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Exploration of various Feature Extraction Techniques using ORL Database

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Abstract:
A digital image is a two-dimensional bitmapped or raster image that has been quantified. Photographs, documents, and other types of digital images can be used in various activities. The ability to change, distort, and sometimes harm digital photos is more and more common as technology advances. Many graphics manipulating softwares such as GIMP and Photoshop are being utilized for making drastic alterations that are difficult to spot.Feature extraction is conducted to the relevant items in order to determine the image's originality, and classifiers are used to categorize them into specified classes using the current approaches. In order to recognize facial photos, the effectiveness of feature extraction techniques is essential. This paper describes how to get the best feature extraction and how it works with the best classifiers.
***Keywords* -** Feature Extraction, Principal Component Analysis,DiscreteWavelet Transform,Histogram of Oriented Gradients, Local Binary Pattern.

1. INTRODUCTION

Digital images are extremely important in everyday life since they are used in so many different areas. However, modern image processing tools can make falsified images appear to be better than the originals. Digital photographs are captured by digital cameras, giving us the ability to do forgeries using advanced software available on the market. It is difficult to determine whether or not the image data is forged.The photographs are sometimes used as evidence in criminal trials. In these cases, the proportion of forgery must be evaluated to ensure the image's authenticity [1].Image reproductivity can happen very quickly due to security difficulties in digital transmission. That is why it is impossible to guarantee digital content [2]. This primarily assists students in falsifying their image credentials for malicious purposes or to their advantage.The major contribution of this work is summarized as follows:

- Existing Feature extraction Algorithms such as PCA, DWT, HOG AND LBP is applied to the test images to extract the required features.

- Enhanced Algorithm ELBP is applied to the same images to extort the significant features.
- The performances of these algorithms are evaluated by applying three different classifiers namely SVM, kNN and MBPNN.

2. BACKGROUND STUDY

A digital picture is a quantitative representation of an input image that a computer can store and manipulate. The values of the images are placed in an array that matches the array's placements. The most important feature of digital photographs is that they automatically recognize the item. Depending on the lighting, rotation angle, and other factors, that particular object appears differently. All relevant sources of tampering evidence are used by forensic examiners.Tampering refers to the alteration of products in such a way that they become destructive to the customer. Feature Extraction is much more useful for determining the proportion of tampering or retaining the original image. Feature Extraction is a technique that allows us to deliver more valuable, redundant data while also reducing the image's dimensionality [3]. It identifies the initial features in order for the selected features to contain the information required to finish the task. After that, various features were extracted using Feature Extraction algorithms applied to the input data.

Following that, classifiers are used to extract only relevant data from the input photos. In order to get the necessary information, the classifiers categorize the image in a specific framework. The existing classifiers are compared to the parameters, and the results are summarized for performance evaluation.

3. PROPOSED METHODOLOGY

1. Feature Extraction: This is the first step where the significant features of the test images are extracted using the proposed algorithms like PCA, DWT, HOG and LBP and the facial image is identified.

2.Proposed System: Finding the best existing algorithm such as LBP and the flaws in that are rectified in the Enhanced Local Binary Pattern.

3.Classification: The classifiers like kNN, SVM and MBPNN are used to classify and evaluate the performance of the feature extraction techniques.

