# Generating and Detecting Face Morphing Using Texture Techniques

*Iman Saleem Razzaq*
*Computer Science Department*
*Computer Science and Mathematics*
*Najaf, Iraq*
imans.alrihbawy@student.uokufa.edu.iq
https://orcid.org/0000-0001-5052-744X

*Bahja Khudair Shukr*
*Computer Science Department*
*Computer Science and Mathematics*
*Najaf, Iraq*
baheeja.k@uokerbala.edu.iq
https://orcid.org/0009-0002-5018-2968

**DOI:** http://dx.doi.org/10.31642/JoKMC/2018/100115

**Received Feb. 1, 2023. Accepted for publication Mar. 8, 2023**

***Abstract—*** *Biometric forms major and very effective role nowadays in many fields such as health, reliability, devices, phones, banking, airport security, and others because of its unique characteristics for each person that cannot be replicated in another person. Therefore, most security systems rely and verify biometric properties. Airport security systems rely directly on facial recognition, but these systems may be exposed to attacks by the use of morphing faces in the passport image that allows multiple users to use the same passport. This paper presents a complete system consist of three stage, the first stage generating morphing faces based on edge detection to determine landmark and combine between landmarks to produce morphing. The second stage passing images on to the face recognition system that using Local Binary Pattern to features extraction, the final stage how to detect image bona fide or morph using texture techniques represented by each Local binary pattern and Gray-Level Co-Occurrence Matrix. With the use of the Wasserstein Distance measure, which has not previously been used in this field. The method gave effective results showing the mechanism of reducing morphing attack. The prposed system is achieved an average accuracy of 75% for AMSL dataset compared with our dataset, with an accuracy of 80%. The power of the proposed work is evident through the FRA and RFF evaluation. Which achieved values as low as possible for dataset FAR 0.25%, indicating the error rate in calculating morphed images is actual, and FRR 0.30, meaning the error rate in calculating the actual images is morphed, these ratios are less than one, the higher system's accuracy in detection. The AMSL dataset ( FAR 0.20 , FRR 27%). It turned out that the training of the proposed method optimized for the features extracted for the landmarks area significantly affects finding the difference and discovering the modified images, even in the case of minor modifications as in the AMSL dataset.*

***Keywords— Edge Detection, Face recognition, Wasserstein Distance, Face landmark, Local Binary Pattern, Gray-Level Co-Occurrence Matrix.***

## I. Introduction

Recognizing faces through the use of biometrics is an area that has seen significant growth in the field of identification both locally and internationally. This is due to the fact that faces are packed with information and vary widely from one person to the next. The field of commerce, the field of social media firms on websites, mobile phones, and other fields all make extensive use of facial recognition systems. International airports are another example of a setting that makes extensive use of this technology [1, 2]. Researchers are showing a lot of interest in the face recognition system in an effort to develop a system that is highly capable of identifying people, despite the fact that many people look very similar to one another [3]. Travelers' faces might be recognized at international airports, which is one of the industries that is showing the highest interest in the technology. The images that are contained within the passport are compared to the traveler's actual face. Facial information from a digital identification taken from a machine-readable travel document is used for this (eMRTD) [3, 4]. How does something like that occur? Airports are equipped with surveillance cameras that snap photos of persons going through the terminals. This live image is then matched with a picture of the same people that was previously stored in the eMRTD when a passport application was submitted. The procedure of comparison is carried out with the use of face-based identification verification technologies. If a particular threshold limit determines that the two photos are identical to one another, the system will either offer an accept or a rejection. If the result is lower than the threshold limit, the system will give a rejection [5, 6]. In addition, there was a stage that involved manual verification between the person verifying the passport and a copy of the traveler's passport. This step was performed by the individual who was responsible for the transit of travelers. The image that was taken of the passenger must be free of any flaws in order for the distinction to be made correctly. In addition to having their eyes open and not wearing glasses, travelers are not allowed to wear masks, and they are required to have a straight posture and keep their hair away from their face [6, 7]. Figure 1 explain result face recognition system for morph image.

