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Evaluation of Face Recognition Systems Using SVM Classifier

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Abstract: *A method of biometric authentication offers automatic authentication of people based on those personal characteristics. Human face is a reliable and safe source of individual identification among all other biometrics, since it is universal, special, falls on the face of the person and is therefore unchangeable. The authentication process primarily involves reading the image, the pre-processing stage, the extraction stage of the element, and then the classification and matching and stage. Systems for authentication are often primarily designated according to the particular application in the identification and verification mode. In this paper, some measures to highlight significant features in face images are included in the pre-processing stage. Using one of the CNN techniques such as VGGFace or FaceNet with various scales and orientations, the feature extraction stage is achieved. These techniques were used to decrease the scale of vectors and increase the efficiency of the proposed method. Finally, to evaluate identification the actual user or reject the one which was forged, classification is done using the Support Vector Machine (SVM) classifier as operation of the suggested process in the mode of identification. In this article, the main assistance is the use of SVM technology in face recognition system.*

Keyword: *human face; biometrics; CNN; SVM; FaceNet.*

1. INTRODUCTION

Getting to know people is an important topic in computer vision and different (biometric) methods Biometrics is used to identify people as face is most common, this biometric can be used everywhere in unrestricted environments after face feature extraction. That's why face Recognition has become a very important tool to be used to increase the accuracy and automatic efficiency of video surveillance devices, video analysis software, security systems and a lot of applications in our practical life, such as the demands of smart, entertainment and marketing interfaces. In contrast to object recognition, face recognition is characterized by being able to analyze the general face, as it is of great importance in supporting machines in the way of recognizing humans and discovering their interactions with their expressions and feelings [1].

There are big and difficult problems and challenges, including a large difference in the angle of rotation of the head and its tilt, the intensity of lighting, changing facial expressions, in addition to determining the age of the person, and if the person is young or old, as well as if the person is male or female.

A significant measure of protection is face recognition and authentication. Numerous techniques, methods and algorithms for face recognition have been developed over the past two decades. On the basis of the significant parameter recognition rate, so-called classification rate [2], The output of those various algorithms and methods are compared. If the rate of classification decreases, the rate of misclassification would then increase. Face recognition is performed on the basis of minimum distance measurement between the vectors of the test set function and the vectors of the train set feature. There are various distance measurement methods available, such as cosine similarity and Euclidean distance measurement [3][4]. It should be possible for a facial recognition device to cope with different changes in face pictures. However, because of the change in facial identification, the differences between the pictures of the same person due to viewing orientation and light are almost always greater than image Differences. Facial properties such as nose, eyes, mouth, and chin are found in geometric feature-based methods [5].

Properties and relationships are used as the descriptors of faces, such as regions, lengths, and angles, between the features. Template matching and neural methods, on the other hand, typically function directly on an image based on face representation, the intensity array for the pixels. Since no detection and calculation of geometric face characteristics is needed, these classes of methods have become more realistic and simpler to implement compared to geometric feature-based

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methods. Vapnik and his colleagues have proposed Support Vector Machines (SVMs) as a very efficient method for multipurpose pattern recognition. [6][7].

Using SVM for face recognition depends on the training process and the kernel function. The selection of the kernel is a keen issue in the training. In most cases, the training set is not linear separable. A set of features that describes one face image is called a vector. The aim of SVM algorithm is finding the optimal hyper plane that able to separate the input vectors into one class of the target as shown in Figure 1.

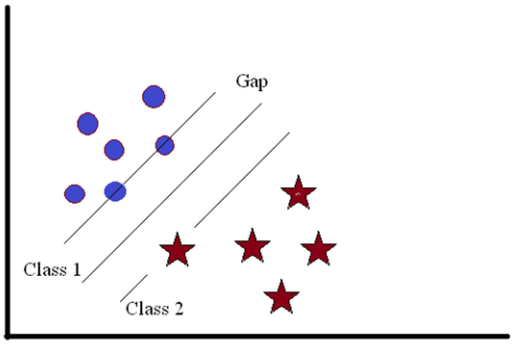

Figure 1 SVM line partitioning

The Radial Basis Function (RBF) in SVM classifier is most productive for our proposed face recognition system. RBF in SVM classifier provides correct recognition results by tackling the problem of misclassification error through SVM. There is sometimes a misclassification error by the SVM for unknown faces (person who is not in dataset), which are not properly categorized, and these faces are far from classes.

