A new method for three-dimensional evaluation of asphalt pavement texture

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ABSTRACT

The surface texture depth is an important indicator for evaluating the skid resistance capabilities and providing suitable surface drainage conditions for asphalt pavement, which has a direct effect on the safety and comfort of road users. Texture evaluation is one of the main goals of the pavement management system. Three-dimensional evaluation is the most accurate method of measuring pavement texture characteristics. In this paper, a three-dimensional automatic device based on a hybrid imaging technique is presented. In this device, a system consisting of two-dimensional digital cameras is designed to provide the required image data. The proposed system has a tool for reducing surface friction. This system also makes it possible to evaluate the texture in rainy conditions. Based on the two-dimensional images taken from the pavement surface, the three-dimensional models of the pavement texture are presented. A method for calculating the mean texture depth is presented. Measuring the depth of pavement texture in different directions is a capability of this method, which makes it possible to uniformly evaluate the depth of the texture in different directions and find the critical direction for texture drainage capacity. The proposed system has been used to measure the depth of texture in different sections of pavement and the results have been compared with the results of the standard sand patch method. This comparison shows a high correlation between the results of the proposed method and a standard pavement texture evaluation method.

KEYWORDS

Pavement texture depth, Low cost evaluation, 3D modeling, Drainage, Pavement management.

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1. Introduction

Pavement texture is the main factors affecting road surface friction. The surface friction condition is one of the most important indicator of pavement safety and the probability of accidents. For this reason, the accurate evaluation of pavement texture characteristics is one of the main goals of pavement management systems [1,2].

In this paper, in order to achieve a method for automatic evaluation of pavement texture with high accuracy, a three-dimensional automatic system for pavement texture measurement is presented. A new method for calculating MTD in three dimensions is proposed. The possibility of automatic evaluation of surface characteristics in the presence of water and any other polluting liquid is one of the innovations of this research.

2. Data acquisition device

One of the main goals of this paper is to provide an automatic, accurate, fast and low-cost system for recording pavement surface texture details. In this work, a data acquisition device is presented to provide images required for further analysis.

The most optimal imaging mode in terms of lighting, camera position and imaging angle has been obtained by performing various data acquisitions and reconstruction of different 3D models. Figure 1 shows the components and output of pavement texture imaging system.

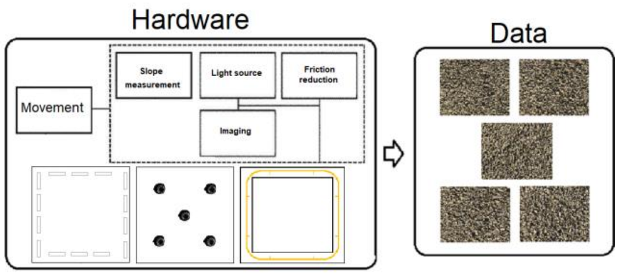

Figure 1. The process of data collection

3. Evaluation of pavement surface texture characteristics

In this research, SfM is used to convert 2D images into 3D models with high accuracy. This method is compatible with image data obtained from the presented acquisition system. Figure 2 shows the 2D images obtained by the presented device and the 3D model made by the SfM method.

In this section, the pavement mean texture depth has been calculated in a planar and directional manner. The calculation method of this index is presented in equation (1).

The volume is calculated by measuring the three-dimensional space lower than the highest point in the point cloud and its area is considered equal to the number of points in the desired area, and the desired index is calculated from their division.

$$D(p) = Maz(z) - z(p) \quad (1)$$

$$Vol = \sum_{P=1}^{N} D(p)$$

$$MTD = \frac{Vol}{A}$$

The directional measurement of texture characteristics is very important in evaluating its effect on characteristics such as friction and surface drainage. The texture depth is an important indicator in evaluating the surface drainage capability of the pavement.

