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CBIR System Using Scaled Conjugate Gradient Feed-Forward Neural Network

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ABSTRACT

Images produced by copious of application has now become the centre of attraction for researchers. The task of retrieval of desired image from the ocean of images is quite tedious task. The paper focuses on mining of database from the picture descriptions that are recovered from the same picture known as Content Based Image Retrieval (CBIR). In this paper, we have used colour, texture and shape picture description and Scaled Conjugate Gradient feed-forward neural network (SCG-FFNN). Initially we have prepared the model using colour histogram for colour feature, wavelet moments for texture feature and edge-histogram and edge-direction for shape features; then trains the dataset using FFNN. The trained database is tested with a picture, and generates the like pictures from it. The execution of the system is calculated with the help of precision and recall parameter and the outcomes are found to be high as compare to other research effort. The practical work has been conducted with Corel and Caltech dataset.

Key words: CBIR, Corel, texture, shape, neural network, feed-forward.

1. INTRODUCTION

The area of digital imaging is a rapidly emerging field. With the outburst of the Internet and also the large-scale development of digital photographic instruments and gadgets, it is not rare to have digital image bases containing more than millions of images. To effectively manage and use these image databases, a system indexing and image search is required [1]. That's why development of suitable system for the recovery of pictures from big collections is a very challenging work.
The first prototype of system was developed in 1970 and this system brings the interest of many researchers. Few of them are QBIC, CIRES, Indexing systems and picture search by content. Pictures are searched from the database according to their visual description or any other descriptions that can be imagined. CBIR systems uses descriptions like colour, brightness, textures and spatial distribution (describing image content) to recognize similar patterns in different images [2].

For the improvement in the retrieval of like pictures from different classes, various algorithms have been perfectly presented. In this article, we have suggested a combination of low-level descriptions and deep learning impression of SCG-FFNN for recovery of the images. The experiment is carried out in two stages: 1) Taking out low-level picture properties– colour histogram for colour, wavelet moments for texture and edge-histogram and edge-direction for shape features. 2) Training and Testing in dataset –Training is for learning SCG FFNN over the properties of pictures in the dataset and applying obtained facts in the recovery of images. And in testing phase previously trained neural network is used in the recovery of the significant images.

Total 500 pictures are taken as samples from Corel dataset for conducting experiments. These samples are equally distributed in five categories that are shown below in the Figure 1.

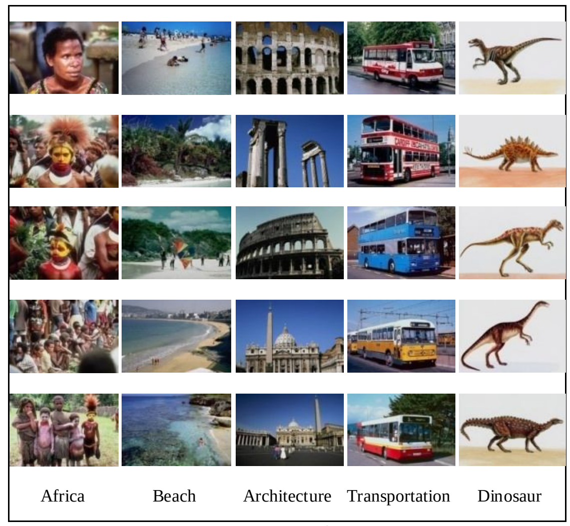

Figure 1: Sample images from Corel dataset

To further check the accuracy of the system, another freely available dataset Caltech is used. This dataset also have the 500 pictures.

2. RELATED WORK

With the growing use of images by the common users, conventional picture retrieval methods become obsolete. New methods used low-level features also called descriptors, of the pictures for indexing and searching like images. Some researchers use colour descriptor to enhance the performance of CBIR system [2,3,6]. The texture property extraction Gabor filters method is used [4,6]. Some The images evaluation is done using likeness calculation among features [4,21]. Some researcher built clusters of similar data by calculating the adjoining neighbours [17]. Jain et al. [7] worked with texture and colour for their research.

