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# Traffic Sign Classification based on Neural Network for Advance Driver Assistance System

***Abstract.*** *Traffic sign is utmost important information or rule in transportation. In order to ensure the transportation safety the automotive industry has developed Advance Driver Assistance System (ADAS). Among the ADAS system, development of TSDR is the most challenging to the researchers and developers due to unsatisfying performance. This paper deals with, automatic traffic sign classification and reduces the effect of illumination and variable lighting over the classification scheme by using neural network according to the traffic sign shape. There are three main phase of the classification scheme such as; pre-processing using image normalization, feature extraction using color information of 16-point pixel values and multilayer feed forward neural network for classification. An accuracy rate of 84.4% has been achieved by the proposed system. Overall processing time of 0.134s shows the system is a fast system and real-time application.*

***Streszczenie****. W artykule opisano metodę automatycznego rozpoznawania I klasyfikacji znaków drogowych z przenaczeniem do inteligentnych systemów wspomagania kierowcy ADAS. Do tego celu wykorzystano sieci neuronowe przeprowadzając normalizację obrazu, ekstrakcję cech i klasyfikację. Osiągnie™o dokładność rozpoznawania rzędu 84% przy przeciętnym czasie rozpoznawania około 0.13 s.* ***Rozpoznawanie i klasyfikacja znaków drogowych z wykorzystaniem sieci neuronowych***

**Keyword**: Traffic sign classification; advance driver assistance system; image normalization; neural network.
**Słowa kluczowe**: rozpoznmawanie znaków drogowych, sieci neuronowe, system ADAS

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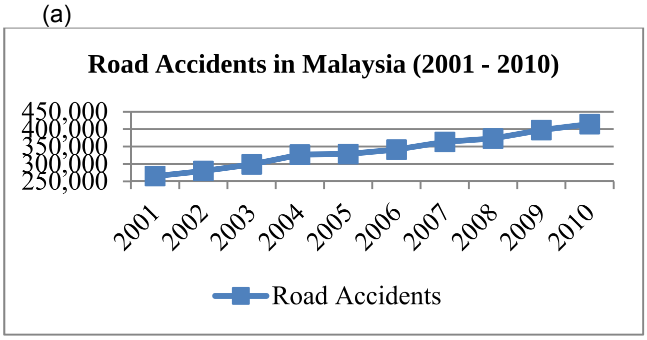
## Introduction

Traffic sign and classification is part of the Traffic Sign Recognition (TSR) system and it is one of the developed systems under Advance Driver Assistance (ADAS) which help to improve the safety issue on the road. In this era of industrialization, the gradual increase of roads and traffic occurs and thus the number of traffic accidents is increasing day by day. As in Fig.1., the number of traffic accidents in Malaysia gradually increased from 265,175 to 414,421 from year 2001 to 2010 which equivalent to an increment of 5% every year [1, 2]. The number of fatal accidents reported in year 2001 and 2010 is 5849 and 6872 respectively. In order to solve the recent concerning issues about road and transportation safety, the automotive industry has developed an ADAS includes Adaptive Cruise Control (AAC), Lane Departure Warning System, Automatic Parking, Blind Spot Detection, and TSR had installed in the car as an additional feature [3].

(a)




(b)