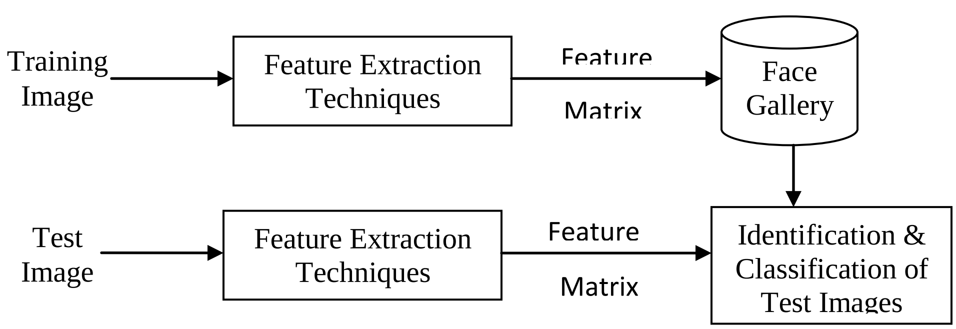

Fig.1 Proposed Methodology

3.1 FEATURE EXTRACTION

The input images are obtained from the different databases through the extraction process, and the relevant images are filtered to improve their presentation or display. The feature extraction procedure extracts the expected features from the photos in question. [4]. When the data for preprocessing is enormous, it is limited in dimension and just a few features are clearly indicated. To limit the growth in dimensionality, it is necessary to reduce the number of features taken into account. [5]. Feature subset selection and feature extraction are two procedures that are frequently employed. The content can be assessed after the related features have been extracted. The extracted knowledge is now easier to comprehend. These techniques are used to extract color, texture, and shape features. A feature database is used to store the extracted features. [6]. The feature extraction techniques are addressed to increase the accuracy of classification and algorithmic complexity, and the final selection is based on prior knowledge combined with a feature extraction technique. The photos are loaded into MATLAB, and the extraction of feature points for each technique is calculated and tabulated.Table.1 shows the number of feature points extracted using the various algorithms.

S.NO	Algorithms	Feature Extraction point
1	PCA	12
2	DWT	90
3	HOG	81
4	LBP	59
5	ELBP	36

TABLE.1 FEATURE EXTRACTION FOR ORL IMAGES

3.1.1 Principal Component Analysis (PCA)

One of the most well-known dimensionality reduction algorithms is this one. Using the correlation matrix and its eigenvalues and eigenvectors, it locates the major components in the data, which are uncorrelated eigenvectors that each represents a fraction of variance. The supervised version of the PCA outperforms the unsupervised variant. [7]. One of PCA's major drawbacks is that it could not identify non-linear correlations that are common in data. It's an unsupervised method for extracting statistical features [8]. It finds the co-variance matrix of the input image by decomposing the eigenvalues. When we receive a larger eigenvalues, the information is naturally stronger. As a result, the larger eigenvalues are considered [9]. In PCA, local information is used in additional to the training examples to extract the features [10].

Procedure:Principal Component Analysis (PCA)
Input : Pre-processed image (X_i) Output : Set of features (F_s)
Step 1 : Input the pre-processed image (X_i) Step 2 : Change the image into matrix i x j Step 3 : Calculate the mean value $M = \frac{1}{N}\sum_{i=1}^{N} X_i$ Step 4 : Derive Deviation from Mean Step 5 : Compute Covariance matrix $M = \frac{1}{N}\sum_{i=1}^{N}(X_i - M)\ (X_i - M^T)$ Step 6 : Calculate the Eigen vectors and order them by their Eigen values. Step 7 : Form the Feature vector.

3.1.2 Discrete Wavelet Transform (DWT)

It is widely regarded as the most effective solution for image recognition [11]. Wavelets are represented by a series of high pass and low pass filters. Wavelets are used to gain information about time and frequency. The levels for disintegration are chosen based on the image [12]. Wavelet detail and approximation are taken into account depending on the requirements [13]. With the use of wavelets, the input signal is segmented into separate sections. DWT [14] provides multi-resolution capability and improved energy compaction. It filters and recursively decomposes at each level, and the approximation coefficients are obtained and applied to the classifiers [15]. It aids time-frequency localization by examining the input images [16].

Procedure:Discrete Wavelet Transform (DWT)
Input : Pre-processed image (X_i) Output : Set of features (F_s)
Step 1 : Load the pre-processed image (X_i) Step 2 : Image normalization (X_n) Step 3 : The normalized image (X_n) should be decomposed. Step 4 :Low frequency co-efficients from step 3 should be decomposed. Step 5 : Decompose from step 4 again. Step 6 : Save all of the low frequency coefficients as a single vector.

