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Enhancing Face Recognition via PCA and Image Enlargement Methods

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Abstract—

A growing number of industries, including the entertainment industry and the security industry, are beginning to show interest in the subject of face recognition. There are occasions when the quality of the recoded film that is obtained from surveillance systems is unsatisfactory. because of the relative separation between the camera and the subject of the shot. These results in the object of attention, such as the face of a person in the picture, having a poor resolution, which makes the process of identification more difficult. Image resolution enhancement is one possible approach to the problem of expanding photographs with a low resolution in order to perform real-time face recognition. After that, the enlarged picture is looked up in a database of photographs that is already accessible in order to either identify or verify the people. However, the optimum performance of face recognition algorithms has not been explored when they are subjected to a variety of picture enlargement methods. This is despite the fact that these approaches have been used. In this study, the performance of a PCA-based face recognition algorithm is explored, along with its compatibility with the three picture enlargement methods that are the most well-known: Nearest Neighbor, Bilinear, and Bicubic. The first step is to reduce the resolution of an input picture to one of six distinct levels. The down-sampled picture is then scaled back up to its original dimensions using one of the aforementioned three methods for image enlargement.

I. INTRODUCTION

In the last two decades, there has been a rising desire to verify persons based on biometric traits [1]. This demand has been driven mostly by technological advancements. Conventional techniques for carrying out auto-recognition, such as both passwords and ID cards are vulnerable to being falsified. As a result of the fact that they are derived from an individual's physiological and behavioral traits, biometric identifiers are universal, one-of-a-kind, permanent, quantifiable, and thus more difficult to forge or steal. Numerous studies have been conducted into the use of biometrics for the purpose of people recognition [2, 3]. Some examples of biometrics that have been investigated include face recognition, ear recognition, palm recognition, finger print recognition, and iris recognition.

Over the course of the last several decades, face recognition has seen fast development, resulting in a greater acceptance of the technology in both commercial and government settings. This is because face recognition may be used for security purposes in a variety of settings, including airports and international border agencies for identification check, automated surveillance systems and social media, and cosmetic surgery face recognition [4-5]. Because it Strikes a good mix between accuracy and the general public's willingness to have their faces scanned, face recognition has emerged as the most promising human biometric for use in automated identification systems. The capacity of humans to identify the faces of other persons is far superior to that of any computer or algorithm.

However, when it comes to recognizing a person from a vast collection of face photos, it is a tiresome effort for a human to simply identify one face among many. One person. A face recognition system is essentially a pattern recognition system that works by acquiring a face image from an individual, extracting certain features (defined as mathematical artifacts) from the acquired data, and comparing this feature set against a template of features already acquired in a database [6]. A face recognition system works by acquiring a face image from an individual, extracting certain features (defined as mathematical artifacts), and the process continues.

Principal Component Analysis (PCA) is a mathematical method that was first presented by Karl Pearson in 1901 for the purpose of analyzing data and developing prediction models. It is being utilized by a large number of people. Face recognition was one of the earliest applications of the PCA approach, which was initially proposed by Turk and Pentland [7]. Additional studies have shown that principal component analysis (PCA) is one of the most well-known and commonly used face recognition methods [8-13]. When using a face recognition approach that is based on principal component analysis (PCA), each facial picture is represented as an algebraic sum of the weighted Eigen vectors (Eigen-faces).

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After that, the computed Eigen vectors of each picture in the database were compared with the extracted Eigen vectors from the extracted images. Several distinct methodologies, such as the Sum of Absolute Difference (SAD) is a tool that is used to either locate the picture in the database that is the closest match or come to the conclusion that there is no match with the photos that are available in the database. A watch list of photos is first generated, then analyzed, and finally saved in a database as part of an automated surveillance system. The recognition system receives input photographs by way of a digital camera's acquisition of the images. The recognition algorithm examines the input picture in relation to the images stored in the watch list database. It then provides a response indicating whether or not the input image has any similarities with any of the previously saved photos. However, the obtained video surveillance material may only provide low-resolution pictures of certain face parts, which presents a problem for the operation of the face recognition system [14].

Cameras for vigilance and a portable electronic gadget the use of embedded cameras has become an increasingly important source of evidence for forensic and criminal investigations. The culprit or criminals may be identified via the use of digital images or video footage taken at the site of the crime. On the other hand, the caliber of Because of the camera's proximity to the action and the angle at which it was positioned; sometimes the recorded picture or video clip is inadequate for the purpose of facial identification. This results in the face of a person in the scene having a poor resolution, which makes the process of identification more difficult. Therefore, the performance of face recognition systems is substantially improved by the deployment of image/video resolution enhancement methods to improve the overall picture quality. This is because these techniques allow for an increase in the image's resolution. When photos with a low resolution are sent into the system, face recognition systems that rely on PCA do not perform very well. Therefore, a method of picture expansion is a viable solution for the problem of expanding the low-resolution input images used in face recognition systems. However, the effectiveness of PCA facial recognition has not been explored using a variety of magnification methods.

