Original Article

Determining Roads Asphalt Damage with Image Processing Algorithms in MATLAB

Hamed Davoudi *, Mohammad Davoudi

M.Sc., Computer Science, Software, Roshd Danesh Higher Education Institute, Semnan, Iran.

Abstract

In recent years, a new application making image processing so significant is the use of image processing techniques (IPTs) in urban planning and road construction to facilitate work and enhance the rate of detecting asphalt damage on road surfaces using the identification of these damages and bettering them prior to further damage to these important communication infrastructures. The paper tried to reduce the existing challenges by properly training of the software and assigning tasks to the machine automatically on the one hand, and on the other tried to extract better answers from machines compared to humans by reducing human interference in identifying and determining the extent of road surface damage using extraction of various features by IPTs and proper analysis in MATLAB software. Regarding this, firstly, 824 images were taken from various places with different conditions (sunny, cloudy, shady, and so on) using a high quality camera. Then the images received in the previous step were stored in a database and the color images were converted to binary (black and white) ones. Then, after edge detection, mean filter was done with Sobel default and the images were divided into some sub-blocks, and the features were examined after applying k-means algorithm. Finally, 199 features of each image were examined and the final pattern was obtained after training the software. The results indicated that the accuracy of the output in terms of percentage was more than 85%, which based on the previous studies, shows acceptable detection by the method presented in this study. The accuracy of the method presented in the classification output was much higher than the percentage output and in almost more than 95% of cases were placed in the correct class that the experts have identified, showing the high accuracy of the proposed method in the method in classification.

Keywords: asphalt damage rate, image processing, learning networks, classification.

Introduction

One of the indispensable needs of humans after the advent of the computer and its advancement in all areas is meeting many of human needs and being well accountable. One can state a stronger reason that is the computer can perform human actions continuously in the long run, after learning, with a low damage rate and sometimes without errors. The continuation of machine (computer) work process has reached the state where it can decide, see and recognize instead of humans. The implementation of human mechanisms in machines has a significant effect on advancing human goals. Designing object recognition systems according to machine vision algorithms so that they can be resistant and efficient to different changes in the image like rotation, transmission and scale is a very significant issue with many applications. This has been divided into several branches with different approaches presented for it, each of which has advantages and disadvantages that do not allow them to be used in all applications, and the appropriate method according to the specific application should be selected [1].

One of the basic topics in different applications, especially pattern recognition and machine learning applications is having a set of appropriate data for evaluation, analysis, and comparison of the proposed methods. Without a proper dataset, one cannot make an accurate and correct evaluation of the proposed methods, as in some cases the methods theoretically seeming efficient do not work well in practice.

Although recognizing objects in the image is an old issue and much effort has been made to improve it, it continues to be a complex issue for many researchers. This is because despite many advances, existing methods still lack enough accuracy and speed to be used in many real complex applications and there is still a long way to develop a system, like the human perceptual system, that can recognize and simulate shapes

Address for correspondence: Mr. Hamed Davoudi, M.Sc., Computer Science, Software, Roshd Danesh Higher Education Institute, Semnan, Iran

How to cite this article: Davoudi, H., Davoudi, M. Determining Roads Asphalt Damage with Image Processing Algorithms in MATLAB. Arch Pharma Pract 2020;11(S1):125-31.

and, in general, patterns accurately in spite of all the obstacles that may exist [2].

The gradient of the image has two parts - direction and intensity - both of which can be used. For instance, first one can create the desired mask through the intensity, all the areas where the intensity is greater than t, and then use the derived information at that point in these areas. Neural networks must perform backpropagation operations each time the algorithm is executed to update different weights and biases. Each repetition of an algorithm known as iterate can update weights and biases so that the neural network algorithm can identify different features and different classes. Gradients can find a minimum point for error, which is of course not the minimum value in the total space, but seems reasonable. This reasonable point is called a local minimum for error [3].