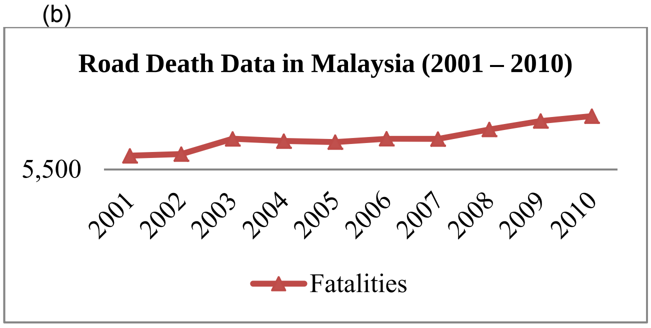



Fig.1. General road accident data in Malaysia (2001 – 2010) Source: MIROS 2013

Different methods have been used in developing efficient TSDR system. The popular techniques for detection are colour segmentation, edge detection, colour conversion, Content-Based Image Retrieval (CBIR), AdaBoost and Sum of Absolute Differences (SAD) [4]. The biggest challenges during development of TSR are illumination and occlusion. Weather conditions such as rain, snow, or fog, and physically damaged or changed surface metal of traffic signs also affect the recognition process [3]. Therefore, a fast and intelligent algorithm is needed to detect and recognize the traffic sign in the real time application.

The images are separated into different group accordingly by applying Fuzzy C-Mean (FCM) segmentation. After that, based on shape and color, the traffic sign is detected. Yet, at non-complicated situation it only able to yield average recognition ratio above 80% whereas CBIR method used able to match the detected traffic signs with the signs in the database accurately [5]. Sign detection and tracking based on image normalization and genetic algorithms (GA) is suitable for detecting triangular sign board but not for circular. Support vector machine (SVM) and NN are being used to in classifying the traffic sign [6-10]. From the result, it shows that NN performs better than SVM in term of processing time and also in term of accuracy [11]. In order to overcome the illumination effect on RGB color detection, Wali et al. [12] threshold the image according the R, G, B channels and then logically sums it up to form the region of interest (ROI) and managed to get 93.3% total detection rate. Colour-Geometric Model (CGM) is used to divide the traffic sign into few classes for recognition whereas SVM is used to supervise the five different shapes of traffic sign and to match the information extracted. [13]. To improve the recognition performance, K-means Algorithm and Modified Cylindrical Distance is used in HSI color space in the detection phase in [14].

The main objective of this paper is to develop an intelligent system is to improve the pre-processing steps and feature extraction and to classify traffic signs according categories and then recognize traffic sign using multilayer feedforward neural network. The main contribution of this paper is the higher accuracy rate with a very low computational time.

## Classification System

In this paper, a robust image processing technique such as artificial neural network is implemented to classify the traffic sign. The details of the proposed methodology architecture are explained below:

### *Methods for Traffic Sign Classification*

The proposed method can be divided into three phases which consist of image pre-processing, feature extraction and and classification. First and foremost, the raw image is pre-processed before being fed into detection algorithm. Results from pre-processed phase are then feed into the classification phase where at first the feature was extracted considering the color information of the 16 point pixel values of the image. At last an artificial neural network is applied to classify the ROI. Before that, the neural network has to be trained by the database images. Fig.2. shows the proposed method for traffic sign detection and classification system.

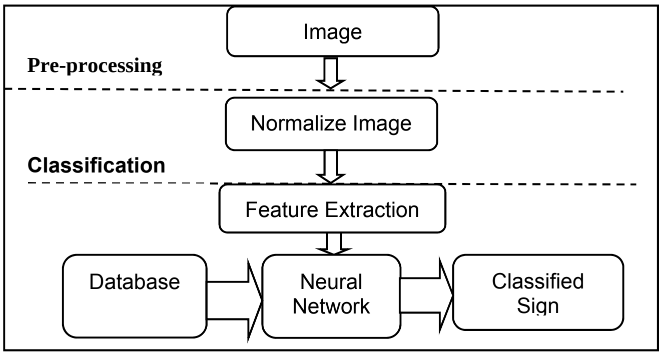



Fig.2. Proposed methodology

### *Pre-Processing Phase*

Due to various lighting condition and illumination problem, it is not suitable for directly processing the raw images that are captured through camera or imaging sensors by image processing techniques. Some pre-process technique required to remove the effect of the illumination [15]. Normalization is applied using the following formula.

$$R'(i,j) = \frac{R(i,j)}{R(i,j)+G(i,j)+B(i,j)} \quad (1)$$

where R'(i,j) is the respective normalized red pixel component and R, G, B is the red, green, blue components respectively. The normalized components are concatenated to form a normalized image as in Fig. 3. for further phase process.

