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Hybrid of Statistical and Spectral Texture Features for Vehicle Object Classification System

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Abstract

Objectives: To increase the performance of the classifier for the vehicle object among a mixed and highly texture background using hybrid feature extraction method without pre-processing. **Methods/Analysis:** Vehicle Object recognition system performance is based on the hybrid of feature vector extraction method and artificial neural network classifier without pre-processing. Every image is divided into single blocks size with 20x20 each. The feature vector is extracted from each single size block of the picture. Normalization is done for the extracted feature vector of the vehicle object in the image. These feature vectors are given as input to the neural network classifier for classification. The feed forward Back Propagation Neural Network (BPNN) algorithm is used to train and test the input feature vector by using Neural Network Classifier (NNC) for the vehicle classification. **Findings**: The idea of the proposed method is that combining the two different literatures namely statistical and spectral texture features without pre-processing for classification. This method is trained and tested with Illinois at Urbana-Champaign (UIUC) standard databases. UIUC database contains car and non-car images with mixed and highly textured background. The findings indicate that the selected input feature vector improves the classification accuracy rate compared to the previous literature. Also the hybrid features maximize the correct classification and minimize the wrong classification. The improved performance results 90.1% of quantitative evaluation is compared with different literature methods of similar work. **Applications/Improvements:** In different applications, the proposed method plays vital part in surveillance, security for vehicles, monitoring the traffic, etc.

Keywords: Back Propagation Algorithm, Feature Extraction, Hybrid Feature, Neural Network Classifier, Normalization, Statistical Features, Spectral Texture Features, Vehicle Categorization

1. Introduction

Recognition and categorization of vehicle in traffic monitoring system are a necessary component. In the real world, identification and categorizing of the vehicles faces different problems like, highly textured, appearance, viewing conditions, mixed and cluttered background, etc. Most of the object recognition and classification methods are done with pre-processing. The research makes an attempt on a hybrid of statistical and spectral texture features to classify the vehicle object without pre-processing. The vehicle of interest is to identify and classify a car and non-car image. This method improves the classification accuracy compared with various literatures.

The work is based on signal timings to identify and adjust the traffic density[1]. This paper shows the design of an online web based traffic management system that presents the traffic density of heavy and lightweight vehicles[2]. This paper explains the predicting financial time series using a forecasting model[3]. The work is classified the each

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bloggers with different methods with past algorithms which are optimal[4]. The work indicates that despite of the large reduction in the feature vector dimensions the recognition accuracy obtained using SOFM technique is same as that of the recognition accuracy of the conventional methods[5]. This work overcomes the limited normalized values in same as actual range at the same preserving time privacy[6].

2. Statistical Features

Statistical functions[7,8] like mean, median, higher moments and standard deviations are the most commonly used features to characterize data set, which are used as pattern features in many applications. Higher moments can be used to classify the original shape of the distribution function. Depending on the statistical analysis of the vectoring, the six statistical features[7,8] are extracted

$$\text{Mean } \bar{x} \equiv \frac{1}{N}\sum_{i=1}^{N} x_i \quad (1)$$

$$\text{Standard Deviation} = \frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2 \quad (2)$$

$$\text{Smoothness} = 1 - \frac{1}{(1+\text{var})} \quad (3)$$

$$\text{Skewness} = \frac{1}{N}\sum_{i=1}^{N}\left[\frac{x_i - \bar{x}}{\sigma}\right]^3 \quad (4)$$

$$\text{Energy} = \sum_{i}\sum_{j} P_d^2(i,j) \quad (5)$$

$$\text{Entropy} = \sum_{i}^{i}\sum_{j}^{j} P_d(i,j)\log P_d(i,j) \quad (6)$$

For each single block size 20x20 of an image, six statistical feature vector measures of texture are calculated.

3. Spectral Texture Feature

Spectral textures features[9-11] are based on the Fourier spectrum. The directionality of two-Dimensional patterns of periodic images can be described using the Fourier spectrum. The Spectral measure of global texture pattern is easy to differentiate.

Distinguish of continuous and non-continuous texture patterns are done easily in spectral texture. This can also be used for quantifying the continuous patterns. The object of interest being the car image has the periodic pattern whereas the mixed background contains the non-periodic patterns. The distinguishing power of the spectral texture is used for classifying the car from the non-car images.

The spectral feature vectors are stated as polar coordinates. This coordinates produces a function called $S(r, \theta)$. In each direction θ and frequency r is single one dimension function. The static value of θ returns the spectrum activities with origin radial direction whereas, fixed value of r returns the behavior at the origin of a circle center. By integrating these functions (7) and (8), global description is acquired[9-11]

$$S(r) = \sum_{\theta=0}^{\pi} S_\theta(r) \quad (7)$$

$$S(\theta) = \sum_{r=1}^{R_0} S_r(\theta) \quad (8)$$

The result coordinates generate two, one dimension function that establishes spectral-energy description for an entire picture. Each sub-block of an image texture spectral measure is calculated. Depending on the size of the sub-block, feature vector varies. For each block, the number of features is populated in Figure 3.