Wavelet transform is of the tools that have many applications in engineering, especially machine learning and pattern recognition. Wavelet theory is in fact a generalization to the theory of transformations and Fourier series, and compensates for the weaknesses of Fourier analyses in local performance and modeling short-term behaviors. There are many ways to remove noise from signals and images by wavelet transform. In the methods of noise removal of the wavelet, noise is shown by wavelet coefficients at small scales and the coefficients on such scales involve the edge information as well [4].

The purpose of applying image processing methods

The purpose of image processing is to extract useful and intended data from the input image [5]. The overall steps for doing this are generally as follows: At first, it is tried to enhance or reduce the input image; for instance, sometimes we need to reduce the image noise. One way to do this is to use low-pass filters. The next step is the location operation, where the exact area of the target object is identified, which usually creates a silhouette or mask image from the area where the object is located. The next step is usually feature extraction from the image. This feature can be color, a dot, a line, or any other desired feature, which depends on the field you are working in. Then in the last step, the machine learning techniques are used to identify and classify the features of the image and to compare them with the features introduced to the system in the training phase.

Past findings

With the ever-increasing progress of road construction, one of the significant issues considered by the officials and managers of these areas is timely and accurate identification of damage to roads and in return, timely repair and improvement of these damages. One of the important applications of image processing is the timely identification of these damages using various methods, which can lead to economic and manpower save and help maintain road infrastructure.

Here, we mention to some examples of what has been done in recent years to determine the extent of road asphalt damage in different parts of the world. Ramli et al. [6] have proposed a new method by retrieving information from images in which road asphalt has been damaged. This method involves selecting digital images from the road surface and providing the resolution of each image. Reza Shahabian Moghaddam et al. [7] have designed hardware similar to a digital camera to capture high-quality images with controlled light conditions. The hardware has eliminated the need for all lighting to completely remove the ambient light from the tarmac and provides artificial lighting so that certain distances from the asphalt pavement surface for all impressions eliminate the need for software operations to improve and enhance the images. Rajab and Saif [8] have used imaging techniques to measure the dimensions of road disruptions. Using ImageJ software, analyses, designs and using filters, geometric and mathematical operations, measurements like mean and standard deviations on images are done freely. The results show that the measurements and the determination of the image damage rate are significantly closer to the manual method measurements. Biglary et al. [9] have presented a method to identify asphalt stripping based on image processing methods where the level of asphalt stripping was first evaluated manually and visually by two methods, Lattman and boiling water. The results of the model developed to validate this stripping index, based on the results of the ITS test, showed that using the proposed stripping index can accurately determine the stripping of the asphalt mixture with 68 to 73% accuracy. Kim et al. [10] have proposed a method to evaluate the performance of asphalt with image processing methods. Image analysis can automatically provide the configuration to work in a continuous information access mode and analysis. Moreover, the software provides a two-dimensional imaging technique with the best balance between speed, accuracy and cost. Although the proposed method is at its conceptual stage, when this method is installed in a vehicle with high-resolution image recording devices, it provides a feasibility study for accurate and quantitative evaluation of cracking operations. Moohan et al. [11] presented a method for detecting and determining the extent of road surface damage using digital IPTs, during which two steps are performed. In the first stage, a video is prepared from the road surface, and in the second stage, the analysis is done to identify the damaged points. In this approach, the first 50 frames are used to prioritize the first three Gaussian modes in the mixed model. Then the method uses morphology to enhance noise and fill gaps in detection objects. Then it filters the detected backgrounds to highlight the identified barriers. After learning and determining the asphalt damage of road surfaces, one can help the authorities in the correct timing and care and improvement of the damaged axes. This will work better than the visual recognition of asphalt damage by experts, which is costly, inefficient and difficult. This is the first important point in prioritizing machine recognition over man, constantly doing it without tiresome. Now, if we make these observations as images taken by even ordinary people with medium cameras, and each time it is recognized after being sent to the machine,

for sure it is cost effective in saving time, long distances and limited communication with experts in this field. Determining the extent of road asphalt damage is a challenging task because of the complexity of the visual patterns and different experiences of experts. . The paper tried to reduce the existing challenges by properly training of the software and assigning tasks to the machine automatically on the one hand, and on the other tried to extract better answers from machines compared to humans by reducing human interference in identifying and determining the extent of road surface damage using extraction of various features by IPTs and proper analysis in MATLAB software. In many cases, this has happened, and the output of machine analyses on images has been much more accurate than that of humans with a lower error rate.

