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Edge Detection Technique Analysis to Determine Deformation In Bridge Structure

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Abstract

Transportation infrastructure is one of the keys to economic development in Indonesia. As a result of the lack of addressing maintenance requirements and rehabilitation, bridge management systems are developed to help plan bridge maintenance and rehabilitation and to avoid a crisis reaction approach to maintain transportation infrastructure. However, the costs associated with developing and maintaining transport infrastructure in Indonesia continue to rise, and funding continues to shrink. Many evaluation methods are designed to operate on existing bridges without impairing their usefulness. Some of these methods are known as nondestructive evaluation (NDE) methods. Four imaging edge detection algorithms were selected for comparison in this paper: Fast Haar Transform (FHT), Fast Fourier Transform (FFT), Sobel, and Canny. This algorithm is used in many edge detection problems and considered here as a possible crack detection technique for bridge inspection problems.

Keywords
bridge structure; minitoring

I. Introduction

Transportation infrastructure is one of the keys to economic development in Indonesia. Transportation is needed to ensure the mobility of people and goods. Therefore, providing a high level of ease of repair through periodic inspection and maintenance is it is important to keep the transport system operational and avoid major replacement efforts. However, over the years, many urban and district transport operators have spent most of their planning and budgeting efforts and allocated money to new construction, while maintenance and rehabilitation are generally managed by less formal methods (Hass et al., 1994). In some cases, crises are the driving force behind commencement of maintenance and/or rehabilitation measures, especially when funds are limited. Such an approach, however, is no longer adequate or appropriate, especially since most transport infrastructure has reached its design service life (PCA, 1995).

As a result of the lack of addressing maintenance requirements and rehabilitation, bridge management systems are developed to help plan bridge maintenance and rehabilitation and to avoid a crisis reaction approach to maintain transportation infrastructure. However, the costs associated with developing and maintaining transport infrastructure in Indonesia continue to rise, and funding continues to shrink.

In 2008, the Government paid more attention to construction of road and bridge infrastructure to achieve targets growth of 6.8%, boosting the pace of investment, and driving the real sector. The budget issued also swelled up to tens of percent of the the previous year. Government allocates budget for Ministry of Public Works of IDR 35.6 trillion, up 41.4% compared to the forecast realization in the Revised State Revenue and Expenditure Budget (APBN-P) 2007. A good transportation infrastructure management system is the key to success transportation system. The bridge inventory in the national transportation infrastructure is very important because of its high cost and direct impact on public safety, so the issue of bridge maintenance is the focus of the project described in this paper.

II. Research Method

This writing method uses descriptive. Descriptive method according to Sugiono (2009) is a method that aims to describe or provide an overview of the object under study through data or samples that have been collected as they are without analyzing and making conclusions that apply to the public. In other words, analytical descriptive research takes problems or focuses attention on problems as they are when the research is carried out, the results of the research are then processed and analyzed to draw conclusions.

III. Result and Discussion

3.1 The Bridge Inspection

Total cost of maintenance, rehabilitation and replacement is related to the average age of the entire bridge network. Many factors tend to accelerate bridge breakdown; for example, truck weights and traffic volumes have been increased dramatically, causing premature physical weathering of all networks, while funds available for maintenance have not been able to keep up with the declining situation. The main component of the bridge maintenance and rehabilitation function is its data content (Saito et al. 1990; AASHTO 1993; Hass et al. 1994).data are collected and analyzed on a regular basis the urgent need to develop an effective bridge management system that improve methods of collecting, organizing, and using data for proper and appropriate planning. performance of maintenance and rehabilitation processes.

Monitoring and inspection of bridges is an expensive but important task in maintaining a secure infrastructure. Traditionally, the main method used to monitor bridges is visual inspection. During a typical bridge inspection, various members of the structure are inspected at close range by trained inspectors who evaluate the condition of the components and give them a rating. This rating is a subjective evaluation of the current state of affairs based on a set of guidelines and experience of supervisors.