II. PCA FACE RECOGNITION WITH VARIOUS IMAGE ENLARGMENT TECHNIQUES

A block schematic of the PCA-based face recognition system that has been developed may be seen in Figure 1. It can be observed from this graphic that first the input image is converted into its Eigen-face vector, and then it moves on to the next step. It then normalized the Eigen-face vector that was produced. Next, the weighted vector of the input picture is determined by projecting the normalized Eigen-face vector onto the Eigen space. Calculations are performed to determine the distance between the weighted vector of the picture being entered and each other image in the database. If the difference, also known as the distance between the weighted vector of the input picture and every image in the database, is larger than a previously determined threshold value, then this indicates that there is no match for the input image in the database. In addition to this, the picture with the lowest

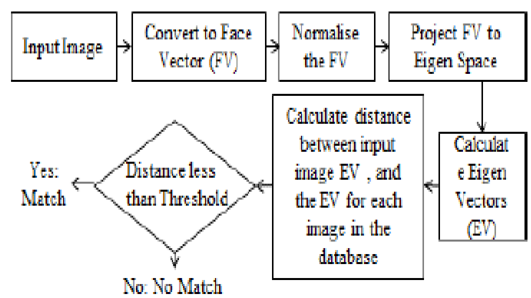

Figure 1. Block diagram of a PCA face recognition process distance is determined by selecting the picture that is either the closest or the best match to the input image.

A. PCA Face Recognition Technique Assume that FF is a collection of photos that are all the same size, and that FF = ff1, ff2, ffNN. A mean adjusted picture ff' is constructed for each image of FF by performing the steps outlined in [15]:

$$f' = f - \bar{f} \qquad (1)$$

Where FF is the average value of the pixels included inside picture ff. After that, each picture ff' is transformed into a column-wise vector, which makes it possible for FF to be shown as a two-dimensional matrix SS. After that, PCA is. Done on matrix S with Singular Value Decomposition (SVD), resulting in the following decomposition:

$$S = U \sum V^T \qquad (2)$$

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Where UU is a unity-matrix, the columns of VV are the orthonormal eigenvectors of the covariance matrix of SS, and are a diagonal matrix of their respective eigenvalues. The covariance matrix of SS is denoted by the symbol SS. The eigenvectors of each different set of pictures FF serve as the foundation of an eigenspace. The primary components in VV that were generated as a consequence are ultimately put to use for matching in the following manner:

$$d_n = \sqrt{\sum_n (m_n - l_n)^2} \qquad (3)$$

After the Euclidean distances between the primary components have been calculated, they are then averaged into an average distance metric, as shown in Equation 4:

$$AvD = \sum D/(N-1) \qquad (4)$$

The picture in the dataset RR for which the value of AAAAAA is reduced is the one that is the best match for the query image qq. B. Improvements to the Image Resolution That Are Built Into Face a method of recognition The setup for improving picture resolution, which is an integral part of the face recognition system, is shown in Figure 2. The library of test images consisted of 130 colored face pictures with a size of 1024 x 1572 pixels. These face pictures were collected from the scarce database of face photographs.

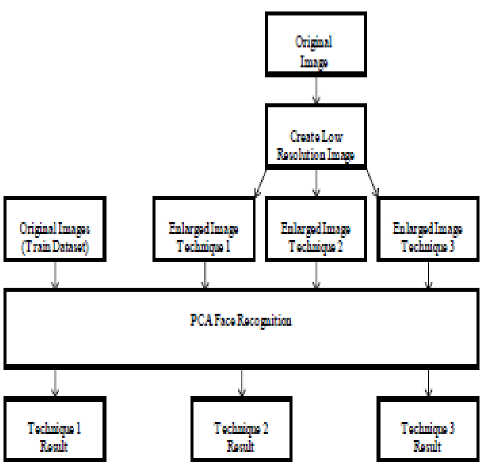

Figure 2. System set up: Image Resolution enhancement embedded in Face Recognition system.

As well as a training set for the algorithm that does facial recognition. The same 130 photographs were then down sampled to a total of six different resolutions, resulting in the creation of six unique sets of test images. Every one of these six modest after that, different resolution sets of test photos were expanded back to their original size using one of the three classic approaches for image enlargement: nearest neighbor, bilinear, or bucolic. This configuration was carried out at six distinct resolutions, including 512 x 786, 256 x 384, 128 x 192, 64 x 96, 32 x 48, and 16 x 24 pixels. The end result is eighteen different result sets including a total of 130 face photos.