Montazer et al. [13] they use SIFT for pictures properties, and then apply k-means clustering. They use dimension reductions to make properties extra effective. They perform experiment on Caltech 101 and Li database. Karakasis et al. [15] presents a framework with image moment invariants as descriptors while Guo et al. [16] proposed EDBTC to extract features. They introduced two features CHF and BHF to compute the distance. Xiang-Yang Wang et al. [24] propose a novel procedure with colour and texture. They transform the RGB to other colour space and then extract the feature. The texture features are taken by rotation and scale invariant descriptor.

Arvind Nagathan and I. Manimozhi [34] proposed a system where they use low-level image features and then apply a feed-forward back-propagation neural network. Hanen et al. [35] incorporate concept of neural network with vector representation of images. They transformed every low level question into a score vector. They showed the results of their work with Corel and Caltech-UCSD.

R Rajkumar and M V Sudhamani [36] combine colour and shape for pictures. The obtained results are used as input in the Siamese neural network. They use one-shot learning method for analysing their work.

3. IMAGE DESCRIPTOR, DISTANCE CALCULATION AND NEURAL NETWORK

The extraction of low-level visual characteristics is the basis of CBIR. The main visual characteristics that can be extracted from a certain picture are described below [4-9].

3.1 Colour

It is a relatively substantial visual description, with free-of-size, resolution of the image, or its orientation (angle of view).

3.2 Texture

It is a measure of the repetitive elements in the image. It characterizes the patterns that are repeated on the intensity of the image that are too fine to be differentiated as independent objects.

3.3 Shape

Shape also called edge is another significant characteristic of the picture. Human visions are very receptive to these characteristic. An edge histogram is used for depicting the frequency and the changes in brightness of the picture.

3.4 Similarity Measures

To compute the likeness between pictures based on the low level characteristics, the most method uses a measure of distance between the images [17]. The zero value implies the two are equivalent; it means they are the same. The distance value obtained by this measure from the set of images, will allow ordering the images recovered by a CBIR system.

Several measures or techniques commonly used to compute the likeness of pictures are shown below [18] using an algorithm based on content or visual characteristics:

Euclidean Distance: In this case, the distance between the vectors that describe two pictures is evaluated. When high values are obtained according to the evaluation, it is indicated that the distance between the characterizations of the images is high and, therefore, that the similarity between them is low. The formula for calculating the Euclidean distance in an n-dimensional space would be [19]:

$$d_E(X,Y) = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2} \qquad (1)$$

Mean Square Error (MSE): It is another technique used to measure distances. Low MSE values will indicate similarity between images. The MSE in statistics is a way to quantify the difference between the implicit value of an estimator and its true value. If this definition is taken to the field of application of image recognition, the estimators would be the images of the collection and the value to be estimated would be the example image of the query with which it is being compared. If X is taken as the parameter of the estimator with respect to X as the estimated value, the mean square error will be that given by the following equation, which calculates the hope (E) of the square of the difference between the estimator and the estimated value (the square is used to take into account errors in both directions in the same way) [20]:

$$MSE(X') = E(X' - X)^2 \qquad (2)$$

Sum of Absolute Differences (SAD): It is an algorithm to find the correlation between two images. Take the absolute differences between every pixel of the first picture with respect to the corresponding pixel of the second picture used for the comparison. Like the Euclidean distance and the MSE, low values of this sum of absolute differences will mean similarity between the compared images. The accuracy of this method can be affected by factors such as lighting, shape or size.

Mahalanobis: It was introduced to find out the likeness between two multi-dimensional arbitrary variables keeping the individual distance between the corresponding variables (as opposed to the Euclidean distance) [21].

