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Using Multi Layer Perceptron Network to Classify Road Cracks

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Abstract: In this paper a method for classifying cracks in asphalt road by using multi layer Perceptron (MLP) neural network is proposed. Training data are road images which are taken from road surface in 30 degree. The RGB images are first changed to gray scale and then binary images are produced by using proper threshold gray level. The structure of network has three layers as input, hidden and output. The network is trained to perform tasks such as pattern recognition. The training rule is categorized as back propagation method and learning method is supervised. After training the network, it classifies each image to longitudinal, transverse, blocks, Alligator and others.

Keywords: Road Crack, Multi Layer Percepetron, Pattern recognition

1 Introduction

Billion dollars are needed through the year to maintain current road condition. Conventional method for investigating road surface is manual. The manual methods are very costly, time consuming, dangerous, labor intensive and subjective [1]. As the papers show many researchers have been try to imply non destructive methods for investigating the road surface. Imaging method is widely used in which a visual digital image from the surface is analyzed to identify distress of road surface.

Based on the view of researchers and responsible company in road maintenance the designed system is different. Some of them believed performance of the road depend on the material used, density of traffic and the weather condition. D. Kaur and D Tekkedil try to predict the performance of road based by using such data and fuzzy logic method [2].

K. Sarabandi and E.S. Li proposed a method in which by using millimeter-wave frequencies make active an alarm in detecting fault on road surface. They used 95 GHz fully polarmetric radar system to measure backscatter waves. The system bandwidth is set to 1 GHs to improve the range resolution of the point target response for time domain gating during post processing. The system only identifies the distress on the asphalt which is above a threshold [3].

A. C. Heath et al have build a system to model longitudinal, corner and transverse cracking in pavements. They used the parameters such as geometry (length, width, and thickness), material properties (slab elastic modules, Poisson's ratio, coefficient of thermal expansion, sub-grade support), load transfer between adjacent slabs (aggregate interlock and dowel properties), environmental loading (temperature and drying shrinkage distribution though the slab depth) and traffic loading (loads, axel configurations and position of axles) to define a problem in their test system [4].

As the brain can detect the distress on the road easily by seeing them, many researchers try to use artificial intelligence method such neural networks and fuzzy logic to classify the distress on the roads.

C. J. Chao and F. P. Cheng based on cause and effect diagramming and fuzzy pattern recognition have examined a diagnostic model. They used two levels of parameters representing the causes of cracks to form fuzzy set. The parameters are material used, fabrication of structural elements, loading and environmental conditions [5].

In our research classifying cracks based on visual image is important. As we are going to use the test system for on line testing, the algorithm must be simple and fast with reasonable error. As the identifying and classifying distress is subject of our research, we consider the problem as pattern recognition. MLP neural network is the best chose for this situation.

2 System setup

The test system includes three sub-systems as image acquisition, image preprocessing to make them ready to feed to the MLP network as classifying part of system. These parts are explaining briefly as follow.

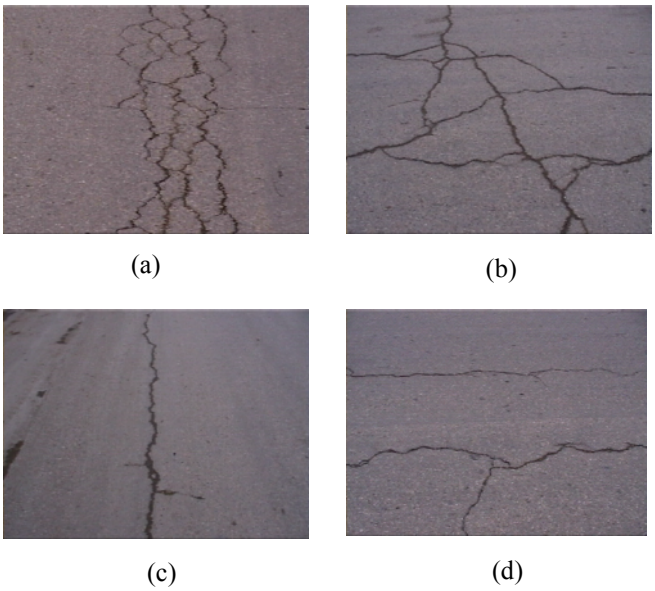

Fig. 1 Original crack images (a) Alligator, (b) Blocks, (c) longitudinal, (d) Transverse

2-1 Image Acquisition

A digital handy cam is used to take road image. The degree of handy cam with horizontal axes is 30 degree and it is 1.5 meter above the surface. Four kind images are shown in fig. 1. The original image has 640 by 480 pixels. Each pixel in horizontal direction represented 0.3 cm and in vertical 0.65 cm long. In other word each original image covers an area with 416 by 144 cm of the road.

Our experience shows the best images are taken in sunny weather two or three hours after rain. As the gray level of the cracks is much different from the background of surface such images are much better than usual images.