Proposed Method

The purpose of presenting this method is to determine the level of asphalt damage on road surfaces with image processing algorithms based on images received from road surfaces and cracks in them. Prior to anything, the research data must be collected and introduced to the system, after which the program is designed in two different phases. As the database size is high, the images must be read properly and then be processed, so that we finally reach a percentage of accuracy. Figure 1 indicates the framework of the proposed method

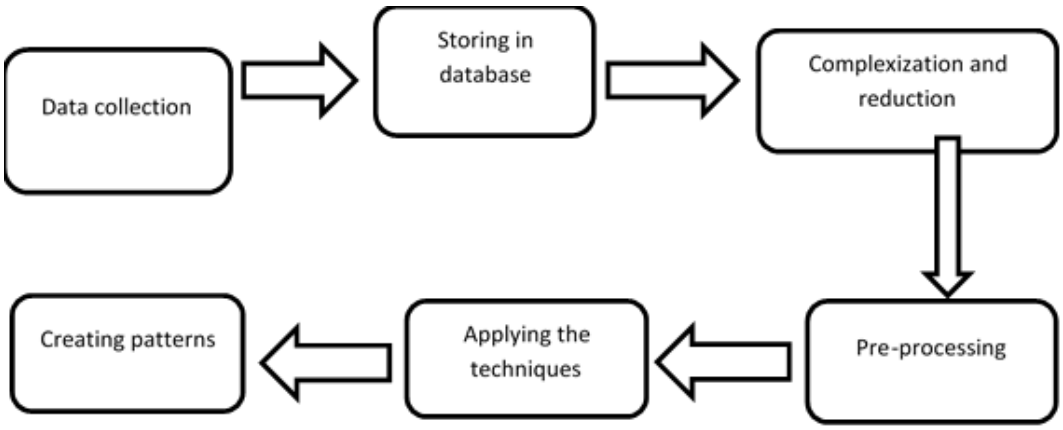

Figure 1: Proposed method framework

1. Data collection

Firstly, 824 images were taken with a high quality camera from various locations with different situations (sunny, cloudy, shady, and so on). After that, by visiting five experts of the Iran Ministry of Roads & Urban Development, each of the images was reviewed by each of the experts. In the next step, using previous experience and knowledge, each expert re-examined each of the images and considered a number for each image as the value and severity of the damage in percentage. In the last step, an average of the opinions of 5 experts was taken for each image, each of them had assigned a number to the desired image, and finally that number was recorded in the database as the asphalt damage in the desired image.

2. Pre-processing

The data collected in the study is 824 items, with 99 features examined for pre-processing of each image. In image processing science, training and test datasets are needed to apply algorithms related to pattern discovery. The development method in this study was to create training and test datasets.

Training: To create a pattern of data in the study
Test: To estimate the accuracy of predicting the pattern created from training data

In this study, 578 images were used for software training, and 246 images were used for testing.

Data collection and storage steps were performed to detect road asphalt damage and then the data size and characteristics of each image were reduced by reducing the volume of data and applying pre-processing methods.

The application of various classification or clustering algorithms in the paper was done to discover the pattern, whose purpose in discovering the pattern was to create a machine to show the whole training dataset.

3. Evaluation

Test dataset were used to compare the accuracy of the proposed method. The number of data in test datasets was 246 images. To this end, after training the software by training dataset, the desired output was received in the test section by introducing the number of each image to the software. According to the number of images that was 824 in the database, each cluster or K-means will eventually be a collection of 199 features. In these 199 features, almost 100 were related to the centers themselves, and 99 to the differences between the centers. We were looking for a relationship between quality and the increased difference between centers and higher numbers of centers.

