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Radial Basis Function Neural Network based Outdoor Natural Scene Classification: A Comparative Study with BPNN

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ABSTRACT

Background: In natural or real outdoor image recognition, the problem is that the patterns or objects are likely to appear in a highly irregular pattern, making it very hard to recognize them and within each class all the images are different from one another. The effect of varying background, lighting condition, occlusion etc. has a great impact on the image recognition process involved in Scene classification using Artificial Neural Network based approach. **Objective:** To develop a two phase image recognition technique for the classification of natural or real outdoor images using the Radial Basis Function Neural Network. **The results:** After the successful training and testing of BPNN and RBF Neural Networks for the extracted features from the real outdoor Images, Compared with BPNN network, the proposed RBFNN classification method provides higher classification rate. The proposed technique also provides a minimum misclassification rate compared with the BPNN Network. **Conclusion:** We have proposed a RBFNN based two phase image recognition technique for classifying the forest and street outdoor images. We further compared the performance of the RBFNN with the BPNN for the features obtained from feature extraction phase. The proposed RBFNN based recognition technique provides a better performance and also takes a minimum number of iterations compared to BPNN.

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INTRODUCTION

Classification of images is an active area of research in Computer Vision. The authors Matti Pietikainen, (2004), Laura Walker Renninger (2004) and Matthew Boutell (2005) present promising classification analysis of indoor-outdoor scene and man-made-natural image. The author Ian Stefan Martin (2005) has used robust techniques in his doctoral work, for learning and segmentation in scene understanding. Manuele Bicego *et al*. (2006) have applied unsupervised approach to scene analysis. Bosch (2007) have recognized natural of recognizing natural objects (e.g., sky, trees, grass) in outdoor different conditions by using objects scene description and segmentation. The researchers in Andrew Payne (2005) implemented a new method for classification on the edges of the indoor-outdoor images. Lance M. Kaplan (1999) worked on mosaic images using an extended self-similar model (ESS) and k-means classification algorithm by exploiting the texture features. Arivazhagan *et al.* (2006) transformed the images into Ridgelet and Curvelet domain and worked on classification of mosaic images using statistical features. G. Y. Chen and P. Bhattacharya (2006) have classified the images based on invariant texture features using Ridgelet packets, Fourier transformation and db4 with a nearest neighbor classifier.

The Artificial Neural Networks (ANN) have become popular and useful techniques for different pattern recognition tasks. The papers Guoqiang Peter Zhang (2000) and Egmont-Peterson (2002) present a review paper on the neural network applications. The classification method involves Image Processing (Gonzalez, 2010), Artificial Neural Network (ANN) (Haykin 2010 and Jacek M Zurada 1999), Fuzzy Logic (Zimmerman 1985) etc. A. Wahi *et al*. (2013) used ANN for natural scene classification and have found 88% classification accuracy of BPNN trained on a lesser number of training set in the forest and the street image dataset. The neural networks are found to popular method for recognition as it can handle multi-dimension non-linear data. The research work presented here focuses on performance evaluation of Back Propagation Neural Networks (BPNN) and Radial Basis Function Neural Network (RBFNN) on statistical features from outdoor-based images. The

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networks BPNN and RBFNN are trained more number of forest and street data set to achieve better performance accuracy than A. Wahi *et al*. (2013). The paper is organized as: Section 2 deals with Radial Basis Function Network, Section 3 describes feature extraction method, data preparation in Section 4, in Section 5 Experiments and finally Section 6 concludes with a conclusion.

The RBF Neural Network Model:

Artificial neural networks are biologically inspired networks to perform complex tasks. There are different types of neural network based on supervised and unsupervised learning scheme. The model consists of several layer(s) with large number of neurons. Each neuron has its own activation function to produce output and is connected to previous layer neurons. The current layer neurons connect with previous layer neurons with the connections known as weights. The details about the network architecture, learning methodology and weights updating can be from (Egmont-Peterson, 2002 and R.C. Gonzalez, 2010).