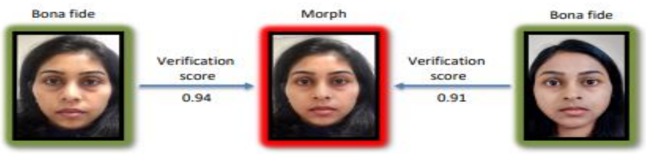


Fig. 1. Accept rate for both two images in face recognition system.

The morphing face has a significant amount of potential both for optical and electrical illusion. Therefore, work has been done in this field in recent years to lessen this problem, as a lot of research has concentrated on the utilization of new devices and technologies or the modification of earlier systems. This work has been done in an effort to reduce the impact that this issue has [8].

The main contributions of this paper are outlined as follows:

- Creating high-resolution images by generating morphed images in various ways, both manually and automatically.
- Creating a developed feature extraction model. Using LBP and GLCM.

The sections of the paper are organized as shown in the following figure: part two discusses difficulties associated with face morphing and face recognition systems. In this three-part series, we will talk about face morphing and generation. whereas the techniques of face morphing are introduced and discussed in the fourth portion. and last but not least, the conclusion.

## 2. Generation Face Morphing

Two databases were used in the proposed system. Made downloaded from the Internet. AMSL represents Data Set of Face Morph Image [9] include: Three files, the first file contains the original images of 201 people, the Face Research Lab London Set, the second file contains images of the same people, but with a smile, and the third file contains the images of the morph images, which have been modified to meet the standards of the personal images used by eMRTD, created by merging a pair of images into an image one. The second dataset was created using an edge detector landmark in face and works warping between two images, find morph image from average pixels.

Figure 2 shows some morph image using our method.


Figure 2: A) represent first person, B) represent second person, D) represent morph image.

## II. METHODOLOGY

In this section, we will describe at the algorithms used to extract features from images for face recognition and morph detection.

### 1. Viola-Jones algorithm

The image consists of an object and the background. The background features may affect the process of discrimination or detection, so first, only the face area is deducted. We can also consider the hair from the background, because it is easy to change its color or shape to become completely similar between people, as its features become similar between the two people. Hair and background will be avoided and focus on facial features and skin texture only. The face is subtracted by this algorithm. This method examines many small sub regions of a grayscale image in order to find a face by looking for specific qualities in each one. Because some an image can contain a large number of different-sized faces, it needs to verify many possible places and scales. The viola jones method consists of four basic phases [10, 11].

- **Haar-Like Features Selecting:** Object recognition uses digital image properties known as Haar-like features. In all human faces, the eye region is darker than its neighbor pixels, whereas the nose region is brighter than the eye region. Add the pixel values from both places and compare them to see which is lighter or darker. The darker area's pixel values will be less than the brighter area's pixel values. If one side of the box is lighter than the other, it could symbolize the brow's edge, or if the middle portion of the box is shinier than the surrounding boxes, it could indicate a nose.
- **An Integral Image Creating:** The integral image aids our capacity to perform these complex calculations rapidly in order to evaluate whether a feature with several attributes matches the criterion.

- **AdaBoost Training:** AdaBoost is a type of machine learning algorithm. every feature for Haar-like appears a low learner. AdaBoost assesses the execution of the classifiers submit in order to select the type and size of feature that will be included in the final classifier.
- **Classifier Cascades Creating:** Multiple windows will be created from the image. In the deliberate cascade, every window is an input. The window is tested at each layer to see if it contains a face or not, according to the strong classifier. If the answer is no, the window will be turned down, and the process will begin all over again for another window. If it's positive, the window is a possible face, and the cascade will advance to the next layer. If the window passes through all layers of the purposeful cascade, it has a face as the.

### 3.1 Local Binary Pattern Algorithm (LBP)

LBP is a texture descriptor that extracts accuracy features of an image. The image is divided into 3x3 blocks. The center of the block in the second row and second column is determined as a threshold boundary and compared with its 8-neighbors. If an adjacent value is greater, it will be set to one, and if it is less than or equal to zero, it will produce 8 binary bits that are converted into a number and placed in the center of the image that corresponds to the block location. The movement can be clockwise or counterclockwise, as well as the threshold limit by setting the bit value larger or smaller**.** Figure 3 explain LBP process [12, 13].

