



Providing a new criterion to evaluate the skid resistance of asphalt pavement

F. Nejad*, N. Karimi, H. Zakeri

Department of Civil & Environmental Engineering, Amirkabir University of Technology, Tehran, Iran

ABSTRACT: The friction of a pavement surface indicates safety of a pavement. Pavement friction properties depend on pavement surface's micro-texture and macro-texture characteristics. Recently, considerable attention has been paid by researchers to find new methods and procedures for more accurate and quick measurement of the pavement skid resistance. Most of the proposed approaches in this regard have been in the range of non-contact methods, the use of laser and digital images. It has been found that image processing as a non-contact method with adequate precision and high speed can prove to be a promising and effective approach for further research on determining the pavement skid resistance. In this paper an intelligent system based on image processing was introduced which analyzes the texture of the pavement and presents a new index for pavement skid resistance by taking the effects of horizontal, vertical and diagonal components of its texture into consideration. By comparing the results of the proposed system and the corresponding British Pendulum Number (BPN) test results it can be said that, the proposed system through using the image processing technology and more accurate assessment of pavement textures is capable of better recognizing the pavement textures and can produce repeatable results associated with the pavement skid resistance.

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1- Introduction

In wet weather, pavement surface characteristics play an important role in road safety. Therefore, road surfaces have to provide an adequate level of friction [2,3,1]. Friction occurs at the contact surface of the rotating wheel and road surface [4]. Skid resistance (SR) is the amount of friction force created from the vehicle's tire and pavement surface interaction, preventing it from sliding [4,5]. The SR of a pavement surface is related to two important surface characteristics: Micro-texture and Macro-texture. [2,3,6]. For measuring texture of the pavement surface, there are two groups of methods: contact and non-contact. In recent years, researchers care about non-contact methods (laser devices and image processing methods) that acquire quick and enhanced results in comparison to traditional methods. In this study, we present an automatic expert system based on image processing that is able to cover 2D analysis of pavement texture and determine pavement skid resistance index in three directions (vertical, horizontal and diagonal), promptly.

2- 2-Proposed Method

This study presents a new method based on hardware and software to determine the pavement skid resistance index from digital images. The central component of the proposed system worked based on wavelet transform and has four distinct modules: Pre-Processing, Feature Extraction, Approximate Indexes in three different directions (Horizontal, Vertical and Diagonal) and classification. In order to obtain images from

the pavement surface, a hardware was manufactured. The hardware's system is based on a linear image acquisition that records pavement surface texture. This device has so many advantages that make it better than digital cameras. With regard to pavement surface imaging systems, they have problems with imaging angle, distance from the surface, intensity of lighting, direction of the lighting and direction of light at different times of the day. A dynamic frame was made in which all of the imaging components were placed inside with the minimum distance from the pavement surface (Figure 1).

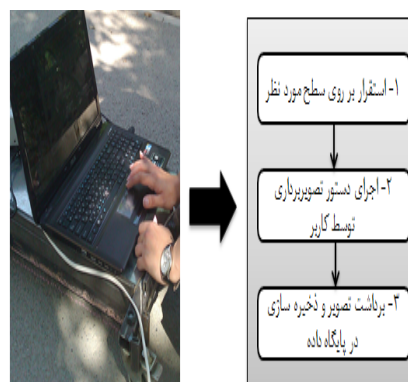


Figure 1: A view of the manufactured hardware

For software, histogram equalization and Fast Fourier Transform (FFT) were used to improve pavement surface image. Then by using wavelet transform, the improved image was compressed and decomposed to its horizontal, vertical

*Corresponding Author, Email: moghadas@aut.ac.ir

and diagonal components. Thus, by using the wavelet, three directions of pavement surface texture were achieved. Given that each of these directions in different circumstances has different effects on pavement skid resistance, an individual index was defined for each of them. In order to achieve to an individual index, a combination of three primary indexes proposed (final skid resistance index), equation 1.

$$SRI = *L\beta.SRI \left(SR_{\eta}^f + SR_{\nu}^f + SR_{d}^e \right) \quad (1)$$

Where:

$$\hat{a} = \begin{cases} 3.33 & var_i < 0.013 \\ 3.64 & 0.013 \leq var_i < 0.02 \\ 4.06 & 0.02 \leq var_i < 0.022 \\ 4.21 & 0.022 \leq var_i \end{cases}$$

The is the variance and SRI_i is the skid resistance index of i = horizontal, vertical and diagonal, components of each pavement image.

Also, in order to evaluate the results of the software, the British Pendulum Number was determined for each image. Finally, half of the images were used for training and another half were used for testing.

3- Evaluation

The proposed system is tested on a new group of images in order to evaluate the results. The data set has been divided into two halves, 1/2 for training, and 1/2 for testing. Analysis of the testing data showed a considerable improvement in the final result of the proposed system. So that the difference between the results of the proposed system and the results of BPN were acceptably close together, also the results was repeatable. This means that the proposed system with a new and flexible analysis method based on image processing and effective parameters in the pavement skid resistance can make sense. Figure 2 shows the final skid resistance index of the proposed system versus corresponding BPNs for a test group of images.

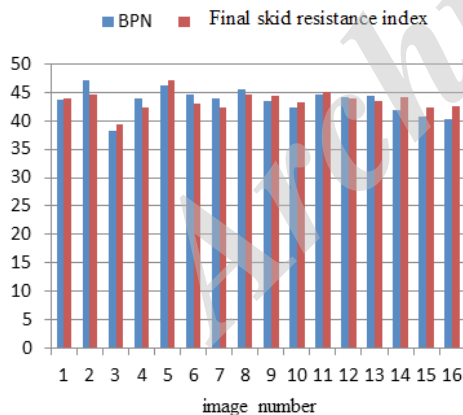


Figure 2: Final skid resistance index of proposed system versus corresponding BPNs

4- 4-Conclusions

In this paper, an automatic system was developed (investigated) based on wavelet transform as to evaluate the pavement skid resistance. The results demonstrated that the proposed system could make an acceptable surface interpretation. The most important aspects of the proposed model was plate acquisition; the theory of separate effects of vertical, horizontal and diagonal components of pavement texture on the skid resistance index and repeatable results. The practical test within this study showed the advantages of the system including: fast velocity, easy to operate and its user friendly function. The results of the proposed system can also be utilized in the network-level and project-level pavement management systems to cause road safety.

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