IMAGE RECOGNITION BY USING ARTIFICIAL NEURAL NETWORK TECHNIQUES FOR VEHICLE CLASSIFICATION

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Abstract: There are some tools required for transportation and traffic engineering, which are dealing with the classification of vehicles on road networks. These tools are useful not only as the quantitative control of vehicle movements, but also as audit system such as for toll road revenue audit. Such tools are then expected to have high capacity in recognizing the vehicle types and could count the number without human intervention. This is the aim of this research to discuss on the development of image recognition for vehicle classification. This early development is focused on static capture of vehicle figure, which is used as input for image recognition. Image recognition is processed through artificial neural network (ANN) with cascade typology. The developed ANN consists of several modules. The first module deals with the extraction of image recognition through frequency domain approach. The second module is assigned for the training process for certain level of acceptance, and determines the appropriate weighted value for the cascade typology. Kohonen SOM is utilized for creating vehicle classifications. These classifications are filtered further by back-propagation Algorithm. The whole system has been developed in a package program with C++ Language under windows. Early tests have shown promising results with a compromised value of recognition that reaches to 96%.

1. INTRODUCTION

In practice, vehicle-classification data are extremely important because they are involved in most aspects of transportation and traffic engineering. There are some tools required for transportation and traffic engineering, which are dealing with the classification of vehicles on road networks. The common tools used for vehicle classification are detector techniques, but there are several problems exists in such techniques (Yuan Xidong, t.al, 1994). These tools are useful not only as the quantitative control of vehicle movements, but also as audit system such as for toll road revenue audit. Such tools are then expected to have high capacity in recognizing the vehicle types and could count the number without human intervention.

Video-image analysis techniques have great potential to improve vehicle classification systems because video images contain much more detailed information about passing vehicles than other detectors can provide (Yuan Xidong, t.al, 1994). All the current methods may have some drawbacks on efficiency related to data capture as well as cost to undertake the survey. It is, however, the properties of the proposed method that could be expected to capture such information with less human effort and consequently accrued costs. The proposed method may be derived as an effective algorithm that crosscuts the drawbacks, although at this stage it is still considered as a prototype model.

The most important element of such techniques is the image recognition algorithm. This is the aim of this research to discuss on the development of image recognition for vehicle classification by applying Artificial Neural Network (ANN) techniques.

Several ANN typology has been developed, specifically in this research cascade typology, a combination of Kohonen and Backpropagation network, is utilized.

2. ARTIFICIAL NEURAL NETWORK

ANN are used successfully in a wide variety of applications including investment, medicine, science, engineering, marketing, manufacturing, and management (Lawrence, 1993). ANN learn from experience (using inductive learning) and not from programming. ANN is good at recognizing patterns, generalizing, and predicting trends. They are fast and tolerant of imperfect data, and do not need formulas or rules from the experts in the application domain (Lingras, 1995).

Several types of ANN for solving a variety of problems have been proposed (Hecht-Nielsen, 1990; Lawrence, 1993; Zahedi, 1990). In its most general form, an ANN consists of several neurons. Each neuron receives inputs from other neurons and (optionally) from the external environment and produces an output (Figure 1).

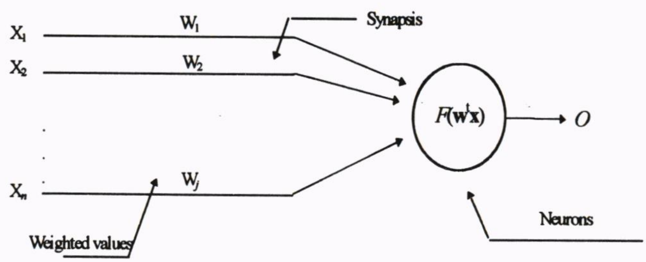

Figure 1. A General Neuron Model

There are two different stages in the development of an ANN model: training and testing. During training stage, the network uses the inductive-learning principle to learn from a set of examples called the training set. The learning process can be unsupervised or supervised.

