GEORGE BROWN PRESS
JOURNALS, BOOKS & PROCEEDINGS

Journal of Computer, Signal, and System Research

Article

Chemicals Pollution Level Detection Based on Image Gray Difference

Leyuan Zang [1], Ruohan Wang [2], Zhenwu Xu [3], Han Wang [4,*] and Lu Liu [5]

[1] Department of Economics, University of Warwick, Coventry, United Kingdom
[2] Tianjin Haihe High School, Tianjin, China
[3] School of Minerals Processing and Bioengineering, Central South University, Changsha, China
[4] School of International Communication, Hebei Institute of Communications, Shijiazhuang, China
[5] School of Business & Management, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia
* Correspondence: Han Wang, School of International Communication, Hebei Institute of Communications, Shijiazhuang, China

Abstract: Due to the complexity of environmental changes in chemical plants, the concentration of some polluted gases is affected and decreased, which changes the pixel characteristics of chemical pollution, resulting in deviations in the grade detection results of existing chemical pollution level detection methods. Therefore, a method for detecting chemical pollution level based on image gray difference is presented. Video images of chemical pollution were extracted by inputting chemical pollution images and selecting chemical pollution characteristic parameters. The intensity of chemical pollution was calculated by image gray difference algorithm, and the gray pixel characteristics of chemical pollution image were classified to realize the detection of chemical pollution level. The experimental results show that the proposed method has more successful times in detecting chemical pollution level and less error rate in detecting results. It can effectively improve the shortcomings of existing chemical pollution level detection.

Keywords: image gray difference; chemical pollution; level detection; error rate

1. Introduction

Under the background of the continuous development of industrial technology, a variety of pollution is increasing, causing certain damage to air, soil and water resources. Among them, pollution from the chemical industry has the most serious impact on the ecosystem, affecting the growth of animals and plants [1]. Some chemical pollutants have not been scientifically treated and discharged into the air, resulting in a serious air pollution phenomenon [2]. At this stage, China has defined and classified various pollution levels, such as air pollution level, etc. However, the classification of chemical pollution level is not perfect, and there is no corresponding level detection technology support [3]. The processing technology of image gray difference is widely used in various fields, and it provides some help by monitoring the changes of various data information [4]. The principle of image gray difference technology is to describe the texture of the video image, find out the approximate value of the pixel according to the gray level change of the pixel, and finally achieve the target of interfering with the pixel point [5]. The gray difference histogram is obtained from the data information, the information is described by the eigenvector, and the corresponding entropy parameter is obtained. The gray difference of the image will change with the change of the parameter [6]. There are many image features of chemical pollution. By using image gray difference technology, the points with large gray values of pixel points are retained, and a clear image of chemical pollution change is obtained, thus achieving the target of detection of chemical pollution level [7].

Received: 09 January 2025
Revised: 13 January 2025
Accepted: 20 January 2025
Published: 22 January 2025

The introduction of image gray difference technology into the detection of chemical pollution level can effectively improve the shortcomings of the existing detection of chemical pollution level. By detecting the physical characteristics and influencing factors of chemical pollution, the damage of chemical pollution to the ecosystem can be reduced. Therefore, this paper puts forward a study on the detection of chemical pollution level based on image gray difference.

2. Study on Detection of Chemical Pollution Level Based on Gray Difference of Image

The process structure of a chemical pollution level detection method based on image gray difference is designed in this paper, as shown in Figure 1.

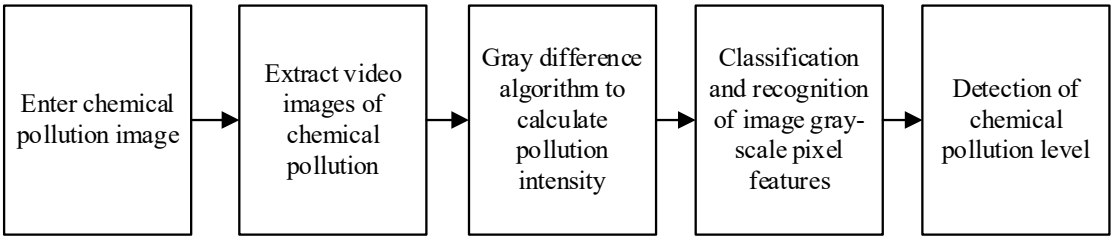

Figure 1. Process of Detecting Chemical Pollution Level based on Image Gray Difference.

As shown in Figure 1, by entering an image of chemical pollution; The video image of chemical pollution is extracted and processed by selecting the characteristic parameters of chemical pollution. The pollution intensity is calculated based on the image gray difference algorithm. Classify and identify the gray-scale pixel characteristics of chemical pollution image, and finally complete the design of detection method of chemical pollution level.

