Road Detection From High Satellite Images Using Neural Networks

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***Abstract*—In this paper, we propose a road detection model approach based on neural networks from satellite images. The model is based on Multilayer Perceptron (MLP) which is one of the most preferred artificial neural network architecture in classification and prediction problems. According the neural network, the RGB values are used for deciding the pixel belongs to road or not. The found road pixels are marked in the output image.**

***Index Terms*—Road Detection, Road Extraction, Neural Networks**

I. INTRODUCTION

A. Road Extraction

The presence of high resolution satellite images and their potential to be used in wide variety of applications such as preparing and updating maps have made the extraction of object, especially roads and buildings, a new challenge in remote sensing. Road extraction provides means for creation, maintaining, and updating transportation network. It also provides data bases for traffic management, automated vehicle navigation and guidance. (Mokhtarzdae, M. et. Al, 2007).

B. Related Researches Review

A road detection strategy based on the neural network classifiers was introduced by (Mokhtarzade and Valadan, 2007) where a variety of input spectral parameters were tested on the functionality of the neural network for both road and background detection.

(Mohammadzadeh et al. 2006) proposed a new fuzzy segmentation method for road detection in high resolution satellite images with only a few number of road samples. Afterward by using an advanced mathematical morphological operator, road centerlines were extracted.

A shoreline detection strategy based on the neural network classifiers was introduced by (Turan, M., K., et. al. 2012). Their algorithm detects the shoreline between land and sea with the 90.03% success rate.

(Barsia et al. 2003) proposed a method for detection road junctions in aerial images artificial with neural networks. The paper describes an approach of automatic junction detection using raster and vector information: mean and standard deviation of gray values, edges as road borders etc. The derived feature set was used to train a feed-forward neural network, which was the base of the junction operator. The operator decides for a running window about having a road junction or not.

II. STRUCTURE OF THE USED ARTIFICIAL NEURAL NETWORK

In this study we have used Multilayer Perceptron (MLP) as a neural network structure. One of the most frequently used neural network architectures in classification is MLP. MLP consists of a network of nodes arranged in layers. The general structure of MLP consist of three or more units arranged in layers of processing nodes: an input layer that receives external inputs, one or more hidden layers and an output layer that produces the classification results. Each node in MLP can be modelled as an artificial neuron (Figure 1.) (Yan, H. et. al, 2006).

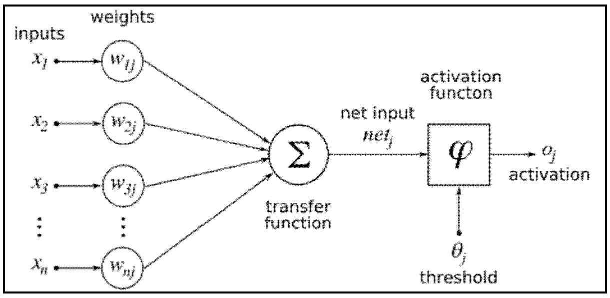

Figure 1. A node of MLP: an artificial neuron.

In the MLP, each neuron j in the hidden layer computes the sum of input x_i weighted by respective connection weight w_{ij} and calculates its output y_j as a function of the sum.

$$y_j = f(\sum w_{ji} x_i)$$

where f is the activation function which transforms the weighted sum of all signals to a neuron as multiplier. Here, activation function (f) can be a simple threshold function or a sigmoidal, hyperbolic tangent, or radial basis function. The sum of squared differences between desired and actual values of output neuron e is defined as follows:

$$e = \sum_j \left(y_{dj} - y_j\right)^2$$

where y_{dj} and y_j are the desired and actual value of output neuron j respectively. Each weight w_{ij} is tuned to reduce the value e immediately. How w_{ij} is tuned depends on the training algorithm adopted (Ubeyli, E. D. and Guler, I., 2004).

III. GENERATING TRAINING DATA AND TRAINING PROCESS

In training process, it is necessary to create own training data. For this reason, according to our neural network we have 27 inputs and 1 output and training data is get manually by selecting a pixel from the image Figure 2. For selected point, R, G, B values of every neighboring pixel like 3x3 matrix, is stored. These 27 data is the input. The output is 1 or 0 (road or not road). In order to get uniform distribution we have used 20 different satellite images and we have created 650 records.

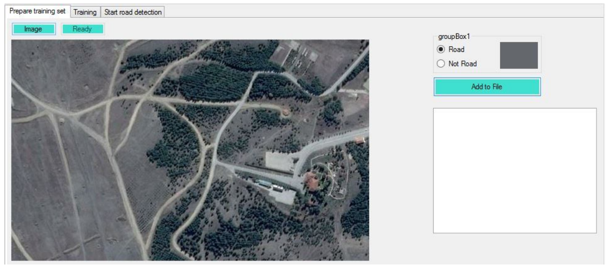

Figure 2. Interface of creating training data

R, G, B values is range from 0 to 255. When numeric values are normalized, neural network training is often more efficient, which leads to a better predictor. The program normalizes R, G, B values by computing with the formula. After the normalization each numeric values is range 0 to 1.

$$Normalized(e_i) = \frac{e_i - E_{min}}{E_{max} - E_{min}}$$

In our training process we have used 650 randomly shuffled records. MLP is designed in three layers including an input layer, two hidden layer and one output layer. In the input layer has 27 neurons and hidden layer has 12 neurons. In the output layer we have one neuron representing road or not. We have used backpropagation algorithm with adjusted training parameters (momentum and learning rate) as the training method and used sigmoid activation function in all layers of MLP shown on Figure 3. For training iteration, maximum epoch number is 100.000 and maximum error rate 0.0001.