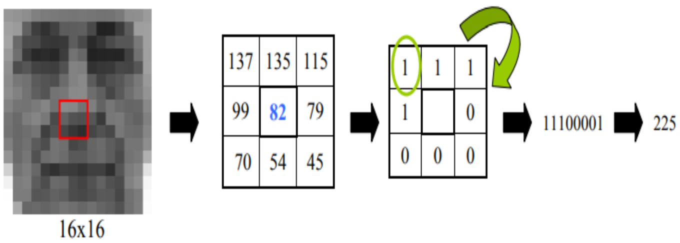


Figure 3: Represent LBP process for input image.

It can be represented by the following equations:

$$LBP(x_c, y_c) = \sum_{n=0}^{7} s(l_n - l_c)2^n \quad (1)$$

$$s1(u) = \begin{cases} 1 & if \quad u > 0 \\ 0 & if \quad u \le 0 \end{cases} \quad (2)$$

Where $lc$ represent center value of block, $ln$ represent values of neighbor, n lever of image, u value of position.

## 2. Gray-Level Co-Occurrence Matrix (GLCM)

This method depends on extracting the statistical characteristics of the image. This algorithm is one of the texture algorithms. Depends on the spatial relationship between pixels within a grayscale matrix. Its principle of operation is to count the number of times the ordered pairs of the gray levels of the image are repeated, creating what is called a GLCM matrix. This is done through specific angles 45, 90, 180, 270 and then applying statistical measures to this matrix. Figure 4 shows calculate of GLCM [14, 15].

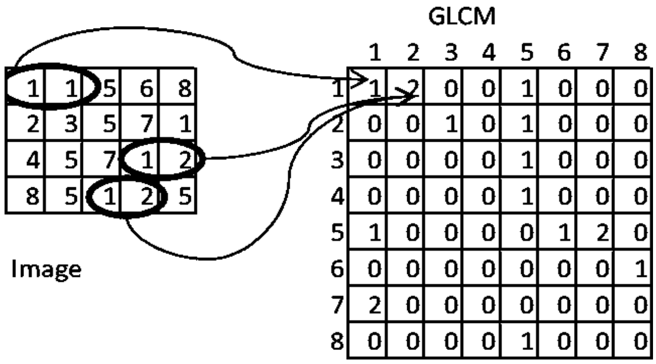


Figure 4: Process compute GLCM matrix.

Table 1: statistic measures.

| **Statistic** | **Description** | **Equation** |
|---|---|---|
| Contrast | Measures the domestic differences in GLCM | $\sum_{r,s} \lvert r-s \rvert^2 q(r,s)$ (3) |
| Correlation | After finding the specified pixel pairs in the GLCM matrix, the occurrence of the common probability between them is calculated. | $\sum_{r,s} \frac{(r-\mu_r)(s-\mu_s)q(r,s)}{\sigma^r \sigma^s}$ (4) |
| Energy | In the GLCM supply's the total of squared elements. | $\sum_{r,s} q(r,s)^2$ (5) |
| Homogeneity | GLCM contains a set of elements that measures how close the distribution of these elements is to the main and secondary diameters of the GLCM matrix | $\sum_{r,s} \frac{q(r,s)}{1+\lvert r-s \rvert}$ (6) |

## 3. Wasserstein Distance

Commonly used measures such as Euclidean, city block and others depend on finding the squared difference or the absolute difference between values directly. As for this method, it depends on finding the distance between two possibilities, it is necessary to find the probability of the features and then find the distance where it works to reduce the difference between them. It is used with machine learning or deep learning in particular, such as the GAN or VAE algorithm, represented by the following equations [16]:

$$if\ p_k \le q_s \quad f = p_k \quad p_k = 0 \quad q_s = q_s - f \quad (7)$$

$$if\ p_k > q_s \quad f = q_s \quad q_s = 0 \quad p_k = p_k - f \quad (8)$$

$$d_k = Inf|p_k - q_k| \quad (9)$$

Where p and q two probability with same size, f variable.

## III. Proposed System

The proposed system consists of two parts. The first part face recognition, and the second part detection face if they are morph or not, but this step comes after deceiving the recognition system if it cannot differentiate between them (origin image and morph image), it is passed to the detection part to make sure if the face is morph or not.

