Indian Journal of Science and Technology, *Vol 9(47), DOI: 10.17485/ijst/2016/v9i47/108690, December 2016*
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Road Surface Crack Detection using Wavelets Features Extraction Technique

Slamet Riyadi[1*], Fiddin Yusfida A'la[1], Chayadi Oktomy[1] and Kamarul Hawari Ghazali[4]

[1]Department of Information Technology, Faculty of Engineering Universitas Muhammadiyah Yogyakarta, Indonesia; riyadi@umy.ac.id, fiddinyusfida@gmail.com, chayadions@ft.umy.ac.id
[2]Faculty of Electrical and Electronics Engineering, University Malaysia Pahang, Malaysia; kamarul@ump.edu.my

Abstract

Evaluation of road pavement is an important task to maintain its quality. In a traditional way, officer checks the road surface by surveying along the road. This traditional method is less efficient because it requires extensive costs, takes a long time, exposes to safety issues, and less accurate due to human subjective factor and fatigue. The objective of this research is to develop a features extraction method based on wavelets to detect crack and non-crack road surface. The method involves road surface acquisition, pre-processing, features extraction using wavelets and classification task using linear discriminate analysis. The developed method was implemented on 56 images and produced 92.8% of accuracy detection of crack and non-crack.

Keywords: crack detection, feature extraction, image processing, discrete wavelet transform

1. Introduction

Road becomes an important function not only to connect one place to another but also has a role in the development of a region. Roads material has a certain lifespan and durability. There are many factors affecting road damage such as material quality, natural factors, and overload usage. These conditions could disrupt and endanger road users. Accidents often occur because the driver cannot control vehicle while anticipating the damage of the road. According to the Bina Marga Roads Manual No.03/MN/B/1983, the road damage is classified into cracking, distortion, surface effects (disintegration), polish aggregate, bleeding and flushing, and utility planting. This research only focused on the road examination to detect presence of cracks.

Currently, examination of the road still uses traditional way by manual observation using human vision. This traditional method is less efficient and effective because it needs extensive costs, takes a long time, exposed to safety issues such as the high intensity of vehicle passing by, the subjective factor, and the fatigue factor[1]. Automated pavement crack detection has undoubtedly improved the assessment process of road pavement condition[2,3]. Photogrammetric approach considered being very effective in the detection of cracks but on other hands, there is a drawback because the camera was used has unique specifications at relatively expensive and complicated operation[4]. The cracks are well detected using continuous wavelet transform with more or less noise according to the texture[5]. Based on the problems discussed above; the objective of this research is to develop a new method that can detect cracks with a more affordable, reliable, and simple operation device using wavelet features extraction method.

2. Methodology

The methodology of the research is described in Figure 1. Firstly, to get the images data, we have to make data acquisition. Then the data was resized and converted to grayscale image. After that, images are processed and extracted using statistical properties extraction. This

**Author for correspondence*

study used mean and standard deviation values as statistical properties extraction. Finally, the linear discriminate was applied to classify the images as "crack" or "non-crack". Discriminate lines make images separated by its class. This result was then compared to visual initialization images to get the percentage of accuracy.

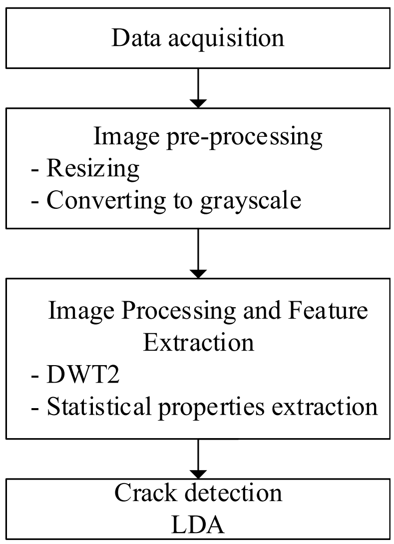


Figure 1. Crack detection diagram.

2.1 Data Acquisition

Figure 2 shows the image acquisition setup according to the following protocols:

- The camera was positioned in perpendicular view to the road.
- Camera and road surface distance should not be too close or too far so the image obtained can be processed well.
- Data was collected at certain hours when it is not too dark and have enough light intensity.

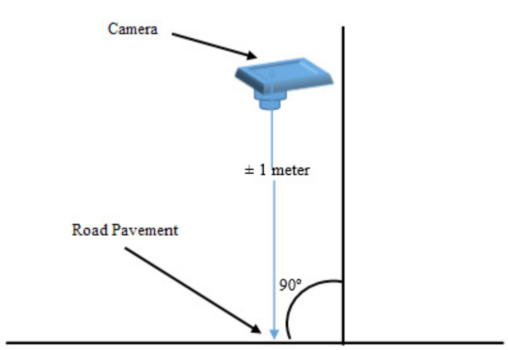


Figure 2. The image acquisition setup.