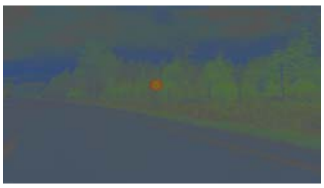


Fig. 3. Normalized image using Equation 1

### *Classification Phase*

In classification phase, artificial intelligence, neural network has been implemented to classify the detected object from the detection phase. Features of the image are extracted as the input for neural network. Before that, the neural network is trained using the database which consisting traffic sign and non-traffic sign images with the same feature extracted from the images. Images from detection phase are resized into 50×50 size before feature extraction and classification process.

### *Feature Extraction*

Specific features from the detected traffic sign are extracted as the input for neural network. The feature is selected as the input of the colour of 16 different pixels as shown in Fig.4. Colour information in RGB colour space are extracted and concatenated and form a 48×1 column matrix as the input for trained neural network.

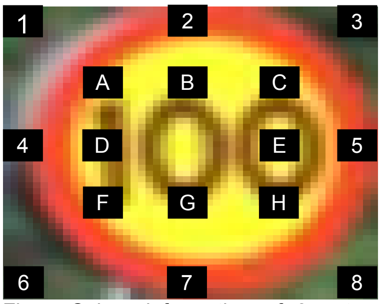



Fig.4. Colour information of 8 outer pixels and 8 inner pixels extracted

### *Multilayer Feedforward Neural Network*

The artificial NN is an adaptive or nonlinear system, which topology includes the perceptron, MLP, RBF network, and etc. In a network, the input information moves in only one direction which is from the input nodes, through the hidden layers' node and to the output nodes as shown in model in Figure 8.

A three-layer feedforward neural network as in Figure 5 is sufficient to classify the various classes of traffic sign. Inputs for the neural network are corresponding to the feature vector length extracted which 42 inputs are fed into the neural network. The output layer is set to has 6 neuron nodes which are the number of classes of traffic sign and hidden layer neuron nodes would be 24 (determine with half of the input vector length). The activation function for each layer is standardized to be sigmoid activation function.
Considering the effect of illumination and physical environment on the traffic sign, traffic sign images with different illumination level and different orientations are also included.

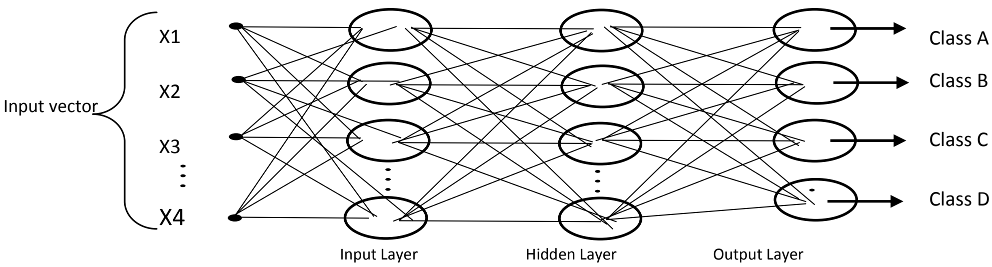



Fig.5. Multilayer feedforward neural networks model; Source: [16]

## Result and Discussion

The performance of every phase of the proposed system discussed and analyzed here in detail. An image processing toolbox of MATLAB R2007a is being used for system development. The proposed system is tested using Intel(R) Core(TM) 2 DUO CPU 2.00GHz and 4GB of RAM. Result of colour thresholding segmentation, edge detection and a multilayer feed forward neural network discussed in term of accuracy and processing time.

### *Dataset Formation*

The 300 test images are taken from the dataset available at [17] which covered Swedish highways and city roads. Point-Grey Chameleon with a 1296x964 resolution at 18 fps was used to record the video of travelled along the journey. An approximate 41 degree field view is created by a focal length lens of 6.5mm the traffic signs. A 90cm wide traffic sign corresponded to 50 pixels in the image at a distance of 30m [18]. The test images used to test the proposed system consist of 187 images with traffic sign and 113 images without any traffic signs. Scene of the test image consists dawn and sunny day. The images are resized to 640×480 at the beginning of the test to shorten the processing time required.

