Research on Image Feature Extraction of Pavement Crack Disease

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Abstract: The traditional highway disease detection technology and method are inefficient and can not meet the needs of modern detection. In this paper, the identification and extraction method of pavement crack disease characteristics is proposed. In the crack disease image, the grey image is transformed to highlight the crack information and background colour. Then, the effects of various image enhancement are compared, and a better algorithm template is selected to remove the black and white noise on the grey image, and the image with high accuracy is obtained. Finally, the image is segmented by stretching threshold, and the crack features are extracted by morphological closed operation. Based on ENVI+IDL development platform, an experimental system for pavement crack disease detection is developed. The experimental results show that the experimental system can effectively detect and extract pavement crack diseases and realize batch processing of multiple disease images.

1. introduction

Roads must be regularly investigated and maintained due to factors such as vehicle driving, weather changes and natural disasters, which can cause various types of diseases on the road surface and even affect traffic[1]. Limited to management tools and technical level can not carry out real-time effective detection of the road surface, but also need to carry out in depth study of road detection and maintenance. With the development of digital image sampling technology and digital image processing technology, automatic road disease detection is possible. The application of new technology and methods to detect road diseases not only saves time and effort, but also eliminates the effects of manual interpretation, which is the ideal solution for road surface damage.

Road surface image interpretation is the key research content of road maintenance and maintenance, and scholars at home and abroad have done a lot of research on road surface crack image extraction. The method of differential shadow is used to identify cracks, and the grayscale value of images with cracks and crackless are used to make a difference, so as to achieve the purpose of identification, but it
is easily affected by noise, and the experimental effect obtained is not ideal[2]. Some scholars use different thresholds to split the image, so as to better judge whether the effect of different segmentation algorithms is effective[3]. B.Chandaa[4], etc, used multi-scale morphological algorithm to detect crack information of crack disease, A.Cuhadar adopt an automatic segmentation algorithm based on the theory of wave transformation, which is not detailed enough. N.Katakam[5] split the image into blocks and then processes each image separately, but missed the overall process. Y.C.Tsai uses dynamic thresholds to split the image, but the algorithm has some disadvantages and the calculation is relatively large. Gao Jianzhen[7] removed noise that caused by the unevenness of grey level image, and then used various algorithms to process the image. Shi Shuming[8] proposed a classifier for crack recognition on asphalt pavement, which is improved on the basis of neural networks, and Liang Zhiyong et al studied how to remove image noise from the formation of image noise. The literature [10] used the correlation model to the gray-scale image in the extraction of road crack disease characteristics, and the effect is better. Based on digital image processing technology, Bloomberg[11] have studied the automatic classification of road cracks, but the expression is not complete enough in the whole feature extraction process. Based on this, this paper will propose a complete set of automatic road crack extraction algorithm process.

2. Image characteristics of road crack diseases

Image pre-processing usually uses image grey level transformation and noise removal. The sources of noise are: natural environmental factors, such as damage to the road surface by some other substances covered, the image is also affected by uneven exposure to natural light; The influence of road surface, such as the particles present on some road surfaces, reflects light, and the degree of unevenness and roughness of road surface will affect the quality of the collected pictures; In the process of image acquisition, with the motion of the acquisition vehicle, the camera installed in the acquisition vehicle will produce vibration, in addition, in the process of image collection and transmission, the collecting equipment will form a Gauss white noise due to force majeed factors. Although low-pass filtering can remove noise information from high frequency bands, edge information can also be removed by this method, and maybe lose valuable information.

The characteristics of the crack image about the road surface are analyzed as follows: (1) The crack part is only a part of the image, and the background part is an important part of the image. Because the pavement material is unevenly distributed when it is built, the grey level background of the pixels and the pixels in the background is similar. The main features of the crack image have the smallest grayscale value in the local area, and the crack target can be obtained according to the grayscale value of the feature. However, due to noise, simple grey level threshold segmentation is not ideal and a lot of useful information is lost. (2) Cracks are only part of the road surface, so the crack part has fewer pixels in the entire image than in the background. (3) Because building roads using different materials produces random noise information, pre-processing is to remove that noise information. (4) The grayscale value of the background overlaps with the grayscale value of the crack.

3. Crack image processing

3.1 Grey level of the image

Because the road crack image is containing brightness and color information. Grayscale of a crack image on a road surface is the conversion of the original color image to a grayscale image, removing color information. Gray image is a special image determined by the same grayscale value of R, G and B, the image grayscale transformation can make subsequent image processing calculation relatively easy, and the grayscale transformation image information and the original image information is similar, still can reflect the characteristics of the image.