Totally Ninety spectral feature vectors are obtained from an each single block of an image size of 20x20.

4. Vehicle Classifier using Neural Networks

Feature vector training is done by using feed forward back-propagation algorithm[12,13]. This algorithm learns to categories a vehicle photo as car or non-car image. The feature vectors extracted from the hybrid method is equal to the number of input units that are provided to the neural network classifier. The target output is fixed at 1 (either ON/OFF). The threshold value is fixed as 0.7. Here, if the output is greater than the threshold value or nearer to 1, it represents car image and less than threshold value or nearer to 0 it represents Non-car image. Different choices of hidden units are trained in the ANN classifier.

In NNC, the input unit of the next unit is a hidden unit which has associated weights. The initial value of weights is initialized first. The given input unit is multiplied by the given associated weights. These calculated feature vectors are produce to the next layer before reaching the output unit. The weights of the hidden units will change till the target output is achieved. A particular class of the output will be reflected on the given output unit in equation (9). An architecture[15] of Artificial Neural Network in Figure 1.

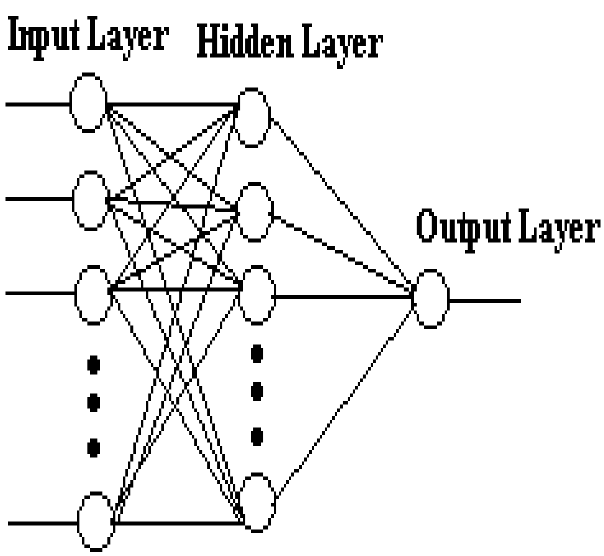

Figure 1. The three layered neural network architecture.

$$O_j^l(k) = f\left(\sum_{m=0}^{Nl-1} w_{jm}^l \, O_m^{l-1} \right) \qquad (9)$$

5. Proposed Work

The proposed method is to combine the two different literatures to increase the performance of the classification accuracy by using a neural network classifier. The idea is to classify side aspects of car objects are mixed with the natural scene and different objects. The work uses UIUC standard car database[15]. Every picture is divided in to single size 20x20 each block with the same size. Hybrid feature extraction is done by using statistical and spectral texture features without pre-processing. The obtained feature vector is given as the input to the neural network classifier. Feed forward Back propagation algorithm is used to train NNC for classification.

Six Statistical feature vectors are obtained from each single size block as stated in the past section using Equation (1) to Equation (6). The statistical feature vectors are evaluated from each squared single block image size 20x20. A total of 60 (6 features x 10 blocks) features are extracted from a single image.

Ninety Spectral texture feature vectors are evaluated from each single squared block image. A total of 900 (90 features x 10 blocks) spectral texture features are extracted using Equation (7) and Equation (8).

Statistical features and Spectral features combined together forms 960 features (60 Statistical features+ 900 Spectral features).

These data are fed to the ZScore normalization using Equation (10) to improve the process performance of the neural network classifier[7,8].

Z = (Vector – Mean (Vector)) / Standard Deviation (Vector) (10)

6. Proposed Methodology/ Framework

The UIUC standard car database[15] is utilized to the experiment. Every image is in equal size of 100x40. Every image is split into to10 sub-blocks with equal size 20x20 each. Hybrid feature extraction is done by using statistical and spectral texture features without pre-processing. Normalization is done for the extracted feature vector of the vehicle object in the image. The feature vectors of each image are given as input to the neural network classifier for classification. To train and test the input feature vector, Back Propagation Neural Network (BPNN) algorithm and Neural Network Classifier are used for vehicle classification. After building the NNC, the similarity measures of the each block of the image are compared for result and analysis. The proposed hybrid (Statistical + Spectral) framework for vehicle classification in Figure 2.