4. Proposed network

The proposed neural network in the paper was a multilayer perceptron (MLP) network. Neural networks must perform backpropagation operations each time the algorithm is executed to create different weights and biases. Each iteration of the implementation of an algorithm known as "iterate" can update the weights and biases so that the neural network algorithm can identify different features and different classes. As is seen in Figure 2, MLP neural network tries to learn through changes in weights (W) and bias (B). The principle of learning in neural networks is iteration, which means the data of a data set is injected into the algorithm several times, and this algorithm can detect differences in the training data by increasing or decreasing W and B. Using this technique, a minimum point is found for features and errors. Now that training has taken place, the network has definite W and B. From now on, the network can process an image by entering the previous training, and present the best response with the least error.

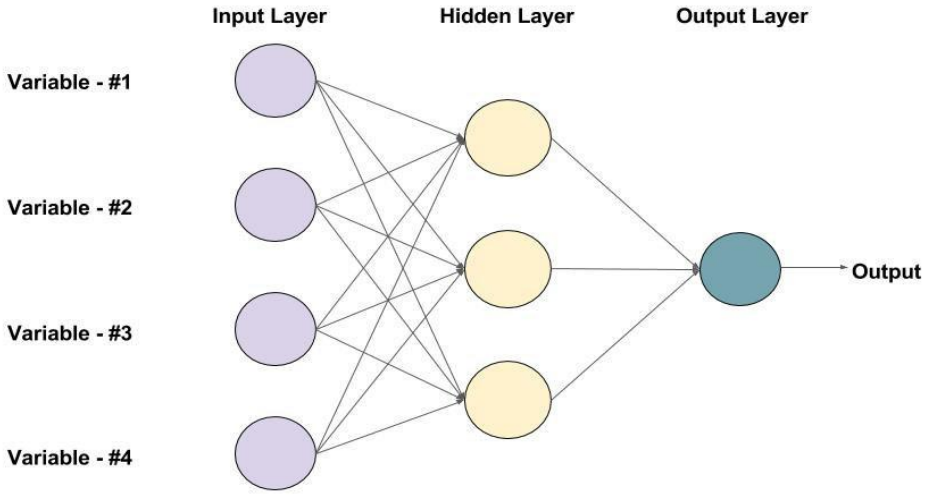

Figure 2: Perceptron network

Training samples are transferred to the network and the output from the network is compared with the actual output. This error is used to change the weight of the neurons so that the error gradually decreases. This is done using the backpropagation algorithm, also called backprop. Normally, data transmission over a network and weight update, so that the error is reduced, is known as Stochastic Gradient Descent (SGD). The rate of changes in weight is determined by a parameter called the learning rate.

In this experiment, the programming environment used to implement and test the proposed algorithm is introduced. MATLAB 2018 was used for programming.

Results

Two types of output are provided by this proposed method. In the first model, the outputs are classified and in classes 1 to 4 and in the second model, it will make predictions based on accuracy percentage.

Classification output:

As is see in Figure 3, in the classification model, after sorting and preparing the information, the percentages that the program predicts are in the range below 12 in group one, between 12 and 20 in group two, between 48 and 20 in groups three and 48 and above are in group four. The reason for this choice is that based on the samples given with this situation, the test and training samples are almost the same, and about 200 images are placed in each group. For this model, the output of which will be classification, a pattern net network was used, which is used to identify the pattern in multi-group class files.

Accuracy percentage output:

Feed forward network is used for the second model based on the accuracy percentage prediction. The features are a bit different, but for the prediction of the classification groups, more wavelet features were used, and for the percentage output, the gradient features provided a more appropriate answer. At the end of the output section, two programs must be executed, which for each image whose number is given by the user, the original image is found next to the edge detected image and the category that the program recognizes is displayed simultaneously with the actual category, which in most cases are equal and this is an indication of the accuracy of the proposed method. In the percentage model, the original image is displayed next to the edge image, along with the correct percentage using the proposed detection method, along with the number that actually existed (experts prediction).