3.2 Crack image enhancement

The original image has a certain amount of noise, which brings some difficulties to the analysis of the image features. Therefore, noise that reduces image quality must be processed. The better method of
denoised effect is image enhancement, and there are two main methods of image enhancement: without considering the degradation of the image, the feature area of the image is selectively highlighted, and the secondary information is weakened; In the case of image degradation, the reduced pixels can be compensated, so that the altered image does not change significantly compared with the original image.

Common noises are: (1) Pulse noise (pepper and salt noise): also known as pepper and salt noise; (2) Gauss noise (normal noise): mainly caused by the internal resistance element; (3) Quantifying noise: mainly in the process of light compensation or contraction of road images; (4) Impact noise: In the process of image collection, a single pixel is destroyed, and the grayscale value will gradually change. In order to eliminate noise, the medium filter and the average filter are used to remove the noise, and the optimal one will be selected to denoised.

3.2.1 The medium filter

The medium filter is a nonlinear signal processing method[12], and the corresponding medium filter is also a nonlinear signal processing filter. The noise in the image is suppressed by neighborhood operation. Select a template that consists of several adjacent pixels, arranged from small to large, and replaces the value of original pixel with the median value before processing using the median filter operation. Figures 1 (b), (c) and (d) are to select different window sizes to process the crack image, the experimental comparison shows that the larger the window, the more information will be lost at the edge of the crack, therefore, this article selects the window of 3×3 as the medium filter template.

![Figures 1. Median filtering effect](image)

3.2.2 Grey level image

The average filter is also known as linear filtering[13], and its main idea is the neighbourhood averaging method. Image enhancement is achieved by removing sharp grey level values from the image. As with the medium filter, a template is selected before the operation is performed, and the template is used to perform the operation of adjacent areas. There are also some disadvantages: while reducing noise, it blurs edge information and detail information, distorting the image. In means filtering, more windows are usually selected for 3×3, 5×5, 7×7, and the results of the processing are shown in Figure 2 (a), (b) and (c) by using different templates for the average filtering of the image.

![Figures 2. Mean filtering effect](image)

After the above two denoised methods to deal with the road surface crack image, from the results, it can be found that the average filter can effectively reduce the noise, but also affect the overall information expression of the image, so that the image becomes blurred, the noise still exists. For the medium filter, because some noise points on the image are randomly distributed, according to the principle, through the way of data arrangement, the use of the image is not contaminated by noise pixels to replace
the noise points, so the suppression effect is better, the outline of the crack image is still clear. The experimental results show that the medium filter is more suitable for de-noise processing of road surface images than the average filter.

3.3 Split of the crack image

3.3.1 Image segmentation

Image segmentation is an important step in the automation of image analysis, and it is the process of classifying each pixel in an image into small areas. A small area is a collection of pixels with the same attribute feature. The degree of segmentation is specifically analysed on the basis of specific problems. In an application, once the object of interest is separated, it stops splitting immediately, but over-segmentation can also have an impact on subsequent processing. The accuracy of image segmentation directly affects the accuracy of detection and recognition of subsequent images.

The image segmentation algorithm is usually calculated based on two basic characteristics of brightness values (discontinuity and similarity). The application of the first feature is to divide according to the discontinuity of the brightness of the image; The second feature divides the image into similar areas according to pre-defined guidelines. Image segmentation includes:

1) the method based on threshold segmentation is to select a threshold according to the grey level difference between the target and background in the image, and divide the background and target object into two parts.

2) Based on the regional growth of the image segmentation, in the target to find a point, according to its growth characteristics, the image is divided into two parts of the target and background;

3) Using the morphological expansion principle to construct a dam, according to the difference between the two gray-scale values of the dam, one is divided into two parts or more parts.

3.3.2 Threshold segmentation

Threshold segmentation is a two-value transformation of an image. Selecting the appropriate threshold divides the grey level of the image into two or more parts, and pixels that belong to the same part are considered to be the same area. The boundary outline of the target object is extracted by using the threshold method, and its essence is morphological segmentation. In the actual application process, there are three different methods of threshold segmentation: global threshold method, (2) local threshold method, and (3) adaptive threshold method.