2.2 Image Pre-Processing

This stage aims to prepare the image before it is processed using wavelet transformation method. First, the image was resized into 480x640 dimension and converted into grayscale image to reduce the computation time.

$$A^{n/2} = \frac{1}{2}\begin{bmatrix} 1 & 1 & & & & & & & & \\ & & 1 & 1 & & & & & & \\ & & & & \ddots & & & & & \\ & & & & & & 1 & 1 & & \\ & & & & & & & & 1 & 1 \end{bmatrix}$$

$$B^{n/2} = \frac{1}{2}\begin{bmatrix} 1 & -1 & & & & & & & & \\ & & 1 & -1 & & & & & & \\ & & & & \ddots & & & & & \\ & & & & & & 1 & -1 & & \\ & & & & & & & & 1 & -1 \end{bmatrix}$$

Figure 3. Haar filter bank.

2.3 Wavelet Transformation

Wavelet transform modifies image to different degrees of resolution or pyramid representation. It could provide more detail information compared with spatial image. Images that have been converted to grayscale on the image pre-processing phase were transformed into frequency sub-bands which is the components are manufactured by reduced levels of decomposition. Implementation of Discrete Wavelet Transform (DWT) was done by passing a high frequency (high-pass filter) and low-frequency signals (low-pass filter). In this case, we used the mother haar wavelet transform to extract features from the image, smoothing process (on average) to get a piece of the low-frequency image and made the process of reduction (difference) to get a slice of high-frequency picture[8]. Haar filter bank is shown in Figure 3.

If an image transformations process is carried out with two-dimensional discrete wavelet decomposition level one as shown in Figure 4, it will generate four sub-bands, namely:

- Coefficient Approximation (CA) or LL sub-band.
- Coefficient Horizontal Detail (CH) or HL sub-band.
- Coefficient Vertical Detail (CV) or LH sub-band.
- Coefficient Diagonal Detail (CD) or LH sub-band HH.

This algorithm has been applied and produced CA values after decomposition as shown in Figure 5.

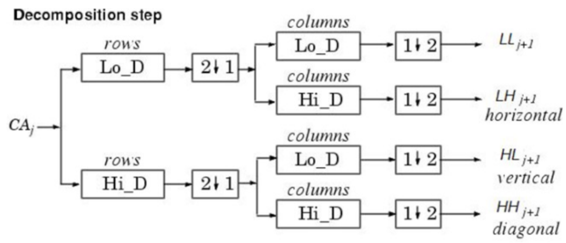
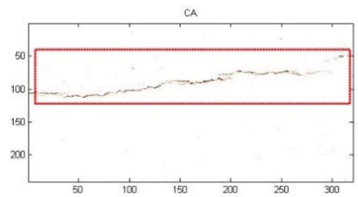
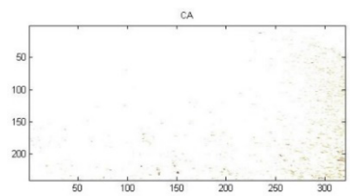


Figure 4. Decomposition step.



(a)



(b)

Figure 5. CA transformation result (a) crack images (b) non-crack images.

2.4 Statistical Features Extraction

Feature extraction is the process that raises the unique characteristics of an object in the form of value that will be used for further analysis. As mentioned in the previous section, Coefficient Approximation (CA) is component that represents the original image which has been filtered by using a Low-Pass Filter (LL). This coefficient is processed and computed further using basic statistical properties. The computed statistical properties are; x_1 represents mean computed using equation (1) and x_2 represents standard deviation computed using equation (2).

$$\mu = \frac{1}{N}\sum_{i=1}^{N} X_1 \tag{1}$$

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x_i})^2} \tag{2}$$

2.5 Linear Classification

Classification method used in this research is Linear Discriminant Analysis (LDA) to find a linear combination of the characteristic or separating two or more classes of objects or events. Classification is divided into two classes, namely "crack" and "non-crack". Crack detection is done with a simple process and does not require a complicated classification process[9]. This classification method uses two inputs, namely the values of feature extraction results in the previous step. Equation of linear discriminant analysis that we used is as follows

$$Y = K + L(1)^*X_1 + L(2)^*X_2 \tag{3}$$

In the case of mean-STD feature extraction, it shown in Figure 6.

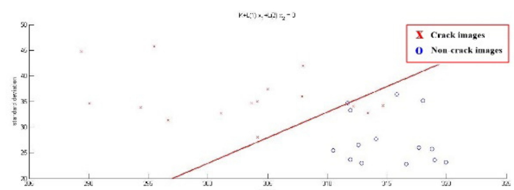


Figure 6. Scatter plot feature extraction (sum-std) and its linear discriminant line.

A total of 56 testing images were classified by quality into good, medium, and low. This qualification based on manual perception. Good quality images are images that can be processed properly and produce a right decision according to manual classification. It is easy to detect because the images have a high contrast between object and background. The sample of good images is shown in Figure 7.

(a)

(b)

Figure 7. Good quality images (a) crack, (b) non-crack.

Medium quality images have cracks that less obvious. It is difficult to recognize these images because it has the same color between object and background and non-crack images displays a less smooth. The sample of medium quality images are shown in Figure 8. Bad quality images are images that can't be processed properly and produce a false decision according to manual classification. This image isn't clear with the same color between object and background, so it's difficult recognized. The sample of bad quality images is shown in Figure 9.