The features of face, like0 nose, mouth, eyes, and chin, are subsequently detected, then extracted using feature extraction methods. Finally, the face is identified by comparing the obtained feature vector against a pre-existing database which contains the data of all subjects [8]. Face recognition process can be feature-based, holistic-based, or hybrid-based [8, 9]. These are explained as follows:

1) Feature-based approach: in this approach, the input image is processed to first detect and extract the unique features of a face. These features include the eyes, nose, chin, and brows. Next, a geometric relationship is obtained from the points of the face, such that the input face is represented by a geometric feature vector [9]. This approach is divided into two subtypes: geometry-based, or elastic bunch graph. The former type analyzes the facial features and their geometric relations, whereas the latter employs dynamic link structures to generate a graph using facial points, where each point are represented as a node of a fully connected graph, and is labeled by using Gabor filter.

2) Holistic approach: this approach extracts and analyzes the global information from a set of faces, where the global information is represented by small features obtained from pixels. In this way, the global information is considered as a reference to the given face. This allows the identification of different faces and the detection of the variations between these faces [10]. This approach is further classified into statistics-based approach and artificial intelligence-based approach. The statistical approach employs techniques such as (PCA)Principal Component Analysis [11], fisher face , Eigenfaces and (LDA)Linear Discriminant Analysis [12]; while the intelligence-based approach uses algorithms such as (NN) "Neural Network", (SVM)"Support Vector Machine", (LBP)"Local Binary Pattern", (RBF) "Hidden Markov Model" and (RBF)"Radial Basic Fuzzy" [13].

3) Hybrid based approach: this approach includes the combination of two or more approaches for the recognition of faces. By using this hybrid approach, the shortcomings of either of the approaches can be overcome. For example, specific image pre-processing algorithms can be combined with CNN's to create a hybrid approach [14]. More examples include the combination of PCA and LDA [15], or Eigenfaces and NN [16].

In this review, we concentrate on the issue of face recognition and show that the discrimination functions obtained by SVMs can provide far higher accuracy of recognition than other methods.

2. PREVIOUS RESEARCHES

The face image features are extracted from the human face with facial recognition based on characteristics extracted after the preprocessing point, so SVM has used features. The researchers started dealing with SVM in the method of face recognition. Those forms have been listed below:

In 2010 Shuangbao Shu et al, proposed a method of face skin color detection in two different color models. The Mahalanobis distance map of the image was applied to improve the applied PCA to establish Eigenfaces space. A SVM method was proposed using the error-correcting codes principle for face recognition with a good recognition result [17].

In 2011 Timotius I et al, proposed the combination of (GDA) Generalized Discriminant Analysis as a feature extraction with SVM for face. The achieved accuracy of this method was above 85% [18].

Sani Maizura et al, 2012 proposed nonlinear feature extractor to reduce the feature dimension of the image, called "Locally Linear Embedding". This method considered the hidden layer of face manifold as the input to SVM. The performance is achieved better recognition rates than the PCA approach [19].

Yang Huachun et al, 2013 proposed a hidden conditional random field (HCRF) model and SVM for face recognition. The input face images were separated as

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input to oriented gradients (HOG). The SVM was used as classifier. The results achieved was higher in recognition rate [20].

In 2016 Bhaskar Anand and Mr. Prashant K Shah proposed a method of face recognition that relies on viola jones in face detection, Speed-up Robust Features (SURF) for feature extraction, Support Vector Machine (SVM) as a classifier and Yale faces and UMIST face databases in the testing process. They used the RBF kernel to describe them. They used matlab and Libsvm libraries to execute multi-class SVM for programming. Outcomes show a strong accuracy for images with differences in lighting, Motions of perspective, face expression and scaling, it was 97.78 for Yalefaces and 97.87 for UMIST database. When it was 97.87, 93.60, 93.86, 87.46 if the scales are 1,2,0.75,0.50 and The SVM classifier is an effective classifier that works well with a wide range of classification problems, including high-dimensional issues. In cases where we need to deal with very high-dimensional data, SVM is sufficient [21].

In 2017, R. Dr. R. K. Gnanamurthy, Senthilkumar, compares the increase in efficiency in the identification rate of various methods of face recognition. Techniques of Face Recognition like KPCA, FDA ,1dPCA, ICA and 2dPCA in most cases Euclidean distance and use the feature of cosine similarity in some instances. For classification, instead of standard distance and categorization calculation methods, they use SVM as classifier. SVM discussed in this search utilizes features derived from various methods of face recognition. The regular Yale face dataset is used for evaluating face recognition algorithms. The results of experimental demonstrate that the SVM classifier outperforms standard classification and distance measuring techniques. processes. In addition, this research analyzes the function of the standard deviation parameter is the RBF kernel in face recognition accuracy [22].