2.1. Extracting Video Images of Chemical Pollution

Due to the difference of intensity and characteristics of chemical pollution and the poor definition of contour of chemical pollution image, the video image of chemical pollution should be extracted by gray difference processing. Select the chemical pollution characteristic parameter to judge the image complexity based on the change of the entropy value. Because most of the images collected for processing chemical pollution are color images, it is easy to lose part of the information data of the images by directly processing the gray difference. Therefore, the window algorithm value range of the images to be processed is defined to avoid the loss of information in the images. Define the center point of the image and combine the frame difference method to reflect the mathematical and physical characteristics of chemical pollution.

Pixels of chemical pollutant gases are obtained by class weighted training, incremental learning based on training classifier, feature set and extended processing of original video images are performed, and positive classes of pollution pixel features are obtained. Keep the contour of the original chemical pollution image, compare the data information in the two images, mark the similar parts with special colors, and reduce the error caused by duplicate data information. Under the 5×5 image window, compare the edge information of the two video images, and adjust the window size appropriately to ensure the smooth and complete edge of the video image. The threshold value of chemical pollution video image is calculated to provide classification recognition rate for chemical pollution level detection.

Based on the difference of dimension characteristics, the feature distances of the two video images are summed together to ensure the difference of chemical pollution characteristics. Normalize the vector component of the chemical pollution video image, set the same dimension of the image, and extract the chemical pollution video image.

2.2. Computing Chemical Pollution Intensity Using Image Gray Difference Algorithm

Chemical pollution is usually caused by the removal of a large number of volatile pollutant gases by chemical plants. In the design of chemical pollution level detection methods, the first step is to calculate the intensity parameters of chemical pollution. The image of pollutant gas discharged from a chemical plant is extracted, and the image is preprocessed by gray scale to judge the pollution level according to the change characteristics of the pixels in the image. Set the visualized area of chemical pollution to be $M \times N$, the number of pollution intensity signals to be n, and the period of pollution intensity detection to be t. Calculate the parameters of chemical pollution intensity as follows:

$$\sigma = \frac{|n-t^2|}{M^2+N^2} \quad (1)$$

According to the calculation formula, the intensity parameters of the chemical plant pollution detection are obtained, and based on the calculated parameter results, the chemical pollution detection model is constructed. Taking into account the errors caused by environmental factors in chemical pollution, the related functions of image signals of chemical pollution are calculated by using the normalization function recognition algorithm. The calculation formulas are as follows:

$$NCC(x,y) = \frac{ER(x,y)}{E_A(x,y)E_{Q(x,y)}} \quad (2)$$

Where (x,y) represents the center point of the image pixel; $E_A(x,y)$ denotes the gray-scale energy characteristic parameter of the image. $E_{Q(x,y)}$ represents the image background feature function; X represents the chemical pollution level vector; Y represents the image shadow coverage factor. Based on the above normalization algorithm, the basic knowledge of image gray level is recognized, and the detected image with a pixel difference greater than 2.53 is excluded. With the constant change of the chemical pollution threshold, the pixel value of the pixel points in the image decreases continuously, which will have a small impact on the grade detection result. Therefore, to control the pixel value of the pixel points, when the pollution gap is small, the resolution of the image will change, and the threshold of gray scale pixel points will be adjusted appropriately.

In the process of image gray processing, the blurring degree of the image is reduced and the classification feature information is preserved. The current gray scale image of chemical pollution is binarized with the original background image, and the foreground target area of chemical pollution is obtained. The shadow of the gray scale image of chemical pollution is adaptively processed with the shadow detection and recognition algorithm.

2.3. Classification of Gray Pixel Features for Chemical Pollution Images

After the calculation based on the above chemical pollution intensity parameters, the gray scale pixels of the image are processed by feature classification. In order to reduce the error in pixel classification, this paper uses the method of pixel classification and recognition. Set the feature sample set of image gray pixels as A, set the pixel clustering kernel function, put the pixel types that may cause pollution in sample set A into sample set B, select the inner product of feature classification, and convert the gray pixels of chemical pollution image according to certain mapping methods.

Assuming that B includes a subset of n-class contaminated pixels, based on the theory of support vector machine, the available range of the pixel correlation function is found in the feature space of the contaminated image pixels, and the core parameters of the available range are determined. Based on the degree and type of chemical pollution, the category of the pixels of the special polluted gas is determined, and the membership of the color characteristics of the gas is calculated according to the diffusion of the gas:

$$r_m = 1 - \frac{d_m(x)}{R_m} \quad (3)$$

Where $d_m(x)$ represents the gas pixel characteristics; R_m denotes the overall membership of chemical pollution. The membership degree of the gray-scale pixel features of the chemical pollution image is obtained according to the calculation formula, and the

gray-scale pixels of the chemical pollution image are classified according to the size of the membership degree.