In unsupervised learning, the desired output from the neurons is not known. The network attempts to classify patterns from the training set into different groups. In supervised learning, the desired output from neurons for each example in the training set is known. The network attempts to adjust the weights of the connections between neurons to produce this desired output. The error in the output is used to adjust the weights of the connections based on a learning equation. Usually, ANN learning algorithms try to minimize the mean-square error. In supervised learning, the trained ANN is tested for a set of examples called the test set.

2.1 Kohonen Self-Organizing Map (SOM)

Kohonen SOM is based on unsupervised learning process. It uses the competitive learning approach. In competitive learning, the output neurons compete with each other and the winner output neuron has the output of 1. The rest of the output neurons have outputs of 0. This network consists of input layer and output layer (Figure 2) where in the training stage the input are processed through the weighted value

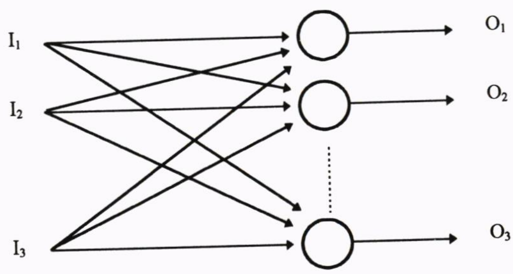

Figure 2. Kohonen SOM

adjustment in the Kohonen SOM layer. The output function is formulated as follows:

$$o = f(\Sigma w_i x_i) \tag{1}$$

Where the w's are weighted vectors:

$$w = [w_1\ w_2 \ldots\ldots w_n]^t \tag{2}$$

And the x's are input vectors:

$$x = [x_1\ x_2 \ldots\ldots x_n]^t \tag{3}$$

In training process Kohonen SOM modulates the weighted adjustment until a certain neuron has the maximum output for certain input. This process can be formulated as follows:

$$w_{new} = w_{old} + \alpha(i - w_{old}) \tag{4}$$

Where,

w_{new} = new weighted value
w_{old} = previous weighted value
α = Training-rate coefficient
i = input value with current weighted

Once the training process is finished, the classification procedure can be initiated by giving an arbitrary input vectors into the network, and then it is proceeded by output calculation for each neuron. Neuron with maximum output is set as a certain classification.

2.2 Back Propagation Network

Back propagation network is a supervised learning network which consists of three layers, namely, input layer, hidden layer and output layer (Figure 3). In training process, the algorithm uses two phases of data flow. First, the input pattern is propagated from the input layer to the output layer and, as a result of this forward flow of data, it produces an actual output, this called a forward-pass phase. Then the error signals resulting from the difference between the actual and calculated output are *back-propagated* from the output layer to the previous layers for them to update their weights, this is called a reverse-pass phase.

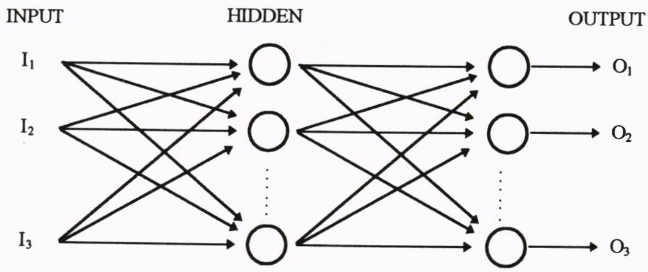

Figure 3. Back Propagation Network.