Formally, this distance between two random variables (x, y) with the same probability distribution and with covariance matrix Σ, is defined as [21]:

$$d_M(x,y) = \sqrt{(x-y)^T\Sigma^{-1}(x-y)} \qquad (3)$$

3.5 Neural Networks

Neural network popularly called NN is a network of small elements i.e. neuron. The technique is used for problems related to clustering, classification, optimization, etc. NN are exceptionally viable if there should arise an occurrence of order issues where identification and acknowledgment of target is required. Due to its dynamic character, NN is most favoured technique. In this approach the weights regulated as per input and output values. In the learning stage of NN, the change in weights continues until the needed output is reached.

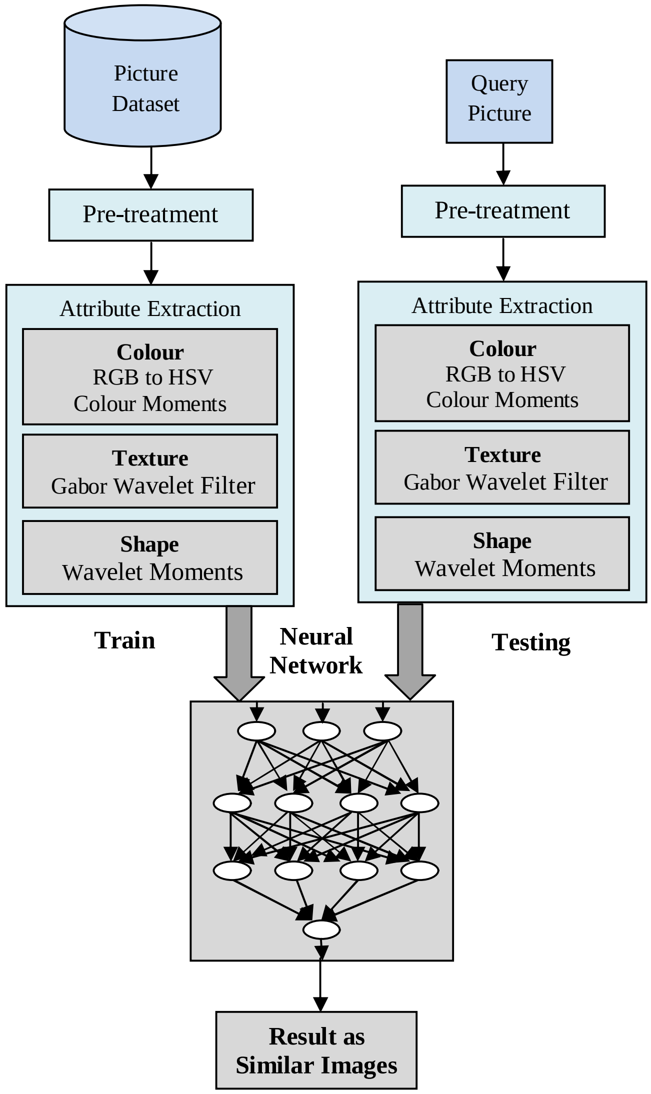

Figure 2: Flow Chart of the projected system

4. PROPOSED SYSTEM ARCHITECTURE

The flow chart of the anticipated procedure is depicted in the above figure no. 2. We proposed the methods of extracting basic characteristics of the picture, which is important to the CBIR framework:

4.1 Colour

The likeness between two given pictures will be computed by comparing the colour histograms of the pictures from the picture collection and that of the query picture. A colour histogram for an image (I) is identified by the probability (P) that the pixel p arbitrary chosen from the image has the colour c_i [24]:

$$h_I(c_i) = P(color\ (p) = c_i | p \in I) \quad (4)$$

In our system, the following steps are involved:

1. *Histogram Creation*
2. *Quantise pixel equally*
3. *Normalize the work done in step (1).*
4. *Switch RGB →HSV*

Image quantised by Matlab function and by proposed system is shown in figure 3.