For many situations, this type of evaluation is appropriate and effective. However, due to the subjective nature of these evaluations, the condition ratings of similar bridge components can vary greatly from inspector to inspector and from state to state.

In addition, inspections do not always have to be carried out on every bridge in a timely manner. Several factors can contribute to the selection of inspection procedures and can change the timing of inspections (Silano 1993; AASHTO 2000). These factors include structural conditions related to design, age, size, and bridge complexity; traffic congestion and the consequences of traffic disturbances; availability of personnel and equipment; weather patterns; environmental conditions; geographic location; and construction methods and procedure records. Any of these factors can affect the extent of bridge damage and the need for MR&R. The agency should therefore develop a strategy for systematic inspection and documentation that includes the frequency of inspections, the nature of the observations, and the equipment for measurement. The objectives of the inspection program should include

- Guaranteed safety and serviceability;
- Identify sources of actual and potential problems at an early stage;
- Systematically record the state of the structure; and
- Studying the effect of changes in load.

In the last two decades there has been a need for more advanced bridge inspection methods to ensure safety and early detection (Abudayyeh et al, 2000). Many evaluation methods are designed to operate on existing bridges without impairing their usefulness. Some of these methods, known as *nondestructive evaluation* (NDE), may be very broad and versatile and can be used in a number of applications, while others are highly specialized. Remote monitoring used in conjunction with visual inspection has the potential to reduce bridge inspection and maintenance costs. Fully automated remote The importance of timely data acquisition and pavement surface analysis is widely recognized (El-Korchi 1990; Koutsopoulos and Downey 1993; Lee 1993).

To achieve timeliness and accuracy in bridge inspections, automation of data acquisition and analysis is required. A number of automated systems for evaluating pavement surface images have been developed (Lee 1990; Longenecker 1990; Klassen and Swindall 1993). This paper focuses on an automated crack detection technique for the bridge deck inspection process (this technique is based on an imaging edge detection algorithm). Specifically, this paper proposes and demonstrates a framework for evaluating the effectiveness of imaging crack detection algorithms in examining concrete bridge deck surfaces, resulting in the selection of the best algorithm. This framework should be used before an automated pavement evaluation system is to be developed.

Edge detection in digital images is defined as sharp intensity transitions. Edge detection algorithms attempt to detect and localize edges without any human input or interference. These algorithms are usually application based and may not produce the same results for a given image. Therefore, investigating different algorithms as proposed in this paper can help in selecting the best one for the bridge image. In addition, once the algorithm is identified as the most suitable for the problem at hand, further improvements can be researched and developed to overcome the limitations that may exist. Four imaging edge detection algorithms were selected for comparison in this paper: *Fast Haar Transform* (FHT), *Fast Fourier Transform* (FFT), Sobel, and Canny. This algorithm is used in many edge detection problems and considered here as a possible crack detection technique for bridge inspection problems. This section provides a brief theoretical background for each of these techniques, which are evaluated using the framework proposed in the next section.

3.2 Experimental Results

A sample of 50 concrete bridge drawings was used in the analysis and comparative study. Half of the images are healthy concrete bridge components, and the other half are cracked and damaged concrete. All images are grayscale images with a resolution of 640×480 pixels. All pictures are bridge deck surfaces (concrete pavement) and does not include backgrounds such as grass or motor vehicle traffic (Figs. 2 and 3 show two sample images). Ideally, a stationary camera mounted on a bridge will focus directly on the concrete, but if the background included in the image, it may be necessary to include a prefilter to remove the anomaly. A MatLab code was developed for each of the four algorithms to read the image, perform the transformation, and extract isolated cracks (commonly referred to as edge images). Edge images were recorded for each technique and for each.