Output analysis of the accuracy percentage

As Figure 1shows, in the percentage output, the task of the detection program with acceptable accuracy is the rate of asphalt damage using the training that has already been seen. Given the high accuracy of the method, the numbers detected by the software for asphalt damage in each image are usually close to the damage reported by experts and recorded in the

database. In Chart 1 20, asphalt images are randomly selected, and their percentage damage, as percentage, is compared with the actual percentage reported by experts. In this comparative chart, the detection rate of the method presented in this study is acceptable.

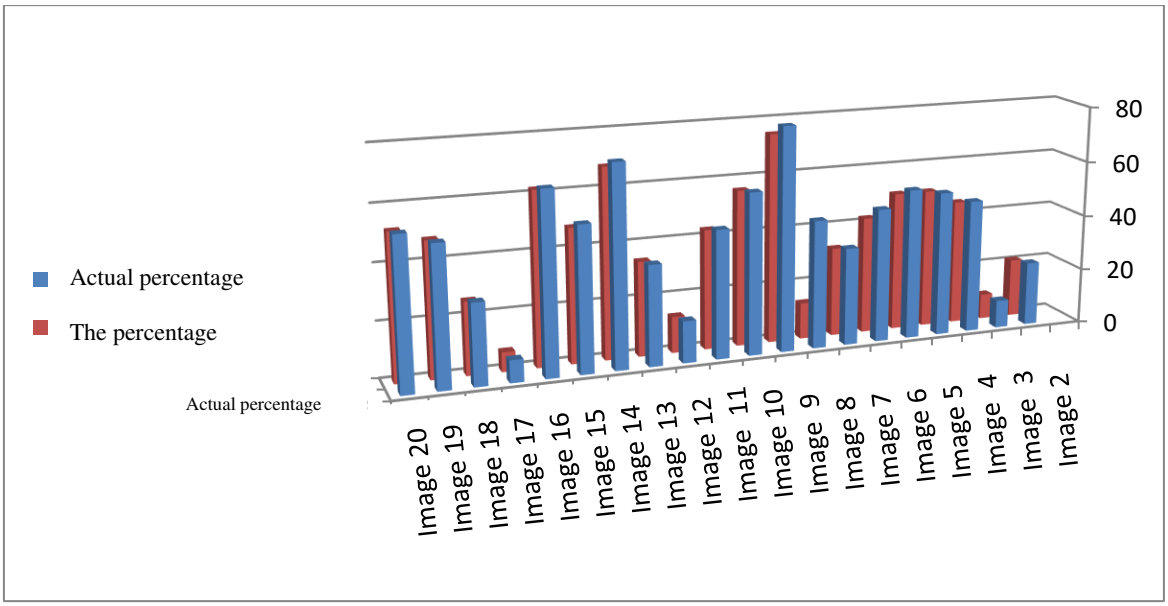

Chart 1: Percentage output

Classification output analysis

As Chart 2 shows, images are classified into 4 groups in the classified output. In the classification program, after sorting the information and preparing it, the percentages that the program predicts are in the range below 12 are in group one, between 12 and 20 in group two, between 48 and 20 in group three and 48 and above in group four. This means that there four classes are seen at the output: Class One, Class Two, Class Three, and Class Four.

As Chart 2 shows, 20 images were randomly selected and the classification output was obtained from them according to the method described above. The chart well illustrates the accuracy of the proposed method in the study in terms of classification.