### 1. Face Recognition System

It includes a preprocessing of the image and then a differentiation process using the LBP algorithm. The figure below shows the initial image processing process. Figure 5 represent steps that using in pre-processing. Using histogram image in order to enhancement illumination of image.

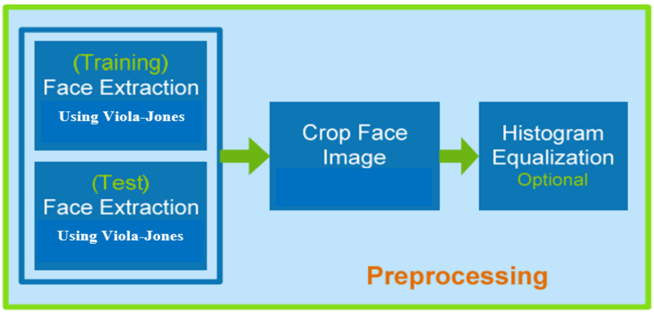


Figure 5: Pre-processing operations for data that using in training and testing.

LBP is applied to the base images after preliminary processing and then histograms are made for the resulting LBP image to find the probability of color values. Then find the closest image through Wasserstein Distance. Figure 6 shows recognition system.

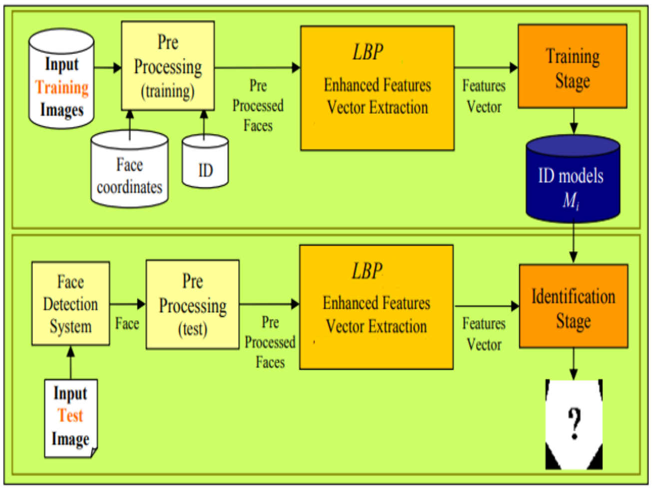


Figure 6: Face Recognition system for dataset (training and testing).

### 2. Detection Morph System

The detection system is based on feature extraction using LBP and GLCM algorithms. Figure 7 shows detection system.

Algorithm 1 describes the entire system from input to output.

| Algorithm1 of Proposed Method: Generation and Detection Face morphing. |
|---|
| Input: Images.<br>Output: Decision morph image or not.<br>Began:<br>1. Generated morph image between two images where determine $img_1$ represent first person and $img_2$ represent second person.<br>2. Resize $img_2$ with same size $img_1$.<br>3. Using Markov filter to find features of face image where shows edge of landmark.<br>4. Reduce edge and focus on strong edge in image using morphology operation.<br>5. Determine landmark of face for each image and work alignment between them.<br>6. Find average value that morph image.<br>7. Create dataset from previous steps.<br>8. Divide dataset in two group training and testing.<br>9. Cropping face only from image using Viola-Jones.<br>10. Apply LBP algorithm on training images and apply histogram on result image to find probability for each them.<br>11. for testing take set images and find LBP features then apply histogram.<br>12. Using Wasserstein distance find the nearest image based on threshold.<br>13. If test image max from threshold then the image is rejected.<br>14. If the image accepted here must verification from image if morph or not.<br>15. Find Features for each both testing image and nearest image using LBP and GLCM.<br>16. Find distance between features vectors then gave decision morph or not.<br>End |