Since the weighted adjustment in the output layer differs from that of in the hidden layer, the following formula is used to determine change in the weighted value:

$$\Delta w_{pq,k} = \eta \delta_{q,k}\, Out_{pj} \tag{5}$$

$$w_{pq,k}(n+1) = w_{pq,k}(n) + \Delta w_{pq,k} \tag{6}$$

Where,

$w_{pq,k}(n)$ = weighted value between neuron p in the hidden layer and neuron q in the output layer before adjusted. k shows the connectivity with the output layer

$w_{pq,k}(n+1)$ = the adjusted weighted value

$\delta_{q,k}$ = value of δ for neuron q in the output layer k

η = A constant value (between 0.01 - 1.0)

Out_{pj} = value of output neuron p in the hidden layer j

p,q = neurons

j,k = layers

Weighted values in the hidden layer can be adjusted with similar procedure. Since there is no output required in this layer, the difference is only in δ value. Therefore, the following formula is used to determine δ in the hidden layer:

$$\delta_{q,k} = Out_{pj}(1 - Out_p)(S\ \delta_{q,k}\, w_{pq,k}) \tag{7}$$

By using this δ, weighted values in the hidden layer can be adjusted through the similar procedure with that of in the output layer.

2.3 Cascade: Kohonen SOM - Back Propagation

This type of network constitutes a combination of two different networks, in this case are Kohonen SOM and Backpropagation. This cascade is intended to improve the output from Kohonen SOM, where the input is processed in the Kohonen SOM network and then the resulted output is further processed in the Back Propagation network. Figure 4 shows this process. By doing this, the result is expected to improve.

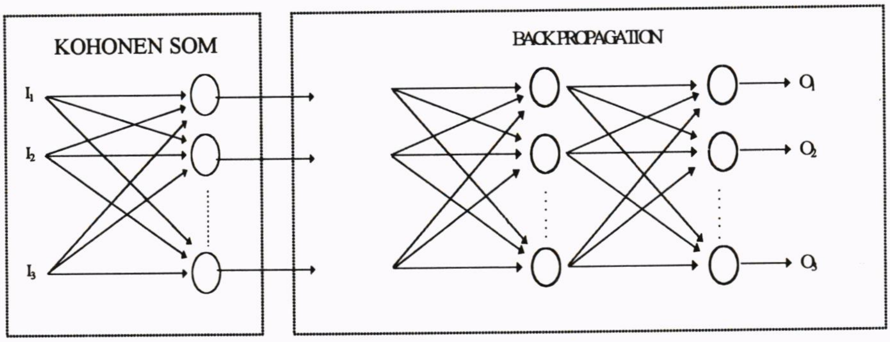

Figure 4. Cascade Configuration

3. SYSTEM DEVELOPMENT

In this early development, static capture of vehicle figure is used as input for image recognition. The captured image of a certain vehicle is taken statically by digital camera and then stored in the files and then the developed algorithm analyzes this file. In general, the vehicle image recognition system consists of several modules. The first module deals with the extraction of image recognition through frequency domain approach. The second module is assigned for the training process for certain level of acceptance, and determines the appropriate weighted value for the cascade typology. Kohonen SOM is utilized for creating vehicle classifications and then these classifications are filtered further by back-propagation algorithm. The third module is intended for interpreting the output from the second module. This system is shown diagrammatically in Figure 5. The whole system has been developed in a package program with C++ Language under windows

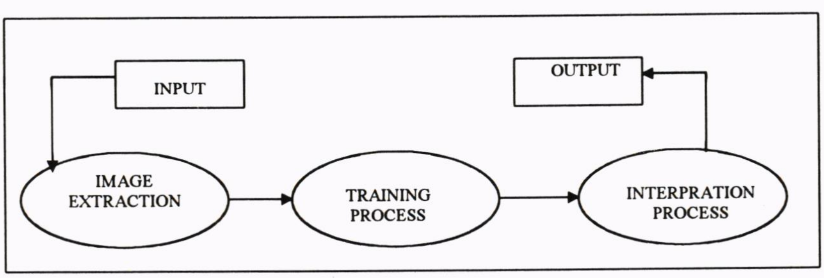

Figure 5. Modules of Vehicle Image Recognition System

3.1 Image Extraction Process

In this module, the extraction image process utilizes a frequency domain approach. Prior to image extraction, the image is transformed first from spatial domain into frequency domain through a Fourier 2-d function. This transformation function can be expressed as:

$$F(u,v)=\frac{1}{N}\sum_{x=0}^{N-1}\exp\left[-j2\pi ux/N\right]\sum_{y=0}^{N-1}f(x,y)\exp\left[-j2\pi vy/N\right] \tag{8}$$

As a result of transformation process, the extracted image forms a power spectrum in the form of 20 concentric circles with a constant radius change from a specified minimum to a specified maximum value (Figure 6).

