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Evaluating the Road Damage of Flexible Pavement Using Digital Image

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Abstract: Project funding becomes the main problem in the evaluation of pavement conditions using mechanical tools. It is due to the price of these tools is quite expensive, added to that one type of tool only measures one particular condition. visual inspection method is a good solution to sort out the problems because it is quite practical, simple and efficient. However, there is a weakness in evaluating the damage of roads visually. The visual assessment method is highly subjective, depending on the assessor. Considering the weakness of the road damage assessment method visually, it is necessary to create an algorithm or a method in detecting and calculating the amount of the road damages quickly and precisely. This research offers the use of digital camera to detect the damages of the roads. The first step of the algorithm process is done by taking pictures using digital camera, so that it is resulting digital images to be processed. The result will give information about the types of road damages and the damage value of the road as well as monitoring the structural strength of the road material (core drill test) and the influence of traffic load on the damage road

Keywords: The road damages, visual evaluation, digital image, structural strength, traffic load

1. Introduction

The road damage is a common problem. Many roads in big cities are in damaged conditions or in the process of damaging. Such condition is a frequent problem for almost every major city in Indonesia. Road segments with minor damage often get no attention so that the damage gets worse and leads to reduce the capacity of the roads. It needs a tool to detect road damages before the damages become severe. This effort can be done by conducting periodic road inspection.

The pavement condition of a road segment can be known through functional analysis as well as structural analysis [1]. Functional analysis is done through the inspection of road conditions. There are two ways of inspection they are; mechanical and visual. Broadly speaking, the damage can be divided into two parts, namely structural damage, including pavement failure or damage from one or more pavement components resulting the pavement can no longer bear the traffic load and functional damage resulting the safety and comfort of road users being disrupted consequently, it will increase vehicle operating costs [2].

The inspection of pavement conditions using mechanical means is strained by the funding issue, because the price of the equipment is quite expensive moreover one tool can only measure one particular condition, such as the flexibility, surface hardness, etc. The visual inspection method offers a proper solution, because it is quite practical, simple and efficient.

There is still a weakness in the assessment of road damage visually. The visual assessment method is highly subjective, depending on the assessor. The appraisal of an assessor can differ greatly from the results of the assessment of others for the same streets. Another thing which needs to be considered is the fatigue of the human eye so that the assessment of road damage visually becomes less precise.

Considering the weakness of the road damage assessment method visually, we need to create an algorithm or method to detect and to calculate the amount of damage value of the road quickly and precisely.

The initial step of the algorithm process involves taking pictures using a digital camera thus, it is resulting digital images to be processed. It will be obtained types of road damages and the damage value of the road. A research in digital image processing for crack damages has been conducted by Loizos, et al. [3]. Another research by Manning [4] obtained a pattern of cracks on the surface of the pavement, while Miradi et al [5] found a crackpattern of linear device tracking (LINTRACK) using photographs to obtain crack length, percentage and crack area. Zhaovun [6] used a method with an initial segmentation image algorithm to calculate the extent and length of damage or road surface defects. Saar et al. [7] conducted research with image processing techniques to

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extract features from images. Neural networks approach is used to detect the defect image areas. Kelvin C. P et al [8] detected inner edge detection for the identification and classification of cracks.

Other researchers Shuzhibiao et al [9], Benedatto et al [10], Keto et al [11], Mousa et al [12] used the image to perform a more detailed evaluation in detecting pavement cracks. Jing et al, [13] performed an analysis in digital image processing using bilinear interpolation to obtain correction images based on the segmentation threshold using statistical analysis.

The value of road damages using digital image will be done by considering how it correlates with structural pavement in the field where the structural analysis is done using cores drill test. The samples are taken to obtain the thickness of pavement and to know the characteristics of the pavement mixture. This process is done to know exactly the arrangement of structures or layers of a road construction, pavement types, percentage of arrangements, and to check any change of damaged road structures.

It can also be known the content of the asphalt toward the core drill results on the asphalt surface layer, the surface layer of the road construction has the composition and rules that have been determined. The material used is a mixture of rock (aggregate) with asphalt [14].

Structural analysis is also used to determine whether pavement is still able to withstand traffic burden [1]. Structural analysis of pavement requires average daily traffic data (LHR) and vehicle axis data obtained from the primary survey, the average growth of traffic calculated from historical traffic data each year.

This study aims to assess the damage of the road quickly and precisely with the digital image and see the condition of the material strength and the volume of traffic available.

2. Numerical Model

2.1 Street Damage

Referring to the Road Inspection Manual Number: 03 / MN / B / 1983 issued by the Directorate General of Highways, the damage or the defect on flexible pavement can be divided into 5 (five) major parts:

a. Cracking

The crack types include: Alligator cracks, Edge Cracks, Edge Joint Cracks, Lane Joint Cracks, Reflection Cracks, Shrinkage Cracks, Slippage Cracks, Widening Cracks.

b. Distortion

The Changes in pavement form are the result of a less solid sub base or sub grade due to movements. Changes in shape can also be accompanied by cracks, besides it also creates a danger to traffic because it allows water to be collected and often makes the damages of the pavement become more severe. The Changes in pavement form include: channel or rut, corrugation and shoving, grade depression, upheaval, and utility cut depression.

c. Disintegration

Disintegration is the breaking of the pavement layer into loose parts, including the removal of the aggregate particles. If it is not handled soon, it will cause the damage worse. Disintegration forms comprise: potholes and raveling.

d. Slippery Surface/ Skid Hazard

The dry surface conditions cause the road to become slippery due to the presence of a thin layer of asphalt on the surface of the road, the polish aggregate of the surface layer and due to much oil harmful to motorists either moderate or high vehicle speed. Slippery surface includes: bleeding / flushing asphalt, polished aggregate.

e. The Damages caused by surface treatment

The differences of working methods in the treatment of surfaces can cause abnormal results. Surface treatment includes: loss of cover aggregate/ the loose of aggregate cover, longitudinal streaking and transverse streaking.