3.1.3 Histogram of Orientation Gradients (HOG)

To apply the HOG, the image is divided into smaller pieces. This method is most beneficial for identifying traits from which valuable data is intended to be derived. Features are extracted by splitting intensity gradients and regional shape properties [17]. For feature extraction, the image is segmented into sub cells, HOG is computed, and the occurrence of gradient orientation is counted. It is mostly used to train the classifier in issues involving facial recognition [18].It's also regarded as a key element descriptor for describing the appearance of items. This approach is quite beneficial for image classification. Estimated features can be extracted for categorization using the HOG feature descriptor. This extraction yields complementary data, which is subsequently fed into classifiers. To locate the face features, the intensity variations are dispersed. HOG features aid classification more effectively. It accurately accumulates discriminative properties [19]. To improve accuracy, the image is separated into blocks and the cells are normalized. For enhanced invariance, this normalization is later employed in shadowing [20].

Procedure:Histogram of Gradients(HOG)
Input : Pre-processed image (X_i) Output : Set of features (F_s)
Step 1 : Input the pre-processed image (X_i) Step 2 : Normalize the image and compute the gradients $H_i = [h_1, h_2, \ldots h_g]$ Step 3 : Accumulate weighted for gradient orientation over spatial cells Step 4 : Normalize contrast with overlapping cells Step 5 : Collect all the generated features $V_{HOG} = [F_1, F_2, \ldots F_i]$

3.1.4Local Binary Pattern (LBP)

LBP is a descriptor which describes the texture's distinct localized patterns on the input pictures [21]. It has been used in a variety of fields, including text recognition; face recognition, and dataset classification. The local dispensing of pixel intensities in the source images [22] is straightforward information to specify. The most essential aspects of LBP are its computational efficiency and invariance lighting. It decreases the number of components required to represent binary patterns.

To reconstruct the form of the image represented by LBP, histograms for each block are computed and then combined into a single vector. LBP is a popular technique for analyzing and modeling texture. If compared to other methods, LBP is effective, specifically in terms of reducing false positives. LBP is often regarded as the most effective technique for extracting features.

Procedure:Local Binary Pattern (LBP)
Input : Pre-processed image (Xi), co-ordinates of center pixel(a1, b1) radius R Output : Set of features (Fs)
Step 1 : Input the pre-processed image (Xi) Step2 : For each pixel Pi, select the size S neighbors' surrounding the central pixel Cp. Step3 : Compare C_v, the centre value, to N_v, the neighbour value. Step4 : if $N_v > C_v$ assign1 else assign2 Step5: $LBP_{N,R}$ (a1, b1) $=\sum_{i=1}^{8} S\ (C_v - N_v)2$; Step6: The histogram value should be extracted. Step7: Extract the expected features (Fs).

3.2 Efficient Local Binary Pattern (ELBP)

The ELBP is a feature extraction method that has been developed to address some of the LBP difficulties. ELBP detects large-scale textural features correctly and obtains local textural information that is sometimes lost in LBP. Noise does not affect ELBP much. To evaluate the feature vector, the ELBP extends the basic LBP by incorporating additional pixels and different neighborhoods. It also organizes the LBP that previously ignored local intensity changes, and provides adequate information to delineate image local structures.The comparisons of support vectors are minimized with the help of the ELBP operator. As a result, the sparsity enhances and the computational ambiguity decreases.

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$$\text{ELBP} = \sum_{i=1}^{P/2} S\left(C_v, C_{v+\left(\frac{p}{2}\right)}\right).2^{i-1} + 2^{\left(\frac{p}{2}\right)+1} \text{S}\ (n_v\text{-}m_v) \text{ where } m_v = \frac{1}{p}\sum_{i=1}^{p} p_i$$

$$\text{S}\ (\text{x}\ ,\ \text{y}) = \begin{cases} \{1, \text{x} - \text{y} \geq 0, \\ \{0, \text{x} - \text{y} < 0. \end{cases}$$

This new method has a good feature extraction result and is very efficient. The proposed technique achieves improved classification accuracy while also having a lower time complexity than the original LBP.

