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Artificial Neural Network (ANN) based Object Recognition Using Multiple Feature Sets

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Abstract - In this work, a simplified Artificial Neural Network (ANN) based approach for recognition of various objects is explored using multiple features. The objective is to configure and train an ANN to be capable of recognizing an object using a feature set formed by Principal Component Analysis (PCA), Frequency Domain and Discrete Cosine Transform (DCT) components. The idea is to use these varied components to form a unique hybrid feature set so as to capture relevant details of objects for recognition using a ANN which for the work is a Multi Layer Perceptron (MLP) trained with (error) Back Propagation learning.

I. INTRODUCTION

Object recognition is one of the most fascinating abilities that humans easily possess since childhood. With a simple glance of an object, humans are able to tell its identity or category despite of appearance variation due to change in pose, illumination, texture, deformation, and under occlusion. Furthermore, humans can easily generalize from observing a set of objects to recognizing objects that have never been seen before. Significant efforts have been made to develop representation schemes and algorithms aiming at recognizing generic objects in images taken under different imaging conditions (e.g., viewpoint, illumination, and occlusion). Object recognition has also been studied extensively in psychology, computational neuroscience and cognitive science. [1].

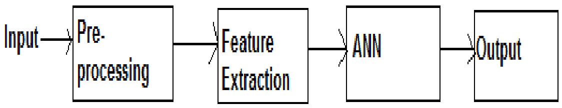
This work is related to the formulation of a simplified ANN based approach for recognition of various objects using multiple features. The work considers the formation and training an ANN for recognizing an object using a feature set formed by Principal Component Analysis (PCA), Frequency Domain and Discrete Cosine Transform (DCT) components. The idea is to use these varied components to form a unique hybrid feature set so as to capture relevant details of objects for recognition using a ANN which for the work is a Multi Layer Perceptron (MLP) trained with (error) Back Propagation learning.

II. SOME OF THE RELEVANT WORKS

Works in the field of object recognition has been continuing over the years and it still is a hot topic of research. Some of the relevant works are as below:

1. Application of ANNs in image recognition and classification of crop and weeds done by C.-C.Yang, S.O.Prasher , J.-A.Landry , H.S. Ramaswamy and A. Ditommaso could distinguish young crop plants from weeds [2].
2. A work done by Markus Weber using Unsupervised Learning of Models for Object Recognition is related to class models from unlabeled and unsegmented cluttered scenes for the purpose of visual object recognition [3].
3. Another work Craig C. Ewert reports the use of a genetic algorithm to control the evolution of ANNs for the purpose of detecting edges in single-line digitized images [4].
4. A work titled ``Moment based Object Recognition using Artificial Neural Network" reported by Saibal Dutta and P.K.Nanda proposed a ANN based scheme for object recognition. The invariance properties of geometric moments as well as lower order moments corresponding to partially occluded objects are used to train a feedforward ANN [5].
5. A work by I.M Qureshi and A Jalil [6], proposed an object recognition procedure using ANN for cases where the images are invariant to rotation, translation and scaling an object. The Sobel operators are used to detect the boundary of an object. The Fourier descriptor classifier is able to classify objects without regard to rotation, translation and scale variation. Fourier descriptor of boundary image generate feature vector by truncation the high frequency components. They have proposed a back propagation neural network to recognize the object based on these feature vectors.

III. SYSTEM MODEL



A. Input and Pre-Processing:

The input block provides the input to the system. The input to the system is a digital image which is processed as per requirement. The input block may be a digital camera or a scanner.

Most pre-processing techniques involve treating the image as a two dimensional signal and applying standard signal-processing techniques to it. Image processing usually refers to certain operations which help in enhancing the appearance of the input and to aid subsequent stages including recognition in this case. Certain image processing operations are geometric transformations such as enlargement, reduction, and rotation, color corrections such as brightness and contrast adjustments, quantization, or conversion to a different color space, digital or optical compositing (combination of two or more images). Here the pre-processing operations carried out include conversion to gray sale, removal of noise and enhancement.