The RBF neural network comes under the special category of multilayer feed-forward networks (Egmont-Peterson, 2002 and R.C. Gonzalez, 2010). The Radial Basis Function Network consists of three layers as the input layer, hidden layer and output layer. Unsupervised learning takes place between the input layer and the hidden layer, while the network follows supervised learning between the hidden layer and the output layer. Gaussian kernel (Radial basis function) is employed as activation function by each node in the hidden layer and weighted sum of hidden nodes serves as output of nodes in the output layer. The output forms the linearity in nature. The input to the network is non-linear data as feature vectors.

The network is used for face and mouth recognition in (Balasubramaninan, 2009), oil spill detection (Topouzelis, 2004), classification of multispectral very high satellite images into 13 classes of various scales (Keramitsoglou, 2007), the OCR system developed for the recognition of basic characters (vowels and consonants) in the printed Kannada text (Sanjeev Kunte, 2007), fabric defect classification (Yu Zhang 2010), object recognition (Saeed Gholami Shahbandi), etc.

Feature Extraction:

This proposed work is aimed with two folded. Firstly, features are extracted from the grayscale images. The colored images fall into two broad categories: images with forest and street. There were total 400 images considered and in each category 200 images. Second, the classifications on extracted features are done by applying Artificial Neural Networks methods. The colored images are converted into grayscale images. The each grayscale image is divided into a large number of non-overlapping blocks of an equal size. The experiments can be done with the block size of [MxM] where M=16 and the features are extracted from commonly used statistical parameters namely mean, standard deviation and variance from above mentioned blocks from grayscale images as mentioned in A. Wahi *et al*. (2013) to obtain N-dimensions data from an image. The features extracted were stored as [1xN] to form feature vector. The process is repeated to all the images and feature vectors are stored in the database.

The normalization method is applied to the data set to obtain normalized feature vectors. The normalized feature vectors are divided into two sets: first is training dataset and the second is testing dataset for neural classifiers. The training data set serves as input to the neural classifiers. The trained network is tested with the test data set and performance is evaluated. The performance evaluation of the neural network is compared based on % classification as parameter. The accuracy can be measured with the help of adjusting the neural weights (Matti Pietikainen 2004). The flowchart diagram of the proposed system has been shown in Figure 1. This efficient image classification method can be implemented in an easiest way by using back-error propagation neural network and radial basis function neural network.

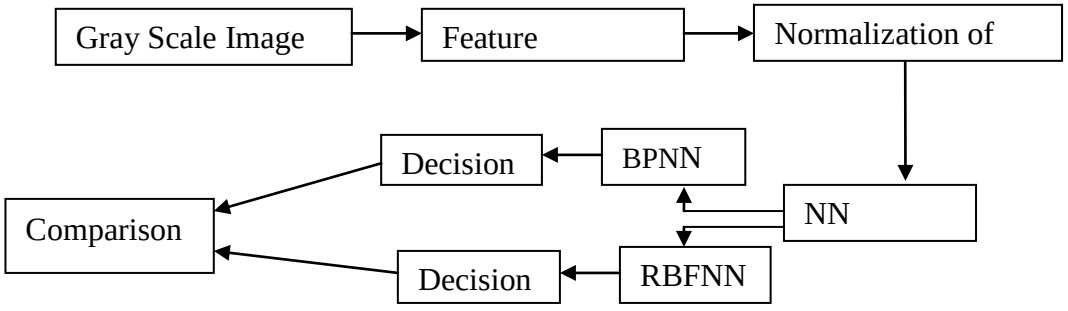

Fig. 1: The flowchart diagram of the system.

