p_i \tag{8}$$

$$\omega_1 = \sum_{i=k}^{L-1} p_i \tag{9}$$

$$u_0 = \sum_{i=0}^{k-1} ip_i / \omega_0 \tag{10}$$

$$u_1 = \sum_{i=k}^{L-1} ip_i / \omega_1 \tag{11}$$

$$u_T = \sum_{i=0}^{L-1} ip_i \tag{12}$$

The threshold t* becomes the optimal 2-valued threshold determination method in the sense of approximation using the least square method of gray image. Kittler's method, like Dajin's discriminant analysis method, is a method to find the optimal threshold based on the statistical properties displayed by gray histogram. The function of the threshold obtained by Kittler method is to minimize the ambiguity of which group of gray levels belongs to the two groups relative to the worst distribution when the observed gray levels are obtained. The discriminant analysis method of Otsu is a group with larger threshold deviation ratio under the condition of different distribution ratio of the two groups. The Kittler method can improve the shortcomings of Otsu's discriminant analysis. Laplacian histogram method is a method that focuses on the gray level changes near the object contour. This method is suitable for the case where the area ratio between the background and the object is very different. Differential histogram method calculates the sum of absolute values of the first-order differential of each pixel with this value for each gray level, and then takes the maximum gray level as the threshold of 2-valued. The differential histogram considered by this method is not necessarily ideal.

2.4 Edge Detection

2.4.1. Edge Detection Principle

To edge detect images, we first need to understand the characteristics of digital edges. When we understand image edges from the perspective of human eyes, we tend to think that the edges of an image are linear because of the limited ability of recognition and understanding. However, due to the limitation of the accuracy of image acquisition equipment, the edges of the image after acquisition are actually a set of connected pixels. If there is a pair of images with black and gray on both left and right sides, then the middle edge and outer edge of the image will be a region of pixels gradually turning from black to gray. The edge gray level will be a low to high "slope". The width of the edge depends on the length from low to high in the process of gray level jump.

From the curve trend of the first and second derivatives of gray value of gray profile, the following conclusions can be drawn: judging whether a pixel is in the edge position can be judged by the first derivative. It can be judged whether a pixel is in low or high gray area by the sign of second derivative. The zero point near the center is the center position of the image edge by connecting the positive and negative edge points of the second derivative. The properties of the first derivative and the second derivative are not only applicable to the position of the horizontal section line, but also to any direction of the image. Because edge detection is the most common method to detect gray level intervals, that is, to get the edge of an image by detecting the discontinuity of gray level, and the discontinuity of gray level can be detected by first and second derivatives. The first derivative can find the boundary, and the two derivative can determine the type of gray mutation. Because of the influence of image noise, the third derivative is very sensitive in edge detection, so it has no application value.

2.4.2. Gradient Operator Method

From the above discussion and combined with mathematical knowledge, the essence of edge detection can be transformed into the calculation of gradient of each pixel, and the gradient result will reflect the change of gray value. By setting the threshold, the derivative of the point whose gray value varies greatly is taken as the judgment parameter of the boundary, so that the edge points can be detected.

In order to further study edge detection, we introduce gradient operator. Set the gradient of image f (x, y) in position (x, y) as the following vectors:

$$\nabla f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix} \tag{13}$$

The direction of the gradient vector is the maximum change rate direction of the f of coordinates (x, y). The magnitude and direction of the gradient are expressed in the following formula:

$$\nabla f = mag(\nabla f) = [G_x^2 + G_y^2]^{1/2} \tag{14}$$

$$\alpha(x, y) = \arctan(\frac{G^y}{G^x}) \tag{15}$$

In a 3*3 neighborhood, the gradient of the intermediate point can be calculated by the following operators and their implementation formulas. Compared with the results obtained by other edge detection operators, Sobel has the following characteristics: first, in the pixels, the high frequency is less and the low frequency is more, because the noise is generally high frequency, so Sobel can suppress noise. Two, from the results of image detection, we can see that the width of

Sobel detection edge is large.

3. Experiments

3.1. Experimental Environment

This experiment is completed under Mirosotf Windows 98. Mierosotf's 32-bit Windows has become the de facto standard of PC operating system. Wnidows98 is an advanced operating system based on micro-kernel structure. It has friendly interface, rich information, strong structure and expansibility. The open program structure leaves enough room for the development of rich and colorful application software. In Windows 98, preemptive multitasking technology is used to make the system respond faster to tasks with high priority, such as user input, data acquisition and so on. In preemptive multitasking system, the operating system has the overall control over multitasking, which can forcibly interrupt the control of an application over the processor, and give the control to a higher priority application. Moreover, preemptive multitasking technology can make one CPU run multiple threads at the same time, which greatly improves the utilization of CPU. Because the system involves real-time video acquisition and processing, the CPU has a heavy load, so it must have multi-threading support of the operating system.