Using fixed global threshold segmentation, not every local area of the image can be taken care of, so it is suitable to use multiple thresholds to split, find the threshold suitable for crack image, adaptive threshold method is based on local threshold. In this paper, adaptive threshold method is used to achieve image threshold segmentation by stretching the contrast between the background color and the crack color. Portrait crack image transformation, Figure 3 (a) is the stretch value (70,35), Figure 3 (b) stretch value is (65,39), transverse crack image transformation, Figure 4 (a) is stretch value (74,30), Figure 4 (b) is the stretch value (98,15), the block crack image transformation, Figure 5 (a) is the stretch value is (68,33), Figure 5 (b) is the stretch value is (73,26). Obviously Figure 3 (b), Figure 4 (a) and Figure 5 (a) extract cracks more clearly but add a lot of noise.
By using stretch segmentation to process different crack images separately, from the results of the experiment, using different stretch values, the background color and crack color in the image will have different effects, enhance contrast, but also increase a lot of noise information. So you need to experiment with each image multiple times to find the most appropriate stretch value (threshold).

4. **Morphological operation of crack images**

Morphological processing is the selection of a set of morphological algebraic operator to process the image, and the shape and structure of the image are processed by the sequence of operator:

1. Noise removal, using on and off operations, is able to remove the added noise generated by the device during the collection and transmission of the image, as well as connect small break points and fill holes and cracks.
(2) The extraction of the edge in the image, the selected structural elements are 4 neighbourhoods or 8 neighbourhoods, these structural elements can be used on the image to obtain the outline of the image boundary. Because the microcomputers are more sensitive than the ones selected by the mathematical morphological method, the method of extracting the edges in the image by mathematical morphological methods is better than the traditional edge detection gradient algorithm, and the edges of the image become smooth.

(3) Describes and defines the characteristics of various geometric parameters and images, including the calculation of target area, length, connectivity, particle size and target refinement, skeleton extraction, and some judgments on the direction of extraction features.

4.1 Expansion and corrosion operations of crack images
(1) Corrosion operation of crack image: used to eliminate all boundary points of an object. If a structural element picks a 3×3 black dot, called a simple corrosion, the result is that the boundary of the area is reduced by one pixel from the surrounding area. If the area is circular, its diameter will be reduced by two pixels per corrosion, using different dimensions of structural elements and removing different objects, i.e. noise. For cracks, if there is a small connection between the two cracks, corrosion can separate the cracks. Figure 6 shows that the image after corrosion operation removes the noise, and also makes most of the crack information lost.

(2) Expansion operation of the crack image: the background point around the image area is merged into the area, and the result is the number of points corresponding to the increase in the area of the area. If the distance between the two target objects is closer, it can be expanded to be connected together. The expansion operation fills the gaps in the target object. Experimental effect from Figure 6. It is known that the image after the expansion operation removes the noise, which reduces the noise of the crack image, but also makes the crack feature narrow.

4.2 Open and close operations of crack images
(1) On operation: the first corrosion operation of an image, and then the processing method of expansion operation[6]. Open operations are used to smooth the contours of the cracks, break the narrow intervals, and the slender protrusions are removed. As can be seen from Figure 7, the contours of the crack image after the open operation are smooth, and some small highlights are eliminated, mainly removing isolated points.

(2) Closed operation: the method of processing corrosion of an image by first expanding and then on this basis, the principle, the operation process and the open operation are opposite. As shown in the following two images, Figure 7 (a) is a two-valued image, and Figure 7 (c) is a closed image. As can be known from Figure 7, the closed operation fills some narrow blank areas and cracks in the crack image, connects the two nearer targets, and smooths the outline of the image, mainly to remove the holes in the crack.
5. Crack image feature extraction method

For feature extraction, the same kind of object features are more similar, and the characteristics of different categories of objects are also more different. Through many experiments, the algorithms are compared and analyzed, and the final algorithm flow is selected as shown in Figure 8. According to this process, different types of cracks are featured. Horizontal crack disease feature extraction effect, as shown in Figure 9 (d), vertical crack disease feature extraction effect, Figure 9 (e), irregular crack disease feature extraction effect, as shown in Figure 9 (f).

6. Conclusion

Due to the many advantages of ENVI-IDL development platform, the research and development of experimental system by IDL language and the experiment of road image data collected are verified on the process of road crack image processing algorithm proposed above, and many experiments show that the crack image processing algorithm and process proposed in this paper have obvious advantages in image crack extraction.
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