Research on Road Surface Cracks Detection Based on Rough Set

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Abstract. The road surface horizontal fracture, sink. Road image by filtering to remove noise, edge detection using several classical operators were analyzed, we propose a rough sets and fuzzy sets based on the morphological model, and apply it to the pavement crack image. By contrast to the other classic method, indicate that the method has successfully completed in the image edge detection.

Introduction

Pavement crack detection complicated, there are a lot of noise, the crack detection difficult to achieve. Priyan Gunatilake aircraft design surface crack detection system [1]; J Pynn design of the road surface crack automatic inspection system [2]; D.H.Ryu fatigue crack detection system design [3]; Atsushi Ito designed concrete brick surface crack extraction and measurement system [4]; Paul W. Fieguth design of the underground pipe surface crack detection system [5].

Edge discontinuity is often gray, based on this feature and made the classic edge of the first-order operator[6-7] and second-order operator detection algorithm is simple and fast, but are susceptible to noise interference, resulting in edge detection is not complete, the results inaccurate. Mathematical morphology [8] is the angle from the collection and analysis to characterize the image, but need to be improved.

This paper adopts a different structural elements, the combination of rough set [9] and mathematical morphology, and apply it to the road surface crack detection on the image. The method is more accurate and detailed, more testing is better than several traditional algorithms.

2 Pavement crack image pre-processing

Asphalt pavement cracks will be displayed on the computer screen and the image data stored in the computer's hard drive. Road surface disease by real-time analysis system can be collected for analysis of image data, automatic identification of crack location, length and other information. Then the analysis results stored in the database file. Asphalt pavement distress can be divided into horizontal cracks, vertical cracks, cracks and pits and other network (Figure 1).

First, pre-processing. The road surface crack image is divided into several different blocks, occupy different between the different blocks of gray range, and these block scan crack the target and the background to distinguish, for pavement crack image segmentation. Appropriate for computing the crack image, the asphalt pavement crack image is subdivided into components or target, to minimize the interference of background pixels.
Binary crack image of the crack segmentation. The target set for a crack, the road set to zero, the result is a crack image processing is divided into binary images. Different segmentation algorithms, the effect is not the same, therefore, for the image will not crack use a variety of corresponding segmentation. Pavement cracks and normal gray level between the road there are obvious differences. For the crack images, objects and background occupy different gray-scale range image segmentation through histogram transformation to obtain the threshold, in the asphalt pavement crack image segmentation, segmentation results for the binary image after gamma correction, and filtering after the binary image blur, image noise is also much to eliminate, to the expected treatment goals.

3 Surface cracks edge detection based on mathematical morphology

3.1 Mathematical morphology algorithms

Pavement crack detection image, that image edge detection, is the basic approach. Around the edges of the image is the pixel gray pixels those changes are not a collection of continuous, widespread in the edge between the object and background, between the object and the object, the identification and extraction of image edges on the image recognition and scene understanding is very important.

The main content of mathematical morphology is to design a set of transformations, concepts and algorithms to describe the basic characteristics of the image. Morphological structure using a set of elements called and set to be analyzed (images) to be used to analyze the interaction picture.

3.2 Structural elements selected

In this paper, consider the horizontal, vertical, diagonal direction of the image in different sizes and other structural features, so using 2 sets of structural elements[9] in the experiments, the first four linear structuring element, after the four protection structure for the inflection point element, each element of a structure can be said that the structural features of the image in a certain direction.

4, Edge detection algorithm of pavement crack image based on rough sets - fuzzy

Between rough sets and mathematical morphology theory has a certain relationship. The fuzzy mathematical morphology, fuzzy degree of each pixel. is defined as the structural elements and the suitability of the image.

First, find images and structural elements of the membership function. For an image, to obtain the degree of membership of each point, and then the erosion and dilation operations, and finally get the image edge.

4.1 Erosion and dilation of crack image

For each crack image pixel for each structural element, the calculation to find the best pixel size characterization. As long as the structural element is self-anti symmetric, the upper and lower approximation of rough sets can, through morphological erosion and dilation to obtain. Therefore, a binary image U, so that one of the objects of X, choose to include the origin and the symmetry of the structure element B, the binary image to strike a rough set-based erosion and dilation algorithms obtained by the upper and lower approximation of X to B.

4.2 Degree of membership

Fuzzy mathematical morphology, image is no longer considered a hard binary point set, but as a fuzzy set processing. In which each pixel is defined as the fuzzy structure elements and the suitability of the image. The method of erosion and dilation operations are defined.

According to rough set point for the collection, from (1) obtain the original image u rough membership function.
\[ \mu_x(x) = \frac{X \cap [x]_R}{[x]_R} \]

Which lead to the fuzzy set U:

\[ F^R_X = \left\{ (u, u_{e^R}(u)) : u \in \cup, u_{e^R}(u) = \frac{X \cap [u]_R}{[u]_R} \right\} \]  

Defined by the corrosion expansion, access to the membership of each pixel.

\[ u_{e^R}(x) = \begin{cases} 
1, & x \in E_B(X) \\
\frac{[x]_R \cap X}{[x]_R}, & x \in D_B(X) \land x \notin E_B(X) \\
0, & x \notin D_B(X) 
\end{cases} \]  

4.3 Corrosion expansion of the strike

The use of (4) and (5), respectively, the fuzzy mathematical morphology corrosion expansion of operations, to obtain binary image pixel for each U in corrosion, expansion of the membership function value. Get the image on the lower approximation.

\[ u_{e_B(A)}(x) = \min_{y \in B} \min_{y \in B} \left[ \frac{X}{X} \right] \left[ 1, 1 + u_A(x + y) - u_B(y) \right] \]

\[ = \min_{y \in B} \min_{y \in B} \left( 1 + u_A(x + y) - u_B(y) \right) \]

\[ u_{d_B(A)}(x) = \max_{y \in B} \max_{y \in B} \left[ u_A(x - y) + u_B(y) - 1 \right] \]

4.4 Pavement crack image edge detection

The resulting output will be 4.3, the rough set upper approximation and lower approximation subtraction, the output of the crack edge.

5. Analysis of experimental results

For each image pixel for each structural element, the calculation to find the best pixel size characterization. And then the erosion and dilation operations, and finally get the image edge. Classical edge detection algorithms, such as sobel operator, roberts operator, Prewitt operator, etc. to the boundary of the gradient edge detection. In order to verify the validity of the algorithm, the road image as an example, to compare several methods of edge detection experiments.

Experiment shown in figure 2, figure 2 (a) (b) (c) (d), respectively robert operator, prewitt operator, sobel operator and the results of this method. It can be seen from the examples in the same parameter setting conditions, can be seen, sobel operator and other classical edge detection operator is not continuous boundary, the proposed algorithm can extract a more complete picture of the edge information, edge connectivity and better accuracy, while maintaining image detail and edge smoothing the edges are made in good results, better than several conventional algorithms.
Figure 2 The result of several pavement crack image edge detection algorithm

6. Conclusion

Highway pavement crack images for practical problems, we propose a rough sets and fuzzy sets based on the morphological model, and apply it to the pavement crack image. By contrast to other classic experiments such as edge detection Sobel operator, Prewitt operator, Roberts operator method, indicating that the method has successfully completed the image edge detection, boundary is more accurate and detailed. If a more closely integrated with the actual, there will be considerable potential for application.

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References


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