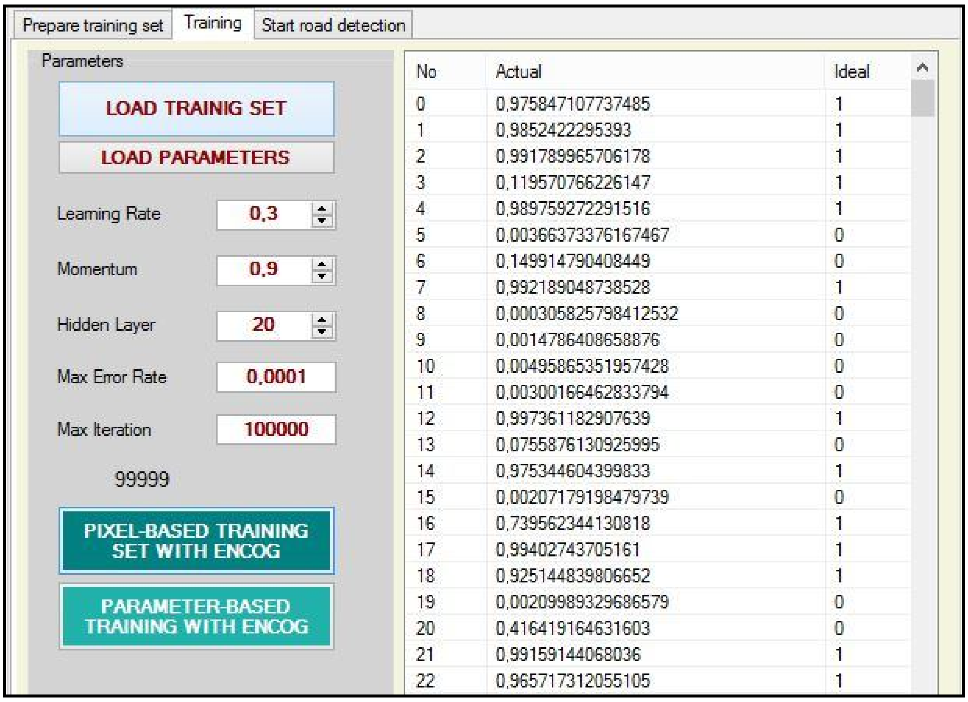

Figure 3. Training phase and training results

In order to find optimal parameters for training phase, we vary the MLP parameters. Momentum is 0.9, learning rate 0.2 to 0.5. The best result have been obtained when the learning rate is set to 0.3, momentum is set to 0.9 and hidden layer neuron is set to 12. In the study, best prediction result has been found as 93.35% (Table 1).

Learning Rate	0.3	0.4	0.3	0.3	0.3	0.2
Momentum	0.9	0.9	0.9	0.9	0.9	0.9
Input Layer Neuron	27	27	27	27	27	27
Hidden Layer Neuron	20	20	15	12	10	12
Success	88.25	87.02	90.88	93,35	90.57	87.17

Table 1. The percentage of success according to different MLP parameters.

IV. IMPLEMENTATION RESULTS OF ROAD DETECTION

Road detection was performed using an artificial neural network consisting of 27 neuron in its input layer in charge of receiving 3 spectral values (R, G, B) as explained in section 2. The hidden layer was made up of 12 neurons and the output layer, having only one neuron, was designed to show the response of neural network. After 100.000 iterations in training phase, the results of the images that have not used in the training is showed in Figure 4.

Figure 4.a. Satellite image

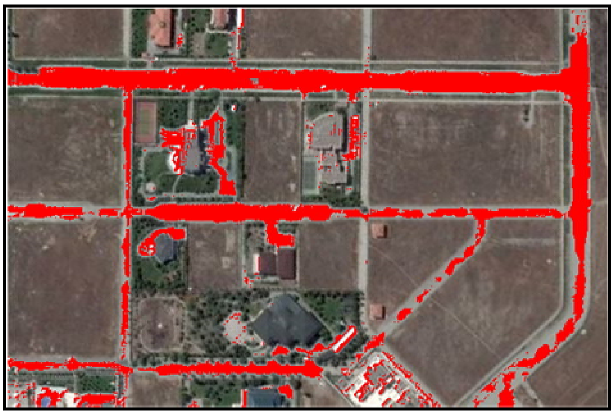

Figure 4.b. After ANN implementation

Figure 5.a. Satellite image

Figure 5.b. After ANN implementation

In Figure 5, the left side images (Figure 4a and 5a) show the satellite image taken from google earth. Right side images (Figure 4b and 5b) depicts the output of the proposed neural network structure.

V. CONCLUSION

According the nature of the problem, number of classes given by the developed software were observed considered relatively sufficient. In this study, some region images was expected to be classified as road or not. This expectation has been met percent 93.35% availability. The algorithm is implemented on two satellite images that are not used in training phase. The developed algorithm is successful for detecting road in a region.

VI. ACKNOWLEDGEMENT

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BIOGRAPHY

Idris Kahraman was born in Bolu / Turkey in 1985. Bachelor degree is owned from Military Academy with System Engineering in 2007 in Ankara, Turkey. The author get his master degree in Computer Engineering from Karabuk University in 2014. He studies in Geographical Information System.

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