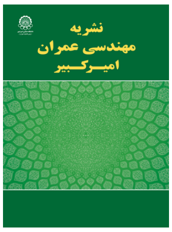

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Providing Criterion to Automatic Evaluation of the Accuracy of Distribution of Tack Coat and Prime Coat Pavement Roads

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ABSTRACT: The coating is one of the most important components that affect the efficiency of the pavements. Parameters are effective in the proper implementation of the coating such as the type of coating, the application time, the rate of application, temperature, uniformity of application, etc. The uniformity of application requires field control in the project implementation, is currently used to control the spreading weight of the tray. This test has many errors due to the lack of continuity. The issue of uniform distribution of coating has become less attention. In this study, the automatic system is presented based on image processing using a camera, GPS, microcontroller board, and ..., which can analyze the uniform distribution and provide a good, moderate and poor classification for coating distribution evaluation. Image quality has improved with image processing and compression and noise reduction have been done. The thresholding was used to separate the coating from the background. After the thresholding, various properties such as the area of the coating, coefficient of variation, local maximum, and minimum, etc. are obtained from the images and used to evaluate the coating distribution. Used categorization algorithms to select effective features in categorizing images. A comparison of the results of the classification of images by a confusion matrix. Finally, the results showed that the presented system has a precision of 86%. Also, using the effective parameters in the model, the uniform distribution index was presented. This index has a value between0 and 100, which indicates the best and worst distributions.

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1. Introduction

The road network is considered as the foundation of the national transportation network and a major factor in economic, cultural, and social growth and development. Therefore, it is important to monitor the proper implementation of road surfaces. Asphalt pavements include a layered structure with a tack AND prime coating layer inserted between the pavement layers to strengthen the bonding between the layers [1].

In Iran, in all projects, the tray test is used as a common method to control the distributed coated weight values. This test involves many errors due to the lack of consistency and overlap. To date, this method is only applicable to the weight distribution of bitumen and is performed for a sample surface at every few cross-sections. Reducing or increasing this amount will not affect the continuation of the work and will only be fined.

Hoang and Nguyen (2019) used an automatic model for detecting asphalt pavement cracks. Image processing techniques including steerable filters, the projective integral of the image, and an enhanced method for image thresholding are employed for feature extraction [2-4]. Kumbargeri et al. (2019) investigated the impact of bitumen and rock performance on chip seals performance by defining a new parameter called "Effective Percent Embedment" using digital image analysis techniques [5]. Chao Xing et al. (2019) have evaluated and confirmed the disruption in asphalt mixtures using image segmentation techniques including fuzzy network noise reduction and contrast enhancement and multilevel threshold OTSU method [6].

In recent years, image processing has been used in various pavement areas such as longitudinal, transverse, and alligator cracks, stripping, and cracking. Moreover, this technology can be considered in controlling the uniform implementation of the coats. Hence, in the present work, a system is proposed to capture the information, control the uniform implementation of the coating, and provide an index indicating the status of the coat distribution. The proposed system is illustrated in "Fig. 1".

2. Methodology

This study presents a new approach based on applicable hardware and software to determine the index of pavement coat distribution of digital images. "Fig. 2" presents a flowchart of the CUD pavement index system. The process of implementing the proposed method is presented in "Fig. 2".

In the present work, it was attempted to develop a high-coverage system to control the uniform coat implementation of the pavements. The proposed system consists of several parts and generally includes two hardware and software parts.

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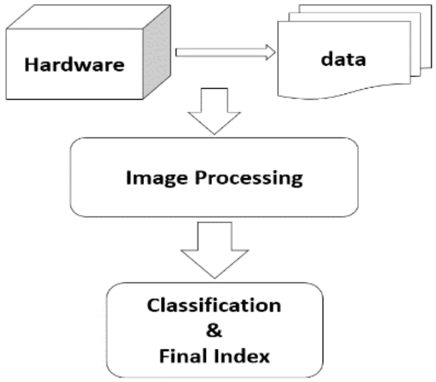

Fig. 1. Components of the proposed system.

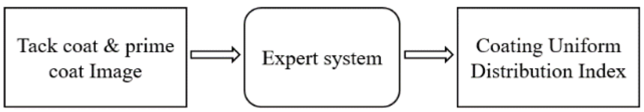

Fig. 2. A flowchart of the pavement CUD index system.

To provide an appropriate index for the uniformity of the coat implementation, the components must be disassembled after upgrading and image reconstruction. For thresholding in this study, 10 methods were investigated that belong to local thresholding, clustering, and entropy classifications.

To compare these methods and to evaluate the quality of the segmentation result quantitatively, the classification Misclassification Error (ME) is measured. The less ME means better image quality for the converted image [7].

To examine these methods more accurately, the actual area and the area obtained by three methods are compared. The actual area was examined by careful examination of the images and the removal of the coated areas, which was also confirmed by the expert. At this stage, the images will be categorized. For proper classification, it was attempted to examine all the parameters involved in the classification. For this purpose, the coating distribution in both horizontal and vertical directions plot. After identifying the parameters, the issue of selecting the appropriate features for the classification algorithm is investigated and finally, based on the results presents an index of uniform coating distribution.