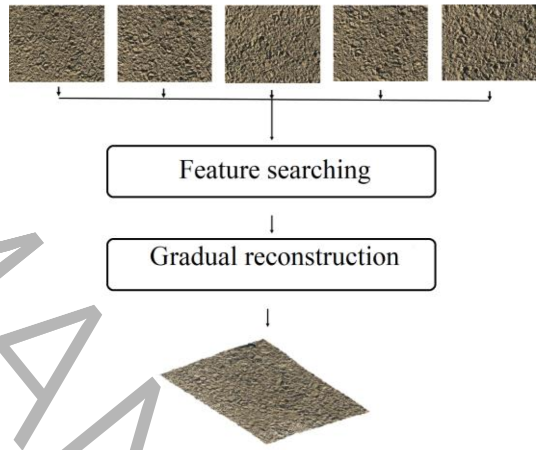

Figure 2. The process of 3D modeling

4. Results and Discussion

The evaluation of the pavement texture in its different states shows its effects on various characteristics of the surface texture. In this research, a method for measuring the pavement texture depth index was presented in a three-dimensional plane. This index is the most important criterion for evaluating the impact of texture on surface friction and drainage. The calculation of this index can be done for the entire surface of the pavement or a part of it, each of which can be considered a separate and unique criterion.

This system has the ability to evaluate linear and planar direction as well. In the linear mode, the pavement texture depth index is a measure of the surface friction. The reason for this claim is that this index indicates how the aggregates are placed next to each other, which affects the hysteresis and adhesion components of friction. If the directional texture is evaluated as a plane, it provides a measure of drainage capability. The depth of the texture in each direction indicates the presence of water drainage channels between the aggregates in that particular direction; Therefore, by checking whether the desired direction is in line with the road surface transverse slope, it is possible to provide a criterion to evaluate the pavement surface drainage.

Table 1 presents the application of this method in evaluating directional pavement surface friction.

Table 1. An example of directional MTD measurement

MTD 0	MTD 30	MTD 45	MTD 90
0.32	0.3	0.29	0.37

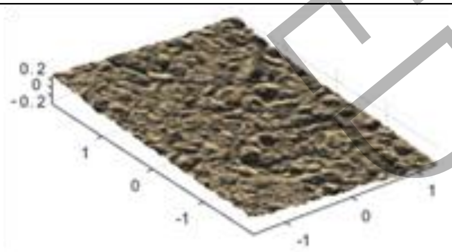

Figure 2 shows the correlation of the measurement results of the presented method with the sand patch method.

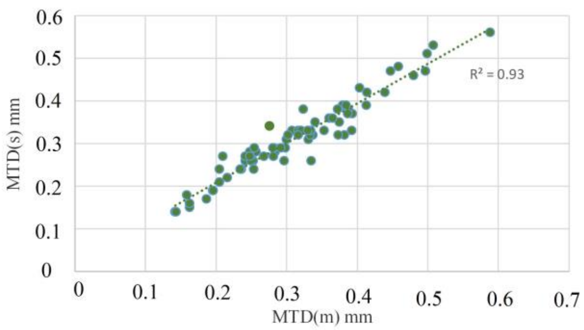

Figure 2. Correlation between the device and sand patch test results

As seen in this figure, the results of the proposed method have a high correlation with the results of the sand method, which is a standard method. The correlation coefficient (R) is equal to 0.96. This correlation shows the efficiency of the proposed method.

5. Conclusions

In this research, a new system was presented to measure the depth of pavement texture. The main achievement of this research is to provide a method based on 2D imaging to achieve accurate 3D texture details using simple and cheap equipment. An automated 3D data acquisition system was presented using a set of five simple digital cameras. Based on the accurate three-dimensional models obtained, the pavement texture depth index was calculated in different modes.

In addition to the ability of calculating texture depth using the conventional method that expresses the characteristics of pavement texture, linear directional evaluation is a measure of pavement surface friction and planar directional evaluation is a measure of pavement surface drainage condition that can be calculated by this method.

The proposed system is also capable of simulating the process of reducing pavement friction due to rainfall. With the help of this feature, a suitable method for monitoring and evaluating pavement behavior in rainy conditions has been provided.

Comparison of the mean texture depth values calculated using the presented system and measured by sand patch test showed a high correlation between their results. A correlation coefficient of 0.96 has been obtained.

6. References

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