3.2. Development Tools

The system uses Mcirosotf VisuaI C++6.0 for software programming. VC6.O is powerful and easy to use. It is one of the most popular development tools at present. The language it uses is C++. C++ is an object-oriented programming language. It is the most popular computer language at present. In VC environment, Wnidow SAPI and other SDKs can be easily invoked, and VC also contains a set of powerful class libraries, namely MFC. The introduction of MFC greatly facilitates programming.

In addition, we also use other special development packages, such as MATLAB, MS Video for Windows SDK, DirectDraw, Winsoek and so on.

3.3. Video Capture

Video capture is the conversion of analog video signals into digital formats that can be used by PC. It is an important part of digital image processing and pattern recognition system, and the first link in the system video flow. The performance of video acquisition module limits the performance of each module in the future, so it also determines the performance of the whole system. The main performance requirements of the system for video acquisition module are: (1) high-speed acquisition (at least 24 frames/second); (2) the acquired image must have a higher resolution (at least 720X576X24); (3) the computer should occupy as little CPU time as possible when completing (1) and (2) in order to save more CPU time for image processing and display. The performance of the video capture module is mainly determined by the performance of the selected video card and the acquisition software.

As a result of performance, most of the video cards currently available in the market can generally meet the above three performance requirements.

3.4. Wavelet Transform

Wavelet transform process:

First, wavelet transform is used to get the wavelet coefficient w.

Secondly, according to a certain threshold method, the smaller coefficients in coefficient W are weakened or removed, andwden is obtained.

Finally, the spectrum data after noise reduction are reconstructed by wden. Haar wavelet, Daubechies wavelet and Biorthogonal wavelet are commonly used wavelet functions, which can be operated by Origin software.

4. Discussion

4.1. Image Processing Analysis

In order to clearly understand the edge detection ability of the above methods, the following basic methods are used to carry out the edge detection experiments of images with 3*3 cross as structural elements.

a)Original picture

b)Border processing pictures

Figure 3. Image processing diagram

From the experimental results, we can see that the algorithm can detect edges well, and retain the original information of the image, and the edge has no breakpoints, and the connection is smooth. This shows that mathematical morphology has obvious advantages in edge detection of the image. However, the processing effect after adding noise is not ideal. The image is affected and the edge is weakened a lot, and contains a lot of noise points, which makes the overall edge of the image not well displayed. Therefore, it is necessary to modify the basic mathematical morphology edge detection algorithm to better control noise and maintain image edge information. From the analysis of experimental results, it can be concluded that the improved hybrid anti-noise algorithm can suppress the influence of noise better than the general algorithm, and the image edge information display is more prominent.

4.2. Selection of Infrared Absorption Spectra of Exhaust Components

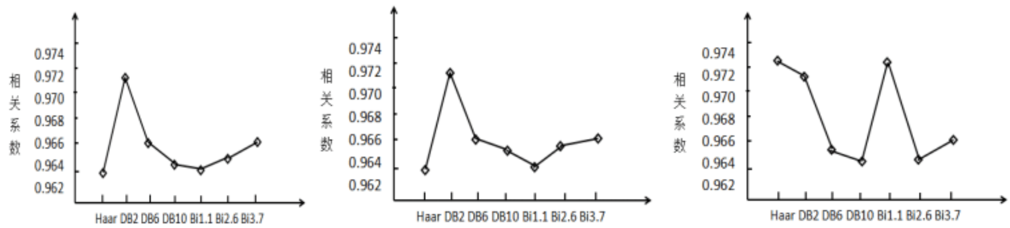
Infrared spectra of gases such as carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbons (HC) in automobile exhaust are analyzed to determine the best infrared wavelength suitable for measuring automobile exhaust.

Table 1. Wavelength of various gas components

Component	Wavelength of measurement
CO	4.64um
CO_2	4.26um
HC	3.4um

Because carbon dioxide (CO2), carbon monoxide (CO) and hydrocarbons (HC) in automobile exhaust are measured simultaneously, three kinds of gases with different concentrations are mixed to fill the whole measuring chamber, so the infrared spectrum range of the three gases should include the measuring wavelength of the three gases, which makes the infrared light source choose to emit continuous spectrum. That is, a certain range of spectra. In order to measure the concentration information of three gases, it is necessary to obtain the change of light energy before and after infrared absorption of gases. In addition, the instability of light source emission power and light intensity are greatly affected by the outside world. In addition to the measuring light path of three gases, a reference channel is added. The measurement wavelength of the reference channel is 4.0 micron. The infrared light under this wavelength is not absorbed by the exhaust components of automobiles. The test results have nothing to do with the exhaust components and are used to compare and analyze with the measured optical path.

