Road Sign Recognition System using Radial Basis Function Neural Network Architecture

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Abstract

In this paper, road sign recognition system (RSR) is implemented with radial basis function (RBF) neural network architecture. The system consists of image pre-processing and algorithm of RBF function to recognition that road sign data set.RSR can be performed with dynamic and static road sign images. Road sign consists of various shapes according to their command. In this paper, the mostly use road signs are applied for training and testing data in the implementation of the system.RBF neural network is used in the recognition system because it is a supervised learning neural network and can have better approximation in pattern recognition than other systems. Road signs for warning for danger, forbidden and restriction, and command signs with various geometrical shapes are trained and tested. The result of the system is described by applying the recognition rate described from training and testing phase in RBF neural network.

Keywords: Road Signs Recognition, Radial Basis Function (RBF), supervised learning, Image processing.

1. Introduction

Road signs recognition (RSR) is part of general case of pattern recognition. Road sign are made with vivid and specific colors so as to attract the driver's attention and to be distinguished from the environment are of specific geometrical shapes for each sign there is a specific template. RSR are important parts in the transportations system. RSR is used to regulate road signs, warn driver, and command or prohibit certain action. An intelligent road sign system would be beneficial in several ways. It could assist the driver before passing them and a warning system sends signal to the response to the road sign. The driver assist system will make the driving safer and easier to the comfortable. Road sign recognition (RSR) system to used static road sign and command sign action. Road sign recognition systems performed dynamic and static image system. This system is used static road sign images.

In this system, it have covered static road sign images and supervised learning network. Regular road sign including *warning for danger, forbidden and restriction, command, and direction signs* are used for the recognition system. In the implement of road sign recognition system, static road sign images are needed to be preprocessed to get the data set for the neural network to train and test. Neural network applied in the system is radial basis function. Radial basis function (RBF) network is used to perform the same network architecture as multilayer perceptrons, but different activation functions. The function (RBF) network can be used for recognition, classification, prediction, or optimization problems. In this system the Gaussian function is used as an activation function for the network to modify the input to give the desired output. The composed of a large number of highly interconnected processing element (nervous) working in unison to solve specific problem. Learning is performed by modifying the strength of the connections between the neurons and the parameters of the activation (thresholds). Radial Basic Function is a supervised learning. A radial basis unction (RBF) network has a hidden layer of radial units, each actually modeling a Gaussian response surface [6].

This paper is organized as follows. In Section 1, the introduction to road sign recognition system is expressed. In Section 2, the related work. In Section 3, theory background related to this system is presented. In Section 4, presents the design and implementation of this system. In Section 5, conclusion of this paper is described.

2. Related Works

Technology is rapidly changing the capabilities of modern vehicles. Many algorithms for the road sign recognition have been introduced. So that it can be a part of the data set system. A.l &J.s [1] presented the "Traffic sign recognition using neural network on open CV: Toward Intelligent Vehicle/Driver Assistance Systems". J.C.Hsien and

S.Y.Chen [3] described the “Road Sign Detection and Recognition Using Hidden Markov Model”, in the 14th workshop, 2003. S.-H, Hsu, C-L.Huang [7] detail expressed “Road Sign Detection and Recognition Using Matching Pursuit Method”. A.S and Oetedjo, d Nagako University of technology [2] proposed a method for “Traffic Sign Classification Using Ring Partitioned Method”. The “Real Time Sign Recognition System Using Artificial Neural Networks for Bengali Textual Information Box” was written by M.O.R and other authors [5] covered four types of road signs regularly seen in their country. The goal of this paper is to develop a road sign recognition system using radial basis function (RBF) network architecture with various types of regularly seen road signs.

3. Background Theory

In this section, the related background theory of Road Sign Recognition Using Radial Basis Function Neural Network Architecture is described.

3.1 Overview of Road Signs

Road signs are important in the transportation system. In typically road signs are classified as follows: they are warning for danger, forbidden and restriction, command and direction signs. The **warning for danger signs** consists of 34 types, 25 types are for **forbidden and restriction** 8 types for **command signs** and 41types of **direction signs**. The shapes of the road signs are mainly divided into diamond, circular, triangular and hexagonal. Some examples for the various road signs are described in the Table 1 with their descriptions.