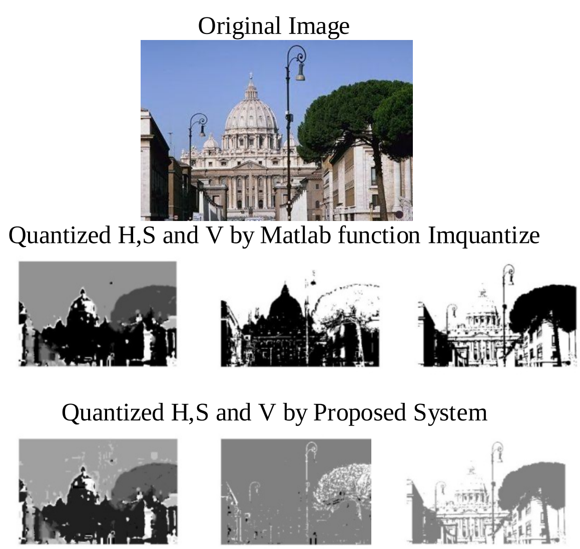

Figure 3: HSV converted Image

4.2 Texture

The texture of a picture is a perceptual property that is easily identified by human, while recovering it by calculation is a very difficult task. Flower and leaf may have different pattern but with same softness or vice-versa. Texture property can be defined as change in intensity of the pixels with the usual intermission [25].

Characteristics of Image: To describe any picture there are six properties are presented. We have identified three of them viz. coarseness, contrast and directionality. These properties are very close to people perception. In the research work [26], they explained the method of computation and obtained the numerical value of the pictures.

1. Image Coarseness
2. Contrast of image.
3. Directionality of image

After obtaining the numerical values for the above three properties for a picture, vector representation which contains the texture description, a database can be made.

4.3 Shape

It is a crucial descriptor of a picture and it helps in identifying the picture. The shape of any picture can be made up of two parts. One is the boundary and other is region. The former tells the perimeter of it; while later describe its region. These two are described by the Fourier descriptor and the invariant moments [27,28].

For computation Geometric and Central Moments are implemented. Shape of any picture is derived by its area and centroid. Also axial revolution, relocation and scaling invariants are used in the calculation.

4.4. Fusion of Colour, Texture and Shape

The outcome of the technique that uses more than one characteristic is significantly better. So this paper utilizes the fusion of three shading, surface and shape attributes.

The weighted sum method is widely used among the scientific community. Taking an appropriate weight, the better of each one will be collected from primitive.

Given N comparison primitives for images $P_1, P_2, \dots\dots, P_N$ and the query image Q, for any T-image of the dataset, the difference between both according to the primitive P_K is denoted as $D_k(Q,T) \in [0,1]$. The combined distance D^c is defined as:

$$D^c(Q,T) = \sum_{i=1}^{N} w_i D_i(Q,T) \quad (5)$$

Where each primitive P_i is assigned a weight w_k such that $0 < w_k \le 1$ and $\sum_{i=1}^{N} w_i = 1$.

4.5 Feed-forward Neural Networks

The architecture of NN consists of so many interconnected neurons [37]. It has three kinds of levels input, hidden and output. There is one input and output level, while hidden level may be more than one. We have used 20 hidden levels in the proposed system.

In figure 4, i_1, i_2,i_3,...i_n are the input neuron and W_1,W_2,W_3,...W_n are the adjusted applied weights. And bias ‘b’ is a constant added to the system to produce the best output result. The y of this system can be represented by:

$$y = f(i) = i_1W_1 + W_2i_2 + i_3W_3 + \dots i_nW_n + b \quad (6)$$

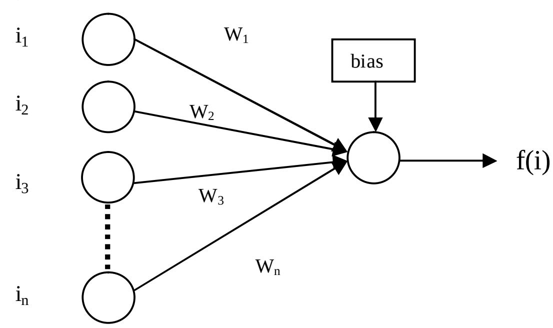

Figure 4: Basic diagram of Neural Network

Figure 5 shows diagram of FFNN, where information flows from input level to output level via hidden levels. If any errors is found then it is back-propagated to adjust weights and the bias value [38].