In 2020, Yu-Chao Liu, Shu Zhang Zi Yue Li proposed that the PCA algorithm would simplify the low dimensional issue of the high dimensional problem. It is fast, simple and orthogonal to each other are the key components, which is able to remove the original components' influence of the data. The PCA algorithm-based face recognition technology can eliminate noise caused to some degree by light, pose, and occlusion. The SVM method can solve the nonlinear problem by using the kernel function and has a perfect impact for classification. In this paper, Untrained images are subjected to dimension reduction and feature extraction in combination with the PCA and SVM methods, and then the features are entered into the SVM for training that use the Gaussian kernel function. To verify the performance of the SVM, a 10-fold cross validation method has been used. This technique is ideal for with a high detection speed required, like autonomous industrial park patrol cars. Vision Dependent Detection of Face expression with Eigenfaces and Multi [23].

In (2020), Hla Myat Maw, Soe M. Thu and Myat T. M. (FER) "Face Expression Recognition " is now one of the most popular fields of biometrics authentication and computer vision research and has attained the enthusiasm of a number of researchers' enthusiasm. The Facial Expression Recognition system based on Vision aims to identify a given image's facial expression. The facial expression is automatically classified in this paper by the system proposed. The method is consisting of extraction of features and classification of expressions. Hybrid filters (Gabor and Median) and histogram equalizations are used to decrease noise and boost images in preprocessing. Feature extraction is to extract feature vectors based on Principal Component Analysis from face images using the Eigenfaces method (PCA). The feature vectors are loaded into a Multiclass SVM (Multi-SVM) classifier to identify facial expressions. Experiments are conducted on the Japanese Female Facial Expression (JAFFE) standard dataset and are 80 percent accurate. Compared with other approaches and results of state-of-the-art output on the JAFFE database, the proposed framework showed satisfying performance [24].

In 2020 W. Thamba Meshach et al. proposed a Facial recognition system based on haar cascade for face detection and for the feature extraction and classification process was used Multi-dimensional Support Vector Machine (MDSVM). It means two level of SVM classifier. They used Gaussian RBF as kernel. The first SVM is classify the features into positive or negative, after that second SVM will classify the positive class into two classes happy and relax but, the negative class into sad and angry. The database used is International A fective Picture System (IAPS). The average accuracy of (95.88%) with 8-fold cross-validation and (94.25%) without 8-fold cross-validation. There is a challenge faced by researchers, which is the human concealment of his true feelings and to show a different expression [25].

3. System Model

We can predict the steps by which it is possible to classify the destination in the images through what is shown in Figure 2, as it is done with the following steps:

1- There is knowledge of the picture and the destination in it.

2- Then, by cropping, resizing, and so on, operations are performed on the image in another step.

3- The image is filtered and separated from the impurities in this step, in order to get the best coordinates.

4- Via template preparation, the coordinates are then implanted and mounted.

5- Then the system switch through the SVM function to the classifier process. This is completed in two steps and the process stops.

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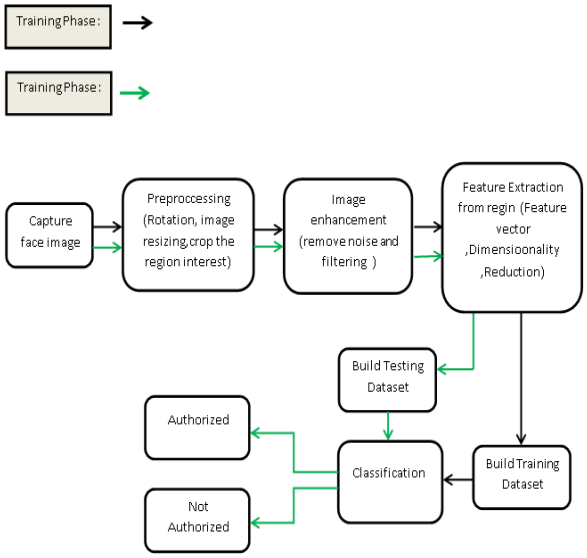

Figure 2 A block diagram showing the primary steps of the face recognition system

There is more complexity to the SVM algorithm than other algorithms. However, it's not difficult to grasp if we have advanced knowledge of mathematics. Also, the basic problem that SVM must solve: There could be several redundant planes in the binary classification problem that can distinguish the two types of data points entirely. The SVM must find an unnecessary plane in these trailing planes; The best hyperbolic classification into two forms of data.