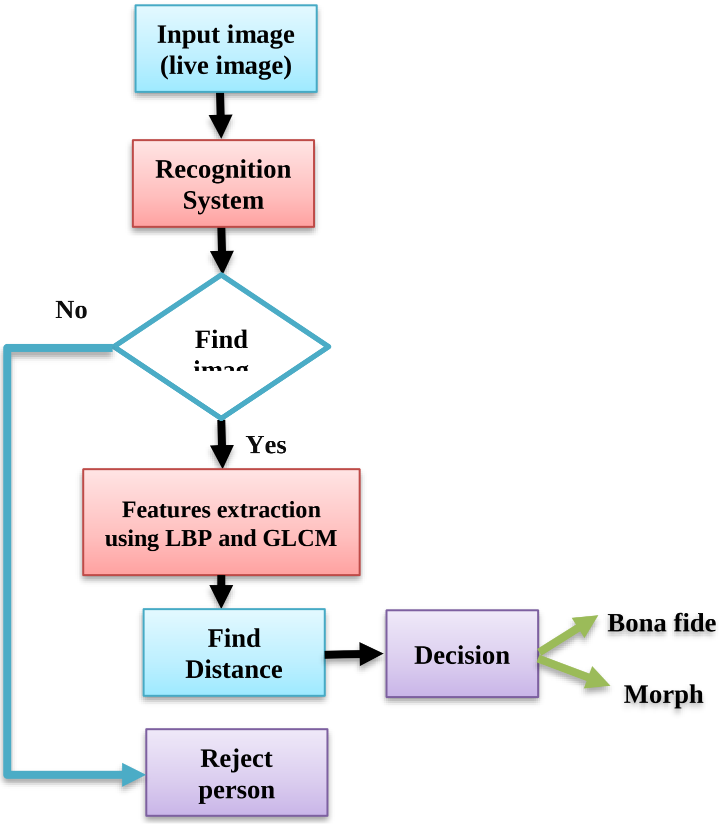


Figure 7: Flowchat explain proposed method for Detection morph process.

## IV. Result and Discussion

In this section, we present the results for the face recognition system and the detection and verification system for faces separately from the recognition system. As shown in the tables below, the ratios of measures obtained after applying the proposed method to the dataset. Metrics used in the detection system:

$$ACCuracy = \frac{|\text{Correctly classified images}|}{|\text{All classified images}|} \quad (10)$$

$$\text{False Acceptance Rate } (FAR) = \frac{|\text{Accepted morphs}|}{|\text{All morphed images}|} \quad (11)$$

$$False\ Rejection\ Rate\ (FRR) = \frac{|\text{Rejected genuine individuals}|}{|\text{All genuine images}|} \quad (12)$$

Table 1 shows the results obtained from the recognition system.

| Dataset | No. Image | Type | Rate (%) |
|---|---|---|---|
| AMSL-Face Morph | 2,167 | Real/Morph | 99 |
| ORL | 400 | Real only | 93 |
| Proposed Dataset | 75 | Real/Morph | 90 |

The above table shows the application of a system on three different bases, in which the accuracy results differ. The base AMSL-Face Morph contains a set of images, the actual converted images are only the front images. The recognition rate was 100%. As for the second rule, ORL, it contains the real pictures, but the images take different shapes, by turning the face, turning to a certain direction, or curving the head. The base that was created in our way has a 100% recognition rate and contains only front photos, as in the images that are placed in passports.

Table 2 shows the results obtained from the detection morph system.

| Dataset | FAR | FRR | ACC |
|---|---|---|---|
| AMSL-Face Morph | 20% | 27% | 75% |
| Proposed Dataset | 25% | 30% | 80% |

It is not very easy to detect the morphing process because of the convergence of the generated images in a way that deceives the systems, but we try to determine the least difference between the images in order to detect the morph. The table above shows the differences in the scale ratios. The more similar the images are, the more difficult the detection process, and any system fails to detect, but in a proposed system, the results were good and indicate the extent of detection despite the closeness of the images to each other. It is necessary to focus on the loopholes that affect the converted images, as these are considered weaknesses that can be exploited for detection.

## 6. Conclusion

This paper presented a model combining the features extracted from machine learning to get the best features for detection. In comparison to other previous publications, the proposed technique yielded promising findings which includes a complete system, starting with the generation of images automatically based on edge for determine landmark, and ending with the detection of the transformation, which is completely automatic, that it can be used for general purposes. Texture algorithms have the ability to detect changes and differences between images with minimal effort. It is possible to combine the statistical features generated by GLCM with features from deep learning such as VGG16 and Face-Net and apply them to large databases because deep learning requires massive data training to give accurate results. Future work on the original image and the morph, in which the facial features are compared, is possible using wavy duplication techniques that allow calculating the changes that occurred between the original image and the improved or modified image and determining the percentage of change in quantity and quality.