### *Pre-Processing Results*

To reduce the illumination effect, shadow effect and also the low light intensity of the images, image normalization is applied. The effect of normalization is shown as follows. Figure 6 illustrated the normalized image from a fairly bright image. Fig.6. (b) shows that the input image is normalized with respective to the total sum of the three channels.

(a) (b)

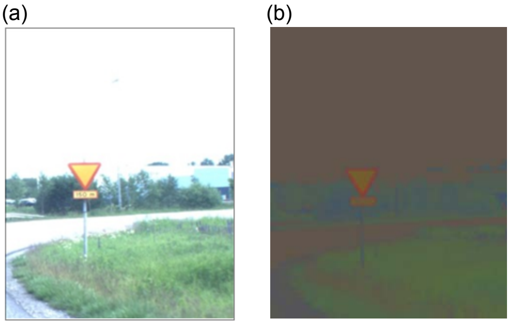


Fig.6. Normalization technique on high illumination image: (a) Input image. (b) Normalized image.

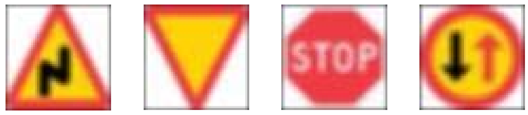
### *Classification Results*

A three layer feedforward neural network being used as the classifier for the traffic sign. A complete standard Swedish traffic signs are taken from [19]. The standard traffic sign images are resized into 50×50 saved in JPEG file format. Rotation from +10˚ to −10˚, Gaussian smoothing effect, and illumination effect is applied to the standard traffic sign images used to train the NN. A total number of 3024 images consist of four different shapes which are positive triangle, inverted triangle, circular, and octagonal. Table 1 shows the database used to train the NN.

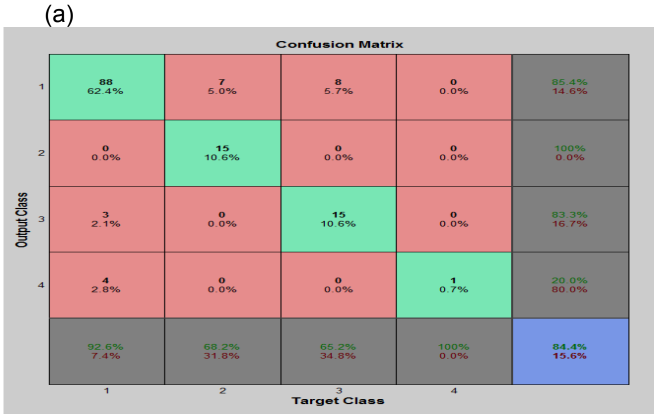
The training has been done several times and only the best architecture being selected for retrain and self-validation. Traffic sign extracted from detection are used to test the trained network. The classification performance of the network is plotted in the confusion matrix using the Matlab function as in Figure 14 and the receiver operating characteristic (ROC) is plotted together in Figure 15.

In Fig.7., class 1 to 4 is referring to circle, inverted triangle, positive triangle and octagonal shape respectively. Low detection classification rate of the class and class 3 most probably due to insufficient variation in the database. The dataset used only contain 1 STOP sign image. Hence, the classification result on class 4 might be not accurate enough as lacking of test images. The circular traffic sign has the highest classification rate which is 92.6%. The test images of the circular traffic sign consist of speed limit signs, mandatory signs, and prohibition signs. The performance of the trained NN is 84.4% correct classification.