Figure. 1. *Haar for a no-crack image of the image.*

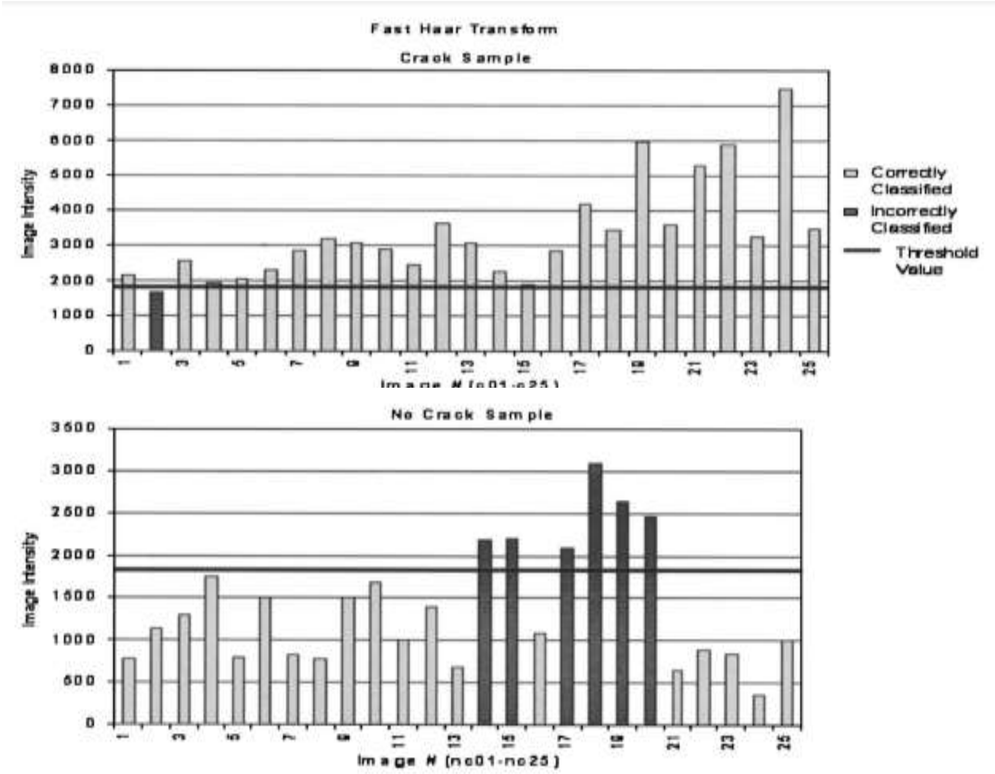


Figure 2. *Intensity data for Fast Haar Transform (FHT)*

Based on the threshold value for the algorithm and the intensity on the edge image, the output image is determined to have cracked or not cracked; this process is schematically shown in Fig. 4. Threshold value is a very important parameter for the performance of any edge detection algorithm. Based on the value of this parameter, it is

decided whether there is a gap or not. In this project, the threshold is determined as the average value of intensity of all pixels in the fracture image. The following is a list of experimental results obtained from the four imaging techniques.

3.3 Fast Haar Transform (FHT)

Fast Haar Transform (FHT), performed significantly better than traditional gradient-based algorithms (Sobel and Canny). It