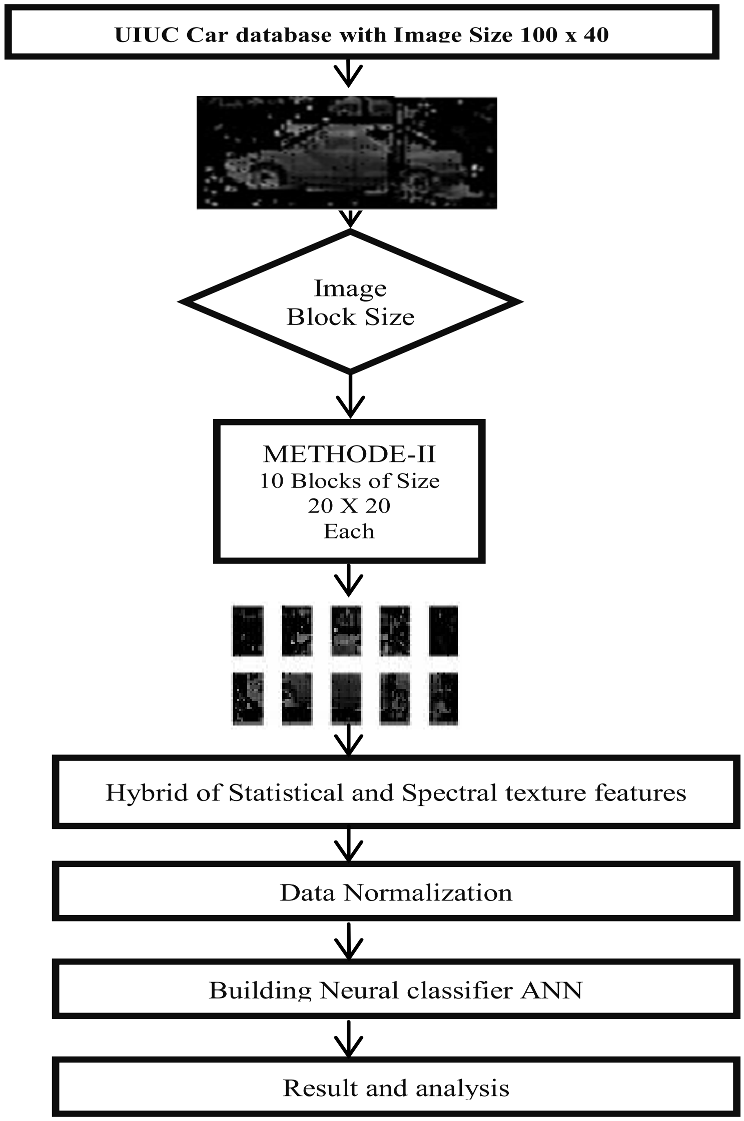

Figure 2. The proposed hybrid (Statistical + Spectral) framework for vehicle classification.

The input unit is based on statistical and spectral features of size 960. Several repeated experiments have been done to achieve the better result. The 960-2-1 is the optimal structure of the ANN classifier. The ANN classifier of Performance graph is shown in Figure 3.

6.1 Discussion

Based on, these four quantities the vehicle classification problem results are categories[7-9]

- True Positive Car Images (TPCI): Categorise a vehicle car into a vehicle car group.
- True Negative Non-car Images (TNNI): Miscategorise a vehicle car into non-vehicle car group.
- False Positive Car Images (FPCI): Categorise a non-vehicle car into non-vehicle car group.
- False Negative Non-car Images (FNNI): Miscategorise a non-vehicle car into a vehicle car group.

The goal of Vehicle classification problem is to maximize the number of correct classification denoted by True Positive Car Image (TPCI) and False Positive Car Image