Types	Road Signs	Shapes	Description
Warning for danger	Diamond		This is left two dimensions.
Warning for danger	Diamond		This is school in front.
Forbidden and Restriction	Circular		There are two way.
Forbidden and Restriction	Hexagonal		Stop.
Command	Circular		There is go ahead (or) turn left.
Command	Circular		There is start drive from right at round about.

Table1: Examples of Road Signs

The typical road signs of 15 for warning for danger signs, 12 for forbidden and restriction signs and 8 command signs are applied in the implementation of the system.

3.2. Image Processing

Static images are applied in this road sign recognition (RSR) system. Static images are needed to pre-process before training in the neural network. Image processing is a physical process used to convert an image signal into a physical image. The image signal can be either digital or analog. The actual output itself can be an actual image or the characteristics of an image. Four steps of image pre-processing performed in the system are resizing the image, gray scaling, edge detection and the binarization.

In this system, the road sign digitized images of (80x80) size are firstly to resize to get the limited size of 25x25 images. After that gray- scaling is proceeded. Grayscale digital image is an image in which the value of each pixel is a single sample, that is, it carries only intensity information. Images of this sort, also known as black and white, are composed exclusively of shades of gray, varying from black at the weakest intensity to white at the strongest. In gray scaling, the RGB images convert to gray-scale. Gray-scale in the transformed image spread over the entire gray range from 0 (black) to 255 (white).

Grayscale images are then processed into edge detection stage with the use of Canny Edge detection library function in the C # program. Edge detection is a fundamental tool used in most image pre-processing application. This process detects outlines of an object and boundaries between objects and the background in the image. The probability of detecting real edge points should be maximized while the probability of falsely detecting non-edge points should be minimized. This corresponds to maximizing the signal-to-noise ratio. The Canny edge detection algorithm is known to many as the optimal edge detector. The Canny Edge Detection Algorithm basically consists of smoothing, finding gradients, non-maximum suppression, double thresholding and edge tracking by hysteresis process.

The Canny algorithm basically finds edges where the grayscale intensity of the image changes the most. These areas are found by determining gradients of the image. Gradients at each pixel in the smoothed image are determined by applying what is known as the Sobel-operator. First step is to approximate the gradient in the x- and y-direction respectively by applying the kernels as shown in Equation (1).

$$K_{Sx} = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \quad (1)$$

$$K_{gy} = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \quad (2)$$

The gradient magnitudes (also known as the edge strengths) can then be determined as a Euclidean distance measure Equation (2) and Manhattan distance measure as shown in Equation (3) and (4).

$$|G| = \sqrt{G_x^2 + G_y^2} \quad (3)$$

$$|G| = |G_x| + |G_y| \text{ , where:} \quad (4)$$

G_x and G_y are the gradients in the x- and y-directions respectively. The directions of the edges are computed by using Equation (5).

$$\theta = \arctan\left(\frac{|G_y|}{|G_x|}\right) \quad (5)$$

Canny's intentions were to enhance the many edge detectors already out at the time. The Canny algorithm basically finds edges where the grayscale intensity of the image changes the most. These areas are found by determining gradients of the images [8].

In the image processing, the last step to perform is the binarization. It is to change the image into binary image. Binary images are images that have been quantized to two values, usually denoted 0 and 1, but often with pixel values 0 and 255, representing black and white. Binary images are used in many applications since they are the simplest to process, but they are such an impoverished representation of the image information that their use is not always possible. Sometimes the output of other image processing techniques is represented in the form of a binary image, for example, the output of edge detection can be a binary image (edge points and non-edge points). Binary image processing techniques can be useful for subsequent processing of these output images.