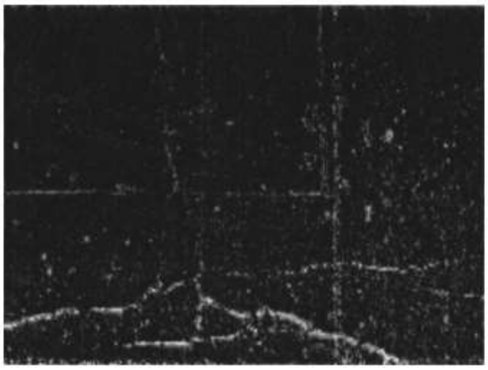


Figure 3. *Fourier for the cracked image in Figure*

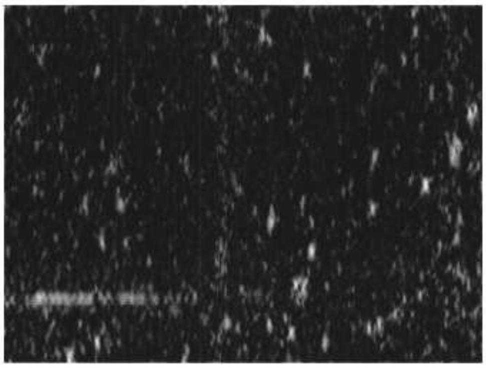
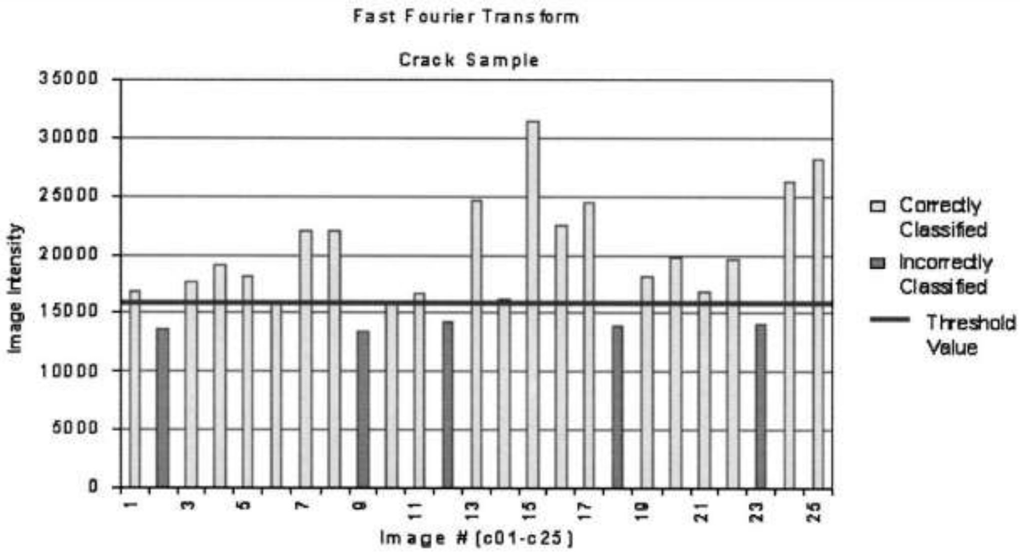