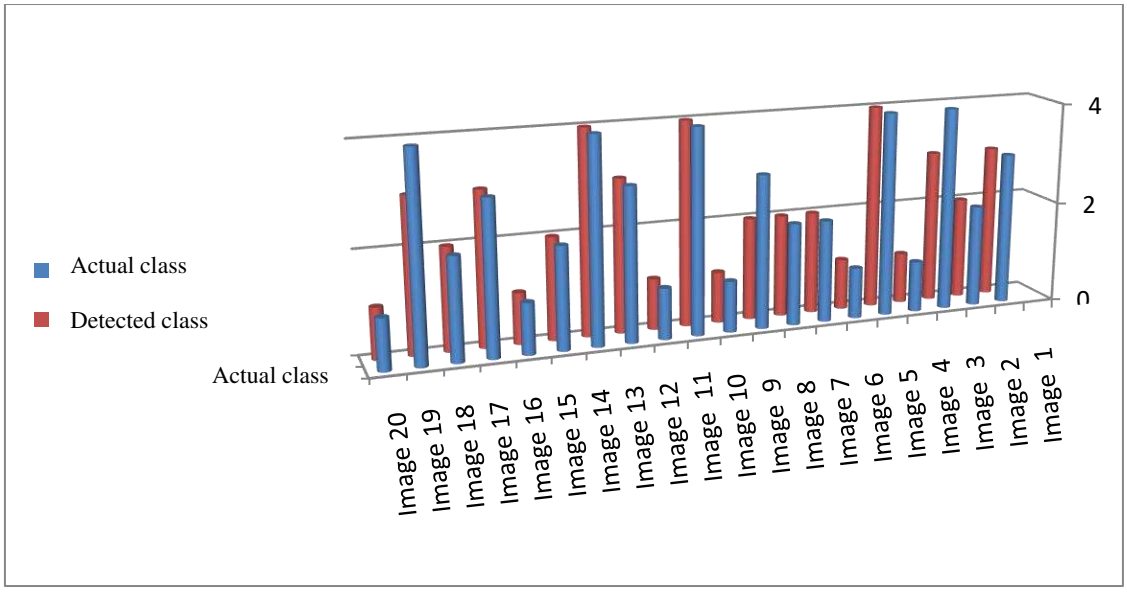

Chart 2: Classification output

After training and test, the program was designed so that each user can enter the image in any situation with different qualities and receive the desired output to make the program more practical and for everyone to be able to use it in various situations.

After running the program, the user opens a window and asks the user for an image path. After selecting the image, the program automatically creates all past operations on the image and provides the desired output to the user.

It has to be noted that, as explained in the previous section, the program provides output to the user in two ways. Figure 5 shows that in this case, the output of the images is presented to the user as classification and percentage.