3.3 Radial Basis Function of the Neural Network Architecture

Neural network is a powerful data modeling tool that is able to capture and represented complex input/output relationship. The radial basis function network models are used for pattern recognition and classification. RBF includes function approximation, regularization, noisy interpolation, density estimation, optimal classification theory and potential functions.RBF networks are feed-forward networks that can be trained with supervised learning. The network consists of three layers: the input layer, the hidden layer, and the output layer. The input layer is basically a dummy layer and just transmits input values to the next layer. The number of units in the output layer is equal to the number of output categories, and the number of units in the hidden layer depends upon the decision surfaces that separate output categories in the feature space. The architecture of RBF is shown in Figure 2.

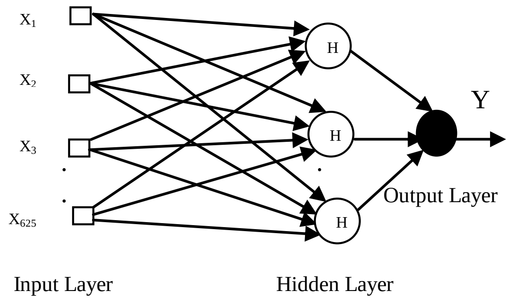


Figure 1: The RBF Neural Network Architecture

For each hidden unit there is a function φ. The collective activations of all the hidden units define the vector to which the input vector has been mapped as in Equation (6).

$$\varphi(x) = [\varphi(x_1), \varphi(x_2), \dots, \varphi(x_M)] \quad (6)$$

Where M is the number of hidden units and x is the input vector. The weights connection to a hidden unit defines the radial basis function for that hidden unit. The input to a unit is then taken to be the Euclidean norm as described in Equation (7).

$$net_j = \| x - w_j \| \quad (7)$$

Various nonlinear hidden unit activation functions are used a Gaussian form Equation (8).

$$\varphi(r) \approx \exp[-r^2] \quad (8)$$

4. System Design and Implementation

In this section the detail features of the road sign recognition system are presented.

4.1. System Design

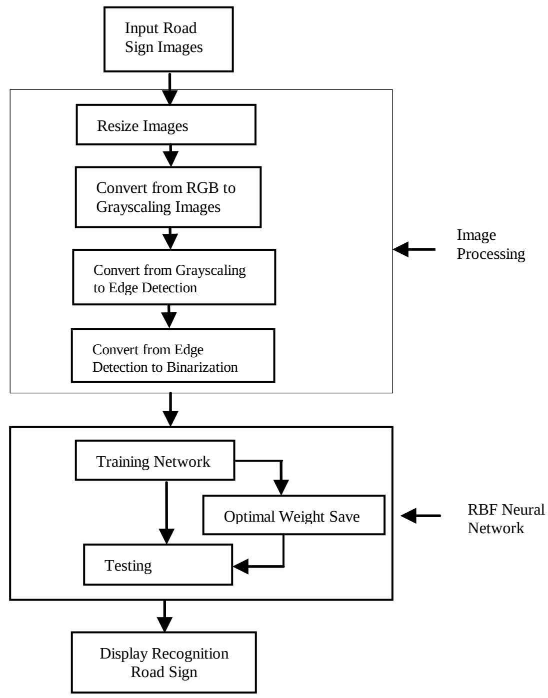


Figure 2: System Design

In this system, it mainly consists of two parts: image processing and RBF neural network architecture. Image processing for this system is explained in section 3.2. The processes of training and testing in the neural network for the road sign recognition system are detail described in the following sections.

4.2. Training Phase

In the training phase, the weight and the input image parameters are initialized. The input data from the user are accepted for the network to be trained. Then the network calculates the net input and actual output for each hidden neuron. And also it calculates the net input and actual output for each output layer neuron by using Gaussian activation function. Then the network computes error between target and actual output from the network and change and update weights depending on predefined sum squared error and maximum error. Training program continues until the maximum error is less than the sum squared error.