3. 3 CLASSIFIERS

The input data as well as insights are identified and categorized using classification. A classifier is a mechanism for correctly implementing classification. Image classification aids in the improvement of image processing in both people and machines [23]. It categorizes the items or images into the predicted groups. In previous investigations, the top classifiers for delivering accurate results were k – Nearest Neighbor (kNN) as well as Support Vector Machine (SVM) [24].

In general, recognition systems are tailored to specific applications in order to improve performance. The three main phases are preprocessing, feature extraction, and classification. The focus of this study is on Extraction Of features and classifying them. The value of attributes has a greater impact on a classifier's performance than the classification model itself [25]. A decent selection of features must be used to express the traits that are distinctive to one class and are constant. When fed by a feature set, the classifier is indeed a composite of these features. It is widely acknowledged that implementing categorization in machines is extremely difficult [26]. As a result, complicated algorithms such as kNN, SVM, and MBPNN are utilized to categorize the input data in this scenario.

3.3.1 k -Nearest Neighbor (kNN)

It is regarded as one of the most straightforward and straightforward machine learning methods. The kNN algorithm connects the known and unknown patterns. kNN [27] examines the training points as nodes. The distance between both the recall and point of reference is calculated using the Euclidean distance method. The collected distances are then arranged in ascending order, with reference points corresponding to the K smallest. For classification, the distance is used [28]. Because of the ability to generalize information in training images, the speed and accurateness rate are good. It's a non-parametric classification system.The training samples' positions are taken into account, and the distance is determined using Euclidean distance. However, until the classifying process is completed, the location of the training images should remain consistent. It is one of the most used supervised learning methods that accept neighbor value for classification [29]. The minimal distance is obtained by using neighbor value and all of the samples collected for training are organized in ascending order. The similarity measure is by far the most essential factor that influences overall performance, although distance is the most crucial component in this classifier [30].

Procedure : k Nearest Neighbor (kNN)
Input : Classify(X,Y,Z) // X: training data Y: class labels of X Z: unknown sample Output: Calculated Accuracy
Step 1: Input the feature vectors Step 2: for i=1 to m do Compute distance $d(X_i, Z)$ end for Step 3: Compute set I containing indices for the k smallest distances $d(X_i, Z)$ Step 4: Return majority label for Y_i where $\{_i \in I\}$ Step 5: Calculate $\frac{Number\ of\ correctly\ classified\ images}{Total\ number\ of\ images}$

3.3.2 Support Vector Machine (SVM)

SVM is a classifier used in learning machines to solve problems like capacity control extrapolation and object classification. It has been proven to be successful in a variety of additional applications, including handwritten digit identification, picture categorization, face identification, object detection, and text categorization [31]. The classification is an optimum hyper plane that accurately divides data points by splitting endpoints within two classes as many as feasible; SVM seeks to discover this sort of classification. The training sequences on the marginal boundaries are the Support Vectors, and the training pattern is [32]. The sparsity of this technique is an advantage because only a tiny subset of training samples is used to produce classifier output.

The goal of SVM is to analyze the image as input from the data collection. SVM's drawback is that not all characteristics are correctly applied, and only a few are employed in local visual features [33]. As a result, it's a good idea to categorize the regional image features as well. This classifier is mostly used for data analysis. Discriminative classifier is another name for it. It's used to scale data with a lot of dimensions. For both small and large datasets, SVM is used [34]. When compared to kNN[35], the SVM works out better in all circumstances. In order to address quadratic programming problems, it has great generalization ability. This ability is controlled by the training error margin and the learning machine's capacity [36]. The SVM classifier's training and implementation are both incredibly difficult. Due to the large amount of the data, SVM can become inefficient at times [37].