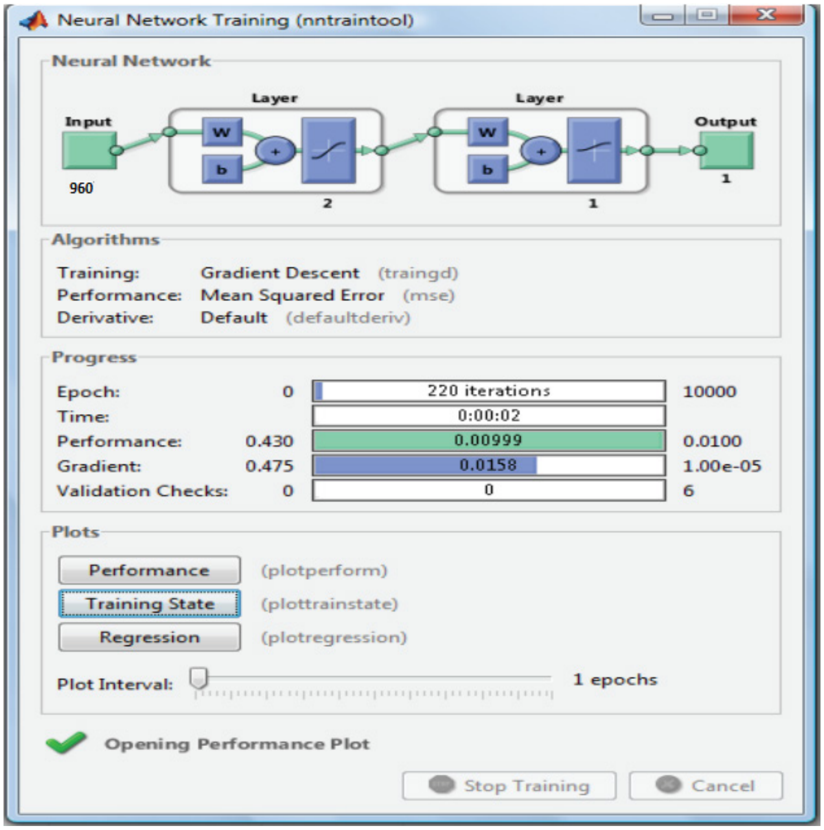

Figure 3. The performance of neural network training for 10 blocks of size 20x20 each.

(FPCI) by where minimizing the wrong classification denoted by True Negative Non-car Image (TNNI) and False Negative Non-car Image (FNNI). The standard formulas are gave in Equation(10) to Equation(13)[7,9,14].

$$TPCI = \frac{Number\ of\ true\ positive\ (TP)}{Total\ no.of\ positive\ in\ data\ set\ (nP)} \quad (10)$$

$$TNNI = \frac{Number\ of\ true\ negative\ (TN)}{Total\ no.of\ negative\ in\ data\ set\ (nN)} \quad (11)$$

$$FPCI = \frac{Number\ of\ false\ positive\ (FP)}{Total\ no.of\ positive\ in\ data\ set\ (nP)} \quad (12)$$

$$FNNI = \frac{Number\ of\ false\ negative\ (FN)}{Total\ no.of\ negative\ in\ data\ set\ (nF)} \quad (13)$$

For the experiment 500 positive car pictures and 500 negative non-car pictures are taken. Based on the feed forward Back Propagation Neural Network (BBNN)[13] algorithm, a threshold parameter is fixed and used for identifying true and false classification. The result is achieved with an active threshold value of 0.7 shown in Table 1.

The proposed method has the maximum overall classification accuracy 90.1% compared to the various literature methods[7,9] in Table 1. The proposed method graph is compared with the various literatures Figure 4. The research work gives a considerable enhancement in classification accuracy performance.

Table 1. Results of experimental methods

Threshold for classification : 0.7	Classifying Positive Images (Car Images)		Classifying Negative Images (Non-Car Images)	
	TPCI	TNNI	FPCI	FNNI
10 Blocks of size 20x20 each	91.1%	8.9%	89.1%	10.9%
	Overall Classification Accuracy (TPCI+FPCI)/2 is 90.1%			

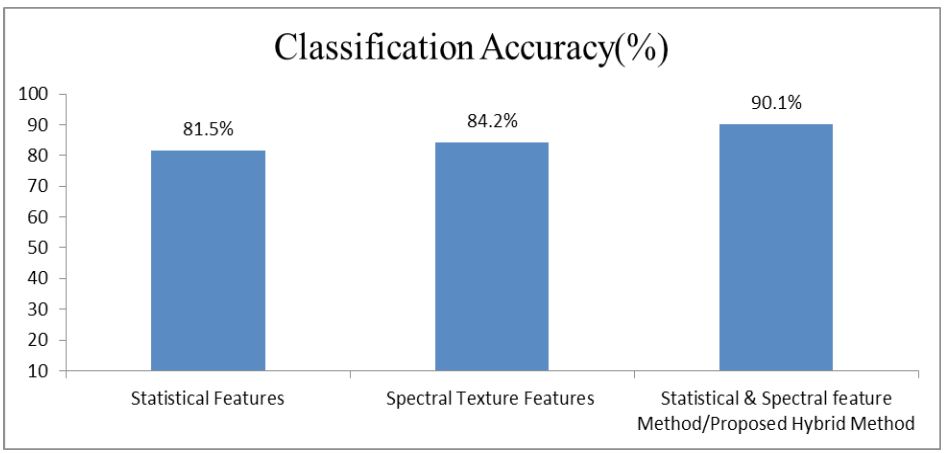

Figure 4. Comparison of proposed work with the literature.

7. Conclusion

An attempt is done to build a better or best neural network classifier for the vehicle classification. The input pictures are mixed with highly textured background for achieving the required result. The novel idea of this research is that the input feature vectors are the hybrid of two different literatures namely statistical features and spectral texture features without pre-processing. The aim is to categories the vehicle car and non-car of real pictures in the world containing side aspects of a mixed and highly textured background. Future work is to improve the performance of the neural network classifier system with various hybrid methods and different classifier algorithm.

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