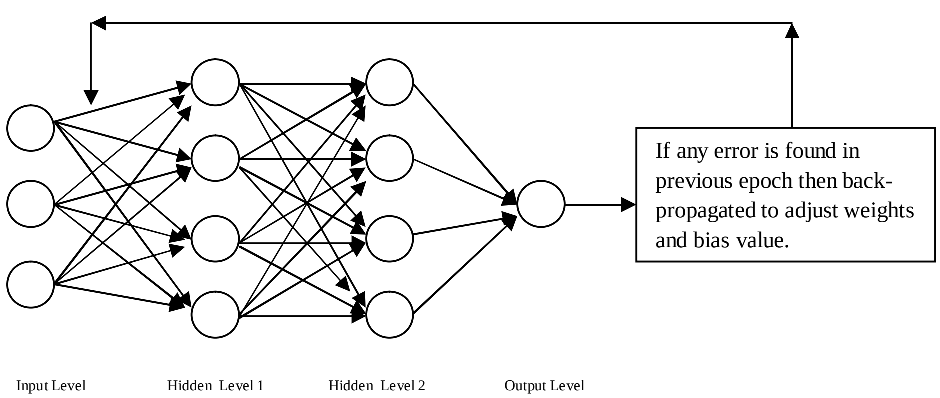

Figure 5: Block diagram of FFNN

5. SIMULATION AND RESULTS

Total 1000 pictures are taken as samples from Corel and Caltech dataset for conducting experiments. In Corel samples are equally distributed in five categories hundred pictures each. The size of picture is either 384×256 or 256×384. The 5 image categories available are: (1) Africa, (2) Beach, (3) Transportation, (4) Architecture and (5) Dinosaur. The file names of pictures are numbers in ascending order from 1 to 500. This image database is known as Corel database in the literature and has been used for experimentation in the *SIMPLIcity* system proposed by Wang et al., 2001 [31].This database is publicly available for experimentation [32, 33].

In training phase, we have used 20 levels FFNN for classification. This FFNN is trained on the attributes recovered from the dataset. After training, the performance can be observed by the performance graph. This performance graph with Corel-Dataset is shown in Fig.7.

Performance graph figure 6 and 8 shows the relationship between MSE and Epochs. The Regression graph with Corel-Dataset is shown in Figure 7.

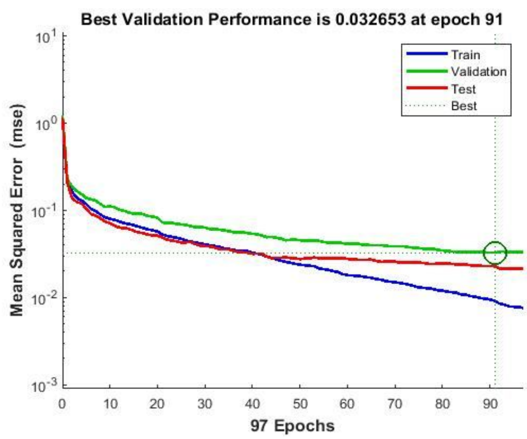

Figure 6: Performance graph – Training Phase

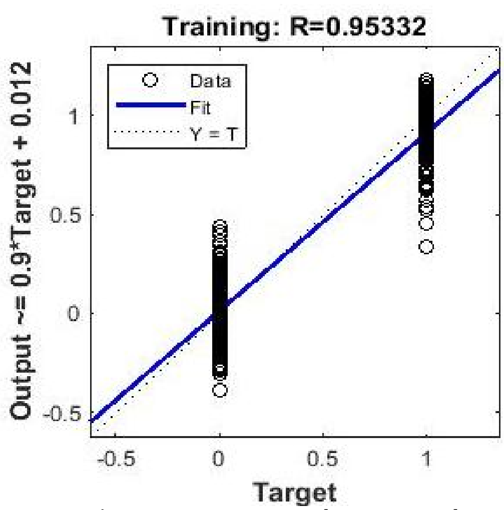

Figure 7: Regression graph – Training Phase

The series of vertical circles at ‘0’ in Target shows input variables while series of vertical circles at ‘1’ shows output variables. Input variables are colour moments, Gabor Wavelet Filter and Wavelet Moments while output variable is Image Categories. This graph indicates that about 95% of regression is achieved.