3. Results and Discussion

According to the results, concluded that among the local thresholding methods, the Feng method has the best performance, in the clustering methods Otsu method and in entropy-based methods, the fuzzy DE method has the best performance in object classification and background separation.

In the next step, paired t-test in SPSS software was used similarly, to analyze the error and evaluate these three methods, the rooted mean square error (RMSE) and mean error (ME), as well as the error percentage, are calculated and hence, a fuzzy DE method is selected and used to classify images.

At this stage, the images will be categorized. For proper classification, it was attempted to examine all the parameters involved in the classification. To investigate the extracted feature with the most impact on the classification, RapidMiner software and various classification algorithms were used.

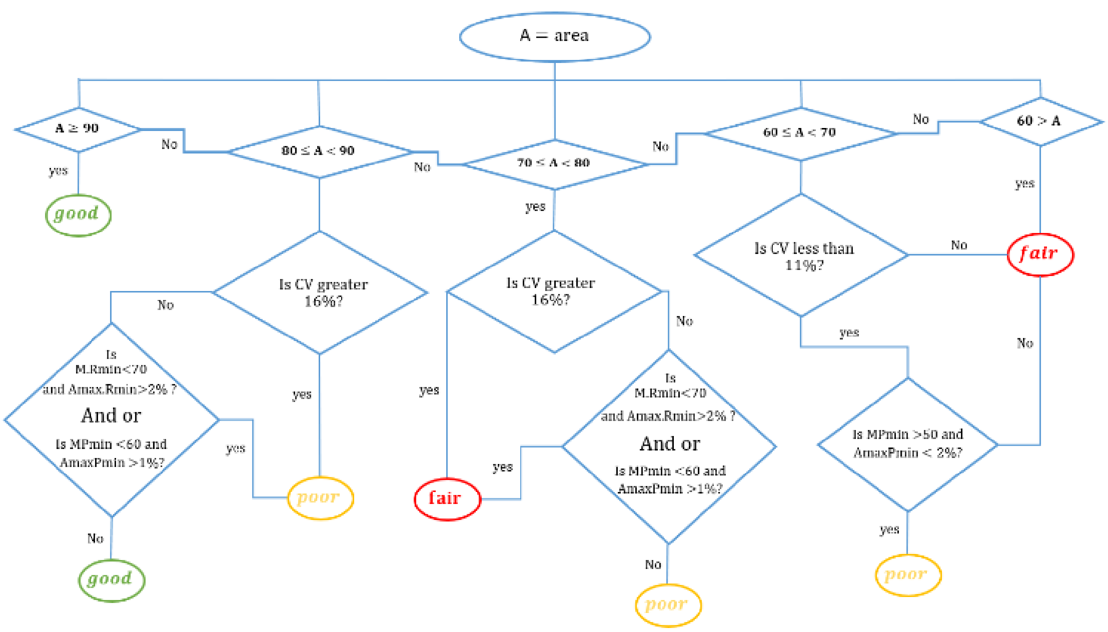

Fig. 3. The model action for classifying the images into three good, fair and poor categories.

Based on the results obtained by the classification algorithms as well as the nature of each attribute and by repeatedly varying the numerical and prioritization intervals in the use of the attributes and comparing the accuracy of the model obtained, the model presented in "Fig. 3" was considered for image classification. In "Fig. 3", to represent the mean relative minimums and the area of the largest relative minimum, M.Rmin, and Amax.Rmin were respectively utilized.

An accuracy of 86.4% was obtained and the time required for each image varies from 7 to 13 s with an average time of 9.5 s. In addition to the image classification, presenting an index indicating the status of the coat distribution can be effective. Since the proposed model contains a high accuracy, effective parameters can be used in the model. The uniform coating distribution index is calculated by Eq. (1).

$$CUD_i = cud^{(1-\frac{P_{\min.i}}{100})} \times A_{cv.i}$$

(1)

$$CUD = \min(CUD_h, CUD_v)$$

Where CV shows the percentage of variation coefficient, Apmin is the area of relative minimums and Mpmin is the average of relative minimums.

The average of the obtained indexes for each good, fair, and poor category was 78.9, 57.5, and 36.5, respectively. The values obtained for each category indicate the good performance of the CUD index.

4. Conclusions

In this study, a novel image processing system was implemented and analyzed for uniform coating distribution. In contrast, using the appropriate image processing and wavelet transform and presenting a different and flexible method for coated surface analysis, the results of this proposed system show that this method is a suitable tool. Another advantage of this method is that there is no need for a specialist in both the installation of the device and the software.

Ultimately, it can be stated that the coat implementation accuracy of the control system with an innovative solution for analyzing tack and prime coats can ensure the proper and correct implementation of the coats quickly and accurately compared to eye and tray controls. The results of this system can be used by relevant authorities to make decisions and manage future maintenance.

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