B. Feature Extraction:

Feature extraction is a special form of dimensionality reduction [2]. When the input data is too large to be processed and contains redundant content with little information then the input data should be transformed into a reduced representation set. This if called features (also named features vector) which denote a unique description of the input pattern. Transforming the input data into the set of features is called features extraction. Carefully chosen features shall extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input. Feature extraction involves simplifying the amount of resources required to describe a large set of data accurately.

C. *Artificial Neural Network* (ANN)*:*

An ANN is a mathematical or computational model inspired by biological neural networks. It consists of an interconnected group of artificial neurons and processes information using a connectionist approach to computation. An ANN is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase. In more practical terms ANNs are non-linear statistical data modelling tools. They can be used to model complex relationships between inputs and outputs or to find patterns in data [7].

The ANN in a feed forward form called Multi Layer Perceptron (MLP) is configured to learn applied patterns. The process of learning patterns by an ANN is called training. MLPs are trained using (error) Back Propagation(BP) depending upon which the connecting weights between the layers are updated. This adaptive updating of the MLP is continued till the performance goal is met. Training the MLP is done in two broad passes -one a forward pass and the other a backward calculation with Mean Square Error (MSE) determination and connecting weight updating in between. Batch training method is adopted as it accelerates the speed of training and the rate of convergence of the MSE to the desired value [7]. The steps are as below,

- **Initialization**: Initialize weight matrix *W* with random values between [0,1].
- **Presentation of training samples**: Input i
. The desired
output is

– Compute the values of the hidden nodes as:

(1)

– Calculate the output from the hidden layer as

(2)

Where —

Or ———

depending upon the choice of the activation function.

– Calculate the values of the output node as:

(3)

- **Forward Computation**: Compute the errors:

(4)

Calculate the mean square error (MSE) as:

————— (5)

Error terms for the output layer is:

(6)

Error terms for the hidden layer:

(7)

- **Weight Update:**

– Between the output and hidden layers

(8)

where ´ is the learning rate (0 <   < 1).

– Between the hidden layer and input layer:

(10)

One cycle through the complete training set forms one epoch. Repeat the above till MSE meets the performance criteria and keep count of the epoch elapsed [7]. The MLP considered here has two hidden layers each of one and half times in length to the input vector. The input and output layers use log-signmoid activation while the hidden layers use tan-sigmoid activation functions.

IV. EXPERIENTIAL RESULTS AND DISCUSSION

Some of the samples collected for the work as input objects are shown in Figure 2. Pre-processing operations are carried out which provide outputs as shown in Figure. 3. Some amount of resizing is carried out for size normalization. The samples after resizing appear as depicted in Figure 4.

Multiple feature sets are used for constituting the feature extraction process. The features considered include Fast Fourier Transformation (FFT), Discrete Cosine Transformation (DCT), and Principal Component Analysis (PCA). Fig (5) shows the images for the corresponding inputs after using FFT.

The FFT features provide a spectral domain representation of the objects. These capture all relevant details that show dependence on frequency and inversely on time. The Principal Component Analysis (PCA) involves a mathematical procedure that transforms a number of correlated variables into a (smaller) number of uncorrelated variables called principal components. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible [7]. PCA of an input therefore represents an important description of a pattern and can be used as a feature set. PCA also contributes towards generating an optimized set of samples capturing relevant information of an input.

The Discrete Cosine Transform (DCT) has excellent energy compaction characteristics with correlated data [8]. DCT also represent a compromise between information packing ability and computational complexity. A few coefficients can be only retained to concentrate most of the relevant information. The training time results derived as shown in Tables I to III for FFT, PCA and DCT features generate a success rate of around 93.5%. Hence, a hybrid set is formed using these three features. A block diagram of the process is shown as in Figure 5.