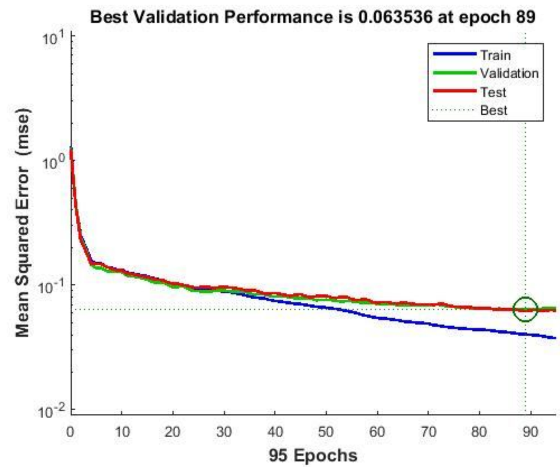

Figure 8: Performance graph – Training Phase

Figure 8 and 9 show the graph for Caltech dataset. This indicates that about 84% of regression is achieved.

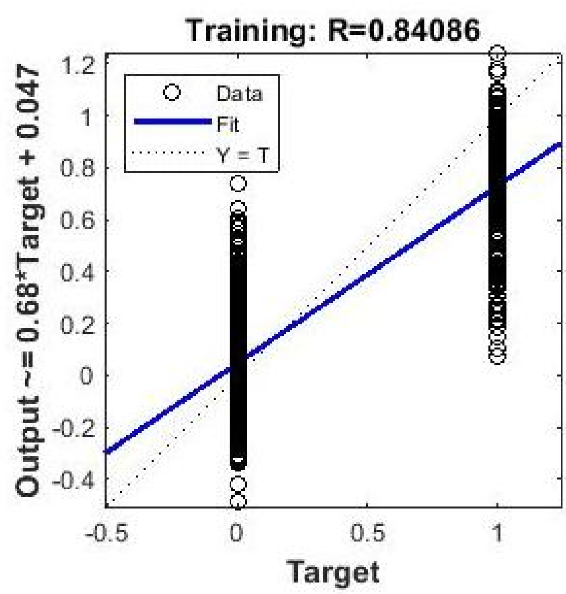

Figure 9: Regression graph – Training Phase

In the testing phase, a picture is input to the method. The like pictures are indexed by the system as shown in the Figure 10.

Figure 10: Retrieved image from Corel dataset

Table 1: Performance Assessment with Corel-Dataset

Class	Category	FNR	FPR	TPR	TNR
1	Africa	0.025	0.160	0.840	0.975
2	Beach	0.060	0.160	0.840	0.940
3	Transportation	0.085	0.220	0.780	0.915
4	Architecture	0.000	0.140	0.860	1.000
5	Dinosaur	0.025	0.020	0.980	0.975