The correlation coefficients between two-dimensional correlated Raman spectroscopic data are processed by non-denoising and various denoising methods respectively, as shown in Figure 4. The experimental denoising parameters include non-denoising processing, Savitzky-Goly filtering (window width 5, polynomial hierarchy 2), Harr wavelet (threshold 50%), Daubechies wavelet (order 2, 6 and 10 in wavelet respectively, recorded as DB2, DB6 and DB10, threshold 50% in each stage) and Biorthogonal wavelet (order of low-pass reconstruction filter). The order-order of the low-pass decomposition filter is (1,1), (2,6) and (3,7) respectively, recorded as Bior 1.1, Bior 2.6 and Bior 3.7, with a threshold of 50% for each stage. Figure 4 (a) shows the similar results between sample 1 and sample 2 before and after data denoising. Figure 4 (b) shows sample 1 and sample 3, and Figure 4 (c) shows sample 2 and sample 3. Because the high-dimensional Raman spectra of diesel exhaust samples have high similarity, and the existence of noise has randomness, which will reduce the similarity between the spectra of samples. Effective noise reduction processing will reduce the noise interference and improve the similarity between spectra. The value of correlation coefficient is an index to evaluate the similarity between spectra, the closer it is to 1, the more similar (correlation) the spectra are, and the closer it is to 0, the more dissimilar (uncorrelated) the spectra are. As can be seen from the graph, 2. The noise reduction algorithm achieves the improvement of the similarity between samples in other cases, and reduces the influence of random noise, except for Haar and Bior 1.1 of sample 1 and sample 3. 2. Noise reduction algorithms vary greatly under different input parameters. Savitzky-Goly filtering is the best in the experimental system.



a) Data processing method b) data processing mode C) data processing mode

Figure 4. Changes of correlation coefficients among samples after different data processing methods

Taking correlation coefficient as a quantitative evaluation index, the evaluation strategy of spectral noise reduction method for high-dimensional data is analyzed. The results show that the establishment of two-dimensional correlated high-dimensional Raman spectroscopy with laser intensity as external disturbance has many advantages, such as fast acquisition speed, simple operation and abundant information. The high-dimensional Raman spectroscopy noise reduction evaluation method with correlation coefficient as evaluation index has many advantages, such as simple operation, quantitative analysis and so on. Savitzky-Goly filtering, Haar wavelet, Daubechies wavelet, Biorthogonal wavelet and other commonly used spectral denoising methods are evaluated experimentally. The results show that the denoising algorithms have different processing results. For the experimental system, Savitzky-Goly filtering is a better choice for denoising.

5. Conclution

The starting point of this research work is that when on-line detection of harmful gases (hydrocarbons, carbon monoxide, carbon dioxide, etc.) emitted by automobiles is carried out by using infrared spectroscopy automobile exhaust sensor. The disturbance of sampling exhaust in the air chamber affects the absorption of infrared light by the components of automobile exhaust, and then affects the detection accuracy and response time. Therefore, it is necessary to study the sensor structure and internal gas flow characteristics. Focusing on computational fluid dynamics (CFD) technology for internal flow field analysis, this paper introduces the research progress of CFD, and expounds the working flow of CFD analysis. The mathematical model, discrete solution method and grid generation technology of exhaust gas sensor flow field are analyzed. Finally, a structured grid, Realizablek E model and SIMPLE algorithm are used to calculate the internal flow field of automotive exhaust gas sensor by non-spectral infrared method. The finite volume method is used to simulate and analyze the internal flow field of automotive exhaust gas sensor.

Firstly, this paper studies the detection system of automobile exhaust gas sensor based on infrared spectroscopy, introduces the theoretical basis of infrared detection, the detection principle of automobile exhaust gas sensor based on infrared spectroscopy and the system composition of automobile exhaust gas sensor based on infrared spectroscopy. Secondly, the mathematical model of flow field analysis of automobile exhaust gas sensor based on non-spectral infrared method is introduced, including hydrodynamic governing equation, additional equation of turbulence model, wall function, discrete method of equation and solution method of flow field.

Secondly, the generation technology of structured and unstructured grids is introduced. In this paper, FLUENT software, Realizablek model and SIMPLE algorithm are used to discretize the internal flow field.

Thirdly, the three-dimensional geometric model of automotive exhaust gas sensor based on non-spectral infrared method is established. The geometric model of internal flow field is extracted by Boolean operation. Structured and unstructured grids are divided. By comparing the quality of grids, structured grids are selected for numerical simulation. The results show that the structure of intake and outlet and main chamber has obvious turbulence and uneven distribution of gas. At the same time, the influence of different flow velocities on gas distribution is different under this structure, and the structure of tail gas sensor needs to be improved.

Finally, through the combination of orthogonal experiment and numerical simulation, the structure of the tail gas sensor is optimized and improved, and the three-dimensional geometric model of the optimal structural parameters is established. The internal flow field of the improved non-spectral infrared automobile exhaust gas sensor was simulated and analyzed by using structured grid generation technology, and the experimental verification was carried out. The numerical simulation results show that the gas distribution inside the improved sensor is uniform, and the flow velocity has little influence on its distribution. The experimental results show that the response time of the improved vehicle exhaust sensor is increased by about 3 seconds, and the accuracy is improved by 2%. At the same time, the measurement accuracy is less affected by the flow velocity.

Funding

This article is not supported by any foundation.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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