Table 1. Example of traffic signs used to train NN

| | Positive Triangle | Inverted Triangle | Octagonal | Circular |
|---|---|---|---|---|
| **Original** |  | | | |
| **Rotational** |  | | | |
| **Gaussian Smoothing** |  | | | |
| **Illumination** |  | | | |

(a)




(b)

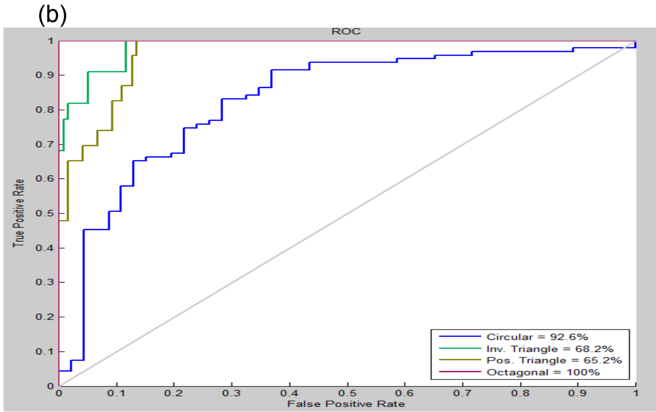



Fig.7. Confusion matrix (a) and ROC plot (b) of NN performance

In this paper, hexagonal and square shape is not included in the classification training. This is due to the feature where yellow colour will be similar to the circular shape feature. While for square shape traffic sign, the detection does not include the detection of white colour content traffic sign. Hence, it is excluded in this phase.

### *Processing Time*

Processing time for the overall system is analyzed in this section. The details on time required for each phase are listed in Table 5. The processing time for the system is 0.134s with 0.122s for pre-process phase and 0.012s for classification. With an average processing time of 0.134s, the system could be applied in real-time application.

Table 2. Processing time for the system

| Task | Processing Time (s) |
|---|---|
| **Pre-process** | |
| Resize image | 0.053 |
| Normalization | 0.069 |
| **Classification** | |
| Feature extraction | 0.001 |
| Classification | 0.011 |
| **Total** | **0.134** |

### *Comparative Study*

A comparative study between the proposed method and some existing methods is presented in Table 3. In our proposed method, the accuracy rate is 84.4% with processing time of 0.134s. Escalera et al. in [6] used AdaBoost and Speeded Up Robust Features (SURF) with an accuracy of 92.7% and processing time of 200ms. Sheng et al. used SVM for sign recognition in [7] with an accuracy of 95.4% which is higher than our proposed method but higher in terms of processing time which is 0.6s. Siyan et al. in [21] has also higher accuracy rate than the proposed method which is 92.9% but a very high processing time of 8s which may not be suitable for real time application. For real time implementation a fast processing time is very much needed. Our proposed method is very suitable for real time application with a processing time of 0.134s.

Table 3. Comparative study of the proposed method with some previous studies

| Reference | Accuracy Rate (%) | Processing time |
|---|---|---|
| [6] | 92.7 | 200 ms |
| [7] | 95.4 | 0.6 s |
| [21] | 92.9 | 8 s |
| Proposed method | 84.4 | 0.134 s |

### Conclusion and Recommendation

This proposed classification system with the integration of AI and image processing techniques gave a satisfying performance system comprises of Neural network classifier presented here. The proposed system is tested with a dataset consist of different lighting condition which has high illumination effect, shadowing effect from physical objects and occlusion due to weather. With a 0.134s processing time, the traffic signs are extracted from the image and classified. An accuracy of 84.4% is achieved by the system. From the experimental result, it shows that the system able to overcome most of the illumination effect in the images.

However, highly distorted image due to illumination and shadowing effect, color temperature created by image normalization due to noisy background will tend to make the system fail to detect the traffic signs. In classification phase, traffic signs only classified according to its shape. Feature such as recognizing the exact sign would be a big leap in classification as currently only few signs can be recognized. Furthermore, due to lack of available dataset of Malaysian traffic sign, the evaluation of the system is only done with the dataset from Swedish. Hence, to implement the system within Malaysia or at international level, different dataset should be used for developing the system.

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