Figure 4. *Fourier for the image without cracks in Figure*



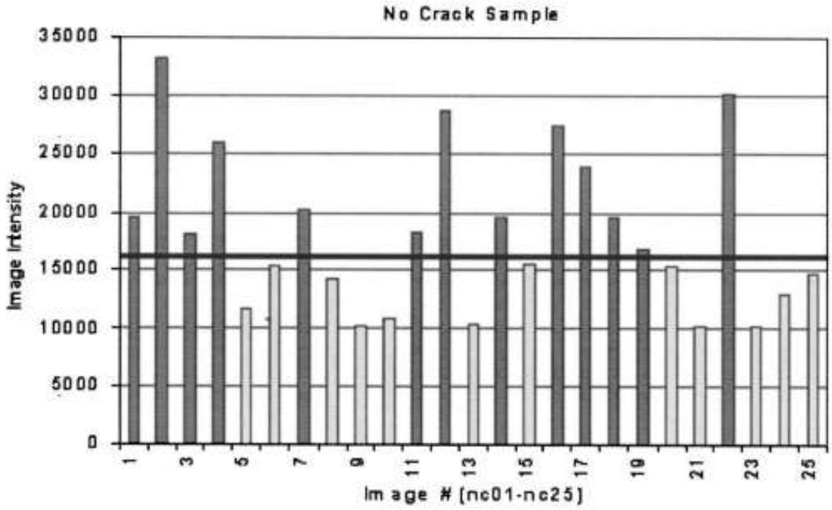


Figure 5. *Intensity data for the Fast Haar Transform (FHT)*

Fast Haar Transform (FHT), removes a lot of noise caused by normal patterns in concrete (high texture images), resulting in a high degree of accuracy is determined by the number of correct crack detections produced by the technique. The overall accuracy is 43 out of 50 (86%) correct detections. The average value of the edge image is 2.4 times larger than the image without the crack, which shows a big difference between cracked and uncracked images and is much better than other algorithms tested. Picture. 5 and 6 are isolated cracks for the two bridge images from Fig. 2 and 3 as determined by the FHT technique, and Figure 7 shows the image intensity data calculated by the FHT algorithm for the 50 images used in the analysis.