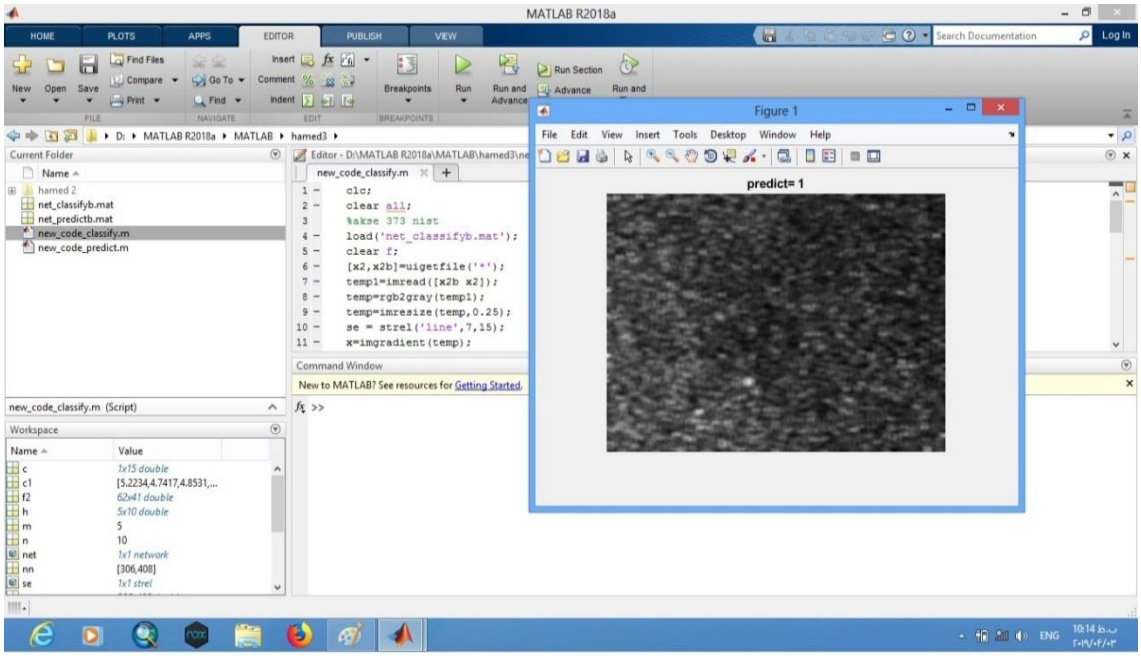

Figure 5: Output

Discussion

Nowadays, the basic challenge in image processing is whether it can act like human eye or not. Human vision is so complex that we have not yet fully understood our vision to develop image processing. Image processing is on the verge of making a fundamental difference in our world, and many studies are still needed to meet our expectation from image processing. Moreover, many operations have to be done to process the visual information. Images usually contain noise that distorts them. Although this problem is not considered very serious for the human visual system, for machine vision systems these noises must be completely filtered and cleaned, which is done using some algorithms.

Conclusion

Nowadays, different approaches have been proposed to identify damages in many areas, especially road construction, but the methods described have to identify these damages in a timely and appropriate manner. One of the problems with traditional approaches is the need for continuous monitoring of road construction experts at the road level and the experimental determination of the level of asphalt damage on the road surface, which incurs high costs, and in many cases, the damage and damage are not correctly identified. This is less common in some developing countries. Sometimes a lot of limitations are associated with going on long distances and sending experts to different axes on the roads. Efforts have to be made to receive diagnostic data in the field of road construction, especially in Iran, with professional and appropriate equipment, to reach an acceptable detection. To this end, the new proposed method in this paper was presented with MATLAB and the accuracy of the proposed method was compared with other methods or programs for evaluation. The accuracy of the output in terms of percentage is more than 85%, which shows acceptable detection by the method presented in this study according to previous studies. The accuracy of the method presented in this study in the classification output is much higher than the percentage output. Moreover, it is in the correct class the experts have identified in almost more than 95% of cases, which shows the high accuracy of the proposed method in the study in classification method.

References

1. Sajjadi, H., Rashidi Baghi, M., Shir Alizadeh, M. Predicting the relationship between stock returns and information asymmetry using artificial neural networks, Regional Conference on Accounting in the Information Technology Age, 2012.
2. Jadidi Osguyi, A. Investigation of the structure and function of SMA asphalt for use in road paving, 4th International Congress of Civil Engineering, Architecture and Urban Development, 2016.
3. Beheshti Shirazi, A. Digital Image Processing Book, 2015.
4. Ghanem, R., Romeo, F., A wavelet-based approach for the identification of linear time-varying dynamical systems, J. Sound Vib. 200p; 234 (4): 555–576.
5. Shan, X., Burl, J.B., Continuous wavelet based linear time-varying system identification, Signal Process. 2011; 91: 1476–1488.
6. Angreni, I., Adisasmita, S., Ramli, M., Evaluating the Road Damage of Flexible Pavement Using Digital Image, International Journal of Integrated Engineering, 2018.
7. Shahabian Moghadam, R., Sahaf, M., Pourreza, H. Automatic diagnosis and classification of pavement damages based on image tissue analysis in the field of location and conversion, Specialized Letter of Transportation Engineering, 2017.

8. Rajab, M., Alavi, M., Saif, M, Application of Image Processing to Measure Road Distresses, Wseastransactions on Infrmation Science & Application, 2008.
9. Bigleri, M., Karimi, A., Sharif Tehrani, Sh. Presentation of the Numerical Index of Asphalt Mixtures Based on Digital Image Processing, Transportation Infrastructure Engineering, Third Year, 12th in a row, 2017.
10. Kim, K., Kang, M., Linking the Effect of Aggregate Interaction to the Compaction Theory for Asphalt Mixtures Using Image Processing, pplied Sciences, 2018.
11. Moohan, M., Kuia, N., Digital Image Correlation Technique for Measurementof Surface Strains in Reinforced Asphalt Concrete Beams under Fatigue Loading, Journal of Materials in Civil Engineering, 2019.