**References**

[1] W. Ali, W. Tian, S. U. Din, D. Iradukunda, and A. A. Khan, "Classical and modern face recognition approaches: a complete review," *Multimedia Tools and Applications*, *80*(3), 4825-4880.
[2] Parmar, D. N., & Mehta, B. B. (2014). Face recognition methods & applications. *arXiv preprint arXiv:1403.0485*.
[3] M. Ferrara, A. Franco, and D. Maltoni, "The Magic Passport," Proc. IEEE Int. Joint Conf. on Biometrics," pp. 1–7, 2014.
[4] M. Ferrara, A. Franco, and D. Maltoni, "On the Effects of Image Alterations on Face Recognition Accuracy," In Bourlai, T. (ed.) Face Recognition Across the Electromagnetic Spectrum, pp. 195–222, 2016.
[5] U. Scherhag, R. Raghavendra, K.B. Raja, M. Gomez-Barrero, C. Rathgeb, and C. Busch, "On the Vulnerability of Face Recognition Systems: Towards Morphed Face Attacks," Proc. IWBF, 2017.
[6] R. Raghavendra, and C. Busch, "Presentation attack detection methods for face recognition systems: A comprehensive survey," ACM Comput. Surv., 50(1), Mar. 2017
[7] L. Wandzik, G. Kaeding, and R. V. Garcia, "Morphing detection using a general-purpose face recognition system," In *2018 26th European Signal Processing Conference (EUSIPCO)* (pp. 1012-1016). IEEE.
[8] D. J. Robertson, A. Mungall, D. G. Watson, K. A. Wade, S. J. Nightingale, and S. Butler, "Detecting morphed passport photos: A training and individual differences approach," Cogn. Res. Princ. Implicat., vol. 3, no. 1, p. 27, Jun. 2018.
[9] Jana Dittmann, Otto-von-Guericke-Universität Magdeburg Faculty of Computer Science (FIN) Department of Technical & Business Information Systems (ITI) Research Group "Multimedia and Security" (AMSL), 39106 Magdeburg Germany,https://omen.cs.unimagdeburg.de/disclaimer/index.php.
[10] N. Hazim, A. Bermani, N. Hazim Barnouti, S. Sameer Mahmood Al-Dabbagh, W. Esam Matti, and M. Abdul Sahib Naser, "Face Detection and Recognition Using Viola-Jones with PCA-LDA and Square Euclidean Distance Related papers Face Recognit ion: A Lit erat ure Review Nawaf Hazim Face Image Recognit ion Based on Linear Discernment Analysis and Cuckoo Search Opt imizat ion w," IJACSA) Int. J. Adv. Comput. Sci. Appl., vol. 7, no. 5, 2016.
[11] M. N. Chaudhari, M. Deshmukh, G. Ramrakhiani, and R. Parvatikar, "Face Detection Using Viola Jones Algorithm and Neural Networks," Proc. - 2018 4th Int. Conf. Comput. Commun. Control Autom. ICCUBEA 2018, pp. 1–6, 2018.
[12] S. Karanwal, and D. Manoj, "Neighborhood and center difference-based-LBP for face recognition," *Pattern Analysis and Applications* 24.2: 741-761, 2021.
[13] B. Niu, G. Zhenxing, and G. Bingbing, "Facial expression recognition with LBP and ORB features," *Computational Intelligence and Neuroscience* 2021 (2021).
[14] S. Abeer, M. A. Talab, and R.R. Al- Dahhan, "Features Extraction for Robust Face Recognition Using GLCM and CS-LBP," *International Conference on Emerging Technologies and Intelligent Systems*. Springer, Cham, 2021.
[15] M. Yogeshwari, and G. Thailambal, "Automatic feature extraction and detection of plant leaf disease using GLCM features and convolutional neural networks," *Materials Today: Proceedings* (2021).
[16] J. Stanczuk, C. Etmann, L. M. Kreusser, and C.B. Schönlieb, "Wasserstein GANs work because they fail (to approximate the Wasserstein distance," *arXiv preprint arXiv:2103.01678,2021*.