The photographs that were produced as a consequence were used as input pictures for the experiment on facial recognition.

III. EXPERIMENTAL RESULTS

In order to investigate the impact on the PCA face recognition algorithm by expanding input photographs that were taken at a variety of distances and using a variety of image enlargement methods, 130 images were examined. Were retrieved from the scarce database and utilized. The PCA face recognition training dataset consisted of the 130 photos, each of which had the original dimensions of 1024 by 1572 pixels. In order to produce six sets of input photos, the test images were first resized to one of six distinct dimensions. These values were as follows: 512x786, 256x384, 128x192, 64x96, and 32x48. One of the test photographs, 001frontal.jpg, was reduced in size and shown in Figure 3 (a) through (f). These are the dimensions that were used. After that, each group of down sampled photos was blown up to their original resolution of 1024 by 1572 pixels with the Nearest Neighbor, Bilinear, and Bicubic scaling algorithms, respectively. True Acceptance (TA), a kind of statistic, was used in order to determine the recognition system's level of accuracy as a percentage. Table I presents the TA results of the PCA face recognition algorithm when the input test images with the size of 1024x1572 were down-sampled to 512x786, 256x384, 128x192, 64x96, 32x48, and 16x24, respectively, and then enlarged back to 1024x1572 pixels using the three different techniques for image enlargement.

The proportion of correct identifications made by the facial recognition system is denoted as follows:

$$TA = \frac{number\ of\ matched\ images}{total\ number\ of\ gallery\ images} * 100\% \qquad (5)$$

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According to the findings, the TA value of the enlarged photos with the size 512x786 that were created using any one of the three different image enlargement procedures is the same as 69.23%. However, as the resolution becomes lower (which reflects photos recorded at varied distances), the quality of the image will suffer. From something like a surveillance camera), the TA drops in an unpredictable manner depending on the kind of magnification used. When compared to the other two ways, the TA is shown to be much lower when using the bilinear methodology, followed by the Bicubic technique, and then finally the Nearest Neighbor method. Figures 4, 5, and 6 illustrate the visual quality of an enlarged down sampled 001Frontal test image with sizes of (a) 512x786, (b) 256x384, (c) 128x192, (d) 64x96, and (e) 32x48 and (f) 16x24 back to 1024x1572 (the original image size) using Nearest Neighbor, Bilinear, and Bicubic techniques respectively. The original image size was 1024x1572
The findings of the TA are shown in Table I and Figures 4, 5, and 6 (a), and they indicate that increasing the input picture by doubling its resolution using any of the three approaches has a little impact on the accuracy of identification as well as the visual clarity of the photos when they were magnified. The TA findings can be seen in Table I (size 256x384) and Figures 4, 5, and 6 (b). These figures demonstrate that when the resolution of the pictures becomes lower, the TA shows a modest decline for the bilinear approach, although the visual quality seems to be comparable across all three techniques. The results of the TA for images with dimensions of 128 by 192 and

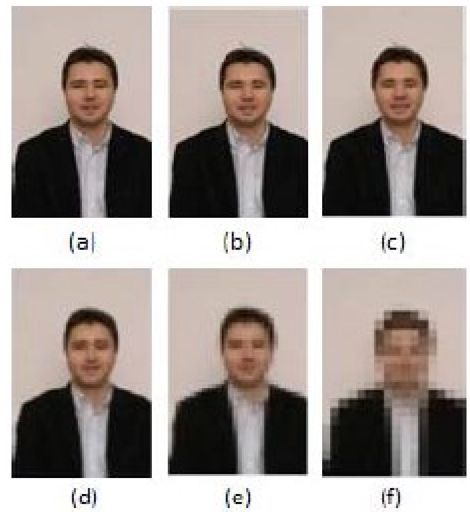

Figure 3. 001Frontal test image was down sampled to different sizes: (a) 512x786, (b) 256x384, (c) 128x192, (d) 64x96, (e) 32x48 and (f) 16x24

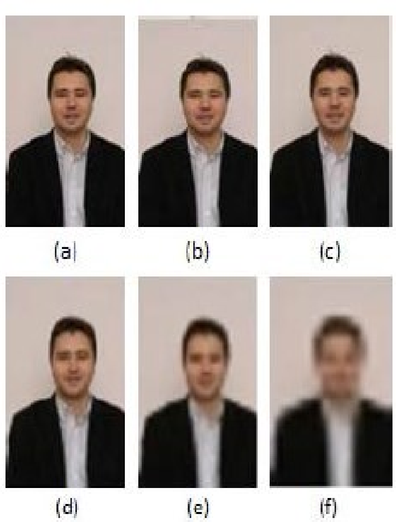

Figure 4. 001Frontal test image with sizes of (a) 512x786, (b) 256x384, (c) 128x192, (d) 64x96, (e) 32x48 and (f) 16x24, enlarged back to the original size of 1024x1572 using Nearest Neighbor technique.