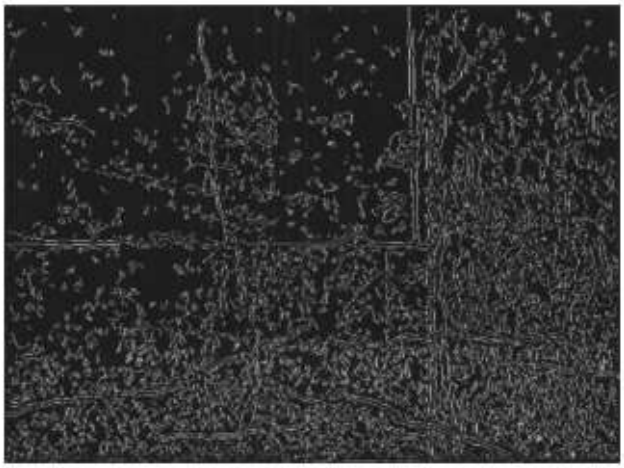


Figure 6. *Sobel for the cracked image in Figure 2*

Figure 7. *Sobel for the image without cracks in Figure 3*

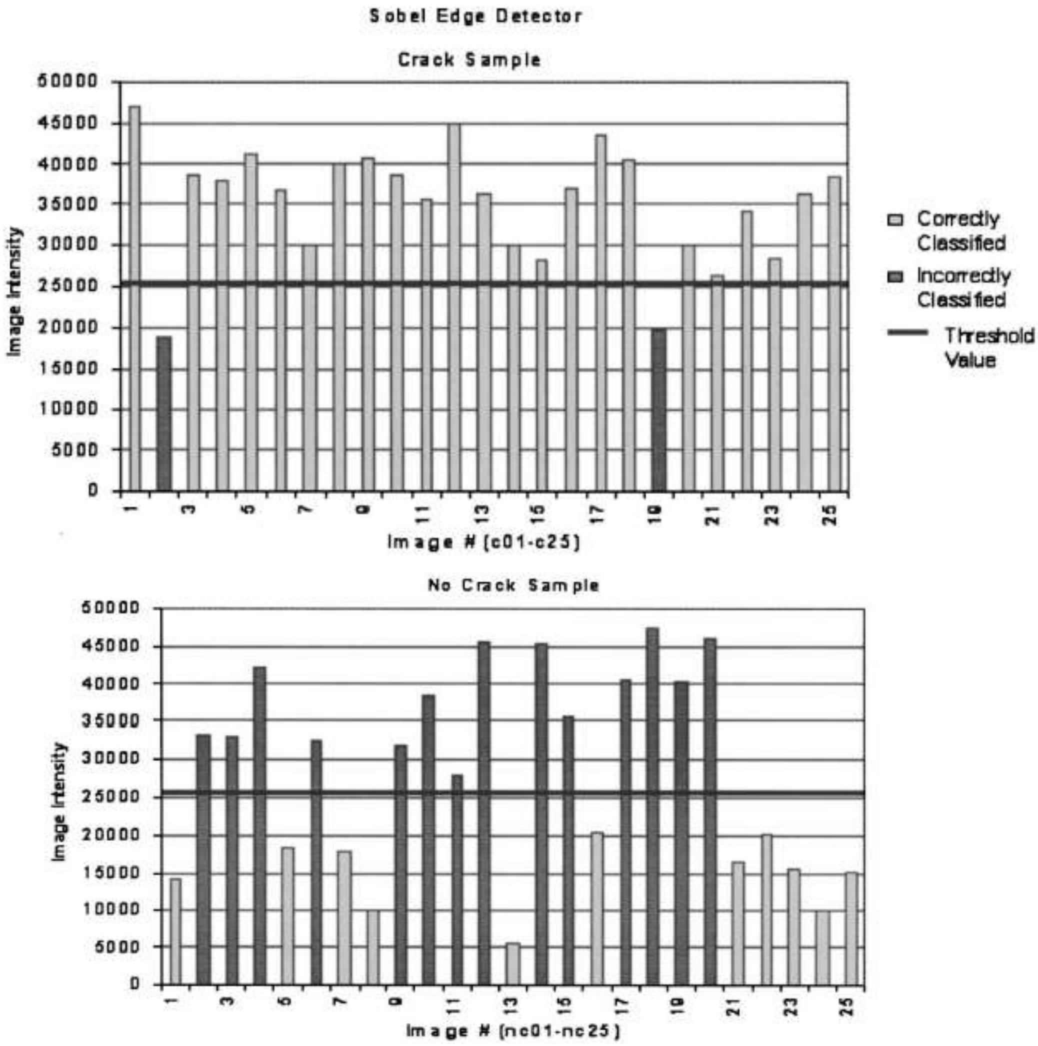


Figure 8. *Sobel Intensity Data*

3.4 Fast Fourier Transform (FFT)

The Fast Fourier Transform (FFT) performed poorly in this test. This is a bit surprising because of the FFT's excellent ability to detect edges. However, the texture of the image causes a lot of misclassification. The overall accuracy of 32 out of 50 (64%) is the lowest of the four algorithms. Average intensity cracked image is only 6% higher than image without cracks, making this transformation almost useless in detecting cracks. Picture. 8 and 9 are the isolated cracks for the two bridge images as determined by the FFT technique, and Figure 10 is the image intensity data for the 50 images used in the FFT analysis.

Table 1. Summary of Analysis Results Analysis

Analysis	**Fast Haar Transform**	**Fast Fourier**	**Sobel**	**Canny**
Crack	24/25	20/25	23/25	25/25
detection (%)	96	80	92	100
No crack	19/25	12/25	11/25	13 /25
detections (%)	76	48	44	52
Combined	43/50	32/50	34/50	38/50
accuracy (%)	86	64	68	76

[a]Data is displayed as *x*/ *y* , where *x*= number of correct detections out of total *y* picture; %=accuracy.

This filter improvement can be achieved by using a prefilter to reduce some of the noise and texture in the image. However, major improvements were not expected, so this implementation was not tested.

3.5 Sobel the Sobel

Edge detection technique also performs relatively poorly. The average intensity of the cracked image was 25% greater.