(a)

(b)

Figure 8. Medium quality images (a) crack, (b) non-crack.

(a)

(b)

Figure 9. Bad quality images (a) crack, (b) non-crack.

3. Result

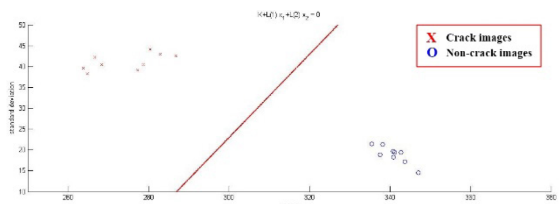
In this research, 30 images used as a data sample for training to determine the discriminant function which is consist of crack and non-crack image and another 56 images were used for real data testing. The images for training (crack and non-crack) were classified and used as a reference for expert visual labeling. Next, the rest of images were classified using the linear discriminant function using equation (3).

$$y = -74.5443 + 0.2691^{*}x_1 + (-0.2699)^{*}x_2 \qquad (3)$$

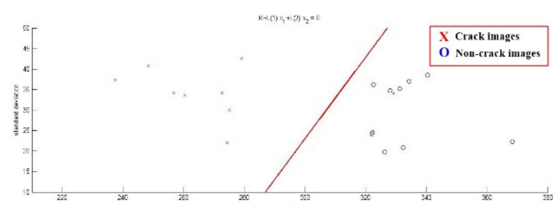
To discriminate the image as crack or non-crack, we implemented the following rules base:

If y <= 0 then image = crack, else image = non-crack

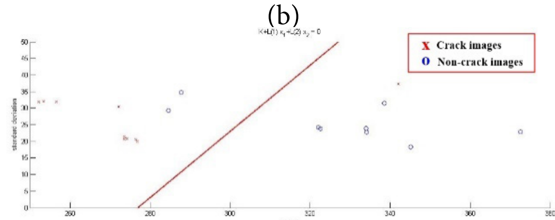
These images were tested using linear discriminant analysis. The result of tested images is shown in Figure 10.



(a)



(b)



(c)

Figure 10. Scatter plot of tested images by quality, (a) good, (b) medium, (c) low.

Scatter plot result quality images are shown in Figure 7 with "x" as crack images and "o" as non-crack. From scattering plot result can be observed that both of crack and non-crack images separated by red lines linear equation. It's mean that testing on good quality images Figure 7(a) scores up to 100% accuracy. Scatter plot of medium-quality images Figure 7(b) can be observed that some images cross the red lines equation, scores up to 94.7% accuracy. Scatter plot of bad quality images Figure 7(c) can be observed that some images cross the red lines. This type crack and non-crack images difficult to distinguish from the background scores up to 94.7% accuracy. The classification results of 56 testing images filtered by quality; good, medium, and low quality which shown in Table 1.

Table 1. Result of pavement cracks detection

Images Quality	Images		Error	Accuracy
	Crack	Non-crack		
Good	9	9	0	100 %
Medium	9	10	1	94.7 %
Low	10	9	3	84.2 %
Average				92.85%

4. Conclusion

Based on this study, it can be concluded that the road's surface crack detection using wavelet transformation and feature extraction based on the road images has been successfully implemented. The system developed in this study can detect pavement crack with 92.85% optimal accuracy. There are some errors due to the effects of light intensity of image and data acquisition affecting the image feature extraction.

5. Acknowledgment

Authors would like to acknowledge Directorate for Research and Community Service, Ministry of Research and Higher Education, Republic of Indonesia for the financial support through Fundamental Research 2015 scheme.

6. References

1. Rababaah H. Asphalt pavement crack classification: A comparative study of three AI approaches: Multilayer Perceptron, genetic Algorithms and Self-Organizing Maps [Thesis]. India: Department of Computer and Information Sciences; 2005.
2. Adu-Gyamfi YO, Attoh-Okine N. Multi-resolution information mining and a computer vision approach to pavement condition distress analysis. CAIT-UTC-009; 2014.
3. Federal Highway Administration**.** Pavement Distress Identification Manual. America: National Park Service; 2006-2009.
4. Ling T-C, Mustaffar CPM. Automated Pavement Imaging Program (APIP) for pavement cracks cassification and quantification – A photogrammetric approach. Remote Sensing and Spatial Information Sciences. 2008; 37:B4.
5. Subirats P, Dumoulin J, Legeay V, Barba D. Automation of pavement surface crack detection using the continuous wavelet transform. ICIP**;** 2006. p. 3040.
6. Marques AGCS. Automatic road pavement crack detection using SVM. Lisbon: Electrical and Computer Engineering. 2012.
7. Gonzalez RC, Woods RE. Digital Image Processing. New Jersey: Prentice Hall; 2002.
8. Darma P. Citra Digital dan Ekstraksi Fitur. Yogyakarta: Graha Ilmu; 2010.
9. Riyadi S, Asnor Juraiza I, Mohd Marzuki M, Aini H. Wavelet-based feature extraction technique for fruit shape classification. Proceeding of the 5th International Symposium on Mechatronics and its Applications (ISMA08); Amman, Jordan. 2008.