TABLE I. PCA FACE RECOGNITION WITH INPUT IMAGES (RESOLUTION 1024X1572) DOWN SAMPLED TO DIFFERENT SIZES

TA (%): Image resolution 1024x1572 down sampled to:	Interpolation methods		
	Nearest Neighbour	*Bilinear*	*Bicubic*
512x786 resolution	69.23	69.23	69.23
256x384 resolution	69.23	68.46	69.23
128x192 resolution	69.23	68.22	68.46
64x96 resolution	68.46	65.39	66.92
32x48 resolution	56.72	49.23	56.15
16x24 resolution	26.15	22.31	25.39

64x96, display a drop for input pictures that have been expanded using Bilinear and Bicubic while the Nearest Neighbor algorithm continues to retain the maximum TA value. The aesthetic value of the sample photographs shown in Figures the Bicubic and Bilinear algorithms exhibit some blurring around sharp edges, but the Nearest Neighbor technique exhibits small blocking artifacts on the face. For example, 4, 5, and 6 (c and d). At resolution 64x96,

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unlike the previous findings, closest neighbor shows a decline in its TA results; nonetheless, this approach still delivers the best recognition TA results, followed by the Bucolic technique, and then the bilinear technique in last place. Visible blurring is seen in Figures 4, 5, and 6 (e), which helped to explain the findings, provided in Table I (a significant drop in the identification accuracy at resolution 32x48). In conclusion, the TA findings (resolution 16 x 24) demonstrate a significant decrease across the board for all three methods. The closest neighbor is still going to provide the best outcome.

Figures 4, 5, and 6(f) show enlarged pictures that highlight evident blurring artifacts in the Bilinear and Bicubic procedures as well as visible blocking artifacts in the Nearest Neighbor technique. On the other hand, as compared to blurring artifacts, it appears that blocking artifacts result in a lower number of errors in face recognition % accuracy.

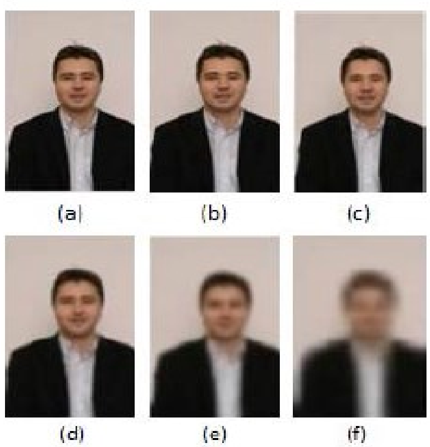

Figure 5. 001Frontal test image with sizes of (a) 512x786, (b) 256x384, (c) 128x192, (d) 64x96, (e) 32x48 and (f) 16x24, enlarged back to the original size of 1024x1572 using Bilinear technique.

In the PCA facial recognition test, the method that consistently produces the best results is the Nearest Neighbor method, followed by the Bicubic method, and then the bilinear method. The closest neighborhood has the fewest computational requirements. A higher level of complexity in its algorithm compared to the other two ways of picture magnification. It has also been found that picture expansion methods that give the highest visual image quality outcomes for human eyesight may not deliver the best result when used to computer algorithms. [Citation needed] [Citation needed] [Citation needed] Therefore, in order to get the best results possible with face recognition during automated surveillance, it is necessary to research the component algorithms, which include methods for pre-processing input photos as well as the face recognition algorithm that will be used.

IV. CONCLUSIONS

In the framework of PCA facial recognition, this research analyses the best performance of classical picture expansion approaches. There are three widely used picture resolutions. A variety of image enhancement algorithms, including Nearest Neighbor, Bilinear, and Bucolic, were used in order to increase the size of a chosen number of pictures taken from a data collection consisting of images of varying resolutions. After the photos had been scaled up, they were sent into the PCA face recognition system, where a total of three distinct image scaling techniques were performed to each of the images. The findings of the simulation reveal that PCA face recognition produces better results when the input photos are expanded using the Nearest Neighbor approach, however the performance of the Bicubic and Bilinear methods is somewhat worse than the performance of the Nearest Neighbor method.

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