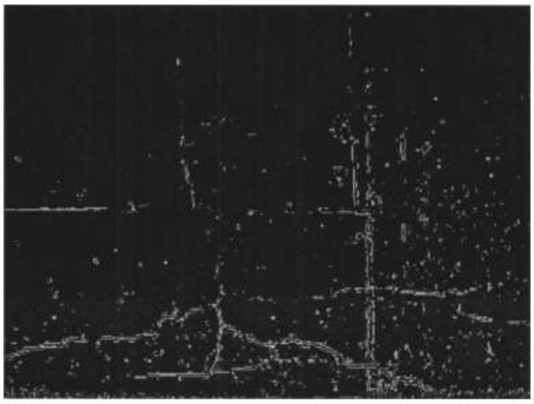


Figure 9. *Canny for the cracked image Figure*

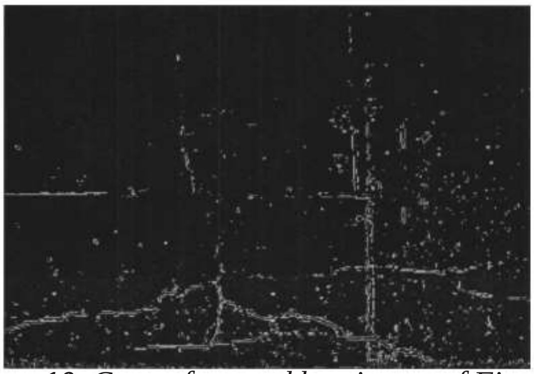


Figure. 10. *Canny for crackless image of Figure.*

Then a picture without cracks. The overall accuracy is 34 out of 50 (68%). Again, the texture of the concrete is the reason behind many misclassifications. This algorithm will require significant changes to be used in the detection of concrete cracks. Picture. 11 and 12 are isolated cracks for the two bridge images as determined by the Sobel technique, and Figure 13 is the image intensity data for the 50 images used in the Sobel analysis.

3.5 Canny Canny

's edge detection technique performs better than Sobel and FFT. Canny uses a blur prefilter that seems to remove noise and aids in the correct classification of most images. is 38 out of 50 (76%). The average intensity of cracked images was 18% greater than that of images without cracks. Picture. 14 and 15 are isolated cracks for the two bridge images as determined by the Canny technique, and Figure 16 are image intensity data for the 50 images used in the Canny analysis.

In short, the fast Haar transform has the most accurate crack detection. The overall accuracy of FHT is 86%. The Canny edge detector performs relatively well with 76% accuracy. The Sobel edge detector performs relatively poorly with 68% accuracy due to noise in the concrete image. The fast Fourier transform also responds poorly due to textures and patterns in the concrete image with an overall accuracy of 64%. As shown in Table 1, there are more false positives than false negatives in crack detection, where positive detection indicates the presence of cracks regardless of whether the image has cracks or not, whereas negative detection indicates no cracks. cracks in the image. For example, FHT shows a crack in the image which has an actual crack (true positive) for 24 of the 25 images used, and 1 false positive (Table 1).

Optimizing criteria for threshold selection can improve yields. By increasing or decreasing the threshold value, it is generally possible to change the distribution of false positives and false negatives without a major impact on the ranking of the algorithm used.

Once an algorithm is selected, the results can be further improved to maximize performance by focusing research efforts on developing optimal criteria for threshold selection specific to concrete bridge drawings. The performance of the Haar wavelet is not surprising because, like other members of the wavelet family, it has the ability to capture image discontinuities. This is due to the fact that wavelets are finite space, which is not true for FFT, and thus have the ability to shows local information in space (eg, cracks).

IV. Conclusion

The traditional visual inspection methods used to monitor concrete bridges are expensive and time consuming. Automated crack detection techniques that limit the need for human inspections have the potential to reduce the cost and time associated with inspecting concrete bridge surfaces. However, engineers are very skeptical about using automated NDE systems and technologies such as imaging techniques. Most of this is due to lack of standardization and difficulty in using technology (equipment) and/or interpreting results. Development of commercial systems, collection of extensive data on the effectiveness of methods, preparation and revision of standards and code, and NDE method training is expected to overcome these difficulties.

Highway departments should begin to incorporate automated inspection techniques into their bridge evaluation programs and strategies to improve the quality of bridge condition data used in decision making. The crack detection technique is only one module in the automated bridge monitoring system. Other modules may include a decision system that reads the data generated by imaging techniques and formulates a maintenance plan, real-time hardware components (cameras and microprocessors), and possible wireless communication technologies for transmitting data to central bridge management system. location. This paper focuses on the crack detection module and provides a framework for evaluating image processing techniques to support automated bridge monitoring systems. Such an evaluation framework is necessary for the selection of the best technique for the problem at hand.

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