Data Preparation:

The colour images of two classes' forest and street were downloaded from mit database. The total number of images was 400 with varying backgrounds and objects. Each image is different from the others in their own class. The forest and street classes constituted 200 images each respective. The images were converted into gray scale from colour images. No preprocessing steps were applied, as images were considered as free from noises. For the purpose, the image was resized to 128x128. Each image was divided into a large number of non-overlapping blocks of size 16x16 and features were calculated for each block as given in A. Wahi *et al*. (2013). Hence a total number of 64 blocks were found from an image. The features were extracted from each block to obtain 192-dimensions data from a single image to form feature vector. The same process was repeated for the rest of the images. The 400 normalized feature vectors were stored in the database. The zero-mean normalization was applied to dataset to obtain normalized feature vectors in the range of [0,1].

The database was divided into two sets: training and testing phases of the neural network. The training data serves as input for neural networks. In the training set 75% randomly, selected feature vectors from the database were selected and the 25 % dataset for testing considered. Hence the total number of 300 feature vectors (150 from each class: forest and street) out of 400 was regarded as training set and rest 100 feature vectors (50 from each class: forest and street) as test data set.

Experimental Results:

The experiments were executed by INTEL XEON E5506 QUAD 2.13GHZ core processor machine with Windows XP and MATLAB 7.0 (Demuth, 2002) as the development tool on the database from (cvcl, 2013). The image database consists of 400 colour images from forests and streets in multi-environment. The sample images are given in the Fig. 1. and Fig. 2. Hence, this constitutes two-class problem for image classification by BPNN and RBFNN. The network was trained with a randomly selected training set. After the successful training of neural networks, the classification performances of the networks were evaluated on 100 test dataset consisting of 50 in each class forest and street respectively. A two hidden layer feed forward network was selected to train with back propagation algorithm using the gradient descent method on the training set. The BPNN classified 88 data correctly and incorrectly 12 data in test phase. In the forest class out of 50 datasets, 40 data were correctly classified and 10 misclassified where as in street class only 2 data out of 50 was misclassified in test phase. Hence, performance of 88% correctly classified result was achieved.

Fig. 2: Sample Images of Forest Class.