3. Experimental Analysis

3.1. Experimental Preparation

In order to verify the validity of the proposed method for detecting chemical pollution level based on image gray difference, the following experimental tests have been carried out in different detection environments of chemical plants. Ensure that the air environment and pollution level of the chemical plant are different, collect chemical pollution gases under different environments, and grade the pollution gases. Gray-scale image acquisition of chemical pollution gas is performed, and the entropy value is calculated according to the gray-scale image collected. Controlling the concentration of chemical pollutant gas, the intensity of gray-scale pixel characteristics will change according to the gas concentration. When the pollution gas is diluted, the accuracy of the test result of chemical pollution level will decrease. Based on the above formulas (1), (2), (3), the chemical pollution intensity parameters and related functions are calculated, and the results are calibrated repeatedly.

3.2. Result Analysis

The proposed method of detecting chemical pollution level is set as experimental group, and the existing method of detecting chemical pollution level in video image processing is set as control group. The error rates of the two methods are compared when the chemical pollution gas is not diffused or diffused. The results are shown in Table 1 and Table 2.

Table 1. Data for Non-Diffusion Detection of Chemical Polluted Gases.

Chemical pollution detection project	Test group	Control group
Number of inspections	500	500
Area of chemical pollution detection area	200	200
Detection time	20	20
Number of successful detections	491	453
Error of detection result	1.80%	9.40%

Table 2. Detection Data of Chemical Contaminated Gas After Diffusion.

Chemical pollution detection project	Test group	Control group
Number of inspections	700	700
Area of chemical pollution detection area	300	300
Detection time	20	20
Number of successful detections	694	621
Error of detection result	0.85%	11.28%

As shown in Table 1 and Table 2, under the same detection times, area and time, the proposed method of chemical pollution level detection has more successful times and less error rate than the existing methods. It is more suitable for chemical pollution level detection.

4. Conclusion

In summary, the method proposed in this paper can detect and determine the pollution level of chemical industry adaptively according to the intensity of pollution discharged by chemical plants. Experiments show that the proposed detection method has a higher probability of success and a lower error rate. It can effectively reduce the occurrence of pollution gas diffusion in chemical plants and improve the accuracy of detection

results. However, the chemical pollution data collected in the experiment is limited, and there may be some deviations in the experimental results. In future research, data collection should be improved.

References

1. F. Li, L. Mao, Y. Jia, *et al.*, "Distribution and risk assessment of trace metals in sediments from Yangtze River estuary and Hangzhou Bay, China," *Environ. Sci. Pollut. Res.*, vol. 25, pp. 855–866, 2018, doi: 10.1007/s11356-017-0425-0
2. K. P. Singh, S. Gupta, and P. Rai, "Identifying pollution sources and predicting urban air quality using ensemble learning methods," *Atmos. Environ.*, vol. 80, pp. 426–437, 2013, doi: 10.1016/j.atmosenv.2013.08.023
3. S. Yin, H. Liu, and Z. Duan, "Hourly PM2.5 concentration multi-step forecasting method based on extreme learning machine, boosting algorithm and error correction model," *Digit. Signal Process.*, vol. 118, p. 103221, 2021, doi: 10.1016/j.dsp.2021.103221
4. M. Krestenitis, G. Orfanidis, K. Ioannidis, *et al.*, "Oil spill identification from satellite images using deep neural networks," *Remote Sens.*, vol. 11, no. 15, p. 1762, 2019, doi: 10.3390/rs11151762
5. H. Liu, H. Tian, K. Zhang, *et al.*, "Seasonal variation, formation mechanisms and potential sources of PM2.5 in two typical cities in the Central Plains Urban Agglomeration, China," *Sci. Total Environ.*, vol. 657, pp. 657–670, 2019, doi: 10.1016/j.scitotenv.2018.12.068
6. M. Qu, W. Li, C. Zhang, *et al.*, "Assessing the pollution risk of soil Chromium based on loading capacity of paddy soil at a regional scale," *Sci. Rep.*, vol. 5, no. 1, p. 18451, 2015, doi: 10.1038/srep18451
7. G. Luo, Z. Han, J. Xiong, *et al.*, "Heavy metal pollution and ecological risk assessment of tailings in the Qinglong Dachang antimony mine, China," *Environ. Sci. Pollut. Res.*, vol. 28, pp. 33491–33504, 2021, doi: 10.1007/s11356-021-12987-7