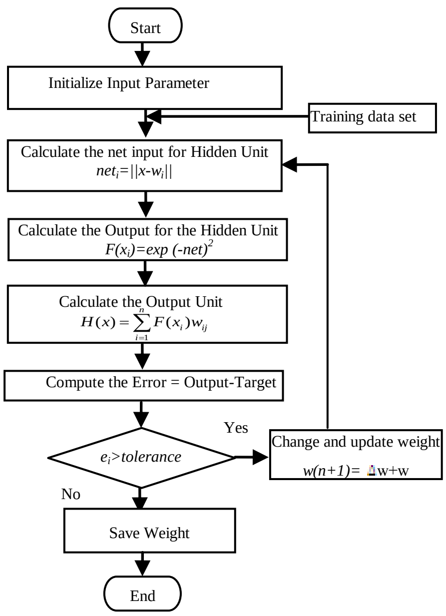


Figure 3: Training Phase of the System

4.3. Testing phase

In this testing phase, the input data from the user are captured for the testing data. The input system consists of critical facts for the road sign image that are needed to determine the result of the system. The testing network consists of only feed-forward propagation. The testing network uses training network's weight as it's knowledge. As the network is a testing network, it does not need target output Figure 4 depicts the testing phase of the system. If the user gives the testing input to the testing network, the system will display the output result which will quote similar to the input data.

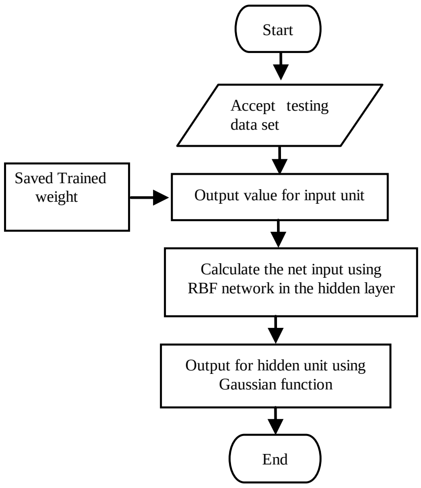
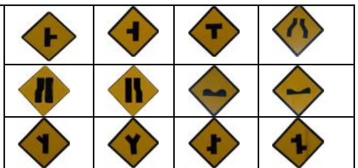


Figure 4: Testing Phase of the System

4.4. Experimental Results

In this system, the input road signs dataset are loaded from training database for the network to be trained. Training phase continues until the maximum error (tolerance) is less than the sum squared error. The testing dataset is derived from the image database. The system can be tested with unknown input data set or noise images. Some of the warning for danger signs, forbidden and restriction signs, and command signs are in very similar. For those images recognition rate for the system is lower than other road signs images. Table 2 shows some examples for similar road signs used in this system.

Table2: Examples of Similarly Road Signs

Warning for Danger Signs	
Forbidden and restriction	
Command signs	

From the following tables, the accuracy of the system can be analyzed with the recognition rate. The first table (3) shows the recognition rate only for warning for danger signs. Testing data set consists of some noisy road signs and the recognition rate is lower than other training data set. In similarly for the second and third tables (4 and 5) where forbidden and restriction signs and command signs are respectively trained and tested. The last table (6) shows the recognition rate for all combined road signs that are trained and tested in the RBF neural network. From all these tables recognition rate for all testing data set are lower than the training data set.

Table (3)

Warning for Danger Signs	*Data Set*	*Recognized Data Set*	*Accuracy Rate*
Training	75	60	80%
Testing	20	12	60%

Table (4)

Forbidden and Restriction Signs	*Data Set*	*Recognized Data Set*	*Accuracy Rate*
Training	60	54	90%
Testing	20	15	75%

Table (5)

Command Signs	*Data Set*	*Recognized Data Set*	*Accuracy Rate*
Training	40	37	92.5%
Testing	25	18	72%

Table (6)

All Road Signs	*Data Set*	*Recognized Data Set*	*Accuracy Rate*
Training	175	150	85.71%
Testing	65	50	76.92%

5. Conclusions

This system is developed by pattern recognition for road signs recognition using radial basis function (RBF) neural network. All the road signs used in this system are static images. Most of the typical and regular signs are used to recognize in the neural network. The recognition rates are also calculated to apply the accuracy of the system. The typical road sign recognition system will assist the driver and make the driving safer, easier and comfortable. Radial basis function is applied in the implementation of the system for its features in better approximation methods. The system is only used for off-line application. The recognized output of the road signs will be displayed as the result of this system.

References

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