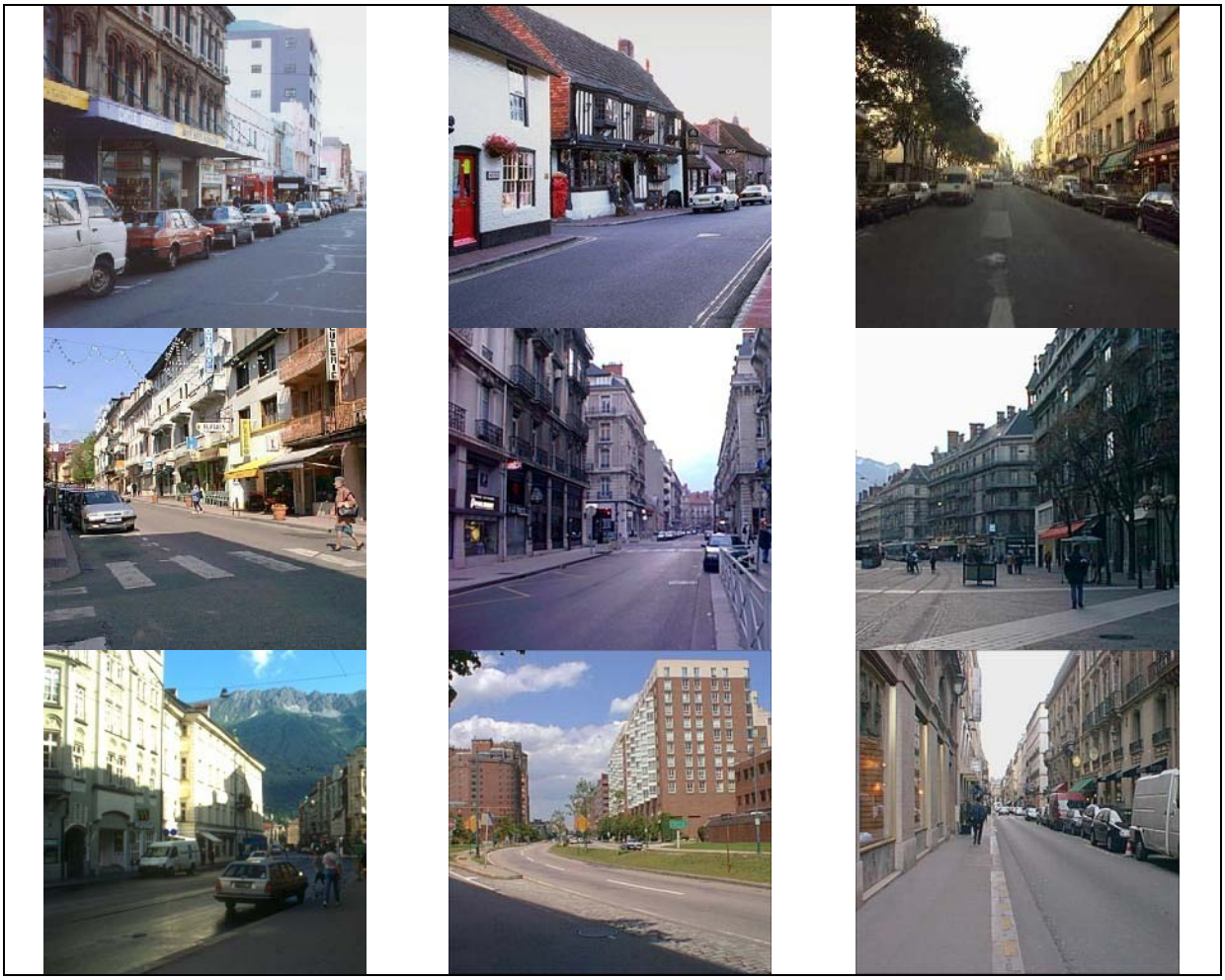

Fig. 3: Sample Images of Street Class.

In the other experiment the RBF neural network with Gaussian spread constant was considered for the purpose. The network was properly trained and tested on above-mentioned datasets. It was found that 91% classification result was obtained in this case. The network misclassified 8 and 1 data from class 1 and 2 categories respectively. By analyzing the results of the above experiments, the RBF neural network performs better compared to BPNN in terms of classification accuracy. The performance results of neural networks were summarized as shown in Table I.

Table I: The Performance of BPNN and RBFNN on 100 Test Data Set for two Class Problem.

Exp. No.	Type of Network	Net Architecture	Classification	Misclassification
1	BPNN	192:50:48:2	88	12
2	RBFNN	192:120:2	91	9

Conclusion:

This paper depicts the simulation results on natural images from MIT database by neural networks. The two- phase image recognition method is presented here. It is considered that the images are free from noise and hence no smoothing and noise removal methods have been performed on the images. In the first phase, a simple and easy feature extraction method from A. Wahi *et al*. (2013) was implemented to have 192-dimensions data. The classifiers BPNN and RBFNN have been considered for training and testing during the second phase of the same data set.

The neural networks were trained with two class problems: Forest and Street images with 300 feature vectors (150 feature vectors from each class) and tested with 100 feature vectors (50 from forest and 50 from the Street) using RBFNN and BPNN. The two-network performance was analyzed based on Classification results. From the classification results, RBFNN is found to be better compared with BPNN in performance. In addition, the result shows that the RBFNN takes a less number of iterations compared to another. A large volume of data number 300 (75% of total) was used to train the classifiers compared to train BPNN with 150 data (37.5% of

total) in A. Wahi *et al*. (2013) had achieved a 88 % classification result. It was found that better performance result was achieved by properly training the classifiers. The RBFNN performs 91% that are better than BPNN as reported in literature A. Wahi *et al*. (2013) as 88%. In future, the features based on PCA or wavelets or Hu moments etc. will be extracted from the data set and different neural networks like probabilistic and SVM neural networks will be considered for performance evaluation. The proposed method may be used in classification systems in the industry.

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