2.1 Image Processing

Image processing is a process to turn an image into another image that involves some specific techniques. The image itself is a two-dimensional image generated from a continuous two-dimensional analog image into a discrete image through a sampling process.

Image processing process has input data in the form of image that has been taken using the camera and has output data in the form of another image that has been through some process using certain image processing techniques.

2.2 Image Extraction

Image extraction process comprises a variety of operating functions, as follow:

a. Wiener Filtering

Wiener Filtering (Gonzales, 2004) is a method to reduce noise based on Mean Square Error. This method uses Least-Square principle that makes the smallest possible error between the actual output and the desired output.

b. Thresholding

Thresholding is the process of converting the grayed image to a binary or black-and white image so that it can be known which region includes the object and background of the image clearly. The resulting threshold image is usually used further for object recognition as well as feature extraction.

c. Image Classification

Image classification is a process that describes and distinguishes the class of data which aims at predicting the class of objects of unknown labels. Classification algorithms which are widely used, namely Decision /

Classification Trees, Bayesian Classifiers / Naïve Bayes Classifiers, Neural Networks, Statistical Analysis, Genetic Algorithms, Rough Sets, K-Nearest Neighbor, Rule Based Methods, Memory Based Reasoning, and Support Vector Machines (SVM). The K-Nearest Neighbor (k-NN or KNN) algorithm is a method for classifying objects based on learning data closest to the object.

3. Research Method

3.1 Object of The Research

The research was conducted in Depok area. The object was road damage including cracks, crocodile skin cracks and holes. Data retrieval of images from road damage, using a Canon 550D digital camera. The steps of research method as shown in Figure 1.

Fig. 1 The flow chart of research method stages.

The preprocessing stage includes the process of digital image selection. the next stage is delivering the resolution of each image to the same size of 480 × 640 pixels.

a. The stages of image extraction

The initial step of developing the application of road damage image extraction is to study the morphological method for extraction of asphalt damage images. In this study the image used is road damage image. In addition, the data used were fifty photos of the road damages. The process of extraction of road damage image is depicted in the form of flowchart as shown in Figure 2.

b. The stages of Image Classification

The process of classification of asphalt damage images is described in the form of flowchart as black and white images so that which area included the object and background of the image clearly can be process of changing the image of gray degree into binary or shown in Figure 3. The flow chart describes the stages of process performed on the road damage image classification. Users must input the image of road damage image. The Stages of the process include the process of image extraction consisting of wiener filtering and thresholding until the image pruning is obtained. The pruning image will be used in the classification process. The Classification process is done using KNN (K-Nearest Neighbor) method.

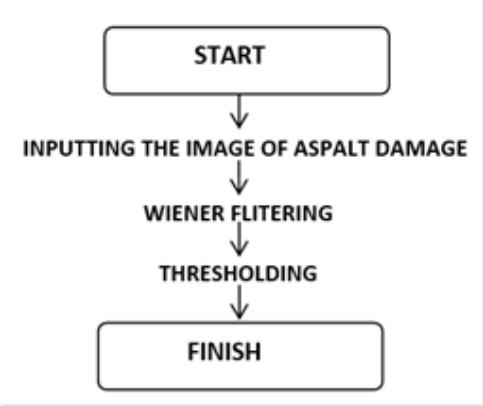

Fig. 2 The flow chart of image eextraction

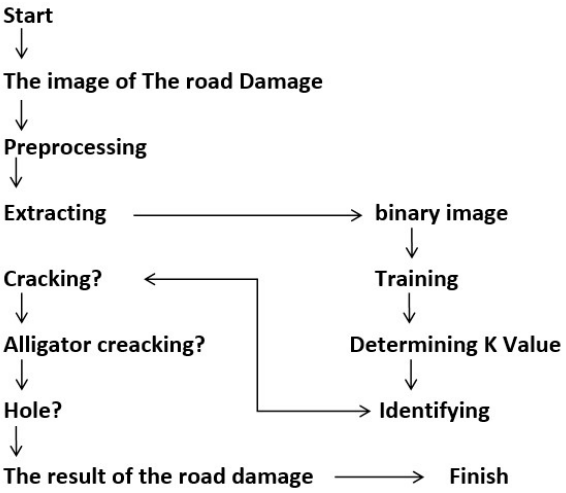

Fig. 3 Flow chart of image cclassification pprocess.

3.2 The Process of Determining The Value of The Road Damage

The result of image extraction will be processed further by classifying the type of damage. In addition, it can calculatee the length of cracks, hole diameter and the depth of hole based on the type of damage conditions, and the value of damage based on digital image.

The ccomparison between the value of damage is done visually using the value of damage as shown in the image. If the level of accuracy is above 80%, then the value of damage is used or Vice versa, if the accuracy of less than 80%, digital image processing will be done again to obtain a greater accuracy of 80%.

4. The expected Result

This research is expected to provide new findings in the field of civil engineering, which enable to contribute on how the road damage assessment can be done quickly and accurately by utilizing advanced technology. The aassessment of the road damage is usually done visually and takes a long time in other hand the use of digital images is believed to obtain a precise and a quick result. In addition it is possible to see the condition of the material strength and it can predict the load of traffic volume on such condition.

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