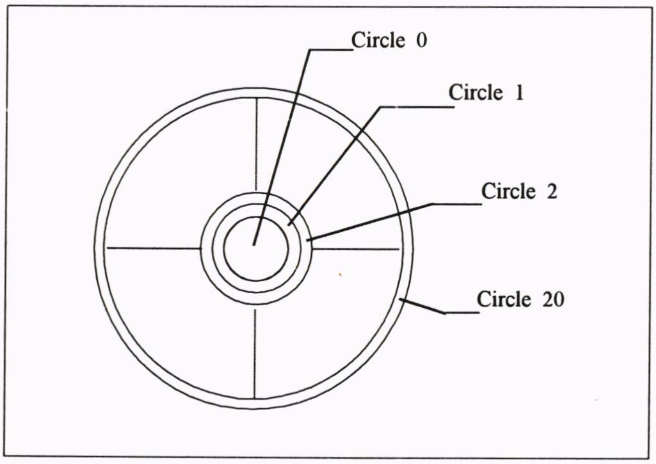

Figure 6. Twenty Concentric circle areas

3.3 Training Process

In this module, a training process is carried out by utilizing a cascade typology. The configuration used is as follows:

A. ANN Configuration;

1. Input nodes = 20
2. Kohonen nodes = 20
3. Layer Number BP = 3
4. Hidden nodes = 8
5. Output nodes = 4

B. Kohonen SOM parameters :

1. Initial value of α = 0.7
2. Neighborhood size = 30
3. Decrement period = 100
4. Maximum iterations = 1000

C. Back-propagation parameters:

1. Error tolerance = 0.001
2. Momentum = 0.001
3. Learning parameter b = 0.2
4. Noise factor = 0.01
5. Maximum iterations = 1000

D. Frequency filter parameters:

1. Lower radius = 8 (pixel)
2. Upper radius = 128 (pixel)

Within this process, four types of vehicles is used, namely, sedan, jeep, station wagon and minibus. Three samples of each type are taken as a trained sample. Having done the training process, the network stores the knowledge in the form of weighted values in a specified file.

3.4 System Validation

Having trained the developed system, the next step is to evaluate the accuracy and performance of the system. Twenty-four images, which consist of six type of vehicle, are taken as a tested sample. The network parameters used in this test are similar with that of used in training process. Due to some limitation and practicality of the training twenty-four (24) data is considered sufficient, and this could gradually increased in the development process beyond this preliminary search.

4. PRELIMINARY RESULT

From the test, it is shown that the system is able to recognize the given sample into their classification with a compromised value of recognition that reaches to 96%. Table 1 shows the results.

Table 1. Test Results

Type of Observed Vehicle	# of Observed Vehicle Recognized as				
	Sedan	Jeep	Station Wagon	Mini Bus	Total
Sedan	6	0	0	0	6
Jeep	0	5	0	1	6
Station Wagon	0	0	6	0	6
Mini Bus	0	0	0	6	6

As can be observed in Table 1 the recognition process appears quite satisfying. Almost all of vehicle types could be recognized without any failure, except for the Jeep type it has around 16% rate of failure, which might be considered high enough. However, the size of both vehicles in our examples came up very similar, so to distinguish more accurately the number of concentric circles can easily be increased with the longer computation time in consequence. It is worth-noted too that this recognition process, for this preliminary test, took approximately only 7 seconds, which may be considered, fast enough.

5. CONCLUSION

The vehicle image recognition system through ANN techniques with a cascade typology has been developed. From the validation process, the system shows a promising result, which is able to recognize the sample images with a compromised value that reaches to 96%.

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