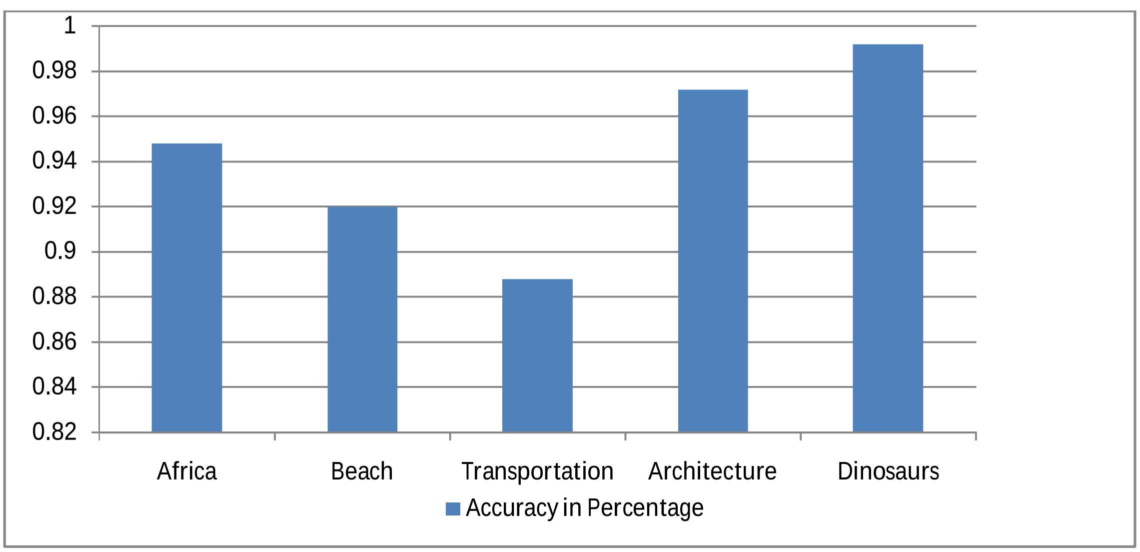

Figure 11: Accuracy in percentage with Corel-Dataset

In the testing phase, a picture is input to the method. The like pictures are indexed by the system as shown in the Figure 12.

Figure 12: Retrieved image from Caltech-Dataset

Table 2: Performance Assessment with Caltech-Dataset

Class	Category	FNR	FPR	TPR	TNR
1	Airplane	0.050	0.005	0.950	0.995
2	Ship	0.200	0.008	0.800	0.992
3	Chandelier	0.150	0.017	0.850	0.9827
4	Watch	0.300	0.008	0.700	0.992
5	Bonsai	0.150	0.005	0.850	0.995

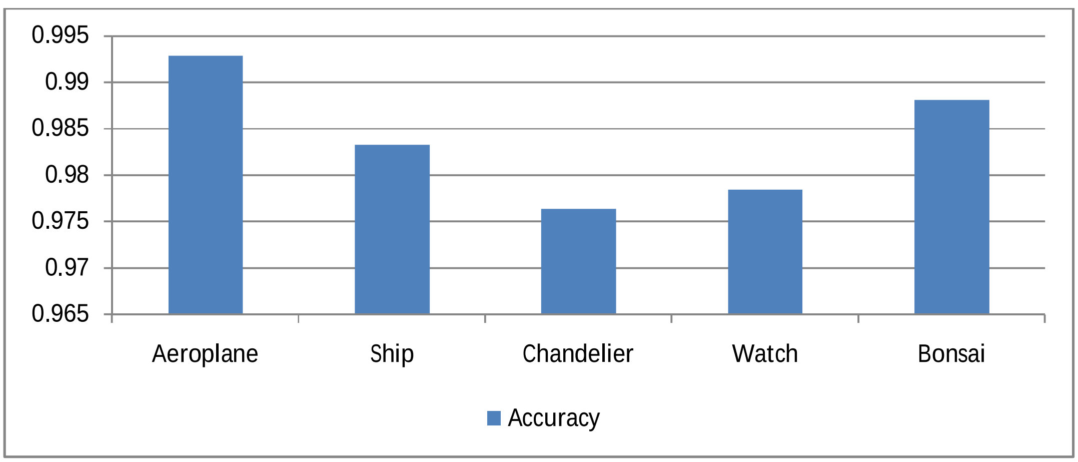

Figure 13: Accuracy in percentage with Caltech-Dataset

Table 3: Proposed Method Verses Individual Methods (By Using Corel-Database)