Procedure : Support Vector Machine (SVM)
Input : Feature Vectors(v) Output: Calculated Accuracy
Step 1: Place the feature vectors from Feature Extraction into this classifier. Step 2: Find a line that divides the features. Step 3: Obtain the S_v support vectors that are nearest to the line. Step 4: Calculate the distance between both the support vectors and the line. Step 5: Maximize the margin Mg = $\frac{2}{\|w\|}$ Step 6: The hyperplane with the highest margin is the best hyperplane. $y_i(w_i^T x_i + b) \geq 1$, (x_i,y_i), I = {1,….n}

3.3.3 Modified Back Propagation Neural Network (MBPNN)

It is a reliable and efficient system that functions well. The MBPNN is made up of three layers: input, hidden, and output, which are fully connected one after the other. In addition to receiving the real output pattern, the input sequence is sent into the input layer. The required output is used for training. The output response is now subtracted from the expected outcome, and this value is used in the hidden layer to compute the adjustment, resulting in the real output. When the MBPNN classifier is applied to any of the extracting features approaches, accurate results and mistakes are achieved. As a result, the obtained output is extremely efficient and user-friendly.When compared to other classifiers, the classification performance is also impressive [38]. The determination coefficient is estimated to evaluate this model. It outperforms binding and offers accurate results. In order to improve the model's stability and accuracy, the input pattern must be optimized [39]. When compared to BPNN, MBPNN training and testing is considerably faster.

Procedure : Modified Back Propagation Neural Networks (MBPNN)
Input : Feature Vectors(v) Output: Calculated Accuracy
Step 1: Feed the Features and determine the hidden layer. Step 2: Compute the distance D between the hidden layers $D = max_v – min_v$ Step 3: Select the weights at random and estimate the maximum weight W_{max} Step 4: Determine the center value C $C = (max_v,min_v)/2$ Step 5: Calculate the output and find out the errors in the output Errors = Actual output – Desired output Step 6: Adjust the weight and update the layer weight of output until desired output is Obtained. $W_{ij} = W_{ij} + \Delta W_{ij}$

4. ORL DATABASE

The ORL database contains 400 photos with a resolution of 112 × 92 pixels. These 400 photographs depict only 40 people, each of them is portrayed in ten images with varied poses taken under various conditions such as lighting, imaging angle, and so on. ORL is a biometric identification database that allows technologies to recognize each and every face. The facial database records every pose, lighting, and face expression. Differences in size and compressions are now tracked in databases. To demonstrate appropriate variety in the ORL database, the very same background is given to all photos. All of the photos have the same size and grey levels. Fig.1 shows the sample images.

FIG.1 SAMPLES OF ORL DATABASE

5.

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RESULTS AND DISCUSSIONS

This section presents the outcomes obtained from both existing and proposed algorithms. These methods are implemented with the real time images on MATLAB 2019a and the performance indicators for classification are tabulated below.

Evaluation Parameters

Parameters	Formula
Accuracy	$\left(\frac{No.of\ items\ classified\ \ correctly}{All\ the\ items\ classified}\right)$ x 100
Precision	$\frac{TP}{TP + FP}$
Recall	$\frac{TP}{TP + FN}$
Fmeasure	$2 * \left(\frac{precision * recall}{precision + recall}\right)$
Time	Execution Completed – Execution Started

As the result implies, the ELBP serves better in all the classifiers. The ELBP takes very less time when compared with other algorithms and produces best results. The best of ELBP performance is caught with MBPNN. Testing and Training is considerably fast in MBPNN Classifier. Fig.2 exhibits the top match with the match case.