The distance is equal to the closest point of this hyper plane and the maximum distance is twice the classification interval, the trailing plane with the highest classification interval is the best SVM trailing plane looking for. You see that just vector support, it is the best hyper plane defined by the support vector machine.

The vectors corresponding to these data points closest to each other on the best plane in the coordinate system are the support vectors. SVM is, therefore, a problem of optimization: Optimized Objects: Best Airplane Over-rated Objective for improvement: maximization of the classification period Limitations: The distance to the best sub-surface from all the data points is greater than or equal to half the maximum classification period.

The literal understanding is quite short, but more complicated than KNN is the mathematical derivation behind SVM. Fortunately, a machine learning library such as scikit-learn exists. As long as we understand the hyper parameters based on an understanding of the algorithm that you need to fine-tune and how to fine-tune, to implement SVM using scikit-learn.

To promote comprehension and memory, we wrote mathematical formulas: RBF in SVM to simplifies understanding. The RBF kernel on two samples x and xj, represented as feature vectors in the input.

$$RBF(x, xj) = e^{(\frac{\|x-xj\|^2}{2\sigma^2})}$$

The value of σ is between 0 to 1. Experimentally the value for gamma is chosen equal to 0.1.

4. COMPARISON AND ANALYSIS

Our results were based on the previous studies shown in the table below:

TABLE I COMPARISON BETWEEN PREVIOUS STUDIES

No.	previous studies	Experimental results
1	2020 [26]	The design face recognition system depends on SVM classifier and Gabor wavelets transform extracts in feature extraction, as dataset they used Yale. the accuracy was 98.7%.
2	2019 [27]	Face recognition system depend on PCA to extract features of images and SVM in classification, the database is FERET milti-pose and the accuracy 99%.
3	2018 [28]	Face recognition system depends on RBF kernel in SVM classifier to achieve accuracy rate equal 100%
4	2017 [29]	Real time system for facial expression recognition based on PCA for feature extraction and two classifiers SVM and KNN classifier for classification to copmparition the accuracy rate. The accuracy was 88% for SVM and 87% for KNN.
5	2016 [30]	A real-time system to identify human emotions through facial expressions using PCA to extract features from images and SVM in classification, the accuracy rate is 96%.
6	2016 [31]	designed a face recognition system using HOC to extract features and SVM in classification. System trained and checked using ORL dataset The accuracy is 87.5%.
7	2016 [32]	The proposed a SVM based approach using edges, color skin for detecting faces and accuracy is (0.94). The system programming using MATLAB.
8	2015 [33]	Facial expression recognition system based on (PCA+LBP) in feature extraction and SVM in classification. the accuracy rate is 87%.

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In 2020 Rashid, S. J. et al. designed a face recognition system that is based on high (median filter and histogram equalization) in pre-processing and Gabor wavelets transform extracts in feature extraction and to reduce the dimension of photos they used PCA and SVM in classification. they use Yale database of 15 person each one has 11 images. This design is implemented in MATLAB 2018a. there the performance and accuracy were excellent (98.7%) [26].

In 2019 Hui Zhia, Sanyang Liua designed a face recognition system based on (PCA)Principal Component Analysis in feature extraction, genetic algorithm is used to optimize search strategy and SVM for classification stage, for database they used FERET multipose. The accuracy was 99% [27].

Rustam et al 2018 suggested a new algorithm for face recognition which was capable of recognize the person's identity accurately. In this research the face database that is used comes from one benchmark face recognition is computer science research projects. Facial image data used in this study consisted of 10 male and 10 female, with each person having 10 facial images with slight expression differences. The total image That was used are 200 images faces with a balanced composition of 100 female face images and 100 males. They obtain 15,625 features. This study presented a gender classification using SVM. The test proved the SVM method with kernel RBF has achieved the maximum accuracy which was (100 %) [28].

In 2017 Hend Ab. ELLaban et al. designed a real time system for facial expression recognition based on six cases : anger ,surprise, sadness, disgust, fear and happiness .The first step is to discover the face using (Viola - Jones) which consists of two steps (Haar cascade and Adaboost) followed by the step of extracting characteristics using (PCA) Principal Component Analysis .The feature extraction based on appearance , for classification they used KNN and SVM to compare the accuracy rate. SVM has proven its strength by classification. Databases taken from the students were used by a front web camera, which was 30 students and each one had 16 images. As a result, the accuracy rate was 88% using SVM classifier and 87% using KNN classifier [29].