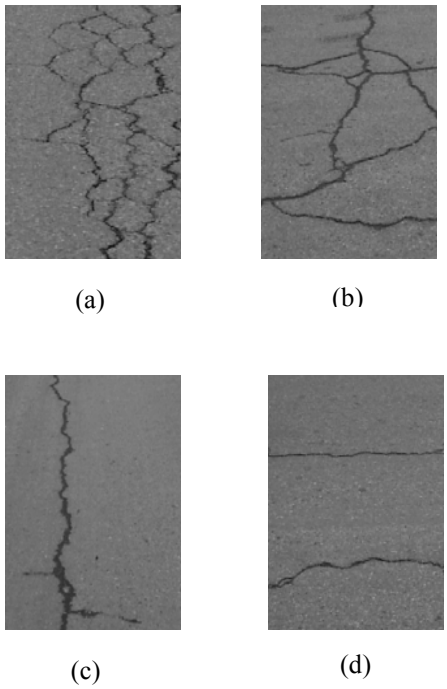

Fig. 2 Scaled crack images (a) Alligator, (b) Blocks, (c) Longitudinal, (d) Transverse

2-2 Preprocessing

All images are preprocessed as follow before training the neural network. As the neural network is MLP, the network inputs have to be in binary format. First each mage is changed to

gray scale then by using proper threshold all images changed to two level as zero and 255 gray scale. As the number of neuron in input layer is limited by speed of processing time and convergence of algorithm, each image is scaled. The scaled image has 251 by 371 pixels. It means each original image change to two new images as shown in fig. 2.

2-3 Classifying by MLP

The scaled images are inputs to the MLP neural network. The network has three layers, input layer has 5859 nodes, hidden layer consists of 140 neurons and there are five outputs in last layer. The back propagation (BP) algorithm is used to train the network. In order to improve the BP method a term called momentum is added to each parameter of network. This term filter out the high frequency variation.

N. A. Kasabov stated the number of hidden layer neurons have to be close to the number of training examples when the training data are sparse and do not contain any common features[6]. As our data meet this feature, the number of hidden layer neurons is set 140. The same reference propose optimal learning rate by

$$\eta = 1.5 \Big/ \left(\sqrt{\sum p_i^2} \right) \qquad (1)$$

In which η is momentum or learning rate and p_i is the number of instances belong to output of each class. In this work they have chosen as table 1.

Table 1 Chosen p_i

	Alligator	Longitudinal	Block	Transverse	Others
p_i	43	35	12	25	25

It has been proven that when back propagation neural network has single hidden layer and non-linear transform functions, it is a universal classificatory machine [7]. In this work activation function in hidden layer and output layer is Fermi which is a non linear activation function. For 0.0005 error limit the number of training images are 140, the number of epochs are 1300 and the momentum based on table 1 data is 0.02244. Figure 3 shows the main page of computer program in Delphi and training form.

3 Experimental results

About 100 road images are tested with the program. The program classifies with the error shown in table 2.

The program classify 7 longitudinal as 4 others and 3 blocks, 3 transverse as others, 1 blocks as alligator and 4 alligators as others. It is because of generality of others. As any cross line in longitudinal cracks make them as block cracks, the noise in longitudinal cracks cause classifying them as blocks wrongly.

Table 2 test result, A=alligator, L=longitudinal, B=blocks, T=transverse

Type	**A**	**L**	**B**	**T**	**Others**
No. of test	20	20	12	20	20
Correct Recognition	16	13	11	17	20
Error	%20	%35	%8.3	%15	0

4 Conclusions

This program is simple and faster than other methods. Because of high speed of classifying it can be used on line. The device for setting up the test system is cheap and easy to use. As future work, the program can be improved to label each group of distress as high, middle and low intensity. The other problem have to be solved is classifying dirty part of the road (for example because of car leakage oil) as crack. Labeling the crack in the road by using GIS system is next step of improving the program.

Acknowledgement

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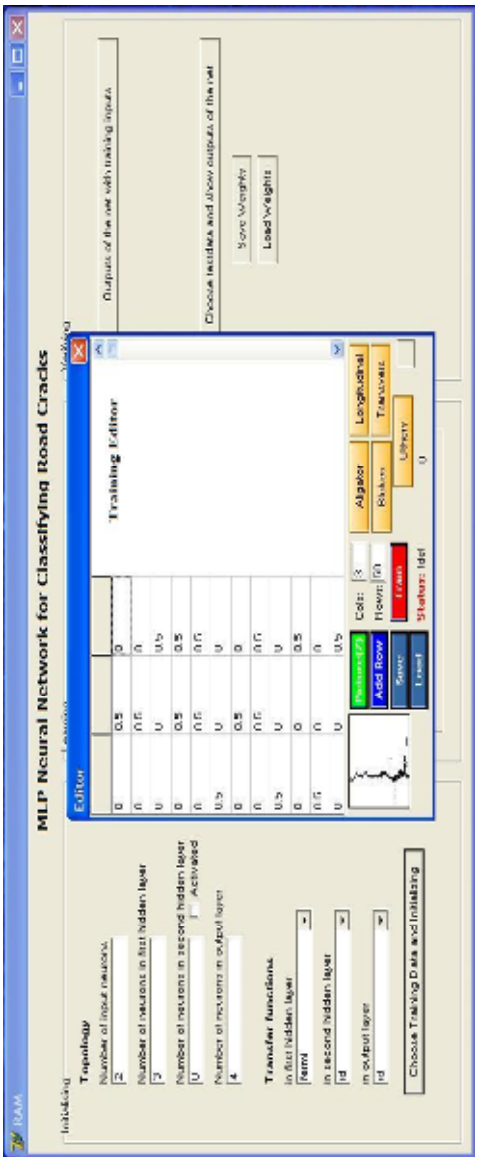

Fig. 3 Main page and training form