FIG.2 MATCH CASE WITH THE TEST CASE

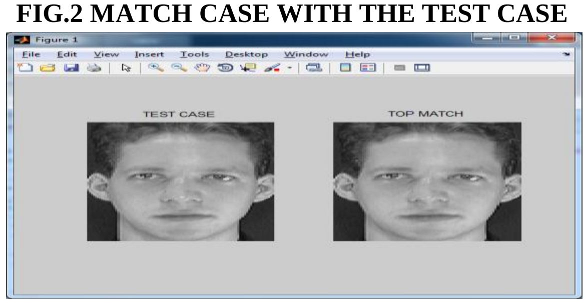

FIG.3 EFFICIENT LBP COMPARED WITH LBP

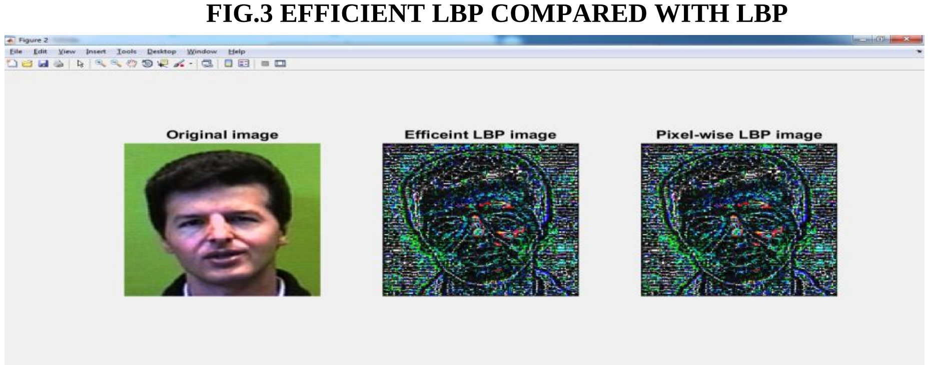

Fig.3 exhibits the variations of an image when classified with LBP and ELBP.

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The results are tabulated in Table.1 and compared to show the accuracy, precision, recall, f-measure and execution time of the various techniques like PCA, HOG, DWT, LBP and ELBP.

Algorithm	Classifier	Accuracy	Precision	Recall	F measure	Time
PCA	KNN	91.4	92.5	95.6	96.3	38
	SVM	94.7	94.6	96.3	97.6	30
	MBPNN	96.5	95.6	97.4	98.8	25
DWT	KNN	85.6	82.4	85.6	92.1	45
	SVM	92.5	86.5	89.5	93.6	38
	MBPNN	96.3	93.4	94.7	94.3	30
HOG	KNN	87.4	89.5	92.4	91.5	48
	SVM	93.6	91.4	93.5	95.3	40
	MBPNN	97.2	96.3	94.3	96.2	36
LBP	KNN	89.6	89	83	87.3	34
	SVM	92.8	92.6	87	85.8	25
	MBPNN	95.4	94.5	92	94.7	18
ELBP	KNN	92.6	92.5	80	95.3	20
	SVM	95.4	96	95	95.8	16
	MBPNN	98.4	97.5	98	97.7	12

Table.1 Classification Results of Feature Extraction Algorithms

In this paper, the feature extraction techniques are compared using classifiers like SVM, kNN and MBPNN. The results display the reliability of SVM. HoweverkNN is less computationally intensive than SVM. But the algorithm should guarantee reliable detection in unpredictable situations depends upon the data. Hence MBPNN is the easy to implement and helps in all the situations. The ELBP provides better result in almost all the cases. It yields good result in less execution time.

6. CONCLUSION

Feature Matching and Image Detection play an important role in Computer Vision and Graphics, as well as all image applications. This has been a particularly active area of inquiry in recent decades, as seen by the massive volume of effort and material produced on the subject. New techniques, such as the Efficient Local Binary Pattern, are said to improve the task and deliver better outcomes. MBPNN identifies the input image and offers an accurate output when recognition is required, lowering the error rate. To achieve good results, the more effective feature extraction algorithm ELBP is applied to the facial dataset and classified. When using the MBPNN classifier, the ELBP feature detection performs admirably the other techniques.

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