In 2016, Rajesh KM et al proposed a real-time system to identify human emotions through facial expressions, they relied on haar cascade for face detection and Dlip for extract features and PCA d to reduce unimportant dimensions of the image, and in a classification process they used a multisvm. As for the dataset used, it is (Ck and Ck+) 320 images for training the system and (IMM) for testing, in addition 50-60 different set of photo for different people captured from webcam. They measured the time taken during the feature extraction (0.9216 sec.) and (0.1956 sec.) during the classification process, also they implement their system using Machine learning and OpenCV in python. The recognition rate was increased by increasing the training images and equal 96%. The detection time was meaningfully less with less run-time [30].

In 2016 Harihara S. D. and Gopala K. M. P. designed a face recognition system using HOC to extract features from images and SVM in classification. The system was implemented using 8 types of datasets, one of which is ORL, with a training rate of 80% of the total number of images for each person, and an examination rate of 20%, the total number of samples is 40. The accuracy rate was 87.5 % [31].

In 2016 Chitra AD. and P. Ponmuthuramalingam have proposed a SVM based approach using edges, color skin for detecting faces in images with low amount of false detection rate. The final results of SVM classifier showed a good recognition percentage for face images. The researcher used 1000 negative samples and 1000 positive samples, 638 support vectors, the training time is (4.2sec.) and accuracy is (0.94) and validation accuracy is (0.895). The system programming using MATLAB [32].

In 2015, Muzammil Abdulrahman and Alaa Eleyan had a goal to design a system for recognizing facial expressions, as facial expressions depend on the movement of 46 muscles in the face, and with the great development in the design and manufacture of robots and trying to make them mimic humans, they have had difficulty interpreting human emotions, as humans can produce thousands of expressions. In feature extraction they used (PCA+LBP) and in SVM in the classification stage. As for the databases used were Japanese Female Facial Expression (JAFFE) and introduced Mevlana University Facial Expression (MUFE). With the great development in the design and manufacture of robots and trying to make them mimic humans, they have had difficulty in explaining human emotions, as humans can produce thousands of expressions. They worked on six facial expressions classes: surprise, anger, disgust, sadness, happiness, and fear. The accuracy rate was 87% [33].

From the above state of are we can conclude the following features of using SVM as classifier in face recognition system:

1. The classification capacity of the SVM classifier is improved, but it should be noted that it is simple to trigger over-processing if the proportion of training samples is too high.
2. The increase in the number of training samples, in order to refine the model and thus increase the training time, contributes to an increase in the amount of computing.
3. The training model is more difficult, and it also raises the average rating time.
4. Through the studies in the table above, SVM has proven a high ability and efficiency in recognizing faces, especially in cases of changing some facial characteristics such as applying makeup, changing hair styles, wearing eyeglasses or wearing a hat.
5. When compared to distance-based classifications,

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the performance of SVM linear classifiers improves as the feature dimension rises.

6. The performance of SVM classifier is Excellent for small feature dimension.
7. There are two basic problems in SVM: Number one is the classification time. Number two the performance of SVM do not be well across all feature dimensions. Kernel SVM classifiers have an excellent classification rate for small feature dimensions, while linear SVM classifiers have the best rate for high dimensional. Being able to recognize faces with variable facial features such as facial hair, different haircuts, and scars.
8. The results show the main limitation of this method is that the possibility of the human being to hide the real emotions by different external facial expressions, which causes misclassification of affect state.

5. CONCLUSION

In this study, we introduced a new face recognition model that employs the VGG-Face CNN for feature extraction, and the Radial Basis Function in SVM classifier. The key contribution of this work is the use of the VGG-Face CNN as a consistent way to extract features from input images, and the Radial Basis Function as a kernel function in SVM classifier. The proposed algorithm has been designed to be able to properly handle images of faces that appear in different poses. We evaluated our model using the three face databases and obtained a recognition accuracy of 100% with the SVM classifier. This rate attests to the effectiveness of the proposed algorithm and may provide inspiration for future works to implement similar algorithms for face recognition.

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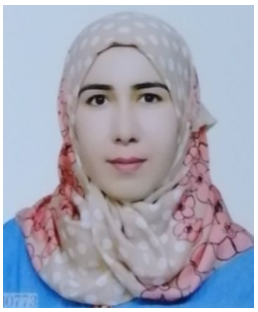
Authors Biography



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