Categories	M-[29]		M-[30]		M-[32]		M-[33]		M-[34]		Proposed (FFNN)	
	P	R	P	R	P	R	P	R	P	R	P	R
Africa	0.50	0.745	0.52	0.760	0.760	0.431	0.745	0.82	0.87	0.70	0.913	0.840
Beach	0.55	0.693	0.48	0.587	0.587	0.328	0.693	0.68	0.87	0.86	0.778	0.840
Transportation	0.65	0.954	0.33	0.963	0.963	0.693	0.954	0.84	0.89	0.77	0.696	0.780
Architecture	0.50	1.00	0.60	1.00	1.00	0.996	1.00	1.00	0.85	0.82	1.000	0.860
Dinosaurs	0.40	0.833	0.58	0.741	0.741	0.355	0.833	0.80	0.92	0.80	0.980	0.980

In the table 3, it can be noticed that this proposed technique (FFNN) offers improved outcomes (P-Precision and R-Recall) over other existing retrieval methods, shown in first five columns.

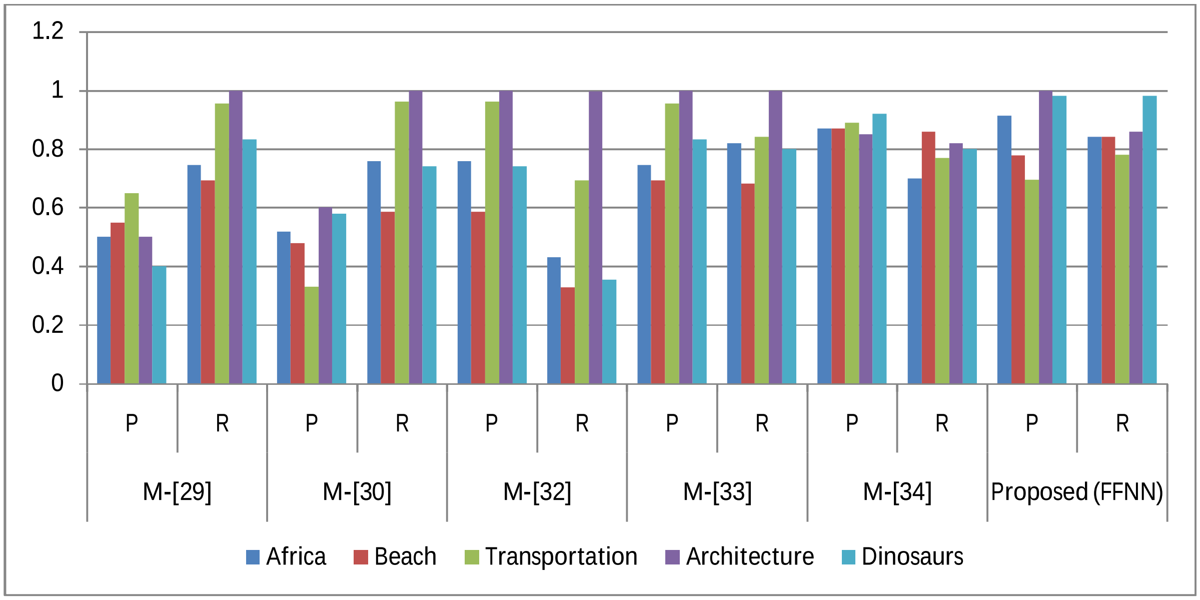

Figure 14: Comparison graph among methods [29, 30, 32, 33, 34] and proposed method.

Figure 14, shows the comparison graph among proposed method and the other methods for their precision and recall performance.

6. CONCLUSION

It is concluded that the final result of this work ends with an efficient CBIR system that accomplish higher exactness. In this system as compared to the earlier methods feed-forward neural network is used along with the image features. Ultimately all techniques in comparison claimed according to its performance evaluation parameters. Our method outperformed the pre-existing techniques.

Future scope in our work will be testing model with a large picture gallery. Also we will implement the system with efficient neural network that might take less time to recover the pictures.

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