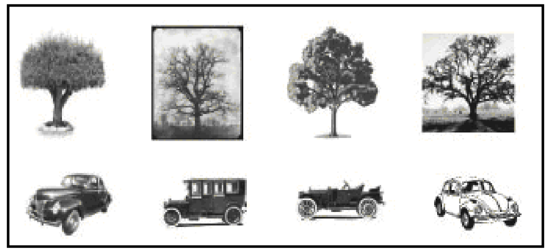


Figure 3: Pre-processed samples

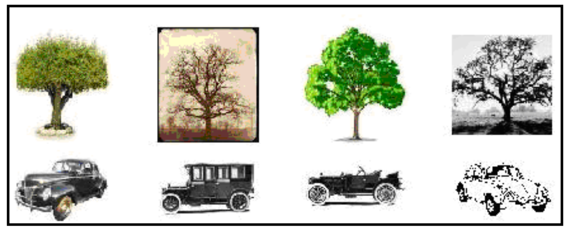


Figure 2: Samples used for the work

Figure 4: Pre-processed and resized samples.

TABLE –I: Training conditions of ANN using FFT

Object	Epochs	Time (sec) for training	Success rate in %
1	202	4.15	91.2
2	202	4.15	91.3
3	202	4.11	91.4
4	201	4.16	91.4
5	201	4.16	91.3
6	201	4.23	91.2
7	202	4.16	91.5
8	201	4.72	91.5

The contribution of each of the feature sets to the formation of the hybrid feature sets is as follows: 30% from FFT, 40% from PCA and 30% from DFT. This break-up considered is due to the results derived from the three feature sets taken independently the results of which are shown in Tables I to III. The results derived using the hybrid feature set is as in Table IV. The results derived using the hybrid features show that the success rates have improved upto 95.5% and the computational times during training have reduced to 2.55 sec.s. Also the number od epochs required to reach the desired MSE level is between 155 and 164 epochs which also show improvement.

TABLE –II: Training conditions of ANN using PCA

Object	Epochs	Time (sec) for training	Success rate in %
1	192	3.60	93.1
2	200	3.53	93.4
3	199	3.50	93.3
4	198	3.51	93.3
5	200	3.48	93.4
6	198	4.23	93.4
7	183	4.16	93.4
8	189	4.72	93.4

TABLE –III: Training conditions of ANN using DCT

Object	Epochs	Time (sec) for training	Success rate in %
1	205	4.55	92.1
2	208	4.50	92.3
3	210	4.45	92.3
4	212	4.46	92.4
5	214	4.47	92.2
6	212	3.50	92.3
7	209	3.52	92.4
8	205	3.49	92.3

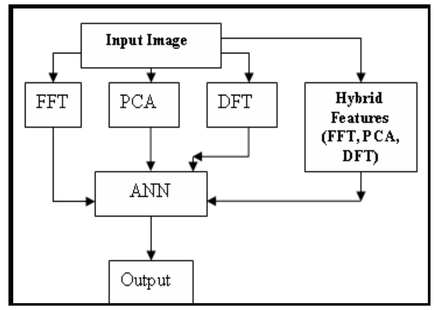


Figure 4: Formation of hybrid features for object recognition.

The results are derived using a eight different objects taken under ten different noise mixed conditions. Also three different illumination variations are considered. The application of hybrid features provides greater success rates at lower computational complexity. Thus the use of the hybrid features for the ANN based application is justified.

V. CONCLUSION

The work shows the application of a hybrid feature set for object recognition using ANN. The hybrid feature formed by FFT, PCA and DFT feature segments captures relevant details of applied objects which can be

TABLE –IV: Training conditions of ANN using hybrid features

Object	**Epochs**	**Time (sec) for training**	**Success rate in %**
1	155	2.55	95.1
2	158	2.61	95.2
3	160	2.62	95.4
4	162	2.64	95.3
5	164	2.67	95.4
6	162	2.68	95.2
7	159	2.56	95.5
8	161	2.61	95.4

recognized with success rates of around 95% despite noise and illumination variations. Further work can include a work which can correctly recognize objects despite the input samples suffering tilt and rotation.

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